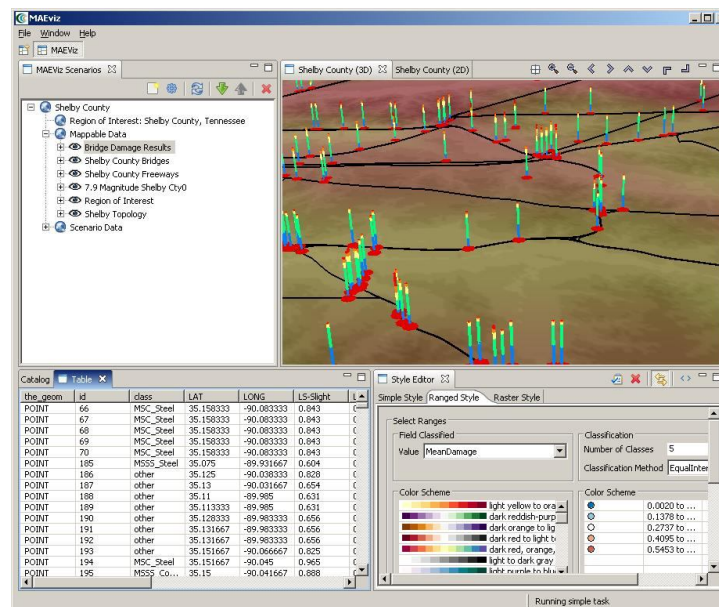


MAEviz Tutorial
Mid America Earthquake Center
University of Illinois at Urbana-Champaign
June 2007

Earthquake Risk Assessment

Using MAEviz 2.1:



Seismic Retrofit of Transportation Systems
(Network-Based Seismic Retrofit)


MAEviz Tutorial for Network-Based Seismic Retrofit (NBSR)

This tutorial will guide you to use MAEviz for assessing system-wide loss of transportation networks under earthquake and determining a set of bridges for seismic retrofit which mitigates the system loss effectively.

In this tutorial, we will use MAEviz to estimate the seismic performance of a simplified Memphis/Shelby County transportation network. Seismic hazard considered in this tutorial is a 7.9 M_w event located at Blytheville, AR. The system performance at different instants in time following an earthquake will be analyzed with and without retrofitting bridges. A Genetic Algorithm (GA), embedded in MAEviz, will be run in order to select a set of bridges for retrofit to mitigate system-wide loss effectively.

In the process, we will see how potential users will launch the MAEviz application, load the GIS data for Shelby County, and then generate earthquake hazard information based on the scenario they want to investigate. After they have loaded this base information, this tutorial will guide users to interactively choose and configure input parameters to assess the seismic performance of Memphis/Shelby County transportation system and to determine effective retrofit strategy and its corresponding system performance. After the analyses are done, we will see the impact of the specified hazard to the Memphis/Shelby County transportation network and an effective retrofit strategy to mitigate the seismic impact on the network. For further information on the process, please refer to the NBSR background documents (give link)

Creating a New Scenario

- From the application's menu bar, click File->New, then expand MAEviz and choose *MAEviz Scenario* (See figure 1). Alternatively, you can click the *New Scenario* button  from the Scenario View's tool bar.

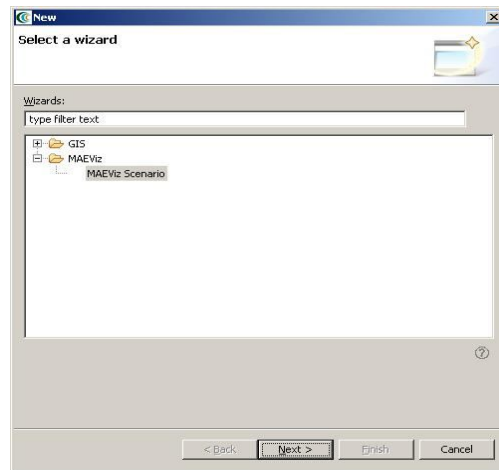


Figure 1

- 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 “NBSR_Tutorial”, 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 Shelby County, TN, so select United States of America from the Country menu. Then select Tennessee and Shelby County from the sub-region dropdown menus that appear. (See Figure 2 below) Note: after pressing the arrow to show a drop down menu, striking the first letter of the entry you wish to select will jump to the first entry in the drop down menu with that letter. For instance, when selecting “Shelby County,” click the arrow for the drop down and strike the “S” key to zoom to Scott County. Shelby County will then be only a few entries away in the drop down list. Click *next* when finished.

