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PHYSICAL PROTECTION OF NUCLEAR FACILITIES
QUARTERLY PROGRESS REPORT
JANUARY-MARCH 1977

MASTER

Leon D. Chapman,
Editor

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January-March 1977

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PREPARED FOR THE U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH
UNDER ERDA CONTRACT NO. AT(29-1)-789

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QUARTERLY PROGRESS REPORT

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PHYSICAL PROTECTION OF NUCLEAR FACILITIES

QUARTERLY PROGRESS REPORT

January-March 1977

SUMMARY

The physical protection of nuclear facilities program consists of four major areas--evaluation methodology development, path generation/selection methodology, facility characterization, and component functional performance characterization. Activities in each of these areas for the second quarter of FY 77 are summarized below.

Evaluation Methodology Development

- An area of significant development effort has been the automated approach to facility evaluation. This procedure combines a collection of functional modules for facility characterization, critical path generation, and path evaluation into a continuous operation for obtaining a safeguards evaluation for an entire facility.
- A number of modifications incorporated into FESEM (Forcible Entry Safeguards Evaluation Model) simplifies input format, provides greater flexibility for the user in defining facility and adversary attributes, and improves the defender/adversary engagement submodel.
- Plotting options added to the EASI graphics capability allow new trade-off comparisons between the attributes of a physical layout of a facility.
- An interactive game played on two graphics terminals of the computer timesharing system is being expanded to help develop safeguards strategies and to study the sequence of adversary and defender action and response.

Path-Generation/Selection Methodology

- A stochastic-pathing Monte-Carlo simulation model developed during this quarter can be used to generate optimal adversary paths to some objective, or set of objectives, within a nuclear facility.

- The subroutine KSPTH has been developed to give an analyst a range of paths over which to estimate adversary success probability.
- A contract has been awarded for the development of a computer program for cost-optimal improvement of detection and delay functional performance within a graph-theoretic representation of a nuclear facility.

Facility Characterization

- Facility characterization activities during the reporting period, January-March 1977, centered on the development of sabotage fault trees for the example reprocessing facility, collection of background data for the mixed-oxide fuel-fabrication facility, development of a uniform procedure for fault-tree analysis, improvement of the computer-graphics data-acquisition procedures, and extension of the analytic capability for quantifying sources of radioactive materials.
- The contract with Falcon Research and Development, primarily to support the fuel-fabrication study, went into effect in January.

Component Function Performance Characterization

- Activities that constitute the neutralization process may be represented in Sniper, a historical game that simulates house-to-house fighting in World War II. Sniper's resolution of neutralization activities is relatively high.
- The Human Engineering Laboratory (HEL), one of two human factors groups in the Army, was visited to study its operation. Of particular interest were HEL programs for (1) studying communications among combatants in urban surroundings and (2) testing conducted at Nevada Test Site (NTS) to determine effectiveness of small-arms fire in penetrating buildings.
- Information applicable to determining security officer performance was obtained through visits to police agencies, corrections institutes, commercial nuclear facilities, law enforcement professional organizations, academic institutions with law-enforcement training schools, and transporters of SNM. Especially stressed were the need to view the security officer's entire career and the need for making the job sufficiently attractive that qualified individuals would be interested in seeking it as a career.

- Efforts have been initiated to define factors that will increase the probability of correct response at the time of detection of an adversary. The determination of these factors and the ability to relate them to a given installation will allow better evaluation of the actual performance involved in functional safeguards areas.
- Climatic factors have been factored into a characterization of the communications security index. Several techniques can be used to evaluate the reliability of the communications system in normal weather and in stormy weather. One particularly promising approach is the frequency and duration method used by electric utilities to evaluate transmission reliability.

EVALUATION METHODOLOGY DEVELOPMENT

In-House Activities

Activities in evaluation methodology centered around the development of an approach to automated facility evaluation, improvements to both FESEM and EASI, and initial implementation of interactive gaming.

