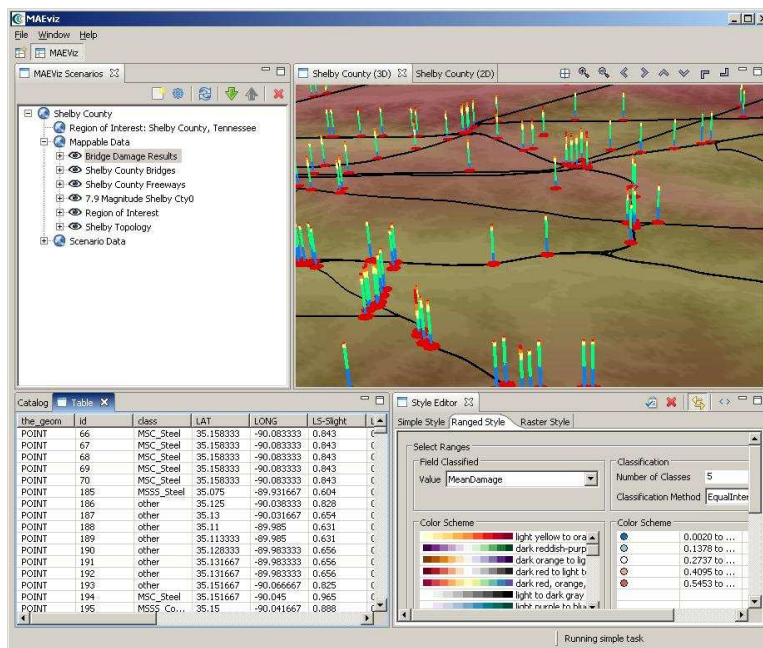**MAEviz Introduction & Tutorial**
Mid America Earthquake Center
University of Illinois at Urbana-Champaign
May 2007

# Earthquake Risk Assessment
## Using MAEviz 2.1:
## A Tutorial for the MAE-Center
## Year 10 Annual Meeting



## Zeytinburnu District Buildings

**Mid-America Earthquake Center**

## *Executive Summary*

The following pages will give you an introduction on MAEviz. First, a description of the layout of the program which will help you get familiar with the work environment before you start using MAEviz. Then, a tutorial where you'll be able to run an earthquake risk assessment analysis. The purpose of this tutorial is to help you feel comfortable using the program and to also give you a clear idea of what MAEviz can do. The last part covers a user's guide where you can find a more extensive explanation of MAEviz capabilities that were not covered on the tutorial.

**Exercise Overview**
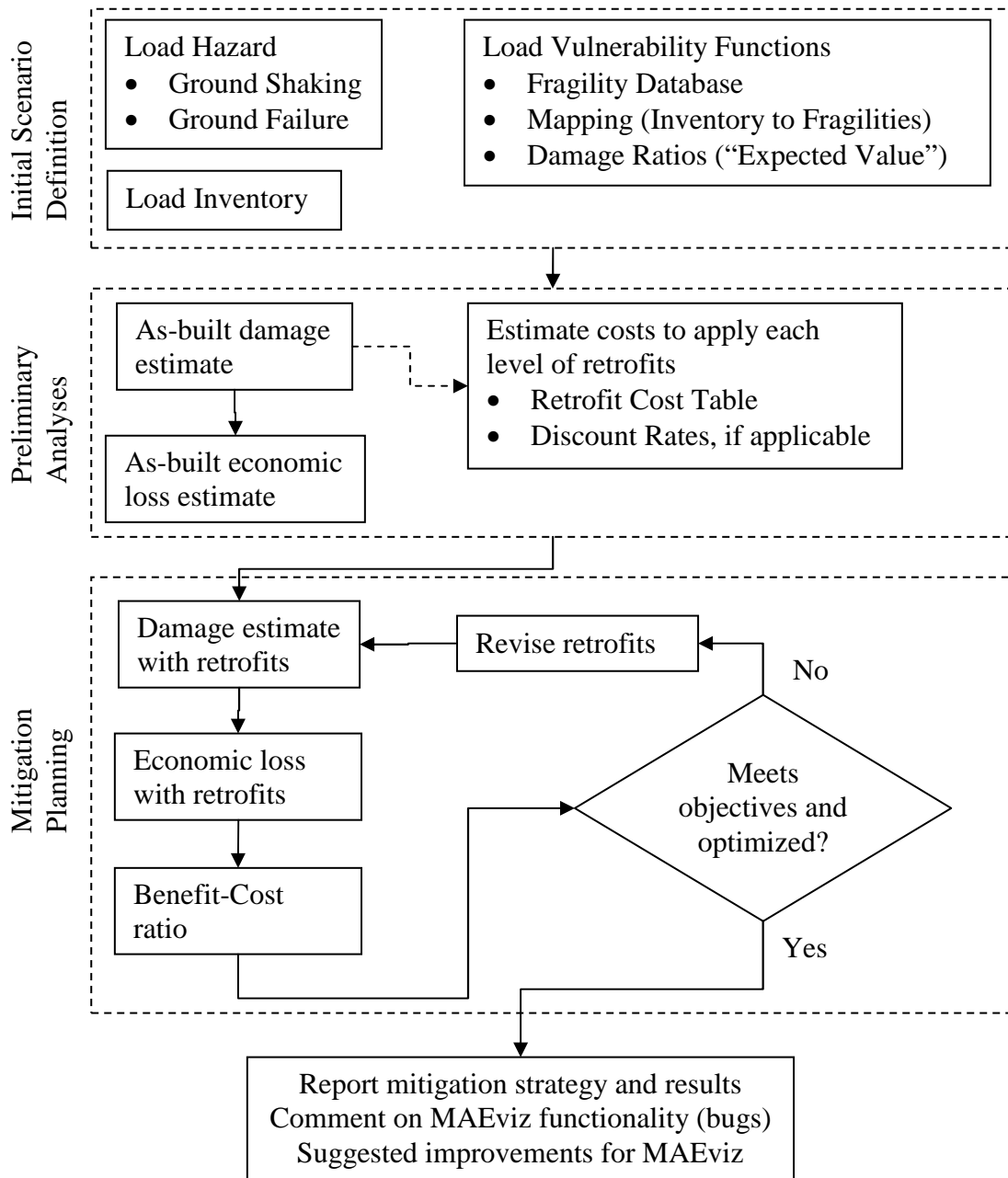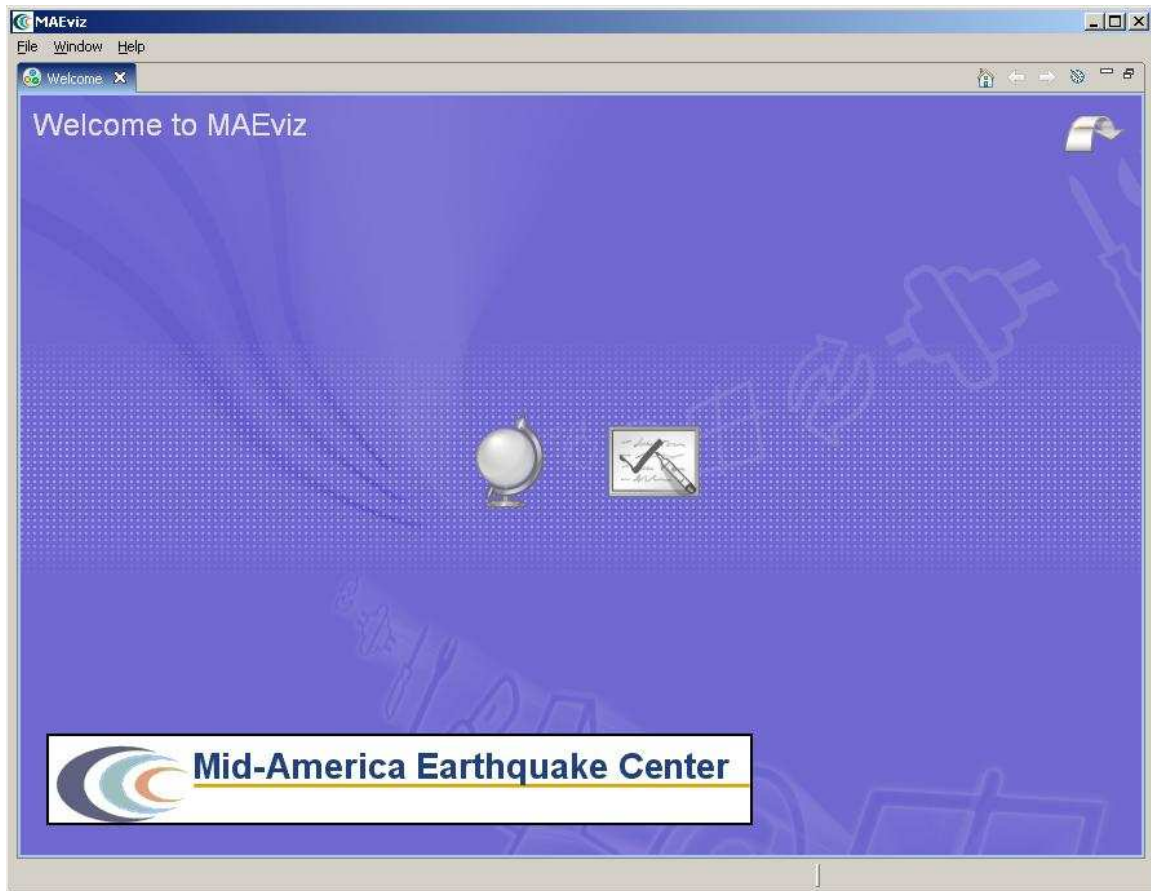
# 1. MAEviz Overview

