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A Feasibility Study for a Computerized Emergency Preparedness Simulation Facility

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Pacific Northwest Laboratory

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ABSTRACT

This report details the feasibility of a computerized Emergency Preparedness Simulation Facility (EPSF) for use by the Nuclear Regulatory Commission (NRC). The proposed facility would be designed to provide the NRC and other federal, state, and local government agencies with a capability to formulate, test, and evaluate the Emergency Preparedness Plans (EPP) which local and state agencies have/will establish for use during nuclear emergencies. In cases of any state emergency (including a nuclear emergency), high level state government officials will direct emergency procedures and insure that state and local emergency teams carry out tasks which have been established in their EPP. When an emergency exists, rapid mobilization of emergency teams, efficient communication, and effective coordination of individual team efforts is essential to safety, preservation of property, and overall public welfare. Current EPP evaluation procedures are qualitative in nature and while they do compare emergency drill performance with the EPP, the nature of the drills often does not provide enough realism to actual emergency conditions. Automated simulation of real emergency conditions using modern computer equipment and programming techniques will provide the NRC emergency evaluation teams a simulated environment which closely approximates conditions which would actually exist during a real emergency. In addition, the computer can be used to collect and log performance and event data which will aid the evaluation team in making assessments of the state or local area's EPP and their Emergency Preparedness Teams performance during emergency drills. Overall, a computerized EPSF can improve drill testing and evaluation efficiency, provide approximate emergency condition realism, and improve public awareness of local emergency procedures.

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SUMMARY

The principal goal in designing and constructing the EPSF is to provide a means whereby NRC emergency preparedness officials can create realistic simulated emergency environments for use during emergency drill procedures. The basic feasibility requirements can be met by the proposed EPSF with further study needed to determine the practical designs and cost of extending simulation realism to field crew radionculide monitors. The concept proposed for emergency simulation, emergency drill testing, and post-drill analysis can be implemented through modern computer hardware and programming.

Several alternative EPSF implementation proposals have been compiled and listed in Table 1. The alternatives range in complexity from a minimal system which meets the important (but not all) requirements of the EPSF to a maximal system meeting or exceeding the EPSF feasibility requirements. The minimal design alternative addresses meteorological simulation, ARAC access and database, on-site meteorological measurements, and graphics display of drill parameters but omits modeling, drill topology modeling, associated historical event logging, simulated radiation monitors via remote telemetry, and field testing.

The minimal EPSF conceptual design could be brought operational within approximately 12 to 15 months from the beginning of project. Inclusion of the radio telemetry system would add approximately three months. Conceptual design options would require approximately 24 months additional or a total of 36 months to finish if all optional areas were undertaken.

Short range goals of EPSF can be met through implementing one of the minimal proposed EPSF alternatives. However, to meet future emergency preparedness drill evaluation requirements and to extend emergency drill realism, an expandable system with many of the EPSF optional features included should be considered by NRC in the long term.

The EPSF has a high probability of improving emergency preparedness testing procedures in the nuclear energy field. Through automation, emergency conditions can be created in a realistic manner via modern computer simulation methods; and a computer can add invaluable assistance to NRC emergency drill evaluation teams in collecting performance evaluation data for post analysis. Even so, there are areas of uncertainty in the EPSF conceptual design. The major question unanswered is just how realistic can an emergency environment simulation be made. Conceptually, meteorology and other physical conditions associated with an emergency can be simulated realistically and accurately. However, automation of factors which have human-behavior implications could involve difficult and/or costly implementations. Unresolved simulation and operational designs should be studied further during early development phases for possible redesign in late phases or deletion with planning for implementation during follow-on development.

TABLE 1. EPSF Alternatives Summary (Cost and Timing)*

Item	Alt-1	Alt-2	Alt-3	Alt-4	Alt-5
Approx CPU	PDP11/34	PDP11/34	PDP11/60	PDP11/60	VAX or PRIME-550
Memory	128 KB	256 KB	256 KB	256 KB	1 MB
Disk	10 MB	15 MB	56 MB	134 MB	200 MB
Basic computer cost	$ 66.0K	$ 86.3K	$126.5K	$150.0K	$202.0K
Misc. peripheral cost	22.5K	22.5K	22.5K	22.5K	22.5K
Van and truck cost	45.0K	45.0K	45.0K	47.0K	47.0K
Basic equipment cost	$133.5K	$153.8K	$194.0K	$219.5K	$271.0K
Basic development cost	210.0K	210.0K	210.0K	210.0K	230.5K
Procurement cost	13.5K	15.0K	19.5K	22.0K	27.0K
Maintenance contract	6.5K	8.5K	12.5K	15.0K	20.0K
Total basic cost	363.5K	387.3K	436.0K	466.5K	549.0K
Time	12-15 mo	12-15 mo	12-15 mo	12-15 mo	12-18 mo
Telemetry system hdw.	---	$ 95.7K	$ 95.7K	$ 95.7K	$ 95.7K
Telemetry development	---	113.0K	113.0K	113.0K	113.0K
Telemetry procurement	---	9.5K	9.5K	9.5K	9.5K
Telemetry total	---	218.2K	218.2K	218.2K	218.2K
System w. telemetry	---	605.5K	654.2K	684.7K	757.2K
Time	---	15-18 mo	15-18 mo	15-18 mo	18-21 mo
Optional development:					
Population, logistics, and terrain models	none	none	minimum	medium	large
Development cost	---	---	$ 50.0K	$100.0K	$150.0K
Integrated dose model	minimum	minimum	medium	maximum	maximum
Development cost	---	---	$ 10.0K	$ 20.0K	$ 20.0K

TABLE 1. (Continued)

Item	Alt-1	Alt-2	Alt-3	Alt-4	Alt-5
Emergency plan model	none	none	none	medium	maximum
Development cost	---	---	---	$ 85.0K	$125.0K
Drill event logs	minimum	minimum	medium	large	large
Hardware cost	---	---	$ 9.5K	$ 9.5K	$ 9.5K
Procurement cost	---	---	1.0K	1.0K	1.0K
Development cost	---	---	20.0K	30.0K	40.0K
Post analysis aids	minimum	minimum	medium	large	large
Development cost	$ 10.0K	$ 20.0K	$ 40.0K	$ 60.0K	$ 60.0K
NRC Headquarters terminal	none	none	yes	yes	yes
Hardware cost	---	---	$ 20.0K	$ 20.0K	$ 20.0K
Procurement cost	---	---	2.0K	2.0K	2.0K
Development cost	---	---	13.5K	13.5K	13.5K
Field testing	minimum	medium	maximum	maximum	maximum
Engineering cost	$ 10.0K	$ 20.0K	$ 30.0K	$ 40.0K	$ 40.0K
Van transportation	---	---	10.0K	10.0K	10.0K
Miscellaneous support	---	---	$ 61.5K	$ 66.5K	$ 76.5K
Approx options total	$ 20.0K	$ 40.0K	$265.0K	$455.0K	$565.0K
Approx options time	3 months	4 months	1 year	1.5 year	2 years
Approx potential total	$ 385K	$ 645 K	$ 920K	$ 1140K	$ 1340K

*References to specific manufacturers and model numbers are intended to be representative of the industry and are not recommendations for specific vendors.

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INTRODUCTION

To meet the energy demands of our country, development and use of non-traditional fuels must be considered. An example of such is nuclear fueled electrical generating facilities. To date some 65 nuclear facilities are operating, with some 165 more under construction, ordered, or planned (NUS-1979). Thus, nuclear fueled electrical power generation plants will ultimately be located in a large number of states and U.S. possessions.

The Nuclear Regulatory Commission (NRC) has the responsibility to regulate the operation of all commercially operated nuclear facilities which generate electricity. The NRC, with this responsibility, provides for the safety of the general public by reviewing the design and construction of these facilities and determining acceptable environmental monitoring programs to detect unacceptable radionuclide levels resulting from planned or unscheduled releases of radioactivity to the environment (atmosphere, surface water, ground water, etc.). In the event of an unscheduled release, the state where the plant is located must take appropriate measures to protect its citizens and property.

States, to cope with possible unscheduled releases from nuclear facilities, must prepare formal emergency plans. The state's nuclear emergency plan defines specific authorities and provides checklists that are to be followed in various emergency situations. This plan is comprehensive since a large number of state agencies will be affected. Also, since the area around the plant site would be most affected, its political subdivision must provide an emergency plan that is compatible with the overall state plan. Further complicating the issue, if a nuclear plant resides near state boundaries, two or more state's EPP will be involved.

To determine if the emergency plans are reasonable and responsive, adequate training must be completed. The levels of competence of this training can only be measured by evaluating the actions of individuals and teams during planned emergency exercises. The NRC, besides providing guidance for the preparation of state and local nuclear incident response plans, reviews these exercises as part of the response plan approval process.

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This sequence of events seems straight forward except in so far as providing a realistic unscheduled release to test the plan. A deliberate release of radioactive material from a controlled source would be unreasonable, unwise, and prone to public criticism. Experiments with harmless tracer material might be used. However, that approach could be impractical since a large array of monitors would be required to accurately determine movement of the tracer, and since the tracer may not behave in a manner similar to radionuclides.

In order to simulate an actual release as realistically as possible, but without environmental compromise, a more practical method would be to simulate apparent plume travel through the use of a computer model. A computer could simulate the release of radioactive material into the environment, compute concentration and dose within an area around the source, and provide realistic data pertaining to a simulated emergency. If an effective remote telemetry system and simulation monitoring devices were employed, radionuclide concentrations could be transmitted to monitoring devices similar to those used by radiation control personnel.

Simulated nuclear emergency drills should exercise difficult phenomena other than radioactive material release. Road blocks, evacuations, diverting local power resources, re-distribution of law enforcement teams, and complete mobilization of emergency disaster forces could be difficult or impossible to duplicate in drill situations. These situations would be especially difficult in areas of high population density or when excessive expense would be involved. All of the above phenomena can be modeled and converted to computerized simulation in a EPSF. The effects of each can be modeled into a total emergency drill situation so that feedback parameters are taken into account. In this way, realistic emergency drills could be scheduled even though certain emergency preparedness elements might have to be absent from the actual drill.

The realism of this type of exercise stems from the fact that the simulation process is driven by local parameters and realtime conditions. Therefore, no two exercises need be exactly alike. Since a minicomputer would be an integral part of the simulation process, other information from the exercise (monitor location and movement, emergency response directives, etc.) can be stored for later explanation by the NRC evaluation team. This will then allow review personnel to quantitatively evaluate the operation of the state's emergency response plan.

The purpose of this study is to determine the feasibility of constructing an Emergency Preparedness Simulation Facility (EPSF) for use by the NRC in their continuing review of state emergency plans for coping with unscheduled releases of radioactive material. Major considerations are given to feasibility requirements, criteria used in the specification, design categories and sub-systems, estimated cost, and implementation plans.

OBJECTIVES

The goal of this feasibility study is to determine if a portable computer facility can be designed and constructed which meets certain requirements. These feasibility requirements, in general, specify functional performance levels which will become design goals during the project design phase. Feasibility is evaluated through presentation of several specification criteria which identify specific areas for which functional performance must be evaluated.

FEASIBILITY REQUIREMENTS

The requirements of the facility, to which this study applies, are:

(A) The computer simulation models must compute realistic atmospheric transport and diffusion within the area of study.

(B) The facility must have the capability of interfacing with the Atmospheric Release Advisory Capability (ARAC) facility at Lawrence Livermore Laboratory (LLL), Livermore, Ca.

(C) The computer should be capable of interfacing to meteorological equipment located at/near the nuclear power plant.

(D) The computer and its associated communication equipment should be capable of producing realistic concentration data to simulated radionuclide monitors at distances up to 50 miles from the reactor site and for time periods up to 24 hours.

(E) The computer and its associated databases should provide access to EPP scheduling parameters for comparison with actual drill events as they occur.

(F) The models should compute integrated dose for any area within the region of the nuclear power plant site.

(G) The computer and its associated software should generate an historical database during the experiment for post analysis evaluations.

(H) The facility, computer, and peripheral equipment must be mobile, easily transportable, rugged, and relatively easy to maintain.

SPECIFICATION CRITERIA

This study addresses the feasibility of each subsystem component based upon the following specification criteria:

(A) This study presents sub-system conceptual design. Special attention is paid to possible, most practical, and most cost effective conceptual design possibilities.

(B) Anticipated problem areas associated with design, procurement, construction, or operation of the facility are presented whenever such problems are considered to be greater than normally experienced with computer facilities.

(C) Anticipated problem areas related to federal, state, or local regulations are presented.

(D) The conceptual design discussions include the various advantages, and disadvantages of each possibility.

