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EVALUATION OF AUTOMATED EMERGENCY RESPONSE SYSTEMS

by

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INTRODUCTION

Automated Emergency Response (ER) systems are playing a greater role in providing prompt and reliable predictions of the impact of inadvertent releases of hazardous materials to the environment. Observed and forecast environmental and accident source term data are input into environmental transport and dispersion models to provide dosimetry estimates used as decision making aids for responding to emergencies. Several automated ER systems have been developed for U.S. Federal Government facilities (Garrett et al., 1982; Knox et al. 1979) and many are available commercially. For such systems to be useful, they must reliably and consistently deliver a timely product to the decision makers.

Evaluation of the entire ER system is essential to determine the performance that can be expected from the system during an emergency. Unfortunately, seldom are ER systems evaluated as a whole. Usually Quality Assurance programs evaluate the performance of individual components of the system. Most atmospheric pollution model evaluation methods usually involve an evaluation of the predictive performance of the transport and dispersion model when compared either with experimental tracer results or results from other models. Rarely, however, is the ability of the ER system to provide timely, reliable and consistent information evaluated. Such an evaluation is vital to determine the system performance during an emergency and to provide valuable information to aid in improving the system.

AUTOMATED EMERGENCY RESPONSE SYSTEMS

Automated ER systems involve more than just dispersion modelling; they encompass the entire flow of data from environmental monitoring to dosimetry estimates. Environmental observations, atmospheric measurements (wind speed and direction, turbulence, temperature, humidity and rainfall) and/or stream flow rates, are fed directly into computers for archiving and are available for immediate use in environmental transport and dispersion codes. Release data, including detailed information of the material released, measured or calculated estimates of the amount released, and information of where and when the release took place, are promptly input into a computer in an automated or semi-automated manner. Transport and dispersion codes assimilate these data, characterize the plume and calculate dose to individuals and/or affected populations. The products of the ER system are custom made to suit the particular application and relevant legal requirements.

Automated Emergency Response programs should successfully provide prompt and consistently reliable information to aid management in responding to a release. Experience has shown that reliability of each component of an emergency response system can be assured through rigorous quality control and robust design. However, the overall system reliability can only be assured by combining individual component reliability with timely coordination and redundancy.

EMERGENCY RESPONSE EVALUATION

Evaluation of an automated Emergency Response system involves the examination and appraisal of the program in its entirety. This entails obtaining a clear understanding of how the overall ER system performs and how the individual components are coordinated. The system evaluation also includes the evaluation of the individual components: the hardware, software, models, procedures and personnel. The evaluation of a model used for emergency response is not necessarily the same as the evaluation of a model used for research. A research model is rarely evaluated by run time, reliability under stress, or user friendliness of operation or output. The evaluation of an ER system amounts to more than simply the sum of the evaluation of the components.

"Validation" and "verification" are often confused with evaluation. They imply a legal, regulatory, or other official sanction for a system or its models. Sanctioning of models and ER systems usually comes under the jurisdiction of governing bodies or their representative agencies who legislate criteria that the system or models must meet to be considered acceptable. Validation or verification can only be achieved after a thorough system evaluation is completed to describe the model or system performance.

System or model evaluation is often used by regulators only to determine adherence to performance standards. However, the fields of Emergency Response and environmental modelling are still in the elementary stages of development. The evaluation process itself provides a valuable learning resource to develop and improve the system or model. This resource must not be neglected for regulatory convenience (Knox, 1985; Weber and Kurzeja, 1985).

EVALUATION OF ENVIRONMENTAL MEASUREMENTS

Quality assurance of environmental measurements include instrument specification, site selection criteria, data sampling rates, documentation, data quality assurance, procedures for instrument calibration and maintenance, traceability of standards to the National Bureau of Standards. Monitoring of the data in real-time as it comes into the computer for archiving is a necessary part of the data QA. Several organizations, such as the American Society for Testing and Materials (ASTM), the U.S. Environmental Protection Agency (EPA), the U.S. Nuclear Regulatory Commission (NRC), The U.S. Department of Energy (DOE) and the World Meteorological Society (WMO) and others, have addressed these topics in detail. Such quality assurance is a vital component in a system evaluation, but they do not evaluate the reliability and availability of timely data for the system.

An Emergency Response system requires meteorological data that is available in real-time so that the atmospheric dispersion codes can be run effectively. An evaluation of an ER system must include an evaluation of the availability of meteorological data. Availability of the data includes reliability of data transmission, instrument performance and the speed with which it can be input into transport and dispersion codes. Accessibility to suitable back-up data, including redundancy in instrumentation and data transmission, if the standard sources are not available, should be evaluated. Meteorological data includes forecast meteorology, which should also be subjected to similar requirements of reliability and availability as well as rigorous QA.