Automated Facility Evaluation

An area of significant development effort during the second quarter of FY 77 has been the automated approach to facility evaluation. This procedure combines a collection of functional modules for facility characterization, critical path generation, and path evaluation into a continuous operation for obtaining safeguards evaluation information about an entire facility. For successful achievement of such a goal, it is necessary to present to the users a large amount of data in a way that is clear, compact, and useful for analysis. Computer graphics is the tool chosen as the primary information medium.

Facility characterization, path generation, and path evaluation are areas in which much work has been done by Sandia. Until the implementation of the automated approach, however, linking these together by making the output of one process the input to the next had been carried out manually and the possibilities for input error and the time required for facility analysis were therefore large. The significant advantages of automating the information exchange process between independent routines are apparent. Also, the facility evaluation process is expected to be enhanced by implementation of the automated procedure on the Sandia NOS timesharing system, which has the benefit of being well suited for user interaction, of having available a number of computer graphics packages already on the system, and of providing results of the analysis quickly.

Each of these three basic modules have the advantage of being replaceable by equivalent functional units that perform the same basic operation but may use different algorithms or techniques in the actual code. The facility characterization code has been modified for use on the timesharing system. The output of this module--a graph in which nodes represent barriers or targets and arcs represent paths between nodes--is the input to the path-generation module.

The path-generation function has been studied most closely for substitution of alternative techniques. Originally, the generator used, SPTH3, supplied only the shortest path from a node exterior to a facility graph to every node in the graph, minimizing only one measure: either time or probability of detection. A newly written generator, KSPTH, finds up to the k^{th} shortest paths from an exterior node to every node in the facility graph. Each of these routines, SPTH3 and KSPTH, uses the Dijkstra-Yen algorithm to find the shortest path; KSPTH also uses the Hoffman-Pavley-Dreyfus algorithm to find the next-shortest path through k^{th} shortest paths. KSPTH could be used to replace SPTH3 simply by specifying k to be 1. The advantage gained by using the k^{th} shortest path algorithm, is the production of a larger subset of all paths in a facility; each path is critical in the sense that it is among the k^{th} shortest paths with respect to time or probability of detection.

Other prospects for path-generation modules are being developed for inclusion in the automated evaluation process. One prospect involves finding paths that minimize detection probability from the facility boundary up to a locus of points whose distance from a target corresponds to the time required for on-site guards to respond to an alarm. This scheme is based on H. A. Bennett's Very EASI evaluation technique for paths.

The output of the path generator is a collection of ordered sets of node identifiers, which represent the paths. With this information, the data concerning the node characteristics (e.g., delay time or probability of detection) which is made available from the facility characterization work can be used to provide the necessary input to an evaluation module that will examine the path. Currently, H. A. Bennett's EASI (Estimate of Adversary Sequence Interruption) path-evaluation method is being used because it has already been implemented on the timesharing system. Its required input is simple; and because it is an analytical technique, it is very efficient in the use of computer time. Information required by this model (other than that concerning nodes) is the expected response time of on-site guards, the standard deviation of response time, and the probability of communication of an alarm to the response forces. The output of EASI constitutes an estimate of the probability of adversary interruption on the specified path. It is possible to obtain plots showing the change in probability of interruption as one or two of the other input variables change.

This EASI evaluation process will be extended to examine as many paths as are generated. Furthermore, other methods, e.g., FESEM and ISEM, could be used as the evaluation module. Although it might be impractical to run these simulation models on all paths identified, they could run on paths shown by the EASI evaluation to be particularly vulnerable.

Path Evaluation Techniques

Some additional plotting options have been added to the EASI graphics capability now under development. These additions allow new trade-off comparisons between the attributes of a physical layout of a facility--first to the equivalent graph, then to path generation, and finally to evaluation and sensitivity analysis.

A number of modifications incorporated into FESEM (Forcible Entry Safeguards Evaluation Model) simplifies input format, provides greater flexibility for the user in defining facility and adversary attributes, and improves the defender/adversary engagement submodel. The number of barrier attributes has been expanded to provide greater detail. Each of these modifications necessitated some changes in the FESEM code, and other changes were made for simplification of the code. Arrangements have been initiated for the preparation of a users manual for FESEM. It is anticipated that FESEM will eventually be released to outside agencies.