(E) The conceptual design discussions include cost estimates for each major subsystem component for hardware, software, and development on a per-year, per-trip, per-mile, or per-unit basis.

(F) Conceptual design discussion estimates time to design and implement. Time estimates are also addressed in section 6.

(G) The conceptual design discussions suggest possible contacts, agencies, and vendors which might be employed during the design and implementation phases of the project. (See Appendix-B)

CONCLUSIONS AND RECOMMENDATIONS

This study indicates that a computer-based EPSF can be developed to support validation and testing of state emergency plans. The technology is available to develop a broad range of capability from a minimal system capable of meeting basic near-term needs to an extended system which will provide enhanced testing and realism.

Implementing a basic system to meet the immediate need for a mobile EPSF is the most important near-term objective. However, we anticipate that NRC will require the capability of extended testing in the three to five year timeframe. Therefore, five alternatives have been developed that provide various approaches to meeting technical, economic, and timing constraints.

Alternatives 1 (without radio) and 2 (with radio) are cost constrained alternatives that either meet the basic requirements (alternative 2) or can be upgraded to meet the basic requirements (alternative 1). These alternatives provide the capability to put a basic system in the field in a timely manner and to more fully explore the EPSF concept under actual conditions. The major disadvantage of these alternatives is that they are not easily expandable beyond meeting the basic requirements. Any future enhancements would necessitate replacement of the computer system.

Alternatives 3, 4, and 5 represent systems which are fully expandable up to the maximal capability anticipated. Major differences between alternatives 3, 4, and 5 involve the sophistication and realism of the software that supports the field tests. Advantages include a more sophisticated basic system and the capability for expansion without replacing computer hardware. The major disadvantages are the higher technical risk and entry cost.

Battelle recommends that NRC implement alternative 1 in FY 80 and plan to add the expansion to alternative 2 in the first quarter of FY 81 based on a design decision in mid-FY 80.

Additionally, Battelle recommends that NRC begin preliminary budgeting for alternative 3, 4, or 5 as an advanced system to be operable in the FY 83 or 84 timeframe. A decision to develop the advanced system will depend on the performance and evalu :on of the basic system coupled with any changes in emergency preparedness planning that evolve over the next year or two.

EPSF SYSTEM OVERVIEW

EPSF PURPOSE

The NRC reviews state emergency plans on a regular basis to insure that state and local nuclear emergency plans meet certain standards and guidelines [6]. Evaluation of state EPP's are based upon emergency drills and qualitative inspections of emergency team performance. Evaluation procedures compare emergency drill performance with the state's EPP to the extent that emergency drill and qualitative inspection allows.

The purpose for implementing the EPSF is to enhance emergency drill realism and to improve drill evaluation methods through automation. The EPSF goal is to create a simulated emergency environment that closely approximates conditions which might actually exist during a nuclear emergency but without jeaopardizing the environment, property, or public welfare and to produce a means from which comprehensive EPP drill evaluation can be made.

EPSF FUNCTIONAL DESCRIPTION

NRC evaluation teams will use the EPSF during emergency drills at nuclear power generating sites around the country. In order to expedite access by the NRC teams, provide reliable interactive operation, and interface to onsite data acquisition equipment, the conceptual design includes a mobile van facility in which computer, storage devices, terminal equipment, data communications gear, and other peripheral equipment will be housed.

Pre-drill activity includes both physical and simulation setup procedures. Before drill testing, the EPSF simulation models will have been tailored to the particular nuclear site through incorporation of site and local area parameters into the EPSF databases. Preliminary simulation runs on the computer can be used to predict emergency situation realism. Physical setup includes transportating the EPSF to the site, selecting an operating location with acceptable power mains and plant access, connecting EPSF data acquisition hardware to onsite measuring devices, setting up EPSF communication equipment, and generally getting the facility ready for drill procedures.

During pre-drill activity, the NRC team will have hypothesized one or more accident simulations to be modeled during the drill, when the drill period begins, EPSF operation crew shall initialize the computer simulation and historical databases. As the simulation progresses, various emergency events will be reported through the EPSF display equipment. At appropriate times, pertinent information will be given to site and state officials either through voice or computer terminal communication.

At the time when the initial simulated emergency condition(s) is reported, the person(s) involved will be required (by the EPP) to inform appropriate channels and take whatever first step actions might be specified in their EPP. At that time, the EPP will have been put into action and from that time on, the EPSF and its crew will dispatch emergency condition information to appropriate channels either through voice communication or remote computer terminals. Emergency voice radio channels, emergency director's telephone circuits, and drill event logistic transactions could be recorded on the EPSF computer storage media and audio equipment providing a comprehensive drill history. Important events (e.g., evacuation orders, roadblock assignments, and executive decisions) and time-of-day will be entered both as simulation model parameters and into the historical database.

After the simulated nuclear emergency has progressed for some predetermined time period, the computer will be able to display certain performance data for the EP evaluation team. Such evaluation might be based on EP logistics, evacuations, and population exposure profiles. These computerized displays could be bar-charts, graphs, or comprehensive x-y color maps. EPSF drill performance graphics can be made available at NRC headquarters so that onsite evaluation personnel can effectively communicate drill statistics with other NRC and government officials.

After these cursive evaluations, NRC teams might want to alter the nature of the simulation drill. Emergency situation modification could be deemed desirable in order to exercise portions of the state's EPP not initially included in the scope of the hypothesized emergency. The evaluation team and EPSF operations crew would alter and tailor an emergency situation during the drill simply by entering executive commands at one of the computer's operating terminals.

An emergency drill would be terminated at the discretion of the NRC teams. Drill history (historical database and voice transmissions, if recorded) would then be available for post-drill analysis. Such analysis could be performed on the EPSF mobile facility's computer or could be transmitted on tape to other systems for extended comprehensive evaluations. Since state EPP's have required communication and mobilization procedures [7], that information will also become part of the computer database for comparison with actual response actions taken during the drill.

Upon drill termination, the EPSF operations crew would dismantle the store portable equipment, make backup copies of site-dependent databases, secure the permanently housed computing equipment, and generally ready the facility for transport to the next drill site.

EPSF OPERATING BENEFITS

The EPSF will improve the quality of state emergency response plans. It will allow public citizen involvement and will increase their confidence toward the state's ability to respond to a nuclear emergency condition. The EPSF will enable states to gain confidence in their emergency plan. As a technology benefit, this type of system can be used to monitor the response of the state to other emergency situations to which state officials must respond. Finally, it allows the NRC a technique to compare plans and determine new emergency plan specifications and techniques.

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EPSF SUB-SYSTEMS CONCEPTUAL DESIGNS

MOBILE FACILITY

Function and General Description

The mobile facility is in essence a room-on-wheels designed to house a minicomputer and its operating personnel, peripheral and communications equipment, support equipment, and observer personnel.

Two types of mobile vehicles were considered: a self-contained motorhome and a truck with towable trailer. The general description of each, costs and procurement times, and advantages/disadvantages are discussed in the succeeding sections.

The truck/trailer combination affords more flexibility and more room for the square foot price than does the motorhome option. The entire computer center, including observers, could be contained in the trailer, whereas the observers would have to be housed external to the motorhome during operation.

The decision to buy or to rent a truck to tow the trailer need not be made at the same time the trailer is purchased. This means that the trailer could be purchased and renovated into a computer facility in one fiscal year and the truck purchased or rented in the next.

Should the engine fail on the motorhome, it would have to be repaired on the spot, or the entire motorhome towed to its destination and then have the engine repaired. The same situation for the trailer would result in another truck towing the computer facility to its destination.

There are no highway restrictions for either type of vehicle. A possible point to consider through is that the motorhome is fueled by either gasoline or propane while the truck would be diesel powered.

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Motorhome

Description

Various "recreational" type vehicles were investigated - motorhomes, campers, travel trailers. Most of these vehicles are not available without the associated recreational equipment included. One motorhome manufacturer, however, does sell a stripped down version with the option to add additional features such as roof mounted air conditioners/heaters, a cargo door, special lighting, drop down bed over the driver/passenger seats, and anything else which could normally be installed in a motorhome.

The motorhome comes in various sizes, i.e., 23 feet long and 29 feet long. The useable length inside of the vehicles, from the drivers compartment to the rear wall, is 16 feet 9.8 inches and 23 feet 6.8 inches, respectively for the above dimensions. Storage cabinets would be built wherever feasible in order to optimize the available space.

Cost and Procurement Time

A 29 foot long stripped down Winnebago motorhome with the standard driver/passenger compartment and the specifications shown below costs about $20000. The air conditioning units located on the front and rear top of the vehicle can provide some heating, but it is advised to install a separate 30000 BTU heater. The total cost of these units of $1500. It is estimated that the remaining costs to prepare the vehicle will be about $10000. This includes power cables, air ducts, tie down points, lighting, air filtering, and storage cabinets. The total cost comes to about $31500 or $180 per square foot.

The procurement time depends heavily on the amount of optional features installed at the motorhome factory. The basic vehicle can be obtained within 1 to 3 months.

Specifications:

Chassis:	M-500 Dodge or equivalent
GVWR:	14,000 pounds
Wheelbase:	178 inches
Tires:	8.00 x 19.5 load range "D"
Engine, Standard:	Dodge 440-3, 440 cubic inch V-8 or equivalent
Transmission:	3-speed automatic
Batteries:	(1) 70-amp and (1) 105-amp deep cycle
Alternator:	63-amp
Body:	12-volt D.C. and 110-volt A.C.
Outlet Circuits:	(1) 20-amp left side, (1) 20-amp right side, and (1) 20-amp air conditioner circuit

Advantages/Disadvantages

The motorhome is a very compact, self-contained unit which can be fueled by either gasoline or propane. It is a smooth riding vehicle with no highway travel restrictions.

The compactness of the motorhome is one of its disadvantages. The inside height of 6 feet 6.5 inches leaves very little room for overhead storage cabinets, lighting fixtures, and power cables. There is little or no room for any one else inside the motorhome except those persons actually operating the computer, and there is no way to separate the observers from the noise and dust restrictions except to put the observers outside the motorhome. It would also be difficult to install the CPU in the motorhome. The CPU would have to be disassembled into its individual bays, moved into the motorhome, and reassembled inside; the same process would be required for removing the computer.

Having the engine as an integral part of the vehicle has its disadvantages. An engine failure would either have to be repaired before the vehicle could continue, or the entire motorhome "towed" to its destination.

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Truck/Trailer

Description

Trailer types which were considered for this application are furniture moving vans and freight shipping vans. Air ride suspension is available on both types of trailers for a "smooth" ride. Various length vehicles are available; those considered for this application are between 30 and 40 feet long.

Trailers can be purchased with various options installed at the factory such as extra insulation, power cables, air conditioners/heaters, etc.. About the same options are available in a trailer as are in a motorhome. All trailers considered have a standard towing hookup and leveling landing gear.

Trucks to tow the trailer can be either purchased or rented for the move, and, if purchased, need not be done so at the same time as the trailer. Any truck with a standard hookup could tow the computer facility trailer.

An additional storage bay beneath the trailer, between the front and rear wheels, is available to carry generators, antennas, and miscellaneous equipment.

Cost and Procurement Time

A 40 foot long air-ride trailer would cost about $13500. This vehicle would be 8 feet wide and between 7 and 10 feet high on the inside. Air conditioning and heating units for this volume are estimated to cost $3500. If the option is taken to procure a truck, it would cost on the order of $20000 (for a Kenworth). The remaining costs to install power cables, air ducts, tie down points, lighting, air filtering, and storage cabinets are estimated to be $10000. The total cost comes to about $47000 for the truck/trailer combination and $27000 for the trailer alone, or $145 and $85 per square foot, respectively.

The procurement time ranges from a few weeks to 3 months, depending on the availability and location of an acceptable trailer.

Advantages/Disadvantages

The trailer option gives lots of room for the cost. A 40 foot long trailer has over 300 square feet of floor space and is between 7 and 10 feet high inside depending on the style of the trailer (furniture van, electronics van, freight van). Air conditioning ducts, lighting fixtures, and power cables could be installed in a false ceiling and still have enough head room for the occupants. Because of the roominess of the trailer, additional facilities can be provided for the computer and observer personnel. Lavatory, kitchenette, and sleeping quarters can be incorporated into the available floor space and still have adequate work areas. Sufficient space exists for communications equipment and storage cabinets.

The rear cargo doors on the trailer make it possible to easily install and remove the CPU in one piece. A dust and noise barrier can be constructed between the computer and the work area thus making it possible for the computer, its operating personnel, and the observers to be self-contained in the computer facility. No other support equipment or facilities (except for external electrical power brought to the trailer) would be needed.

