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INTERIM REPORT

PHYSICAL PROTECTION OF NUCLEAR FACILITIES

Progress Report

August 1978

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PHYSICAL PROTECTION OF NUCLEAR FACILITIES

Progress Report

SUMMARY

New Activities

New activities during August included the initial development of a subroutine which extends adversary pathfinding capabilities for both theft path and general sabotage path modeling. This subroutine will be used to replace MINDPT. Two new functional modules, PATHS and BATLE, were incorporated into the Safeguards Automated Facility Evaluation (SAFE) methodology.

Continuing Activities

Continuing activities during August included characterization of the Standardized Nuclear Unit Power Plant System (SNUPPS) and fault tree analysis for pressurized water reactors (PWRs) and SNUPPS. Work on the extension of Safeguards Engineering and Analysis Data Base (SEAD) schemas to provide characterization of sensor performance is continuing.

The MINDPT and PATHS pathfinding routines used in SAFE were updated to provide the SAFE methodology with greater flexibility.

FACILITY CHARACTERIZATION

In-House Activities

During August, the principal activities related to facility characterization were the Standardized Nuclear Unit Power Plant System (SNUPPS) characterization and the fault tree analysis in support of the Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (NRC/NRR) program at Los Alamos Scientific Laboratory (LASL). The SNUPPS characterization will be used in the Nuclear Power Plant Design Concepts for Sabotage Protection program and in a demonstration of the Safeguards Automated Facility Evaluation (SAFE) methodology.

On August 16, NRC personnel were briefed on the SNUPPS characterization program. The purpose of this briefing was to familiarize B. Immerman of the NRC Office of Regulatory Research (RES) and W. Pasedag of NRC/NRR with the SNUPPS characterization effort and the SNUPPS facility and to illustrate how the information being developed in the characterization will be used in the design study. Various drawings of the SNUPPS facility were distributed and a preliminary set of fault trees was shown and discussed. The methodology for the vital area analysis was also discussed and an example shown.

During August, work continued in support of the NRC/NRR program at LASL. Several analyses were performed. For pressurized water reactor (PWR) No. 4, the event space solution (adversary scenarios truncated to three or fewer literals per term) and the location space solution (vital areas) were obtained. This completes the fault tree analysis for PWR No. 4. For PWR No. 5, the development of the fault tree has been completed. Work was begun on the development of the fault tree for boiling water reactor (BWR) No. 2.

Contractual Support

Dikewood Industries

During August, approximately four-fifths of the Dikewood Industries

effort was expended on fault tree development. Fault trees were developed and drawn for the treetop, the auxiliary feedwater system (AFWS), and the emergency electric power system. Dikewood's remaining effort centered on writing and revising system description drafts for SNUPPS.

SNUPPS Fault Trees -- During August, eight generic fault trees (contained in the treetop) were analyzed to determine what changes are required to adapt the treetop specifically for SNUPPS. The fault trees have been modified, entered into the computer, and plotted. These eight fault trees, combined with the four trees completed in July, complete the adaptation of the generic treetop to SNUPPS. Several needed improvements to the treetop have been identified and will result in modifications to the treetop in the immediate future.

Also during August, the AFWS fault tree was entered into the computer corrected, and plotted. Minor revision of this fault tree has been made; however, computer-file correction and replotting has not yet been done.

The large and small loss-of-coolant accident (LOCA) fault trees of the treetop will be revised to recognize three sizes of LOCAs; connecting trees will also be correspondingly revised. Essentially no progress was made this month in the computer entry of the safety-injection-loops tree or in the writing of the tree for the charging pumps; this work will be done in September.

SNUPPS System Descriptions -- The following three system description drafts for SNUPPS were received from Dikewood:

Reactor Protection System (second, revised draft)
Reactor Coolant Boundary System (first draft)
Auxiliary Feedwater System (second, revised draft)

These drafts, extensively annotated, were returned to Dikewood for final editing and typing. The draft of the Residual Heat Removal System description was received on September 1.

Falcon R&D

Falcon R&D's primary effort in August was focused on the development of loop and subloop combinational fault-tree methodology. The former concerns system failure criteria when the system is designed for functional redundancies. The latter deals with equivalent, yet simple, logical representation of functionally redundant subsystems when they are interconnected by cross-ties.