Interactive Gaming

An important aspect of a safeguards system is the strategy to be employed in the event of an attack upon a nuclear facility. To develop strategies and to study the sequence of adversary and defender action and response, an interactive safeguards game that can be played on two graphics terminals of the timesharing system is being developed. As a first step in this development, it has been demonstrated that two time-sharing terminals can communicate. As an example, a simple two-person game has been implemented. Work on a more realistic game is continuing, especially in the area of rules and information displays.

Documentation

The report, The EASI Approach to Physical Security Evaluation, by Harold A. Bennett, was published in January 1977. A rough draft version of a user's manual for EASI has been reviewed by the NRC research staff; recommended changes have been incorporated and publication is expected in June 1977.

Initial applications of the EASI evaluation method to ERDA sites such as Oak Ridge and Argonne National Laboratory have produced favorable reactions. The new system performance requirements for safeguards regulations have apparently motivated some engineering firms (e.g., Stone and Webster, Bechtel) to request information about EASI.

Final editing and revising of a Sandia report documenting programs for EASI on Hewlett-Packard programmable calculators have been completed.

Contractual Support

Application of TRW Physical Security Model to Nuclear Facility

TRW submitted a rough draft of the final report concerning the application of its physical security model to a typical nuclear facility, the Allied-General Nuclear Services (AGNS) Reprocessing Plant. A meeting of Sandia, TRW, and AGNS personnel was held at the TRW facilities in Redondo Beach, California, on February 8, 1977, to discuss this draft and suggest possible modifications. The final report is to be submitted in April. The TRW contract consisted of four tasks. Tasks 1 and 4 have now been completed. A provision of the contract termination at the completion of Task 4, which followed Task 1 chronologically, was exercised and the TRW contract was terminated. Tasks 1 and 4 have clearly shown that the TRW model can be used in the evaluation of some aspects of fixed-site nuclear facilities; however, the model does not appear to be generally applicable for all safeguards problems. It did not seem appropriate to increase the availability and ease of implementation, as noted in Tasks 2, 2A, and 3 at this time. This is predicated on the required effort to increase the utility and applicability of the model for general safeguards problems and the current flux in methodology development at Sandia. The TRW model may be re-examined at a later date in the light of additional methodology as it becomes available.

PATH GENERATION/SELECTION METHODOLOGY

In-House Activities

Path generation/selection methodology activities for this quarter focused primarily on (1) the development of a Monte-Carlo simulation of adversary paths within a network representing a nuclear facility, (2) a technique for finding the K shortest paths and (3) a contract to develop a methodology to optimally allocate resources over a graph-theoretic representation of a nuclear facility.

Stochastic Pathing

A stochastic-pathing Monte-Carlo simulation model developed during this quarter can be used to generate optimal adversary paths to some objective, or set of objectives, within a nuclear facility. Two versions of the model are now operational. One can be used to generate minimum time adversary paths while allowing the traversal times of individual segments along the paths to be random variables described by prespecified probability distributions. The other version is used to generate minimum-detection-probability paths while allowing the detection probabilities along individual segments of the paths to be random variables described by prespecified probability distributions.

The model output includes an estimate, for each path generated, of the probability that the path is optimal. The model also generates a probability distribution function for the total traversal time (for the time version) or a composite detection probability (for the detection-probability version) of a path when it is shortest. Also included in the output is an estimate of the probability that, for each segment considered, an individual segment is on the shortest path. The latter measure is potentially useful for allocating resources (guards and sensor systems and related elements) at strategic locations throughout the facility.

A number of further modifications of the model is being considered. Currently, the capability most actively pursued involves combining the two existing versions into a third version, which takes into account a combination of the measures of time and detection probabilities. This third version could conceivably be more appropriate for path generation than either of the other two.

Path-Finding Techniques

It has been recognized for some time that shortest time paths do not necessarily maximize an adversary's success probability (as estimated by the simulation code FESEM or by the EASI method). It is possible that a near-shortest-time path is actually optimal. In order to give an analyst a range of paths over which to estimate adversary success probability, the subroutine KSPTH was developed.

