

Error Generation Libraries for the open Simulation Framework

OSFEG

DEVELOPER'S MANUAL

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1. INTRODUCTION

This project concerns the definition and development of libraries to ease the generation of analytical and stochastic perturbations, or a combination of them, in the models that will be integrated into the open Simulation Framework (openSF) system. It will be applicable to other projects that imply the use of openSF.

1.1. Purpose

The objective of this document is to provide a detailed description and an operation manual of the error generation libraries used during the development and deployment of the models implied in a simulation creation process.

The intended readerships for this document are model developers and scientists that are in charge of integrate those models into the open Simulation Framework.

This document is also useful to software engineers responsible of the testing stage.

1.2. Scope

This document shows a detailed description of the libraries and an API that should be used as a reference manual by model developers. It also includes a brief architecture description and some examples of use.

This document contains the following sections:

- An introduction (current section 1) for giving a quick overview of the project;
- A list of related documents to provide a documentary background (section 2)
- An introduction to the libraries, installation and linking instructions (section 3)
- A description of the architecture, the process logic and some examples of use. It also includes the coding guidelines (section 4)

1.3. Acronyms and Abbreviations

The acronyms and abbreviations used in this document are the following ones:

Acronym	Description
AD	Architectural Design Applicable Document
ADD	Architectural Design Document
ADR	Architectural Design Review
API	Application Programming Interface

Acronym	Description
AR	Acceptance Review Analysis of Requirements
AT	Acceptance Test
ATP	Acceptance Test Plan
ATR	Acceptance Test Report
CASE	Computer Aided Software Engineering
CBS	Cost Breakdown Structure
CDR	Critical Design Review
CFI	Customer Furnished Item
CM	Configuration Management Configuration Manager
CMP	Configuration Management Plan
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
DBMS	Database Management System
DD	Detailed Design
DDD	Detailed Design Document
DDR	Detailed Design Review
DMS	DEIMOS Space
DRR	Document Review Record
ECP	Engineering Change Proposal
E-R	Entity Relationship
FAT	Factory Acceptance Test
GUI	Graphical User Interface
HOOD	Hierarchical Object-Oriented Design
HW	Hardware
I/F	Interface
I/O	Input/Output
ICD	Interface Control Document
IRD	Interface Requirements Document
IT	Integration Test Information Technology
ITP	Integration Test Plan
ITR	Integration Test Report

Acronym	Description
ITT	Invitation To Tender
KOM	Kick-Off Meeting
MD	Managing Director
MMI	Man-Machine Interface
MoM	Minutes of Meeting
MR	Management Review
NCR	Non-Conformance Report
O/S	Operating System
ODBMS	Object Data Base Management System
OO	Object-Oriented
OOAD	Object-Oriented Analysis and Design
OOP	Object-Oriented programming
PA	Product Assurance
PAM	Product Assurance Manager
PAP	Product Assurance Plan
PDR	Preliminary Design Review
PM	Progress Meeting Project Manager
PMP	Project Management Plan
POL	Policy
PRO	Procedure
QA	Quality Assurance
QAM	Quality Assurance Manager
QAP	Quality Assurance Plan
QR	Qualification Review
QRE	Quality Record
RAMS	Reliability, Availability, Maintainability and Safety
RD	Reference Document
RDBMS	Relational Data Base Management System
RFD	Request for Deviation
RFQ	Request for Quotation
RFW	Request for Waiver
RID	Review Item Discrepancy
RUP	Rational Unified Process

Acronym	Description
SAM	System Administration Manual
SBR	Software Budget Report
SCMP	Software Configuration Management Plan
SCR	Software Change Request
SCVR	Software Code Verification Report
SDD	Software Design Definition (Document)
SDP	Software Development Plan
SDTER	Software Design and Test Evaluation Report
SDVR	Software Design / Documentation Verification Report
SICD	Software Interface Control Document
SIM	System Installation Manual
SIP	Software Integration Plan
SIRD	Software Interface Requirements Document
SITP	Software Integration Test Plan
SITR	Software Integration Test Report
SIVR	Software Integration Verification Report
SMAP	Software Maintenance Plan
SMJ	Software Migration Justification
SMP	Software Migration Plan
SMR	Software Modification Report
SNCR	Software Non-Conformance Report
SOM	Software Operations Manual
SOP	Software Operations Plan
SOM	System Operations Manual
SOW	Statement Of Work
SPANR	Software Problem Analysis Report
SPAP	Software Product Assurance Plan
SPAR	Software Product Assurance Report
SPR	Software Problem Report
SR	Software Requirements
SRD	Software Requirements Document
SRN	Software Release Note
SRP	Software Retirement Plan
SRR	System Requirements Review

