D5.9	**Prototype of uncertainty computation and integration with the OpenTURNS toolbox**
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Open Cyber-Physical System Model-Driven Certified Development

Executive summary[4]:

D5.9 deliverable provides a report on the implemented uncertainty computation support in the OpenCPS project.

There are two prototypes available:

- The OpenTURNS FMI plugin which uses FMUs to run the model
- The OpenModelica - OpenTURNS integration which uses the OpenModelica build simulation for the model

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[1] Access classification as per definitions in PCA; PU = Public, CO = Confidential. Access classification per deliverable stated in FPP.

[2] Deliverable type according to FPP, note that all non-report deliverables must be accompanied by a deliverable report.

[3] Due month(s) according to FPP.

[4] It is mandatory to provide an executive summary for each deliverable.

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[5] Indicate Main Author(s) with an "X" in this column.

[6] Deliverable leader according to FPP, role definition in PCA.

[7] Person(s) from contributing partners for the deliverable, expected contributing partners stated in FPP.

[8] Typically person(s) with appropriate expertise to assess deliverable structure and quality.

[9] Status = "Draft", "In Review", "Released".

CONTENTS

ABBREVIATIONS

List of abbreviations/acronyms used in document:

Abbreviation	Definition
FMI	Functional Mock-up Interface
FMU	Functional Mock-up Unit
M&S	Modelling and Simulation
N/A	Not Applicable
NPP	Nuclear Power Plant

1 UNCERTAINTY COMPUTATION

Uncertainties studies [1] have been used at EDF for safety demonstrations and to check that the operational margins prescribed by environmental standards and operational constraints are well respected.

The uncertainty propagation method, a methodology and a corresponding open source tool, called OpenTURNS [2], have been jointly developed by EDF, Phimeca and AIRBUS. The idea is thus to apply this approach to existing Modelica models in order to capitalize as much as possible on the modelling efforts and bridge the gap between dedicated uncertainties tools and well-established modelling environments.

In this document we present the software prototypes for uncertainty computation developed in the OpenCPS project.

1.1 Uncertainty computation with FMI

EDF via a contract with the French SME Phiméca, has developed a Python module to make OpenTURNS compliant with the FMI standard. This module will make it easier to use OpenTURNS for uncertainties studies (e.g. propagation of input uncertainties to the model outputs, sensitivity analysis …) involving Modelica or any other models that can be exported to FMI. This module called otfmi is under a LGPL3 license and can be freely downloaded via Github (https://github.com/openturns/otfmi) as well as its associated documentation [5], [6]. The otfmi module has been successfully tested on the partial model of NPP secondary loop in demonstrator D6.7.
A first prototype (not available publicly) has also been developed to interface the otfmi module with the OpenTURNS GUI in order to make it more intuitive to the user.

1.2 Uncertainty computation with OpenModelica

A prototype for propagating uncertainties through Modelica models was already developed by LIU in collaboration with EDF in the framework of the ITEA2 OPENPROD project [3], [4]. This work proposed an architecture where:

1. The uncertainties study is specified in the Modelica models with special variable attributes (e.g. to tag some variables as uncertain and associate them to distribution laws);

2. The OpenModelica compiler produces the classical executable model and interprets the special variable attributes to generate the files requested for the connection to OpenTURNS (i.e. a specific wrapper as well as Python and Modelica scripts to drive the computations);

3. OpenTURNS is used to perform the propagation of uncertainties and produce the requested results by running OpenModelica models in parallel.

In the OpenCPS project, the architecture has changed to be based on FMUs instead of OpenModelica compiled models (Figure 1). The simulation of FMUs is currently performed by otfmi. There is also ongoing work in progress to support OMSimulator composite FMU models as

well. This way not only OpenModelica compiled FMUs but any FMUs, from other tools, can be supported.
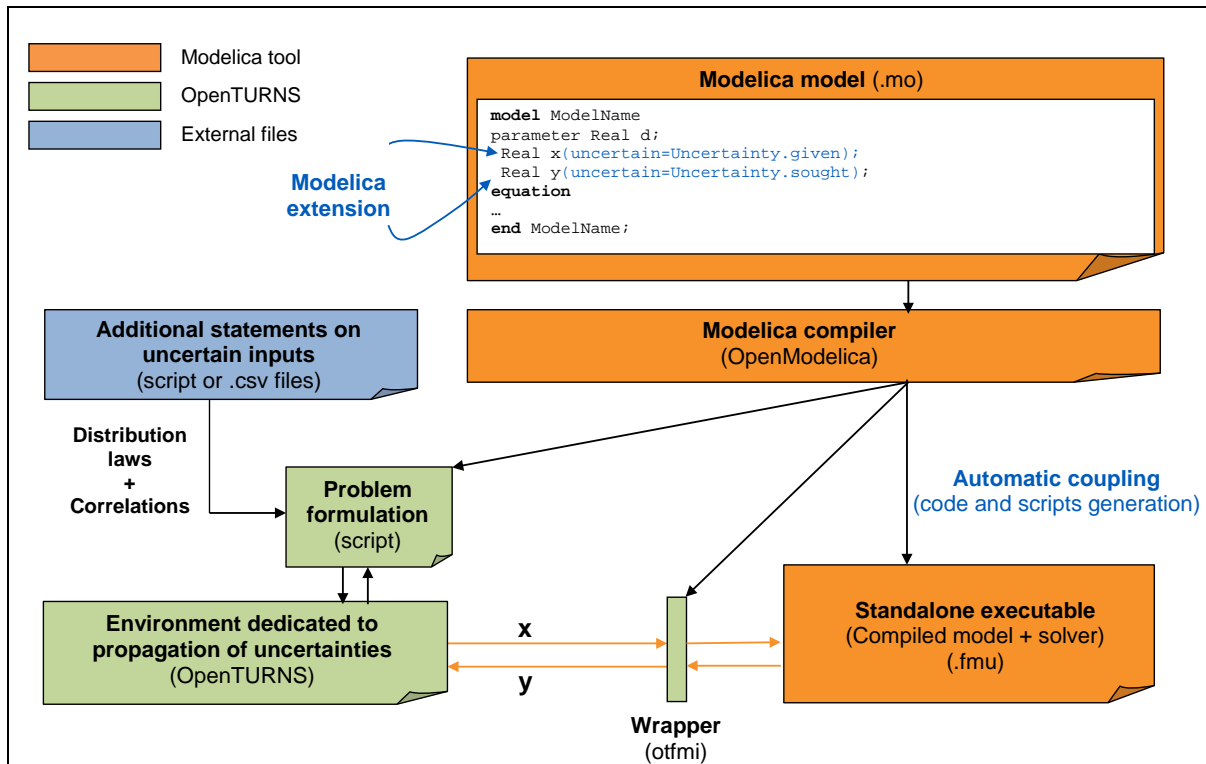

Figure 1. OpenTURNS - OpenModelica connection

The objective within OPENCPS is to provide an interface in the OpenModelica Connection Editor to run the uncertainty propagation. The prototype is in works and will become part of the open-source OpenModelica project [7] in the beginning of 2019 and will be further tested and developed by LIU and SICS during the 4 month project extension.

REFERENCES

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