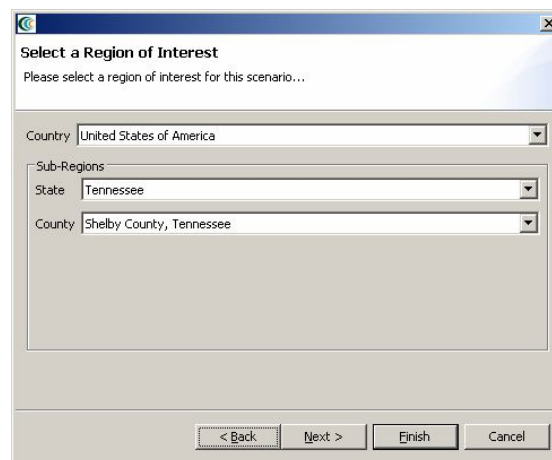


Figure 2

- 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.

Viewing the Scenario and Adding Data

- At this point, your scenario has been created. You will see your scenario listed in the Scenario View and a blank outline of Shelby County has appeared in the Visualization View. See Figure 3.

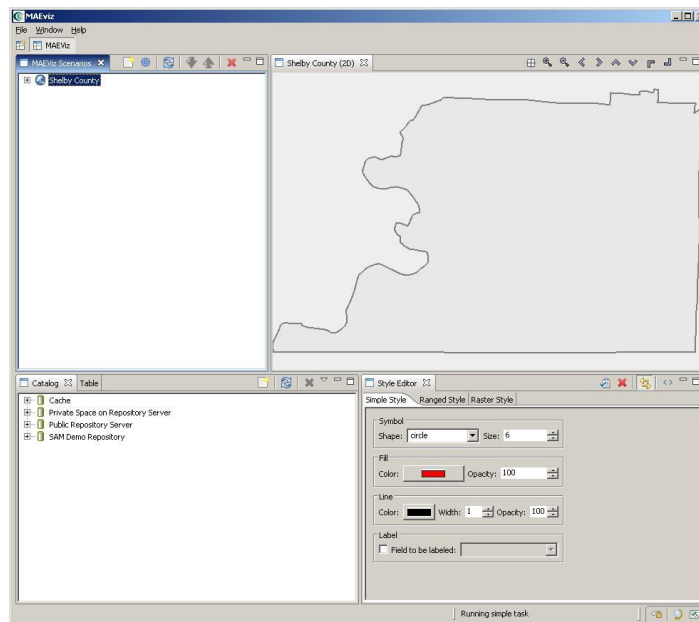


Figure 3

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

- First, we will add bridge data to the scenario. In the Catalog view (the lower-left view of your workbench is arranged in the default setting, as shown in Figure 4), expand the *Public Repository Server* item, then *Bridges*. Expand *Bridge* again, and click and drag *nbsr TestBridges* item into the Visualization View.

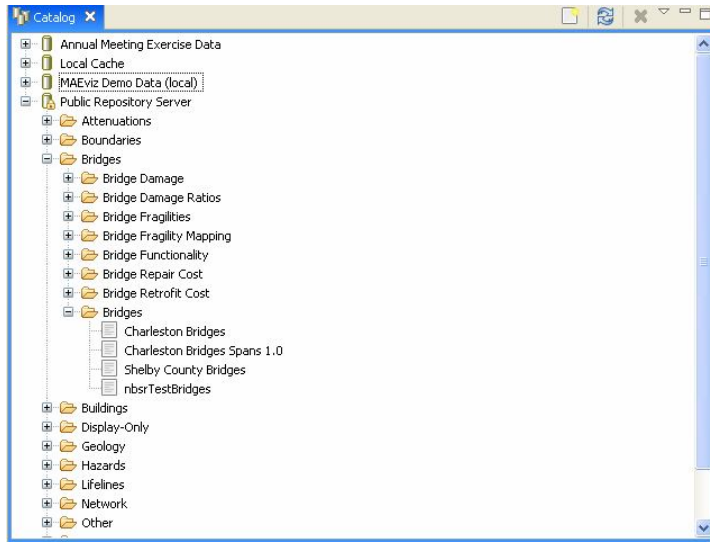


Figure 4

- At this point, an nbsr TestBridges data should have been added to the Visualization View. We will also add transportation network data to the Scenario. Under the Catalog View, still under the Public Repository Server item, expand *Network* and then *Road Network*. Click and drag *NBSR test data – Road Network* into the Visualization View as well. Alternatively, you can right-click the item and select *Load Dataset*.
- At this point, your Visualization View should look something like Figure 5.

