Curve Comparison Using esiCORA

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1 Abstract

CAE simulation is essential for the development of new vehicles and their integrated safety systems. The difficulty here is to assure correlation between simulation and test results.
Common industrial practice is to compare time history results graphically. Such comparison is daily used in Injury Studies and thus it has to be accurate and reliable.

The CORA rating developed by Partnership for Dummy Technology and Biomechanics (PDB) calculates the correlation between two unique curves. The result is a number between zero and one, which indicates best correlation of test and simulation results, if the value is high (closer to one).

CORA combines Corridor method and Cross Correlation method to assess the correlation of the curves within a specified time range.

Visual-Environment, the single integrated environment for all your CAE needs. It includes a comprehensive modeling tool to generate quality meshes on complex geometries for various engineering domains ranging from Crash and Passenger Safety to NVH, Welding & Assembly, Casting, Electromagnetics, CFD & Multiphysics, and more...

Visual-Viewer is the Visual-Environment integrated post-processing tool for CAE applications, providing dedicated plotting solutions where CORA rating is embedded.

2 Introduction

CORA (Correlation and Analysis) rating is a curve comparison technique, to evaluate the time-history signals. It performs correlation analysis of simulation curves with reference curves (testing curves). This method is mainly used in injury studies.

In Visual-Viewer, the CORA rating can be computed using the following two options:

- esiCORA computation for the selected curves:
  - **esiCORA Value**, computes the CORA value and attaches it to the selected curve
  - **esiCORA Report,** generates a detailed report for the selected simulation and reference curve(s)

- esiCORA rating computation for an entire load case:
  - Allows generation of CORA report for multiple load cases and sub load cases

3 CORA rating for selected curve

Visual-Viewer provides a quick option to compute the CORA rating with minimum of user input. The CORA rating can be used to compute the CORA rating for the selected simulation- and the reference curves.

First user select one or several curves graphically from Visual-Viewer Plot Window or Explorer tree.

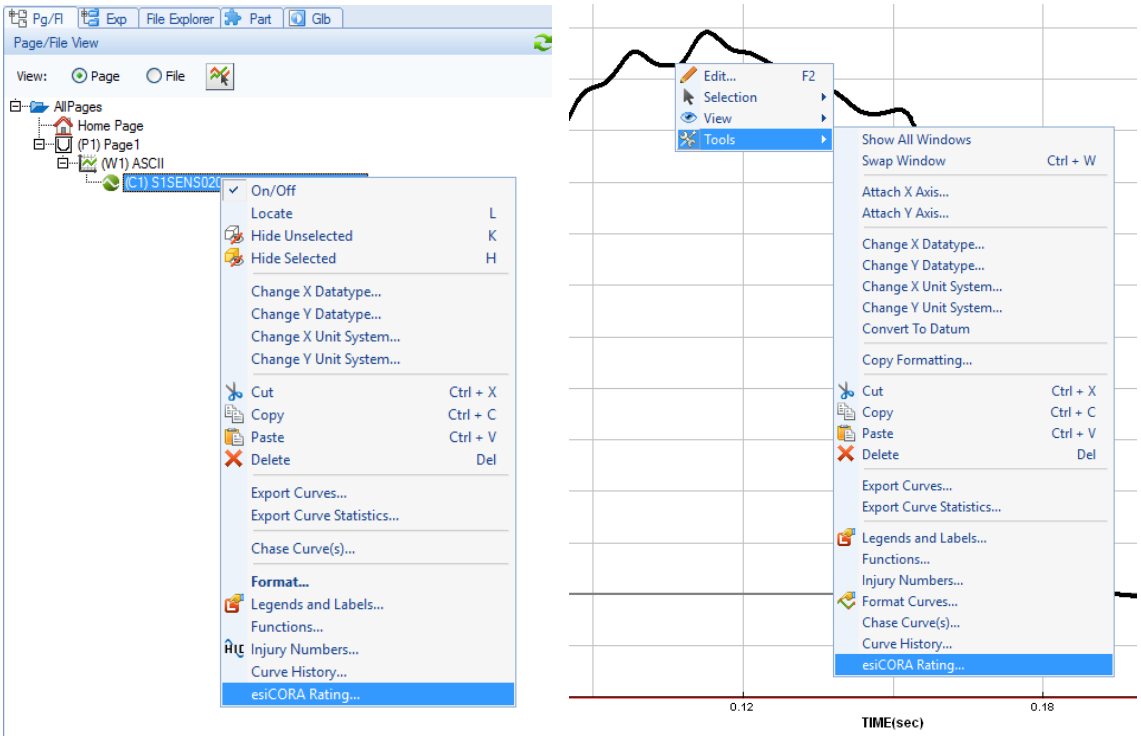
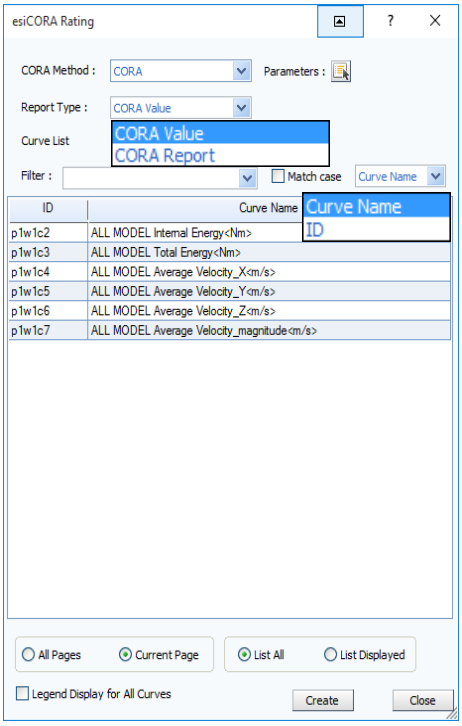


