CAPRA

Probabilistic Risk Assessment Platform

User Manual

Software

FUNVUL-Simplified-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. A simple analytical model methodology is used in the FUNVUL Simplified software to define new vulnerability functions.

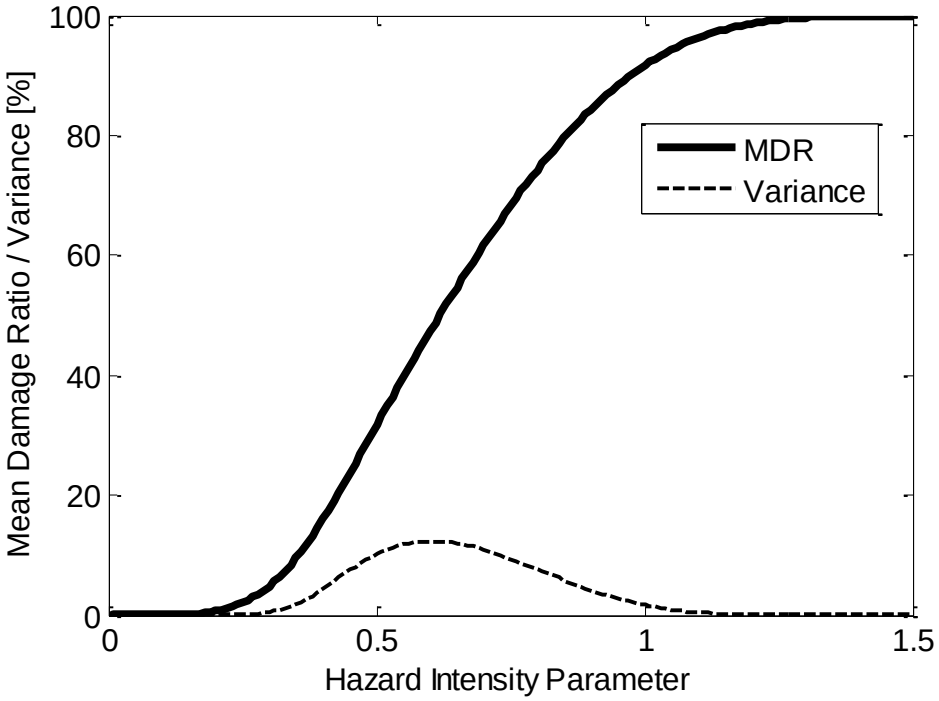


Figure 1 Example vulnerability function

1.2. Theoretical framework

This software uses a simple analytical methodology to obtain new vulnerability functions based on a few parameters. The methodology used to obtain new vulnerability functions are based on the methodology proposed by (Yamin et al. 2014) and (Council 1985) with a few modifications. The vulnerability functions are represented by three main parameters the hazard intensity parameter value, the expected and the variance value of the MDR for either physical or human damage. For this case it is only required to know a unique or several points for the three parameters defined before to obtain the complete vulnerability function. And adjustment for the basic parameters defined in the methodology has been done until get the desire curve shape. For additional information refers to (Yamin et al. 2014) and (Council 1985).

The Eq. [1, 2] presents the basics formulas used to obtain new vulnerability functions based on minimum parameters. The first equation allows to obtain the expected value of the MDR. The second equation allows to obtain the variance value for the MDR.

$$E_{MDR}(x) = \begin{cases} 0 \mid x \leq X_0 \\ E_{MDR_{max}} * \left(1 - E_{MDR}(x')\right)^{\left(\frac{x}{x'}\right)^{\rho}} \mid X_0 < x < X_f \\ E_{MDR_{max}} \mid x \geq X_f \end{cases} \quad \text{Eq. [1]}$$

$$\sigma_{MDR}(x) = \begin{cases} 0 \mid x \leq X_0 \\ \frac{\sigma_{MDR_{max}} * x^{(r-1)} * [1-x]^{(s-1)})}{MDR(x)^{(r-1)} * [1-MDR(x)]^{(s-1)}} \mid X_0 < x < X_f \\ 0 \mid x \geq X_f \end{cases} \quad \text{Eq. [2]}$$

where:

$E_{MDR}(x)$:= Expected MDR function.

x := hazard intensity value associated with the hazard being considered.

X_0 : = hazard intensity value at which damage begins.

$E_{MDR_{max}}$:= Maximum value of the $E_{MDR}(x)$. Recommended values between [0 – 100%].

$E_{MDR}(x')$:= Known value of the expected MDR at x' intensity. Recommended values between (0 – 100%).

x' := Intensity for the known MDR.

ρ := curvature of the function before and after the x' intensity. Recommended value of 2.

X_f : = Intensity value at which damage is complete.

$\sigma_{MDR}(x)$:= Variance of MDR function.

$\sigma_{MDR_{max}}$:= maximum variance of MDR. Recommended values between [5 – 25%].

r := shape factor of bell for variance function. Value of 2 recommended.

s := adjustment factor, defined as follows:

$$s = \frac{r-1}{E_{MDR}(x)} - r + 2$$

1.3. Objectives

The principal objectives of this software are:

- Integrated tool to obtain one of the input parameters for the hazard risk assessment required by the CAPRA-GIS software.
- Visualize existing vulnerability functions from a DB or existing files (*.fvu or *.txt file) for physical and human damage.
- Obtain new vulnerability functions based on a simple methodological approach. The vulnerability function could be saved into a *.fvu file.
- Compare existing and new vulnerability functions.

1.4. Expected results and calculus limitations

This software displays an individual graph with the vulnerability function for each one of the physical and human damage. This information could be saved to a *.fvu file. This software has a limitation for the calculus of the vulnerability function. Only allows a total of 49 points to defined new vulnerability functions. Also, the user shall understand the methodology to avoid get wrong results. This software has the following limitations:

- The user cannot add, edit, delete or save any record from the integrated CAPRA-DB.
- The input *.txt file format should have the structure as specified in the section 4.1.2.
- Only can be displayed one curve in the **PhysicalGraph** or **HumanGraph** Tab for existing and new vulnerability function.
- The maximum number of points to define a new vulnerability function are 49. If you want to obtain higher hazard intensity values, you can modify the Intensity step value.
- This software does not verify if the user is using consisting hazard intensity for a given hazard type or hazard units for a given hazard intensity.
- When an existing vulnerability function is loaded the user should be aware that the hazard type and hazard intensity must be listed in the parameter area in the **ExisitngFVU** Tab. Otherwise, the vulnerability parameter is not defined.
- This software does not calculate automatic conversion among difference hazard units. The user can use the Intensity factor parameter in the **NewFVU** Tab. This limitation applies for comparison purposes between existing and new vulnerability functions. The user should be aware that he/she is using the same hazard type and intensity parameter.

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 Microsoft Office Access, please install the Microsoft Access Database Engine. It can download from: http://www.microsoft.com/download/en/confirmation.aspx?id=23734.

