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PHYSICAL PROTECTION OF NUCLEAR FACILITIES

Progress Report

April 1979

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PHYSICAL PROTECTION OF NUCLEAR FACILITIES

Progress Report

SUMMARY

New Activities

Activities initiated during April included (1) development of a pathfinding algorithm for multiple-target, single-adversary sabotage paths, (2) further improvements to the Safeguards Automated Facility Evaluation (SAFE) methodology, the Brief Adversary-Threat Loss-Estimator (BATLE) model, and the Estimate of Adversary Sequence Interruption (EASI) Graphics program, (3) participation in the 1st Annual Symposium on Safeguards and Nuclear Material Management, and (4) assistance in the Three Mile Island accident.

The multiple-target sabotage path algorithm which was developed solves the path problem associated with a single sabotage team which has as a goal the destruction of more than one target. The problem involves determining in what order and along what path the adversary must travel in order to minimize the probability of interruption.

Improvements to the SAFE methodology now allow the analyst to analyze larger problems on the Sandia Laboratories NOS computer time-sharing system and to perform the facility digitization process without regard to the orientation of a layout drawing on the digitizing table. In addition, a model for calculating guard response times within SAFE is being developed.

The BATLE model was modified to reflect weapon type and range, cover, and posture of the target and provide a ambush (first-shot) capability. The EASI Graphics package was modified to include an option to examine the probability of system win as a function of the system variables.

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The 1st Annual Symposium on Safeguards and Nuclear Material Management was conducted by the European Safeguards Research and Development Association (ESARDA) in Brussels, Belgium, on 25-27 April 1979. A Sandia paper* which describes the evolution of methodologies for evaluating the effectiveness of physical protection systems was presented at that meeting.

Assistance was supplied to the NRC Probabilistic Analysis Staff (PAS) for the evaluation of the Three Mile Island accident. This work included a series of SANDIA-ORIGEN calculations of the radionuclide inventory of the core and decay heat generation rates.

Continuing Activities

Work continued on the effort to analyze sabotage fault trees for operating reactor facilities. Two factors have contributed significantly to the elimination of the backlog of facilities awaiting fault tree analysis: (1) the development of a capability at Los Alamos Scientific Laboratory (LASL) to prepare the computer input data needed for the fault trees and (2) the development of a new procedure for the analysis of the fault trees.

Other continuing activities included (1) development of COBOL and FORTRAN interfaces for the Safeguards Engineering and Analysis Data-Base (SEAD), (2) the application of the SAFE methodology to various nuclear facilities, and (3) documentation of the Safeguards Network Analysis Procedure (SNAP) and the SAFE methodology.

FACILITY CHARACTERIZATION

In-House Activities

The principal effort during April continued to be the joint program with LASL for the Nuclear Regulatory Commission, Office of Nuclear

*L. D. Chapman, et. al., "Safeguards Methodology Development History," SAND79-0059, to be published.

Reactor Regulation (NRC/NRR) to analyze sabotage fault trees for operating reactor facilities. All of the fault trees for boiling water reactor (BWR) facilities (BWR 2 through BWR 8) are currently being modified to reflect system changes specified by LASL. The computer analysis for several of these facilities will have to be redone. Five pressurized water reactors (PWR) facilities were studied this month; the status of this work is summarized as follows:

PWR 6 - fault tree development in process

PWR 7 - location analysis in the process of being redone due to modifications

PWR 8 - fault tree plotted, location analysis done

PWR 9 - fault tree being plotted

PWR 10 - fault tree being plotted

LASL has developed the capability of preparing the computer input data for the fault trees. All of the data received from LASL during March and April have been on punched cards (except for PWR 6). This fact has aided the data input process considerably.

A new procedure for analysis of the fault trees was implemented this month. A bottom-up substitution procedure is now being used rather than the top-down approach normally used in the Set Equation Transformation System (SETS) analyses. The development of this new procedure has greatly reduced the analyst and computer time required to complete a major portion of the analysis. Analyses that formerly required days can now be accomplished in a few hours; computer run times have been reduced from minutes to seconds. As a result of LASL's contribution to data preparation and the improvement in analytic capability, the large backlog of facilities awaiting analysis is being eliminated.

The development of an in-place reduction algorithm for the SETS code continued, and a description of a new factoring algorithm was written. Work also continued on the solution of the large directed graph (digraph) supplied by Lawrence Livermore Laboratory from their Material Control and Accounting program.

A series of calculations was performed at the request of NRC/PAS to assist in the evaluation of the Three Mile Island accident. Commencing on 31 March, the SANDIA-ORIGEN computer code was used to predict the radionuclide inventory of the reactor core and the accompanying decay heat generation rates. The SANDIA-ORIGEN code was originally developed for analyzing and characterizing a light water reactor (LWR) spent-fuel reprocessing facility and has since been used for a variety of fuel-cycle problems. The ease of input preparation and code operation allowed fast turnaround; the initial results were telephoned to PAS within a few hours after the request was made. Subsequent code runs were performed as requested for varying conditions and the output listings were flown to Washington, D.C. The development of the SANDIA-ORIGEN code and LWR fuel-cycle models allowed rapid response to NRC's request for detailed calculations related to the Three Mile Island accident.

PATH-GENERATION/SELECTION METHODOLOGY

In-House Activities

Single-Target Adversary Paths

Documentation of the ADPATH (adversary paths) code is currently being performed. ADPATH has been tested, modified, and put into final form and is now ready for use in finding single-target theft and sabotage paths for insiders or outsiders in a digraph model of a facility. The details of ADPATH's performance during testing were reported in the January-March 1979 Quarterly Report.