KSPTH finds the K shortest time paths from the boundary to every node in a sabotage graph, where K is an input parameter. There can be more than K such paths, since several paths can have the same length, and KSPTH finds all the paths having the K shortest lengths. (A trivial modification would allow KSPTH to produce the K least-detection-probability paths.) Typically, we are interested primarily in the paths leading to the target nodes, but the paths to the barrier nodes must be found in the process.

The algorithms in KSPTH are very efficient. First, Dijkstra's algorithm is used to produce the shortest paths from the boundary to every node in the sabotage graph. Then, for $k = 2, 3, \dots, K$, the Hoffman-Pavley-Dreyfus algorithm finds the k^{th} shortest paths to every node. For a sabotage graph having N nodes and N_A arcs, the run time of KSPTH is $O(N^2) + O(NK)$, and the array storage requirements are $O((N + N_A)K)$. Therefore, both the run time and storage grow only linearly with K.

Sample run times and array storage requirements are given in Tables I and II, where

$$\begin{aligned}n_1 &= \text{number of target nodes} \\n_2 &= \text{number of barrier nodes} \\n_3 &= \text{number of boundary nodes} \\N &= n_1 + n_2 + n_3\end{aligned}$$

For example, in the largest problem shown (155 nodes and 656 arcs) $K = 20$ shortest paths to each of 150 barrier and target nodes were found in less than 3 seconds. This means that KSPTH can be readily used at an interactive graphics terminal.

Table I

CDC 6600 Run Times (seconds)

Prob.	$n_1-n_2-n_3$	Nodes N	Arcs N_A	Run Time (seconds)			
				K=1	K=5	K=10	K=20
1	1-10-8	19	40	0.015	0.043	0.089	0.164
2	1-31-14	46	112	0.060	0.167	0.321	0.508
3	20-58-4	82	514	0.223	0.534	0.971	1.748
4	30-120-5	155	656	0.637	1.061	1.686	2.752

Table II

Array Storage

Prob.	$n_1-n_2-n_3$	Nodes N	Arcs N_A	Array Storage (decimal)			
				K=1	K=5	K=10	K=20
1	1-10-8	19	40	511	1036	1755	3205
2	1-31-14	46	112	1237	2878	4986	9087
3	20-58-4	82	514	4039	8958	15,136	27,560
4	30-120-5	155	656	5715	12,284	20,570	37,315

Contractual Support

Optimal Improvements in Physical Protection

A 6-month contract for \$34K has been let to Westwood System Engineering, Inc., to develop a computer program to optimally improve detection and delay functional performance within a graph-theoretic representation of a nuclear facility.

As indicated in previous graph-theoretic work, weighted graphs can be used as partial mathematical models of facility security systems. In particular a subset of arcs within the graph represents paths which an adversary might travel in order to achieve a specified goal, either theft or sabotage. The weights in the graph represent either time to travel each path segment or detection probability.

Once a graph model of the security system is developed, the user would like to know the best way to allocate a given budget over the graph to improve the system performance. Note that only arc weight changes are being considered, not changes in the topology of the graph. This translates into determination of optimal improvement of safeguards (e.g., alarms, barriers) without significantly altering a given site's physical layout.

Initially, this problem will be treated as a linear-programming problem. Depending on the results obtained, a decision will be made whether to continue work in the non-linear aspects of the problem.

FACILITY CHARACTERIZATION

In-House Activities

Facility characterization activities centered on the development of sabotage fault trees for the example reprocessing facility, collection of background data for the mixed-oxide fuel-fabrication facility, development of a uniform procedure for fault-tree analysis, improvement of the computer-graphics data-acquisition procedures, and extension of the analytic capability for quantifying radioactivity sources.