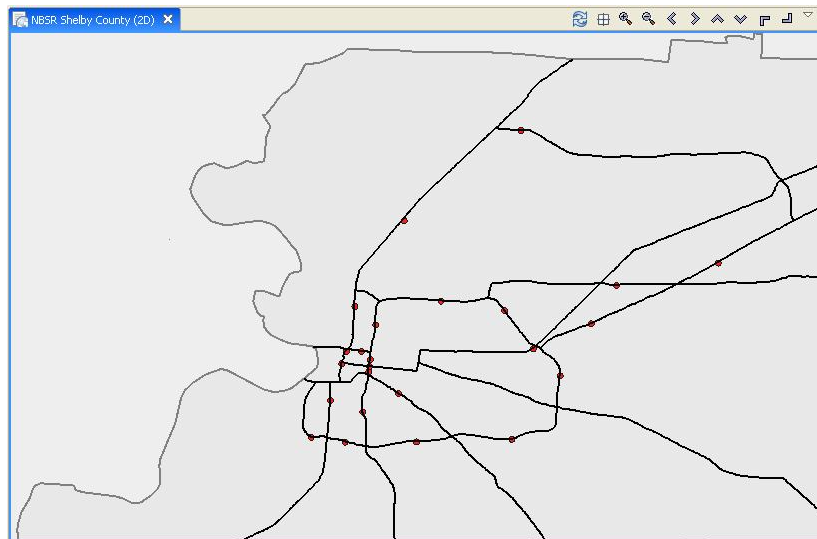



Figure 5

Generate Earthquake Hazard

- For this tutorial, consider hazard from a 7.9 Mw event located at Blytheville, AR. To do so, click the Execute Analysis toolbar button (), right click your scenario and select Execute Analysis or click on the Analysis from the top level menu and select Execute Analysis.
- This causes the Run Analysis Wizard to be shown. See Figure 6. From this page, expand *Hazard*, select *Scenario Earthquake Analysis* and click next.

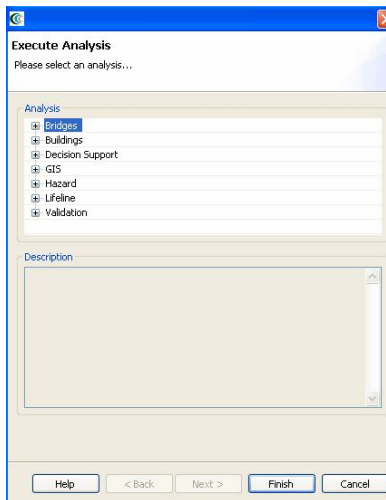


Figure 6

- In the next page (Figure 7), select the source event you want to use for analysis. For this tutorial, select Blytheville event (the first event in the list).



Figure 7

- The next page prompts you to select an attenuation function for the estimation of ground motion. Choose Fernandez and Rix (2007) and click next. At this point, the window in Fig. 8 will be shown.
- Set the *Grid Spacing* at 0.05 for finer raster data of ground motion estimation in the study region, and click next twice, then choose PGA for hazard output selection.

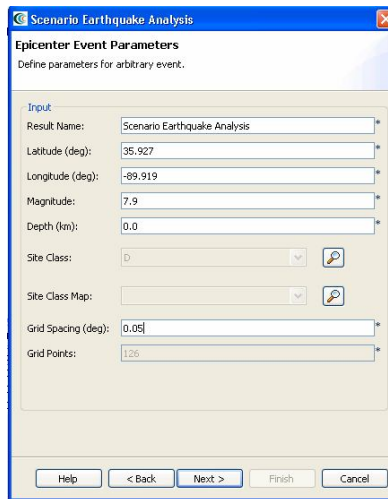


Figure 8

- At this point, a seismic hazard map should have been added to the Visualization View, and your Visualization View should look like Figure 9.

