METRO Risk Assessment Methodology

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Abstract

The American Recovery and Reinvestment Act introduced the Transit Security Grant Program. This program allows transit authorities to apply for grants to cover projects protecting against weapons of mass destruction and other terrorist attacks. This paper looks at how to calculate potential risk for two attack scenarios at three Washington Metropolitan Area Transit Authority stations. Risk is measured as the likelihood of the event taking place versus the result of losing the asset. The likelihood is split into the potential threat of an attack at the asset and the likelihood the attack is successful. Using Analytica and influence diagrams, this paper explores which scenario has the most risk.

Problem Background

The federal government introduced the American Recovery and Reinvestment Act (ARRA) to help create jobs and improve the economy throughout the United States[1]. This money goes to several different types of agencies and businesses across the United States. One such agency is the Federal Emergency Management Agency (FEMA). FEMA has three main grant programs in which it disperses this money: ARRA Transit Security Grant Program (TSGP), ARRA Port Security Grant Program (PSGP), and ARRA Fire Station Construction Grants (SCG)[2]. FEMA prioritizes and disseminates money to projects that are "shovel-ready" and "infuse resources into local economies quickly while meeting critical security needs". This project will attempt to create a methodology in which the Metropolitan Washington-DC area METRO transit system can identify high risk assets, enabling the jurisdiction to develop projects to reduce risk and effectively request funding from FEMA's Transit Security Grant Program.

Model

The risk of an event can be measured as the consequence of the event versus the likelihood the event takes place. Risk of a terrorist attack is commonly broken down into three pieces. Common practices at measuring the risk of a potential terrorist attack breaks down the likelihood of an attack into two pieces. The likelihood of the attack is measured as the potential threat of an attack taking place against the likelihood the attack would be successful. Our project looks at two possible terrorist attacks at three light rail stations owned by Washington Metropolitan Area Transit Authority (WMATA) located within the Washington, DC metro area. We chose three stations of varying size and importance to WMATA and the Washington, DC area. We chose Union Station, West Falls Church Station, and Metro Center Station. The two possible attacks at each asset consist of a small conventional explosive (SCE) and a large conventional explosive (LCE). The SCE is defined as a small amount of explosives that would amount to the size of a backpack whereas the LCE is a large amount of explosives that would require a vehicle to transport. These are similar to the attacks on public transit systems in Madrid and London.

Our group looked at each of the three functions of our fundamental objective to determine which means objectives that make up each function. Looking at each one individually, we determined several means objectives that measure value for each of the functions. Below is the Affinity Diagram that resulted from our discussions. Each function has a different number of measures with a different value function for each.

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[1] The Act. http://www.recovery.gov/About/Pages/The_Act.aspx

[2] FEMA: American Recovery & Reinvestment Act (ARRA) http://www.fema.gov/government/grant/arra/index.shtm