Fig.1: Using CORA Rating option for the selected curve with context menu



On selection esiCORA Rating option, you will get the **esiCORA Rating GUI** (Graphical User Interface) where user can select the desired reference curves.

The **Filter options** enables to filter the curves which are displayed in the table by wildcard, match case as well as curve name or ID.

User can decide which **Report Type** he is interested in:

- **CORA Value** as text or
- **CORA Report**

Fig.2: CORA Rating GUI

3.1 Report Type = CORA Value as text

The CORA rating value can be displayed as text which will be attached to the simulation curve as a text.

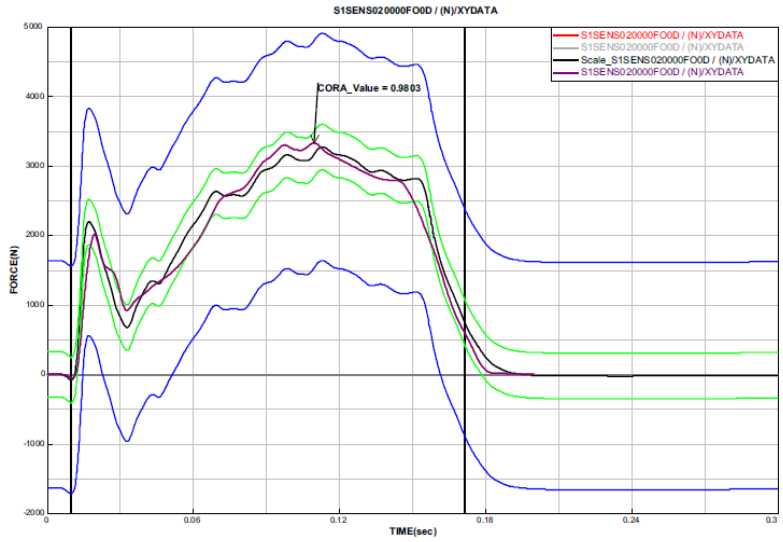
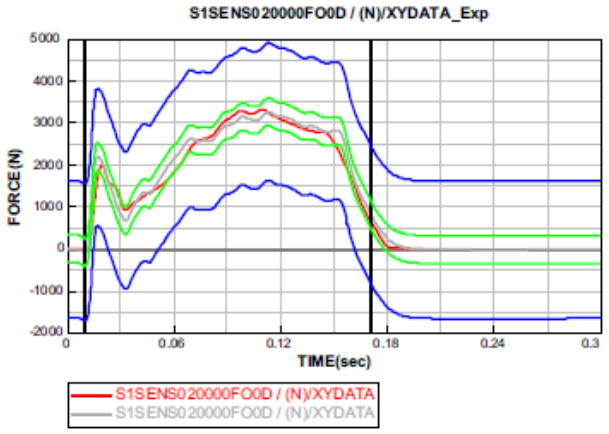
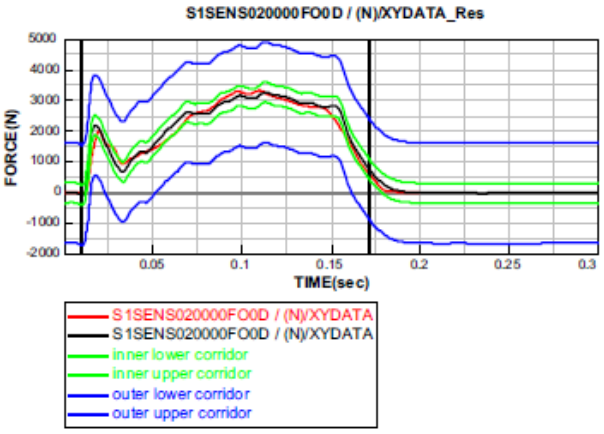


Fig.3: CORA Rating value will be attached to the curve

3.2 Report Type = CORA Report

The curves which are plotted in Visual-Viewer for the esiCORA report will be summarized and displayed in tables.





Signal Report

Rating of: S1SENS020000FO0D / (N)/XYDATA

No.	Name				Rating	Weight
1	Corridor Method				0.9778	0.5
2	Correlation method	Value	Rating	Weight	0.9829	0.5
a	Cross correlation function	0.9964	0.9946	0.2		
b	Size	0.9599	0.9599	0.4		
c	Phase shift	-0.0008	1.0	0.4		
3	Combination of 1 and 2				0.9803	
	Overall Rating:	0.9803				

Parameters	Evaluation Interval	0.0101-0.1711
Method 1	Max. Half width of inner corridor	0.1
	Max. Half width of outer corridor	0.5
	Corridor Curve file	None
	Reference value	3271.921
	Transition exponent	2.0
Method 2	Limits for phase shift	0.0048-0.0193
	Rating Exponents(shape,size,phase)	3.0,1.0,1.0

Fig.4: CORA Report will be created for the selected simulation and reference curves

4 CORA Report as a load case template

On selection of “Tools > CORA Report” option, user can create a full report with the help of load cases for several simulation curves.
This dialog is divided by two tab dialogs, **Parameters tab** and **Loadcase tab**.