A failure criteria model has been developed which is recursively generative. It is simple to use but does have one drawback: if the number of subsystems is large (greater than about four), the computational storage requirements could become excessive. (It should be noted that the same model can be applied to redundant components within a subsystem.)

Examination of the subloop representation has returned to first principles. Efforts to describe specific reactor heat transfer loops have been abandoned. Instead, abstract cases are being explored. It is hoped that investigation into these theoretical loops will reveal the fundamental disablement combinations in the minimal cut sets and thereby indicate an equivalent tree representation. If this happens, the model will be tested with actual loops.

PATH-GENERATION/SELECTION METHODOLOGY

In-House Activities

Design of a Subroutine for Both Theft and Sabotage Paths

A single subroutine which finds both theft and sabotage paths is being developed. This subroutine employs the technique (discussed in the July 1978 Quarterly Report) used to solve the theft-path problem with an inside assistant and the algorithm currently used in MINDPT to solve the sabotage-path problem. The new subroutine, which will replace MINDPT, represents an extension of adversary pathfinding capabilities, not only to theft paths but also to more general sabotage paths. This extension of capabilities results from two facts:

1. The new code seeks paths in a facility digraph where delay times and detection probabilities may depend on the direction of travel and where the nodes are used to denote each side of a barrier or target so that either one or both sides can be alarmed, and
2. The user specifies a set of possible starting nodes for the adversary, a feature which allows the adversary to be either an insider or an outsider.

The paths produced by this subroutine minimize the accumulated detection probability from the set of starting nodes up to a locus which is a guard-response time away from the destination. The subroutine then minimizes the time from the locus to the destination. For sabotage problems, the destination is a target; for theft problems, the destination is off-site but the theft path must pass through a target.

The new subroutine has not been coded nor thoroughly tested. When these tasks are completed, the subroutine will be used to replace MINDPT in SAFE, thus providing greater capability for sabotage-path and theft-path modeling.

COMPONENT FUNCTIONAL PERFORMANCE CHARACTERIZATION

In-House Activities

Generic Component Data Base Modeling

A prototype FORTRAN interface between the BARRIER module of the Safeguards Engineering and Analysis Data Base (SEAD) and users of the Estimate of Adversary Sequence Interruption (EASI) model has been exercised by NRC. The only modification required was an increase in the amount of central processing unit core storage needed to accommodate the SYSTEM 2000 data management system. The extension of SEAD schemas to provide sensor performance characterization is a continuing activity.

Security Officers

Training -- Portions of the training program for security officers who accompany shipments of special nuclear materials have been published by the Nuclear Regulatory Commission as NUREG-0465 and distributed for comments. This training program was developed by Missouri Southern State College (MSSC), Joplin, Missouri, under subcontract to Sandia Laboratories for the NRC Office of Standards Development.

A meeting was held with the Sandia security organization to discuss the MSSC training program. A copy of the complete training package was given to the security organization members with a request for their comments.

Contractual Support

Generic Component Data Base Modeling

All work performed by SRI International under contract to Sandia Laboratories has been completed and final drafts of remaining sections of Volume II: Data on "Entry Control, Assessment and Communications" have been submitted to Sandia for publication and distribution to the safeguards' users community. Publication of the handbooks and automation of methods to retrieve the material contained therein will be done at Sandia.

Neutralization

Human Parameters -- A draft report which describes the logic of subroutine PSYCHO and its integration into the Sandia deterministic neutralization model was completed by Applied Psychological Services (APS) and submitted to Sandia for review. Upon receipt of review comments, APS will modify the report and submit it for final approval.

A meeting was attended at Allied-General Nuclear Services (AGNS), Barnwell, South Carolina on August 17, 1978, to discuss the possible use of members of the AGNS security force as subjects for tests developed by APS. Attendees at this meeting included representatives from Sandia

Laboratories, APS, and staff members from the security and personnel departments at AGNS. The APS tests were described and questions regarding them answered. AGNS personnel were receptive to the idea of the proposed tests, and a tentative test date of mid-October was agreed upon.