2.2. Installation process

The following steps must be followed for the installation of the software:

1. Verify that all software requirements are meet before installation. Please see section 2.1.2.
2. Enter in the Windows™ Explorer and select the path where the installer is located, then, go to the Installers File folder.
3. Run the **setup.exe** program in this drive; this command starts the installation process (see Figure 2). Please follow the instructions given by the installer assistant during the process. It is recommended to install the program in the default path as specified in the installer.
4. Once the installation has been completed successfully, please go to *Start/CAPRA Suite/FUNVUL Simplified V1.0.0* in the menu Start to start the program and verify is working properly. Also, you can use the direct access created in your desktop.

If you cannot install this software or get any error message during the installation process or when the program starts, please send an email with the description to ecapra@uniandes.edu.co.

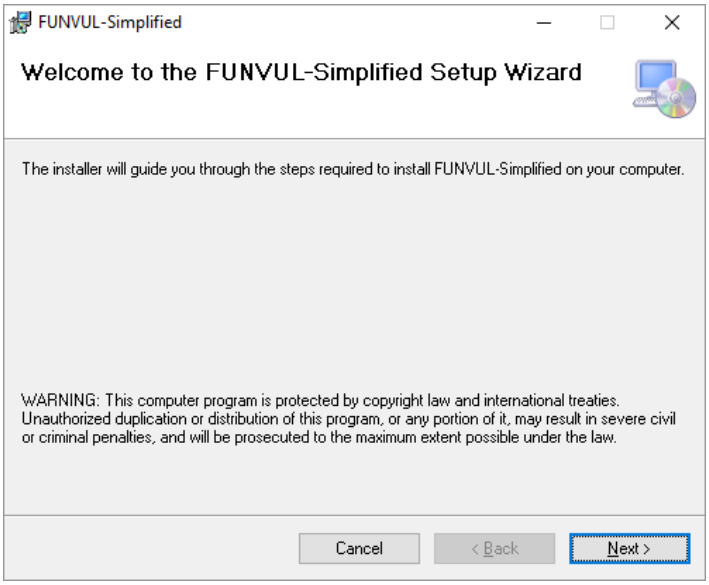


Figure 2 FUNVUL Simplified Installation window

Chapter 3

Graphical user interface

3.1. General description

This software allows the user to create new and visualize existing vulnerability functions. The methodology used to create new function is presented in section 1.2. The user can load vulnerability functions from default DB included with the software, existing *.fvu and *.txt files.

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

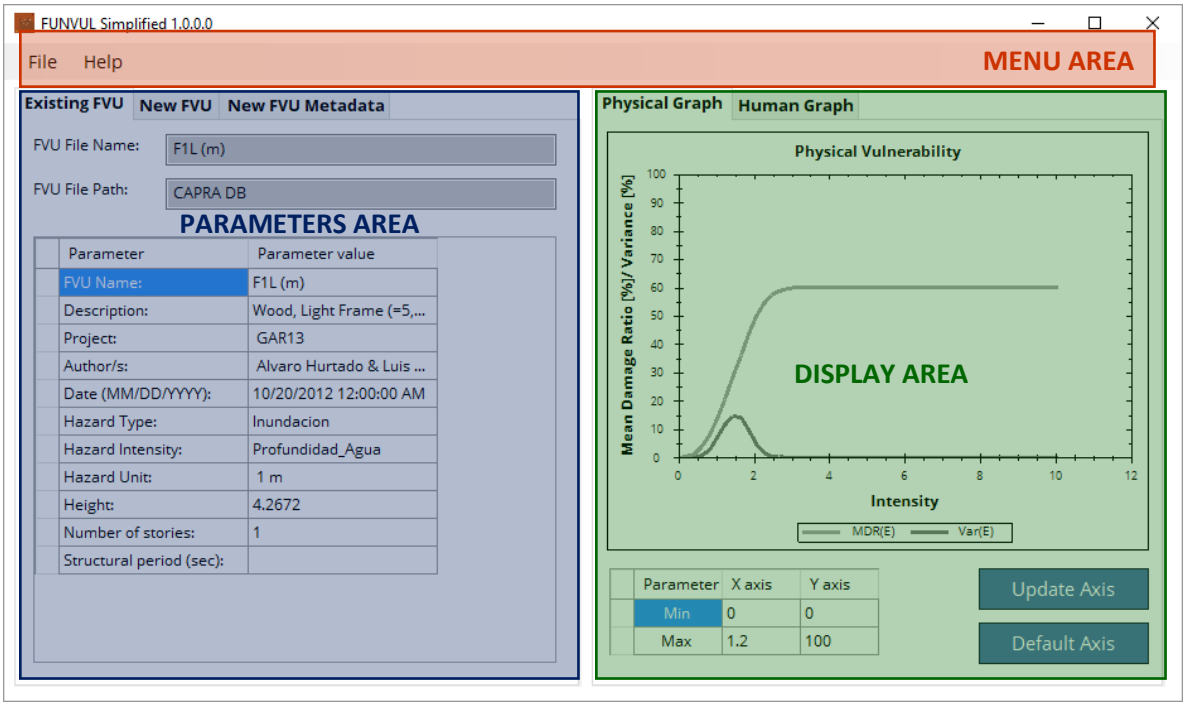


Figure 3 FUNVUL Simplified main window

3.2. Tools and Menus

3.2.1. Menu area

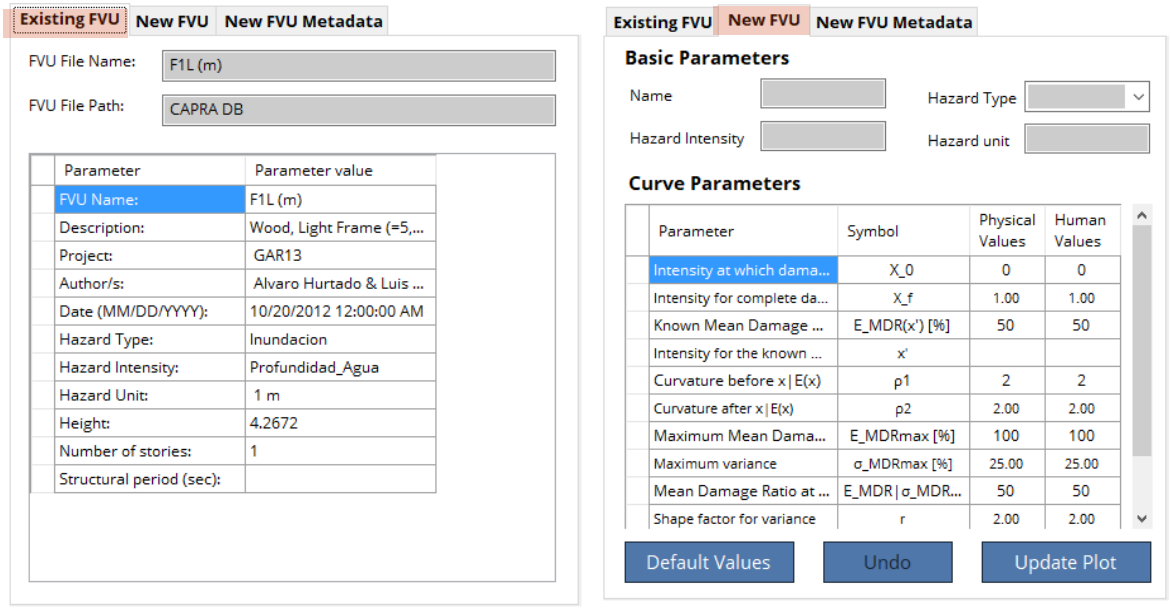
The software menu bar has two drop down menus to get access at different functions. The File drop down menu item includes access to functions that allows the user to load and save files and close the application. The Help drop down menu allows the user to get access to the documentation resources of the software and the about information.

