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ESSEX
CORPORATION

FINAL REPORT

EMERGENCY MANAGEMENT
COMPUTER-AIDED TRAINER (EMCAT)

CONTRACT NAS8-35815

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CONTRACT NAS8-35815

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FOREWORD

During the past two years, Essex Corporation developed the Emergency Management Computer-Aided Trainer (EMCAT) system. This work was performed under contract NAS8-35815 to the Technology Utilization Office of the National Aeronautics and Space Administration (NASA), Marshall Space Flight Center (MSFC). Technical direction was provided by the National Fire Academy (NFA), an agency of the Federal Emergency Management Administration (FEMA). The direction and support of Mr. Kenneth Smith and Ishmail Akbay of NASA/MSFC and Mr. William Blair NFA are gratefully appreciated.

The purpose of the EMCAT system is to provide a low cost, realistic, real-time simulation system for training fire ground command personnel in resource allocation and strategy decisions. Multiple scenarios were developed to demonstrate the flexibility of the EMCAT system and its ability to fulfill various training needs.

The EMCAT development effort was divided into two phases, the Requirements and Design Phase and the Implementation Phase. This cost sharing development effort resulted in three EMCAT systems, two for delivery to NASA and one for Essex Corporation's use. Five scenarios were also developed to operate on the system.

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1.0 INTRODUCTION

This final report describes the Emergency Management Computer-Aided Trainer (EMCAT) developed by Essex Corporation under contract to NASA's Marshall Space Flight Center (MSFC) and the Federal Emergency Management Administration's (FEMA) National Fire Academy (NFA). This document constitutes a deliverable end item for the Implementation Phase of the EMCAT development contract.

1.1 Background

In early 1980, the Technology Utilization Office at MSFC was approached by the Huntsville Fire Department for help in developing a computer-based training system for fire fighting personnel. A prototype EMCAT system was developed by NASA first using video tape images and then video disk images when the technology became available. This prototype was demonstrated at various fire fighting conferences and was evaluated by personnel from the National Fire Academy.

The association of these two federal agencies led to a development contract for an operational EMCAT system. This contract was awarded to Essex Corporation in October 1983. During the performance period of the contract, two operational EMCAT systems were to be produced for delivery to the Government. Also, various scenarios would be produced to develop a simulation methodology and to demonstrate the system's flexibility. The contract effort has led to a marketable fire ground incident training system, which the Essex Corporation intends to produce.

The EMCAT system is meant to fill the training needs of the fire fighting community with affordable state-of-the-art technologies. An automated real-time simulation of the fire situation was needed to replace the outdated manual training methods currently being used. In order to be successful, this simulator had to provide realism, be user friendly, be affordable, and support multiple scenarios. The EMCAT system meets these requirements and therefore represents an innovative training tool, not only for the fire fighting community, but also for the needs of other disciplines.

1.2 Scope

This document presents the final report for the EMCAT system developed by Essex Corporation. Three areas are covered: operational considerations, software, and hardware. The intent of this document is to provide final development information about the EMCAT system to NASA and FEMA.

2.0 IMPLEMENTATION

This section provides information about the requirements and design concepts used in developing EMCAT, including trade-offs made during the process. Three areas are addressed: hardware, software, and video scenes.

2.1 Hardware

This section discusses the EMCAT hardware requirements and hardware design. The EMCAT hardware consists of the components required for the task, including the computer and the video disk player, the interfaces required between the components such as the video disk control card, the computer support hardware such as the disk drives and printer, and the operator interfaces such as the keyboard and monitors.

2.1.1 Requirements

The EMCAT hardware components must meet certain requirements. First, they must provide the capabilities required to perform the functions defined below. They must also be affordable and easy to transport, set up, and operate. The more detailed requirements for the system are listed below.

1. The functions that the hardware must perform are:

   a. Operate software
   b. Output video images
   c. Allow for operator interaction
   d. Allow for software control of video images
   e. Provide status information to the operator
   f. Allow for easy scenario swapping.

2. The hardware system must be affordable to many smaller training groups. This can be accomplished by using simple, commercially available ("off-the-shelf") components. A modular approach using readily available components and standard interfaces helps keep the system price down for users that already own some components.

3. An integrated package is required to provide ease of handling and transporting, compactness, and ease of set-up. Since component level maintenance is desired for simplicity, the various components in the system must be integrated intact. All components must be removable by non-skilled personnel for maintenance. The system console must conform to human engineering design standards and must be attractive.

4. A highly desirable feature to make the system much more versatile to the users is the ability to use the individual components for their original purpose. This would allow other software to be used on the computer and other video disks to be used on the player.

2.1.2 Component Selection

The components which are required, along with the selection criteria for each, are listed below.

1. The computer selected to control the EMCAT system is the Apple IIe computer. In terms of capabilities required, availability of higher level languages and operating systems, availability of interface hardware, and price, the Apple was superior to other available computers. The Apple also has the advantage of having an extensive line of software available, thus providing the user with a computer for tasks other than EMCAT.