There are no highway restrictions for a trailer of the size being considered (namely 8 feet wide and less than 12 feet high). The trailer can be towed by any standard towing truck on the highways, and can be shipped piggyback by rail, boat, and by air. When the trailer is not in use, there is no maintenance required on it.

The option for purchasing the towing truck or having the trailer towed by a towing company has its advantages and disadvantages. If the truck is purchased, it need not be done so at the same time as the trailer is purchased. Thus, the trailer could be modified into a computer facility without having to commit at that time to the means for towing it. If the truck purchase option is exercised and the truck breaks down, time need not be wasted waiting for repairs since the trailer, with a standard hookup, could be towed by any towing company nation wide. Not buying a truck and having a towing company move the trailer each time would cost on the average of $4.00 per mile. One trip across the United States and back would pay for the purchase of a $20000 truck. This tradeoff will need more consideration.

COMPUTER AND PHERIPHERAL EQUIPMENT

The EPSF feasibility study team recommends a multi-phased development of minicomputer and peripheral equipment. Exact procurement versus fiscal period depends upon the actual configuration(s) selected by NRC for implementation.

Each EPSF configuration includes a minicomputer with capability determined by the task and requirement to be fulfilled. The minimally expandable configurations incorporate a 16-bit mapped memory computer with enough one-line storage to implement the intended functions. The maximal configuration incorporates a 32-bit virtual address minicomputer with oneline storage to accommodate large databases and complex emergency drill simulations. The 16-bit configurations have the advantage that they can be implemented at lower cost and less development time. A 32-bit system has the advantage of being much more expandable and adaptive to changing emergency drill requirements.

Minicomputer Design Considerations

The EPSF computer, peripheral equipment, system software, application programs, and simulation models will be the principal instrument for presenting simulated accident event data, concentration values, equipment failure nature, local environmental variables, and other important phenomena to the public utility or state emergency preparedness personnel and the NRC evaluation team. The computer can also record/store emergency team performance event data, simulation history, and other information pertinent to NRC evaluation teams. Finally, the computer can implement the data communication protocols required by remote computation facilities and any remote telemetry radiation monitors.

Many factors need to be considered in selection of computing equipment hardware, system software, application programming tools, and physical layout within the mobile facility. The principal design considerations and their technical ramifications are:

Memory addressing and word size considerations:

Typically, the application programs associated with complex simulation have the tendency to be large, thus requiring a large address space to execute within and also a moderate physical space. Simulation software also requires high numerical precision, especially when multi-order integral approximation techniques apply. Many minicomputer vendors now offer 32-bit word minicomputers which use virtual addressing methods to extend virtual program size well beyond the limits imposed by 16-bit systems. These machines provide large address space, high resolution, high speed computing at costs not much higher than maximally configured 16-bit minis. Another computer sub-system possibility would be to employ a 16-bit minicomputer with mapped memory. Many of the 16-bit minicomputers do not offer virtual addressing but do provide software linkages for program overlays and chains. Through chaining and overlays, large programs can be squeezed into these class of machines, but with additional development effort on the part of programmers.

On-line storage considerations:

EPSF data storage requirements will be determined by the nature of several databases which could become a part of the overall emergency simulation input and display. These databases, including geographical and topological local characteristics, emergency preparedness plan characteristics, and historical emergency drill database, would require large on-line mass storage. On the other hand, an EPSF designed primarily for simulation of meteorological phenomenon would not require nearly as much storage than if topological parameters were included. Thus, total online storage requirement should be determined by actual application.

Interactive considerations:

The EPSF operation crew will interact with the computer software routines through alpha-numeric video terminal input/output, graphics, display output, and manual graphics input (lightpen, joystick, etc.). Typically, computer responses from the EPSF software tasks will need to be interactive in nature, i.e., rapid responses with medium to high throughput and low delay. Therefore, the EPSF computer hardware and system software must be configured for efficient interactive use by operators and emergency personnel.

Real-time considerations:

A number of factors exist in the EPSF plan which dictate that the EPSF hardware/software system be capable of realtime computing (input/output, event driven program execution, time scheduled program execution, etc.). The system will perform data communication using at least one, and possible two different data communication protocols. The software drivers and communication oriented application programs will require realtime program scheduling. Remote telemetry also requires that realtime software drivers and applicatioprograms be implemented. Finally, interactive requirements for rapid displays of large graphics databases implies that priority structured task execution may be required.

External communication considerations:

During development and production phases, external EPSF programming will best be supported through 9-track magnetic tape, low-speed accoustic couplers, and voice grade telephone circuits. Card reader equipment might also be employed, however, the EPSF implementers can probably get along without one. A magnetic tape unit will provide the same capability, and the van space might be better utilized for some other purpose. Printer output should be provided by a medium-speed, low-chad printer with wide carriage and 96 character ASCII set. During production phase, EPSF evaluation data output can be provided by the magnetic tape unit, line printer, and removable disks. For on-line access to the computer and the simulation EPP drill, NRC should consider installation of medium speed RS-232 modems at the mobile van and at NRC headquarters. The headquarters terminal could be a A/N video or a graphics terminal.

Data communication considerations:

Two known data communication possibilities exist at this time. The EPSF models and meteorological simulation routines will ultimately require initialization parameters which are available from ARAC. The ARAC access protocol resembles the DEC/DDCMP protocol and requires RS-232 serial/asynchronous data communication interface equipment. If implemented, communication with remote simulation radiation monitors will require a telemetry interface and controller. The exact nature of the telemetry controller is an unknown at this time. However, it will probably require a specially designed serial CPU interface and a micro-processor controller. In this scheme, the micro-processor would provide low-level protocol, error correction, and re-transmission while the main computer would supply message content and addressing information. In any case, selection of central computer and peripheral equipment vendors will require consideration of the standard communication interface equipment which they offer. Special attention must be paid to conformity with ANSI, EIA, and CCITT standards and recommendations.

Environmental considerations:

The EPSF mobile van and computer equipment, when in production phase, will be transported to many areas of the country. Since computer equipment performance tends to be sensitive to environmental conditions and since the facility will be situated in and transported through many different geographical and environmental situations, it will be necessary to design the van facility and the EPSF computing equipment housing for maximum environmental isolation and control. Thus, computer and van sub-system personnel will have to work together in laying out the van configuration, hardware mounting

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requirements, air conditioning, air filtering, shock and vibration absorbtion, and many other physical environmental factors. In addition, the design engineers must pay particular attention to facility power: Type of a.c. circuit, voltage and frequency regulation, filtering and noise, and housing and transportability of portable electrical generating plant.

Ruggedness considerations:

The mobile van must be as "easy a ride" as possible to eliminate possible damage to the computer and other peripheral equipment housed within. However, some vibration and bumping is inevitable from bumpy or under-construction roads, railroad crossing, and loading/unloading of equipment. People in the field with experience in transporting compu[illegible] equipment report varied success with regard to moving equipme[illegible] without altering its configuration or reliability. Some critical components, e.g., movable disk heads and CPU boards, must be locked in place during transportation periods. Other critical components (equipment racks) should be sturdily mounted but with shock absorption. During transport through extreme cold and hot climate areas, the facility must be environmentally controlled from heat, freezing, high humidity, etc.

Maintenance considerations:

NRC should consider full contract maintenance of the computer and related peripheral equipment. The nature of teh EPSF indicates that maintenance by a NRC sponsored mobile team might be unfeasible. The cost of a maintenance contract is estimated at 10 to 15 percent of the purchase price annually. However, this may vary (upward) due to the mobile nature of the EPSF. In any case, the exact terms, conditions, and price will have to be worked out in a contractural agreement with the appropriate vendor(s).

The feasibility of constructing a computation sub-system to perform simulation, graphics, data communication, and interactive operator terminal input/output within the mobile EPSF is high. Certain problems associated with equipment procurement, system configuring, and software development will be encountered. However, these problems are considered of normal nature which would be encountered during the development of any special purpose computation facility.

Central Computer Conceptual Design

32-Bit Minicomputer with Paged Virtual Memory

The state-of-the-art trent in minicomputer architecture has caused 32-bit systems with paged virtual memory to be offered by several vendors at costs not much higher than large configuration 16-bit systems. These systems offer high performance computing, hardware floating point calculations, and interactive realtime environments. Since a maximumly configured EPSF would run large complex simulations, substantial graphics input/output, moderage to large databases, and external data communication, the most feasible type of minicomputer in that configuration would be a 32-bit paged virtual memory system.

16-Bit Minicomputer with Mapped Memory

Minicomputer equipment manufacturers have been offering 16-bit work systems with mapped memory, medium to large physical memory, and high performance operating systems for several years. Because a several year backlog of experience on these machines exists, operating system and software development has progressed to a high level of capability and reliability. These systems also offer high-speed floating point hardware, a wide selection of on-line storage devices, and multi-tasking operating systems for reasonable cost.

It is technically feasible to use a 16-bit minicomputer in the EPSF. High-level languages and a hot of system and application software exists for virtually every 16-bit minicomputer. Some vendors offer paged virtual addressing and those which do not have program overlay and chaining executives which allow programming of large programs in limited space. A medium capacity 16-bit minicomputer will meet the needs for an EPSF designed primarily for meteorological and radionuclide dispersion simulation and display.

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On-Line Storage Devices

A number of peripheral manufacturers, including the CPU vendors, offer medium to large storage disk drives and controllers for the popular mini-computers. The cost of disk drives varies between $50 and $700 per megabyte depending on vendor, size, data rate, and access time. Controllers price at $2.5K to 10K and will interface up to 4 or 8 drives.

Technically, it is possible to configure the system with disks from a vendor other than the CPU manufacturer. This approach might offer an initial cost savings. However, additional maintenance contracts would be necessary if more than one manufacturer's computer equipment has been used in the EPSF. In addition, interfacing, system installation, checkout, and acceptance could be delayed when multiple CPU/disk vendors have been chosed in the bid cycle. The more practical approach is to purchase disk drives and controllers from the CPU manufacturer as part of the basic system bid.

Data and program file transfer of large data files to and from the EPSF computer should be provided for by a magnetic tape unit. A 9-track 45-ips dual density unit can be obtained for up to $15K. Through magnetic tape, EPSF developers will be able to read source programs and database files from offsite development systems. Magnetic tape will also be used for transfer of EP drill simulation event data for remote post-analysis.

User Interface Peripheral Equipment

The programming activity and normal operation of the EPSF can be provided for by two to four alphanumeric terminals. These terminals should at a minimum provide 96 character ASCII, selectable speed up to 9600 baud, and EIA RS-232 interfacing. In some configurations, vendors supply one hardcopy terminal with the basic system configuration. In this case, the hardcopy terminal would be used as the system console and the remaining program development terminals should be CRT video. The alphanumeric terminals can be used for program development and as operator positions during the DPP drills. Upper-lower case video terminal prices range from $1K to $3K each. Several CRT terminals with limited graphics and screen addressing capability are available for about $1.5K to $2K.

Program development activities and production operation of the EPSF computer will require some printed output. Good quality upper-lower case output will provide an immediate method of reporting EPP drill events and EPP team performance parameters. Several printer types exist, including line-printer, impact matrix character printer, and electrostatic printer/plotter. A 300 lpm line-printers output both upper and lower case 96 character ASCII sets and price at $5K to $15K. Character matrix printers price at about $3K to $4K and can output 300 to 400 characters per second. Either of these possibilities are feasible EPSF alternatives, providing good quality output, low noise, and low paper chad. However, as a space saving means, the smaller matrix printer may be more desirable in a van installation. An electrostatic printer is also a feasible alternative. However, these units require maintenance of toner bath level and quality, electrostatic plotter paper tends to fade and smudge, require additional care during transportation, and take special precautions in below freezing temperatures.

Color Graphics Display Unit

Operation crews need to interact with geographic, topological, and event data contained within the EPSF online storage. These data could represent geographic area maps, major waterway outlines, highway routes, hospital locations, and other graphic information relating to emergency preparedness. In addition, databases could be required for population density and distribution, highway traffic characteristics, and other data required to model emergency events such as evacuation and road blocking. Finally, major simulation input and output variables will be displayed so that operation crew and EP evaluators can have visual interaction with modeled meteorological conditions, radionuclide concentration levels, monitor locations, and other pertinent drill parameters.

For fast visual interaction with machine and data, a high quality color graphics display unit should be employed in the EPSF. Monochrome graphics devices would also be feasible for displaying a limited set of emergency drill parameters. However, in order to attain maximum visual perspection through computer graphics, color adds a dimension of realism not possible with monochrome graphics.

