Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 26-27, 2017

Introduction to Modeling Procedures for Physical Protection Vulnerability Assessment

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1. Introduction

There is a method for evaluation physical protection performance of facility, which is called vulnerability assessment (hereinafter refer to as "VA"). VA include expert judgment, table-top exercise, computer simulation, physical protection training, and time series analysis. In these assessment tools, the most appropriate tool to comprehensively assess the actual performance of a facility is physical protection training, but there are many constraints such as time, space, manpower, budget, and safety.

For the above reason, computer simulations are being used in various fields today. Simulation is a method to solve problem by modeling the characteristics of the reality. Although it takes more time for initial modeling than actual physical protection training such as data collection and 3D CAD work. However, once a reliable model is obtained for a facility, various simulations can be carried out using it. In this paper, we will discuss general VA modeling procedure, and concrete part will be described based on AVERT, a US commercial tool that KINAC is studying.

2. VA simulation modeling procedure

The characteristics of the VA simulation generally have a wide range of modeling, and include a considerably comprehensive element due to various types of modeling such as terrain, roads, building, people, weapons, vehicles, etc. Because relatively core algorithm is simple, how well to model various elements of facility is key to VA simulation. The following is a list and procedure of data that should be collected for modeling.

2.1 Basic infrastructure nearby facility

Basic surveys such as road, mountains, rivers, and sea near facility should be preceded. In VA simulation, modeling of infrastructure is an important factor because adversary groups should be able to start from various external locations and external response force are also located outside facility. Most of this information is publicly available and can be obtained from website recently provided by Ministry of Land, Infrastructure and Transport. In case of topographical maps, we used method of directly modeling and viewing past contour files, but recently we can directly import files provided by website and use them with some modifications.

Fig. 1. INSA (KINAC) in Daejeon with 3D information

2.2 Road and building data inside facility

It's necessary to collect data on major roads and buildings inside facility. An important part of VA simulation is building associated with guard, various fences and barriers for protection. In case of nuclear power plants, main building is MCR or nuclear reactor building where adversary wants to attack. Since this information is a security element, it is necessary to use data through appropriate procedures, and the reliability of data should be ensured through site visits.

2.3 Guard and external response force

For security guards, we should investigate exactly how many people are working, what weapons they have, and what role they play in event of situation. In case of a patrol guard, patrol route and cycle should be included. For external response personnel, it should be investigated where they are located, how many responding personnel are, what weapons are in possession, and how long it takes to get ready to go.

2.4 Scientific security equipment layout

Scientific security equipment is important because they are responsible for detection in VA simulation. Installation location and equipment specification are important. Depending on equipment specifications, detection rate, range, etc. can be adjusted in simulation. Layout of equipment needs to be verified by visiting site based on data collected. In some cases, drawings provided by facility and equipment on site may be inconsistent. So it is important to verify angle of view of CCTV and installation location and kinds of detection sensor.

2.5 3D modeling and Arrangement in simulator

Based on the survey, 3D modeling and layout are performed. Arrange the main roads and buildings based on initial topography and, if necessary, simplify detailed mountain, river and sea topography. It is important to determine and model level required for simulation because amount of data greatly increases according to detail of model related to nature. Fence of exterior of facility and foyer are installed, and corresponding personnel and role are given. Once Arrangement complete, we should divide rating on entire map. Classes are generally divided into public, private, and restricted areas.

2.6 Threat level setting and attacking arrangement

Level and strategy of adversary must be set. Generally, nuclear facilities are set up at DBT level set by government. DBT shows the number of adversary, weapons, and vehicles are roughly listed. Strategies can utilize strategies such as minimum time penetration, firepower avoidance, and detection avoidance. Strategies can be modeled manually by user with reference to actual physical protection training

2.7 Ensuring reliability of modeling and simulation

Verifying large-scale models is not easy, and there is no perfect solution. There are two main methods. One is the method of modifying model by doing actual simulation, analyzing strange points, and other one is modifying model and simulating model in a procedural manner. Both methods can be used to obtain a reliable model. Here are some specific issues that came up after trial and error. (1) Confirm road continuity, (2) Role and scope of individual person, (3) Set values of various data, (4) terrain mapping and navigation mesh.

3. Simulation Results (Example)

In the introduction of VA simulation, we will briefly explain what kind of results can be created by using the model that was performed according to previous procedure through a virtual facility example.

3.1 Configuration of simulation

Table I: VA simulation configuration of virtual facility

Guard	Adversary	Barrier	Detector
Rover(1)	Bad Guys(3)	Fence	BMS
Responders(3)	Sniper(1)	Door	PIDAS
Sentry(2)			CCTV

Configuration of facility is shown in Table I. Guard and adversary usually have rifles and pistols, while B-1 sniper has a sniper rifle and attacks inside of roof of building near facility. As shown in figure 2, facility has six CCTV (yellow zone), each door with a BMS sensor. Facility is equipped with a double fence, and a PIDAS volume sensor is installed between fences.