## *Welcome*



**Figure 1**

When MAEviz is first launched, the welcome screen appears. From the welcome screen, users can select to read an overview of information about MAEviz, follow built-in tutorials, or just begin working in MAEviz (by selecting *Workbench* which will take you to the main MAEviz screen, also known as the *Workbench*).

## 1.1 Workbench Layout

The MAEviz workbench consists of a number of *Views* which each contain information about a specific part of MAEviz. Each view is like a sub-window within the MAEviz workbench window, and can be minimized, maximized, moved, or even torn away from the main window into its own window. These interactions are done by clicking the minimize and maximize view icons in the view's title bar, or by clicking and dragging on the view's border or title bar.

Figure 3 shows some of the most commonly used views in MAEviz.
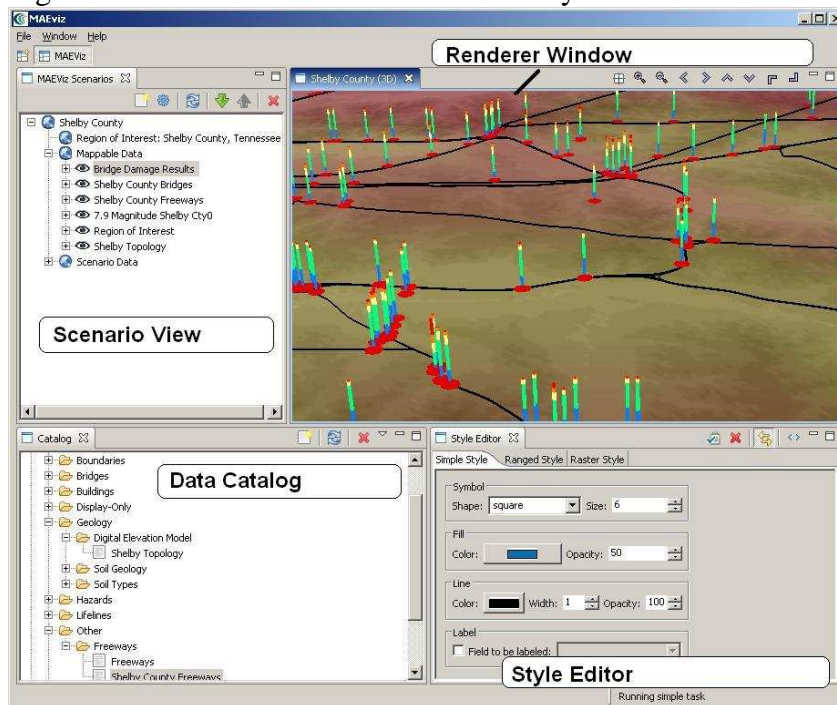


**Figure 3**

### *Scenario View*

The Scenario View is where you find a list of all the data for the scenario or scenarios that you are currently working with. Each scenario that you are working with is listed as a top-level item in this view, which can be expanded by clicking the plus (+) icon next to its name, to see the details of the scenario. Inside each scenario, you can see a list of the Mappable scenario data, which are the layers of data that appear in your rendered map, as well as a list of Scenario Data, which includes all data for the scenario, whether it is renderable or not.

The Scenario View is also where you would go to do the major operations on your scenarios: adding an earthquake hazard or other data, running damage analyses, etc.

### Visualization View

The Visualization Window Views are where the rendered maps of your scenario will appear. Each scenario can have its own rendered 2d and 3d map, so you can see the visualization of your scenario. It is here that you can get a quick visual overview of the results of your analyses. You can control the camera position by using the mouse, or click the view control buttons in the toolbar.

### Data Catalog View

The Catalog is a list of all the data that is available for you to use in your scenarios. It is organized first by *repositories*, which are stores of MAEviz data. Repositories can represent local data, or data stored on a remote server. Within each repository, the data is organized by the type of data that it is. To add data to a scenario, you can navigate to and find the data within this view, then drag it into either the Visualization View for your scenario, or onto the scenario's name in the Scenario View.

### Style Editor View

The Style Editor is used to adjust the way in which a layer of data is displayed in the Visualization View. If the Style Editor is not visible, you can show it by right clicking a Mappable Data layer in the Scenario View, and selecting *Change Layer Style*. Once this view is showing, you can adjust the color, shape, opacity, etc of the map layer. To apply your style changes, you must click the *Apply* button () in the view's toolbar.

## 1.2 Other Views

Although these are some of the main views you will use, there are a few other views that are shown at various times while using MAEviz.

### Table View

The Table View is used to display tabular data, generally the attributes of a set of inventory data or analysis results. The most common way to see this view is by right-clicking a Mappable Data layer in the Scenarios View and selecting *Show Attribute Table*.

### Reports View

By right-clicking on a scenario name in the Scenarios View, and selecting *Reports*, you can access the Reports View. From the Reports View, you can select a report to run, right-click and run it. Then the selected report will be generated and displayed. From that point, you can choose to print or save the report.

### *Fragility View*

If you right-click a fragility dataset from the Catalog View, you can select *View Fragility* to access the Fragility View. The Fragility View shows a list of fragility types, that you can drill down into to select and view a particular fragility curve. When you have found the fragility curve that you want to view, right-click it and select *View Fragility Set* to view a graph of the fragility curve.
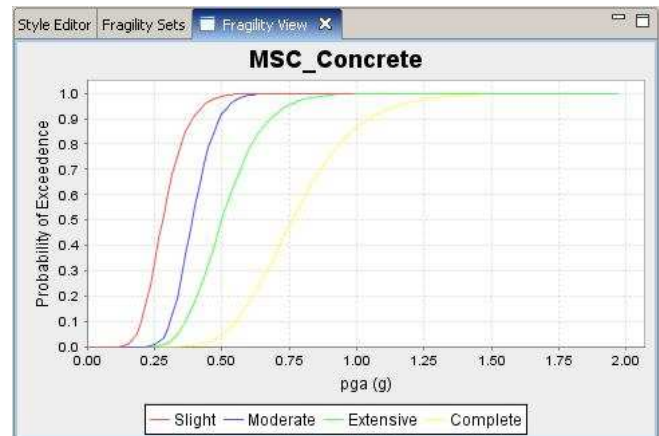


# 2. MAEviz Tutorial

The tutorial covers the typical steps that will be needed in order to perform an earthquake risk assessment. Here are the steps:

- Create a New Scenario
- View the Scenario and Add Data
- Running an Analysis
- Analyzing the Results

### *Example Scenario*

In this demonstration, we will use MAEviz as a specific stakeholder would use the tool. Consider the stakeholder to be an Emergency Manager with a problem. Zeytinburnu Municipality of city of Istanbul has contracted your group to undertake a seismic risk assessment of the buildings in Zeytinburnu District, Istanbul, Turkey. You are to execute an analysis for the approximately 17000 buildings in the district using MAE-Center building fragility curves and MAE-Center building fragility mapping for Turkish building inventory. The most probable hazard for the region is a 7.5 Mw earthquake to the south of the City on a branch of the North Anatolian Fault. You have at your disposal fragilities which have been developed for various levels of seismic resistance, indicated by code levels ranging from Pre-Code to High Code, which reflect levels of intervention.