Reprocessing Facility

A rather extensive review of the reprocessing facility is under way to define possible sabotage targets that could cause significant off-site release. The major sources of radioactivity at the example reprocessing plant are shown in Figure 1, which is the first level of the sabotage fault tree for that facility. The double-diamond symbols indicate the events that have been completely developed to the primary event level. In addition, detailed fault trees have been developed for the loss of electrical power, an event that appears in a number of branches in the tree. The analyses of the plutonium product facility (PPF), the fuel-receiving and fuel-storage station, and the high-level liquid-waste-solidification facility are next in priority for further development. Efforts to characterize the PPF and the waste-solidification facility are hampered somewhat by the fact that the information available on these processes is tentative and sketchy. Data from related NRC and ERDA studies are being used to help develop a reasonable description of the required facilities.

Mixed-Oxide Fuel Fabrication

Background information on the mixed-oxide fuel-fabrication process was collected, and a brief summary of the major steps in the process was prepared. The major sources of radioactive material in a fuel-fabrication plant were identified in this preliminary review. There are 10 areas in the plant in which significant quantities of radioactive material can be located. Because the fuel-fabrication process does not involve large amounts of stored thermal energy (which can provide a dispersal mechanism for the contained radioactivity) as does a power reactor or reprocessing facility, the possibilities of significant off-site release as a result of sabotage are not readily apparent.

Figure 1. First level of the sabotage fault tree for a nuclear-fuel-reprocessing facility.

Computer-Graphics Data Acquisition

Since facility characterization is an important element in the automated evaluation procedure, efforts are being made to automate the process of going from a blueprint to computer-usable data. We are pursuing improvements directed toward minimizing the time required for digitization of the facility layout and toward minimizing digitization error so that very little manual processing of the data will be required. We have been conducting a search for a digitizer that will be compatible with both of our graphics units: the Tektronix 4051 and Tektronix 4014. Obtaining our own digitizing equipment will obviate the need for relying on the availability of other equipment for development and production work; furthermore, the freedom to select our unit will ensure getting the characteristics most applicable for our needs.

A Talos Cybergraph digitizing system has been ordered. During the time that the Talos system has been on order, the need arose for a facility to be digitized. Programs were written for a Bendix digitizer located at Sandia and the facility was digitized. This operation provided much valuable experience and pointed to several areas where modifications could be made for reducing the time required to characterize a facility and for reducing the errors made in digitizing. New approaches in the facility characterization process are being examined.

Quantification of Radioactivity Sources

A new input/output structure was developed for the ORIGEN^{*} computer code. The code is now operational on the timesharing system. ORIGEN can be used to compute the radionuclide inventory in such inputs to the consequences model as spent fuel, the process line, and waste storage tanks. Contacts have also been made with other laboratories involved in analysis of the dynamics of boiling solutions to help quantify expected release fractions from the various liquid sources.

Other Activities

Other activities concern the development of additional techniques for manipulation of fault trees. A great deal of information on access-control requirements, damage-control options, and the like can be acquired

^{*} Oak Ridge National Laboratory Generation and Depletion Computer Code.

by appropriate reduction of the facility fault trees. The possible application of digraph techniques (as used by LLL) to the physical protection fault-tree development is also being explored.

Contractual Support

Fuel-Fabrication and LWR Study Support

The contract with Falcon Research and Development (primarily to support the fuel-fabrication) went into effect in January. Falcon has experience in the study of physical vulnerability of facilities that may be helpful in several areas of the overall program.

Fault-Tree Preparation

Significant progress was made by contractors in the development of input to the fault-tree analyses currently under way. The contractors are collecting information and preparing, under the direction of Sandia employees, the details of the required fault trees.

Fault-Tree Reviews

Arrangements have been made with Allied-General Nuclear Services (AGNS) to have its personnel review the fault trees developed for the reprocessing facility. This review should significantly increase confidence in the accuracy and completeness of the trees. The first trees have been sent to AGNS for review, and we expect to interact with them periodically during the reprocessing plant analysis.

