PDR

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

SEP 5 1978

MEMORANDUM FOR: Clifford V. Smith, Jr., Director
Office of Nuclear Material Safety and Safeguards

FROM: Saul Levine, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NO. 22 - "MCSS" MODEL FOR MC&A EVALUATION

Introduction

This Research Information Letter transmits the product of completed research on the Material Control Systems Simulator (MCSS), which is part of an ongoing project for development of a method for evaluating Material Control and Accounting (MC&A) Systems. The product consists of a computer model, examples of its utilization, and user documentation. The documentation is in two manuals: "MCSS User's Manual" and "MCSS Program Reference Manual." The study was performed by Lawrence Livermore Laboratory (LLL) for the Office of Nuclear Regulatory Research (RES) in partial response to a research request (NMSS-77-1) from your office, identifying a need for evaluation methods for fixed site MC&A.

The MCSS computer program permits the determination of material accounting uncertainty and system response to particular adversary action sequences that constitute plausible material diversion attempts. The adversary actions considered are those featuring theft by stealth and/or sabotage by either insiders (i.e., adversaries having authorized access to the facility) or outsiders or both. The program is intended for use in situations where randomness, uncertainty, or interaction of adversary actions and material control system components make it difficult to assess safeguards effectiveness against particular material diversion attempts. Although MCSS was tailored to meet the needs of the overall methodology, it may be used independently in the design or analysis of material handling and processing systems.

The scope of an MCSS application encompasses the entire Material Access Area (MAA) in a fuel processing facility. When necessary, the resolution can simulate the minute-to-minute movement of SNM, in amounts potentially resulting in the diversion of dangerous quantities of SNM over a year's time or less. The SNM may be in any realistic form: solid, powders, or liquid in discrete containers.

Background

Prior to publishing the most recent regulation (in 10 CFR 73.50), detailing a new scheme for regulating fuel processing facilities, evaluation of licensee compliance was based upon a stated system of guards, barriers and other hardware and procedures. The new regulation, based on performance, makes it possible for the licensee to tailor a safeguards system to the actual nature of his facility which may make possible savings in their design while maintaining adequate protection. It may be noted that some responsible authority has always been required to certify that a particular safeguard system performed adequately. The availability of the MCSS model provides an alternative method for the certification of results by examining system performance in a systematic and uniform way at a higher level in the hierarchy than heretofore used for determining compliance.

Discussion

The MCSS program provides a set of predefined modeling functions that are generic simulations of material processing and safeguard components. To simulate a particular system, the user selects MCSS functions that represent the relevant components, then assigns parameter values to define the performance characteristics and interconnection of all functions in the model. Initial values of system state variables are specified and the model is run to observe either its detailed behavior during a single simulation run or its probabilistic behavior over a set of replicated runs.

Computer simulation is often the only practical means of approaching the design or analysis of complex systems, especially those in which uncertainty is involved. But the simulation of complex systems is itself a complex problem, and the effort required to implement a computer simulation must be carefully weighed against the benefits expected from it. The details of simulation technique can easily obscure important information and insight concerning the system under investigation. MCSS simplifies the simulation problem by providing a predefined set of functional elements whose specification in system models requires only information pertaining to the performance characteristics of material processing and safeguard components. Details concerning data structure, communications among interacting elements, scheduling of events, etc. are supplied and managed by the MCSS control program. The user needs no prior knowledge of computer programming or simulation.

In its basic form, MCSS is a Monte Carlo simulation. That is, numerous aspects of the operation being simulated are treated by sampling from various frequency distributions. Hence, the output of MCSS is statistical in nature, similar to many real life operations. For example, the model "computes" the amount of SNM that may be held up in transfer mechanisms (a random variable) and thus disappear temporarily from the facility's inventory of SNM. Therefore, since the computational structure of the model consists of a theory of how a chain of cause and effect is represented both logically and numerically, it follows that uncertainties in either the logic and/or numerical values will always remain a possibility. Regardless of this uncertainty, a rational approach to difficult decision problems is a valuable asset, if only to make the regulatory process systematic and uniform when comparing different facilities to the same set of standards.

Results

The primary product of this research is a computer program, which is hereby transmitted. MCSS is a conventional FORTRAN program that requires only an ANSI standard compiler for initial installation on most computing systems. Once the program has been installed, different model systems may be defined and operated without any additional compilation. The FORTRAN program is generated from a source program written in a specialized marco language that provides the control mechanisms of structured programming and simplified statements for recurrent segments of code. Its organization is based on the top-down philosophy of systematic programming and its coding is made uniform by use of structured programming. Details of the program are described in the MCSS Program Reference Manual.