In the process, we will see how the Emergency Manager will launch the MAEviz application, load the GIS data for Zeytinburnu District, and then generate earthquake hazard information based on the scenario he wants to investigate. After he has loaded this base information, he can interactively choose and display information for the specific items he wants to evaluate – the buildings, as well as load fragility information about these particular structures. From there, we will witness an analysis of the impact of the hazard. These factors have important social and economic impacts.

## 2.1 Creating a New Scenario

- When you start MAEviz for the first time, you will be shown the welcome screen (Figure 2). To begin working with MAEviz, click the rightmost icon ( ) which will take you directly to the MAEviz workbench.
- From the application's menu bar, click File->New, then expand MAEviz and choose MAEviz Scenario (See figure 4). Alternatively, you can click the New Scenario button ( ) from the Scenario View's tool bar.
- The New Scenario Wizard will now be showing. This is where you define the scenario that you would like to work with. Enter a name for your scenario, such as "Zeytinburnu District", and then optionally enter any descriptive information about the scenario in the large text box. Click next.
- At this point, you will be selecting the region of interest that you would like to work with. We will be analyzing a region which is in Turkey. That is why; select Turkey from the Country menu, and Istanbul from the City menu and Zeytinburnu District from the District menu that appear in Figure 5 below. Then, click finish when completed.
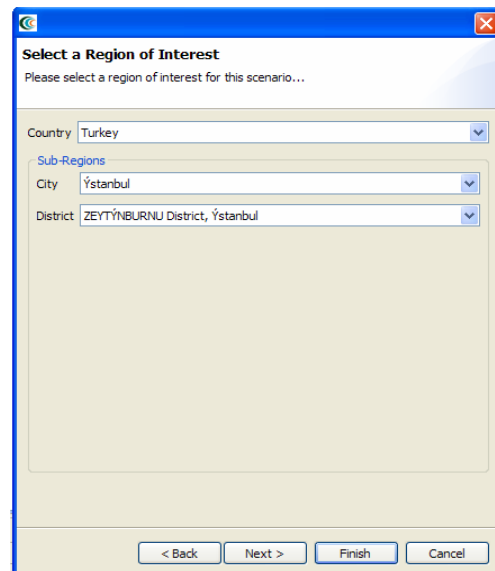


Figure 4



Figure 5

- The next screen of the wizard allows you to select an analysis to run immediately. If we wanted to run an analysis first, we could continue with this screen. But for this tutorial, we will add some other data to our scenario first, then come back and run an analysis later. So at this point, just select *Finish* to complete the wizard and have MAEviz initialize your new scenario.

8

## 2.2 Viewing the Scenario and Adding Data

At this point, your scenario has been created. You will see your scenario listed in the Scenario View. A blank outline of Zeytinburnu District has appeared in the Visualization View. See Figure 6. (The outline may not be visible without connectivity to NCSA)
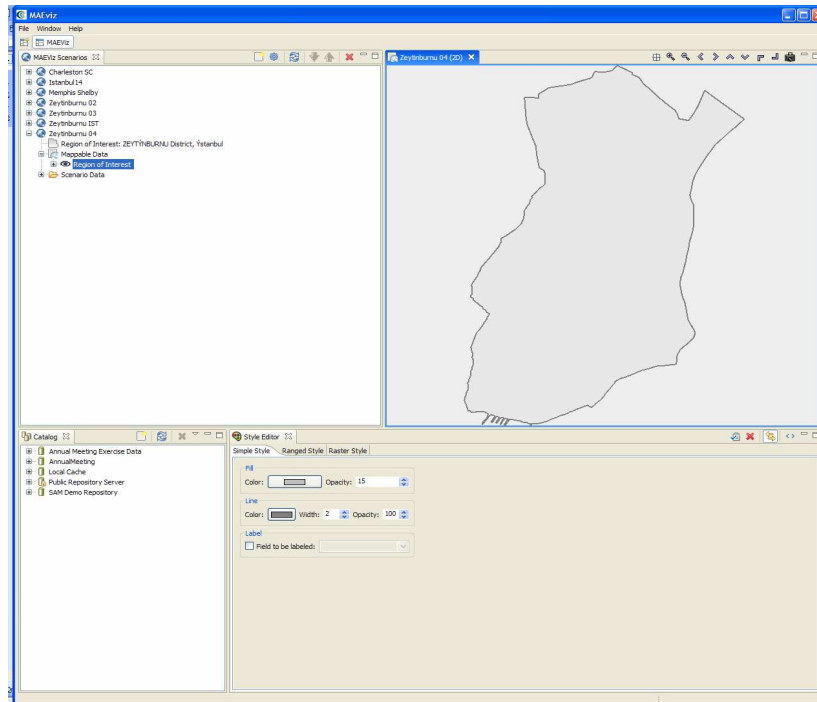


**Figure 6**

At this point, we will learn how to add data to our scenario, and how to manipulate the Visualization View.

- First, we will add boundary data to the scenario. In the Catalog view (the lower-left view if your workbench is arranged in the default setting, as shown in Figure 6), expand the *MAEviz Demo Data* item, then *Boundaries, District Polygon.* Click and drag the *Mahalle Boundary* item into the Visualization View.
- Then, we will add building inventory to the scenario for the Zeytinburnu District. In the Catalog view (the lower-left view if your workbench is arranged in the default setting, as shown in Figure 7), expand the *MAEviz Demo Data* item, then *Buildings, Building Inventory v4* Click and drag the *Istanbul Building Data* item into the Visualization View. Alternatively, you can right-click the item and select *Load Dataset*.
- At this point, a boundary and buildings of Zeytinburnu District of Istanbul should have been added to the Visualization View.
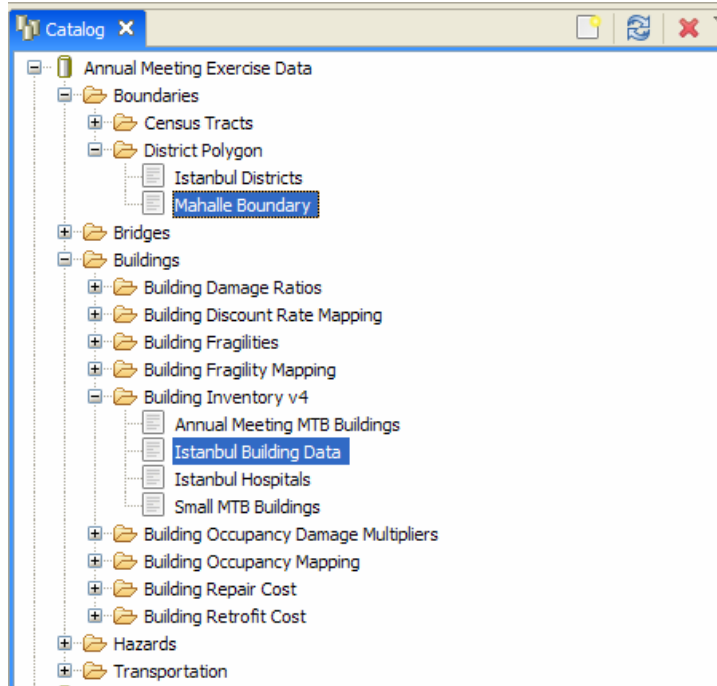
9

