CE311S Lab #1
Defining Events Within the Context of Lifeline Design

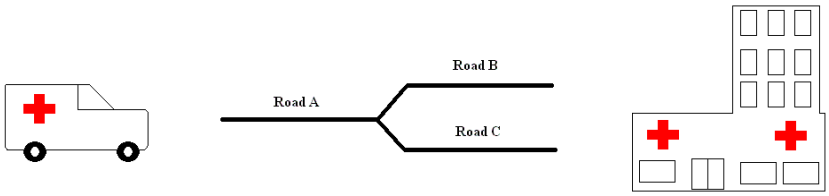
Purpose

In this laboratory you will use event theory to analyze the reliability of a critical road system for emergency vehicles during an earthquake and to determine the tradeoffs between road costs and reliability.

What You Will Be Doing

You have been hired to evaluate proposed designs for a series of three roads that connect a residential area and a hospital. The roads should be designed such that at least one route to the hospital is open in the event of an earthquake. Using a computer program, you will simulate the performance of each proposed design in the event of an earthquake.

You will select the best design based on how the road system performs during earthquake simulations and based on the costs associate with the design. One of the things that you will be interested in is the reliability of each individual road and the road system as a whole. Reliability refers to the likelihood or probability that something will work, or in the case of this lab, that a road survives an earthquake.



Let A = Event {Road A remains intact during an earthquake}
B = Event {Road B remains intact during an earthquake}
C = Event {Road C remains intact during an earthquake}

Procedure

Go to the Lab Web page. There are two programs in this folder that you will be using ("Lifeline.exe" and "Road Designs.exe") and a spreadsheet called "1 – Spreadsheet.xls". Download these files to the desktop of your computer.

I: Evaluate Uncertainty in Performance of One Proposed Design for Road System

You will use the LabView program to simulate the performance of the road system in ten different earthquakes.

1) Answer Questions 1 and 2.

2) Open the program "Lifeline.exe."

3) Be sure to enter the construction cost of each road shown below. Click on the run (⇨) button in the toolbar.

Road A Construction Cost: $40m
Road B Construction Cost: $35m
Road C Construction Cost: $20m

4) Click on the button labeled "Next Trial" to generate a simulation. Record in Table 1 how each road performed for all of the ten simulations. For each simulated earthquake, define the event that describes the observed road conditions in terms of the events A, B, and C, and determine whether or not the ambulance can make it to the hospital.

5) Answer Question 3.

II: Comparison of Different Proposed Designs for Road System

You will use this program to compare the performance of different proposed designs for the road system. in each proposed design, a different amount of money will be spent on constructing Roads A, B, and C. For each set of construction costs that you enter, the program performs simulations of ten earthquakes. The computer output will tell you how many times out of ten the roads within the system failed and how many times the ambulance did not make it to the hospital. Based on these results, the average cost of the proposed road system is calculated. (Basically, the computer is doing everything you did in Part I for each set of costs you enter.)

1) Open the program "Road Designs.exe" and click the run button in the toolbar.

2) Enter 10 in the box for the total number of earthquake simulations.

3) From the ranges given below, decide on the construction costs for each road for the first proposed design and enter them in Table 2. Use the construction cost ranges listed below. Click on the button labeled "Next Trial" to generate ten simulated earthquakes. Record the results in Table 2 and calculate the frequency that the ambulance does not get to the hospital.

   Construction Cost Range:
   • Roads A, B, and C: $10m - $80m each

4) Repeat step 3 for other combinations in the cost range. Do at least 6 combinations.

5) Repeat steps 3 & 4 for the following cost range:

   Construction Cost Range:
   • Roads A, B, and C: $85m - $110m each

6) Finish remaining questions: 4, 5, & 6.

Table 1: Evaluate Uncertainty in Performance of One Proposed Design for Road System (Part I) (10 pts & 10 pts for the next table)

Trial #	Define the Road Conditions (let prime be unusable road: e.g. AB'C')	Does the Ambulance Get to The Hospital?
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Table 2 - Comparison of Different Proposed Designs for Road System (Part II)

Proposed Design of Road System	Cost of Road A (x $10m)	Cost of Road B (x $10m)	Cost of Road C (x $10m)	Number of Times Road A Fails out of !0	Number of Times Road B Fails out of 10	Number of Times Road C Fails out of !0	Number of Times Ambulance Does *Not* Get to Hospital	Frequency Ambulance Does *Not* Get to Hospital	Total Construction Cost of Road System
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

Questions

1) Identify the sample space (i.e., a list of all possible outcomes) of the system that you will analyze in this laboratory and include a clearly labeled Venn diagram. Use the events A, B, and C as defined on the first page of the handout. (Hint: Go through the Event Theory tutorial to learn about the Venn diagrams)(15 pts)

2) As the design engineer, you are interested in the event that the ambulance can make it to the hospital. List all of the possible road combinations that allow an ambulance to get to the hospital. Indicate on the Venn diagram the area that corresponds to this event. (5 pts)

3) As you can observe from the data collected in Part I, even though we are spending the same amount on constructing the road system, the performance of the road system varies from one earthquake to the next. This is an example of uncertainty in civil engineering. What are three potential causes for this uncertainty? Be sure to explain how each cause for uncertainty affects the performance of the road system. (15 pts)

4) Using the data from Part II, how does increasing the construction cost of an individual road affect the reliability of that road during an earthquake? (10 pts)

5a) Using the data from Part II, plot the frequency of failure for the road system versus the construction cost of the proposed road system. You may use the spreadsheet template called "1 – Spreadsheet.xls". (10 pts)

5b) Explain how cost affects performance of the road system as a whole. (15 pts)

6) As an engineer you must take both performance and costs into consideration in order to select the best design for construction. If a design fails, there is a cost of failure that includes the cost of repairs and the costs due to human injuries and fatalities. For the road system you designed, assume a failure cost of $50m when the ambulance does *not* get to the hospital. Considering this cost of failure and the construction cost, if you were the engineer designing the road system tested in this laboratory, what design would you propose? Why? (10 pts)