

# User Manual

Software

**FUNVUL-Components V1.0.0** 

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Chapter 1 Introduction	



# 1.1. Problem description

The CAPRA Probabilistic Risk Assessment Platform allows to conduct risk assessment against several natural hazards. The vulnerability module requires the definition of vulnerability functions as defined in the CAPRA platform. The vulnerability functions shall be defined for the different assets records in the exposure DB. Those functions allow to quantify the physical and human damage loss in terms of mean damage ratio, MDR that can suffer an asset for a specific hazard scenario.

The vulnerability function represents the expected and variance of the MDR for a given hazard intensity parameter value. Figure 1 shows and example of a vulnerability functions. There are several methodologies to obtain vulnerability functions. The methodologies are based on expert judgment, analytical models and past events. The Probabilistic seismic vulnerability assessment of buildings in terms of economic losses is used in the FUNVUL Components software to define new vulnerability functions.



# 1.2. Theoretical framework

This software uses the methodology proposed by (Yamin et al. 2017). For additional information refers to (Yamin et al. 2017).

The following figure includes the methodological approach used in this software.





Figure 2 Algorithm for the software approach, (based on Yamin et al. 2017)

# 1.3. Objectives

The principal objectives of this software are:

- Integrated software to obtain vulnerability functions using an analytical methodology for the hazard risk assessment required by the CAPRA-GIS software.
- Obtain vulnerability functions by rigorously losses calculated using repair and replacement commercial costs. The model considers seismic hazard, demand parameters, damage states, and repair cost and times.
- Estimates integrated damages, costs and time of repair for continuous increasing values of the seismic intensity parameter.
- Considers the repair costs from all structural, non-structural, and content components in the analysis.
- Considers business interruption costs based on the probable downtime due to the repair works.
- Considers results from nonlinear multi-degree-of-freedom dynamic analysis.
- Combines all uncertainties in the seismic hazard, in demand parameters, damage states, and repair costs and times, by means of Monte Carlo simulation techniques.

# 1.4. Expected results and calculus limitations

This software calculates the vulnerability function trough two phases. The user shall understand the methodology to avoid get wrong results. This software has the following limitations:

- This software only allows to create one vulnerability function at a time.



- This software allows to visualize only the previous graph for comparison purposes.
- The user cannot add, edit, delete or save any field from the files "Component\_DB.xlsm", "Fragility\_DB\_V3.xlsm" and "EDP\_DB.xlsm" other than those fields as specified in section Error! Reference source not found.
- If you are using the "Component\_DB.xlsm" file, you must also open the "Fragility\_DB\_V3.xlsm" file.
- If you prepare the input \*.txt file format without using the "Component\_DB.xlsm", "Fragility\_DB\_V3.xlsm" and "EDP\_DB.xlsm". Those files should have the structure as specified in the section **Error! Reference source not found.**.
- The maximum number of iterations for consideration of uncertainties in model, damage states and cost & time are limited to 10 each one. It also depends on the available RAM capacity where this software is installed.
- This software only considers a maximum of 100 records for the complete intensities scales, used for the response history analysis, *RHA*.
- The *RHA* for nonlinear dynamic analysis are out of the scope of this software.
- The fragility function database included in the "Fragility\_DB\_V3.xlsm" file can be modified under criteria of the user.
- The maximum number of points to define a new vulnerability function depends on the number of intensities considered in the nonlinear *RHA*.
- This software does not verify if the user is using consisting units among the different parameters that shall be defined.
- This software does not calculate automatic conversion among difference parameters units.
   The user should be aware that he/she is using the same parameters units as required or defined in this software.





# Chapter 2 Software installation



# 2.1. Minimum installation requirements

The hardware and software requirements for the installation of this software are specified in the following sections.

#### 2.1.1. Minimum hardware requirements

The following are the minimum hardware requirements:

#### 2.1.1.1 Processor and OS

- PC or compatible computer with Pentium III processor (or higher) and processor speed over 1.5 GHz.
- Operating systems: Microsoft XP or Higher.

#### 2.1.1.2 RAM Memory

- Free hard drive capacity of 250 Mb or Higher.
- 512 Mb Extended Memory (RAM).

#### 2.1.2. Software requirements

The following are the minimum software requirements:

- If the computer where this software is going to be installed does not have installed MATLAB Runtime version 9.2 (2017a), please install the MATLAB Runtime version 9.2 (2017a). It can download from: <u>http://www.mathworks.com/products/compiler/mcr/index.html</u>.

## 2.2. Installation process

This software does not required installation. You must only follow the next steps:

- 1. Verify that all software requirements are meet before installation. Please see section 2.1.2.
- 2. Enter in the Windows<sup>™</sup> Explorer and select the path where the software package folder is located, then, go to the Application File folder.
- 3. Run the FUNVULComponents.exe; this command starts the programs.

If you cannot run this software or get any error message during the program starts, please send an email with the description to <u>ecapra@uniandes.edu.co</u>.





# Chapter 3 Graphical user interface



# 3.1. General description

This software allows the user to create new vulnerability functions. The methodology used to create new function is presented in section 1.2.

The FUNVUL Components main window is divided in three areas; menu area, parameters area and display area. (see Figure 3).

FUNVUL Components					
Phase Edit Help	MENU AREA *				
PHASE 1         Paths for I/O files         Component file path:         EDP files path:         PARAMETERS AREA         FDB files path:         Results files path:         Global Parameters         Number of iterations         Model Uncertainty         Beta model uncertainty         Scale Factors for Costs & Times         Costs         Time         No	DISPLAY AREA				
Status, initialize	Run Analysis				

Figure 3 FUNVUL Simplified main window

# 3.2. Tools and Menus

#### 3.2.1. Menu area

The software menu bar has three drop-down menus to get access at different functions.

- <u>Phase drop-down menu item:</u> includes access to Phase 1 and Phase 2.
- <u>Edit drop-down menu</u>: allows the user to "Clear form Data" and add "Default Values" to the forms fields for each Phase.
- <u>Help drop-down menu</u>: allows the user to get access to the documentation resources of the software, the license and the about information.

#### 3.2.2. Parameters area

This area displays two different forms and a Status text box at the bottom part. Each form depends of the Phase that is under analysis.

#### 3.2.2.1 Phase 1 Form

This form contains the parameters field required to perform the Phase 1 analysis. This form has been divided in four blocks.





FUNVUL_Components						
Phase Edit Help						
PHASE 1 Paths for I/O files Component file path: EDP files path: FDB files path: Results files path:	ock 1					
Global Parameters Number of Brock 2 Beta model uncertainty Scale Factors for Costs & Times Costs Block 4No Time No V	Number of Iterations Model Uncertainty Damage States Uncertainty Costs & Time Uncertainty					
Status: Initialize						

Figure 4 Tab overview for parameters area

#### Block 1: Paths for I/O files

- **Components file path:** field to define the path where are stored the "Components.txt" file. The values are editable.
- **EDP files path:** field to define the path where are stored the "IML.txt", "Drift.txt", "RDrift.txt", "Accel.txt", "PR\_COL.txt" and "PR\_BEAM.txt" files. The values are editable.
- **FDB files path:** field to define the path where are stored the "damage\_state.txt" and "damage\_cost\_time.txt" files. The values are editable.
- **Results files path:** field to define the path where are stored the "ParametersPhaseI.txt" and "RF\_I.mat" files. The values are editable.

#### **Block 2: Global Parameters**

- Number of stories: field to define the number of stories of the building.
- Beta model uncertainty: field to define the beta model uncertainty.

#### **Block 3: Number of Iterations**

- Model Uncertainty: field to define the number of iterations for account model uncertainty.
- **Damage States Uncertainty:** field to define the number of iterations for account damage states uncertainty.
- **Cost & Time Uncertainty:** field to define the number of iterations for account cost and time uncertainty.

#### Block 4: Scale Factors for Costs & Times

- Costs: field to define if considers scale economy for repair cost.
- Time: field to define if considers scale economy for repair time.



#### 3.2.2.2 Phase 2 Form

This form contains the parameters field required to perform the Phase 2 analysis. This form has been divided in five blocks.