Acronym	Description
SRS	Software Requirements Specification
SRTMR	Software Requirements Traceability Matrices Report
SRVR	Software Requirements Verification Report
SS	System Specification
ST	System Test
STD	Software Transfer Document
STP	Software Test Plan
STR	Software Test Report
STSER	Software Test Specification Evaluation Report
SUM	System User Manual
SUTP	Software Unit Test Plan
SUTR	Software Unit Test Report
SVAP	Software Validation Plan
SVEP	Software Verification Plan
SVTR	Software Validation Test Report
SVTS	Software Validation Test Specification
SVVP	Software Verification & Validation Plan
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined / Decided
TER	Test Execution Record
TN	Technical Note
TP	Test Plan
TR	Test Report
TRR	Test Readiness Review
TS	Technical Specification
UML	Unified Modelling Language
UR	User Requirement
URD	User Requirements Document
UT	Unit Test
UTP	Unit Test Plan
UTR	Unit Test Report
VTS	Verification/Validation Test Specification
VTP	Verification/Validation Test Procedure

Acronym	Description
VTR	Verification/Validation Test Report
V&V	Verification & Validation
VVM	Verification & Validation Manager
VVP	Verification & Validation Plan
VVR	Verification & Validation Report
WBS	Work Breakdown Structure
WIN	Work Instruction
WPD	Work Package Description

2. RELATED DOCUMENTS

2.1. Applicable Documents

The following table specifies the applicable documents that shall be complied with during project development.

Table 1: Applicable documents

Reference	Code	Title	Issue
[OSF-ICD]	openSF-DMS-ICD-001	OpenSF Interface Control Document	2.1
[AD 2]	EOP-SFP/2012-12-1686/PB/ag	Change Request for the openSF V3 activities description.	-

2.2. Reference Documents

The following table specifies the reference documents that shall be taken into account during project development.

Table 2: Reference documents

Reference	Code	Title	Issue
[OSFI-DM]	OSFI DM	OpenSF Integration Libraries – Developers Manual	2.0
[OSF-SUM]	openSF-DMS-SUM-001	OpenSF System User Manual	2.0

2.3. Standards

The following table specifies the standards that shall be complied with during project development.

Table 3: Standards

Reference	Code	Title	Issue	Date
[XML]	(www.w3.org/TR/xml11/)	Extensible Markup Language (XML) 1.1	Second Edition	Sep 29 2006
[UML]	www.uml.org/#UML2.0	Unified Model Language (UML)	2.1	Oct 6 2006
[BNF]	(see also en.wikipedia.org/wiki/Backus-Naur_form)	Algol-60 Reference Manual	5	1979

3. GETTING STARTED

3.1. Introduction

In the frame of concept and feasibility studies for the Earth Observation (EO) activities, mission performance in terms of final data products needs to be predicted by means of so-called end-to-end (E2E) simulators.

A specific mission E2E simulator is able to reproduce all significant processes and steps that impact the mission performance and gets simulated final data products.

The open Simulation Framework (openSF) is a generic simulation framework product aimed to cope with these major goals. It provides end-to-end simulation capabilities that allow assessment of the science and engineering goals with respect to the mission requirements.

This openSF tool lets users to integrate and execute pieces of code, «models» that form the building blocks of a simulation process.

Typically those pieces of code, «models» are handled by openSF as simple executable programs with three interfaces, input, output and configuration.

Under this scenario appears the goal of performing a statistical analysis of the E2E simulator driven by the errors and perturbations present in the parameters involved in a simulation chain.