COMPONENT FUNCTIONAL PERFORMANCE CHARACTERIZATION

In-House Activities

Neutralization

Modeling. Activities that constitute the neutralization process can be conceptualized as elements of a game being played by the security forces and the adversary. "Sniper," a historical game that simulates house-to-house fighting in World War II, was played to gain insights into the neutralization process at fixed-site nuclear facilities. Sniper's resolution of neutralization activities, which is relatively high, has a potential for serving as a useful tool for studying the neutralization process.

Human Parameters. A trip to the U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD, was the occasion for visits with John Erickson, Chief, Human Engineering Applications; Dr. Leon Katchmar, Chief, Systems Performance and Concepts; Don Egner, Team Leader, Military Operations.

The Human Engineering Laboratory (HEL) is one of two human factors groups in the Army. HEL carries out human factors studies for DARCOM (Development and Readiness Command) with emphasis on new inventory items. Most of its work is in direct support of Army request; exploratory R&D is accomplished at only very limited levels of effort. The several members of the HEL staff known by Sandia human factors personnel have a good reputation as applied human factors designers.

In support of Army programs, HEL maintains a Human Factors Data Bank, which is also available for use by other government laboratories. Unfortunately, the data bank has not been computerized. It consists of over 100,000 reports and books stored in filing cabinets. We were assured that, although a large manual effort might be required to do an information search, the HEL staff have experts available to expedite any request. Apparently, a study is under way at HEL to improve the current situation, but it is not known whether computerization is included; the first step might be only to replace the documents with microfiche copies.

HEL is the leading DARCOM agency for the MOBA (Military Operations in Built-Up Areas) program. The purpose of the program is to study the general problem of military combat in urban areas, a problem similar to

that of fixed-site safeguards neutralization. The program appeared to be a low-level effort at HEL, with the major emphasis placed on a task identification to describe the overall problem. HEL has a draft copy report defining 19-20 tasks required for understanding the problem. We have been promised a copy of this report. Apparently, only three or four of the tasks identified fit within HEL's charter and it was not clear what DARCOM will do in support of the remaining tasks. The draft report may help our understanding of the fixed-site security problem, but it appears that Sandia will have to continue largely independent of the Army MOBA program. HEL was interested in the simulated testing of urban combat which has been discussed at Fort Hunter, Liggett, California. HEL confirmed that essentially no data exist for understanding the urban combat problem. The HEL people were also interested in learning details of our tests with smoke obscurants and may send a representative to Sandia.

Two areas of work at HEL in support of the MOBA program were of interest to us. HEL people have collected some test data as part of a test program studying communications among the combatants in urban surroundings. They stressed that effective personal communications are very important for implementation of successful tactics. Since this is an area in which Sandia has little experience, this program may be of benefit to our upgrading designs for fixed-site safeguards. The other area of interest is a series of tests that HEL is running at the Nevada Test Site to determine effectiveness of small-arms fire in penetrating buildings. The personnel are studying a range of small arms from rifles to machine guns and considering walls made of brick, concrete block, and reinforced concrete. These data appear to be directly applicable to design of hardened buildings, to feasibility studies of assault tactics where breaching holes may have to be provided in captured buildings, and to studies of possible SNM dispersal that might be caused by rounds fired into buildings. The existence of these data has been brought to the attention of D. Gould, 1754, for incorporation into the barrier data base.

Although HEL expressed interest in our programs, it cannot provide a full-time consultant to Sandia because of its heavy Army commitments. Dr. Katchmar did provide a copy of an unsolicited proposal sent to HEL by Dr. John Senders describing a test of dueling performance. An important consideration derived from Sender's work on prediction of human

performance is that when a penalty is assessed for improper performance, an individual's motivation is strongly affected by his perception of whom will suffer the consequences. For instance, his behavior can be radically different depending on whether the injured party or parties are (1) himself, (2) persons toward whom he has positive feelings, or (3) persons toward whom he has negative feelings. Hence, such factors as morale can have very great weight.

Security Officers

It is generally recognized that the evaluation of the human component of the safeguards system, and in particular the security officer, is vital in ascertaining system effectiveness. Human performance evaluation consistent with human dignity and rights is an important aspect of evaluation methodology development. It is also important to recognize the vagarious nature of individual performance in any evaluation.