FUNVUL_Components	FUNVUL_Components		
Phase Edit Help	Phase Edit Help		
PHASE 2 Paths for I/O files EDP files path: Block 1 Results files path: Basic Data from Phase I Model Uncertainty Damage States Uncertainty Costs & Time Uncertainty Group List Global Parameters Block 3 Building Replacement Value Interruption Time Replacement Value	PHASE 2         Time Limits         Maximum time for intervention [days]         Previous required time before mark intervention [days]         Additional time after intervention [days]         Numbers of work crews for structural repair         Numbers of work crews for non-structural repair         Cost Limits         Lower intensity to no damage [g/g]         Maximum allowable residual drift for demolition [%]         Perecentage of building replacement value [%]         Bidirectional factor for total cost model         Intensity level for building evacuation [g/g]		
Status: Initialize	Status: Analysis total time: 2.9531 segundos		

Figure 5 Tab overview for parameters area

#### Block 1: Paths for I/O files

- **EDP files path:** field to define the path where are stored the "IML.txt", "Drift.txt", "RDrift.txt", "Accel.txt", "PR\_COL.txt" and "PR\_BEAM.txt" files. The values are editable.
- **Results files path:** field to define the path where are stored the "ParametersPhaseII.txt", "RF\_I.mat" and "RF\_II.mat" files. The values are editable.

#### Block 2: Basic Data from Phase I

- **Model Uncertainty:** field with the number of iterations for account model uncertainty. The value is not editable.
- **Damage States Uncertainty:** field with the number of iterations for account damage states uncertainty. The value is not editable.
- **Cost & Time Uncertainty:** field with the number of iterations for account cost and time uncertainty. The value is not editable.
- Seismic Group List: field to select the group names for the analysis in the Phase 2.

#### **Block 3: Global Parameters**

- **Building Replacement Value:** field to define the building replacement value.
- **Interruption Time Replacement Value:** field to define interruption time replacement value.

#### Block 4: Time Limits

- Maximum time for intervention: field to define the maximum days of time for intervention.



- **Previous required time before start intervention:** field to define the previous requires days of time before start intervention.
- Additional time after intervention: field to define the additional days of time after intervention.
- **Number of work crews for structural repair:** field to define the total number of work crews for structural components.
- **Number of work crews for non-structural repair:** field to define the total number of work crews for non-structural components.

#### Block 5: Cost Limits

- Lower intensity to no damage: field to define the lower intensity for no damage.
- **Maximum allowable residual drift for demolition:** field to define the residual drift for demolition.
- **Percentage of building replacement value:** field to define the maximum percentage of building replacement value.
- **Bidirectional factor for total cost model:** field to account the bidirectional factor for total cost model.
- **Intensity level for building evacuation:** field to define the intensity level for building evacuation.

#### 3.2.3. Display area

The display area allows the user to visualize the results from each one of the phases.

- **Phase 1 Graph:** display the vulnerability raw curve for the three main groups of components for cost or time.
- **Phase 2 Graph:** display the vulnerability curve for the total repair cost, time and normalized cost including business interruption.



Figure 6 Tabs overview for Display area



The function for each button is described below.

- Run Analysis button: run the analysis for the active phase.
- Load Data button: load data and fills the Basic Data from Phase I variables for Phase 2 form.
- **Export Data button:** export files to format \*.txt for the results from Phase 2.
- **Update plot:** update the plot based on the selected option.

## 3.3. Input parameters setting and data type

The following table specify the input setting and data type for all parameters used in the software. Also, some recommended values are included.

Item	Parameter	Format type	Value	Units
1	PARAMETER AREA – PHASE 1			
1.1	Component file path	String (see section 4.1.3 for format input file)	-	-
1.2 EDP files path		String (see section 4.1.2 for format input file)	-	-
1.3	FDB files path	String (see section 4.1.1 for format input file)	-	-
1.4	Results files path	String (see section 5.1 for format output file)	-	-
1.5	Number of stories	Integer	-	-
1.6	Beta model uncertainty	Double	0.1 – 0.5 Default value 0.2	-
1.7	Model Uncertainty	Integer	Default value 10	-
1.8	Damage States Uncertainty	Integer	Default value 10	-
1.9	Cost & Time Uncertainty	Integer	Default value 10	-
1.10	Costs	String	No Yes	-
1.11	Time	String	No Yes	-
2	PARAMETER AREA – PHASE 2			
2.1	EDP files path	String (see section 4.1.2 for format input file)	-	-
2.2	Results files path	String (see section 5.2 for format input file)	-	-
2.3	Parameter values Table	String	-	-
2.4	Model Uncertainty	Integer	-	-
2.5	Damage States Uncertainty	Integer	-	-
2.6	Cost & Time Uncertainty	Integer	-	-
2.7	Seismic Group List	String	List	-
2.8	Building Replacement Value	Double	-	Currency Units
2.9	Interruption Time Replacement Value	Double	-	Currency Units
2.10	Maximum time for intervention	Integer	Default value 365	Days
2.11	Previous required time before start intervention	Integer	Default value 30	Days

#### Table 1 Input parameters





Item	Parameter	Format type	Value	Units
2.12	Additional time after intervention	Integer	Default value 30	Days
2.13	Number of work crews for structural repair	Integer	Default value 4	-
2.14	Number of work crews for non-structural repair	Integer	Default value 4	-
2.15	Lower intensity to no damage	Double	Default value 0	g/g
2.16	Maximum allowable residual drift for demolition	Double	0 – 100 Default value 2.5	Percentage
2.17	Percentage of building replacement value	Double	0 – 100 Default value 100	Percentage
2.18	Bidirectional factor for total cost model	Double	Default value 1.5	-
2.19	Intensity level for building evacuation	Double	Default value 1.2	g/g
3	DISPLAY AREA			
3.1	Plot Results Phase I	String	Cost Results Time Results	-
3.2	Plot Results Phase II	String	Total Repair Time Total Repair Cost Total Normalized Cost	-
4	OUTPUT – PHASE 1			
4.1	*.txt file path	String	-	-
5	OUTPUT – PHASE 2			
5.1	*.txt file path	String	-	-





Chapter 4 Setting input data and files	



# 4.1. Input file and file format

This software uses a unique types of input files. Those types are \*.txt format files. It can be load it specifying the folder path where they are stored. The required file format structure of each one is presented in the following sections. Please refer to each one of these sections to verify that your input files have the required file format.

## 4.1.1. Fragility DB files format

There are two files in \*.txt format. The first file "damage\_state.txt" contains the specification for the fragility function. The second one "damage\_cost\_time.txt" contains the specification of the cost and time for each fragility function. Those files contain information written in records. Each record corresponds to each fragility functions. It can be read using the Notepad program. Also, those files can be created using the **"Fragility\_DB\_V3.xlsm"** spreadsheet file. To create those files the user should complete the information in the sheets "damage\_state" and "damage\_cost\_time". For more detailed information about each field please refer to FEMA P-58 (FEMA 2012).

## 4.1.2. EDP files format

There is a total of six different required files for EDP that can be obtained from the nonlinear Response History Analysis, RHA. Those files contain information written in records. Each record corresponds to one seismic intensity level. Those files can be created using the **"EDP\_DB.xlsm"** spreadsheet file.

#### 4.1.2.1 Seismic record file

The "IML.txt" file contains the information for the seismic records used in the nonlinear RHA. The file has three columns. The first column corresponds to the seismic record group. The second column corresponds to the seismic record name. The third column corresponds to the seismic record intensity. Each record corresponds to each seismic record intensity (see







Figure 7 Typical Structure for input IML.txt file

#### 4.1.2.2 Result files

The result files are plain text files that contains result information from the performed nonlinear RHA for each seismic record intensity as specified in the IML.txt file. The total number of columns for each file varies and depends of the result type. Each column is related to each component as defined in the Component DB. There is a total of five result files required. Those files are:

- "Drift.txt": this file contains the maximum inter-story drift ratio obtained from nonlinear RHA performed.
- "RDrift.txt": this file contains the maximum inter-story residual drift ratio obtained from nonlinear RHA performed.
- "Accel.txt": this file contains the maximum story relative acceleration ratio obtained from nonlinear RHA.
- "PR\_COL.txt": this file contains the maximum plastic hinge inelastic rotation for columns, obtained from nonlinear RHA performed.
- "PR\_BEAM.txt": this file contains the maximum plastic hinge inelastic rotation for beams, obtained from nonlinear RHA performed.