The Open Simulation Framework Error Generation Libraries (OSFEG from now on) will be used as a tool to ease the mathematical modeling of a perturbation within statistical analysis scenarios.

OSFEG offers to developers a well-documented interface to ease the modeling and generation of a perturbation over desired parameters.

The libraries provide an error-modeling interface based on a XML file definition and its correspondent implementation in C++. A detailed description will be seen in section 4.

3.2. Conventions used in this Manual

This chapter lists all the conventions used throughout this Developer's Manual

3.2.1. `$OSFEG_HOME`

All through the contents of this Developer Manual, a “variable” called `$OSFEG_HOME` is exhaustively used as a placeholder. The variable value points to the root folder that contains the openSF installation. Typically, this folder could be similar to this:

`/home/user_name/OSFEG`

3.3. Initial Requirements

The OSFEG system is prepared to run in a hardware and software platform with the following requirements. These must be fulfilled before installing the distribution.

3.3.1. Hardware requirements

This software is ready for the following architectures and operating systems:

- Operating systems:* Linux.
- Architectures:* Intel™ 32-64 bits and AMD™ 32-64 bits.

3.3.2. Software requirements

This is the list of suggested compilers for the sources.

Table 4: suggested compilers for sources

Language	Compiler	Licensing	Distribution Site
C/C++	GNU C/C++ compiler v4.0 or superior	GNU General Public License, GNU Lesser General Public License	http://gcc.gnu.org

Nevertheless, developers can use their favorite compilers in each case, but this section only provides instructions for using the OSFEG libraries with the suggested compilers.

Binaries distribution assumed that the following list of libraries is installed in your system before being able to use them.

Note that OSFEG Source and binary packages include Xerces v3.0 libraries for C/C++.

Table 5: Linux pre-requisites

Component	Purpose	Licensing	Distribution Site
De-compressor	Extract files from release packaged in a compressed tarball	N/A	N/A
libstdc++6	This package contains an additional runtime library for C++ programs built with the GNU compiler.	LGPL	Linux repository or http://www.gnu.org
libc6	Contains the standard libraries that are used by nearly all programs on the system. This package includes shared versions of the standard C library and the standard math library, as well as many others.	LGPL	Linux repository or http://www.gnu.org
libgcc1	Shared version of the support library, a library of internal subroutines that GCC uses to	LGPL	Linux repository or http://www.gnu.org

	overcome shortcomings of particular machines, or special needs for some languages.		
--	--	--	--

3.4. Installation

OSFEG comes in different distributions depending on the needs of the user:

- Source package, including necessary sources in every language supported, for including and compiling with other sources.
- Binary package, including headers and static/dynamic libraries for linking with other sources. There is a version of this package for each supported target machine and Operating System.

Figure 1 shows a high-level view of the contents of different OSFEG distributions.