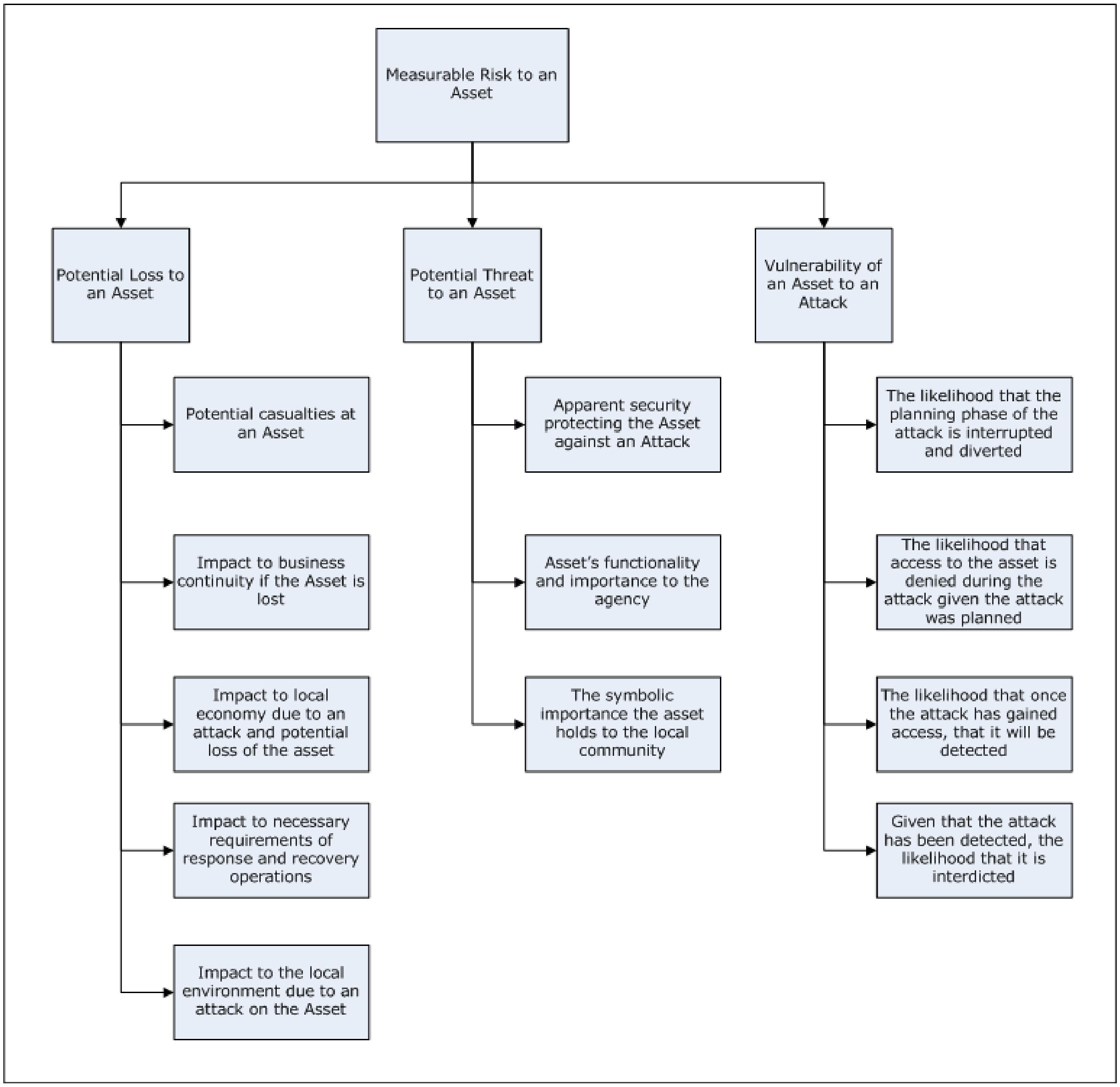

Figure 1: Affinity Diagram for our Model

Possible Loss of an Asset

The first function on the affinity diagram is the consequence portion of the risk formula. We looked at the consequence of losing an asset as several pieces that the owner of the asset would consider disastrous. The first item that came up was the potential casualties lost at the asset. The number of people can vary at an asset throughout a day and depending on the day. However, it is assumed that the attacker would perform the attack at the time when the most possible casualties would take place. This could be a peak travel time or a special event when the crowd at the asset would be at its highest possible density. The values that are gathered for each asset measured would give the most likely maximum amount of people at a given time. The second parameter was determined to be the loss to business continuity of the owner. If the asset were loss, the owner is concerned with the loss of revenue that the owner's business would incur. This is a function of dollars earned by the asset and amount of time the asset would be down. The impact to the local economy due to the loss of the asset was determined to be the third parameter. For most assets, they have a certain level of impact on the economy in the area. For example, small light rail stations in a suburban area have little impact to the economy compared to light rail stations in a downtown metropolitan area where there are several businesses relying on the light rail system for commuters. The fourth parameter is potential impact to provide emergency response and recovery services to the area. Transit agencies are usually a critical part to a metropolitan area's response and recovery plans. In the event of a disaster, be it terrorism, natural or man-made, the transit system is usually charged with mobilization of military resources and the local population. The last parameter was determined to be the impact to the environment if the asset was lost. Although the loss of an asset might be trivial in some cases, the owner is concerned with any potential long lasting effects that the attack might have on the environment.

Our elicitation process determined the five categories used to measure the impact of losing an asset. After the measures were determined, we had the group determine weights on how important each factor was to the function. As a team, we decided that the Rank Sum method of determining weights was an appropriate method to elicit a first list of potential weights for each factor. Through our discussions, we determined that each factor had a unique ranking of order of importance. The table below displays the ranking for each factor and the finalized corresponding weights.

Consequence Factor	Rank	Weight
Potential casualties at an Asset	5	.33
Impact to business continuity if the Asset is lost	3	.20
Impact to local economy due to an attack and potential loss of the asset	4	.27
Impact to necessary requirements of response and recovery operations	2	.13
Impact to the local environment due to an attack on the Asset	1	.07

Threat of a Potential Attack

Through a similar elicitation process, we gathered information from experts on how terrorist view potential attacks. For the purpose of this analysis, we made some general assumptions about the terrorist groups views on assets. Although terrorist groups vary in how they look at each potential target, it was agreed upon that they can be generalized into three measures. The first parameter is measured as the apparent security protecting against an attack. This measure is determined through a potential list of possible countermeasures in place that would be viewable by the public. This represents any possible threats to the success that would take place as determined by the terrorist. The second parameter is the asset's functionality and importance to the agency. From the terrorist's perspective, the most attractive targets tend to have a high importance to the owner. The last parameter is measured as symbolic importance to the local community. A potential attack can be devastating from several perspectives, but a terrorist will usually try to be recognized by attacking a high profile target that is easily recognizable.