- With the Parameter tab, the user will be able to change the parameter or settings.
- Within the Loadcase tab user will specify the simulation and reference curves.

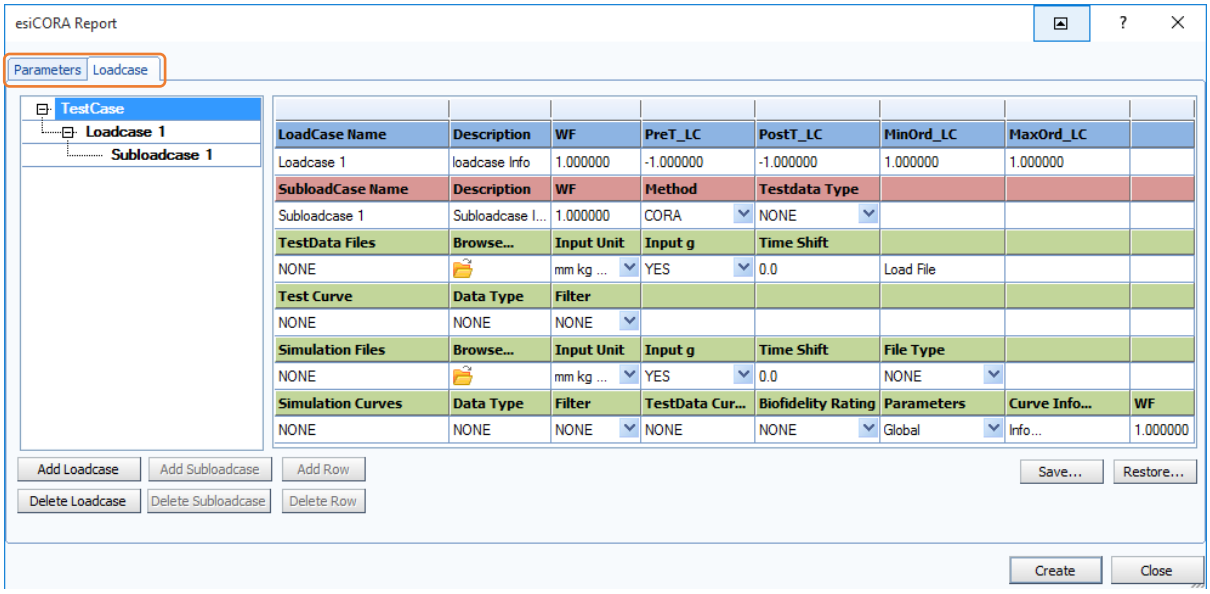


Fig.5: esiCORA Report dialog

4.1 The Parameters Tab dialog

This dialog provides the option to modify the CORA report parameters and CORA report settings parameters and displays the global CORA Computation parameter values.

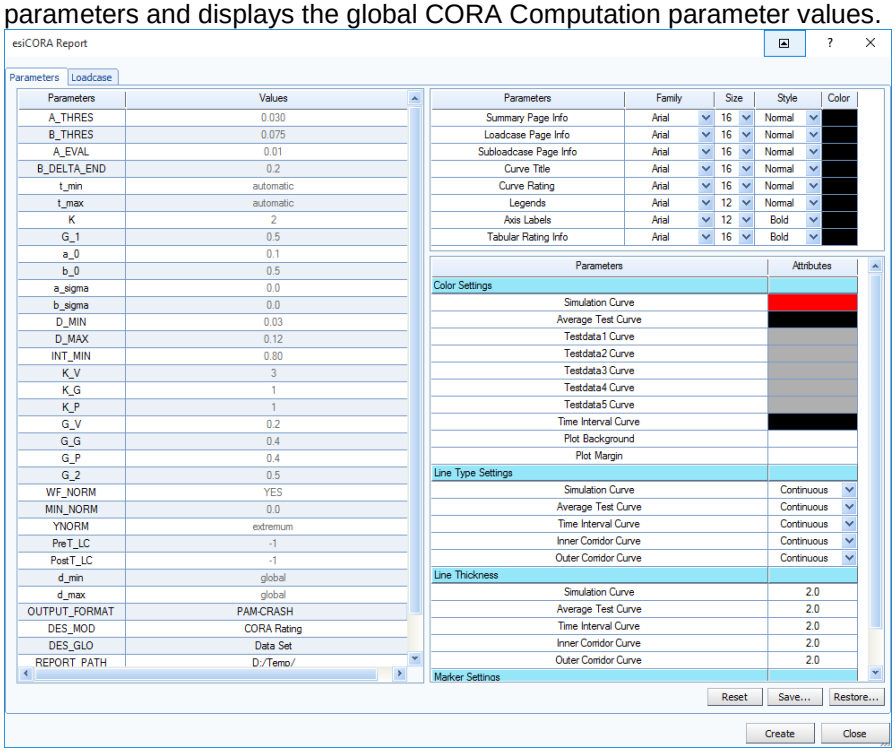


Fig.6: Parameters Tab Dialog

The description of the global CORA computation parameters is explained in the Visual-Viewer help.