3.2 Simulation results of virtual facility

When simulation is performed, plan infiltration route of adversary group comes out, and events occurred during mission execution. Figure 3 shows what causes Bad guys to be detected when they enter facility. When 1000 simulations were performed, 530 was detected by PIDAS, and 47 and 70 were detected by eye and ear of southern guard (SW Sentry) respectively. In this way, initial detection point, cause of detection, point of neutralization, and cause of neutralization can be identified using event log analysis or statistical results. Based on this analysis, a quantitative physical protection effectiveness value can be obtained. If defender is successful defense 60 times through 100 times simulation because perform Monte Carlo simulations, physical protection effectiveness value will be 60%.

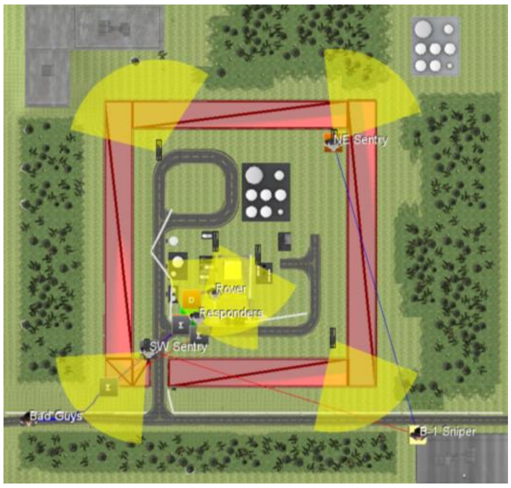

Fig. 2. VA simulation results of virtual facility

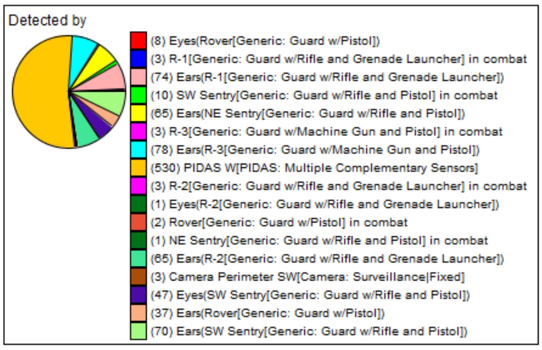

Fig. 3. Detection cause analysis of Bad guys

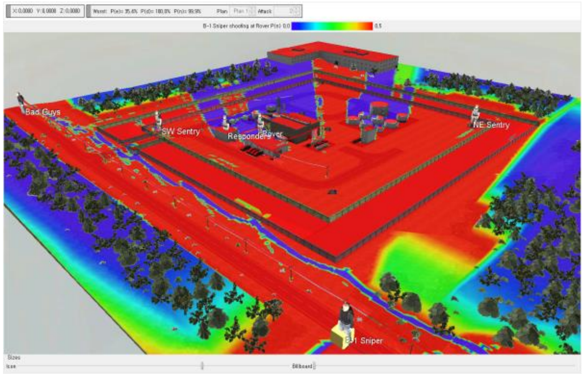

Fig. 4. Sniper shooting at guard P (n) 0-0.5 (blue to red)

Once vulnerability assessment model is constructed, it can be found incidentally, as well as physical protection effectiveness value and event log, as well as a detection probability map of facility and a map of neutralization probability of facility. Figure 3 shows neutralization probability distribution when facility is viewed from perspective of B-1 Sniper. Blue color is close to 0% probability due to blind spot, and red color is more than 50% probability. In addition, various results that cannot be derived from general human thoughts can be obtained through VA simulation.

4. Conclusions and future work

In this paper, the procedures and methods for constructing model for VA simulation are mentioned in detail. In addition, we briefly introduced results of VA simulations of virtual facilities and explained what results of vulnerability simulations are. We will introduce simulation procedures of complex facilities through future studies, and introduce simulation results and analysis methods. Finally, we will also introduce our own vulnerability assessment simulation program currently being developed by KINAC.

REFERENCES

[1]Mary Lynn Garcia, Vulnerability Assessment of Physical Protection Systems, Butterworth-Heinemann (2005).
[2]Mary Lynn Garcia, The Design and Evaluation of Physical Protection Systems, Butterworth-Heinemann (2008).
[3]Sung Soon Jang, et. al, "Development a Vulnerability Assessment Code for a Physical Protection System: SAPE (Systematic Analysis of Physical Protection Effectiveness)", Nuclear Engineering and Technology, v41, n5, p747 (2009).