We elicited values for the potential threat to an asset in a similar manner to the elicitation process used for the potential loss of an asset. We had experts look at each of the three parameters and rank each one according to how a terrorist would rank each parameter. As with the parameters for the potential loss of an asset, we used the Rank Sum method for the first set of weights for each factor in potential threat to the asset. The table below lists each factor with the respective rank and weight.

Threat Factor	Rank	Weight
Apparent Security protecting the Asset against an Attack	3	.50
Asset's functionality and importance to the agency	1	.17
The symbolic importance the Asset holds to the local community	2	.33

Vulnerability to an Attack

The next measure determines how likely an attack would be successful given the current countermeasures in place at the asset. First we must define what an 'attack' is. For the purpose of this project, we have considered two types of attack scenarios, a large conventional explosive device (LCE) and a small conventional explosive device (SCE). An LCE is determined to be a vehicular borne improvised explosive device (VBIED) that contains approximately 4,000 lbs of TNT equivalent explosive material. This attack scenario is considered to be similar to the vehicle bomb that attacked the Alfred P. Murrah federal building in Oklahoma City, OK on April 19, 1995[3]. An SCE is defined as a small improvised explosive device that contains approximately 50 lbs of TNT equivalent explosive material that can fit within a backpack or duffel bag. This attack scenario has become a common method of attack for terrorists to use against public transportation. Two examples of this are the attacks on the London public transportation system on July 7, 2005[4] and attacks on the Madrid public transportation system on March 11, 2004[5]. Each of these attacks has its own level of difficulty to obtain materials and execute the attack but for the purpose of this assessment we will not look at those two factors.

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[3] September 11, 2001, Documentary Project. http://memory.loc.gov/ammem/collections/911_archive/

[4] London Attacks. BBC News. http://news.bbc.co.uk/2/shared/spl/hi/uk/05/london_blasts/what_happened/html/russell_sq.stm

[5] Madrid train attacks. BBC News. http://news.bbc.co.uk/2/hi/in_depth/europe/2004/madrid_train_attacks/default.stm

The third measure of how likely an attack would be successful is determined through a decision model process broken up into four steps. Each step will be a Bernoulli trial determining whether there is a success at that step or a failure. The first step is how likely that a successful plan can be put into place and established. Assuming that this is successful, the second step is determining how likely that an attack could gain access to the asset in order to perform the attack. The next parameter is to determine if the attack is detected at the asset given that it gained access. If the attack is detected, the last parameter is the likelihood that the attack is stopped or thwarted. Through this decision tree, there are two different branches that result in a successful attack on the asset. The figure below outlines the decision process.