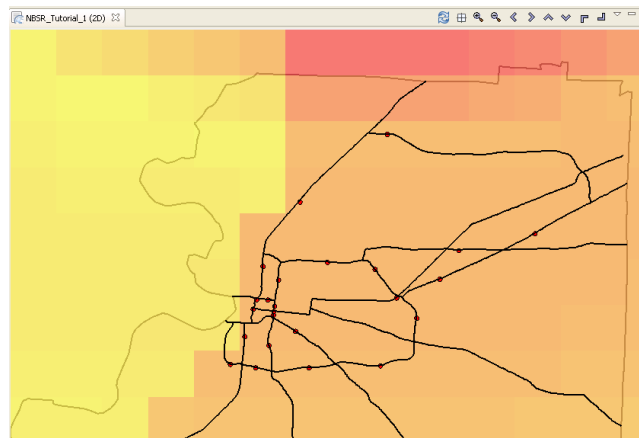


Figure 9

Running an Network Analysis

Now that we loaded inventory data and generated a seismic hazard, we will learn how to run a network analysis. In this tutorial, we want to assess the post-earthquake system performance before and after the specified seismic event.

- First, we will launch the Run Analysis Wizard again.
- This causes the Run Analysis Wizard to be shown as shown in Fig. 10. From this page, expand *Decision Support* and select the *Network-Based Seismic Retrofit using Static Traffic Model*. Click *next*.

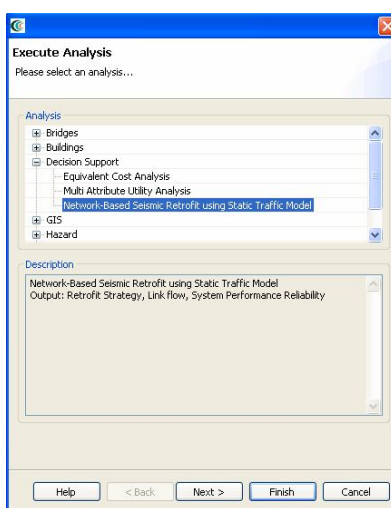


Figure 10

- The next page (Figure 11) prompts you to select the data you want to use in running your analysis. If it tells you that no datasets in any of the given input data field, you must load appropriate datasets that contain this data to run analysis. Enter a name for your results, such as “NBSR_Test”
- To help you locate the necessary input data, use the Find Dataset button (🔍) to load necessary datasets for the analysis.
- When we click the next button, Figure 12 prompts you to enter total available budget you would like to spend for retrofitting bridges and to select optimization algorithm. Entering 500,000 (a half million) and selecting *Genetic Algorithm* for this example analysis.
- Check “Day 1” and “Day 7” for *Time to be analyzed*. The NBSR model will analyze the system performance at Day 1 and 7 levels with and without retrofit (Day 0 is default).