**Figure 7**

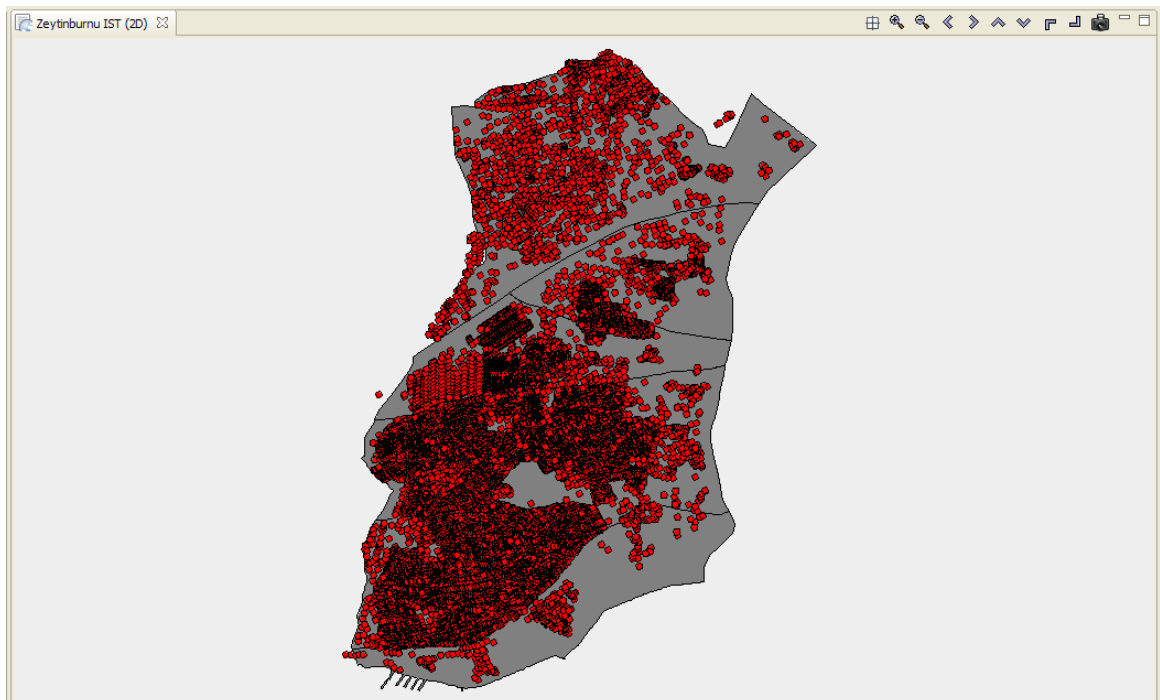- At this point, your Visualization View should look something like Figure 8.



**Figure 8**

- To make the view easier to see, we will adjust *Mahalle Boundary* map style. From the Scenario View, expand Zeytinburnu, then Mappable Data. You should see the list of the data that you added to the Scenario. Right click on *Mahalle Boundary*, and choose *Change layer style*.

- In the Style Editor (Figure 9), the Simple Style tab should be active. Set the *Opacity* level near the grey box named *Fill*, to 30 to see the datasets under this dataset. To apply the style change, click the *Apply Style* button in the Style Editor's tab bar. ( ⊞ )
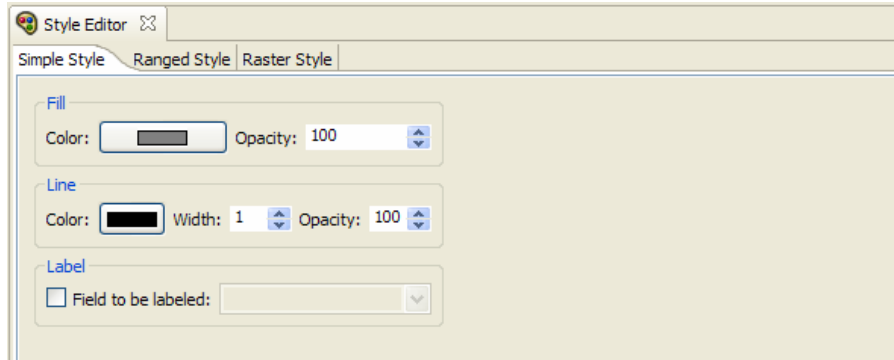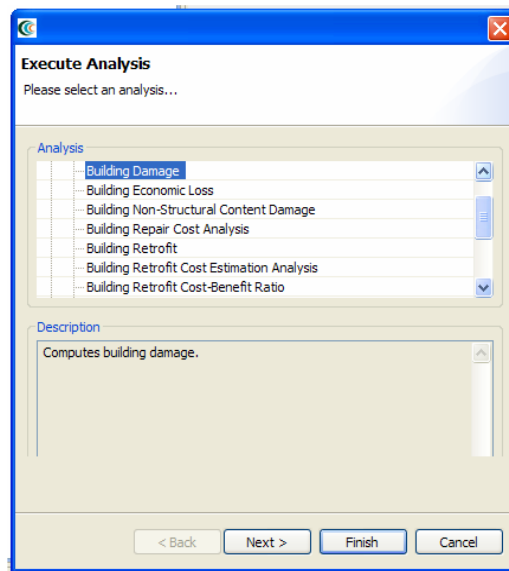


**Figure 9**

- To zoom/pan/etc, use the controls at the top of the Visualization View. Use these to adjust your view.
- To view a 3d rendered view of the same information, right click the entry for your Scenario, and choose *Render in 3d (VTK)*. This will bring up a second Visualization View that shows the same map, but from a 3d rendered perspective.
- After adjusting your view, if you want to restore to the original default view in the Visualization, click the *Zoom to full extent* button in the toolbar ( ⊞ )

## 2.3 Running an Analysis

Now that we have a basic map to look at, we will learn how to run an analysis. Analyses in MAEviz consist of any sort of calculation that generates data. For example, generating a deterministic earthquake map based on a magnitude and epicenter would be considered one type of analysis. The other type that we will use in this exercise is to load pre-generated hazard maps. Using that earthquake map as well as building inventory data to generate information about building damage would be another type of analysis.

In this example, we want to find building damage results based on a deterministic earthquake hazard that was pre-generated.

- First, we will launch the Run Analysis Wizard. To do so, you can click the Execute Analysis toolbar button ( ⚙ ), or right click your scenario and select *Execute Analysis* or click on Analysis from the top level menu and select *Execute Analysis*.
- This causes the Run Analysis Wizard to be shown. See Figure 10. Here you can select which analysis you want to run. (this is the same as the page that was displayed in the last step of the New Scenario Wizard). From this page, expand Buildings, and select the Building Damage analysis. Click *next*.

11

**Figure 10**

- The next page (Figure 11) prompts you to select the data you want to use in running your Building Damage analysis. If it tells you that no datasets containing Fragilities, Expected Value or Fragility Mapping have yet been loaded in your scenario, then to run this analysis, you must load those datasets that contain these data.

- To help you locate or generate the necessary input data, the Analysis Wizard provides two types of buttons, the *Find Dataset* button (🔎), and the *Generate Dataset from Analysis* button (⚙)



**Figure 11**

- To find a Fragilities dataset to run your building damage with, click the *Find Dataset* button ($\mathscr{P}$). The window that appears contains a list box of all Fragilities Datasets that could be found in any of the data repositories that you are connected to. Select *Default Building Fragilities* from the list like in Figure 12, and click Finish. To find an Expected Value dataset follow the same steps for the related field and select *Building Damage Ratios* from the list, and click Finish. Follow the same steps for the Fragility Mapping dataset but select *Istanbul Building Fragility Mapping* from the list.
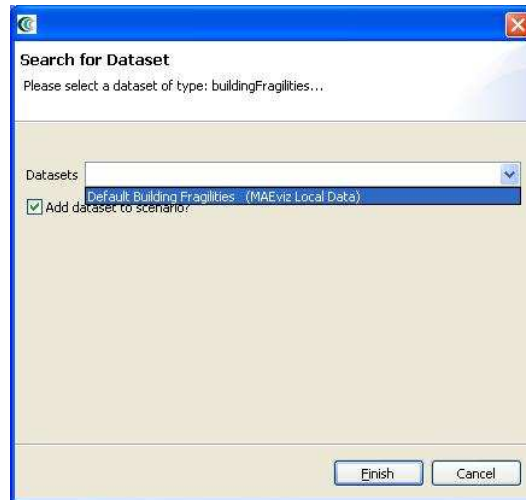