The typical structure of those files is presented below.



2.5204E-02 5.0408E-02 7.5612E-02  0.1008 0.1260 0.1512	1.4036E-02 2.8072E-02 4.2108E-02  5.6145E-02 7.0189E-02 8.4226E-02	Seismic record intensity	Seismic record name	Seismic record group
0.1764 0.2016 0.2268 0.2518 	9.8262E-02 0.1122 0.1263 0.1403			

Component

Figure 8 Typical Structure for input results files

#### 4.1.3. Component file format

The "Components.txt" file contains the information for the components that would be considered for the vulnerability analysis. The file format is a plain text with records. Each record corresponds to each component and has the following structure:

- 1<sup>st</sup> Column: Component Story floor location
- 2<sup>nd</sup> Column: Component group name
- 3<sup>rd</sup> Column: Component subgroup name
- 4<sup>th</sup> Column: Fragility function name
- 5<sup>th</sup> Column: Component description
- 6<sup>th</sup> Column: Demand parameter
- 7<sup>th</sup> Column: Component quantity
- 8<sup>th</sup> Column: EDP file name
- 9<sup>th</sup> Column: EDP file column index
- 10<sup>th</sup> Column: Component correlation

This file can be created using the "Component\_DB.xlsm" spreadsheet file.

1 1 1	S F C	S1 F1 C1	B1041.003a C3032.002a E2022.010a	ACI 318 SMF , Conc Col & Bm Suspended Ceiling, SDC C, A Fragile Contents, doors, wi	Story Drift Ratio Peak Floor Acceleration Story Drift Ratio	4 15 3	Drift Accel Drift	1 1 1	1 0 0
2	S	S2	B1041.091a	Non-conforming MF with weak	Story Drift Ratio	4	Drift	2	1
2	F	F2	C1011.001a	Wall Partition, Type: Gypsu	Story Drift Ratio	10	Drift	2	0
2	С	C2	E2022.010	Unsecured fragile objects o	Peak Floor Acceleration	6	Accel	2	0
•••									•••

Figure 9 Typical Structure for input component file





Chapter 5 Visualization output files



# 5.1. Phase 1

This software automatically saves the results from the Phase 1 of the analysis. There are two output files "ParametersPhaseI.txt" and "RF\_I.mat". The first file is a plain text file that contains the input information specified by the user in the Phase I form (see Figure 10). The second file contains the results that will be used for the Phase II analysis.

```
******Path for I/O files*****
Component file path: C:\FUNVUL-Components\DB\Tutorial2-3
EDP files path: C:\FUNVUL-Components\DB\Tutorial2-3\EDP_DB
FDB files path: C:\FUNVUL-Components\DB\Tutorial2-3\Fragility_DB
Results files path: C:\FUNVUL-Components\DB\Tutorial2-3\Results_PhaseI
******Global Parameters*****
Number of stories: 2
Beta model uncertainty: 2
******Basic Data*****
Number of simulations for model uncertainty:10
Number of simulations for cost & time uncertainty: 10
Number of simulations for cost model?: YES
Do you consider scale factor for time model?: YES
Figure 10 Output file "ParametersPhaseI.txt" example
```

# 5.2. Phase 2

This software automatically saves the results from the Phase 2 of the analysis. There are output files "ParametersPhaseII.txt" and "RF\_II.mat". The first file is a plain text file that contains the input information specified by the user in the Phase II form (see).

```
******Path for I/O files*****
EDP files path: C:\FUNVUL-Components\DB\Tutorial2-3\EDP DB
Resutls from Phase I files path: C:\FUNVUL-Components\DB\Tutorial2-3\Results_PhaseI
******Basic Data from Phase I******
Number of simulations for model uncertainty:10
Number of simulations for damage states uncertainty: 10
Number of simulations for cost & time uncertainty: 10
******Global Parameters*****
Building replacement value: 10000000
Interruption time replacement value: 500000
******Cost Limits Parameters*****
Lower intensity limit to no damage value: 0
Maximum allowable residual drift for demolition value [%]:2.5
Perecentage of building replacement value [%]: 100
Bidirectional factor for total cost model value: 1.5
Intensity level for building evacuation value: 1.2
******Cost Limits Parameters*****
Maximum time for intervention value [days]: 365
Previous required time before start intervention value [days]: 30
Additional time after intervention value [days]: 30
Numbers of work crews for structural repair: 4
Numbers of work crews for non-structural repair: 4
                            Figure 11 Output file example
```

Additional to those files the user can export four plain text files with the results from the Phase 2 analysis. Those files are:

 "CostmodelResults.txt": file that contains the total cost information for each seismic intensity. It has five columns: intensity, mean, standard deviation, percentile 95<sup>th</sup> and percentile 5<sup>th</sup> (See Figure 12).



- "TimemodelResults.txt": file that contains the total cost information for each seismic intensity. It has five columns: intensity, mean, standard deviation, percentile 95th and percentile 5<sup>th</sup> (See Figure 12).
- "FVU Results.txt": file with the vulnerability function data. It has three columns: intensity, mean and standard deviation (See Figure 13).
- "FVUSimplified\_Results.txt": file with the vulnerability function data. It has the same • structure that the input\*.txt file format for FUNVUL-Simplified (See Figure 14).

Intensity	/ - Mean - Star	dard deviation -	percentile 95	- percentile 5
0.00	0.00	0.00	. 0.00	. 0.00
0.02	9409.19	132919.38	0.00	0.00
0.04	7780391.86	32637842.98	86060416.45	0.00
0.06	8590714.83	32497929.81	88386808.31	0.00
0.08	10312835.30	32228123.71	97753640.78	0.00
0.10	19550873.17	43712922.20	150000000.00	0.00
0.12	21782878.02	43221131.98	150000000.00	619101.36
0.14	24677566.14	42609186.17	150000000.00	1564421.90
0.16	27700323.44	41994951.50	150000000.00	2594106.40
0.18	30422986.90	41402381.98	150000000.00	3676724.50
0.20	34563587.54	40607596.79	150000000.00	5543504.14

. . .

Figure 12 Output file Cost/time Results example

. . .

Intensity - Mean - Standard deviation 0.0000 0.0000 0.0000 0.0200 0.0001 0.0009 0.0400 0.0519 0.2176 0.0600 0.0573 0.2167 ... ... ...

Figure 13 Output file FVU Results example

76 0.0000 0.0000 0.0000 0.0000 0.0000 0.0200 0.0001 0.0000 0.0000 0.0000 0.0600 0.0573 0.0469 0.0000 0.0000 0.1000 0.1303 0.0849 0.0000 0.0000 0.1400 0.1452 0.0830 0.0000 0.0000 . . . ... ... . . . . . .

Figure 14 Output file FVU Simplified Results example

## 5.3. Error file

This software generates automatically an error file when the analysis cannot be conducted. The user shall review this file in order to know the errors. The file name is "error.dat" and has a complete list of the errors. It can be open using any text editor.

The following figure presents an example of the content of this file.





You must define a valid directory for PDS Data! You must define a valid directory for get and save Results Data! The Building replacement value must be positive! The Interruption time replacement value must be positive! The value of Lower intensity limit to no damage must be zero or greater than zero! The value of Maximum allowable residual drift for demolition must be greater than zero! The Perecentage of building replacement value must be greater than zero! The value of Bidirectional factor for total cost model must be greater than zero! The value of Intensity level for building evacuation must be greater than zero! The value of Previous required time before start intervention must be greater than zero! The value of Additional time after intervention must be greater than zero! The value of Numbers of work crews for structural repair must be greater than zero!

Figure 15 Output file example





# Chapter 6 Step-by-step tutorial



# 6.1. Tutorial 1: Setting up the input files

This tutorial shows you how create and setup of the files required to perform an analysis using FUNVUL-Components. The step you must follows are the followings:

- 1. Setting up the results for the Engineering Demand Parameters, EDP
  - a. Open the folder where do you download the software. Go to **FUNVUL-Components\DB\SETUP**. Open the file **EDP\_DB.xlsm**. You will get the following window.