3.2.2. Parameters area

This area has three different Tabs. Each tab contains parameter information for the existing and new vulnerability functions and has buttons to execute tasks.

- **Existing FVU Tab:** It contains information from existing vulnerability functions, these parameters are automatic added when a Load Data method is used. The values are not editable.
- **New FVU Tab:** It contains input fields to define the basic and curve parameters for new vulnerability functions. And a button to plot the new vulnerability function.

- **New FVU Metadata Tab:** It contains the fields with the basic information to be included in the *.fvu file for the new vulnerability function, and the button to save the *.fvu file.



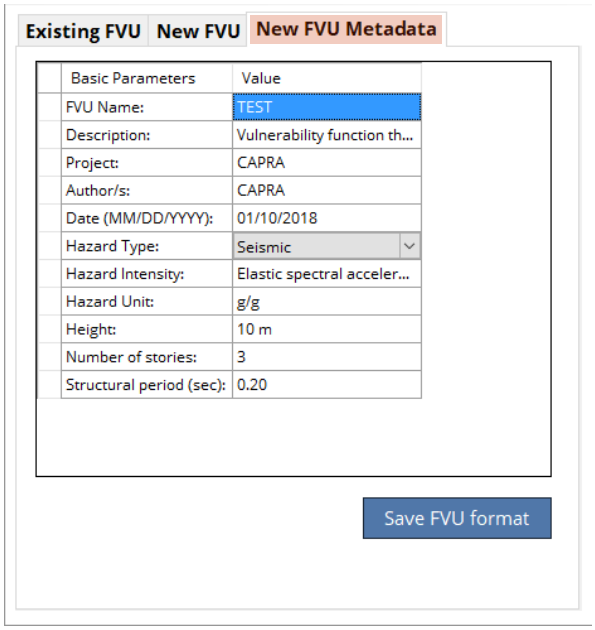


Figure 4 Tab overview for parameters area

The function for each button is described below.

- **Default Values button:** fill the curve parameters table in the **New FVU Tab** with recommended values.
- **Undo button:** allows the user undo once the parameters definition in the **New FVU Tab.**
- **Update Plot button:** add the vulnerability curve to the Physical and Human Graphs using the curve parameters defined by the user in the **New FVU Tab** the new vulnerability function.

- **Save FVU format button:** allows the user to save in a *.fvu file the new vulnerability function using the input data in the **New FVU Tab** and **New FVU Metadata Tab**. It shows a dialog window to select the location directory for the *.fvu file.

3.2.3. Display area

The display area allows the user to visualize the existing and new vulnerability functions for physical and human curves. It has two tabs.

- **Physical Graph Tab:** display the vulnerability curve for existing or new physical vulnerability functions or both. It also has functions to control the axis scale. The vulnerability curve name includes the "*(N)*" for new at the end in the legend. The expected value of the MDR is shown with a blue line. The variance of the MDR is shown with a light blue line.
- **Human Graph Tab:** display the vulnerability curve for existing or new human vulnerability functions or both. It also has functions to control the axis scale. The vulnerability curve name includes the "*(E)*" for existing at the end in the legend. The expected value of the MDR is shown with a light grey line. The variance of the MDR is shown with a grey line.

Each Tab has two main elements. The first element is the graph pane where the vulnerability curve is displayed for the expected and variance of the MDR. This pane allows to the user copy, save among other functions on the graph. The second element is a control for the scale of graph axis using input parameters for values of max and min for each one.

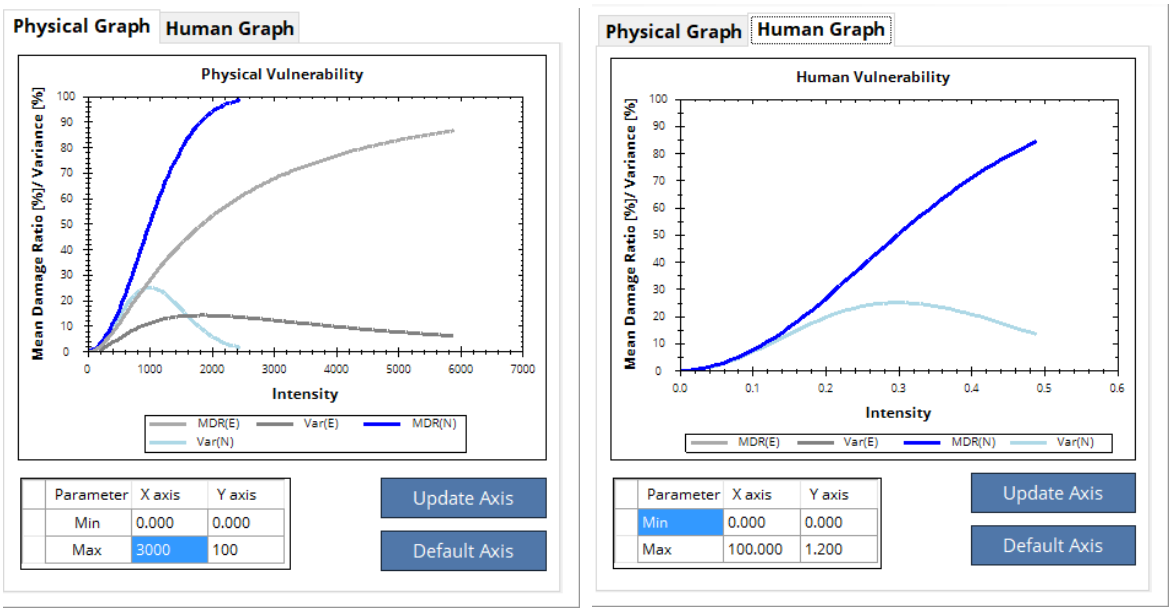


Figure 5 Tabs overview for Display area

The function for each button is described below.

- **Update Axis button:** set the values of min and max for the X-axis and Y-axis from the values specified in the input table.
- **Default Axis button:** set the values of the X-axis and Y-axis to its default values.

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.