Stream transport codes are less subject to the requirement of real-time data availability as often mean flow rates and dispersion curves may be used with much less deterioration of model results.

However, as a closer scrutiny of stream transports is brought to bear, it is likely that greater demands for real-time data availability will occur.

EVALUATION OF SOURCE TERM MONITORS AND/OR MODELS

Monitors for measuring the amount of radiological, chemical or biological material released to the environment must also undergo a QA program to ensure calibration, traceability, maintenance and reliability. In a similar manner, since performance of the system depends on source term data availability, an alternate means of providing source data, must also be evaluated.

EVALUATION OF TRANSPORT/DISPERSION AND RADIOLOGICAL MODELS

The wide variety of means by which pollutants may be released into the environment, as well as the variety of pollutants themselves, requires the use of many different kinds of environmental transport, dispersion and dosimetry models. The diversity of models requires greatly varied techniques of model evaluation. Model evaluation must be model specific, but a common overall methodology of evaluation is recommended.

Model Evaluation includes examination and evaluation of the appropriateness of the model's concept, the veracity of the numerical algorithms, quality assurance and control of the model software, comparisons with observations and other models, as well as operational performance.

"Conceptual appropriateness" involves determining whether the primary physical and/or chemical processes and scales of motion, relevant to the particular application, are included in the model and evaluating the method of parameterizing these processes. However, it is often necessary to apply models to situations for which they were not originally intended. Although such applications may have diminished value, particularly from a research perspective, they may nevertheless yield useful results as aids to decision making. Therefore, the consequences and implications of using models beyond their usual range of applicability should be evaluated.

"Veracity of numerical algorithms" involves determining how faithful the numerical algorithms are to the mathematical equations which describe the physical processes i.e. the computational correctness. The importance of discretization, truncation, numerical diffusion, stability errors etc. in the model results should also be evaluated.

Quality assurance of the software involves assuring that the algorithms within each software module are computationally correct. In addition, it includes assuring that the software architecture is structured such that correct module linkages occur and that the overall software is designed to allow for reliability and consistency. This enables software modifications to be implemented with minimal system disruption. Access to modify ER codes should be controlled by procedures. Sensitivity to hardware and firmware changes should also be evaluated.

Model evaluation also involves comparisons with observational data and other model results. Comparing the predictive performance of the model with results from tracer experiments suitable for the application has considerable value for operational models, particularly when special attention is given to criteria in Protection Action Guides. Considerable debating in the scientific community has not resolved which statistical tests are most appropriate in evaluating models. Nevertheless, much guidance is available in the literature (Bowne and Londergan, 1985; Weber and Kurzeja, 1985). Model evaluation results must, however, be considered in light of the total system performance.

EMERGENCY RESPONSE EVALUATION

The most important aspects of an Emergency Response System are timeliness, reliability, availability and consistency. The information which is assimilated, calculated and displayed must be reliably available to the decision maker in a timely fashion, and the product quality must be consistent and uncertainties appreciated. Evaluating the performance of an Emergency Response System as a whole involves evaluating how well the system delivers the product as well as the quality of that product.

Evaluating the ER system includes evaluating how well the individual components are integrated into the system, as well as evaluating the individual components. The fraction of time that the ER system is available for operational use is a vital statistic. This includes evaluating the reliability of the computer systems, power supplies, instrumentation, data transmission, communications and personnel. This should also be supplemented with an evaluation of the time required to make the system operational, if it is down for various reasons.

The performance of an ER system while working under the added stress and work load required during an emergency should also be determined. Emergencies rarely occur during normal working hours, and often occur during holidays. Computer systems, personnel and maintenance is often under considerable stress during an emergency because of the pressure of immediate concerns combined with stretched resources. Availability of well-trained personnel, vital to the successful operation of the system, should be evaluated: from meteorologists to interpret model outputs and meteorological data, to technicians to ensure that the hardware and software are well maintained. This kind of evaluation is best conducted during frequent emergency response exercises. Such exercises ensure that the human components of the system are also well exercised.

SUMMARY

The evaluation of Emergency Response Systems involves evaluation of the system as an integrated program. The components of such a system all must be individually evaluated. However, the interdependence of the components is vital to the performance of the system as a whole. Timeliness, reliability and consistency with which information is received, assimilated, calculated and disseminated in a useful form, must be evaluated.

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