To assure that the security officer will, with reasonable certainty, function as required under all circumstances, each step in his career should be structured, designed, and described to ensure that an individual can be selected who is equipped physically and mentally to do the required job.

The job description will provide the basis for establishing qualifications that will be used in the selection of individuals for such a career. These selection criteria will include physical agility, as well as psychological, medical, and education/intelligence attributes. Whatever criteria are established must be demonstrably applicable to the job and not based on whim or caprice.

Once the qualifications of the job are determined and their importance established, methods must be found to ensure that individuals wishing to become security officers are properly evaluated in terms of these qualifications. Methodology used in such selection must be shown to measure/evaluate the applicable criteria reliably. The reliability of measurement must be established over all groups within the population, to preclude possible criticism in the areas of equal rights and opportunity.

Training programs must then be devised to ensure that, upon completion of the training, individuals are capable of performing the task required of a security officer. The fundamental performance skills should be obtained in a training program and other skills provided during an on-the-job training period. To ensure that the required skills have been acquired, upon completion of training, it may be necessary to stress performance-type measurements and simulation rather than more conventional testing procedures. Specifying certain lengths of training periods without making certain that the students absorb the material does nothing to assure that the individual will perform as desired.

One other aspect of the security officer career requires attention. The nature of a job that requires the ability to perform abnormal job functions on a day-to-day basis dictates periodic retraining in seldom-used skills. The nature and frequency of this retraining must be specified. This retraining period could and probably should be used as an evaluation tool. The designing of appropriate simulation and performance measures would allow required evaluation to be made. Such retraining could also serve the useful purpose of breaking the normal job patterns of the security officer for brief periods, thus possibly reducing the tedium and monotony of performing the day-to-day requirements.

It is generally accepted that the best indicator of future performance of an individual is an evaluation of his past performance. The total career performance of a security officer must be considered in any evaluation methodology; therefore, employee records of security officers should be available to appropriate evaluators. The content of these records and the thoroughness with which they are maintained are important.

A consensus concerning the above considerations was obtained through visits to the following organizations and individuals knowledgeable in the areas of selection, evaluation, and training:

Organizations

Police Agencies

Albuquerque Police Department

Los Angeles Police Department

California Police Officers Standards and Training (POST)

Corrections

Federal Bureau of Prisons

National Institute of Corrections

Commercial Nuclear Facilities

AGNS Reprocessing Plant, Barnwell, SC
Duke Power Company, Seneca, SC
Georgia Power Company, Baxley, GA

Law Enforcement Professional Organizations

International Association of Chiefs of Police, IACP,
Gaithersburg, MD
American Society of Industrial Security, ASIS, Washington, DC

Academic Institutions with Law Enforcement Training Schools

Rio Hondo College, Whittier, CA
Missouri Southern State College, Joplin, MO

Transporters of SNM

Tri-State Motor Transit Co., Joplin, MO

Individuals - Discipline and Affiliation

Dr. M. Henning, Psychologist, Falcon R&D, Albuquerque, NM
Dr. R. Young, Testing Specialist, UNM, Albuquerque, NM
Dr. P. Horstman, Police Psychologist, Prince Georges Co.,
Police Dept., MD
Dr. D. Horstman, Clinical Psychologist, Civil Service Commission,
Washington, DC
Dr. J. Fabricatore, Clinical Psychologist, working with LAPD,
Private Consultant
D. I. Gillmore, Mgr., Burns International Security Services,
Inc., Albuquerque, NM
Dr. A. Siegel, Psychologist, Applied Psychological Services,
Inc., Wayne, PA
J. McCollum, Community Programs Officer, U.S. Department of
Justice, Albuquerque, NM
Sgt. Rouse, Security Police, KAFB, Albuquerque, NM
Dr. L. Plumlee, Psychologist, Consultant to Sandia Laboratories,
Albuquerque, NM

Conferences

2nd Annual Symposium on "The Role of Human Behavior on Physical
Security," sponsored by NBS and DNA, Gaithersburg, MD

Man/Machine Interaction Evaluation

Efforts have been initiated to define factors that will increase the probability of correct response at the time of adversary detection. Detection occurs when some individual in the security force has cognition that a perturbation has occurred in the system. It is necessary, then, that some individual, most probably in the primary or secondary control room, receive and interpret some signal correctly. The probability of these being done correctly is dependent on many factors (such as displays used and freedom from personal fatigue). The determination of factors and the ability to relate them to a given installation will

allow better evaluations of the actual probabilities involved in functional safeguard areas. Along with defining the required factors, we are accumulating data necessary to evaluate effectiveness.

