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EVALUATING ALTERNATIVE RESPONSES TO SAFEGUARDS ALARMS

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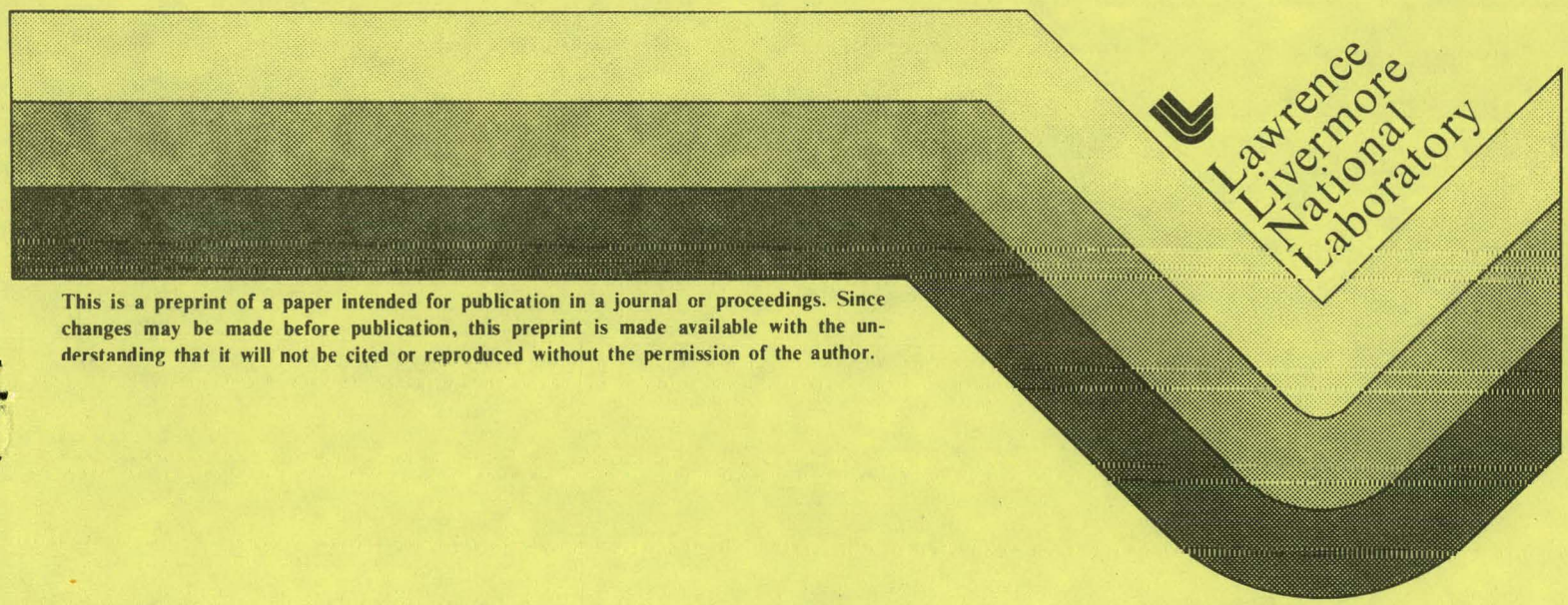

DISCLAIMER

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Abstract

This paper describes a quantitative approach to help evaluate and respond to safeguards alarms. These alarms may be generated internally by a facility's safeguards systems or externally by individuals claiming to have stolen special nuclear material (SNM). This approach can be used to identify the most likely cause of an alarm--theft, hoax, or error--and to evaluate alternative responses to alarms. Possible responses include conducting investigations, initiating measures to recover stolen SNM, and replying to external threats. Based on the results of each alarm investigation step, the evaluation revises the likelihoods of possible causes of an alarm, and uses this information to determine the optimal sequence of further responses. The choice of an optimal sequence of responses takes into consideration the costs and benefits of successful thefts or hoaxes. These results provide an analytical basis for setting priorities and developing contingency plans for responding to safeguards alarms.