	Α	В	С	D	Е	F	G	Н
1				HELP INFORMATION FOR INPUT DATA				
2							_	
3		Sheet	Column	Description	Units	Input Value	Ex	port Data
4		IML	1st Column	Corresponds to the name of each group for the ground motion records	-	Alphanumeric		
5			2nd Column	Contains the name of each ground motion record used in the incremental dynamic analysis, IDA	-	Alphanumeric		
6			3rd Column	Contains the intensity value for each ground motion record used in the IDA	g/g	Double		
7								
8		Drift	ith	Each column corresponds to each story of the building under consideration	%	Double		
9								
10		<u>RDrift</u>	ith	Each column corresponds to each story of the building under consideration	%	Double		
11								
12		Accel	ith	Each column corresponds to each story of the building under consideration	g/g	Double		
13								
14		PR COL	ith	Each column corresponds to each defined plastic hinge rotation elements for columns	rad	Double		
15								
16		PR BEAM	ith	Each column corresponds to each defined plastic hinge rotation elements for beams.	rad	Double		
17								
18								
19								
20								
21								
- 22	-	Inpu	HELP IML	Drift   RDrift   Accel   PR_COL   PR_BEAM   (+)		1		

- b. You must fill out or copy and paste your results to each of the EDP sheets. The order of the data is explained in the "Input\_HELP" sheet. It is highly recommended that all sheets have the same number of rows.
- c. You must fill out of the EDP sheet information. You can copy and paste the results from other sources. For this tutorial, open the file EDPSampleData.xlsx (This file is stored in the Components\DB\Tutorial1 path) and copy the information to the sheets in the EDP\_DB.xlsm as follows:

EDP	Copy from sheet (EDPSampleData.xlsx)	Paste to sheet (EDP_DB.xlsm)
Intensity level	IML_SAMPLE	IML
Inter-story drift	Drift_SAMPLE	Drift
Residual inter-story drift	RDrift_SAMPLE	RDrift
Story relative acceleration	Accel_SAMPLE	Accel
Plastic hinge inelastic rotation for columns, or other as required per user.	PR_COL_SAMPLE	PR_COL
plastic hinge inelastic rotation for beams, or other as required per user.	PR_BEAM_SAMPLE	PR_BEAM



d. After you finished to copy the data from **EDPSampleData.xlsx** to **EDP\_DB.xlsm.** You must click on the **"Export Data" button**. This will open a window asking you for the directory where the EDP files will be saved. Please specify a valid path, then click on "OK" button.

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🗸 🔜 This PC	^ ∨ Fol	ders (7)				
> 🧊 3D Objects			3D Objects			
> 💿 A360 Drive			ob objects			
> 📃 Desktop						
> 🔮 Documents			Desktop			
> 🕹 Downloads						
> 🁌 Music			Documents			
> 📰 Pictures						
> 🦉 Videos		_				
> 🏪 Local Disk (C:)			Downloads			
> 💣 Network						
	~		Music			
,	older name:	This PC				
						-

 e. Finally, close the both files and then, go to the path that you specify and review that the files as listed in section 4.1.2 are in this path. Also, you can compare your results files with the files stored in the FUNVUL-Components\DB\Tutorial1\ Results\_Step\_1 path.

#### 2. Setting up the Fragility Database.

a. Open the folder where do you download the software. Go to FUNVUL-Components\DB\SETUP. Open the file Fragility\_DB\_V3.xlsm. You will get the following window.

	A	В	C	D	E	F	G	H	I
1									
2			HELF	PINFORMATION FOR INPUT DATA	<u> </u>				
3								****	
4		Sheet	Column/Row	Description	Input Value	E	гроп DB в	5 *.Kt	
5		Fragility DB FEMA P58	ith	Refers to FEMA P-58 for complete information		_			
6 7		Cost DB FEMA P58	ith	Refers to FEMA P-58 for complete information	-				
9		Fragility DB User Defined	ith	Fragility DataBase to be used in the FUNVUL Components. The user can defined new fragility functions. Its structure shall be the same as defined in FEMA P-58 Fragility function DB.	-				
11		Cost & Time DB User Defined	ith	Cost&Time DataBase to be used in the FUNVUL Components. The user can defined new Cost&Time functions. Its structure shall be the same as defined in FEMA P-58 Cost function DB.	-				
12 13 14		Fragility Functions	- FDB	Allows the user to visualize the fragility function You must specify a Fragility DB	- {Summary, damage_state}				
15			Function	You must specify a fragility function name from the list.	-				
16		Repair Cost Functions	- FDB	Allows the user to visualize the repair cost function You must specify a Fragility DB	- {Summary, damage_state}				
19			Function	You must specify a fragility function name from the list.	-				
20									
21		Repair Time	-	Allows the user to visualize the repair time function	-				
22		Functions	FDB	You must specify a Fragility DB	{Summary, damage_state}				
23			Function	You must specify a fragility function name from the list.					
	4	▶ Input	HELP Sur	nmary Cost Summary damage_state dam	nage_cost_time	Frag	ility C	osts T	îr



Colombia

- b. Please read all the information given in the "Input\_HELP" sheet. If you are an advance user or you want to edit the fragility functions, please refer to FEMA P-58.
- c. In the Fragility, Costs and Time sheets you can visualize all the information related with the fragility functions available in this file.
- d. For this tutorial, it will be only added one fragility function to User Defined DB from FEMA P-58 DB, just for illustrative purpose. For this copy the entire row for the B1031.001 fragility function from the **Summary** sheet to **damage\_state** sheet. Paste the data at the following row (Row 28).
- e. Repeat the same process with for the information from **Cost Summary sheet** to damage\_cost\_time sheet. At the end you will get the following:

1	A	В	С	D	E	F	G	H	
6	B1041.001a	YES		2 Concrete		B1041.001a	ACI 318 SMF, Conc Col & Bm = 24" x 24", Beam one side	ACI318 C No	ot !
7	B1041.001b	YES		2 Concrete		B1041.001b	ACI 318 SMF, Conc Col & Bm = 24" x 24", Beam both sides	ACI318 C No	ot :
8	B1041.003a	YES		2 Concrete		B1041.003a	ACI 318 SMF, Conc Col & Bm = 36" x 36", Beam one side	ACI318 C No	ot !
9	B1041.003b	YES		2 Concrete		B1041.003b	ACI 318 SMF, Conc Col & Bm = 36" x 36", Beam both sides	ACI318 C No	ot :
10	B1041.091a	YES		2 Concrete		B1041.091a	Non-conforming MF with weak joints and column flexural response, Conc Col & Bm = 24" x 24", Beam one side	Non-Confi No	ot :
11	B1041.091b	YES		2 Concrete		B1041.091b	Non-conforming MF with weak joints and column flexural response. Conc Col & Bm = 24" x 24". Beam both sides	Non-Confi No	ot :
12	B1041.093a	YES		2 Concrete		B1041.093a	Non-conforming MF with weak joints and column flexural response, Conc Col & Bm = 36" x 36*, Beam one side	Non-Confi No	ot :
13	B1041.093b	YES		2 Concrete		B1041.093b	Non-conforming MF with weak joints and column flexural response, Conc Col & Bm = 36" x 36", Beam both sides	Non-Confi No	ot :
14	C1011.001a	YES		7 Gyp Wall		C1011.001a	Wall Partition, Type: Gypsum with metal studs, Full Height, Fixed Below, Fixed Above (Ductil)	Quantity is No	orn
15	B2022.001	YES		6 Cladding		B2022.001	Curtain Walls - Generic Midrise Stick-Built Curtain wall, Config: Monolithic, Lamination: Unknown, Glass Type: Unknown, Details: A	None No	ot :
16	C3011.002b	YES		8 Int finish		C3011.002b	Wall Partition, Type: Gypsum + Ceramic Tile, Partial Height, Fixed Below, Lateral Braced Above (Ductil + Enchape)	Costing ba No	orn
17	C1011.004a	YES		7 Masonry wall		C1011.004a	Wall Partition, Type: UR masonry Full Height, Fixed Below, Fixed Above (DMI Fragil)	Quantity is No	orn
18	C1011.004b	YES		7 Masonry wall		C1011.004b	Wall Partition, Type: UR masonry Full Height, Fixed Below, restrianed Above, confining RC elements (DES Fragil)	Quantity is No	om
19	C1011.005a	YES		7 Masonry wall		C1011.005a	Wall Partition, Type: UR masonry Full Height, Fixed Below, Fixed Above + tyle fragil (DMI Fragil Enchape)	Quantity is No	orn
20	C1011.005b	YES		7 Masonry wall		C1011.005b	Wall Partition, Type: Conf. masonry Full Height, Fixed Below, restrianed Above, confining RC elements + tyle (DES Fragil Enchapter)	Quantity is No	orn
21	C1011.006a	YES		7 Masonry wall		C1011.006a	Facade, Type: UR masonry Full Height, Fixed Below, Fixed Above + glass (Fragil DMI)	Quantity is No	orn
22	C1011.006b	YES		7 Masonry wall		C1011.006b	Facade, Type: Conf. masonry Full Height, Fixed Below, restrianed Above, confining RC elements + glass (Fragil DES)	Quantity is No	orn
23	D2022.025a	YES		1 HVAC		D2022.025a	Gas Piping (dia > 2.5 inches), SDC A or B, PIPING FRAGILITY	Costing ba No	orn
24	D2021.011a	YES		1 HVAC		D2021.011a	Electrical (2.5 inches in diameter or less), SDC A or B, PIPING FRAGILITY	Costing ba No	orn
25	D2022.011a	YES		1 HVAC		D2022.011a	Water Piping - Small Diameter Threaded Steel - (2.5 inches in diameter or less), SDC A or B, PIPING FRAGILITY	Costing ba No	orn
26	E2022.010	YES		5 Misc		E2022.010	Unsecured fragile objects on shelves, unknown restraint (Accel)	Costing to Ar	ay
27	E2022.010a	VES		5 Mise		E2022.010a	Fragile Contents, doors, windows, unknown restraint (Drift)	Costing to Ar	av
- 28	B1031.001	YES	4	Steel		B1031.001	Bolted shear tab gravity connections	Costing is No	it \$
29 30									*
		Input_HEL	P Su	mmary Cost !	Summary	damage_st	ate damage_cost_time Fragility Costs Time 🕀 : 📢		Þ
Re	ady 🔠						Average: 0.452424242 Count: 94 Min: 0 Max: 4 Sum: 14.93 🔠 🖽 🗕	+	100%

f. Finally go to the Input\_HELP sheet and then click on "Export DB to \*.txt" button. This will open a window asking you for the directory where the Fragility DB files will be saved. Please specify a valid path, then click on "OK" button.

Select a Folder						$\times$
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Organize 🔻						?
This PC     This PC     Doints	↑ ∨ Folders (7)					^
> 🗇 A360 Drive		3D Objects				
> 📃 Desktop > 🚊 Documents		Desktop				
> 🕹 Downloads						
> E Pictures		Documents				
> 📕 Videos > 🏪 Local Disk (C:)	ļ	Downloads				
> p Network	~ <b>``</b>	Music				~
1	Folder name: This PC					
			Tools 🔻	ОК	Cancel	

g. Finally, close the file and then, go to the path that you specify and review that the files as listed in section 4.1.1 are in this path. Also, you can compare your results files with the files stored in the FUNVUL-Components\DB\Tutorial1\ Results\_Step\_2 path.



#### 3. Setting up the component files.

a. Open the folder where do you download the software. Go to FUNVUL-Components\DB\SETUP. Open the files Component\_DB.xlsm and Fragility\_DB\_V3.xlsm. You will get the following window.

	А	В	С	D	Е	F	G	Н
1					_			
2		HE	LP INFORMATION FOR INPUT DATA		<u> </u>			
3					_			
4	Sheet	Column	Description	Input Value	_	Fragility	Function DB	User Defined
5	Components	Col1: Story Floor	Indicate the number of the story floor	Integer				
			Refers to each one of the three groups defined as follows. "S" $\cdot$			Total	number of	
		Col2: Group	Structural component, "F" - Nonstructural components, "C"	{S, F, C}		com	ponents	2
6			Contents components				pononio	
		Col3 · SubGroup	Refers to each of the subgroups defined by the user for each	Alphanumeric				
7			group					
			Indicates the name of the fragility function assigned to the			Expo	rt Component D	ata to *.txt
		Col4: Fragility Function	component. The fragility function name corresponds to the	Alphanumeric				
8			same in the Fragility DB					
9		Col5: Description	Contains the description of the component. This information is	Alphanumeric				
10		Col6: Demand Parameter	Contains the demand parameter.	Alphanumeric				
11		Col7: Quantity	Contains the quantity of components	Integer				
		Col8: PDS file	Indicates the name of the PDS file related with the damage	{Drift, RDrift, Accel,				
12			measure.	PR_COL, PR_BEAM}				
		Col9: Column Index	Indicates the key column from the PDS file to read the	Integer				
13			damage.					
		Col10: Correlation	Indicates if exists damage correlation. 1 correlation exists. 0	{0, 1}				
14			correlation does nt exists.	( , , , , , , , , , , , , , , , , , , ,				
15								
10								
17								
18								
19								
20								
21		In the life of the local						
	$( \rightarrow )$	Input_HELP Componen	ts (+)		4			

- b. Before to continue, please read all the information given in the "**Input\_HELP**" sheet.
- c. In the cell **H5** in the "**Input\_HELP**" sheet you can specify the Fragility function DB. Keep in mind that this software uses only the User Defined DB, the FEMA P-58 is just for reference (Refer to step 2 for additional information).
- d. Go to the "**Components**" sheet. Each row represents a component, for additional information refer to section 4.1.3.Then input the following data:

Parameter	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8
Story floor	1	1	1	2	2	2
Group	S	F	С	S	F	С
Subgroup	S1	F1	C1	S2	F2	C2
Fragility Function	B1041.003a	C3032.002a	E2022.010a	B1041.091a	C1011.001a	E2022.010
Quantity	4	15	3	4	10	6
EDP_file	Drift	Accel	Drift	Drift	Drift	Accel
Column Index	1	1	1	2	2	2
Correlation	1	0	0	1	0	0

At the end you will get the following:





4	А	в	С	D	Е	F	G	н	I	J
1	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
2	Story Floor	Group	SubGroup	Fragility Function	Description	Unit	Quantity	PDS file	Column Index	Correlation
3	1	s	S1	B1041.003a	ACI 318 SMF, Conc Col & Bm = 36" x 36", Beam one side	Story Drift Ratio	4	Drift	1	1
4	1	F	F1	C3032.002a	Suspended Ceiling, SDC C, Area (A): A < 250, Vert support only	Peak Floor Acceleration	15	Accel	1	0
5	1	С	C1	E2022.010a	Fragile Contents, doors, windows, unknown restraint (Drift)	Story Drift Ratio	3	Drift	1	0
6	2	S	S2	B1041.091a	Non-conforming MF with weak joints and column flexural	Story Drift Ratio		Drift	2	1
					Wall Partition, Type: Gypsum with metal studs, Full Height, Fixed					
7	2	F	F2	C1011.001a	Below, Fixed Above (Ductil)	Story Drift Ratio		Drift	2	0
8	2	С	C2	E2022.010	Unsecured fragile objects on shelves, unknown restraint (Accel)	Peak Floor Acceleration		Accel	2	0
9										
10										
11										
12										
13										
14										
15										
16										
17										
18						-				
19										
20										
21										
22										
23										
24										
25										
26										
27										
		Input	HELP Co	mponents (+)						

e. Now go to "**Input\_HELP**" sheet. Then verify that the total number of components given in the cell **H6** is 6.