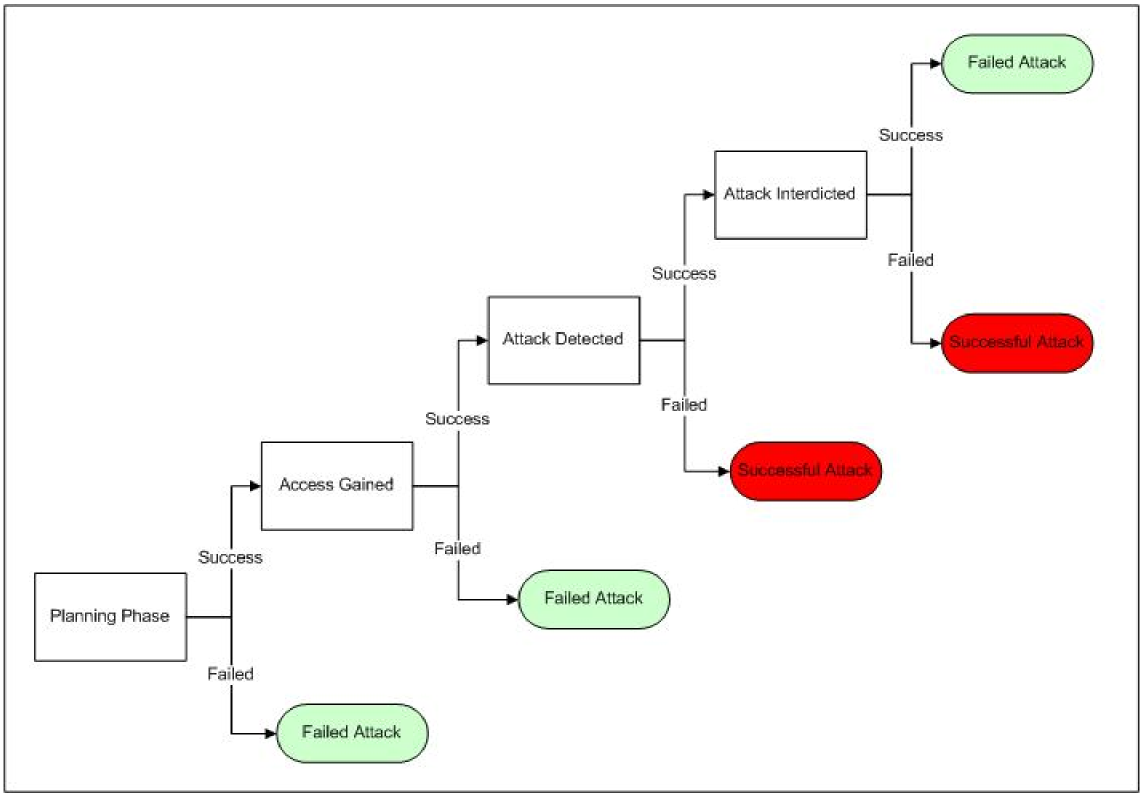

Figure 2: Decision Tree for a Potential Attack

Counter-terrorist countermeasures are evaluated to determine how effective each asset is at defending against each type of attack. A group of experts was elicited to give a value of contribution each countermeasure makes towards each phase. The success of each phase is measured as a gap-filling process given the effectiveness of each countermeasure present at the asset. Our group looked at three countermeasures: bollards, cameras, and guards. Each countermeasure's effectiveness is modeled as a Uniform random variable. Appendix 1 has these values and the relationships to each phase.

Asset Scoring

The next step in our process was to look at the possible values for each measurement to determine the possible range of variation within each function. Using this info we determined a list of WMATA stations that had specific attributes that would allow for an interesting comparison. For our project, we decided that a sample of three stations would demonstrate a variety of values for each category. Each alternative has a high value in one function and varying levels in the others. The three stations we used are West Falls Church Station, Union Station, and Metro Center Station.

Through an elicitation process, we gathered information on each of the three stations and how they measured each of the factors used in our risk analysis. The elicitation process determined the exact range of variation for each measure. Using this range, we calculated a linear single dimension value function for each of the measures under the consequence and threat portions of our risk model. After gathering each of data for each of the stations, we evaluated the SDVF defined for each station. Using the weights determined above, the score for each asset was calculated. The figure below shows the contribution each factor makes to the score for possible loss of an asset. The same approach was taken with the potential threat to an asset. Appendix 1 has the results of our SDVF for each factor in our model.