Several manufacturers sell good quality raster/vector color display units. These devices have resolutions of about 250 to 1000 pixels in each direction (x and y) and from 8 to 100 discrete intensity levels. Manual interaction through cursor control, lightpen, tracking ball, and joy stick are offered as options on some units. Prices range from $20K to $50K depending upon resolution, speed, and options selected. A television compatible, 525 line unit can be purchased for about $20K to $30K while high speed 1000 line, non-TV compatible units sell for approximately $50K.

Central Computer Cost and Implementation Time Factors

Implementation phases and approximate time intervals required to acquire and configure the central computer sub-system are:

System feasibility study, specification, and ADP procurement approvals	1-2 months
Bid cycle and place order	1 month
Delivery time (vendor dependent)	2-4 months
Installation, checkout and acceptance	1 month

Some model development and programming can take place before delivery of the computer. Modeling and database personnel should be able to formulate and begin programming the basic outlines which will be required in the EPSF. System programming of the data communication and graphics packages will probably have to begin after system delivery which will provide ample time to survey the marketplace and user community to determine the availability of software modules.

Depending on specific vendor(s) and specifications, the expected cost of the minicomputer and its peripheral equipment will be from $86K to $222K. The lesser figure is for a 16-bit minicomputer with minimal online storage and computing capability. This system will support some, but not all, of the EPSF feasibility requirements. The larger cost figure is for a 32-bit computer with online storage and memory to support large model implementation, large databases, and comprehensive drill evaluation tools.

New equipment models are expected from at least one of the minicomputer vendors within the next 6-9 month period which could drive the cost of the 32-bit systems down. The cost of maintenance contracts varies with manufacturer and equipment type. However, ten percent of the initial purchase price is a reasonable figure for annual maintenance. The cost of a maintenance contract for the EPSF will probably be somewhat higher due to the portable nature of the system.

Procurement, specification, and installation of the computer hardware will require the services of a computer system engineer and computer hardware technician. Actual involvement by these personnel will be determined by project scope and complexity.

Central Computer Design Problem Areas

The problem areas assocated with development of the DPSF computer subsystem stem from two facts; the system is intended to be mobile, and equipment type and vendor is yet unknown.

The most serious forseen hardware problem areas are environment and maintenance. Since the system must be configured to implement a special purpose application, the equipmetn types will be somewhat limited and mil-spec equipment bids will, in general, not be available. In essence, rather that purchasing equipment which has been designed to withstand severe environments, the EPSF must create an environment which is acceptable for the equipment. Therefore, it can be expected that some unusual modifications to otherwise normal equipment configurations will have to be made during implementation and testing to insure isolation of the equipment from a severe environment and from other possible equipment damaging factors.

In some areas of the country, maintenance of the computer equipment could become a problem. In general, computer equipment vendors locate their service centers at or near their regional offices. These regional offices will normally be situated in major metropolitan areas in order to service the most possible customers in as short a time as possible. Certainly, some of the potential EPSF setup locations will be near computer vendor service centers. However, other EPSF reactor locations are very remote from the large metropolitan areas. In such cases, special provision with the maintenance contractor will be necessary in order to insure timely and effective maintenance of the EPSF computer hardware equipment.

A critical issue with the EPSF software design is the matter of interactive and realtime programming of various software modules. Some of the minicomputer vendors offer operating systems with effective realtime user interfaces while others do not. One possible solution would be to modify vendor supplied operating system software to incorporate features needed by the EPSF. Another would be to use limiting specifications or sole-source procurement of certain hardware items.

A certain amount of software compatibility and transportability may be desirable in the EPSF, especially when the system goes into production mode. If follow-on model development work is to be considered, this work would best be accomplished on a development system other than the EPSF, since EPSF may not be at a fixed location and operational for more than a few days a month. The easiest situation for programmers to use would be to have an identical hardware/software environment available at the development site. This will not be possible in total. Thus, it will be necessary for programmers to use standard programming languages and techniques, high level program generation, and system independent data representations. Inclusion of ANSI standard requirements within equipment and software specifications will help. However, no two vendor implementations are ever alike, thus placing the burden of ultimate program and database transportability and compabitility upon the system and application programmers.

Selection of actual hardware components for use in the EPSF must address interfacing compatibility. For example: Most terminal equipment vendors offer RS-232 serial asynchronous interfaces as do most or all computer equipment manufacturers. However, to display large amounts of interactive graphics with high data rate and low delay, parallel direct memory access (DMA) interfacing of graphics display terminals may be necessary in order to keep system overhead at a minimum. It will be possible to purchase parallel DMA logic for interfacing certain terminals to some computers but not necessarily others. Thus, vendor compatability or sole-source equipment bids could be required, or it may be necessary to design and build special DMA interfaces for the EPSF.

ARAC DATA COMMUNICATIONS

Functional Specifications

Date communications between the EPSF computer and the Atmospheric Release Advisory Capability (ARAC) computer center at Lawrence Livermore Laboratory (LLL) is required. The ARAC facility maintains an up-to-date data base of weather information compiled from reports issued by the National Weather Service, Air Force Global Weather Center, and meteorological stations located at reactor sites. This data is used as input to sophisticated atmospheric dispersion models that execute on ARAC computers. Remote ARAC computer stations have been established at selected sites across the nation (e.g., Savannah River, Rocky Flats, etc.) and are connected to the ARAC central facility via telecommunications data links. A similar data link between the EPSF computer and ARAC must be established to access weather data and other initializating parameters required by EPSF models. Hardware components necessary to connect the EPSF computer to the ARAC facility are:

* Bell 202S modem (1200 baud dialup)
* Asynchronous computer interface (EIA RS-232)
* Bell-801 Automatic Calling Unit (ACU)
* ACU computer interface

Communications software that operates under the Digital Eauipment Corporation (DEC) RT-11 V2 operating system has been developed at LLL for used at remote ARAC stations. The software consists of a low level communications protocol modeled after DDCMP (marketed by DEC) and an application specific higher level protocol. Both protocols must be adapted for use with the EPSF computer operating system.

Time and Cost

A software development effort of approximately three man-months will be required to adapt the ARAC communicaitons software for use with the EPSF computer. Hardware cost estimates are included in cost data given in the section on central computer cost.

FIELD DATA COMMUNICATIONS

Discussed in this section are alternative methods for distributing simulated concentration data to emergency response teams. Each method requires that a field data communications channel be established. To be consistent with overall EPSF design/development milestones, the implementation of this channel should follow the phased approach suggested for implementation of the overall EPSF system.

During Phase 1, a communication consultant should be hired to explore in detail the feasibility of using a radio telemetry system for distribution of data to simulated field data collection units. A preliminary investigation has shown the use of radio telemetry for this application to be feasible but expensive. By accurately determining design and development costs, identifying problem areas, and projecting system performance, the feasibility of using a radio telemetry systen can be evaluated. Design and construction of a prototype system would be accomplished during Phase 2. Finally, construction of 25 portable radionuclide monotirs would be accomplished during the final phase. Equipment cost data for the complete telemetry system is established in the section on radio telemetry.

Functional Specifications

During a radiation emergency, a two-way voice communication system is used by the emergency director's office to dispatch radiological monitors to desired field test points. Pertinent data (e.g., airborne and ground radiation levels, wind direction, etc.) recorded by the monitors is reported to the director's office for use in evaluating the severity of the radiation release and deciding a proper emergency response. A requirement of the EPSF system is that simulated concentration data be introduced into this communication path, replacing data that would normally be collected by the monitors using portable radiation detection equipment. It is desirable that the instroduction of data be done in a manner transparent to both the director's office and the monitors. Two alternative methods for introducing simulated data into the emergency communications system are discussed below.

Radio Telemetry System

Description

Simulated concentration data is introduced into the emergency communications system by broadcasting digital data generated by the EPSF computer system to portable EPSF communications units. During the exercise, these communication units replace the radiation detection equipment normally used by the radiological monitors. The data received by a unit is read by the radiological monitor and reported to the director's office using the emergency communications systems.

Data broadcast on the radio telemetry system is encoded in an information packet that contains an address field, data field, and check field. The portable communications units are designed to receive, decode, and display the concentration data. Incorporated in the units are a radio receiver, microprocessor, and display panel. Only those information packets whose address field matches the address assigned to the unit and are received without error (as verified by the check field) are decoded and displayed. By including an address field in the information packet, data can be sent to selected units even though the receive frequency of all units is the same.

For a receive only unit, information packets that are received in error are ignored. Each packet is transmitted several times to reduce the probability of a data loss due to random noise. If all transmissions are received in error, the operator is notified of an error condition and must take corrective action (i.e., move to a different location). The radiological monitor's position (required to compute concentration) is reported to the director's office using the emergency communications system and relayed to the EPSF computer operator.

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By incorporating a transceiver in the portable communications units, digital position information can by input directly to the EPSF computer by the radiological monitor. Prominent landmarks within the simulation area are assigned a code that is input by the monitor using a small keypad and transmitted to the EPSF computer. The computer receives the position code, calculates the position-time dependent concentration and transmits the concentration back to the portable unit. Thus the need for the EPSF computer operator to query the director's office or monitor the emergency communications system for position information is eliminated.

Basic components of the radio telemetry system include a base telemetry station located at the EPSF computer site, a repeater network (required to broadcast 50 miles in all directions from the base station), and a remote telemetry station incorporated into each portable unit. The base station transmits information packets generated by the EPSF computer to the repeater station(s) at frequency F1. Contained in the transmitted signal is a subaudible tone that activates the transmitter at the selected repeater station. By keying each repeater station in the network to a different subaudible tone, repeaters are selectively activated one at a time depending on the desired direction of transmission (i.e., the location of the receiving unit). When a repeater is activated, it retransmits the information packet at frequency F2 to all portable units within range. Tha packet is then decoded if received by the addressed unit. (A two-way simplex telemetry system would incorporate a transmitter (F1) in each remote unit and a receiver (F2) at the base station).

The radio telemetry system can be configured to make use of existing in-place repeater networks, or can incorporate a portable repeater network designed explicitly for use with the EPSF telemetry system. Differences in these two possible configurations are dictated by differences in the repeater network.

To be considered for use in the EPSF system, an existing or portable repeater network must broadcast in all directions (versus point-to-point), must have open channels available in the same frequency range at all reactor sites, and must support readily available and affordable transceivers.

Cost

Equipment Description	Cost Each
Base station including:	$5K
* computer interface	
* transceiver	
* rollup tower and antenna	
Repeater station including:	$7.5K
* trailer	
* battery power supply	
* subaudible tone keyed transceiver	
* rollup tower and antenna	
* environmental packaging	
Portable communications unit including:	$3K
* Microprocessor and supporting electronics	
* battery power supply	
* transceiver and antenna	
* environmental packaging	

The above cost estimates are for a two-way simplex radio telemetry system. For a one-way system (base station-to-repeater-to-portable unit) the cost of the base station and each portable unit is reduced by approximately $500.

The total equipment cost for a two-way simplex system consisting of one base station, two repeater stations, and 25 portable communications units is approximately $95K. If existing repeater stations are used, the cost is reduced by $15K.

In addition to equipment costs, hardware and software development costs will also be incurred. A major software development effort will be required to implement the communications protocol for the EPSF computer and microprocessor based portable communications units. While low level communications protocols that are well suited for this application (e.g., HDLC and SDLC protocols) are available on LSI single chip controllers, a high level application dependent protocol must be developed. Selection and integration of the microprocessor, display, and packaging system is not complex but does required that many design details be specified before a prototype unit can be fabricated. THe selection and integration of the radio communication equipment under the direction of a reputable communications consultant is also required.

Estimated hardware and software development costs for the radio telemetry system are as follows:

Software development - communications protocol	$15K
Hardware development - portable communications unit	$10K
Hardware development - radio communications equipment	$20K

Problem Areas

Frequency allocation and availability:

Operating frequency changes within a narrow band can be made in some radio equipment by simply changing crystals. However, large changes in the operating frequency (e.g., HF-to-VHF) cannot be made or require extensive alterations performed by the manufacturer. Thus, whether using existing or portable repeater networks, operational simplicity demands that a uniform frequency be available at all reactor sites.

Existing broadcast repeater networks that are possible candidates for use in the radio telemetry system are operated in all states by the state patrol and in some states by an association of law enforcement agencies. The state patrol networks provide good coverage of most populated areas, but operate at highly variable frequencies so that interstate communications is generally not possible. In addition, channels allocated to the state patrol are fully utilized in most states and not available for EPSF use unless mandated by the Governor's office. Thus, variable frequency allocation and limited frequency availability present significant road blocks to the use of state patrol repeater networks.