**Figure 12**

- For our hazard, we want to use a pregenerated hazard earthquake. So this time, use the *Add* button, to add pregenerated hazard earthquake and select the *Istanbul 7.5M 0.2 sec SA* dataset like in Figure 13, and then click *Finish* to run the building damage analysis.
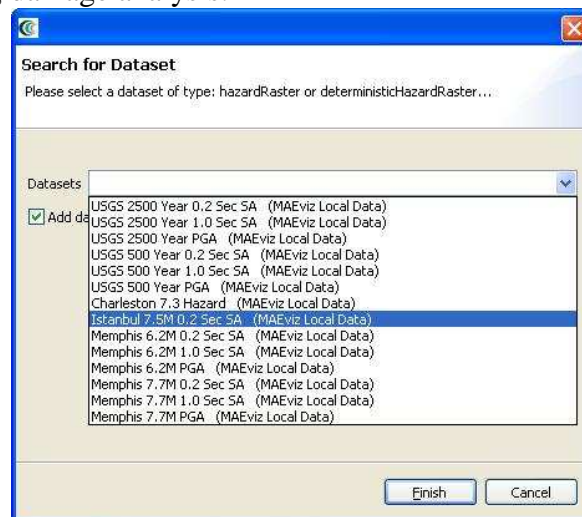


**Figure 13**

- Once the progress bar has finished, you should see new datasets added to your Scenario View and map: The Building Inventory v4 dataset that you selected to use, a Building Damages dataset which will contain the damage information,

and the earthquake hazard dataset. Your Visualization should now look similar to Figure 14.
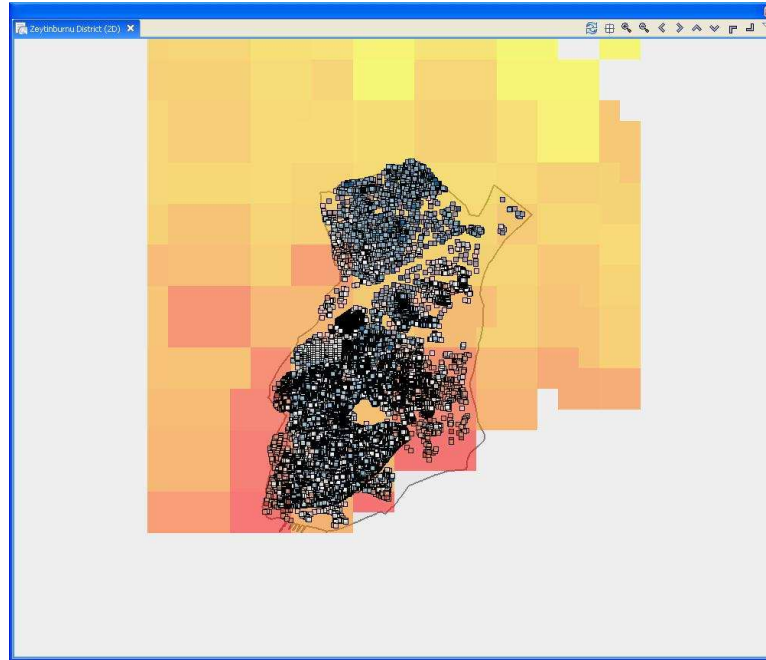


**Figure 14**

- To create a Building Economic Loss dataset, click the Execute Analysis toolbar button (⚙), or right click your scenario and select *Execute Analysis* or click on Analysis from the top level menu and select *Execute Analysis*. Select the *Building Economic Loss* analysis from the Buildings category. You should see a window similar to the one in Figure 15. Use the *Find Dataset* buttons for the fields where No datasets are found, and click Finish again to create the Building Economic Loss. This will generate a Building Economic Loss dataset which will contain the economic losses for the buildings.



**Figure 15**

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- To execute the *Building Retrofit Cost Estimation Analysis*, click the Execute Analysis toolbar button ( ), or right click your scenario and select *Execute Analysis* or click on Analysis from the top level menu and select *Execute Analysis*. This analysis is required to execute the *Building Damage by Field* analysis. Make sure the values for each field match the selections in Figure 16. You will want to enter a descriptive name for the resulting dataset like "Zeytinburnu Building Retrofit Cost Estimation Analysis", and then click Finish.



**Figure 16**

- At this point, we have the estimation for the cost of retrofitting. Now, we will retrofit the buildings using the *Building Retrofit by Field* Analysis. To execute this analysis follow the same steps described above and select *Building Damage by Field* under the Buildings. Enter a descriptive name like "Zeytinburnu Building Damage by Field". The rest of the fields should match Figure 17, click next. The next window allows us to select fragilities for each structure type in the inventory. This can be changed, but we leave that as an exercise for the user. Make some selections and then click Finish.  See Figure 18.
- The resulting dataset of this analysis gives the retrofitted building damage after the earthquake. You can select the field as Essential Facility and choose the essential facility to retrofit or to see what the cost to retrofit to certain code levels is.
- You can select the *Building Retrofit Analysis* to retrofit the buildings one by one. But, this analysis will not be used in this tutorial.

15

Figure 17

**Figure 18**

- Now we can execute the *Building Repair Cost Analysis* both for non-retrofitted and retrofitted buildings individually. To run this analysis follow the same steps mentioned above and select *Building Repair Cost Analysis* as a replacement for the previous ones. For the first analysis of repair cost, we will use the pre-retrofitted building damage data for Zeytinburnu district for the Building Damage field. Like in Figure 19-a. This will give us the repair cost for the buildings which are not retrofitted. For the second analysis we will follow the exact same steps with the first one but select the *Building Damage by Field* dataset as the retrofitted building damage. From the drop down menu, select *Zeytinburnu Building Damage by Field*. See Figure 19-b.



**Figure 19-a**



**Figure 19-b**

- The last analysis for the Zeytinburnu Buildings is the *Building Retrofit Cost-Benefit Ratio* Analysis. This analysis requires both Pre- and Post-Retrofit Building Economic Losses. That is why we will execute the *Building Economic Loss* Analysis again for the retrofitted building damage created by the *Building Damage by Field* Analysis. This will be executed just like the previous one but we will select the result of the *Damage by Field* Analysis in the drop down menu.
- After creating the Building Economic Loss for the retrofitted buildings of Zeytinburnu District, we can execute the *Building Retrofit Cost-Benefit Ratio* Analysis for the region by right clicking your scenario and selecting *Execute Analysis*. Then, choosing the *Building Retrofit Cost-Benefit Ratio* Analysis under the Buildings. Enter a descriptive name for the result, such as Zeytinburnu Building Retrofit Cost-Benefit Ratio and select the post retrofit economic loss dataset for the Building Post-Retrofit Economic Loss/Repair Cost field like in Figure 20 by selecting the Post-R dataset from the drop down menu. Click next.



**Figure 20**

- In this window, you will see an option to select All or None, press the "None" button. Now, scroll down and find the TotLoss field and select it. Your window should look like Figure 21. Click finish.
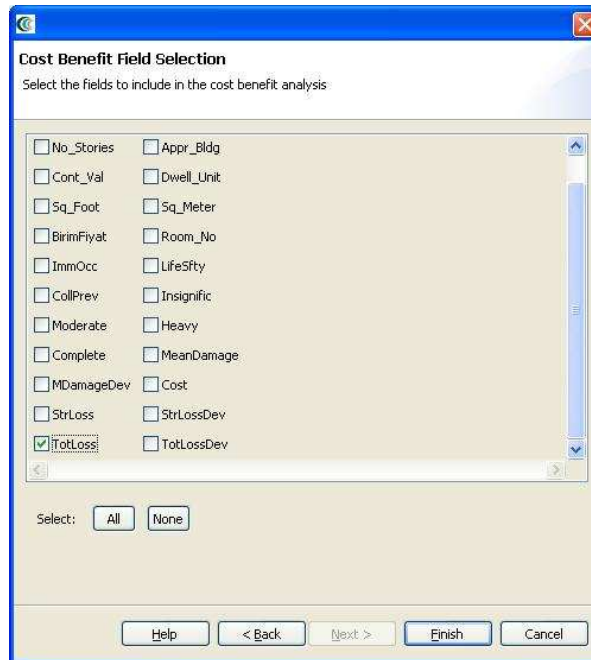
Figure 21

## 2.4 Analyzing Results

Now that the analysis that we were interested in has been completed, it's time to analyze and try to make sense of the results. There are various ways of viewing and visualizing the results, which we will learn now.