	HE	LP INFORMATION FOR INPUT DATA			
Sheet	Column	Description	Input Value	Fragility Function DB	User Defined
Components	Col1: Story Floor	Indicate the number of the story floor	Integer		
		Refers to each one of the three groups defined as follows. "S" $\cdot$		Total number of	
	Col2: Group	Structural component, "F" - Nonstructural components, "C"	{S, F, C}	components	6
		Contents components		components	
	Col3: SubGroup	Refers to each of the subgroups defined by the user for each	Alphanumeric		
	const suboroup	group Indicates the name of the fragility function assigned to the	1 uprimiterie	Export Component I	Data to *.txt
	Col4: Fragility Function	component. The fragility function name corresponds to the same in the Fragility DB	Alphanumeric		
	Col5: Description	Contains the description of the component. This information is	Alphanumeric		
	Col6: Demand Parameter	Contains the demand parameter.	Alphanumeric		
	Col7: Quantity	Contains the quantity of components	Integer		
	Cole: PDS Ala	Indicates the name of the PDS file related with the damage	{Drift, RDrift, Accel,		
	COID. FDS Jile	measure.	PR_COL, PR_BEAM}		
	Col0: Column Index	Indicates the key column from the PDS file to read the	Integer		
	cors, countrintex	damage.	integer		
	Col10: Correlation	Indicates if exists damage correlation. 1 correlation exists. 0 correlation does nt exists.	{0, 1}		

f. Then click on **"Export Component Data to \*.txt" button**. This will open a window asking you for the directory where the Fragility DB files will be saved. Please specify a valid path, then click on "OK" button.

XII Select a Folder							$\times$
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Organize 🔻							?
🗸 💻 This PC	^ ∨ Fo	olders (7)					^
> 🧊 3D Objects > 🤝 A360 Drive			3D Objects				
> 📃 Desktop > 🔮 Documents > 🚽 Downloads			Desktop				1
> 👌 Music > 📰 Pictures			Documents				
> 📕 Videos > 🏪 Local Disk (C:)			Downloads				
> 🥩 Network							
	Folder name	: This PC	IVIUSIC				
				Tools 🔻	OK	Cancel	

g. Finally, close the file and then, go to the path that you specify and review that the file as listed in section 4.1.3 are in this path. Also, you can compare your results files with the files stored in the FUNVUL-Components\DB\Tutorial1\ Results\_Step\_3 path.



# 6.2. Tutorial 2: Phase 1

This tutorial shows you how to obtain the results from Phase 1 to create the vulnerability function. The step you must follows are the followings:

1. Open the **FUNVUL Components** software. For this click on FUNVULComponents.exe file in the path **FUNVUL-Components**\Software. Wait until the program is loaded completely. Once the program is loaded completely you will get the following window:

承 FUI	FUNVUL_Components ·				
Phase	Edit	Help			ъ

2. Go to and click on Phase\Phase 1 on the Menu. It will display the following:

FUNVUL_Components	- 0	×
Phase Edit Help		r
PHASE 1         Paths for I/O files         Component file path:         EDP files path:         FDB files path:         Results files path:         Results files path:         Model Uncertainty         Beta model uncertainty         Scale Factors for Costs & Times         Costs         Time         No<		
Status: Initialize	Run Analysis	

3. <u>Specify the component file:</u> For this click on the "..." button that is close to the input field Component file path. Then a new window will be opened. In this window select the folder **FUNVUL-Components\FUNVUL-Components\DB\Tutorial2-3**.





承 Select Folder to Open			×
← → × ↑ 📙 « FU	NVUL-Components > DB	✓ Ö Search DB	م
Organize 👻 New folde	r		
1. 1. 0. i I	Name	Date modified	Туре
> 🗶 Quick access	SETUP	4/18/2018 8:14 PM	File folder
> 👩 Creative Cloud Files	📙 Tutorial1	4/18/2018 8:14 PM	File folder
> 🗦 Dropbox	Tutorial2-3	4/18/2018 8:14 PM	File folder
<ul> <li>ConeDrive - Personal</li> <li>ConeDrive - Universida</li> <li>Universidad de Los A</li> <li>This PC</li> <li>This PC</li> <li>Network</li> </ul>			
	<		>
Folder	: Tutorial2-3		
		Select Folder	Cancel

4. <u>Specify EDP DB:</u> For this click on the "..." button that is close to the input field EDP files path. Then a new window will open. In this window select the folder **FUNVUL-Components\DB\Tutorial2-3\EDP\_DB**.

承 Select Folder to Open					×
← → × ↑ 📙 « DB	> Tutorial2-3	ٽ ~	Search Tutorial2	-3	٩
Organize 👻 New folder					?
Cuick accore	Name	Da	ate modified	Туре	
/ A Quick access	EDP_DB	4/	18/2018 8:14 PM	File folder	
> 👩 Creative Cloud Files	- Fragility_DB	4/	18/2018 8:14 PM	File folder	
> 🎎 Drophox	Results_Phasel	4/	18/2018 8:14 PM	File folder	
	Results_Phasell	4/	18/2018 1:51 PM	File folder	
> 💪 OneDrive - Personal					
> 🝊 OneDrive - Universida					
> 📓 Universidad de Los A					
> 💻 This PC					
> 💣 Network					
<					
Folder:	EDP_DB				
		[	Select Folder	Cance	I

5. <u>Specify Fragility function DB:</u> For this click on the "…" button that is close to the input field FDB files path. Then a new window will open. In this window select the folder **FUNVUL-Components\DB\Tutorial2-3\Fragility DB**.

DB	> Tutorial2-3	🗸 👌 🛛 Search Tutori	al2-3
Organize 🔻 New folde	ir -		
	Name	Date modified	Туре
📌 Quick access	EDP_DB	4/18/2018 8:14 PM	1 File folder
o Creative Cloud Files	Fragility_DB	4/18/2018 8:14 PM	1 File folder
tt Dronboy	Results_Phasel	4/18/2018 8:14 P№	1 File folder
Se propoox	Results_Phasell	4/18/2018 1:51 PM	1 File folder
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a OneDrive - Universida			
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🥩 Network			
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E-14-	Eragility DR		



6. <u>Specify Results path:</u> For this click on the "..." button that is close to the input field FDB files path. Then a new window will open. In this window select the folder **FUNVUL-Components\DB\Tutorial2-3\Results\_PhaseI**.

承 Select Folder to Open				
🔶 🔶 👻 🕇 📙 « DB	» Tutorial2-3	ٽ ~	Search Tutorial2	-3 🔎
Organize 👻 New folde	r			III ▼ (
1.0.1	Name	Da	te modified	Туре
r Quick access	EDP_DB	4/	18/2018 8:14 PM	File folder
o Creative Cloud Files	Fragility_DB	4/	18/2018 8:14 PM	File folder
Contraction Contraction	Results_Phasel	4/	18/2018 8:14 PM	File folder
<ul> <li>OneDrive - Personal</li> <li>OneDrive - Universida</li> <li>Universidad de Los A</li> <li>This PC</li> <li>Network</li> </ul>	Kesuits_Phaseii	4/	18/2018 1:51 PM	File tolder
Folder	Results Phasel			
Tolde.	resorce_, nose	[	Select Folder	Cancel

- 7. In the input box for number of stories please input the value **2**.
- 8. To specify the other input parameters, please click on **Edit\Default Values**. After that, it will display the following:

FUNVUL_Components		- D
ase Edit Help		
Paths for I/O files		
Component file path: C:\Fi	NVUL-Components\DB\Tutorial2-3	
EDP files path: C:\FUNV	IL-Components\DB\Tutorial2-3\EDP_DB	
FDB files path: C:\FUNVU	L-Components\DB\Tutorial2-3\Fragility_	
Results files path: C:\FUNV	L-Components\DB\Tutorial2-3\Results_F	
Number of stories	Model Uncertainty 5	
Number of stories	Model Uncertainty 5	
beta model uncertainty 0.		
Scale Factors for Costs & Times	Costs & Time Oncertainty 5	
Costs Yes		
Time Yes		
tus: Initialize		

9. Now click on the **Run Analysis button**. Wait until the program finished the analysis. IT will be display the following windows:





HASE 1 Paths for I/O files		Plot Resul	ts Phase l				
Component file path: C:\FL	NVUL-Components\DB\Tutorial2-3	1					
EDP files path: C:\FUNV	L-Components\DB\Tutorial2-3\EDP_DB						
FDB files path: C:\FUNVU	L-Components\DB\Tutorial2-3						
Results files path: C:\FUNVU	L-Components\DB\Tutorial2-3 Proccess successfu	lly performed!					
ilobal Parameters	Number of Iterations	0.7					
Number of stories	Model Uncertainty 5						
Beta model uncertainty 0.	Damage States Uncertainty 5	0.2					
cale Easters for Costs & Times	Costs & Time Uncertainty 5						
Losts Yes		0	0.2	0.4	0.6	0.8	1
Time Yes v		⊖ Cost	Results 🔘	Time Result	5	Upda	ate pl

- 10. Click on the **OK button**.
- To visualize Cost results please select in the graph area the "Cost Results" radio button. Then click on the "Update plot" button. After that, you will get the following.