Parameters	Description
A_THRES	Threshold to set the start of the interval of evaluation [0,...,1]
B_THRES	Threshold to set the end of the interval of evaluation [0,...,1]
A_EVAL	Extension of the interval of evaluation [0,...,1]
B_DELTA_END	Additional parameter to shorten the interval of evaluation (width of the corridor: A_DELTA_END*Y_NORM) 0 = disabled
T_MIN	Set the evaluation interval (tmin - tend) for all signals tmin =max (ta-αevlau(tb-ta), tstart)
T_MAX	tmax =min (ta+αevlau(tb-ta), tend)
K	Transition between ratings of 1 and 0 of the corridor method [-] (1 = linear, 2 = quadratic ...)

Table 1: A sample of the customizable CORA computation parameters

4.2 The Loadcase Tab dialog

The load case dialog provides the option to create load cases and sub load cases. With this load cases, you can create as many complex scenarios you like. This dialog will have Tree View for better navigation and Loadcase table to assign the curves and specifies the parameter.

The **Tree view** shows the defined load case and sub load cases.

On Selecting "TestCase" tree item in the tree control, then all Load Cases info will be displayed in the Table. Subsequent on Selecting the particular Loadcase, say "Loadcase 1", the corresponding Loadcase information will be populated in the table.

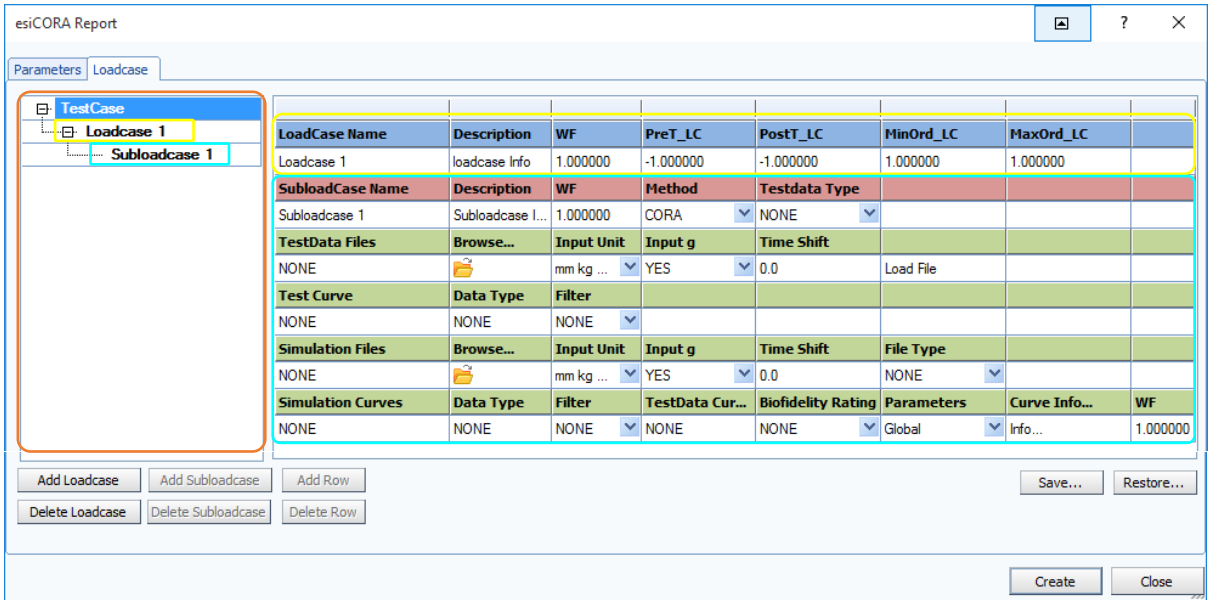


Fig.7: Loadcase tab dialog to build-up different load cases

Each Load case contains several sub load case parameters. Multiple load cases can be added for CORA rating report computation.

4.2.1 Sub Load Case

On selecting the sub load case item in the tree control, the corresponding sub load case data will be shown in the table, only. This allows focusing on specific load case data.