2. The video disk player selected to generate the video scenes is the Pioneer LD-V6000 advanced Laserdisc. This player is an industrial quality machine capable of very fast scene switching and communication with a computer through a standard serial interface (RS-232C).

3. The other components include a text monitor, two disk drives, a printer and interface, a clock, and a video disk interface. These were selected from those available as meeting the requirements at the lowest cost and are listed below.

   a. Text Monitor - Sanyo 12 in. Monochrome Monitor
   b. Disk Drives - Apple Disk II or MicroSci A2 5¼ in. floppy drives with Apple control card
   c. Epson RX-80 printer and Dumpling buffered interface
   d. Clock Card - Timemaster II H.O. from Applied Engineering
   e. Video Disk Interface - Apple SuperSerial Card.

2.1.3 Enclosure Design

The EMCAT enclosure must house the hardware components in a manner that places them in the correct operating orientation as well as makes them accessible for repairs. These factors were considered in designing the enclosure shown in Figure 1. The cabinet closes into a solid box for transport and has been provided with casters and handles. When opened, the cabinet provides an ergonomically correct workstation for the system operator and easy access to the components.

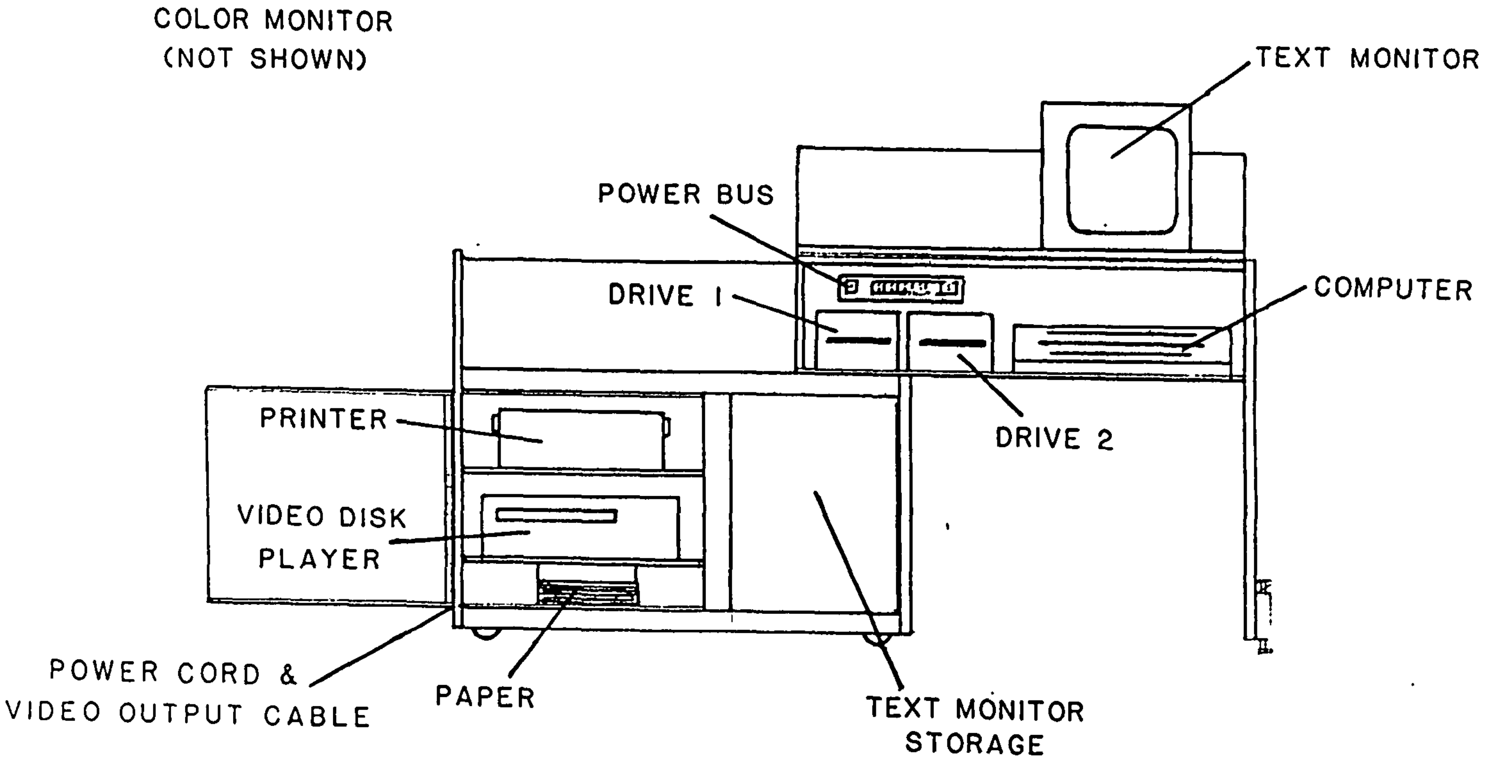

FIGURE 1 - EMCAT SYSTEM LAYOUT

2.2 Software

The EMCAT software provides the brain of the system. Without it no simulation would exist, only a set of video images without any control. This section discusses the requirements for the software and provides a review of the methods of implementation.