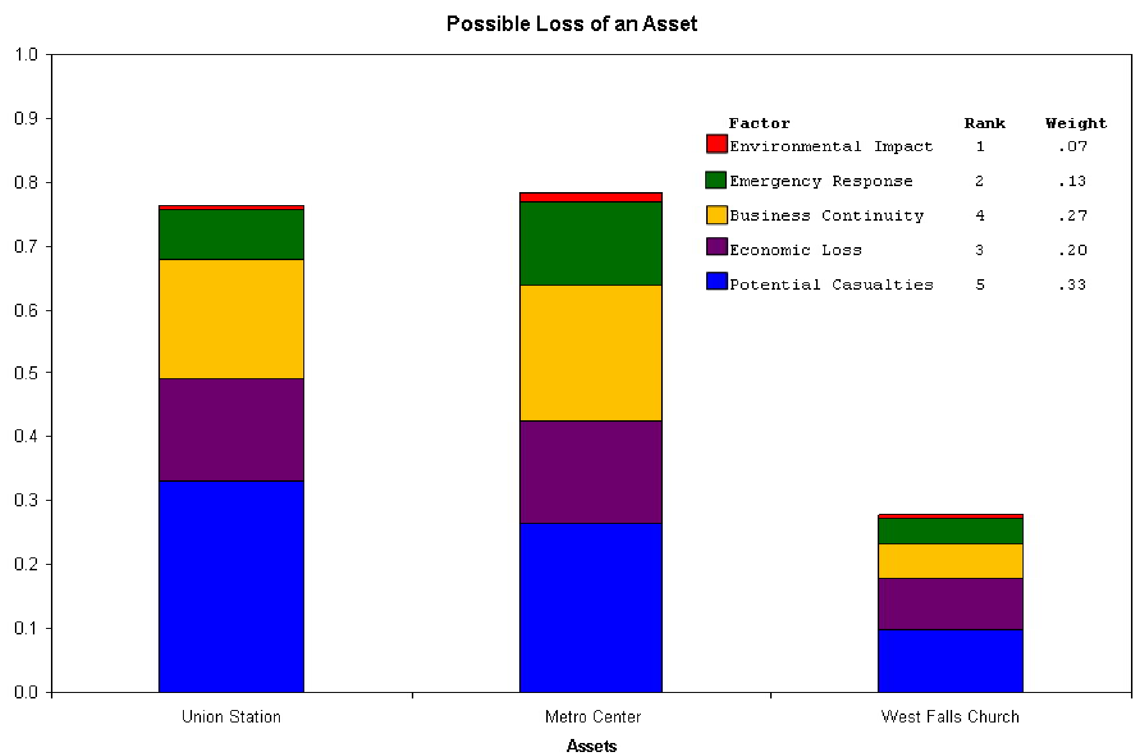

Figure 3: Contribution each factor makes to possible loss score.

Results

Our group chose to represent our risk model using influence diagrams in Analytica. The software provided us with the ability to accurately represent our weighting methods in addition to providing uncertainty around inputs in the possible vulnerability module. The model is broken into six modules: the list of assets and attacks, sub models of possible loss, potential threat, and vulnerability, and the objective value of total risk. The figure below shows the highest level view of our model in Analytica.

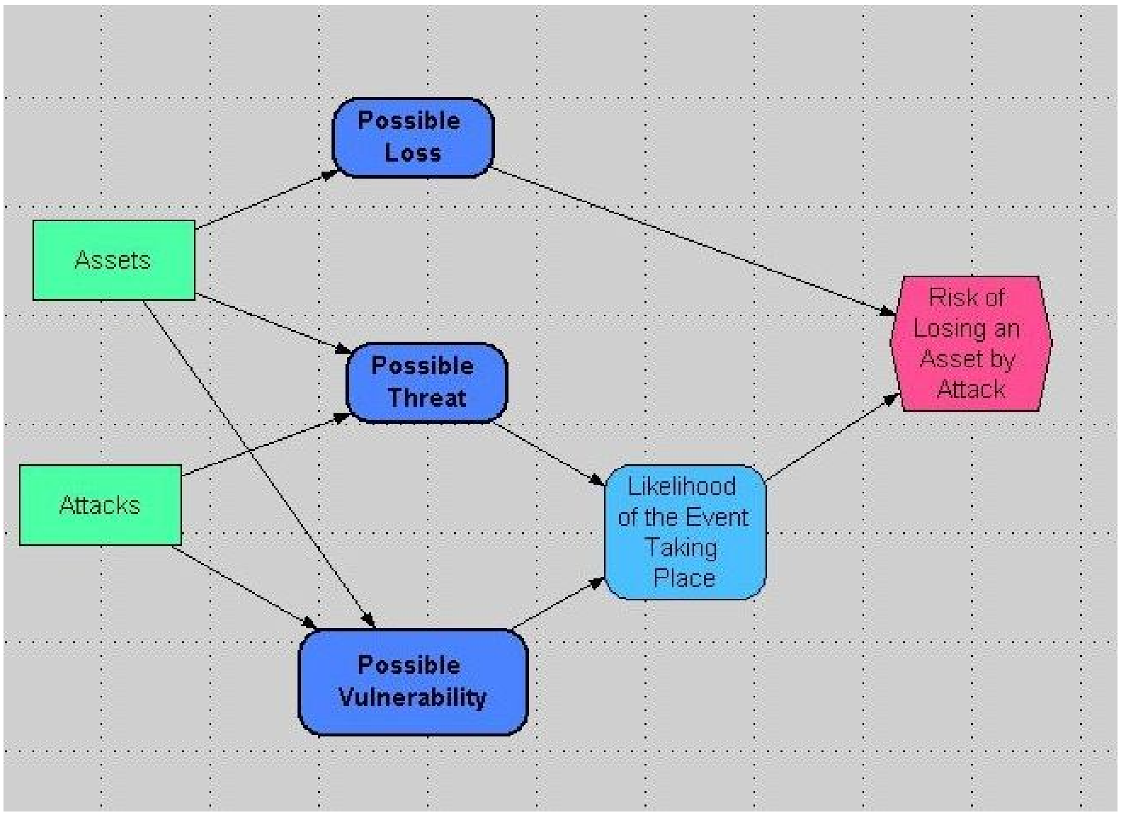

Figure 4: High-level view of our model in Analytica

Analytica used 1000 Monte Carlo simulation runs to develop a set of results using the calculations described above. The results from the simulation is shown in the figure below. The results show that the SCE scenario at Union Station has the most risk out of the scenarios considered in our project. Looking at each factor and the respective score for this scenario, it is apparent as to why this scenario has the most risk. Union Station has high potential casualties and potential economic impact scores in the potential loss factors. However, the Union Station SCE scenario scored highest in symbolic importance and target visibility and high in apparent security resulting in a very high score for potential threat to the asset.