Multiple-Target Sabotage Paths

An algorithm has been developed to solve the path problem associated with a single sabotage team which has a goal of more than one target. The problem is to find in what order and along what path a given set of targets should be visited so that the adversary will minimize his interruption probability. An outline of the basic ideas behind the solution process was presented in the March 1979 Progress Report. Coding of a subroutine to implement this algorithm has begun.

COMPONENT FUNCTIONAL PERFORMANCE CHARACTERIZATION

In-House Activities

Safeguards Engineering and Analysis Data-Base

Development of COBOL and FORTRAN interfaces to the enhanced SEAD modules was emphasized during this reporting period. COBOL interfaces are required for ad hoc retrievals and data-base maintenance. FORTRAN interfaces are used to link SEAD to the SAFE methodology.

Updating of the old BARRIER data base is almost complete. No difficulties are anticipated in replacing the old BARRIER data base with the new version, which will serve as an interim repository pending implementation of the SEAD maintenance interfaces. The work on SEAD is a joint project being sponsored by both the Department of Energy and NRC.

EVALUATION METHODOLOGY

In-House Activities

Automation of System Evaluation

SAFE Applications -- Application of the SAFE methodology to various nuclear facilities continued in April. A representative of Savannah River Operations visited Sandia for the purpose of applying the SAFE methodology to a facility which is being studied at Savannah River. The complete analysis of this facility was accomplished in 1-1/2 days.

The digitized facility layout for the Standardized Nuclear Unit Power Plant System (SNUPPS) reactor is currently being reviewed. Corrections have been made to the layout which reflect up-to-date SNUPPS design plans. After the physical protection system for the SNUPPS is defined, the analysis will continue.

Improvements to SAFE -- Further improvements to the SAFE methodology have been made. The first improvement was an alteration of the

deterministic pathfinding code so that larger facilities can be analyzed within the restrictions imposed by the Sandia NOS computer time-sharing system. This improvement required relatively few changes to the code and resulted in only a slight increase in computer run time. The second improvement was made to the facility digitization program. This change will allow the user to place the facility layout drawing on the digitizing table without having to worry about correct drawing orientation. This capability will eliminate some of the errors which occur during the digitization phase.

Initial work was begun on the development of a model for calculating guard response times within SAFE. Guard positions will be input graphically, and then shortest-time paths to targets in the facility can be determined using existing shortest-path routines and a modified facility graph. The analyst can then examine the results in order to choose guard response times that are required as input by SAFE.

SAFE Documentation -- Work is proceeding on the preparation of a draft of the document, "Safeguards Automated Facility Evaluation (SAFE) Methodology, Volume 2: Methodology Description." Partial rough drafts of this document have been reviewed and illustrations are being prepared. Areas that require further description have been identified and are being documented.

Model Development

Expansion of the BATLE Model -- Improvements are being made to the BATLE model. Attrition rates have been greatly expanded to reflect weapon type and range, cover, and posture of the target. Two additional weapon categories have been added to the model: semi-automatic rifles and submachine guns. An ambush or first-shot capability has also been added that allows the user to specify whether a first shot is fired and, if so, which side fires the shot and the length of the firing time. Another modification will allow the user to alter the effects of the training degradation rule, if so desired.

EASI Graphics -- Another option has been added to the EASI Graphics package. This option allows the user to examine the probability

of system win as a function of the system variables for a specific facility analysis. The probability of system win is defined as the product of the probability of interruption and the probability of neutralization, i.e., the probability that the defenders are able to subdue the adversary. An estimate of the probability of neutralization can be obtained from BATLE. The new option regards the probability of neutralization as another variable of the system and provides the capability of plotting the probability of system win as a function of the probability of neutralization and one of the other variables of the system (response time, probability of communication, task time, or probability of detection).

Symposium on Safeguards and Nuclear Material Management

The European Safeguards Research and Development Association conducted the 1st Annual Symposium on Safeguards and Nuclear Material Management in Brussels, Belgium, on 25-27 April 1979. The majority of the roughly 100 papers that were presented at this meeting related to nuclear material accounting. This emphasis on nuclear material accounting is consistent with the role of ESARDA in support of activities of the International Atomic Energy Agency (IAEA) which are, in essence, exclusively of an accounting nature.

A paper was presented which describes the evolution of methodologies (developed primarily by Organization 4416 under the sponsorship of the NRC Office of Regulatory Research) for evaluating the effectiveness of physical protection systems. Based on the content of the papers which were even peripherally related to the modeling of physical protection systems, it is clear that the Sandia developmental effort in this area is years ahead of any similar efforts in other countries. Moreover, since it is currently beyond the scope of IAEA responsibilities, physical protection assurances are relegated to domestic authorities. Consequently, in the absence of domestic pressures for authorities to provide physical protection assurance, it is doubtful that any substantial developmental effort in this area will be initiated in the near future.

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Safeguards Network Analysis Procedure

Application of SNAP -- The SNAP course was completed in February 1979 in preparation for the application of SNAP to four nuclear facilities. For these applications, visits will be made to the various sites. Following this activity, SNAP facility models will be developed. An analysis of each facility will be made using different guard and adversary scenarios.

SNAP Documentation -- A preliminary draft of the report "An Application of SNAP Using the Guard Tactics Simulator Facility" is currently in review. This report describes the results of an exercise conducted to demonstrate the feasibility of applying SNAP to an analysis of the physical protection system of a realistic nuclear facility.

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