FUNVUL_Components		- 🗆 X
Phase Edit Help		۲
PHASE 1 Paths for I/O files Component file path: EDP files path: FDB files path: Results files path:	C:\FUNVUL-Components\DB\Tutorial2-3 C:\FUNVUL-Components\DB\Tutorial2-3\EDP_DB C:\FUNVUL-Components\DB\Tutorial2-3\Fragility C:\FUNVUL-Components\DB\Tutorial2-3\Results_F	Plot Results Phase I
Global Parameters	Number of Iterations       Nodel Uncertainty       ty       0.2       ty       5 & Times       Yes	The second secon
Status: Analysis total time: 3.2	344 segundos	Cost Results O Time Results Update plot Run Analysis

12. To visualize Time results please select in the graph area the "**Time Results**" radio button. Then click on the "**Update plot**" button. After that, you will get the following.





PHASE 1			Plot Results Phase I
Component file path: EDP files path: FDB files path: Results files path:	C:\FUNVUL-Cor C:\FUNVUL-Cor C:\FUNVUL-Cor	Components\DB\Tutorial2-3 m mponents\DB\Tutorial2-3\EDP_DB m mponents\DB\Tutorial2-3\Fragility m mponents\DB\Tutorial2-3\Results F	
Global Parameters Number of stories Beta model uncertainty Scale Factors for Costs Costs Time	2 7 0.2 & Times Yes ~ Yes ~	Number of Iterations Model Uncertainty 5 Damage States Uncertainty 5 Costs & Time Uncertainty 5	Line to the set of the

13. Now modify the number of iterations for all three inputs box to 10. Then click on "Run Analysis" button. Then visualize the cost results (repeat the process in step 11). You will get the following results:

FUNVUL_Components			×
Phase Edit Help			ъ
PHASE 1 Paths for I/O files Component file path: EDP files path: FDB files path: Results files path:	C:\FUNVUL-Components\DB\Tutorial2-3 C:\FUNVUL-Components\DB\Tutorial2-3\EDP_DB C:\FUNVUL-Components\DB\Tutorial2-3\Fragility C:\FUNVUL-Components\DB\Tutorial2-3\Results_F	Plot Results Phase I	
Global Parameters Number of stories Beta model uncertainty -Scale Factors for Costs Costs Time	Number of Iterations       0.2       0.3       & Times       Yes	end of the second secon	.2 lot
Status: Analysis total time: 8.890	6 segundos	un Analysis	

It displays the previous iteration in gray scale. With this you can compare between two analyses.



# 6.3. Tutorial 3: Phase 2

This tutorial shows you how to obtain the results from Phase 2 to obtain the final vulnerability function. The step you must follows are the followings:

1. Open the **FUNVUL Components** software. For this click on FUNVULComponents.exe file in the path **FUNVUL-Components\Software**. Wait until the program is loaded completely. Once the program is loaded completely you will get the following window:

FUNVUL_Components	_	×
Phase Edit Help		ъ

2. Go to and click on Phase\Phase 2 on the Menu. It will display the following:

FUNVUL_Components	-	×
Phase Edit Help		r
PHASE 2 Paths for I/O files EDP files path: Results files path: Basic Data from Phase I		
Model Uncertainty Seismic Damage States Uncertainty Group List Costs & Time Uncertainty		
Global Parameters		
Status: Initialize Load Data Run Analysis		

3. <u>Specify EDP DB:</u> For this click on the "..." button that is close to the input field EDP files path. Then a new window will open. In this window select the folder **FUNVUL-Components\DB\Tutorial2-3\EDP\_DB**.





承 Select Folder to Open					×
← → ~ ↑ 📙 « DB :	• Tutorial2-3	ٽ ~	Search Tutorial2	-3	P
Organize 👻 New folder					?
) de Ouisk accore	Name	Da	ate modified	Туре	
V A Quick access	EDP_DB	4/	18/2018 8:14 PM	File folder	
> 💊 Creative Cloud Files	Fragility_DB	4/	18/2018 8:14 PM	File folder	
Dronhov	Results_Phasel	4/	18/2018 8:14 PM	File folder	
> Stopbox	Results_Phasell	4/	18/2018 1:51 PM	File folder	
> 📃 This PC					
> 💣 Network					
<					>
Folder:	EDP_DB				
		L	Select Folder	Cance	

4. <u>Specify Results path from Phase I:</u> For this click on the "..." button that is close to the input field FDB files path. Then a new window will open. In this window select the folder **FUNVUL-Components\FUNVUL-Components\DB\Tutorial2-3\Results\_PhaseI**.

承 Select Folder to Open					×
← → • ↑ 🔂 « DB	> Tutorial2-3	✓ <sup>™</sup> S	earch Tutorial2-	3	P
Organize 👻 New folder					?
1 O ith server	Name	Date r	modified	Туре	
M QUICK access	EDP_DB	4/18/2	2018 8:14 PM	File folder	
o Creative Cloud Files	Fragility_DB	4/18/2	2018 8:14 PM	File folder	
tt Dronhov	Results_Phasel	4/18/2	2018 8:14 PM	File folder	
Stopbox	Results_Phasell	4/18/2	2018 1:51 PM	File folder	
🝊 OneDrive - Personal					
🝊 OneDrive - Universida					
📓 Universidad de Los A					
🛄 This PC					
💣 Network					
	<b>(</b>				>
Folder	Results_Phasel				
		s	elect Folder	Cancel	

5. Click on the "Load Data" button. Once the process has be finished it will fill out the data "Basic Data from Phase I", the number of iterations and the seismic group list will be updated. In the Seismic Group List you can select which groups will be included for the analysis. It will display the following results:





Phase Edit Help					,
PHASE 2 Paths for I/O files EDP files path: C:\FUNVUL-Compon Results files path: C:\FUNVUL-Compon	ents\DB\Tutorial2-3\EDP_DB				
Basic Data from Phase I Model Uncertainty 10 Damage States Uncertainty 10 Costs & Time Uncertainty 10	Seismic All All G1 Group List G2				
Global Parameters Building Replacement Value Interruption Time Replacement Value					
Status: Initialize		Load Data	Run Analysis		

- 6. Select **G1** from the **Seismic Group List**.
- 7. Specifying the Global Parameters. Input the following values:

**Building Replacement Value:** 100,000,000 (you must avoid use any digit grouping symbol).

**Interruption Time Replacement Value:** 500,000 (you must avoid use any digit grouping symbol).

FUNVUL_Components	_	×
Phase Edit Help		ъ
PHASE 2 Paths for I/O files EDP files path: C:\FUNVUL-Components\DB\Tutorial2-3\EDP_DB		
Results files path:       CAFUNVUL-Components/DB\Tutorial2-31Results		
Global Parameters Building Replacement Value Interruption Time Replacement Value S00p00		
Status: Initialize Load Data Run Analysis		

8. Click on the slide bar. Then to specify the additional input parameters, click on **Edit\Default Values**. After that, it will display the following:





FUNVUL_Components	- 🗆 X
Phase Edit Help	لا
PHASE 2	
Maximum time for intervention [days] 365	
Previous required time before start intervention [days] 30	
Additional time after intervention [days] 30	
Numbers of work crews for structural repair 4	
Numbers of work crews for non-structural repair 4	
Cost Limits	
Lower intensity to no damage [g/g] 0	
Maximum allowable residual drift for demolition [%] 2.5	
Perecentage of building replacement value [%] 100	
Bidirectional factor for total cost model 1.5	
Intensity level for building evacuation [g/g]	
Status: Initialize	
	Load Data Run Analysis

9. Now click on the **Run Analysis button**. Wait until the program finished the analysis. IT will be display the following windows:



10. To visualize results you can select one option from the drop-down list. For this case select "**Total Normalized Cost**". Then click on the "**Update plot**" button. After that, you will get the following.