The variable frequency allocation problem is recognized as a significant limitation in law enforcement communications systems and is slowly being corrected by the establishment of National Law Enforcement channels. These channels, already established in some states, are uniform across the nation, allowing interstate and interagency communication if compatible transceivers are available. Unfortunately, the system will not be available for use in more than a few states until after 1985.

Other communications systems that have been investigated for use include the Local Government System, National Backbone System, and Civil Defense National Radio System. Preliminary indications are that these systems are point-to-point communications links between state, regional, district, and local state and civil defense offices and do not provide the required broadcast communications.

A portable repeater network can be used to avoid the problem of variable frequency allocation assuming that a single open frequency can be made available by the Inter-Department Radio Advisory Committee (IRAC). IRAC controls frequency allocations to government agencies in the same manner that the FCC controls frequency allocations to the private sector. Formal requests for allocations must be submitted to IRAC for review and action.

Low traffic frequencies in use in government and private sectors should also be considered for use. The proposed EPSF communications protocol can withstand limited interference without degrading system performance or introducing data errors. However, on heavily used channels, interference generated by the EPSF telemetry system may not be acceptable to the FCC or IRAC.

Repeater placement and testing:

Portable repeater stations must be carefully placed to maximize communication range and minimize RF shadows within the test area.

Proper placement requires that a pretest survey of each test area be conducted to identify accessible repeater sites that offer the required characteristics. Field tests may be required to characterize potential sites, or reception data may be available from local television and radio stations or law enforcement agencies. Once repeater sites are selected and the repeaters are installed, the telemetry system must be field using two-way voice communication to characterize the system before the emergency preparedness exercise. Significant setup time will be required to complete the site survey and field test, at least for the first exercise at any one reactor site.

Maintenance:

Preventive maintenance and field maintenance of the telemetry system will undoubtedly be required. In-field maintenance can be reduced by acquiring spare subsystems (e.g., repeater stations, portable communications units, etc.) and/or spare components (e.g., transceivers, computer interface, etc.). However, at least one trained radio technicial should be on-site during the simulation exercise to correct any radio problems that would otherwise require that the exercise be aborted (at considerable expense).

Support personnel:

In addition to maintenance responsibilities, a trained radio technician and perhaps a helper will be responsible for pre-exercise site surveys and system setup, testing, operation, and takedown. Clearly, these personnel will be occupied for several days before, during, and after the exercise and will be full time members of the EPSF team.

Voice Communications System

Description

The emergency preparedness exercise provides a valuable tool for evaluating and improving coordination between the emergency director's office and the in-field radiological monitors. To maintain good coordination, it is necessary that reliable voice communications channels be established and that the monitors respond quickly to instruction issued by the director's office. To test and improve communications and response, it is not required that simulated concentration data be transmitted from the EPSF computer to the field. Rather, calculated concentration data could be made available directly to the director's office once established that the monitor is at the desired field test point. Using the existing emergency voice communications system, this data could be relayed from the director's office to the in-field monitors when the latter reported their position. The flow of data is in the reverse of the normal direction, but the information is transfered without the need for an expensive radio telemetry system. In addition, the major objectives of the simulation exercise are still accomplished.

Time and Cost

Assuming that communications between the EPSF system and the director's office are established for other reasons, introducing concentration data into the communications system in the above described manner can be accomplished at no cost.

Problem Areas

Problems likely to be encountered using this method of data communications are generic to all proposed data communications techniques, including radio telemetry systems. In general, the shortcomings of data communications systems used in this application include failure to verify the monitors field position before releasing the concentration data, and lack of procedural realism in the monitor's required actions.

Unless some method of verifying the field position of each monitor is developed, the correctness of the data received by a monitor cannot be guaranteed. Concentration levels at many locations could conceivably be given to the director's office and/or monitors even though the monitors position remained fixed or was incorrectly input to the EPSF computer.

When using portable monitoring equipment, the monitor may wish to sample continuously while driving in a car, check for differences in air and ground concentration levels, or observe the effects of microtopology on the recorded levels. However, during the exercise the monitor will be receiving only one data point per position report. The data will be computed on the basis of position and time without regard for variations in sampling methods. Continuous readings giving concentration as a function of position will not be available.

Advantages/Disadvantages

When compared to the radio telemetry system, a voice communication system utilizing existing two-way radio equipment has significant advantages. Equivalent functionality can be gained without using special purpose equipment that adds significant design, maintenance, operating, and capital equipment costs to the EPSF development and operating budgets.

WIND AND WEATHER SENSING EQUIPMENT

Meteorological data is required to drive the atmospheric transport and diffusion model. As a minimum, the necessary data required is wind speed and direction along with an indication of atmospheric stability. The latter can be obtained by a variety of methods. The NRC, for their radiological dose calculations, requires that stability be determined by a temperature difference method (USNRC, 1972). Implementation of that method only requires temperature data at two altitudes in the atmosphere.

Discussed below is the portable meteorological system that would be required for the EPSF. The alternative for this system is the capability to interface directly to the utility's onsite meteorological system.

Portable Meteorological System

To supply meteorological data to the atmospheric dispersion model via the minicomputer system, a portable meteorological system may be required. It should consist of a telescoping tower with the ability to support both a wind speed and wind direction sensor. The system should consist of a translater and data coupler so appropriate digital information can be supplied to the minicomputer within a given time interval. The criteria of the system components are given below.

Wind Speed Sensor

The sensor should consist of a photo-transistor LED light source and solid state amplifier assembly that has an operating range of at least 0-90 mpg (40 m/sec). The starting speed should be at least 016 mph (0.27 m/sec). The sensor should have an accuracy of plus or minus 1% or 0.15 mph (0.07 m/sec), whichever is greater. The sensor should operate in temperature ranges of -50 degrees F to 155 degrees F (-45 degrees C to 68 degrees C) and have a distance contrant of 5 feet (1.5 m). The power requirements should be 12 VDC @ 15 ma. The sensor should have a weatherproof connector for the associated cabling. The sensor should have NBS traceability.

Wind Direction Sensor

The sensor should contain a Ambiguous Point Logic (APL) system to eliminate discontinuities over the full azimuth range. The range should be 0-360 degrees with threshold of 0.75 mps (0.34 m/sec). Accuracy should be plus or minus 3 degrees. The sensor should operate in a temperature range of -50 degrees F to 155 degrees F (-45 degrees C to 68 degrees C). The sensor should have a weatherproof connector for the associated cabling.

Temperature Difference System

A temperature system between the 10 and 50 foot tower level should have an accuracy of plus and minus 0.05 degrees C. The operating range should be -30 degrees C to 50 degrees C. The sensors should have weatherproof connectors for the associated cabling and be housed in an aspirated temperature shield. The temperature shield should limit radiation errors to 0.2 degrees F.

Translator

Equipment should be a signal-conditioning module for interfacing with the analog sensors to convert the inputs from these sensors into a standardized- voltage/current output. It should be capable of handling 10 channels of data with voltage output of 0-1 volt. Power requirements should be 115 VAC. The system should contain TWA circuitry for each sensor with a time constant of 60 seconds.

Data Coupler

This equipment should be capable of interfacing with the minicomputer system. The system should be capable of supplying data on a 1 or 2 second interval, or a 2, 5, and 10 minute interval.

Tower

The tower should expand to a distance of 50 feet with mounting arms at 10 and 50 feet. It should be guyed at the appropriate levels.

Cabling

Signal cables should be two conductor, No. 18 AWG with weatherproof connectors.

Cost and Time Requirements

Total system cost should be approximately 2500 dollars. Since these items are "off-the-shelf" they should be available within 1 or 2 months.

Maintenance

The system itself will require little maintenance. However, on an annual basis, the system should be calibrated against current standards (USNRC, 1972). This calibration can be performed in the field except for wind tunnel testing of the wind speed sensor.

Interface With Existing Meteorological System

One alternative to the portable meteorological system is to interface directly with the existing onsite meteorological system. Due to the large variety of systems currently being used at reactor sites, this alternative may not, at this time, be practicable. However, as more systems are standardized the alternative becomes more feasible. The NRC Hydrology and Meteorology Branch is presently recommending that sites either have portable instrumentation for use in emergency situations or that meteorological data from the onsite system be transmitted through a microprocessor with the capability of phone access. The latter recommendation would allow direct interfacing with the EPSF. The timetable for implementation of the phone access system is unknown, but second generation EPSF will probably not require a portable meteorological system. Instead a modem for computer interface would be used.

SOFTWARE AND PROGRAMMING

Vendor Supplied Software

In order to create an efficient programming environment in the EPSF, certain minimal software should be required in the minicomputer specifications (either as standard packages or for supplemental cost). Efficient programming aids, high-level languages, debugging aids, and data manipulation packages will help to expedite timely implementation of EPSF system software, simulation model programming, and databases. Essential vendor supplied software packages include:

* Operating system - Operating system should support multiuser program development, realtime task execution and scheduling, device independent input-output formats, and user written device drivers.
* Interactive program development utilities - The utilities package should include text/program editor, macro assembler, file transfer, librarian, link cataloger, and documentation aids.
* Fortran IV compiler (ANSI-1966 and/or ANSI-1977 versions) and runtime support package - Industry compatability can be supported through the

Fortran-IV (1966) standard. For large model and database implementation, the 1977 specification offers many desirable characteristics.

* Online interactive debugging aid for use with assembly or high-level language programs - Systems with online debugging aids provide much higher program development efficiency than ones without that facility.
* Indexed Sequential Access Method (ISAM) software package - Support of the EPSF database work should be provided by an ISAM package which has become an industry standard indexed data specification. Implementation alternatives with large database applications include an ISAM package.

Additional vendor supplied software may be considered for the support of functions such as data communication protocols, special documentation preparation, simulation program implementation, and high-level graphics. The items above would also be candidates for possible implementation by the EPSF development contractor.

Contractor Supplied Software

The software outlined in the above section represents the tools required by programmers to build comprehensive application software systems. The EPSF development effort will require programming of a multitude of application program modules to perform the necessary EPSF simulation, database management, graphics display, data acquisition and transmittal, and other end-user oriented tasks. The origin of these tools could be a vendor, computer user's group, national program library (such as the Argonne ADP Library), other computer users, developed by EPSF contractor, or a combination. The types of packages which may have to be considered include:

* Simulation packages - These software packages normally supply (either in high-level language or subroutine call form) model subelement implementation such as differential equation solvers and queueing/network modeling systems.

* High-level graphics - Many vendors and user groups have packages which convert high-level graphics notations to device dependent graphics codes. Device independent graphics packages also exist which allow output to any number of graphics devices without the need to reprogram user application programs.
* Data acquisition - Both low and high level acquisition programming will be necessary to interface the EPSF simulations with onsite weather measuring devices, ARAC meteorological databases, and the remote telemetry system.

MODELING, DATABASE, AND ANALYSIS

Atmospheric Transport and Diffusion Models

To provide a realistic simulation of atmospheric transport and diffusion processes, three types of models can be employed: Gaussian, trajectory, or mass-consistent. The various merits and disadvantages are given below.

Gaussian Model

The Gaussian model is the least complex of the three methods presented. It also requires the least amount of input data. This type of model is widely used in environmental impact assessment as a preliminary screening tool. Since it simulates the transport of the emitted pollutant with the prevailing wind to any given distance it is not well suited for use in areas of complex terrain. Its most useful form is in determination of concentrations on an annual basis in areas of uniform terrain.

Trajectory Model

Gaussian in nature this type of diffusion model accounts for the spatial and temporal variation in the transporting wind field. To accomplish this with any degree of realism, an ample amount of meteorological data should be available in the area of the computational grid. The dispersion process can be the concept of an "expanding disk" or by following the path of a massless particle with and without horizontal diffusion (Start and Wendell, 1974; Powell, et al, 1978; and Renne and Elliott, 1976). The wind data input to this model can be historical or predicted. This model has yielded reasonable results in areas of complex terrain if ample meteorological data is available. It generally provides more realistic concentration values during the first several hours after a release than would be predicted by the mass-consistent model.

Mass-Consistent Model

The most complex of the three models, the mass-consistent model predicts pollutant concentrations by obtaining a solution to the equations of motion. It requires a large amount of computer memory. Presently, the most complete facility for this type of computation is the ARAC system at the Lawrence Livermore Laboratory [i]. This type of model also requires ample wind data to adequately describe flow conditions in the study area. The most effective use of the EPSF would require a dial-up capability to obtain these type of model results from LLL.

Summary of Atmospheric Model Considerations

For a program of this type it seems more appropriate to use a trajectory model unless the accident scenario involves a large release for an extended time period. To supply meteorological data to the model the onsite meteorological system can be used with additional data being made available from the National Weather Service (NWS) data file of the ARAC system. However, since the type of onsite system can vary from site to site a portable meteorological data system may be required as part of the EPSF. This would preclude any interface problems with the EPSF.