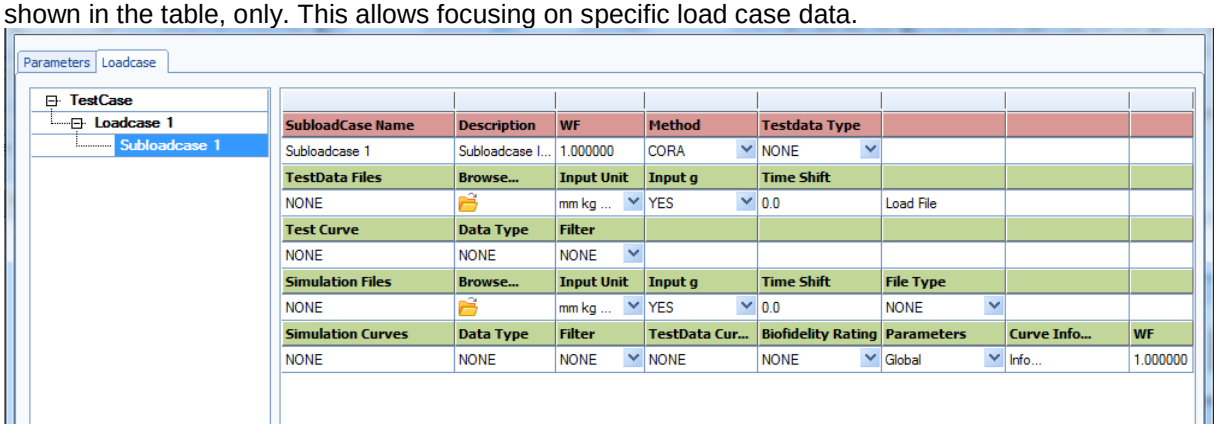


Fig.8: Sub Loadcase table

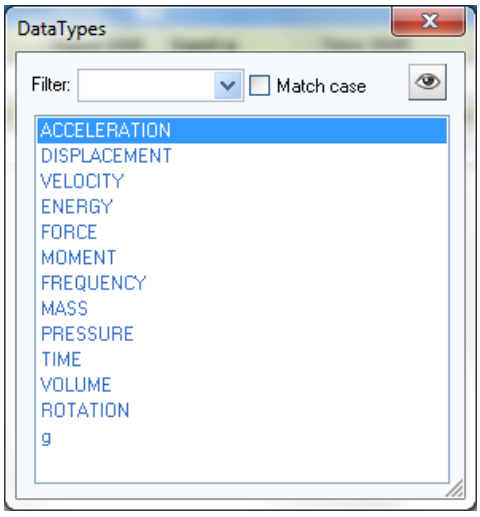
With the parameters, you can specify the sub load case name and a description, the CORA computation method, WF (weight factor), Solver type, Validation case, Test data files, the Test data curves as well as the Simulation data files and the Simulation data curves.

The complete set of tests can be applied by defining a load case for each body region and a sub load case for each test. The weighting factors and corridors can be modified accordingly in the table.

4.2.2 Test Data Files

The **Test Data file** will be taken as an input and used for the correlation analysis of simulation curve. Multiple files can be selected for test data. The average of the selected curves will be created. The average curve will be used in CORA rating computation.

For each test file, you can specify the input unit system and optional an offset for the time shift. The option **Load File** is used to load the test data file. If the file is already loaded, then a message will be posted weather to reload the file or not.



The test data file curve names will be listed as per the first test data file. If more than one test data file is added, the selected curve will be created from all the test data files for CORA rating computation.

If necessary user can specify the test data curve data type. On click of the appropriate cell the curve data types dialogue will be posted as shown on the picture on the right.

Fig.9: Specify the data type for each test data

4.2.3 Simulation Files

The CORA rating will be performed on the simulation curve with reference to the test curves. For each file user can optionally specify the input unit system and a time shift offset.

By default, when the Load Case dialog is posted, the data will be shown for one load case and one sub load case. Multiple load cases and sub load cases can be easily added using the "Add" buttons.

On selection of this "**Simulation Curve"** cell, the following dialog will be posted to select the simulation curve.

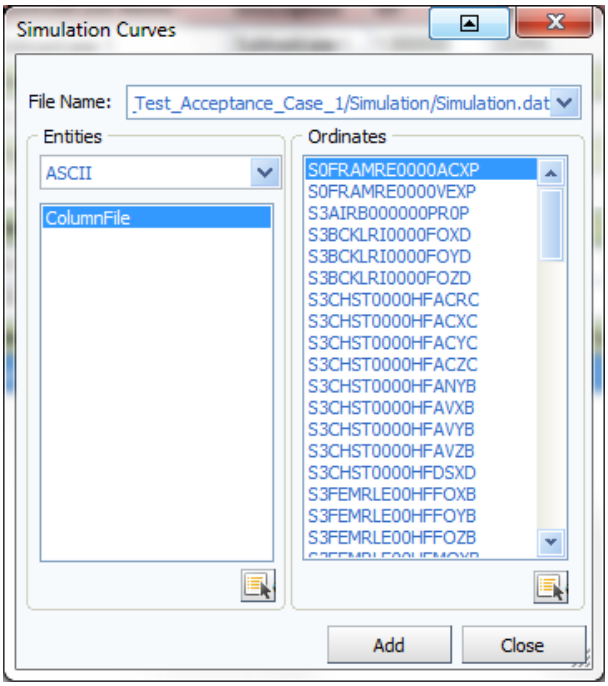


Fig.10: Selection of the simulation curves with its entities and ordinates

For the simulation curve name, the name mapping will be done based on the entity id, entity type and component.

There are options to specifies the curve **Data Type** for simulation as well for the test data curve. Both the test and simulation curves should have the same data type.

On click of the **Save** button, the load case data will be saved to the load case configuration xml file.
On click of this ***Restore*** button, the load case data from the load case configuration file will be read and update the same to the CORA Report dialog.

esiCORA supports working with Visual-Viewer **templates** and **session files**. Both options allows to run the esiCORA in **batch mode**.