Table 1 Input parameters

Item	Parameter	Format type	Value	Units
1	**LOAD DATA**			
1.1	From *.fvu file	*.fvu file (see section 4.1.1)	-	-
1.2	From *.txt file	*.txt file (see section 4.1.2)	-	-
1.3	From CAPRA-DB	String	-	-
2	**EXISTING FVU TAB**			
2.1	FVU File Name	String	-	-
2.2	FVU File Path	String	-	-
2.3	Parameter values Table	String	-	-
3	**NEW FVU TAB**			
3.1	**Basic parameters**			
3.1.1	Name	String	-	-
3.1.2	Hazard Type	String	Empty Seismic Wind Landslide StormTide NotHurricaneRain HurricaneRain VolcanicAsh Tsunami SeismicLandslide Rain Landslide Flood Scouring	-
3.1.3	Hazard Intensity	String	-	-
3.1.4	Hazard Unit	String	-	-
3.2	**Curve Parameters**			
3.2.1	Intensity at which damage begins, X_0	Double	≥ 0 Default value 0	Hazard units
3.2.2	Intensity for complete damage, X_f	Double	> 0 Default value 1	Hazard units
3.2.3	Known Mean Damage Ratio, $E_{MDR}(x')$	Double	> 0 Default value 50	Percentage
3.2.4	Intensity for the known mean damage ratio, x'	Double	> 0	Hazard units
3.2.5	Curvature before x|E(x), ρ	Double	≥ 1 Default value 2	-

Item	Parameter	Format type	Value	Units
3.2.6	Curvature after x|E(x), ρ	Double	≥ 1 Default value 2	-
3.2.7	Maximum Mean Damage Ratio, $E_{MDR_{max}}$	Double	> 0 Default value 100	Percentage
3.2.8	Maximum variance, $\sigma_{MDR_{max}}$	Double	> 0 Default value 100	Percentage
3.2.9	Mean Damage Ratio at maximum variance, x'	Double	> 0 Default value 50	Percentage
3.2.10	Shape factor for variance, r	Double	≥ 1 Default value 2	-
3.2.11	Intensity step, dX	Double	> 0 Default value 0.01	Hazard units
3.2.12	Intensity factor, m	Double	> 0 Default value 1	-
4	**NEW FVU METADATA TAB**			
4.1	FVU Name	String	-	-
4.2	Description	String	-	-
4.3	Project	String	-	-
4.4	Author/s	String	-	-
4.5	Date (MM/DD/YYYY)	Date	MM/DD/YYYY	-
4.6	Hazard Type	String	Empty Seismic Wind Landslide StormTide NotHurricaneRain HurricaneRain VolcanicAsh Tsunami SeismicLandslide Rain Landslide Flood Scouring	-
4.7	Hazard Intensity	String	-	-
4.8	Hazard Unit	String	-	-
4.9	Height	String	-	-
4.11	Number of stories	String	-	-
4.11	Structural period (sec)	Double	> 0	sec
5	**AXIS LIMITS TABLE**			
5.1	X axis Min	Double	≥ 0 Default value 0	Hazard units
5.2	X axis Max	Double	> 0 Default value 1.2	Hazard units
5.3	Y axis Min	Double	≥ 0 Default value 0	Percentage

Item	Parameter	Format type	Value	Units
5.4	Y axis Max	Double	> 0 Default value 100	Percentage
6	**OUTPUT**			
6.1	*.fvu file path	String	-	-
6.2	*.fvu file name	String	-	-

Chapter 4

Setting input data and files

4.1. Input file and file format

This software uses two types of input files to load information of existing vulnerability functions. Those types are *.fvu and *.txt format files. You can load it using the File/Load Data from the menu bar. 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. *.fvu file format

This file contains information written in records. It can be read using the Notepad program. The file format structure is divided in three sections. The first section contains the values of the three parameters for the physical vulnerability. The second section contains the values of the three parameters for the human vulnerability. The last section contains additional information that includes basic information (g.e. description, name, author, etc.). It also, can includes the value of specific parameters used to obtain the vulnerability function. (see Figure 6). For the detailed file format structure please refer to the CAPRA-GIS manual (ERN-AL 2011).

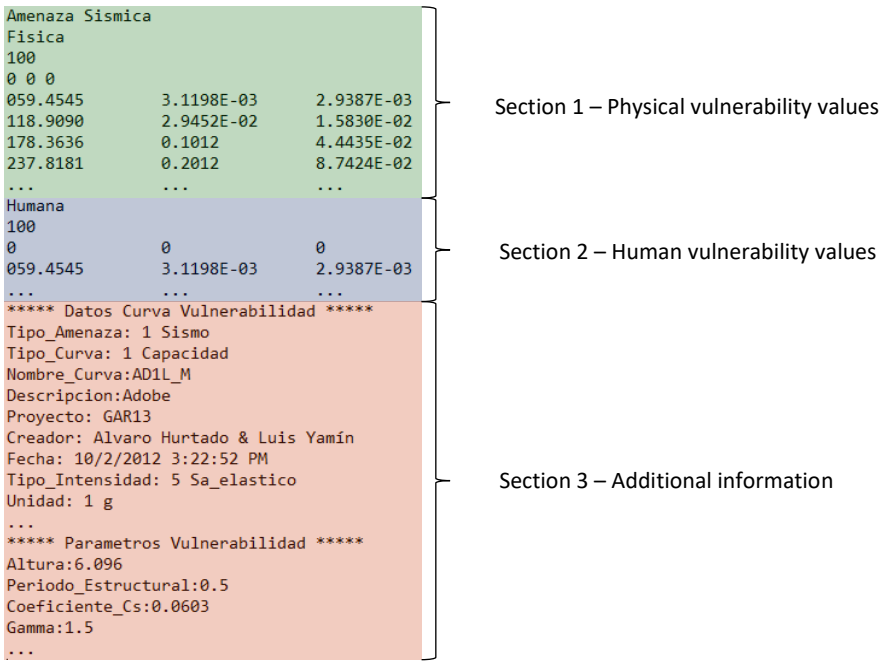


*Figure 6 Typical structure of input/output *.fvu files*

For the files that are saved using the software this section is divided in three subsections. The first one contains the basic parameters. The second and last one contains the value of the parameters for the physical and human vulnerability respectively.

4.1.2. *txt file format

This file contains information with the values for the three main parameters that defines the physical and human vulnerability function. The first record contains the number of records of the dataset that defines the vulnerability function. The next records contain the values for the three main parameters. Each record has five double number Tab-separated values. The first one corresponds to the hazard intensity value. The second one corresponds to the expected value of the MDR for physical damage. The third one corresponds to the variance value of the MDR for the physical

damage. The fourth one corresponds to the expected value of the MDR for human damage. The fifth one corresponds to the variance value of the MDR for the human damage. The additional information in the file. (see Figure 7).

1st record	60				
2nd record	0	0	0	0	0
3rd record	0.2	0.1	0.01	0.2	0
4th record	0.3	0.2	0.015	0.4	0.15
	0.4	0.3	0.02	0.6	0.3
	0.5	0.4	0.01	0.8	0.15
…	0.6	0.5	0.008	0.9	0.05
	0.7	0.6	0	1	0
nth record	...	...	...	...	...