Population, Logistics, and Terrain Modeling

One of the possible actions taken by an Emergency Preparedness Director during an emergency condition would be to order a partial or complete evacuation from a specified geographic area. It would thus be necessary in a drill situation to simulate the consequences of such a decision and to evaluate the effectiveness of the evacuation procedures. Such a simulation requires a database containing information on the population distribution in the area surrounding the nuclear power plant. Other required information includes diurnal variations in the population distribution (work locations, working hours, etc.); the location and capacity of transportation routes leading out of the immediate area; and data on significant terrain features, such as mountain ranges and large bodies of water. A unique database would, of course, have to be created for each reactor site. but the techniques (software) used to create the database and retrieve information from it would be common to all sites.

All geographically related information could be stored in and retrieved from the database by a geocoded information retrieval system [8]. In such a system, each data item is retrieved from the database according to its geographic coordinates. Data for a specific area would be retrieved and fed into an evacuation simulation model along with information related to the specific evacuation plan, such as routes to be taken, location of roadblocks, time staging of evacuation, etc. The model would then simulate the consequences of the evacuation plan in terms of the redistribution of population over time. As a side benefit, the evacuation simulation model could also be used to evaluate emergency evacuation procedures triggered by other types of emergency conditions.

Integrated Dose Model

The "bottom line" in accidental atmospheric release of radionuclides is the amount of exposure to the population. Thus it is necessary to provide a model which will calculate the estimated radiation dose to the population in a simulated emergency situation.

The integrated dose model would require inputs from both the atmospheric transport and diffusion model and the population evacuation logistics model. The atmospheric model would provide the predicted geographic distribution over time. Additional assumptions would have to be made regarding the extent to which people in a given area remain indoors or in other ways protect themselves against the radioactivity in the environment. These assumptions could be related to the instructions given to the general populace over the communications media by the Emergency Preparedness team.

The integrated dose model could actually be run as part of the post-drill analysis, provided that a sufficiently detailed history of events and conditions during the drill is recorded. This is discussed further in the following sections.

Logging of Drill Events and Conditions

For purposes of automating the post-drill analysis of the Emergency Preparedness team's performance, it will be necessary to keep a record of the simulated sequence of events and conditions as they occur during the drill. This history will consist of two parts: the simulated environmental conditions resulting from the hypothetical radionuclide release, and the actions taken by the Emergency Preparedness team members in response to these conditions. All recorded data will be time-sequenced to permit a "playback" of the entire emergency drill. The following paragraphs describe the creation of this log of events and conditions.

History of Simulated Release Conditions

The atmospheric transport and diffusion model and the population distribution model will both predict dynamic (time-varying) conditions resulting from the simulated release, the weather conditions, and the emergency procedures taken by the Emergency Preparedness team during the drill. At periodic intervals, a "snapshot" record will be made of the weather conditions and the predicted radionuclide concentrations at various geographic locations within a 50-mile radius of the release point. Similarly, snapshots of the simulated population distribution will be made at various times during the drill (probably much less frequently than radionuclide concentrations, depending on whether or not an evacuation procedure is simulated). These snapshots will be stored on disk files and later spooled to magnetic tape. The exact frequency at which the simulated conditions are logged will be determined by research and experimentation and may differ depending on the nature of the specific drill exercise. The important point is that the EPSF will be capable of approximately recreating the environmental and population-related conditions which were simulated during the drill without having to rerun the simulation models themselves. This "playback" capability will be necessary to drive the integrated dose model and other phases of the post-drill analysis.

History of Emergency Preparedness Team Response

The second type of historical record logged during the emergency drill will consist of the actions taken by the Emergency Preparedness team. These actions include the dispatching of radiation monitors, the locations and readings of these monitors, and decisions or directives issued (such as evacuation orders and procedures). In addition to event information stored on computer media, time-sequenced audio recording of all voice communications between members of the Emergency Preparedness team will be provided for evaluation by the NRC.

Post-Drill Analysis

After a drill has been completed, it will be useful to the NRC to have an automated drill analysis capability to assist in the evaluation of the effectiveness of the state's EPP and the degree to which the Emergency Preparedness team followed the procedures specified in the EPP. The simulation and event histories logged during the drill will be recalled and used to generate information regarding the effectiveness of the decisions and actions which were taken.

One measure of the emergency response team's effectiveness is the integrated dose received by the population, relative to the severity of the release, the weather conditions, and other adverse factors which may have been present. The integrated dose model, as previously described, will provide this information. The effectiveness of evacuation procedures and other emergency directives can also be reported.

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Another service which can be provided by the post-analysis software is a comparison of the EPP with the actual steps taken by the Emergency Preparedness team. In order to generate this comparison, the state's EPP must be converted into a representation which can be stored in the computer. This representation will be partially quantitative and partially logical (e.g., if Condition B occurs, then Action C is required). Prior to the computer-generated comparative analysis, it may be desirable to apply some data management techniques to organize the restructure the information contained in the log files so that the emergency team's responses can be directly compared to the computer representation of the EPP.

Of course, the computer-generated post drill analysis is not meant to replace the human judgment of the NRC evaluation team. It will, however, provide valuable information to assist the NRC team in the evaluation and review process.

Computer Graphics Applications

Computer graphics displays can provide a valuable visualization tool to the NRC team both during and following an emergency preparedness drill. For example, a two- or three-dimensional display of the simulated radioactive plume (spatial distribution of radionuclide concentration) could be viewed by the NRC evaluators during the drill to provide them with a better understanding of the simulated accident conditions. A map showing the changes in population density distribution as predicted by the population evacuation model would aid the evaluators in determining the effectiveness of an evacuation plan. These displays would not be shown to the emergency preparedness team during the drill; they would be forced to rely on conventional means of ascertaining the environmental conditions and population movements. However, an additional benefit provided by the EPSF would be the availability of models and graphics software to assist an Emergency Preparedness team in the event of an actual accidental release.

Computer graphics can also be applied to the post-drill analysis. Bar charts, line graphs, and other types of plots can be used to visually represent the quantitative measures of performance attributed to the Emergency Preparedness team and to show the degree to which the emergency team followed or failed to follow the procedures outlined in the EPP.

SPECIAL EQUIPMENT AND PROJECTS

Outside Consultants

Two consultants will be required during the EPSF development program. A radio communication consultant should be retained to study the remote monitors radio communication requirements and make recommendations of design and methods. An emergency preparedness consultant should be used during all phases to help with the development of EPP models and associated databases. One to two months each during each development phase should be allowed for these consultants.

Audio Recording Equipment

During an emergency drill procedure, emergency directors communicate with each other, state officials, law enforcement agencies, and emergency field crews via radio, telephone, and other voice communication media. These essential communications can be recorded at the EPSF by multichannel audio recording equipment with a channel set aside for timestamping. Recording will allow NRC drill examiners to review drill communications during post-evaluation. Time stamping will be necessary so the tape can be synchronized with digitally recorded event history during playback.

A multichannel analog recorder will cost approximately $7500 and cabling another $1000. Equipment for timestamping and synchronization will cost $1-2K plus up to 1.5 man-month development time.

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Simulation Radiation Monitors

Simulation radiation monitors are a desirable feature in the EPSF to provide field crew realism. Such simulated monitors can be constructed from readily available electronic components. Problem areas associated with these monitors stem from radio communication and position detection aspects, not monitor design itself. Monitor cost estimates are presented in the section on Field Data Communications. Development time for the simulated monitor (not including VHF/UHF radio protocol) is estimated at 3 man-months.

Monitor Location Detection

In order to attain a high degree of drill realism, the matter of automatic monitor location detection should be studied further. Several possibilities exist each of which could represent high cost and/or difficult implementation. Known methods for automatically determining position include Loran, aircraft navagation methods, and ADF/ALF. The communication consultant will be requested to report on this aspect of the EPSF simulation method. Recommendations for follow-on work will be based upon these studies.

NRC Headquarters Terminal

EPSF drill reporting and public relations can be enhanced through a graphics computer terminal located at the NRC headquarters. The purpose of this equipment is to put NRC commissioners and other officials on-line with simulation drills. This capability will provide a means whereby NRC evaluation teams located at the nuclear power facility can communicate drill events and results with NRC headquarters personnel in a rapid and effective manner. The price of this equipment is estimated at $12K to $20K depending on graphics resolution and screen size requirements.

IMPLEMENTATION PLAN

Several EPSF implementation possibilities exist. This study addresses five such development alternatives which range in scope from relatively simple to complex development efforts. As such, time and cost estimates vary substantially from one alternative to the next.

In each alternative, three distinct development phases exist:

* Phase-1 -- Design, procurement, and construction
* Phase-2 -- System integration and prototype testing
* Phase-3 -- Conversion to production use

The first phase of the EPSF development project will be devoted mainly to design, specification, procurement, and installation of the essential hardware components. System software specification, and some contractor supplied development efforts can be undertaken during phase-1. Formulation of the modeling and database techniques can be performed during the early development phase.

Phase-2 EPSF development addresses integration of the hardware, system software, and models into a working unit for testing and evaluation. Any major equipment acquisition not addressed in phase-1 will be performed. Model and database development will be accelerated in order to incorporate emergency drill parameters which exist in a prototype drill region (southeastern Washington and Oregon). Relationships with EP and local utility personnel will be established with EPSF prototype drills as the primary goal.

During the third EPSF development phase, attention will be focused on getting the facility ready for production use. Any procedures determined faulty during phase-2 will have to be cleaned up during the third phase. The EPSF operation crew will need to be trained and documentation and subsystem operation manuals will need to be written. Drills in nonprototype areas should be initiated during the last development phase.

The equipment and development costs in the five alternatives presented include only those factors required to bring the system to a state of minimal readiness based upon EPSF requirements. Through follow on development and hardware procurement, the systems could be expanded to include additional desirable simulations, databases, graphics, and applications. The incremental costs for expansion of EPSF capability are addressed in the section on expansion options.

The following sections specify the cost estimates for equipment, software, engineering, development, procurement, and maintenance. Procurement, including transportation etc., has been estimated at 10 percent of quoted hardware costs. Maintenance of computer related components is based upon a 10 percent per year basis of the purchase price.

Two additional implementation alternatives exist which are not listed and itemized in the following sections because their utility and/or implementability would be limited. An EPSF could be implemented with the central computer located in a fixed location somewhere in the country. Drill evaluation peripheral equipment would have to be transported to the various sites, set up, and connected to the central EPSF computer via telecommunications. This approach would have limited usefulness since graphics output data rates would be limited to that which could be leased on a temporary basis from the common carrier vendors.

Another option would be to simply install ARAC terminal equipment in the van and then use the ARAC meteorological models at LLL to provide concentration and dispersion information. The ARAC terminal equipment consists of DEC PDP11 minicomputers with minimal storage and peripheral equipment and the RT-11 operating system. Such systems are not easily adaptable to sophisticated realtime applications. The utility and expandability would be very limited and, therefore, this configuration is not recommended.

IMPLEMENTATION ALTERNATIVE 1

The first and simplest proposed implementation for EPSF consists of a 16-bit minicomputer housed within a mobile home or small van. The minicomputer for this configuration would be a medium speed 16-bit processor with low speed-capacity cartridge disk drives and minimal MOS memory allotment. This configuration could be constructed and made operational within a 12 to 15 month time period. Of the five alternatives presented, alternative 1 has the least capability and addresses only minimal feasibility requirements. This system configuration would have the following features:

* Communication with the ARAC center and storage of ARAC database
* Local wind data from portable wind sensor equipment
* Meteorological and concentration models
* Manual input of EP monitor locations (keyboard or display pad)
* Voice radionuclide communication method
* Color graphics display of concentration and meteorological simulation output and monitor locations
* Magnetic tape history file containing concentration, meteorological, and monitor locations
* Alternative 1 is expandable to alternative 2 through follow on development and addition of 128 KB memory, one disk drive, and one CRT terminal.
* Alternative 1 does not simulate topology, population density factors, evacuation logistics, traffic patterns, diurnal variations, or the emergency plans.
* Alternative 1 does not include a telemetry system but does include a radio communication study.