### 2.4.1. Table View Results

- First, we will view the results in a tabular grid, similar to excel. In the Scenario View, right click on the *Pre-Retrofit Building Damage* layer, and select *Show Attribute Table*. The Table View should appear in the bottom right of the application window. Like other windows, you can move or resize it to make it easier to view.

- Now we will use the Table View to locate the buildings that suffered the most damage. Scroll to the right edge of the table view, and click the column header labeled *MeanDamage*, which is the column for the mean damage value for the building. This will sort ascending the table by the mean damage value.

- Now that we can see which buildings in the table have the highest mean value of damage, let's locate those buildings in our map of the area. Make sure the Building Damage layer is still selected in the Scenario View, and make sure you are viewing the 2D Visualization View.

- Then, in the Table View, click on the last row with mean damage Value of highest. You will see one of the dots representing a building in the Visualization View change color to show that this is the selected building.

- Hold shift and click the last row with desired mean damage value. This will select all the buildings in between. You will see these buildings all change color in the Visualization View. This way, you can see which buildings will suffer the most damage. See figure 22.
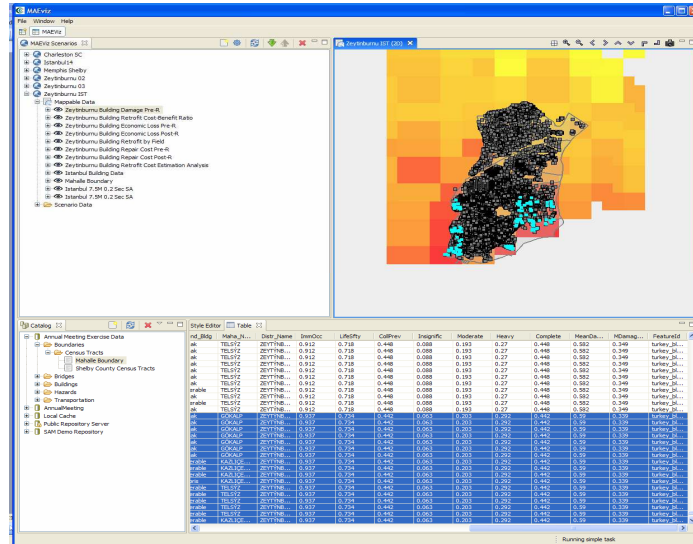


**Figure 22**

## 2.4.2. Aggregating Data

- MAEviz also provides the ability to aggregate data to a geographic boundary, such as the census-tract level.
- Now, we want to do an aggregation analysis. Use the Analysis button ( ) again to start the analysis wizard. This time, choose *GIS->Aggregate To Polygon*
- For the *Polygon* field, choose *Mahalle Boundary*. This indicates that you want to aggregate your damages to that dataset.
- For the *Dataset* field, choose your Pre-Retrofit Building Damage dataset. This is where you select which layer contains the data that you want to aggregate over the census tracts.
- Also, give the result a descriptive name, such as Building Damages in Sub-Districts like in Figure 23
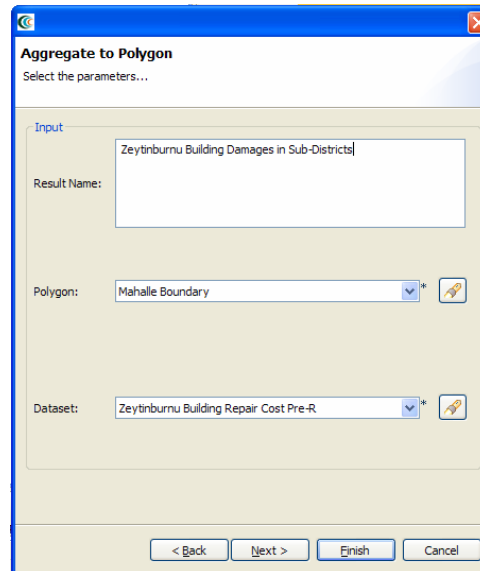
**Figure 23**

- Click *next*. You will arrive at a dialog page prompting you to choose which fields to aggregate by, and how to aggregate them (sum, max, average, etc). The defaults are fine, so click *finish*.
- When the analysis finishes, we need to change the style on the aggregation so that we can easily visualize the results.  Right click your new dataset from the Scenario View, and choose *Change Layer Style*
- In the style view, select the *Ranged Style* tab.
- Under the Value field, select *MeanDamage*. This indicates that we want to color the census tracts by the mean damage value for the buildings in that census tract.
- Under the color scheme box, select a color scheme that will be easy to see, such as light blue to dark purple.
- Change number of classes to 5, which will give us 5 different colors to shade by. Also change Classification Method to Quantile. Like in Figure 24.
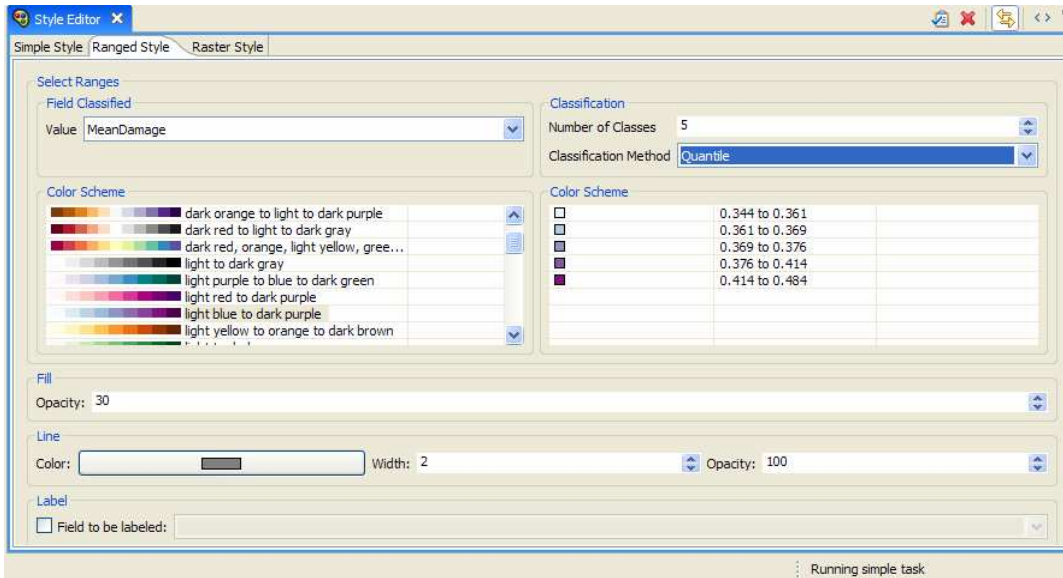
**Figure 24**

- Next, press the Apply Style button ( ![icon] ) to apply these style changes. The Visualization view will update to show the census tracts colored by the average damage value of the buildings within them.
- It will be easier to see the color difference if we change the order of the dataset to the highest at our visualization. Click your *Zeytinburnu Building Damages in Sub-Districts* dataset from the Scenario View, and click the ( ![icon] ) button until the selected dataset rise up to the highest or desired level. This will show the *Building Damages in Sub-Districts* dataset clearly in our visualization like in Figure 25.
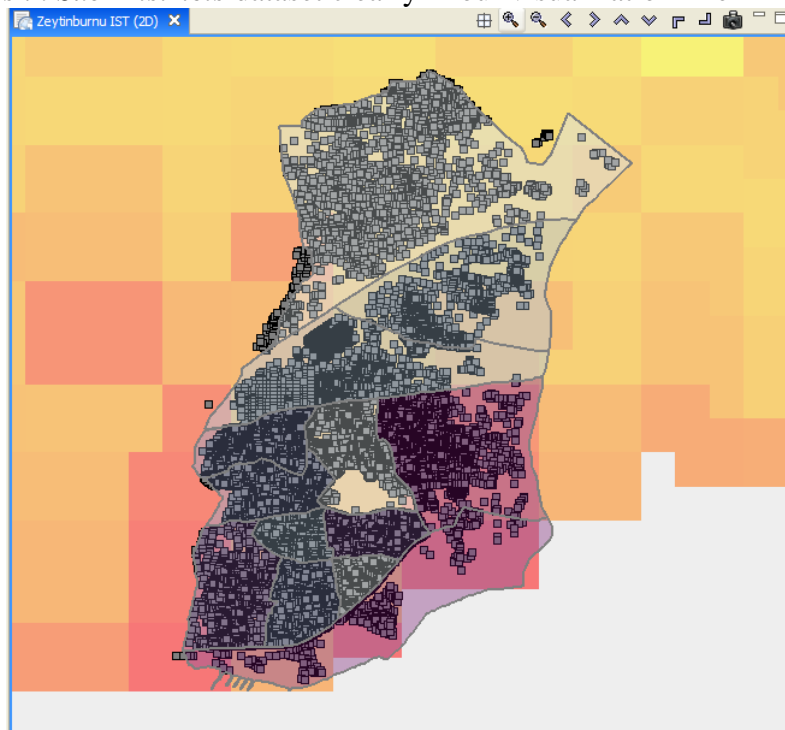