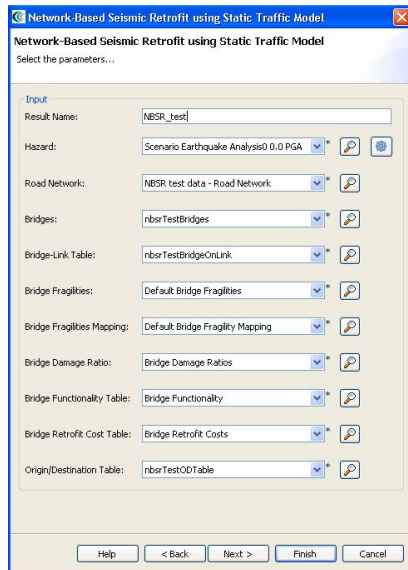


Figure 11

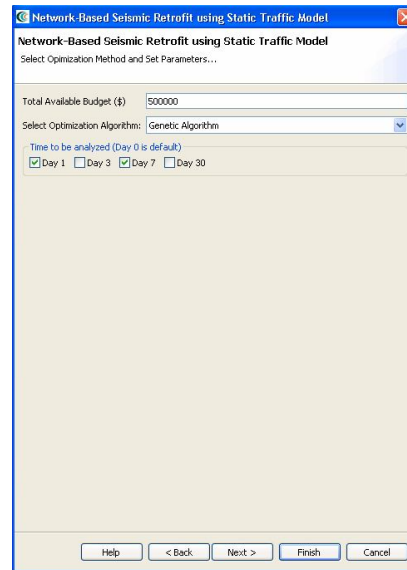


Figure 12

- The next page (Figure 13) asks you to enter parameters for Genetic Algorithm. Entering number of populations, number of generations, probability of crossover operation and probability of mutation operation. You may enter the values as shown in Fig. 13.
- Note that the quality of solution highly depends on the number of populations and generations and the analysis time is proportional to the size of population and generation.
- For selection and crossover operator, use default operators.
- Last, a user needs to select whether *all retrofit method* or *one retrofit method*. If *all retrofit method* is chosen, genetic algorithm tries to find an effective retrofit strategy considering all retrofit schemes while one selected retrofit is considered in the solution if *one retrofit method* is chosen. For this analysis, select one retrofit method and choose *Elastomeric Bearing* and click *Finish*.
- The analysis may take up to 20 minutes depending on the performance of your machine.

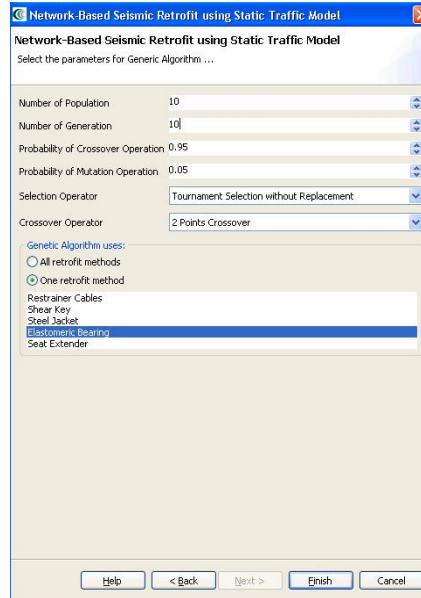


Figure 13

Analyzing Results

Now that the analysis that we were interested in has been completed, the visualization view will look like Fig. 14. This section will illustrate how to understand and interpret results. There are various ways of viewing and visualizing the results, which we will learn now.

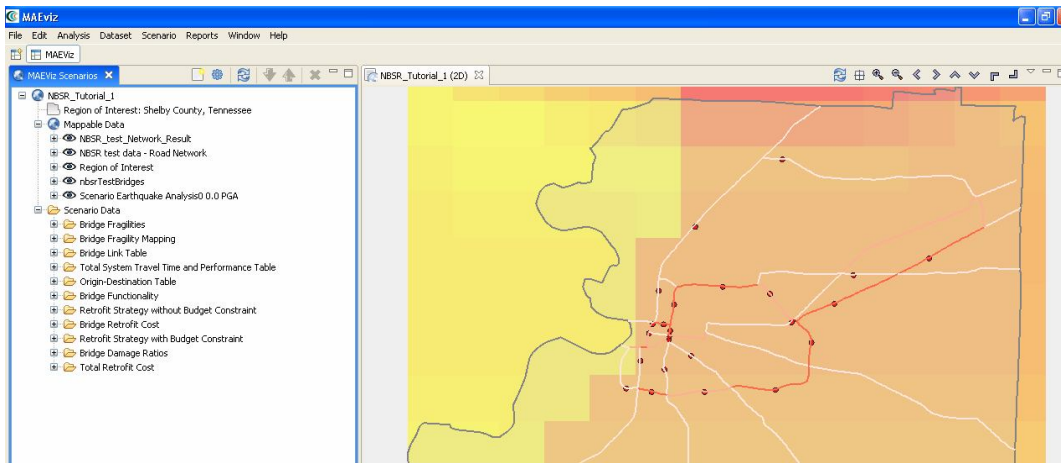


Figure 14

Results for Roadways

- In the Scenario View (shown in Fig. 15), right click on the NBSR_test_Network_Result layer, and select *Show Attribute Table*. The Table View should appear in the bottom right of the application window.
- Now we will use the Table View to read post-EQ link properties such as traffic volume and travel cost with and without retrofit.
- First, you can check the link capacity, travel time (cost) and travel volume under Pre-EQ condition by reading values the column headers labeled *precap*, *prelc* and *prelf*, respectively.
- These link properties following an earthquake without retrofit at different time levels can be seen under the column headers labeled (time level)worcap, (time level)worlc and (time level)worlf. For instance, the post-EQ link capacity without retrofit at Day 0 level has the column header labeled d0worcap.
- The link properties with retrofit can be seen under (time level)wrcap, etc.
- You can use shift+click or ctrl+click to select links of your interest. You will see the color of them changed in the Visualization View.
- Note that the capacity of a link which does not have a bridge(s) does not change under earthquake condition.