*Figure 7 Typical Structure for input *.txt file*

Chapter 5

Visualization output files

5.1. Output files and file format

This software allows to the user to save the new vulnerability function into a file. The output file has the *.fvu file format. Please refer to section 4.1.1 for further information. This file can be displayed using the CAPRA-GIS software. It also can be read using any text editor program.

```
Wind Hazard
Physical
49
0       0       0
0.05    0.0004010464    0.0004008855
0.1     0.003203871     0.003193606
...     ...             ...
1.25    0.9506319       0.04693088
1.3     0.9613783       0.03713009
...     ...             ...
2.4     1               0
Human
49
0       0       0
0.05    0.01906991      0.01870625
0.1     0.07412528      0.06863073
...     ...             ...
0.5     0.8541839       0.1245538
0.55    0.9026794       0.08784931
...     ...             ...
2.4     1               0
****Vulnerability Global Metadata****
FVU Name:TEST2
Description:125
Project:12
Author/s:AIH
Date (MM/DD/YYYY):12/11/2017
Hazard Type:WIND
Hazard Intensity:WIND VELOCITY
Hazard Unit:KPH
Height:3M
Number of stories:1
Structural period (sec):0.6
****Vulnerability Physical Metadata****
Physical-Intensity at which damage begins:0
Physical-Intensity for complete damage:2
Physical-Known Mean Damage Ratio:50
Physical-Intensity for the known mean damage ratio:0.6
Physical-Curvature before x|E(x):3
Physical-Curvature after x|E(x):2
Physical-Maximum Mean Damage Ratio:100
Physical-Maximum variance:25
Physical-Mean Damage Ratio at maximum variance:50
Physical-Shape factor for variance:2
Physical-Intensity step:0.05
****Vulnerability Human Metadata****
Human-Intensity at which damage begins:0
Human-Intensity for complete damage:1
Human-Known Mean Damage Ratio:50
Human-Intensity for the known mean damage ratio:0.3
Human-Curvature before x|E(x):2
Human-Curvature after x|E(x):2
Human-Maximum Mean Damage Ratio:100
Human-Maximum variance:25
Human-Mean Damage Ratio at maximum variance:50
Human-Shape factor for variance:2
Human-Intensity step:0.05
```

Figure 8 Output file example

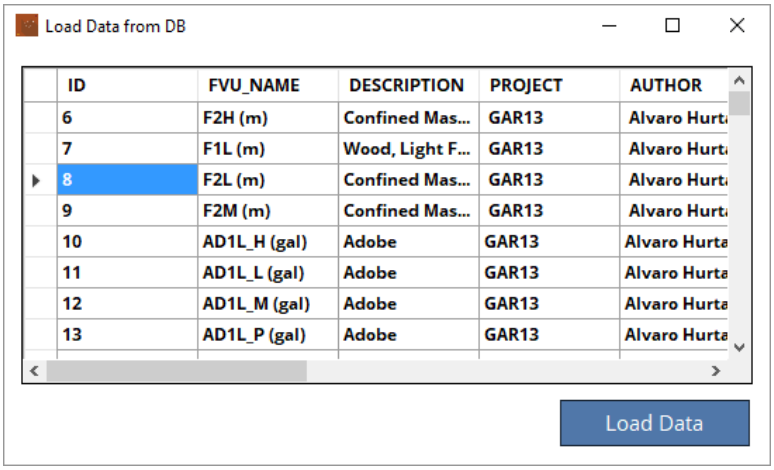
Chapter 6

Step-by-step tutorial

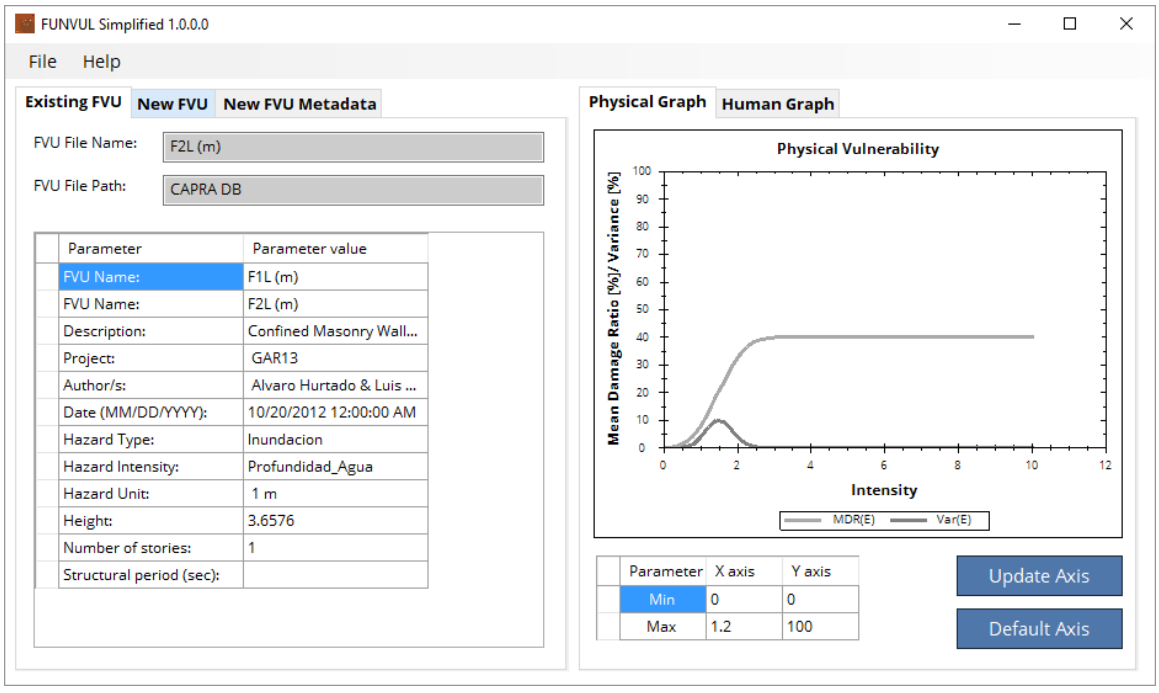
6.1. Tutorial 1: Load data from CAPRA-DB

This tutorial shows you how to load data from the include CAPRA-DB. The step you must follows are the followings:

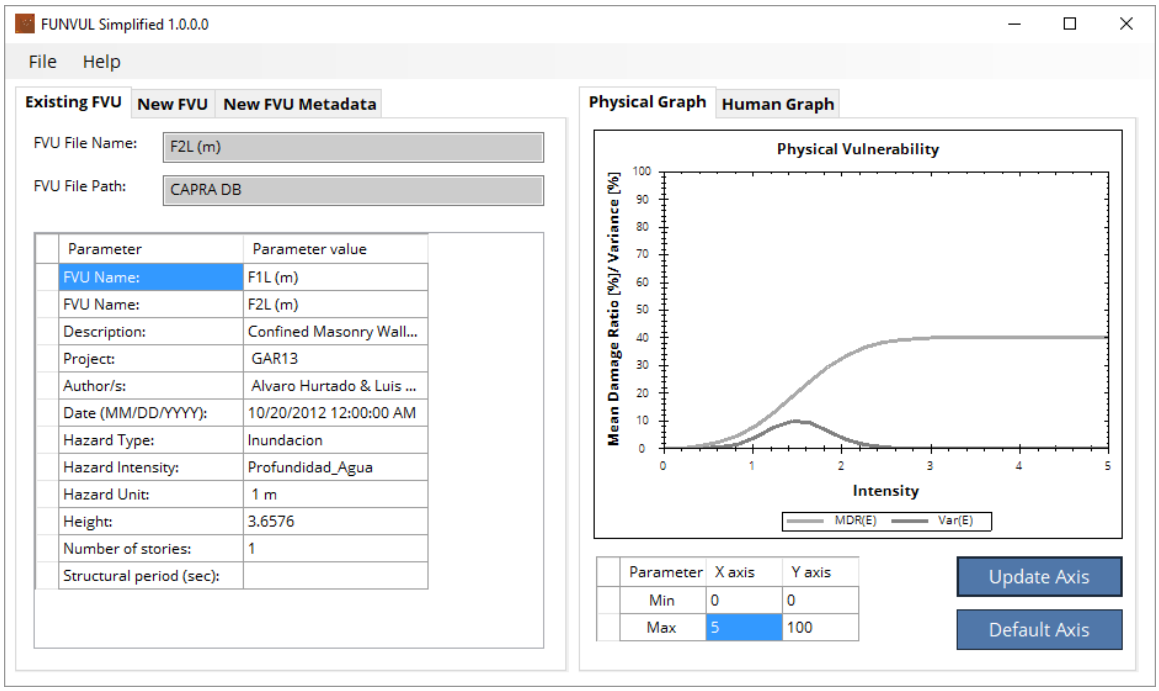
1. Open the **FUNVUL Simplified** software. Wait until the program is loaded completely.
2. Go to **File/Load Data/From CAPRA DB** and click on. It will appear a new window (see figure below). Then select the **F2L(m)** FVU from the list. You can see the additional information in this table.



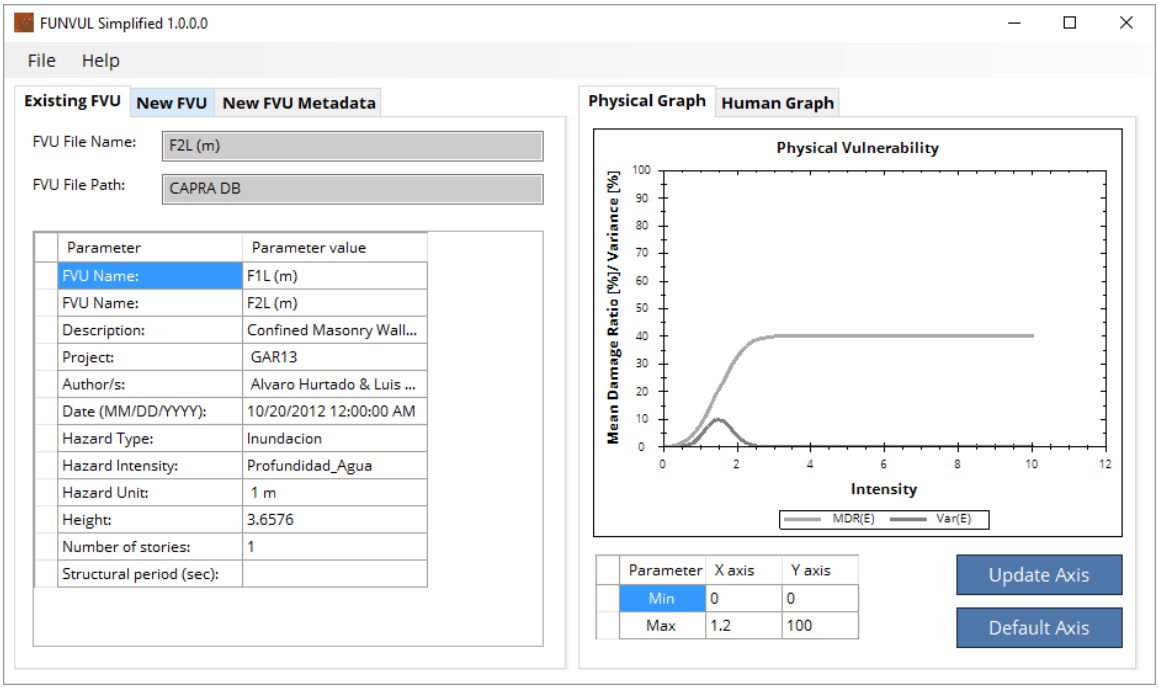
3. Once you have selected your vulnerability function from the list, then click on the **Load Data** button.
4. Review that all information has loaded correctly in the **Existing FVU Tab**. The selected existing vulnerability function will be plot automatically and its appear in the **Physical Graph Tab** and **Human Graph Pane**. (See the figure below).



5. To adjust the axis limits, now go to the **Axis Limit Table** on the **Physical Graph Tab**. Input value of 5.0 for the Max in the X axis. Then click on the Update Axis button (see figure below).



6. To restore axis limits to its default, click on the **Default Axis** button. The physical curve returns to its original axis limits (see figure below).