1. Introduction

This paper describes the Alarm/Response (A/R) Model[1], a quantitative approach to help authorities evaluate and respond to safeguards alarms indicating special nuclear material (SNM) may be missing. This paper focuses on two types of safeguards alarms: internal alarms generated by the material control and accounting (MC&A) system, and external alarms (or threats) received from outside individuals claiming to possess stolen SNM.

We consider internal alarms caused by thefts, hoaxes, or errors. Errors include measurement or bookkeeping errors, and process losses. External alarms, which we call communicated threats, are inherently more urgent than these MC&A alarms, since the individual claiming to have SNM may threaten adverse consequences if demands are not met by a stated deadline.

In response to safeguards alarms, authorities will take appropriate actions such as investigating to determine the likely cause of the alarm, initiating measures to recover stolen SNM, and replying to any communicated threat. These response options may be evaluated in advance and included in contingency plans. The A/R Model can help decision makers respond in an actual alarm situation or develop these contingency plans.

2. Analytical Framework

The A/R Model is an extension of the Aggregated Systems Model (ASM)[2,3], a probabilistic risk analysis tool for nuclear safeguards, developed for the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. The ASM has been applied to many safeguards decisions, ranging from rapid on-site assessments of existing safeguards systems to detailed cost-benefit studies of new safeguards requirements[4]. The A/R Model uses the same probabilistic data assessment procedures developed for the ASM.

The A/R Model explicitly represents three components of the safeguards problem: threats, safeguards capabilities, and threat consequences. Potential threats include insiders attempting to steal SNM or to perpetrate a hoax (intentionally misplacing SNM or falsifying records to give the appearance of theft). Safeguards capabilities are described according to the system's ability to generate alarms and to resolve those alarms correctly. Data for this component include alarm probabilities, false alarm rates, and probabilities that resolution procedures will correctly identify the cause of the alarm.

In making the choice among alternative responses to alarms, decision makers must consider the ultimate consequences of threats involving SNM. The A/R Model includes consequences such as risks to the public from stolen SNM or successful hoaxes. Since few data exist on such risks, the model incorporates subjective judgments and allows decision makers to explore the sensitivity of alarm/response decisions to those judgments.

3. Uses of the Alarm/Response Model

The model currently has three distinct uses:

- Determining likely causes of safeguards alarms

- Evaluating alternative responses to alarms, such as, resolution procedures, recovery measures, replies to communicated threats
- Analyzing the value of more timely alarms.

In the paragraphs below we briefly describe how the model assists decision-making in each area.

Determining Likely Causes of Safeguards Alarms

The A/R Model can be used in two similar ways to help determine the probability that a safeguards alarm was caused by a theft, a hoax, or an error. First, when an alarm is received, the model can determine a revised or updated probability distribution over the possible causes of the alarm. This is accomplished by applying a technique called Bayesian updating to previously-assessed data on error frequencies and the likelihood of theft or hoax attempts. The resulting probability distribution shows the most likely cause given that the particular alarm has occurred. This information can help authorities choose a resolution procedure for investigating the alarm. Second, the A/R Model can use the results of an investigation to update the probability distribution over the possible causes. This can help the authorities select additional resolution steps. For example, when a physical inventory of SNM is completed, either all material is accounted for (MAF), which means the books balance, or material is unaccounted for (MUF). Based on the MAF or MUF outcome, the likelihoods assigned to possible causes--theft, hoax, or error--are revised using the Bayesian updating technique.

Evaluating Alternative Responses in Alarm/Response Situations

Determining the likely causes of safeguards alarms is one step in the larger problem of evaluating alternative responses to those alarms. All three types of responses (resolution procedures, recovery measures, and replies to communicated threats) are evaluated using a total cost criterion. The total cost of resolution procedures and recovery measures is the sum of immediate costs for the investigation, plus long-term economic and non-economic costs to the public. The total cost of reply to a communicated threat is the cost of meeting or refusing an extortionist's demand. In every case, the A/R Model identifies the alarm response alternative with the lowest total cost.

For any alarm, the optimal sequence of responses can be established in advance in the form of contingency plans. These plans will show the appropriate actions to take after the alarm and after each resolution procedure is completed. The actions will depend on whether the outcome of each resolution procedure is MAF or MUF.