**Figure 25**

### 2.4.3. 3D Damage Bars

- Now let's add 3D damage bars to the buildings to make it easier to visualize damage across the entire map. Right click the Building Damage layer in the Scenario View, and choose *Ranged 3D Visualization...*
- Now we can choose which fields we want to display 3D damage bars for. For this example, we will want to see the chance of each damage state, so select *Insicnific, Moderate, Heavy,* and *Complete*. See Figure 26
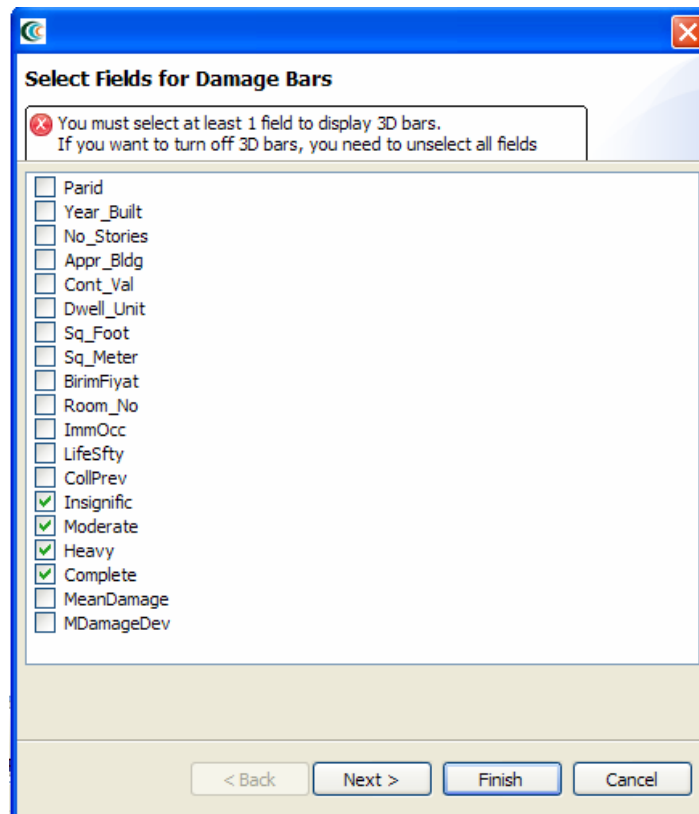


**Figure 26**

- Click *next*. At the next screen, you can choose colors for the various fields. Choose a reasonable set of colors, or use the defaults, then press *finish*. Then, right click the datasets other then Building Damage in your scenario and select toggle visibility to make them invisible like in Figure 27. If there are too many things on the view it could be difficult to separate the items. Then, select *Render in 3D (VTK)*.
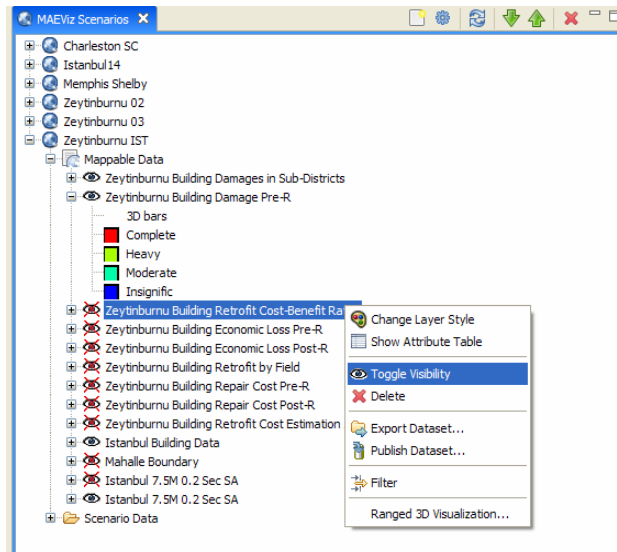
**Figure 27**

- This will bring the 3D Visualization View to the front, and you will see that damage bars have been added for each building. Zoom in and you can quickly see the probable damage states for each building based on the bars. The size of each color in the bar represents the likelihood that the building will be in that damage state. (Figure 28)



**Figure 28**

### 2.4.4. Filtering Data

- Now let's look at just those buildings that have an essential facility of Fire Station. Right click the Building Damage layer, and select *Filter*.
- This brings up the filters dialog. Click *new* to create a new filter.
- This bring up the filters dialog. In the Create Filter dialog, you must pick a field and value to filter by. Choose *EFacility* by double clicking on it in the Fields list. This adds the filed to the query at the bottom of the page. Next, click on the "=" sign button. Finally, to find all of the unique values for the field we selected (EFacility), click the *Get Unique Values* button. Double click on the value EFFS. The dialog should look like Figure 29.



**Figure 29**

- Press *Finish*. When it finished, you should see that all of the damage buildings except the Fire Station have been removed. This is because it is only displaying the damage bars for buildings of essential facility EFFS. See Figure 30.

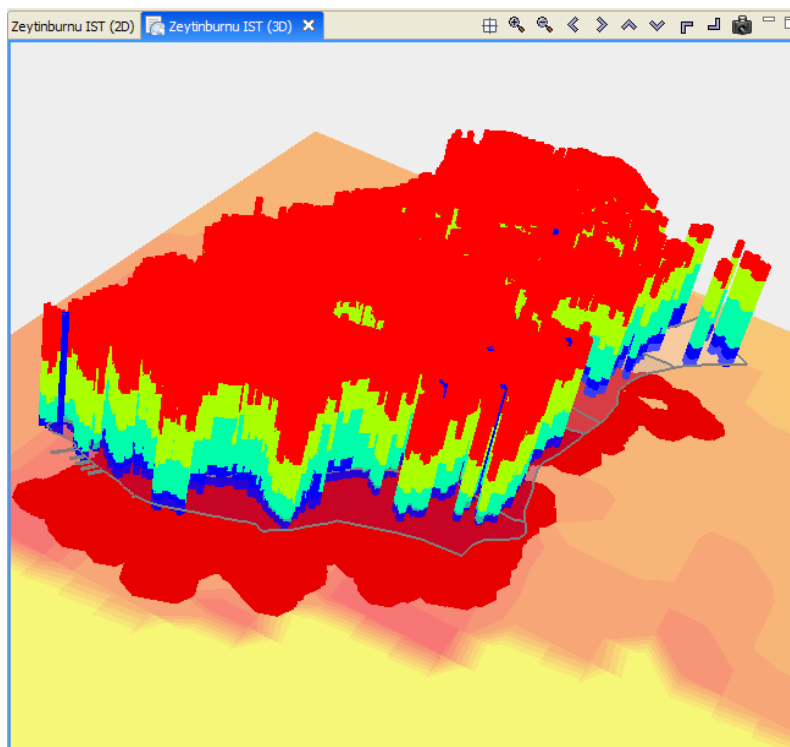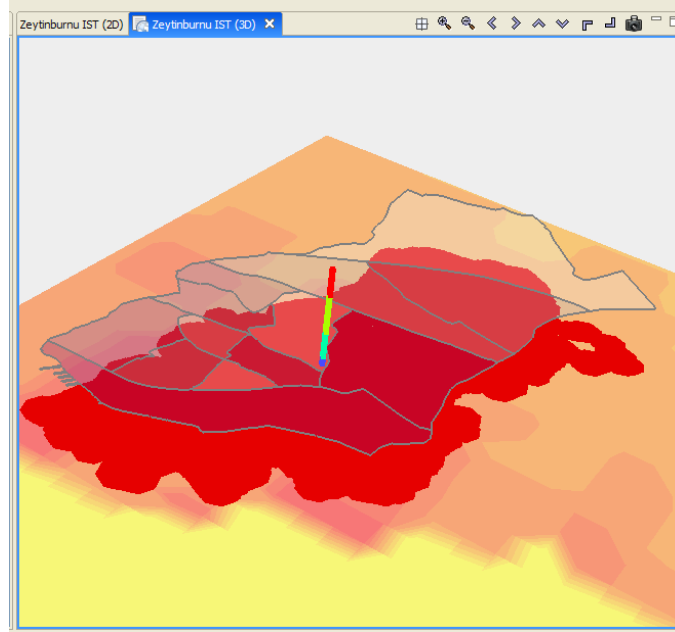**Figure 30**