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Alternative 1 Equipment Summary

Item(s)	Cost ($1K)
16-bit minicomputer with:	
Realtime operating system	66.0
Fortran IV compiler	
128K bytes MOS memory	
2 cartridge disk drives (10 mb)	
Floating point hardware	
Multi-channel EIA RS-232	
1 alphanumeric CRT terminal	
300 lpm line printer	
45-ips 9-track magnetic tape	
Bell-801 ACU interface	
Memory backup power	
Color graphics display with:	20.0
19-inch monitor	
Manual input display pad	
Self-contained display selection	
Portable weather tower and interface	2.5
Custom van with:	
32-35 ft. bed	45.0
Truck	
Air conditioning	
Wiring	
Insulation	
Customization	
Total equipment cost	133.5

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Alternative 1 Development Costs

Item	Man-Years	Cost
Minicomputer system:		
Computer hardware engineering	0.2	
Computer hardware technician	0.1	
Software system management	0.1	
Software development engineering	0.1	
System procurement	0.2	
Microprocessor:		
Meteorological system interface	0.1	
Portable unit design	---	
Radio system interface	---	
Communication protocol	---	
ARAC sub-system:		
Hardware (in minicomputer hardware)	---	
ARAC communication and application software	0.3	
Modeling, database, graphics:		
Meteorological and concentration models	0.2	
Low-level graphics software	0.2	
High-level graphics software	0.1	
Graphics application (2 week each)	0.3	
Database engineering	0.2	
User interface application software:		
Telemetry user interface	---	
Overall drill interface	0.3	
Outside consultants:		
Radio communication	0.1	
Emergency preparedness	0.1	
Miscellaneous:		
Mechanical engineering	0.1	
Administrative	0.2	
Documentation	0.3	
Total (man-years)	3.2	
Development cost		$ 210.0K
Equipment cost		133.5K
Procurement cost		13.5K
Maintenance contract (1 year)		6.5K
Total cost		$ 363.5K

IMPLEMENTATION ALTERNATIVE 2

This EPSF development alternative incorporates all the basic components and development efforts included in alt-1, plus it takes into account an estimate for inclusion of radio-controlled monitors (25 ea). The proposed implementation would consist of a 16-bit minicomputer housed within a mobile home or small van. This configuration could be constructed and made operational within a 15 to 18 month time period. This system configuration would have the following basic features:

* Communication with the ARAC center and storage of ARAC database
* Local wind data from portable wind sensor equipment
* Meteorological and concentration models
* Manual input of EP monitor locations (keyboard or display pad)
* Digital communication with simulated radionuclide monitors
* Color graphics display of concentration and meteorological simulation output and monitor locations
* Magnetic tape history file containing concentration, meteorological, and monitor location history
* Alternative 2 would not be readily expandable to incorporate large database or complex simulations but would support some additional small to medium scale simulation, database, and graphics application software
* Alternative 2 does not simulate topology, population density factors, evacuation logistics, traffic patterns, diurnal variations, or the emergency plans

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Alternative 2 Equipment Summary

Item(s)	Cost ($1K)
16-bit minicomputer with:	87.0
Realtime operating system	
Fortran IV	
256K bytes MOS memory	
3 cartridge disk drives (15 mb)	
Floating point hardware	
Multi-channel EIA RS-232	
2 alphanumeric CRT terminals	
300 lpm line printer (EIA RS-232)	
45-ips 9-track magnetic tape	
Bell-801 ACU interface	
Telemetry system interface	
Memory backup power	
Color graphics display with:	20.0
19-inch monitor	
Manual input display pad	
Self contained display selection	
Portable weather tower and interface	2.5
Custom van with:	45.0
32-35 ft. bed	
Truck	
Air conditioning	
Wiring	
Insulation	
Customization	
Portable monitor equipment:	95.0
Base station (in van)	
Repeater station (portable)	
25 portable r/n monitors	
25 telemetry unit transceivers	
Total equipment cost	249.5

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Alternative 2 Development Costs

Item	Man-Years	Cost
Minicomputer system:		
Computer hardware engineering	0.3	
Computer hardware technician	0.1	
Software system management	0.2	
Software development engineering	0.2	
System procurement	0.2	
Microprocessor:		
Meteorological system interface	0.1	
Portable unit design	0.2	
Radio system interface	0.3	
Communication protocol	0.2	
ARAC sub-system:		
Hardware (in minicomputer hardware)	---	
ARAC communication and application software	0.3	
Modeling, database, graphics:		
Meteorological and concentration models	0.2	
Low-level graphics software	0.2	
High-level graphics software	0.1	
Graphics application (2 week each)	0.4	
Database engineering	0.3	
User interface application software:		
Telemetry user interface	0.2	
Overall drill interface	0.3	
Outside consultants:		
Radio communication	0.2	
Emergency preparedness	0.1	
Miscellaneous:		
Mechanical engineering	0.1	
Administrative	0.3	
Documentation	0.3	
Total (man-years)	4.8	
Development cost		$ 316.5K
Equipment cost		249.5K
Procurement cost		25.0K
Maintenance contract (1 year)		8.5K
Total cost		$ 599.5K

IMPLEMENTATION ALTERNATIVE 3

EPSF alternative 3 includes a more powerful computer system than that used in options 1 and 2. The minicomputer is a high speed 16-bit processor with medium capacity high speed disk drives. High speed processing would be achieved with high throughput bus and cache memory technology. The system would be capable of running many medium scale simulations, databases, and color graphics displays. The alternative 3 system has the following basic characteristics:

* Communication with the ARAC center and storage of associated database
* Local wind data from portable wind sensor equipment
* Meteorological and concentration models
* Manual input of EP monitor locations (keyboard or display pad)
* Voice radionuclide communication method
* Color graphics display of concentration and meteorological simulation output and monitor locations
* Magnetic tape history file containing concentration, meteorological, and monitor location history
* Alternative 1 does not simulate topology, population density factors, evacuation logistics, traffic patterns, diurnal variations, or EPP
* Alternative 1 does not include a telemetry system but does include a radio communication study
* Several system characteristics which relate to feasibility requirements are not directly included in the alternative 3 plan estimate. However, the system hardware configuration allows for substantial expansion in the EPSF application programming and display. See section EPSF Expansion Options for follow on expansion and incremental development costs.

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Alternative 3 Equipment Summary

Item(s)	Cost ($1K)
16-bit minicomputer with:	126.5
Realtime operating system	
Fortran IV software	
ISAM database software	
256K bytes MOS memory	
2 disk drives (56 mB)	
Floating point hardware	
Multi-channel EIA RS-232	
2 alphanumeric CRT terminals	
300 lpm line printer	
45-ips 9-track magnetic tape	
Bell-801 ACU interface	
Memory backup power	
Color graphics display with:	20.0
19-inch monitor	
Manual input display pad	
Self contained display selection	
Portable weather tower and interface	2.5
Custom van with:	45.0
32-35 ft. bed	
Truck	
Air conditioning	
Wiring	
Insulation	
Customization	
Total equipment cost	194.0

Alternative 3 Development Costs

Item	Man-Years	Cost
The basic development cost is the same as for Alternative 1. System expansion estimates are given in section on EPSF Expansion Options.		
Total (man-years)	3.2	
Development cost		$210.0K
Equipment cost		194.0K
Procurement cost		19.5K
Maintenance contract (1 year)		12.5K
Total Cost		$436.0K

IMPLEMENTATION ALTERNATIVE 4

EPSF alternative 4 uses the same basic minicomputer specified for alternative 3, but with substantially larger disk storage. Through this configuration, the system would be capable of running medium to large simulations, databases, and graphics applications. High speed processing would be achieved with high throughput bus and cache memory technology. The alternative 4 system has the following basic characteristics:

* Communication with the ARAC center and storage of associated database
* Local wind data from portable wind sensor equipment
* Meteorological and concentration models
* Manual input of EP monitor locations (keyboard or display pad)
* Voice radionuclide communication method
* Color graphics display of concentration and meteorological simulation output and monitor locations
* Magnetic tape history file containing concentration, meteorological, and monitor location history
* Alternative 4 does not simulate topology, population density factors, evacuation logistics, traffic patterns, diurnal variations, or EPP
* Alternative 4 does not include a telemetry system but does include a radio communication study
* Several system characteristics which relate to feasibility requirements are not directly included in the alternative 3 plan estimate. However, the system hardware configuration allows for substantial expansion in the EPSF application programming and display. See section on EPSF Expansion Options for follow on expansion and incremental development costs.

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Alternative 4 Equipment Summary

Item(s)	Cost ($1K)
16-bit minicomputer with:	150.0
Realtime operating system	
Fortran IV software	
ISAM database software	
256K bytes MOS memory	
2 disk drives (134 mB)	
Floating point hardware	
Multi-channel EIA RS-232	
2 alphanumeric CRT terminals	
300 lpm line printer	
45-ips 9-track magnetic tape	
Bell-801 ACU interface	
Memory backup power	
Color graphics display with:	20.0
19-inch monitor	
Manual input display pad	
Self contained display selection	
Portable weather tower and interface	2.5
Custom van with:	47.0
37-40 ft. bed	
Truck	
Air conditioning	
Wiring	
Insulation	
Customization	
Total equipment cost	219.5

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Alternative 4 Development Costs

Item	Man-Years	Cost
The basic development cost is the same as for Alternative 1. System expansion estimates are given in section on EPSF Expansion Options.		
Total (man-years)	3.2	
Development cost		$210.0K
Equipment cost		219.5K
Procurement cost		22.0K
Maintenance contract (1 year)		15.0K
Total Cost		$466.[illegible]K

IMPLEMENTATION ALTERNATIVE 5

Alternative 5 represents the most comprehensive, capable, and costly system among the five presented EPSF hardware options. This configuration includes a high speed 32-bit minicomputer with large mass storage for the simulation of complex processes, implementation of large databases, and presentation of detailed color graphics. Thus, Alternative 5 is the most expandable and adaptive of the five options. This system would be most acceptable for implementation of an EPP model in computer software for comparison of EP drill events with emergency plans. This system configuration would have the following basic features:

* Communication with the ARAC center and storage of associated database
* Local wind data from portable wind sensor equipment
* Meteorological and concentration models
* Manual input of EP monitor locations (keyboard or display pad)
* Voice radionuclide communication method
* Color graphics display of concentration and meteorological simulation output and monitor locations
* Magnetic tape history file containing concentration, meteorological, and monitor location history
* Alternative 5 can be expanded to include simulation of large complex processes, implementation of large databases, and detailed color displays
* Alternative 5 does not include a telemetry system but does include a radio communication study. The Alternative 5 system can be expanded to include the telemetry system.

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Alternative 5 Equipment Summary

Item(s)	Cost ($1K)
32-bit minicomputer with:	202.0
Realtime operating system	
Fortran IV software	
1 million bytes MOS memory	
2 disk drives (134 mB)	
Floating point hardware	
Multi-channel EIA RS-232	
3 alphanumeric CRT terminals	
300 lpm line printer	
45-ips 9-track magnetic tape	
Bell-801 ACU interface	
Color graphics display with:	20.0
19-inch monitor	
Manual input display pad	
Self contained display selection	
Portable weather tower and interface	2.5
Custom van with:	47.0
37-40 ft. bed	
Truck	
Air conditioning	
Wiring	
Insulation	
Customization	
Total equipment cost	271.5

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Alternative 5 Development Costs

Item	Man-Years	Cost
Minicomputer system:		
Computer hardware engineering	0.2	
Computer hardware technician	0.1	
Software system management	0.1	
Software development engineering	0.1	
System procurement	0.2	
Microprocessor:		
Meteorological system interface	0.1	
Portable unit design	---	
Radio system interface	---	
Communication protocol	---	
ARAC sub-system:		
Hardware (in minicomputer hardware)	---	
ARAC communication and application software	0.3	
Modeling, database, graphics		
Meteorological and concentration models	0.2	
Low-level graphics software	0.3	
High-level graphics software	0.3	
Graphics application (2 week each)	0.3	
Database engineering	0.3	
User interface application software:		
Telemetry user interface	---	
Overall drill interface	0.3	
Outside consultants:		
Radio communication	0.1	
Emergency pprparedness	0.1	
Miscellaneous:		
Mechanical engineering	0.1	
Administrative	0.2	
Documentation	0.3	
Total (man-years)	3.5	
Development cost		$230.5K
Equipment cost		271.5K
Procurement cost		27.0K
Maintenance contract (1 year)		20.0K
Total cost		$549.0K

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EPSF EXPANSION OPTIONS

The five EPSF development plan outlined above give estimated hardware and development efforts for systems with small to large application expandability. The alternative 1 system would provide only partial compliance with the feasibility objectives while alternatives 4 and 5 would provide systems which could be used in comprehensive and complex emergency simulation drills. As such, the possible investment that could be incured through development of each alternative increases substantially from one alternative to the next.