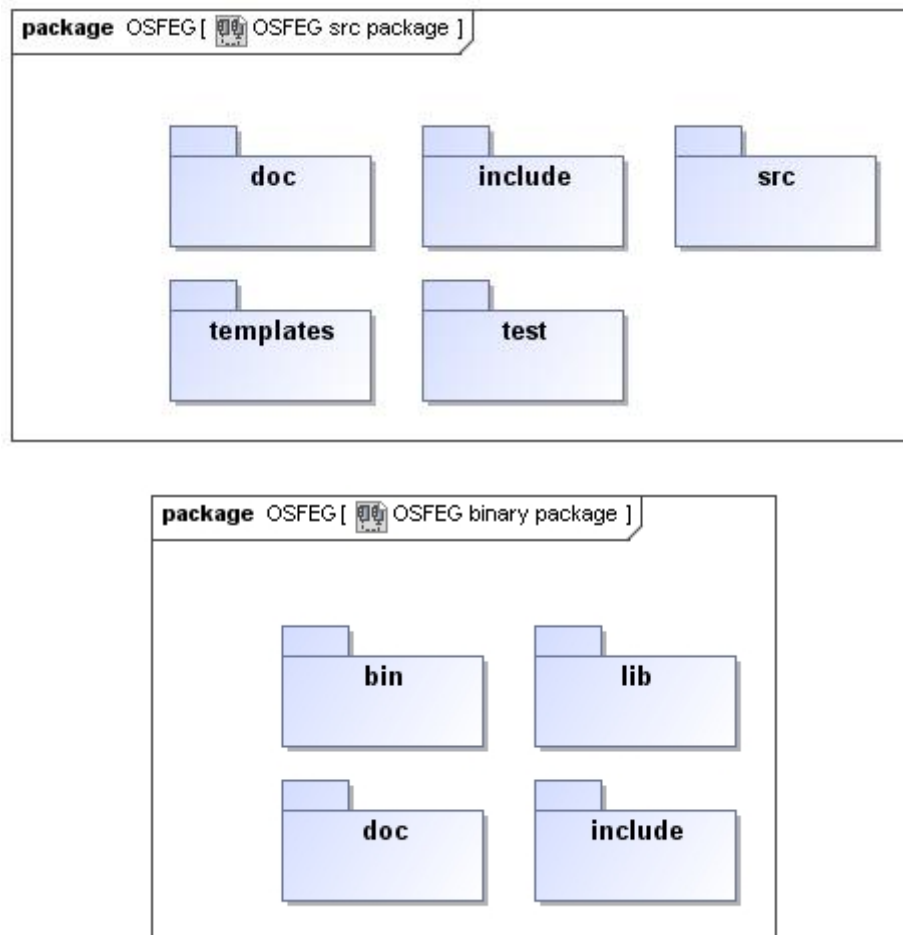


Figure 1: OSFEG distributions

To install the OSFEG libraries, you shall follow the instructions corresponding to your operating system.

3.4.1. Linux Installation

3.4.1.1. Source Package

First, extract the integration libraries into the desired location

```
~/ $ tar -xvzf OSFEG_<version>_src.tar.gz
```

Next, enter into the target folder and run

```
~/ $ cd OSFEG
```

Now, the user must configure the compilation process by running

```
~/ $ make configure-linux
```

At this point the user is able to compile the libraries and build the test binaries simply running

```
~/ $ make all
```

If the installation has been successful, the folder structure should be as follows:

- ❑ \$OSFEG_HOME/src: Source files of the OSFEG Libraries
- ❑ \$OSFEG_HOME/lib: Dynamic and static libraries of OSFEG
- ❑ \$OSFEG_HOME/include: Header files
- ❑ \$OSFEG_HOME/tests: Source code of the test binaries
- ❑ \$OSFEG_HOME/bin: Test executable files and additional files for testing the correct installation of OSFEG Libraries.
- ❑ \$OSFEG_HOME/doc: Documentation of the libraries API in rtf and html format.
- ❑ \$OSFEG_HOME/templates: Definition files for compilation.

3.4.1.2. Binary Package

The binaries package is a set of the libraries and tests, previously build for a particular operating system and architecture. The binaries package must exactly match your current system configuration.

The binary package distributed should be named

```
OSFEG_<version>_lib_<operating_system>_<system_arch>.tar.gz
```

Where:

- ❑ <version> - the OSFEG current version,
- ❑ <operating_system> - the target OS, typically linux,
- ❑ <system_arch> - the target system architecture and

For installation purposes just extract the files as follows:

~/\$ tar -xvzf <OSFEG_package_name>.tar.gz

- ❑ \$OSFEG_HOME/lib: Dynamic and static libraries of OSFEG
- ❑ \$OSFEG_HOME/include: Header files
- ❑ \$OSFEG_HOME/bin: Test executable files and additional files for testing the correct installation of OSFEG Libraries.
- ❑ \$OSFEG_HOME/doc: Documentation of the libraries API in rtf and html format.

4. OPENSF ERROR GENERATION LIBRARIES

In this section, the following is given:

- A detailed description of the functions implemented within the error generation libraries.
- A complete set of examples of how to use the APIs and how to compile and execute them.

4.1. Error definition files

In this section will be described the mathematical functions implemented within the error generation libraries. The libraries include the most used analytical and random functions to perturbate parameters in E2E simulation modeling scenario.

The parameter perturbation functions are defined through an XML file. An example it is shown at the end of this section.

