UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 5 1980

MEMORANDUM FOR: William J. Dircks, Director
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Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Victor Stello, Jr., Director
Office of Inspection and Enforcement

Robert B. Minogue, Director
Office of Standards Development

FROM: Robert J. Budnitz, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NO. 94 TRANSFER OF DOCUMENTATION FOR THE FIXED-SITE NEUTRALIZATION MODEL

Introduction

This memorandum transmits the documentation (Refs. 1,2,3) of completed research on phase 1 of the Fixed-Site Neutralization Model (FSNM). This work constitutes part of a continuing NRC research project entitled, "Effectiveness Evaluation Methods for Fixed-Site Physical Protection." The study was performed by Vector Research, Inc. (VRI), under contract to Sandia National Laboratories, Albuquerque (SNLA), the NRC prime contractor for the project. Interest by the Office of Nuclear Regulatory Research (RES) was motivated by a research request (NMSS 77-1) coordinated among your offices'1/ identifying a need for evaluative methods for fixed-site theft and sabotage prevention systems. The reasons for transferring the work prior to the completion of phase 2 is to be responsive to the user request, and because there are no current plans for funding the completion of phase 2.

1/Memorandum for S. Levine from C. Smith, Sandia Laboratories Fixed-Site Physical Security Evaluative Methodology, dated 2/2/78.

The purpose of this study was to develop a computer program to assist in the detailed evaluation of the effectiveness of safeguards systems at existing or proposed facilities. The model provides a method for analyzing the capability of fixed-site nuclear facilities to protect against attempts at theft or sabotage, whether overt or covert. The model was intended to serve as a design aid for the physical layout and security force requirements for future sites, while also assisting in the evaluation of existing sites and exploring alternative means to upgrade them as may be necessary to meet regulatory requirements.

Discussion

The FSNM is a computerized dynamic Monte Carlo simulation of armed engagements and their attendant processes viewed in the context of fixed-site neutralization. FSNM simulates the engagement process between an adversary force attempting to steal or sabotage special nuclear material (SNM) being guarded by a security force on a fixed-site, augmented by an off-site response force. The model recognizes the fundamental differences which exist between overt combatants and insiders, between combatants and unarmed workers, between leaders and subordinates, and individual differences (e.g., physical skill levels, decisionmaking capabilities, and levels of acceptable personal risks) among players. In accordance with the input scenario, players may move, fire, observe, become suppressed, recover from suppression, become wounded or killed, and possibly surrender or be captured, all in the course of a simulation. As they attempt to carry out those plans described in the scenario, individual adversaries can be simulated to penetrate the physical facility, move to attack a vital area or gain control of vital facilities and SNM, and attempt to escape from the site. At the same time, guard response can be simulated as they are alerted to an attempted intrusion, move to protect the vital area, and try to neutralize the adversary forces in armed engagements, perhaps with the assistance of an off-site response force.

Because the FSNM is a stochastic model, random numbers are used at several points in the logic to determine courses of action selected by leaders, whether or not detections will occur, the firing accuracy of particular shots, and the effects of accurate shots from weapons. This gives the user the capability of assessing the overall effects of the variability inherent in the firing, observation, and decisionmaking processes on the outcome of the engagement. Using the Monte Carlo technique, replications of certain model input data can be performed using different random numbers (but all other model inputs remain the same) to determine probabilities, expected values, and other statistics.

The program updates the values of all state variables at periodic time intervals under user control. Thus, it is a time-stepped simulation. The time step which should be selected by the user is less than half the shortest time between events; otherwise, there will be anomalies in the model output. Since the firing phenomena of weapons occur very quickly, time steps should be on the order of fractions of a second, leading to longer computer run times. In all cases, it is prudent to ascertain that the primary outputs of a study are insensitive to the time step (interval) chosen.

While the user-supplied time step organizes the simulation processes in time, two geographical entities called "nodes" and "arcs" organize it in space. For every position where a person in the simulation can change his direction of motion, there is a node. Various types of nodes are distinguished, according to ehther they are in open areas, rooms, halls, roofs, stairs, doors, or windows in the site being represented. The data describing each type of node are organized into distinctive types of records that relate to the particular node. Typically, these records provide information about the node as a point as well as the region in which it is contained.

Movement in the FSNM is constrained to be along straight line segments called arcs. Each arc connects two nodes, but not all pairs of nodes are connected by an arc. No arc exists when barriers prohibit direct passage from one node to another or when it is judged that no one would have reason to travel directly between two nodes. "Paths" are ordered sequences of arcs, whereby movement from an initial location to an ultimate destination can take place by passage along a series of arcs. The representation of terrain by nodes and arcs results in a network in which every node is connected to at least one other node. These constructs (nodes, arcs, and paths) allow the essential positional, dynamic, line-of-sight, and cover effects of terrain (including structures) to be represented economically in the computer, in terms of both storage and computation time.