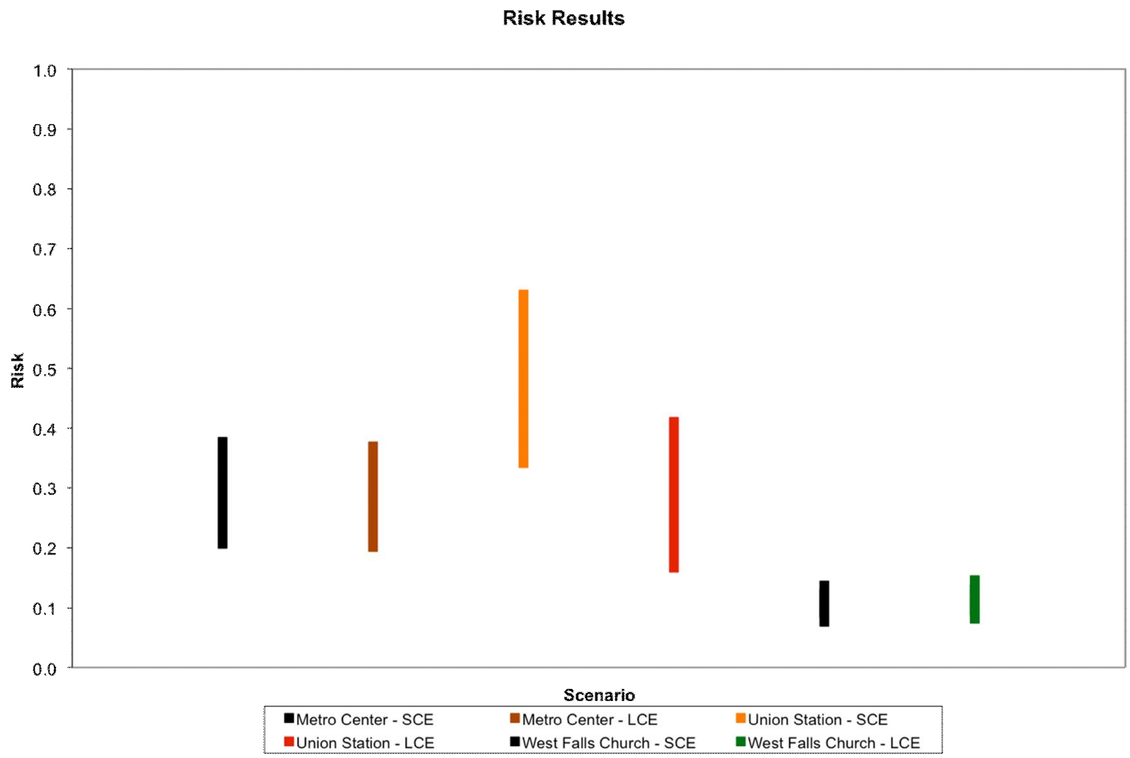

Figure 5: Plot of simulation results for risk value

Given the scenarios in this project, our suggestion is to look at countermeasures that would help decrease the risk for the SCE scenario at Union Station. Any countermeasures implemented would help decrease the apparent security score and the vulnerabilities Union Station has to a SCE attack. It is also possible that the countermeasure would have system-wide effects and reduce risk at other assets. For example, a team of explosive detecting canines can be deployed to this asset for peak hours and roam the system for other periods of the day. Another suggestion could include a project to provide baggage screening points for patrons entering Union Station. Both of these solutions would decrease the potential threat and the likelihood of a successful SCE attack at Union Station. It is recommended that WMATA develop proposals showing how much risk could be reduced from projects of these types. These proposals can be forwarded to TSGP in request of funds to complete their desired projects.

Appendix 1

This table has the inputs and overall score for potential loss for each station.

Asset	Casualties	Economic	Business Continuity	Emergency Response	Environment	Potential Loss
Union Station	1.0	0.8	0.7	0.6	0.1	0.764
West Falls Church	0.3	0.4	0.2	0.3	0.1	0.279
Metro Center	0.8	0.8	0.8	1.0	0.2	0.784

This table has the inputs and overall score for potential threat for each scenario.