4.3 Sample CORA Report

Here below you will see a “sample CORA Report” for one load case having two sub load cases and each sub load case is having one signal.

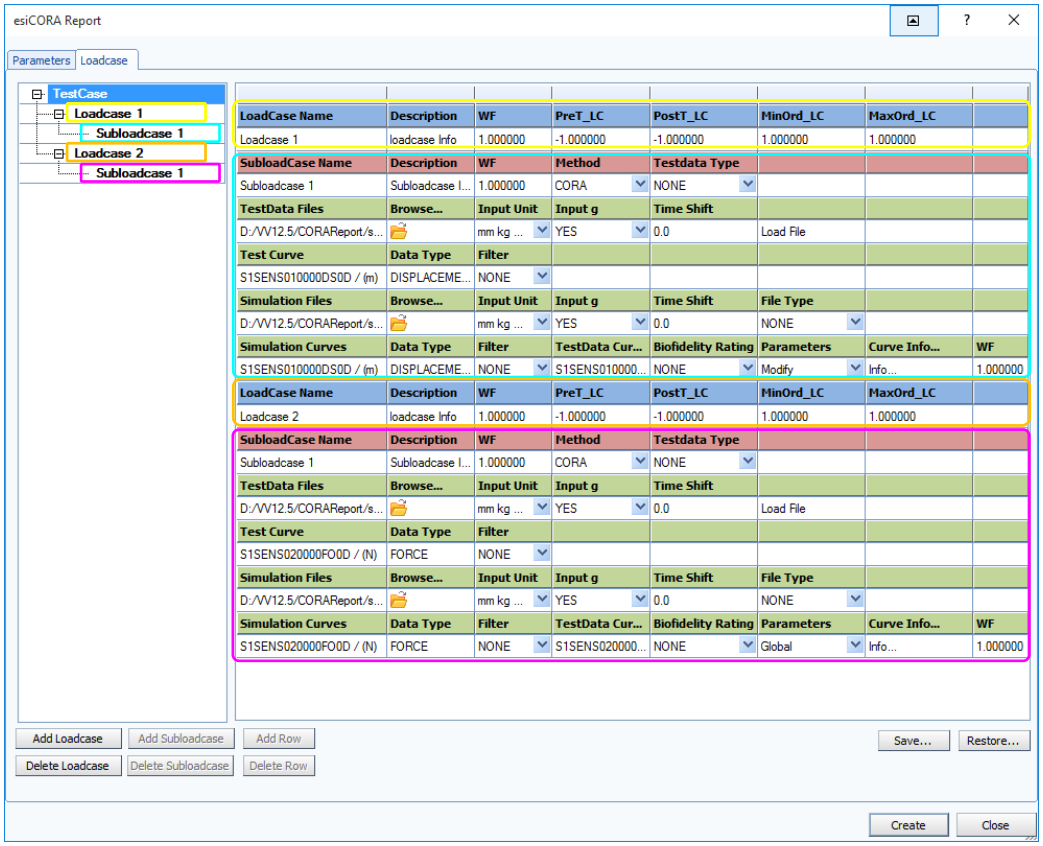
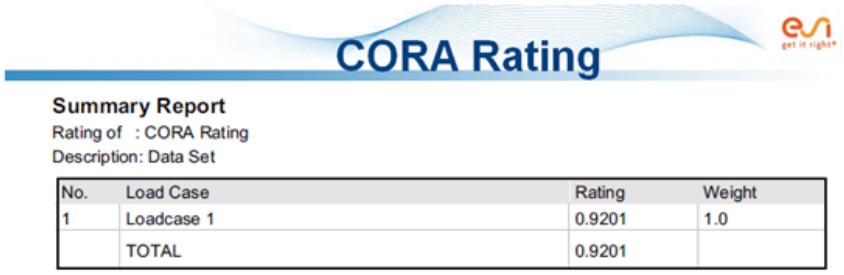


Fig.11: Sample CORA Report

The report will have pages for the summary report, load case report and experiment report pages as shown below.