## 2.4.5. Reporting

- Now we have finished generating and looking at the data, we will generate a printable report of the information that we have learned. Right click the name of your Scenario in the Scenario View, and select *Reports...* This will open the Report Selection View. This gives us a list of reports that MAEviz can generate. (Figure 31)
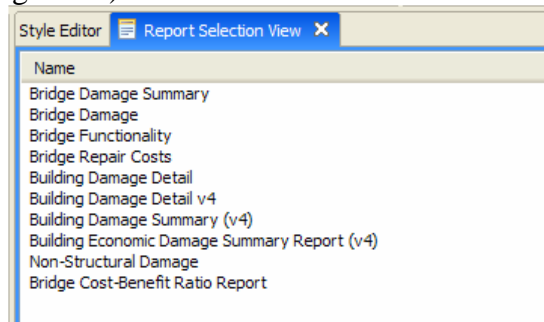


**Figure 31**

- In this case, we only want a summary of the building damage, so we'll use the *Building Damage Summary (v4)*.
- To run the Building Damage report, double click that entry in the list. The Report View will appear, with a preview of your building damage summary report. (Figure 32)



**Figure 32**

- You can print this report by using the print button ( ) or save it using the save button ( ). Use the small arrow next to the save button if you want to select a different format for saving the report (such as PDF, HTML, etc)

# 3. Conclusion

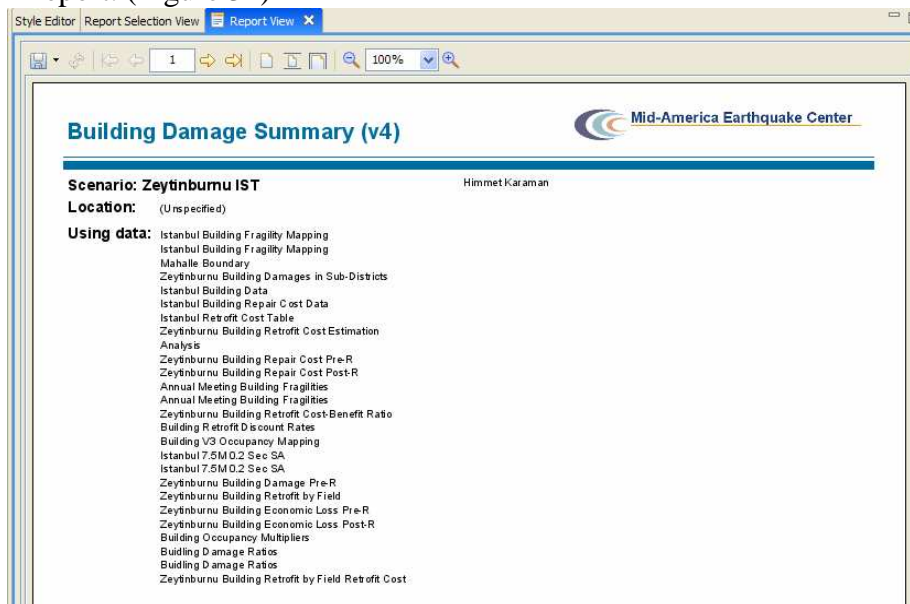Based on this simple building damage analysis, we can conclude that the MAEviz tool helps to identify areas of high risk. MAEviz could also have been used to look at some mitigation options that may be beneficial to consider. The Emergency Manager in our example is able to take the information and results from this analysis and evaluate detailed options for specific buildings base on proprietary information in the department's databases and files. Furthermore, probabilistic scenarios can also be evaluated in addition to a deterministic earthquake such as the one we used in this example. The analysis could also be expanded to look at other components in the region such as the utility networks, schools (since these typically serve as temporary shelters), hospitals, police stations, etc. Some of these data are available with the default installation of MAEviz and is left as an exercise to the user.

The MAEviz tool provides an environment for visual exploration, analysis and evaluation of engineering options pertinent to investigating building and bridge retrofit options. In future version of MAEviz, these results will feed into the traffic models and the decision support to aid in selecting retrofit options, emergency routing, and pre/post mitigation planning. Furthermore, the use of cyberenvironments will enable MAEviz users to more effectively collaborate and share results and the use of web services will allow MAEviz to move computationally intensive analyses to bigger machines when available.

Please contact the Mid-America Earthquake Center for further information on MAEviz.

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# APPENDIX

*Important Information for first time users*

## Running MAEviz

First, ensure that you have Java version 5.0 (also known as 1.5.0) installed.  (available from http://java.sun.com/)

## The MAEviz Portal

The primary means of running MAEviz is via the MAEviz web portal.  To login to the portal and run MAEviz:

- Point your browser to http://maeviz.ncsa.uiuc.edu
- If this is your first time logging in, click the "New Account" link from the left hand navigation menu, and create a new account.
- Now, MAEviz should appear as a choice in the top bar, next to "My Workspace." Click this choice to enter the MAEviz area of the portal.
- Links should be available for downloading and using MAEviz.

## Tips

MAEviz includes a variety of capabilities which can help the user more effectively analyze and visualize seismic risk. The following is a list of capabilities that may be useful when performing an assessment.

The following commands are accessed by right-clicking on a layer in the scenario view (located to the upper left by default).

**Show Attribute Table** opens up a table tab with all of the attributes associated with the selected dataset. For buildings, the data includes structure type, occupancy, square footage, appraised value, and various other attributes. Also note that when a column header is selected, the data is sorted by that column, and when a row is selected, the corresponding data point is highlighted in the Visualization pane. Data can also be copied and pasted from the Attribute table to Microsoft Excel. *Note that performance will be improved if an existing attribute table is closed before opening a new table.*

**Toggle Visibility** switches a layer from visible to invisible and vice-versa. Use this when there are multiple layers of data in the Visualization that you don't need to see. For instance, after running a damage analysis, there will be a new data layer with points corresponding to the buildings in the inventory, so there will be two points shown for each building: one for the original inventory dataset, and one for the damage dataset. In that case, it would be useful to toggle the visibility for the original inventory dataset to hide it, leaving only the damage dataset visible, and avoiding clutter in the Visualization. *Hiding datasets can also improve performance of MAEviz since there is less data to render in the Visualization.*

**Delete** removes the dataset from the scenario, although not necessarily from the Local Cache.

**Export Dataset** exports data for manipulation outside of MAEviz. The type of output depends on the data being exported. For example, building inventory would be exported as a shapefile, while building fragilities would be a comma-delimited text file.

**Filter** allows the user to parse the data viewed in datasets using logical statements (e.g., Structure Type equals W1 to hide rows of data for building types other than W1). The data is not removed from the dataset, only hidden. To return to the full data, remove the filters that were specified and click on Show Attribute Table.

**Publish Dataset** exports data to a repository selected by the user. The data remains in xml format and maintains usability in MAEviz. This is as opposed to an "exported" dataset, which would have to be re-ingested into MAEviz to convert the data to xml format and set up the appropriate directory structure in MAEviz. *Datasets that are published with filters applied retain only the data that passes the filter.* For example, if a filter is applied so that only W1 structures are shown and the dataset is then published, the published dataset will contain only W1 structure data.