Asset	Symbolic Importance	Target Visibility	Apparent Security		Potential Threat	
			SCE	LCE	SCE	LCE
Union Station	1.0	1.0	0.6	0.4	0.932	0.898
West Falls Church	0.2	1.0	0.7	0.9	0.549	0.583
Metro Center	0.3	0.9	0.6	0.5	0.549	0.532

This table has the inputs used in vulnerability. Each input is a Uniform Random Variable.

Input	Uniform(a,b)	
	a	b
Probability of Successful Planning Phase	0.50	0.90
Bollards LCE	0.30	0.50
Cameras LCE	0.25	0.40
Armed Guards LCE Detection	0.10	0.17
Cameras SCE	0.20	0.30
Armed Guards SCE Detection	0.03	0.06
Armed Guards LCE Interdiction	0.03	0.09
Armed Guards SCE Interdiction	0.09	0.17

Appendix 2

This appendix has screen shots of our model in Analytica.

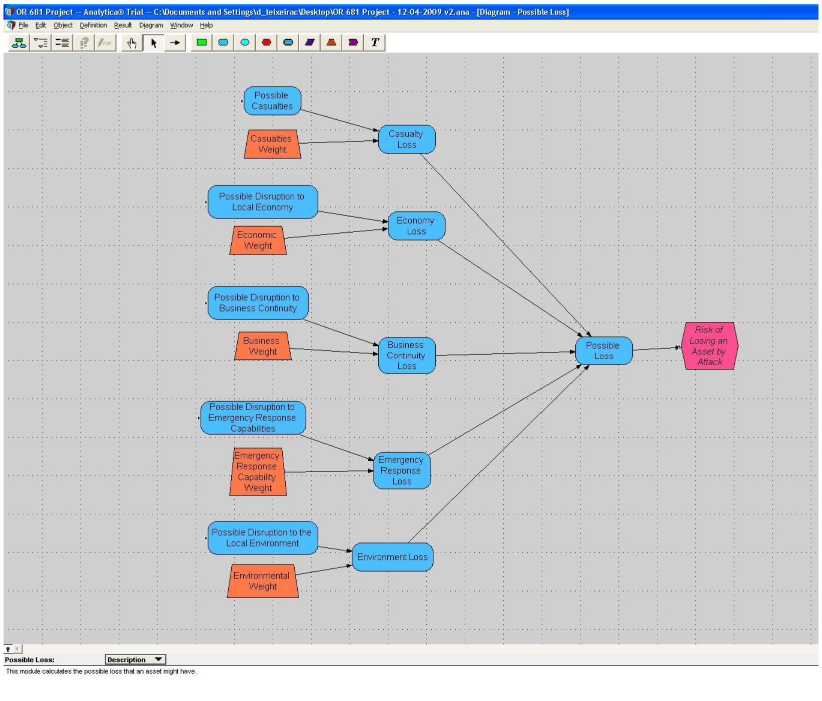

Figure 6: Possible Loss Sub-Model

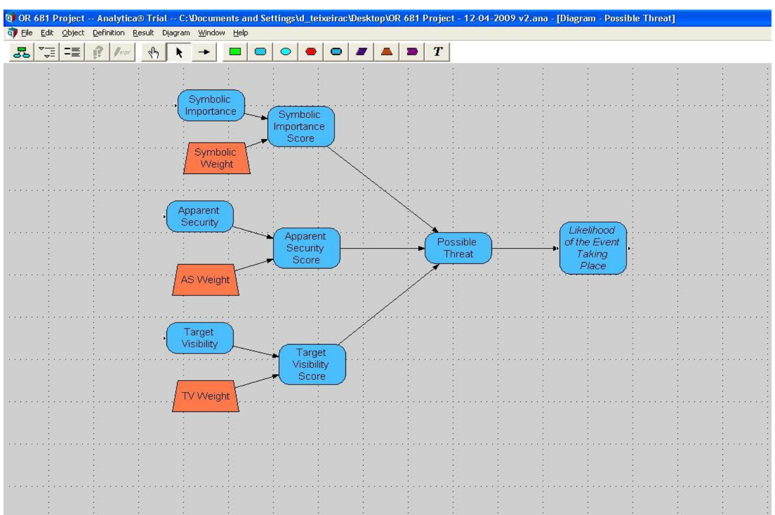

Figure 7: Potential Threat Sub-Model

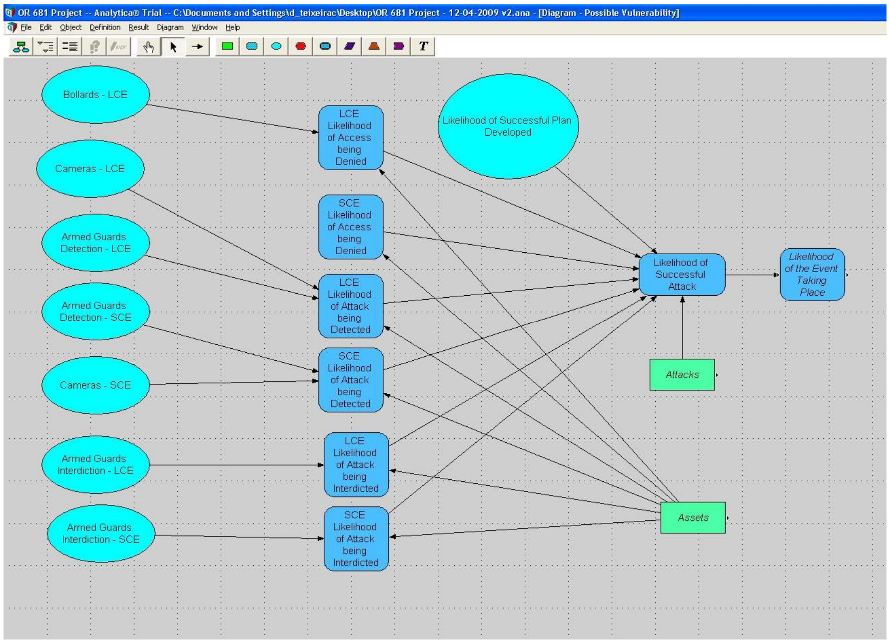

Figure 8: Vulnerability to Attack Sub-Model

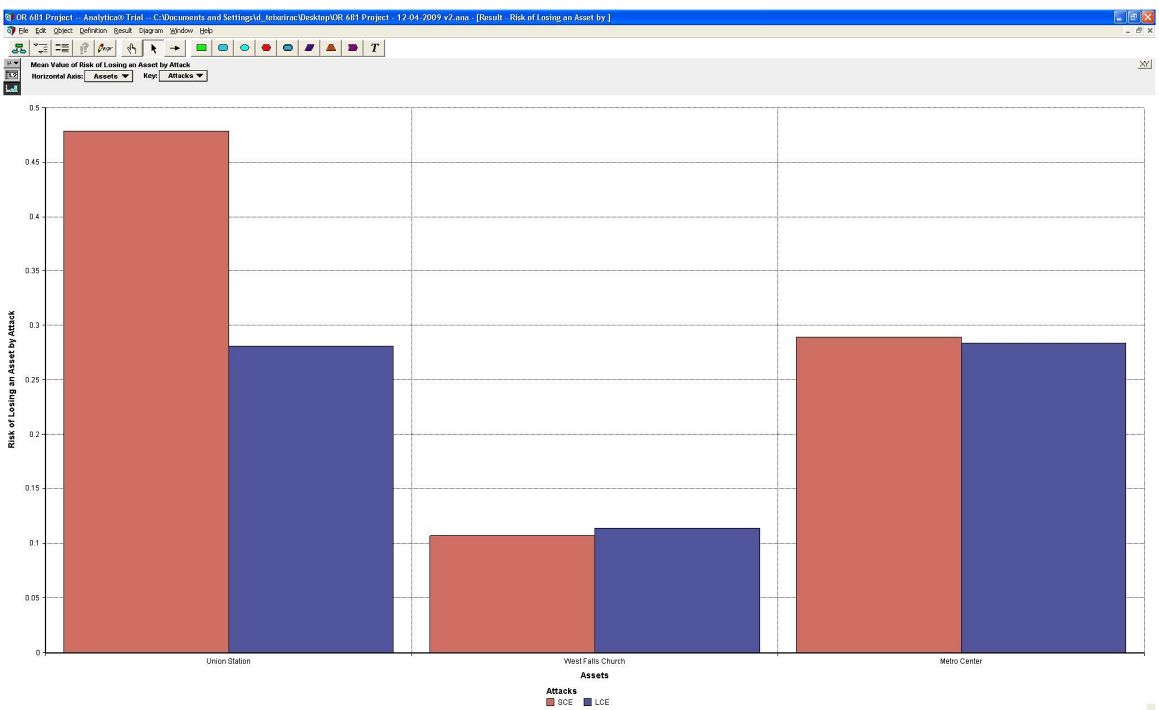

Figure 9: Analytica Results for Risk