CORA Rating

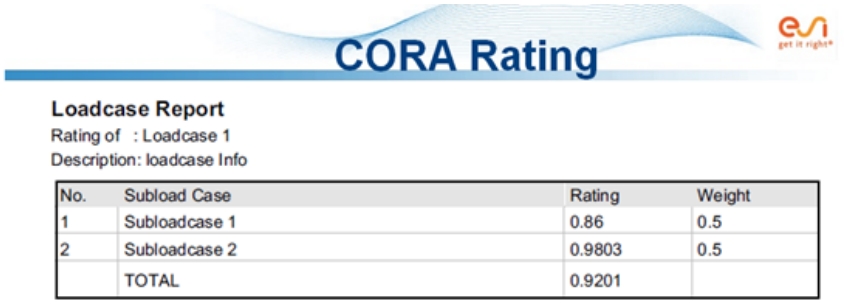
Summary Report

Rating of : CORA Rating

Description: Data Set

No.	Load Case	Rating	Weight
1	Loadcase 1	0.9201	1.0
	TOTAL	0.9201	

Fig.12: Page 1 of the sample esiCORA Report



CORA Rating

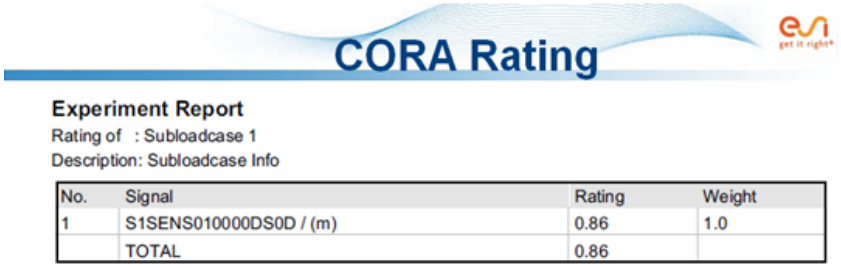
Loadcase Report

Rating of : Loadcase 1

Description: loadcase Info

No.	Subload Case	Rating	Weight
1	Subloadcase 1	0.86	0.5
2	Subloadcase 2	0.9803	0.5
	TOTAL	0.9201	

Fig.13: Page 2 of the sample esiCORA Report



CORA Rating

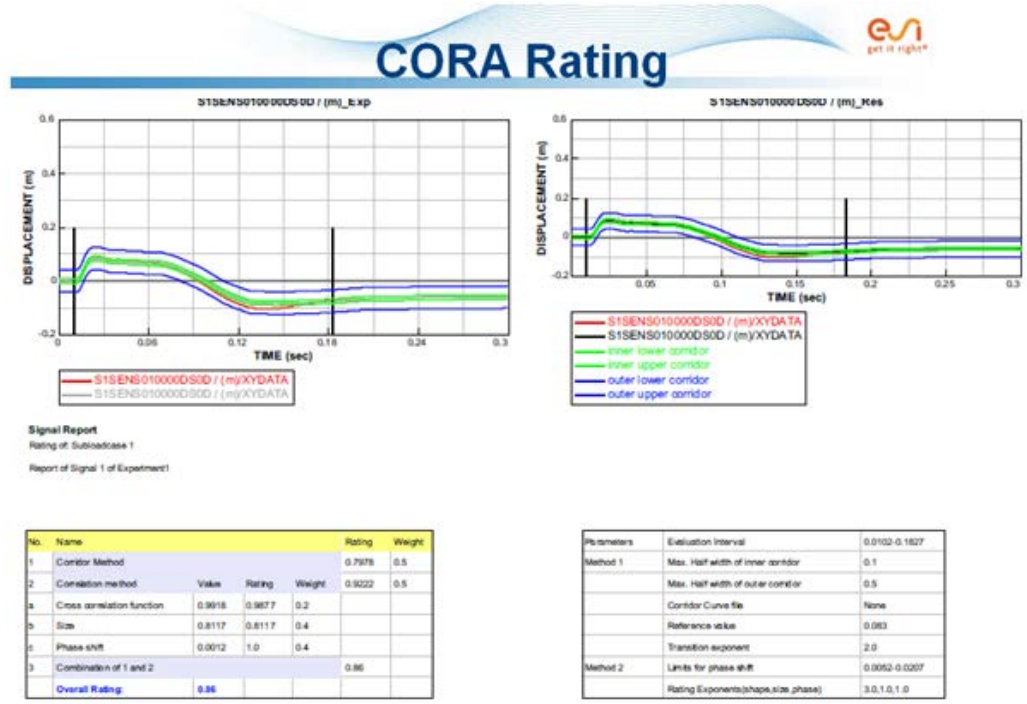
Experiment Report

Rating of : Subloadcase 1

Description: Subloadcase Info

No.	Signal	Rating	Weight
1	S1SENS010000DS0D / (m)	0.86	1.0
	TOTAL	0.86	

Fig.14: Page 3 of the sample esiCORA Report



CORA Rating

DISPLACEMENT (m)

TIME (sec)

S1SENS010000DS0D / (m)/XYDATA

inner lower corridor

inner upper corridor

outer lower corridor

outer upper corridor

Signal Report

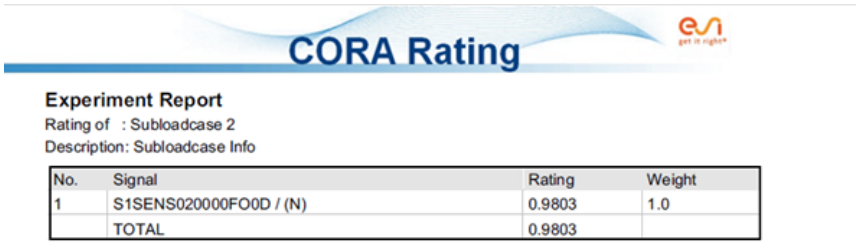
Rating of: Subloadcase 1

Report of Signal 1 of Experiment1

No.	Name				Rating	Weight
1	Corridor Method				0.7978	0.5
2	Correlation method	Value	Rating	Weight	0.9222	0.5
a	Cross correlation function	0.9918	0.9877	0.2		
b	Size	0.8117	0.8117	0.4		
c	Phase shift	0.0012	1.0	0.4		
3	Combination of 1 and 2				0.86	
	Overall Rating:	0.86				