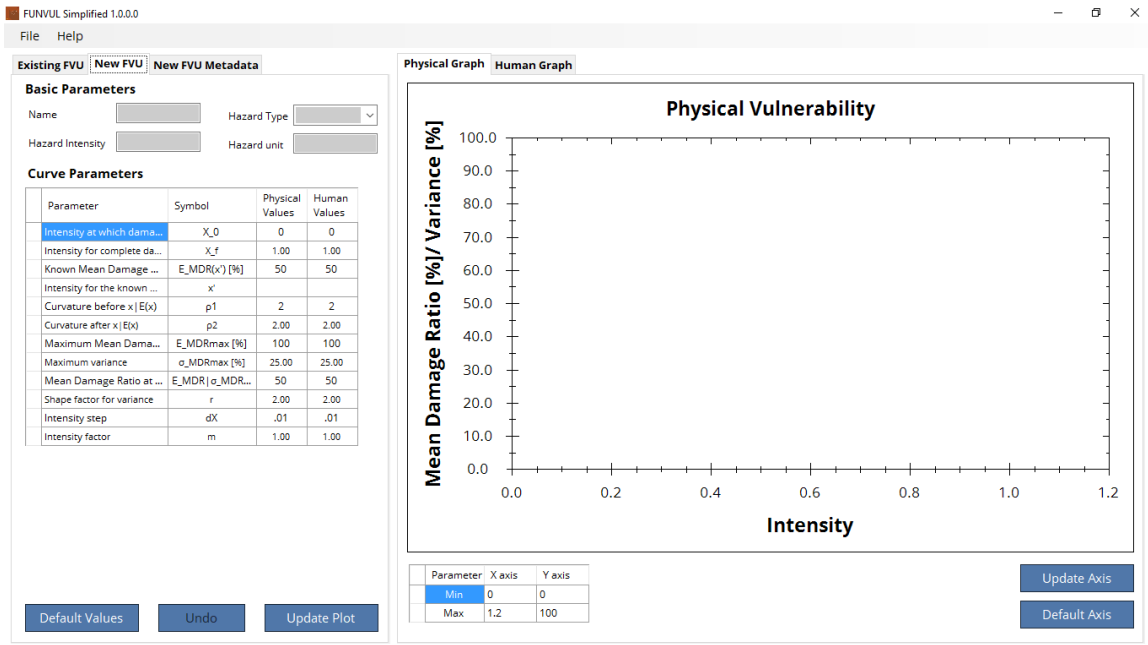


7. Close the program.

6.2. Tutorial 2: Create new vulnerability function

This tutorial shows you how to create a new vulnerability function, compare with an existing vulnerability function and saved to a *.fvu file. The step you must follows are the followings:

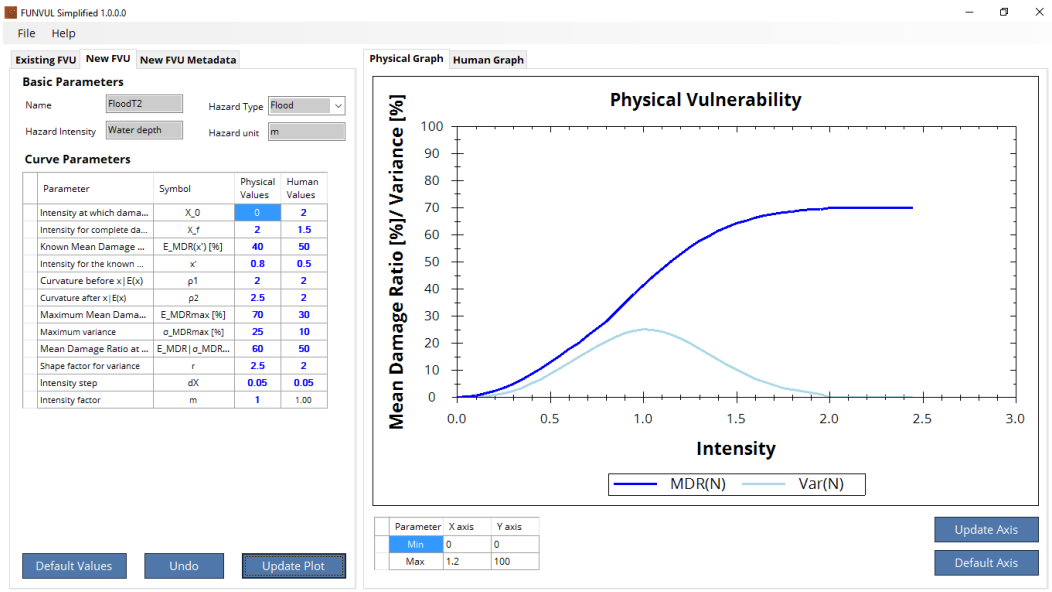
1. Open the **FUNVUL Simplified** software. Wait until the program is loaded completely.
2. Go and click on the **New FVU Tab.**



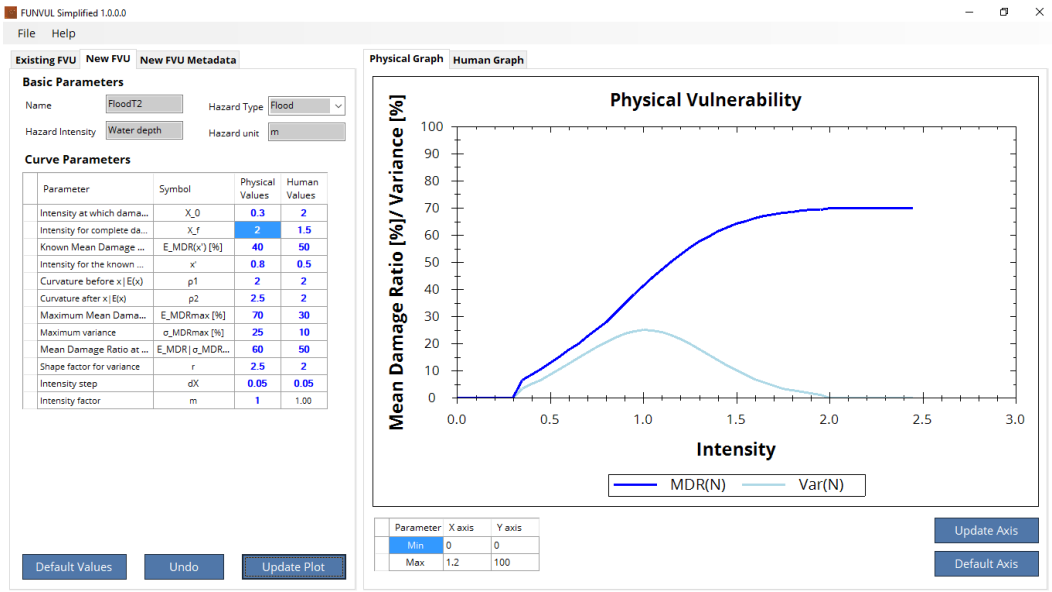
3. Fill-out the Basic parameters with the followings values:
   Name: **FloodT2**
   Hazard Type: Choose the **Flood** item from the drop-down list.
   Hazard Intensity: **Water depth**
   Hazard Unit: **m**
4. Fill-out the curve parameters with the following values:

Symbol	Physical	Human
X_0	0	0.2
X_f	2	1.5
E_MDR(x') [%]	40	50
x'	0.8	0.5
ρ1	2	2
ρ2	2.5	2
E_MDRmax [%]	70	30
σ_MDRmax [%]	25	10
E_MDR|σ_MDRmax [%]	60	50
r	2.5	2
dX	0.05	0.05
m	1	1