This section is especially relevant because the error definition file describes the mathematical behavior of the parameters perturbation. It is also included a detailed description of the variables involved in the function definition.

4.1.1. Error Functions

4.1.1.1. Deterministic Functions

Deterministic functions are those whose value it is known in the entire time domain.

□ Affine

This function calculates the perturbation as an affine value. An affine transformation consists in a linear transformation and a translation.

- $error = a_1 + a_0 * t$

```
<affine>
  <float value="1" /> <!-- Linear Transformation Variable a0 -- >
  <float value="1" /> <!-- Translation Variable a1 -- >
</affine>
```

□ Bias

This function calculates the perturbation as a constant value.

```
<bias>
  <float value="1" /> <!-- Constant Value -- >
</bias>
```

□ Linear

Calculates the perturbation as a linear value:

- $p = a * t$

This is a particular case of affine transformation when translation variable is equals to 0.

```
<linear>
  <float value="1" /> <!-- Linear Transformation Variable a -->
</linear>
```

□ Parabolic

This function calculates the perturbation as a parabolic value.

- $p = a_0 + a_1 * t + a_2 * t^2$

```
<parabolic>
  <float value="1" /> <!-- a0 -->
  <float value="1" /> <!-- a1 -->
  <float value="1" /> <!-- a2 -->
</parabolic>
```

□ Polynomial

This function calculates the perturbation as a generic polynomial value. This function has as many float parameters as degrees of the desired polynomial plus one.

```
<polynomial>
  <float value="1" /> <!-- a0 -->
  <float value="1" /> <!-- a1 -->
  ...
  <float value="1" /> <!-- a(n-2) -->
  <float value="1" /> <!-- a(n-1) -->
</polynomial>
```

□ Step

This function calculates the perturbation as step function.

- if $\text{simTime} < t \Rightarrow p = a_0$
- if $\text{simTime} > t \Rightarrow p = a_1$

```
<step>
```

```
<float value="3" /> <!-- t -->
<float value="1" /> <!-- a0 -->
<float value="-1" /> <!-- a1 -->
</step>
```

□ Sinusoidal

Calculates the perturbation as sinusoidal function

- $p = a * \sin(2 * \pi * f * t + \phi)$
- f(Hz)
- phi(deg)
- t(secs)

```
<sinusoidal>
<float value="10" /> <!-- Amplitude a -->
<float value="10" /> <!-- Frequency f in Hz -->
<float value="0" /> <!-- Angle phi in deg. -->
</sinusoidal>
```

□ Tangent

Calculates the perturbation as tangent function

- $p = a * \tan(2 * \pi * f * t + \phi)$
- f(Hz)
- phi(deg)
- t(secs)

Remember that the tangent function have singularities when the angle evaluated is $(+/-) * n * \pi / 2$.

```
<tangent>
<float value="10" /> <!-- Amplitude a -->
<float value="1" /> <!-- Frequency f in Hz -->
<float value="0" /> <!-- Angle phi in deg. -->
</tangent>
```

4.1.1.2. Sampling Functions

Error Generation libraries implements three interpolation methods, linear, polynomial and spline sampling.

In order to define the points of the interpolation there is a common set of variables that are listed below.

- xMin: Min value of abscise axis

- xMax: Max value of abscise axis
- step: Increment between abscise values

The number of points must be :

$$\frac{xMax - xMin}{step} = nValues$$

□ Linear Sampling

This function makes an interpolation with the given points assuming it follows a linear rule. In out of range values

```
<linearSampling xMin="1.0" xMax="10.0" step="1">
  <float value="1" />
  <float value="3" />
  <float value="5" />
  <float value="7" />
  <float value="3" />
  <float value="2" />
  <float value="2" />
  <float value="10" />
  <float value="4" />
  <float value="3" />
</linearSampling>
```

□ Polynomial Sampling

This interpolation method builds a polynomial grade n, being n the number of specified points. This interpolation minimizes the Least Square Error. Ref: Neville Method.

```
<polynomialSampling xMin="1.0" xMax="10.0" step="1">
  <float value="1" />
  <float value="2" />
  <float value="1" />
  <float value="2" />
  <float value="1" />
  <float value="2" />
  <float value="1" />
  <float value="2" />
  <float value="1" />
  <float value="2" />
</polynomialSampling>
```