EVALUATION METHODOLOGY

In-House Activities

Automation of System Evaluation

During August, two new functional modules were added as options to the Safeguards Automated Facility Evaluation (SAFE) methodology. These new options consist of a stochastic pathfinding routine and a macro neutralization module. The stochastic pathfinding routine, PATHS, supplements two currently available pathfinding options: KSPTH for shortest time paths and MINDPT for shortest timely detection paths. PATHS repetitively uses the basic pathfinding scheme of MINDPT to operate on facility data that are generated by random draws from user-chosen distributions with mean values based on the user's estimates for the facility data.

The macro neutralization model, BATLE, can be used to estimate the probability of neutralization along any path or set of paths. The necessary input data for BATLE are supplied through interaction between the program and the user. These data include information which describes the physical surroundings and the attributes of the combatants. BATLE is an available option when any of the pathfinding routines are used.

A demonstration of SAFE was given to R. Robinson, NRC/RES, and A. Giarrantana, NRC Office of Nuclear Material Safety and Safeguards (NMSS). The purpose of this demonstration was to present the current status of SAFE and, in particular, to illustrate the use of the two new options.

An update was made to the MINDPT and PATHS pathfinding routines used in SAFE. These changes allow any node which is used in the facility representation to be a terminal node of a path (the last node on a path).

Previously, it was necessary to use a target (in the case of sabotage) or an outer boundary node (in the case of theft) as the terminal node of a path. This new feature gives more flexibility to the SAFE methodology.

Contractual Support

Safeguards Network Analysis Procedure

Based on a review of the literature on gaming, an evaluation of the uses and benefits of a gaming capability in the Safeguards Network Analysis Procedure (SNAP) was completed. The advantages frequently cited by the proponents of gaming include (1) the training and motivation value of games, (2) the improved model validation achieved if the analyst is permitted to participate in the execution of the model, and (3) the incorporation of complex human decision-making processes within the model. The primary disadvantage of gaming is the increased time and cost of executing the model.

The design and coding of a subset of the SNAP interactive module were completed. This coding will be integrated into a copy of the current version of SNAP. Although only a small subset of the gaming features is included, it is anticipated that the demonstration module will illustrate the potential uses of gaming in SNAP models.

An outline of the final report has been completed and writing has been started on several sections. A subset of the appendices for the final report has also been completed.

A major effort during August centered around the implementation and debugging of the WAIT and TASK node changes. While this activity is time-consuming, its completion will represent the accomplishment of a major portion of the coding revisions for the new capabilities in SNAP. The coding for this portion of the project is approximately 90 percent complete.

Coding implementation and debugging activities also included development of the new engagement combining procedures. With the completion of these procedures, it is now possible for several forces to be simultaneously involved in the same engagement. In addition, forces may now join an ongoing engagement, and the arrival of a force at a particular location in the facility may now trigger the merging of two previously separate engagements into one larger engagement. These changes more accurately reflect what might happen in an actual facility and will provide the user with greater flexibility in modeling his system.

A new capability has been added to allow the user to communicate with other forces when he is involved in an engagement. The user may signal a particular WAIT node, or he may initiate a series of SIGNAL nodes for more complicated actions. Thus, the user may model situations such as a guard force requesting help when it begins an engagement.

A design has been completed for data input error checking. This will aid the user in debugging his input and enable him to get SNAP models running more quickly. Data input checking will be performed on a field-by-field basis, as well as on a more general level, for node definition, storage requirements, etc.

Coding efficiencies have been incorporated to enable further reduction in core requirements for SNAP. GASP IV is the host language for SNAP. Additional core reduction was achieved by removal of all unnecessary code from GASP as well as any unused COMMON variables. The core requirements have been currently reduced to approximately 55K octal words on a CDC 6500 computer. In addition, the overlay processing procedures in SNAP were modified to greatly reduce input/output requirements for the program. Thus, SNAP should run efficiently on SANDIA NOS in an interactive mode.

A set of briefings on the SNAP technique was presented to the Test and Evaluation (T&E) Branch of the NRC/NMSS on August 23 and 24. A set of adversary scenarios which was generated with the Board Game was used as input to the SNAP model. Representative output was demonstrated to NRC.

TECHNOLOGY TRANSFER

Technical guidance and support were provided to R. Hatter of NRC/NMSS in the application of the SAFE methodology to an example facility. Several models, including the Forcible Entry Safeguards Effectiveness Model (FESEM), SAFE, PATHS, and BATLE, were run during this application. Mr. R. Hatter has complete access to all of these models via telephone to the Sandia computer system.