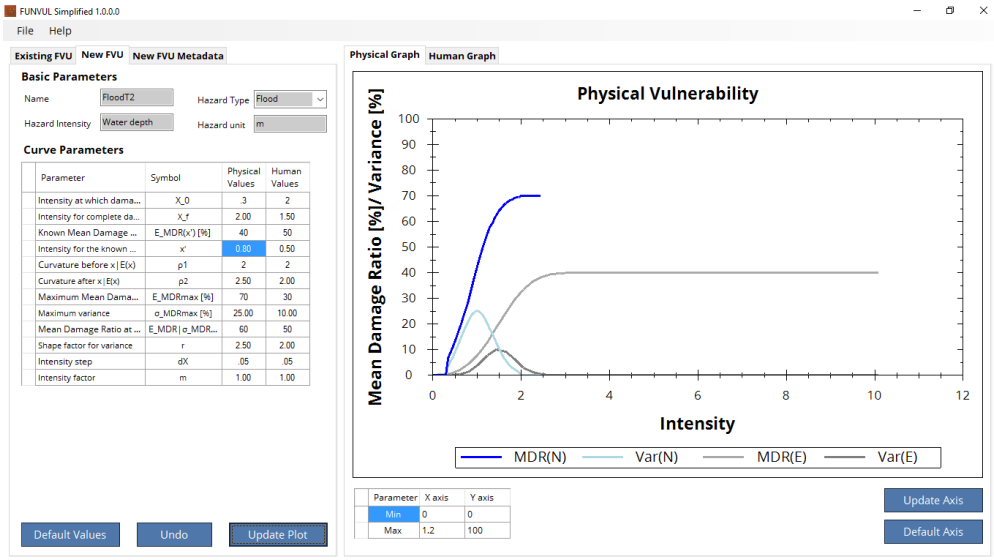
5. Click on the Update Plot button. The new vulnerability function will appear in the **Physical Graph Tab** and **Human Graph Pane** (see the figure below). When you change or input a new parameter in the Curve Parameter it turns blue and bold.



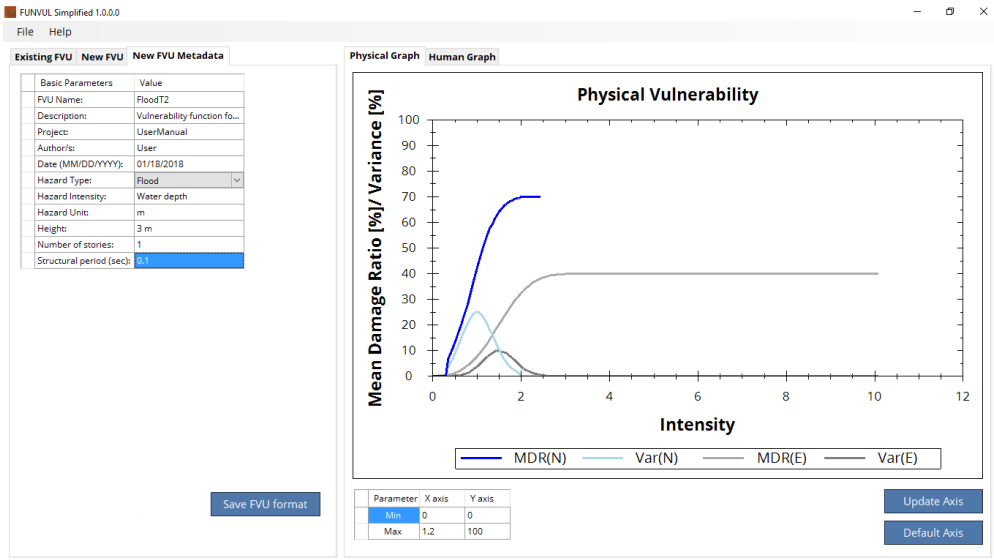
6. Now modify the input value of the X_0 parameter to 0.3, then click on Plot New FVU button (see the figure below). You can understand the function of the X_0 parameter.



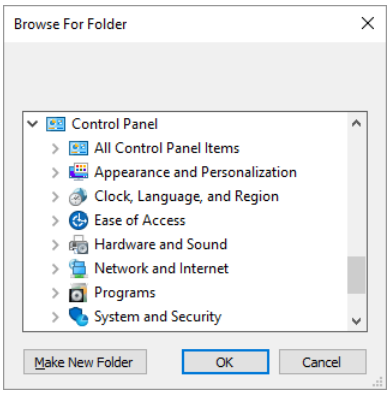
7. Comparison with existing vulnerability function. Repeat steps 2 to 4 from the previous Tutorial 1. At the end you will get the following:



8. Finally save your vulnerability function to *.fvu file format. Then go to the **New FVU Metadata Tab.**
9. Fill-out the parameters with the following input values:
   FVU Name: **FloodT2**
   Description: **Vulnerability function for the tutorial 2**
   Project: **UserManual**
   Author/s: **User**
   Date (MM/DD/YYYY): **01/18/2018**
   Hazard Type: **Flood**
   Hazard Intensity: **Water depth**
   Hazard Unit: **m**
   Height: **3 m**
   Number of stories: **1**
   Structural period (sec): **0.1**



10. Then click on the **Save Fvu format button**, a new browser folder window will appear (see figure below).



11. Select the folder where you want to save the *.fvu file, and then click on the **OK** button. The file will be created and saved on the selected directory. You will get an information message with the complete path where the file was saved. The name of the output file is the same that you specify in the FVU Name parameter in the **New FVU Metadata Tab**.
12. Then close the program.

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 CAPRA-DB does not exist	This error occurs when the CAPRA-DB is moved or deleted from the application folder.	You must uninstall the software and reinstall again.
Your computer does not have installed Microsoft Office Access	Your computer does not have installed Microsoft Office Access, please install the Microsoft Access Database Engine.	See instructions in section 2.1.2.
You must load a valid file	This occur when you do not specify a valid file format.	See valid input files in Chapter 4**Error! Reference source not found.**
Invalid format *.fvu file	This occur when the *.fvu file is damage or does not comply with the structure required by the software.	See structure required for *.fvu files in Chapter 4**Error! Reference source not found.**
Invalid format *.txt file	This occur when the *.fvu file is damage or does not comply with the structure required by the software.	See structure required for *.txt files in Chapter 4
Error reading CAPRA-DB	This error occurs when the CAPRA-DB is corrupted or has been modified from external source.	You must uninstall the software and reinstall again.
Complete all parameters	This error occurs when you do not fill the complete input values for the curve parameters in the **New FVU Tab** and the parameters in the **New FVU Metadata Tab.**	Review the input values are complete in the **New FVU Tab** and **New FVU Metadata Tab.**
You must define a valid range	This error occurs when you enter invalid input values for the **Axis limits table.**	Review the input values entered in the **Axis limits table** are ok.
You must define correct parameters	This error occurs when you enter invalid input values for the curve parameters table in the **New FVU Tab.**	Review that the input values are agree with the specified in section 3.3.
Please fill out the complete information	This error occurs when you do not fill the complete input values for the curve parameters in the **New FVU Tab** and the parameters in the **New FVU Metadata Tab.**	Review the input values are complete in the **New FVU Tab** and **New FVU Metadata Tab.**

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

Chapter 8

References

Council, Applied Technology. 1985. ATC - 13 Earthquake Damage Evaluation Data for California. Redwood City, CA.

ERN-AL. 2011. Metodología de Modelación Probabilista de Riesgos Naturales. Informe Técnico ERN-CAPRA-T1-1. Consorcio Evaluación de Riesgos Naturales - América Latina.

Yamin, Luis E., Alvaro I. Hurtado, Alex H. Barbat, and Omar D. Cardona. 2014. "Seismic and wind vulnerability assessment for the GAR-13 global risk assessment." *International Journal of Disaster Risk Reduction* 10 (Part B):452-460.