□ Spline Sampling

Interpolate the given “n” points with Cubic Splines Method.

```
<splineSampling xMin="1.0" xMax="20.0" step="1">
```

```
<float value="2" />  
<float value="3" />  
<float value="2" />  
<float value="3" />  
<float value="2" />  
<float value="3" />  
<float value="2" />  
<float value="3" />  
<float value="10" />  
<float value="2" />  
<float value="3" />  
<float value="2" />  
<float value="4" />  
<float value="7" />  
<float value="2" />  
<float value="3" />  
<float value="2" />  
<float value="3" />  
<float value="2" />  
<float value="7" />  
</splineSampling>
```

4.1.1.3. Nondeterministic Functions

These functions correspond to common random function implementation with seed management for testing purposes.

□ Beta Distribution

This function generates random values with Beta function as probability density function.

```
<parameter name="Beta distribution">  
  <beta seed="1" v="2" w="5" xMin="0.0" xMax="1.0" />  
</parameter>
```

□ Gamma Distribution

This function generates random values with Gamma function as probability density function.

```
<parameter name="Gamma distribution">  
  <gamma seed="1" location="0.0" scale="0.5" shape="9" />  
</parameter>
```

□ Exponential Distribution

This function generates random values with Exponential function as probability density function.

```
<parameter name="Exponential distribution">  
  <exponential seed="1" a="1" b="1.5" />  
</parameter>
```

□ Normal Distribution

This function generates random values with Gaussian function as probability density function.

```
<parameter name="Normal distribution">  
  <normal seed="1" mu="100.0" sigma="10.0" />  
</parameter>
```

□ Uniform Distribution

This function generates random values following a Uniform Distribution.

```
<parameter name="Uniform distribution">  
  <uniform seed="1" xMin="0" xMax="1" />  
</parameter>
```

□ Poisson Distribution

This function returns the perturbation as a generated random value with Poisson function as probability density function.

```
<parameter name="Poisson distribution">  
  <poisson seed="1" mu="10" />  
</parameter>
```

□ Truncated Gaussian Distribution

This function returns the perturbation as a generated random value with Truncated Gaussian function as probability density function.

```
<parameter name="Truncated gaussian distribution">  
  <truncatedGaussian seed="1" mu="0.5" sigma="0.2" xMin="0.4" xMax="0.6" />  
</parameter>
```

□ Uniform Discrete Distribution

This function returns the perturbation as a generated random value with Uniform Discrete function as probability density function.


```
<parameter name="Uniform discrete distribution">
  <uniformDiscrete seed="1" i="0" j="1" />
</parameter>
```

□ **Distribution with custom Probability Density Function**

Returns the value of a random variable generated with a custom probability density function given. It is only recommended to use it by expert developers/scientists.

```
<parameter name="Custom PDF">
  <customPDF seed="24" xMin="0.0" xMax="12.0" step="1">
    <float value="7" />
    <float value="43" />
    <float value="21" />
    <float value="10" />
    <float value="2" />
    <float value="6" />
    <float value="23" />
    <float value="31" />
    <float value="7" />
    <float value="2" />
    <float value="7" />
    <float value="43" />
    <float value="21" />
  </customPDF>
</parameter>
```

4.1.1.4. **Binary and Composite Operations**

Error Generation Libraries implements the basics mathematical operations in binary mode. The operations implemented are :

- **Addition**
- **Subtraction**
- **Multiplication**
- **Division**
- **Exponentiation**
- **Root**

Composite operations consist of a deterministic function with one or more of its parameters following another function or binary operation.