Figure 1 shows an illustrative response plan for an alarm that indicates a missing item containing a large quantity of SNM. A decision tree format is used to show the best reponse in all contingencies, including resolution procedures following internal alarms or communicated threats and replies to communicated threats. Square decision nodes show the least-cost resolution procedure, recovery measure, or reply to a communicated threat. Response plans such as shown in Figure 1 can be tailored to the type of alarm, the quantity of SNM involved, and whether a communicated threat is received. The response plans can be developed in advance, to ensure timely action in an alarm/response situation.

Analyzing the Value of More Timely Alarms by Safeguards Systems

The third use of the A/R Model is to analyze the value of more timely safeguards alarms. More timely alarms are valuable if they improve the safeguards authority's ability to determine the cause of the alarm, speed recovery of SNM, or prevent an incorrect reply to a threat. Information on the value of

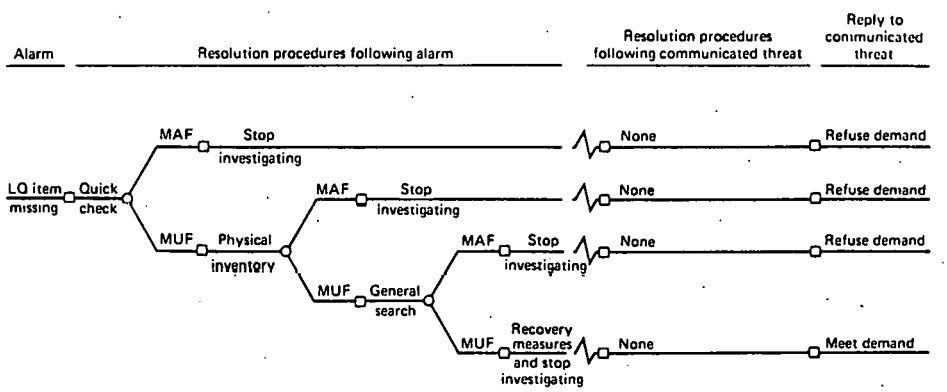

FIG. 1. Illustrative contingency plan for large quantity item alarm.

more timely alarms can assist in setting detection performance standards for safeguards systems.

For example, suppose someone were considering requiring more rapid detection standards. The A/R Model could be used to determine whether the value of more rapid detection exceeds the increased cost to comply with the more stringent requirements. Again, a total cost criterion is used: implementation cost plus future costs for resolution procedures, recovery measures, and replies to communicated threats. The value of more timely alarms is defined as the reduction in total cost when alarm times are shorter.

In addition to determining the value of shorter alarm times, the A/R Model can help evaluate the benefit of increased alarm probabilities. The analytical approach is the same.

4. Conclusions

The A/R Model provides a logical approach to the evaluation of alternative responses to alarms. It can be applied to a variety of safeguards decisions, ranging from responding to internal or external alarms to developing contingency plans. The model can also help determine the value of more timely alarms or more effective responses.

The model incorporates the needed information, analyzes that data systematically, and identifies its logical implications. In addition, it allows decision makers to quantify their judgment on critical factors and, if necessary, to use probabilities to describe the level of uncertainty in these factors. The model also allows the decision maker to judge the adequacy of available data and to determine whether it is best to gather additional information or to make a decision based on available data.

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5. References

1. R. A. Al-Ayat, B. R. Judd, and R. K. McCord, Analyzing Safeguards Alarms and Response Decisions, Lawrence Livermore National Laboratory, Livermore, CA, NUREG/CR-2404, UCRL-53034.

2. R. A. Al-Ayat, J. M. Huntsman, and B. R. Judd, An Aggregated Systems Model for Nuclear Safeguards, Volumes 1 and 2, Lawrence Livermore National Laboratory, Livermore, CA, NUREG/CR-1140; UCRL-52712 (June 1979).

3. R. A. Al-Ayat, and B. R. Judd, "A Model for Analyzing SNM Safeguards Decisions," Energy and Technology Review, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52000-81-10 (October 1981).

4. R. A. Al-Ayat, D. R. Dunn, and B. R. Judd, "Quantifying the Effectiveness of Integrated Safeguards Systems." Proceedings of the 3rd ESARDA Symposium on Safeguards and Nuclear Material Management, 6-8 May 1981.

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