Parameters	Evaluation Interval	0.0102-0.1827
Method 1	Max. Half width of inner corridor	0.1
	Max. Half width of outer corridor	0.5
	Corridor Curve file	None
	Reference value	0.083
	Transition exponent	2.0
Method 2	Limits for phase shift	0.0052-0.0207
	Rating Exponents(shape,size,phase)	3.0,1.0,1.0

Fig.15: Page 4 of the sample esiCORA Report



CORA Rating

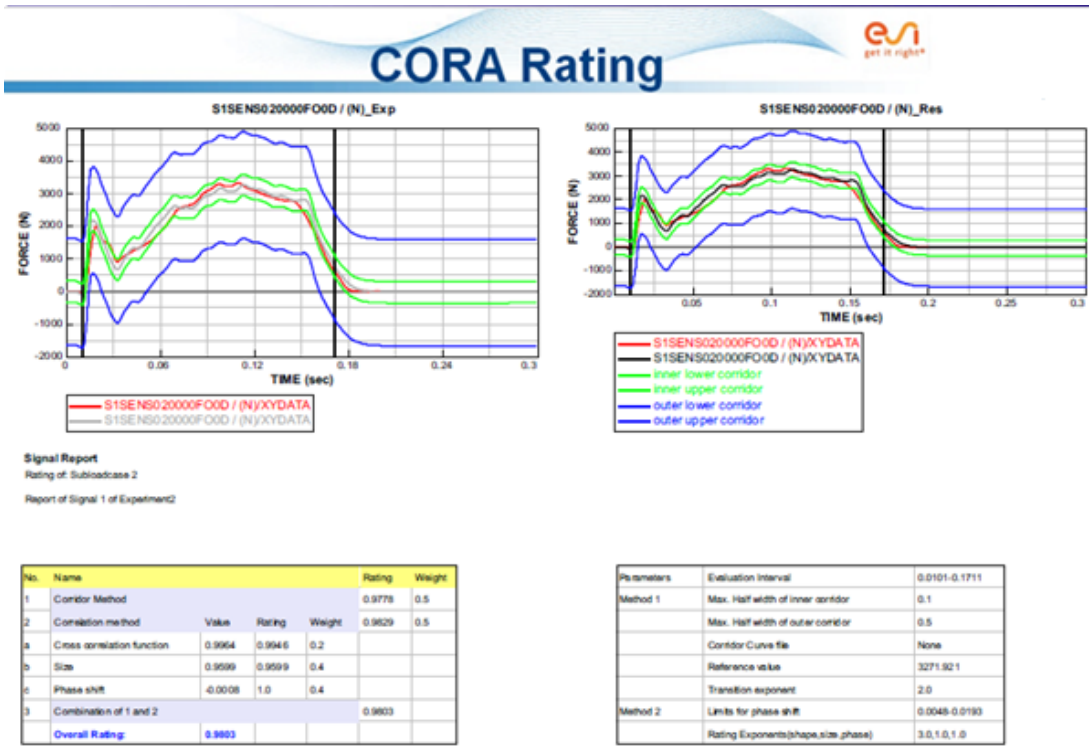
Experiment Report

Rating of : Subloadcase 2

Description: Subloadcase Info

No.	Signal	Rating	Weight
1	S1SENS020000FO0D / (N)	0.9803	1.0
	TOTAL	0.9803	

Fig.16: Page 5 of the sample esiCORA Report



No.	Name				Rating	Weight
1	Corridor Method				0.9778	0.5
2	Correlation method	Value	Rating	Weight	0.9829	0.5
a	Cross correlation function	0.9964	0.9946	0.2		
b	Size	0.9599	0.9599	0.4		
c	Phase shift	-0.0008	1.0	0.4		
3	Combination of 1 and 2				0.9803	
	Overall Rating:	0.9803				

Parameters	Evaluation Interval	0.0101-0.1711
Method 1	Max. Half width of inner corridor	0.1
	Max. Half width of outer corridor	0.5
	Corridor Curve file	None
	Reference value	3271.921
	Transition exponent	2.0
Method 2	Limits for phase shift	0.0048-0.0193
	Rating Exponents(shape,size,phase)	3.0,1.0,1.0

Fig.17: Page 6 of the sample esiCORA Report

5 Summary

The esiCORA rating is a curve comparison technique to evaluate the time-history signals. It performs correlation analysis of simulation curves with reference curves (e.g.: test curves).

The esiCORA rating can be computed with minimum of user input and knowledge of all the CORA options using the right click menu for the selected curve. User can decide to get the CORA value assigned to the selected curves or plotting the corridors and rating parameter as a report.

With the second option user, can create a full CORA report for various load case and its sub load cases. It is possible to fill out CORA parameter in the GUI or load with a configuration file.

While running the esiCORA report all curves are saved to a user given directory. Beside the report a Power Point or PDF document will be created.

For automation esiCORA can be used in Visual-Viewer templates or session files.

6 Literature

References should be given in the last paragraph of your manuscript. Please use following scheme:

[1] Users_manual_cora_36.pdf, Carsten Thunert, GNS mbH 2012, pages 68
[2] CORrelation and Analysis (CORA) in Visual-Environment, Megha Seshadri ESI Group 2016