In order to keep evaluation of the various options as simple and concise as possible, the five alternatives presented have not included features which cannot be built into each alternative because of complexity. Rather, the hardware and development costs given above provide only for hardware and software which performs the very basic requirements for EPSF. Desirable EPSF features which might be included in development phase or added during follow on development are listed and cost estimated in this section. The possible EPSF configuration alternatives for which each option can be implemented are also listed.

Thus, a minimally configures EPSF would cost approximately $340K to fabricate and put into operation. The basic cost for a maximally expandable EPSF would be approximately $500K. The additional cost of implementing all development options listed in this section would be approximately $125K hardware and $600K development (9 man-years).

Radio Telemetry Option

The incremental cost for inclusion of radio telemetry and portable simulation radionuclide monitors is $195.1K broken down as follows:

Item		Cost ($1K)
Portable monitor equipment		95.0
Base station (in van)		
Repeater station (portable)		
25 portable r/n monitors		
25 telemetry unit transceivers		
Telemetry computer interface		0.7
Development cost:		113.0
Minicomputer engineering	0.1 m-y	
System software	0.1 m-y	
Portable unit design	0.2 m-y	
Radio system interface	0.3 m-y	
Communication protocol	0.2 m-y	
Graphics applications	0.1 m-y	
Application interface	0.2 m-y	
Communication consultant	0.1 m-y	
Documentation	0.1 m-y	
Administration	0.3 m-y	
Total development	1.7 m-y	
Procurement		9.5
Total option cost:		218.2

The radio telemetry option can be added to alternatives 3, 4 and 5. Note that Alternative-2 includes the radio telemetry option for direct comparison with Alternative-1 which does not. Inclusion of the radio telemetry option will add 3 to 6 months to the initial system startup time. A higher than average administrative estimate has been included in this area to allow for acquisition of a radio frequency allocation from IRAC.

Population, Logistics, and Terrain Model and Database

Simulation of emergency situation logistics requires, as a prerequisit, that population density and terrain also be modeled. Therefore, these options must be considered together as one overall package. To perform effective geographical and topological modeling, large database will be required. Thus, this option applies only to EPSF alternatives 3 to 5 which have disk storage capable of supporting medium to large database programming. There is no additional hardware associated with this option. The minimum incremental development effort which could be expended on this work would be as follows:

Item		Cost ($1K)
Hardware cost:		0.0
Development cost:		97.3
Simulation engineering	0.4 m-y	
Database engineering	0.4 m-y	
Graphics applications	0.1 m-y	
Application interface	0.2 m-y	
Database technician	0.2 m-y	
Administration	0.1 m-y	
Documentation	0.1 m-y	
Total development	1.5 m-y	
Total option cost:		97.3

Expansion of the terrain models to a number of states and local areas would require additional work in the database area, primarily for digitizing and coding local area parameters.

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Integrated Dose Model

An integrated dose model can be included in any of the five EPSF development alternatives. However, in order to compute a realistic dose based upon predicted population exposure, the nature of a dose model might somewhat differ depending on whether or not population density has been modeled. A "rough approximation" dose model could be included in alternatives 1 and 2 for near negligible cost. However, in order to tie dose calculations into the population and evacuation logistics system, the following approximate expenditures would be required:

Item		Cost ($1K)
Hardware cost:		0.0
Development cost:		20.3
Simulation engineering	0.1 m-y	
Graphics application, Application interface, and documentation	0.2 m-y	
Total development	0.3 m-y	
Total option cost:		20.3

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Emergency Preparedness Plan Model

Advantages of coding EPPs into the EPSF application and databases would be that drill events and conditions could be compared with state plans during drills or post analysis. Development of this capability in EPSF could possibly use technology from the Radiological Emergency Response Analysis Device (PRERAD) codes [10]. PRERAD is a method for grapnical representation of emergency plans for visula analysis which has been used by NRC.

Item		Cost ($1K)
Hardware cost:		0.0
Development cost:		83.8
Database engineering	0.4 m-y	
Graphics applications	0.1 m-y	
Application interface	0.2 m-y	
Database technician	0.2 m-y	
EPP consultant	0.2 m-y	
Documentation	0.1 m-y	
Administration	0.1 m-y	
Total development	1.3 m-y	
Total option cost:		83.8

Expansion of the EPP models to include plans for a number of states and local conditions would require additional work in the database area, primarily for digitizing and coding of the plans.

Emergency Drill History Logs

Historical emergency drill logs would be recorded in two ways. First, simulation events and changing parameters would be entered into a emergency drill historical database. This database could be dumped to magnetic tape if necessary during a drill. Second, all pertinent voice communication (emergency director's communication circuits, etc.) would be recorded on multi-channel voice grade magnetic tape. In addition to voice, the tape would also contain a date and time stamping mechanism so that a "drill playback" could be performed with voice communication synchronized with digital simulation events. The estimated development efforts for emergency drill logs are:

Item		Cost ($1K)
Hardware cost:		9.5
Multichannel tape recorder		
Associated cables and hardware		
Computer driven timestamp interface		
Development cost:		38.5
Hardware engineering	0.2 m-y	
Database engineering	0.1 m-y	
Application interface	0.1 m-y	
Database technician	0.1 m-y	
Documentation	0.1 m-y	
Total development	0.6 m-y	
Procurement:		1.0
Total option cost:		49.0

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Post Drill Analysis Aids

Automated post drill analysis would use as input the simulation and drill logistics data contained in historical databases. Post drill analysis aids could be of two types -- programs which access the database for specific types of information and then display that data in graphical form, and programs which use the emergency plan model to search the drill logistics history for problems. Development efforts in this area could be small or large depending upon how comprehensive an aid were to be implemented. A minimal effort for automated post drill analysis would be:

Item		Cost ($1K)
Hardware cost:		0.0
Development cost:		40.6
Database engineering	0.1 m-y	
Application programming	0.3 m-y	
Graphics application	0.1 m-y	
Documentation	0.1 m-y	
Total development	0.6 m-y	
Total option cost:		40.6

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NRC Graphics Terminal

EPSF drill reporting and public relations would be enhanced through a graphics computer terminal located at the NRC headquarters. This terminal should be EIA RS-232 compatible and be capable of producing either softcopy or hardcopy graphics output. This option would include the necessary modem equipment to couple the terminal to the EPSF via temporaty or dedicated telecommunications lines. Development would entail approximately 2 to 3 man-months to adapt EPSF graphics to the NRC based terminal. In summary, the costs of the NRC terminal option would be:

Item		Cost ($1K)
Hardware cost:		20.0
Graphics terminal with hardcopy		
Modem equipment		
Development cost:		13.5
Low level graphics	0.1 m-y	
Graphics application	0.1 m-y	
Total development	0.2 m-y	
Procurement:		2.0
Total option cost:		35.5

Field Testing

Comprehensive emergency simulation methods would need testing in the field (during actual drill conditions). This could involve as much as 2-4 man-months in the field by members of the development team. Based upon typical travel time and expenses, the cost for field testing would be:

Item	Cost ($1K)
Hardware cost:	0.0
Engineering cost: (.3 m-y)	22.5
Travel and housing expenses:	9.0
Total option cost:	31.5

In addition to man power and travel expenses, the estimated expense of transporting the EPSF via highway travel is approximately $4 per mile.

Miscellaneous Support

If comprehensive model and EPSF procedure enhancement were to be undertaken over an extended period (1.5 to 2 years) and if the EPSF development contractor were to remain responsible for EPSF support during that time, support cost of the facility during that time would be approximately:

Item		Cost ($1K)
Hardware cost:		0.0
Engineering cost:		36.5
Hardware technician	0.2 m-y	
System manager	0.2 m-y	
Administrative	0.2 m-y	
Total	0.6 m-y	
Maintenance contract: (10% per year of basic computer cost)		40.0
Total option cost:		76.5

The maintenance contract cost above is based upon the Alternative-5 system. This figure can be decreased by $10K for Alternative-4 and $15K for Alternative-3.

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APPENDIX A

VENDORS AND CONTACTS

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VENDORS AND CONTACTS

Communications equipment vendors:

Repco, Inc.
1940 Lockwood Way
Post Office Box 7065
Orlando, Florida 32854
(305) 843-8484

Motorola Two-way

Interlux Corp.
34 Middlesex Circle
Waltham, Massachusetts 02154
(617) 891-1785

General Electric Co.
Mobile Radio Department
Lynchburg, Virginia 24502

Communications consultants:

William Bailey
Repco, Inc.
1940 Lockwood Way
Post Office Box 7065
Orlando, Florida 32854
(305) 843-8484

Eric Campbell
W. J. Purdy Co.
Burlingame, California
(415) 347-7701

James Goosman
Spectrum Engineering
Seattle, WA
(206) 329-4084

Other communication contacts:

E. Read Apgar, Communications Chief
Department of Emergency Services
State of Washington
4220 E. Martin Way
Olympia, WA 98504
(206) 753-5255

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Mr. Soulsby
Federal Communications Commission
District 14 Field Office
Bellevue, WA
(206) 442-7653

Vince Anello
Defense Civil Preparedness Agency
(206) 486-0721 Ext. 323

R. E. O'Brien, Radio Engineer
Washington State Patrol
Division of Technical Services - Communications
2803 156 Avenue SE
Bellevue, WA 98009
(206) 455-7763

Captain R. A. Morris, Chief Engineer
Washington State Patrol
Division of Technical Services
2803 156 Avenue SE
Bellevue, WA 98009
(206) 455-7761

Bryon Lawver, Project Director
ARAC
Lawrence Livermore Laboratory
FTS: 532-6234

Trailer and motorhome vendors:

Rod Stein
Western Trailer Sales
745 South Lucile St.
Seattle, WA 98108
(206) 762-7850

Don Sullivan
Fruelhauf Division Fruelhauf Corp.
1810 Frontier Loop
Pasco, WA 99301
(509) 545-9524

Larry Schatz
Lewis Street Trailer Sales
1724 West Lewis
Pasco, WA 99301
(509) 547-8447

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Minicomputer equipment vendors:

Data General Corporation
Route 9
Westboro, MA 05181

Digital Equipment Corporation
Maynard, MA 01754

Interdata

International Business Machines
San Jose, CA

PRIME Computer, Inc.
40 Walnut Street
Wellesley Hills, MA 02181

Computer peripheral equipment vendors:

Ampex Corporation

California Computer Products, Inc.

Control Data Corporation

Data Products

Diablo

Hewlett-Packard Co.

Kennedy

Lear Siegler

Memorex

Pertec

Plessy Peripheral Systems

Quantex

STC Storage Technology Corporation

Tektronic, Inc.
P. O. Box 500
Beaverton, OR 97077

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Texas Instruments

Weather measurement system vendors:

Belfort Instrument Company
1600 S. Clinton St.
Baltimore, Maryland 21224
(301) 342-2626

Science Associates, Inc.
230 Nassau St.
Box 230
Princeton, NJ 08540
(609) 924-4470

Meteorology Research, Inc.
Box 637
464 W. Woodbury Rd.
Altadena, CA 91001
(213) 791-1901

Teledyne Geotech
P. O. Box 28277
Dallas, TX 75228

Climatronics Corp.
140 Wilbur Place
Airport International Plaza
Bohemia, New York 11716
(516) 567-7300

WeatherMeasure Corp.
P. O. Box 41257
Sacramento, CA 95841
(800) 824-5811

Climet Instruments Co.
1320 West Colton Ave.
P. O. Box 151
Redlands, CA 92373
(714) 793-2788

Nuclear power industry contacts:

Frank McElwee
Washington Public Power Supply System
3000 George Washington Way
Richland, WA 99352
(509) 375-5000

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16. ABSTRACT *(200 words or less)* This report details the feasibility of a computerized Emergency Preparedness Simulation Facility (EPSF) for use by the Nuclear Regulatory Commission (NRC). The proposed facility would be designed to provide the NRC and other Federal, State and local government agencies with a capability to formulate, test, and evaluate the Radiological Emergency Response Plans (RERP). When an emergency exists, rapid mobilization of emergency teams, efficient communication, and effective coordination of emergency teams, efficient communication, and effective coordination of individual team efforts is essential to safety, preservation of property, and overall public welfare. Current RERP evaluation procedures are qualitative in nature and while they do compare emergency drill performance with the RERP, the nature of the drills often does not provide enough realism to actual emergency conditions. Automated simulation of real emergency conditions using modern computer equipment and programming techniques could provide the NRC emergency evaluation teams a simulated environment which closely approximates conditions which would actually exist during a real emergency. The computer can be used to collect and log performance and event data which will aid the evaluation team in making assessments of the State or local area's EPP and their Emergency Preparedness Teams performance during emergency drills. Overall, a computerized EPSF could improve drill testing and evaluation efficiency, provide approximate emergency condition realism, and improve public awareness of local emergency procedures.

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