Communications

One effort during the reporting quarter consisted of integrating climatic factors into a characterization of the subsystem security index. Climatological environment can cause degradation in communications between response forces. For example, hard-wire communication links could be disabled by lightning, and telephone lines could be downed by wind or snow storms. Two states, normal weather and stormy weather, might be used to describe the environment. Several techniques can be used to evaluate the reliability of the communications system in these two environmental states. One particularly promising approach is the frequency and duration method used by some utility systems to evaluate transmission reliability. Presumably, one should be able to predict the duration of communications impairments and the frequency with which these impairments might occur. It should be noted that if weather conditions are severe enough to degrade communications, the response time of reserve defenders would be increased because of hazardous road conditions. Also, during severe weather conditions intrusion-sensor performance would be impaired and therefore the probability of detection would also be decreased. That is, this particular aspect of the communications subsystem functional modeling overlaps other subsystem functional modeling, and the techniques for characterizing the environment might be incorporated into other submodels.

An assessment of the applicability to the safeguard communications function of three specific ERDA-sponsored quantitative studies concerning the effects of lightning on communications systems has been initiated. In one of these studies* a simple closed-form solution is obtained for the surge current resulting when lightning strikes a buried communications cable. The other two studies deal with thunderstorm-day statistics: the effects of the electromagnetic fields from lightning on process

*"On the Use of Tailored Return-Stroke Current Representations to Simplify the Analysis of Lightning Effects on Systems," is scheduled for publication in the IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19, May 1977, pp. 95-96.

control computers and related communications networks, and the magnitudes of the voltages induced in networks from nearby strikes. Over the years methodologies have been developed to quantify the effectiveness of certain protection techniques. These methodologies might be used as a criterion to assess the communications subsystem security index at a fixed-site nuclear facility.

Contractual Support

Generic Component Data Base Modeling

The need for a hardware-oriented "generic data set" has been identified. We felt that this data set, which is to contain optimized sub-models, should be constructed by a group with extensive experience in systems analysis. The SRI safeguards group, headed by G. C. Bryne, appears to have the necessary experience and ability. This group has already performed a number of studies pertinent to our commitments to several government agencies, including the BISS program. Recent SRI studies performed for Sandia include "Summary of Intrusion Detection Sensors, Closed Circuit Television, and Video-Motion Detectors," "Technology Survey and Investigation--Base Security Devices and Systems," and "Alarm Transmission Techniques and Security." Since this work is a logical outgrowth of the above-listed studies, a contract was awarded to SRI and work on the project started in late March.

The objective of Task I in this project is to compile a generic data set that characterizes the various classes and subclasses of security equipment that can be used in safeguards programs under the jurisdiction of the NRC. This data set will interface with Sandia's design and evaluation methodology at the previously identified subsystem functional level (detection, assessment, communication, and delay). In Task II, SRI will convert this data set into computer-usable form for inclusion in Sandia's numerical models for the evaluation and design of safeguards systems. Task II will be initiated upon completion of Task I and receipt of authorization from a Sandia contracting representative.

Definition and Evaluation of Human Attributes for Neutralization Modeling

It is necessary to isolate, define, and measure the personal, psychological, and group-interactive variables needed for a model that simulates the acts and behaviors of the interaction of the defender with a small, hostile attacking force. Discussions with potential subcontractors have been ongoing pursuant to engaging in such work. The work in this area will have to be closely coordinated with the development of any neutralization model to ensure that the required parameters are available in a usable form.

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