The program is currently operable on the CDC 7600 computers at LLL. The memory requirements will vary somewhat on different computing systems and will increase as new modeling functions are added, but the file size for the two examples run required only 52K words. However, many new functions and a two or three fold increase in the dynamic storage space available for model systems would require only about 128K words of memory, which is available on most mid-sized computers.

The contractor will prepare the code for operation on any computer designated by the NRC, and will provide tutorial instruction for its use.

Results are automatically tailored to the particular type of system being simulated because the MCSS program output is generated in the form of reports printed by the individual functions involved in a system model. Special report generation functions are also provided to gather, condense, and print output data in formats especially useful in system design and assessment applications.

Two example applications are documented. In the first example, the material balance uncertainty due to different measurement errors is determined for 4-week operating periods. Then data are collected over 10 and 50 replications of the 4-week operating period to determine the means, variances, and observed probability distributions of material balance errors at specified times over the set of runs.

In the second example, it is supposed that certain coordinated actions of two adversaries might accomplish diversion from batches in processing within the material balance area. Three actions are required by one adversary and four actions are required by the other to complete the material diversion. Various stimuli are presumed generated by these adversary actions and specific characteristics of the stimuli are assigned. Monitors, control actions, and decision functions of a hypothetical material control system are defined and parameter values are specified. The simulation run is then replicated 50 times while data are gathered for determination of means, variances, and observed probability distributions of the material balance uncertainty and the material control response variables at specified times during the time interval of the simulated diversion attempt.

Recommendations

As they are now envisioned, systems that satisfy the NRC's performance based regulations will require the interaction of several different types of process and safeguards functions, many of which will involve uncertain phenomena that can be characterized only in terms of probabilistic parameters. Complexity and uncertainty involved in these systems make the credible prediction of their performance with respect to public safeguards very difficult. And the economic and strategic importance of these predictions only increase the need for credibility. By focusing attention on their functional elements, MCSS provides a systematic means of decomposing complex SNM processing facilities and their material control systems into subsystem models that can be validated individually and combined to predict safeguards effectiveness at the hierarchical levels of the NRC's performance based regulations.

For these reasons, it is recommended that MCSS be used as an ancillary aid by NMSS and other offices for (1) evaluating proposals for new MC&A systems and to upgrade existing safeguards systems, and (2) doing so with performance based regulations, that is, regulations which refer explicitely to the MC&A system in operational terms.

The sixteen MCSS functions documented in the user's manual represent a variety of basic process and material system components. They demonstrate the general capability and features of the MCSS program but are not a complete repertoire, and many new functions are planned for addition in the future. It is also expected that revisions in many functions will be made as the requirements of design and assessment applications are better defined. It is thus further recommended that Dr. R. L. Shepard of the Technical Support Branch be kept abreast of all applications of the MCSS model for purposes of considering such extensions and other desirable modifications.

Saul Levine

Saul Levine, Director
Office of Nuclear Regulatory Research

The sixteen MCSS functions documented in the user's manual represent a variety of basic process and material system components. They demonstrate the general capability and features of the MCSS program but are not a complete repertoire, and many new functions are planned for addition in the future. It is also expected that revisions in many functions will be made as the requirements of design and assessment applications are better defined. It is thus further recommended that Dr. R. L. Shepard of the Technical Support Branch be kept abreast of all applications of the MCSS model for purposes of considering such extensions and other desirable modifications.

Original Signed by
Saul Levine

Saul Levine, Director
Office of Nuclear Regulatory Research

DISTRIBUTION:
SUBJ
CIRC
CHRON
Robinson rdg
Robinson cpy
Murphey cpy
Durst
Arsenault
Jupiter
Scroggins
Levine
Branch

SAFER:RES
Murphey
8/7/78

SAFER:RES
Shepard
8/7/78

RJ Engle
8/8/78

OFFICE	SAFER:RES	SAFER:RES	SAFER:RES	RES	RES	RES
SURNAME	Robinson:dgm	Durst	Arsenault	Jupiter	Scroggins	Levine
DATE	7/26/78	8/8/78	8/16/78	7/18/78	8/31/78	8/31/78