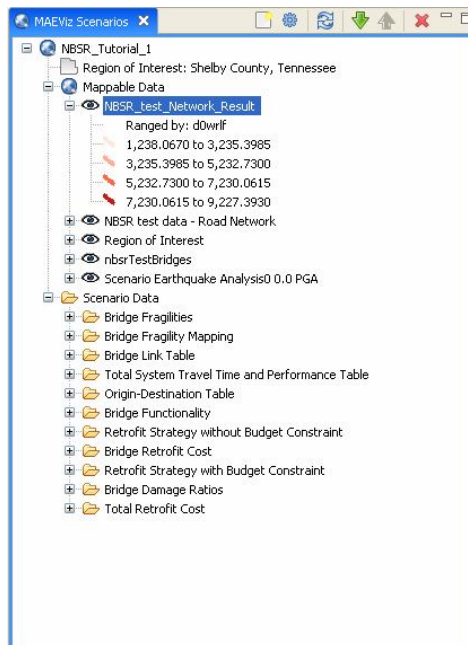
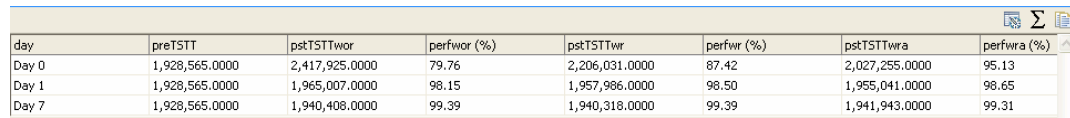


Figure 15

System Performance

- In order to see the system performance with and without retrofit at specified time levels, expand *Scenario Data* and *Total System Travel Time and Performance Table* in *Scenario View*. Right click on the *NBSR_test_TSTT_Performance* layer and select *Show Attribute Table*. The Table View should then appear in the bottom right of the application window (Fig. 16).



day	preTSTT	pstTSTTwor	perfwor (%)	pstTSTTwr	perfwr (%)	pstTSTTwra	perfwra (%)
Day 0	1,928,565.0000	2,417,925.0000	79.76	2,206,031.0000	87.42	2,027,255.0000	95.13
Day 1	1,928,565.0000	1,965,007.0000	98.15	1,957,986.0000	98.50	1,955,041.0000	98.65
Day 7	1,928,565.0000	1,940,408.0000	99.39	1,940,318.0000	99.39	1,941,943.0000	99.31

Figure 16

- Column headings in the table are summarized in Table 1. If you moved your mouse pointer over a heading, the description of the heading would appear.

Table 1

Colum Heading	Remarks
preTSTT	Pre-EQ total system travel time
pstTSTTwor	Post-EQ TSTT without retrofit
perfwor (%)	Post-EQ system performance without retrofit
pstTSTTwr	Post-EQ TSTT with retrofit considering specified budget constraint
perfwr (%)	Post-EQ system performance with retrofit considering specified budget constraint
pstTSTTwra	Post-EQ TSTT with retrofitting all bridges
perfwra (%)	Post-EQ system performance with retrofitting all bridges

- Note that the system performance at Day 0 is less than that at other time levels (i.e., Day 1 and Day 7) because capacity of a bridge increases as time elapses.
- Generally, the system performance with retrofit is higher than that without retrofit. However, if a user specifies small size of population and generation, it's less likely to have a good solution. As a result, it's possible to have lower system performance with retrofit. In such case, you may want to increase the size of population or generation to get better solutions.
- You can draw a chart to visualize the results effectively. First, right click on the *NBSR_test_TSTT_Performance* layer and select *Show Chart*.
- The window in Fig. 17 prompts you to configure a chart. Select Post-EQ system performance fields and click *Finish*.