The physical objects or entities that are represented in the simulation are as follows: the site, its buildings, the floors of its buildings; barriers; sensors; remote controls (activated delays); people and their weapons, equipment, and vehicles. Each of these types of entities is described by the information contained in a distinctive record type in the internal data structure.

The input for the FSNM is a complete description of the scenario to be simulated, e.g., number of adversaries and guards, their locations, their weapons, entry and exit paths, etc. The specific physical characterization of the given fixed site also must be described together with site-specific descriptions of security forces, response forces, equipment, plans, and standard operating procedures.

The model determines the effects of a specific combination of input factors on the outcome of any scenario in which an adversary force, on one or more coordinated attacks, trespasses onto a site for the purpose of sabotage or theft. The detailed output is a complete time history of every event or other stimulus to which each individual guard or adversary has been subjected and his responses to those stimuli.

Results

The primary product of phase 1 is the documentation of the first version of a computer program which has the capability to simulate in great detail an engagement between guards and adversaries at a nuclear facility. The FSNM is written in non-ANSI Standard FORTRAN and is operational either "interactively" or through "remote batch" on the AMDAHL 470V/6 computer at Wayne State University. Essentially no conversion is required to make this program operational on an IBM 360/370 series computer, since both machines have a virtual memory configuration. The FSNM requires approximately 98K 32-bit decimal words of memory.

Although the program has undergone extensive testing and trial runs, no specific NRC application has as yet been made. A plan was outlined for joint RES/NMSS initial user testing of the FSNM. Details of this plan were coordinated with the appropriate staff from your office and a 3-day tutorial on the FSNM and its operation was arranged by SNLA with Mr. John Lenz, a former employee of VRI who had worked extensively on the FSNM. Following the tutorial, NMSS responded that the FSNM was not yet ready for user testing and suggested a number of improvements that could be made to the model. As a result of this user guidance, only half of the original plan was undertaken, that portion to prepare an extensive input file that would faithfully simulate the Guard Tactics Simulation (a manual board game developed by NMSS). This was done and subsequently documented.

There was also an indirect benefit that resulted from this study. While the FSNM was being developed, SNLA was creating a macro engagement model to be compatible with existing evaluation tools. This model is called BATLE (Brief Adversary Threat Loss Estimator) and was designed primarily to be part of the SAFE (Safeguards Automated Facility Evaluation) methodology. Initial versions of BATLE were quite simple and lacked user acceptance due to inadequate representation of certain factors. Due to the experience gained from developing and applying the FNSM, a more sophisticated version of BATLE was developed which has improved its credibility and acceptance.

Recommendations

Since the current documentation is being transferred to NMSS before the model has been fully completed, it is recommended that it not be utilized in any regulatory application at this time. In fact, due to the complexity of the model, it is probably more suitable as a research tool than as a regulatory tool.

It is also recommended that if phase 2 of the study is funded in the future, that the Mark-II version (Ref. 4) and the FSNM improvements suggested by NMSS be adopted. In general terms, this consists primarily of the following steps:

1. Incorporate human element aspects into the model. This includes the major personal, psychological, and group interactive variables important to such a simulation (as they pertain to individual combatants).

2/Memorandum for J. Durst from R. Zimmerman, A Program to Make a First Application of the VRI Fixed-Site Neutralization Model (FSNM), dated 8/30/78.

3/Memorandum for T. Sherr from B. Mendelsohn and B. Hatter, Fixed-Site Neutralization Model Tutorial Trip Report, dated 10/4/78.

2. Develop more realism and capability into the Leader Plan Selection Module. This module simulates the decision process by which a security force leader selects a course of action when faced with a situation arising from some adversary action.

3. Publish a more complete User's Guide. This will include full documentation of the above improvements and useful information gained through initial testing of the model.

Technical questions regarding FSNM may be referred to R. C. Robinson on extension 74375 of the Safeguards Research Branch.

T S Mueller / Acting

Robert J. Budnitz, Director
Office of Nuclear Regulatory Research

References

1. Engi, D., et al, "Fixed Site Neutralization Model Programmer's Manual," Sandia National Laboratories, Albuquerque, New Mexico, NUREG/CR-1308 (SAND79-2242), Vols. 1 and 2, December 1979.

2. Engi, D., et al, "Fixed Site Neutralization Model User's Manual," Sandia National Laboratories, Albuquerque, New Mexico, NUREG/CR-1307 (SAND79-2241), December 1979.

3. Engi, Dennis, & Charlene P. Harlan, "A Study of the Fixed Site Neutralization Model (FNSM)," Sandia National Laboratories, Albuquerque, New Mexico, NUREG/CR-0787 (SAND79-0873), November 1979.

4. Blum, R., L. Proegler, "Developments, Extensions, and Other Improvements to the Fixed Site Neutralization Model FSN (Mark-II)," Vector Research, Inc., Ann Arbor, Michigan, VRI-SANDIA-3, FR78-3, October 1978.

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