11. Now select **G1 and G2** from the Seismic Group List. Then click on "**Run Analysis**" button. Then visualize the total normalized cost results (repeat the process in step 10). You will get the following results:



It displays the previous iteration in gray scale. With this you can compare between two analyses.

12. Finally, click on the Export Data button. You will export the results from Phase II to a editable txt formats as specified in the section 5.2. A new window will be open. You must select the path where it will be stored the files. Select the C:\FUNVUL-Components\DB\Tutorial2-3\Results\_PhaseII.





Select Folder to Open					>
• 🛧 📙 « DB	> Tutorial2-3	ٽ ~	Search Tutorial2	-3	P
Organize 👻 New folder	r				?
o Creative Cloud Fil	Name	D	ate modified	Туре	
** D	EDP_DB	4/	'18/2018 8:30 PM	File folder	
Se Drobbox	Fragility_DB	4/	(18/2018 8:30 PM	File folder	
🝊 OneDrive - Persor	Results_Phasel	4/	18/2018 9:18 PM	File folder	
	Results_Phasell	4/	/18/2018 1:51 PM	File folder	
<ul> <li>Universidad de Lo</li> <li>Camilo Andres F</li> <li>Juan Felipe Dora</li> <li>This PC</li> <li>Network</li> </ul>					
~	<				
Folder	Results_Phasell				
			Select Folder	Cancel	

After you select the folder, it will display a new window with the message that "The files were successfully saved!". Then click on OK button.

HASE 2		🔶 🔤 Plot Resu	lts Phase II	
Paths for I/O files EDP files path: C:\FUNVUL-Components\DE Results files path: C\FUNVUL-Components\DE	NTutorial2-3\EDP_DB			
Basic Data from Phase I Model Uncertainty 10 Seismic Damage States Uncertainty 10 Group L Costs & Time Uncertainty 10	All G1 G2	OK		RDC + BIC(N) - RDC + BIC(O)
Global Parameters Building Replacement Value Interruption Time Replacement Value	10000000 500000	000	0.5 Elastic spectral accelera Total Normalized Cost	1 1.5 ation [g]

13. Now go to the **C:\FUNVUL-Components\DB\Tutorial2-3\Results\_PhaseII** path. You will find the five files are specified in the section 5.2.





# Chapter 7 Problems and errors



The main problems and errors produced during the use of this software can be related to the followings issues.

Error Message	Description	Solution
	The MATLAB Runtime is not installed	
Your computer does not have installed the	and ensure you	See instructions in
MATLAB RUNTIME VERSION 9.2 (R2017a)	have installed version 9.2 (R2017a)	section 2.1.2
	This occur when you do not specify a	Select or specify a valid
You must select a valid directory!	valid path.	path.
	This occur when the required file	Varify that the file is
The Components.txt file does not exist!	does not exist in the Component	stored at this path
	Path.	stored at this path.
You must define a valid directory for	This occur when you do not specify a	Select or specify a valid
Component Data!	valid path.	path.
The IML.txt file does not exist!	This occur when the required file	Verify that the file is
	does not exist in the EDP DB Path.	stored at this path.
The Drift.txt file does not exist!	This occur when the required file	Verify that the file is
	does not exist in the EDP DB Path.	stored at this path.
The RDrift.txt file does not exist!	This occur when the required file	Verify that the file is
	does not exist in the EDP DB Path.	stored at this path.
The Accel.txt file does not exist!	This occur when the required file	Verify that the file is
	does not exist in the EDP DB Path.	stored at this path.
The PR_COL.txt file does not exist!	This occur when the required file	Verify that the file is
	does not exist in the EDP DB Path.	stored at this path.
The PR_BEAM.txt file does not exist!	This occur when the required file	Verify that the file is
	does not exist in the EDP DB Path.	stored at this path.
You must define a valid directory for EDP Data!	Inis occur when you do not specify a	Select or specify a valid
The demage state tot file does not evict	This assuration the required file	path.
The damage_state.txt me does not exist!	doos not ovist in the EDR Bath	stored at this path
The damage cost time tyt file does not exist!	This occur when the required file	Vorify that the file is
The damage_cost_time.txt me does not exist:	does not exist in the FDB Path	stored at this nath
You must define a valid directory for Fragility	This occur when you do not specify a	Select or specify a valid
Specification Data!	valid path.	path.
You must define a valid directory for save	This occur when you do not specify a	Select or specify a valid
Results Data!	valid path.	path.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of stories!		format type and valid
		values.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of stories!		format type and valid
		values.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of beta uncertainty model!		format type and valid
		values.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of beta uncertainty model		format type and valid
		values.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of iterations for model uncertainty!		format type and valid
	The inclusion in	values.
You must define a numeric value greater than 0	i në input value is wrong.	Refers to Table 1. For
for number of iterations for model uncertainty!		values
Vou must define a numeric value greater that 0	The input value is wrong	Pofors to Table 1 For
for number of iterations for damage state	The input value is wrong.	format type and valid
uncertaintyl		values
uncertainty:		values.





Error Message	Description	Solution
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of iterations for damage state		format type and valid
uncertainty!		values.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of iterations for cost & time model		format type and valid
uncertainty!		values.
You must define a numeric value greater than 0	The input value is wrong.	Refers to Table 1. For
for number of iterations for cost & time model		format type and valid
uncertainty!		values.
You must define a valid directory for obtain and	This occur when you do not specify a	Select or specify a valid
save Results Data!	valid path.	path.
The Building replacement value must be	The input value is wrong.	Refers to Table 1. For
positive!		format type and valid
		values.
The Interruption time replacement value must	The input value is wrong.	Refers to Table 1. For
be positive!		format type and valid
		values.
The value of Lower intensity limit to no damage	The input value is wrong.	Refers to Table 1. For
must be zero or greater than zero!		format type and valid
		values.
The value of Maximum allowable residual drift	The input value is wrong.	Refers to Table 1. For
for demolition must be greater than zero!		format type and valid
		values.
The Percentage of building replacement value	The input value is wrong.	Refers to Table 1. For
must be greater than zero!		format type and valid
		values.
The value of Bidirectional factor for total cost	The input value is wrong.	Refers to Table 1. For
model must be greater than zero!		format type and valid
		values.
The value of Intensity level for building	The input value is wrong.	Refers to Table 1. For
evacuation must be greater than zero!		format type and valid
		values.
The value of Maximum time for intervention	The input value is wrong.	Refers to Table 1. For
must be greater than zero!		format type and valid
		values.
The value of Previous required time before start	The input value is wrong.	Refers to Table 1. For
intervention must be greater than zero!		format type and valid
		values.
The value of Additional time after intervention	The input value is wrong.	Refers to Table 1. For
must be greater than zero!		format type and valid
		values.
The value of Numbers of work crews for	The input value is wrong.	Refers to Table 1. For
structural repair must be greater than zero!		format type and valid
		values.
The value of Numbers of work crews for non-	The input value is wrong.	Refers to Table 1. For
structural repair must be greater than zero!		format type and valid
		values.

If you get any other error from those listed above, please send an email to <u>ecapra@uniandes.edu.co</u>. Please include a short description of the error.





# Chapter 8 References



- FEMA. 2012. Next-Generation Methodology for Seismic Performance Assessment of Buildings. Report No. FEMA P-58. Prepared by the Applied Technology Council (ATC) for the Federal Emergency Management Agency, Washington, D.C.
- Yamin, Luis E., Alvaro Hurtado, Raul Rincon, Juan F. Dorado, and Juan C. Reyes. 2017. "Probabilistic seismic vulnerability assessment of buildings in terms of economic losses." *Engineering Structures* 138:308-323. doi: <u>http://dx.doi.org/10.1016/j.engstruct.2017.02.013</u>.