An example of an error definition file implementing all the binary and some composite operations it is shown below:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
  <parameter name="Affine and sinusoidal">
```

```

<affine>
  <sinusoidal>
    <float value="10" />
    <float value="90" />
    <float value="0" />
  </sinusoidal>
  <float value="5" />
</affine>
</parameter>
<parameter name="Sinusoidal and beta">
  <sinusoidal>
    <beta seed="1" v="1.0" w="2.0" xMin="10.0" xMax="15.0" />
    <float value="10" />
    <float value="0" />
  </sinusoidal>
</parameter>
<parameter name="Addition">
  <addition>
    <exponentiation>
      <sinusoidal>
        <float value="10" />
        <float value="90" />
        <float value="0" />
      </sinusoidal>
      <float value="2" />
    </exponentiation>
    <subtraction>
      <sinusoidal>
        <float value="40" />
        <float value="90" />
        <float value="5" />
      </sinusoidal>
      <bias>
        <float value="1" />
      </bias>
    </subtraction>
  </addition>
</parameter>
<parameter name="APE">
  <addition>
    <exponentiation>
      <sinusoidal>
        <float value="2" />
        <float value="4" />
        <float value="0" />
      </sinusoidal>
      <float value="2" />
    </exponentiation>
    <root>
      <addition>
        <exponentiation>
          <polynomialSampling xMin="1.0" xMax="10.0" step="1">
            <float value="1" />
            <float value="2" />
            <float value="1" />
          </polynomialSampling>
        </exponentiation>
      </addition>
    </root>
  </addition>
</parameter>

```

```

        <float value="2" />
        <float value="1" />
        <float value="2" />
        <float value="1" />
        <float value="2" />
        <float value="1" />
        <float value="2" />
    </polynomialSampling>
    <float value="2" />
</exponentiation>
<exponentiation>
    <polynomialSampling xMin="1.0" xMax="10.0" step="1">
        <float value="1" />
        <float value="2" />
        <float value="1" />
        <float value="2" />
        <float value="1" />
        <float value="2" />
        <float value="1" />
        <float value="2" />
        <float value="1" />
        <float value="2" />
    </polynomialSampling>
    <float value="2" />
</exponentiation>
</addition>
    <float value="2" />
</root>
</addition>
</parameter>
</errorsFile>

```

4.2. Process logic

In this section, the process logic of using the libraries in models source code is shown.

Steps for using the Error Generation Libraries:

1. Include the OSFEG.h header file in your code

```
#include "OSFEG.h"
```

2. Create an instance of the ErrorSources class passing the name of the XML error definition file. The constructor throws an exception in case of error, so remind to catch it.

```
ErrorSources * reader = new ErrorSources(errorDefinitionFile);
```

3. Access the perturbation values by the complete name of the parameter and a double specifying the simulation step.

```
reader->getError(paramName, step);
```

4. Destroy the instance once not needed.

```
delete reader;
```

4.3. Examples of use

4.3.1. C++ Programming Language

Here is an example of C++ code that uses the error generation libraries.

cppExample.cpp

```
#include "OSFEG.h"
#include <iostream>
#include <cstdlib>
#include <string>

using namespace std;

int main(int argc, char *argv[]) {
    cout << "Reading error sources definition file" << endl;
    try
    {
        string config(argv[1]);
        cout << "Reading error sources definition file " << config << endl;
        // Create an ErrorSources
        ErrorSources * reader = new ErrorSources(config);
        double step;
        string paramName = "Example Param Name";
        reader->getError(paramName, step);
        delete reader;

    } catch (const runtime_error &e)
    {
        cerr << e.what() << endl;
    } catch (...)
    {
        cerr << argv[0] << " failed" << endl;
        exit(1);
    }
    exit(0);
}
```

4.3.2. C++ Compilation and Execution process

The compilation process needs to specify the base location of the packages with these environment variables:

- ❑ OSFEG_HOME, typically < openSF_install_dir>/OSFEG

To compile your sources you must specify the location of the header files and the library binaries. This sentence is a valid example for compiling one of the distributed test sources.

```
g++ cppExample.cpp -o cppExample -I$OSFEG_HOME/include -L$OSFEG_HOME/lib  
-losfeg-common -lxerces-c
```

Integration libraries come in two distribution types, shared or static libraries.

If you have linked the shared libraries you can execute the binary files after specifying the location of those shared libraries like this:

```
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:$OSFEG_HOME/lib
```

Linking with static libraries does not imply to specify the location of the linked libraries since the executable already includes the object files.

The sentences for executing the test binaries is:

```
./cppExample <arguments>
```

End of document