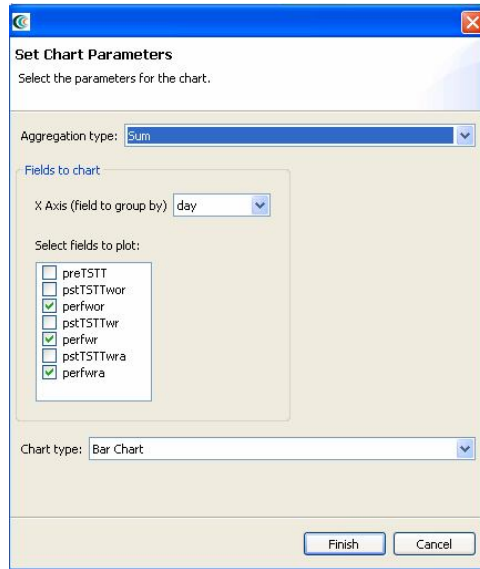


Figure 17

- Now, a chart which looks like in Fig. 18 should appear in the bottom right of the application window. This chart would help you compare the system performances with and without retrofit at different time levels. As shown in Fig. 18, the system performance with retrofit with budget constraint (i.e., a half million dollar) is very close to that with retrofit without budget constraint. This implies that the system performance does not increase much even though if you spend more than a half million dollars.

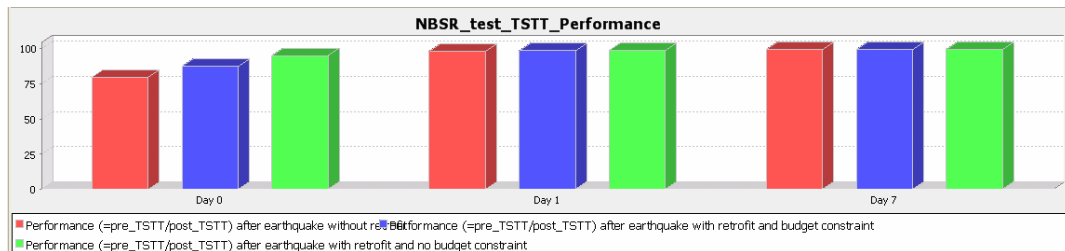


Figure 18

- Next step is to see which bridges are retrofitted and how much retrofit cost is spent for each bridge. To do so, select *Retrofit Strategy with budget constraint* under *Scenario Data*. Right click on the *NBSR_test_Retrofit Strategy with Budget Constraint* and select *Show Attribute Table*.
- The table in Fig. 19 should then appear in the bottom right of the application window. The first column is for bridge ID, the second one is for retrofit scheme and the last one is retrofit cost.

- The post-EQ system response with retrofit considering budget constraint shown in previous section was obtained after retrofitting bridges with a retrofit scheme(s) in Fig. 19.

bridge	retscheme	retcost (\$)
201	EB	\$93,827
251	EB	\$103,334
544	EB	\$84,114
456	EB	\$67,373
231	EB	\$46,603
267	EB	\$32,653
282	EB	\$63,033

Figure 19

- If you want to calculate the sum of retrofit cost, simply click Statistics button(Σ) located at top right of the table pane and select *retcost*. This gives you some statistical data such as sum, average, median, etc. As shown in Fig. 20, total retrofit cost is about 490K and the number of retrofitted bridges is seven. This would help you to estimate budget for enhancing network performance under seismic conditions.

bridge	Count	7
retcost	Maximum	103,333.5401
	Mean	70,133.9499
	Median	84,113.5017
	Minimum	32,653.3987
	Standard Deviation	23,529.6435
	Sum	490,937.6491

Figure 20

Conclusion

This tutorial has shown that MAEviz has a capability to assess system performance of transportation network and to determine effective retrofit strategy using limited budget. This capability would help decision makers to establish effective seismic retrofit programs for mitigating potential system-wide loss. Specifically, MAEviz can provide decision makers with post-EQ system performance with and without retrofit considering budget, retrofit options for bridges and associated budget under a given scenario earthquake. Probabilistic scenarios can also be evaluated in addition to a deterministic

earthquake such as the one we used in this example. The analysis in conjunction with the component (e.g., bridge) loss assessment which is already built in MAEviz would provide users useful insight in anticipating potential loss on transportation network systems.

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. In future version of MAEviz, dynamic traffic assignment (DTA) model will be implemented in MAEviz to more accurately assess system behavior and system-wide loss.

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

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