2.2.1 Requirements

At a top level, the EMCAT software is required to support the following functions:

1. Accept Operator Inputs
2. Resource Allocation and Tracking - including personnel, equipment, water, and time
3. Structure/Situation Tracking - including fire and smoke progression, fire and water damage, victim condition, and task progress
4. Video Scene Control - including determining the proper video scene to reflect the current situation and controlling the video disk player through the interface card.
5. Update Operator Status - including the status display on the text monitor and printed reports both during and after the simulation.

The software must provide these functions in a real-time mode and must provide these functions for multiple fire ground scenarios. Flexibility shall be provided to customize a scenario to individual user's needs, realizing that such customizing is limited by the video disk.

In addition to the functional requirements listed above, the software must conform to certain programming standards. These include the use of structured programming and code modularity. The use of a compiled language, such as PASCAL, is also required to provide the processing speeds needed to keep up with all of the functions in a real-time mode.

2.2.2 Implementation

To meet the requirements on the software discussed above, the Apple Pascal system, version 1.2, was selected for developing the EMCAT software. The system not only provides the PASCAL compiler, but also provides an editor and the necessary file management utilities to support the software development. The PASCAL language is designed for structured programming techniques which simplifies code debugging and maintenance.

The EMCAT simulation software was generated in three sections to better utilize the available memory resources of the Apple computer. An introductory section provides operating instructions, scenario pre-plan information, and several other options for an instructor/operator. The main section is automatically invoked by the introductory section. The main section performs the functions required to support the simulation session. The reporting section is automatically invoked by the main section upon termination of the simulation. The reporting section provides final status information to evaluate the trainee's performance in the simulation.

2.2.2.1 Database

The software was designed to allow for multiple scenarios by using a database to provide most of the information to define the scenario. An editor has been developed to allow the user to modify the databases. This provides the benefit of allowing database changes prior to any simulation session, thus providing the capability for users to custom tailor the scenarios to their needs. At the start of a simulation session, the software reads in the database information.

One section of the database defines the units and areas in a session, including the burn and put-out characteristics, the search order and time, and the location of victims. This information defines the scenario's structure and default progression.

Another section of the database defines the resources available for the scenario. Up to 10 companies can be included, with the arrival time, number of firefighters, amount of water, and various fail flags for each company defined. The services available and the number of hydrants available are also defined.

The final section of the database defines the tasks which can be performed by the operator. These include search and rescue, laying a line, putting water on an area, trenching, ventilating, and operating the machinery. The information provided for each task includes the number of firefighters required, the various times required, whether a task is cancelable and, if so, the time required to make the resources available for reassignment. The effects of some tasks, such as search and rescue, are built into the software. The effects of other tasks, such as putting water on the fire, are defined by the rules.

For more information about the contents of the database, see Section 5 of the EMCAT System Operations Manual.

2.2.2.2 Physical Simulation

The EMCAT software is designed to provide a simplified simulation of the real physical properties and behavior of the fire in the structure. This approach was taken to allow the software to more closely simulate the effects of time and operator inputs on the fire. Most of the inputs for this software are provided by the area definition portion of the database.

The default fire progression is defined by a series of ignite times in the database and by a series of coefficients which can be set by the rules. The ignite time indicates the elapsed time into the simulation at which each area will ignite. In a default progression, each area will ignite in a predetermined sequence. The coefficient provides for an adjustment to the ignite time in response to certain actions by an operator. It can be positive which causes the ignite time to be accelerated, or negative which causes the ignite time to be delayed. For example, water in one area may cause an adjacent area's slow coefficient to be set to delay or completely halt the fire spread. Venting an area may cause that area's coefficient to be set to accelerate the spread of fire into that area.

Once an area is on fire, the simulation uses the following equation to determine the amount of fire involvement in that area:

$$\%FIRE = \%FIRE + (CFIRE) - (CWATER * WATER^{1.2})$$

In this equation, the WATER term is the amount of water (in gallons per minute) being put in the area. The CFIRE coefficient, which is defined in the database, determines how fast the fire in the area will build (CFIRE is in percent growth per second). The CWATER coefficient, which is also defined in the database, determines how fast the fire in the area will be extinguished (CWATER is in percent extinguishment per GPM per second).

The fire growth equation is invoked every 4 seconds for each area on fire. The amount of water being put into an area is automatically factored in. If the water is increased, the effectiveness of it increases exponentially as in an actual fire. Insufficient water into an area can cause the fire growth to slow down, but not stop.

2.2.2.3 Tasks

The operator's inputs to the EMCAT simulation are defined by the tasks which the available firefighters can perform. As tasks are performed, they affect the default fire progression, the disposition of victims, or the resources of the scenario. The manner in which a task affects the scenario is defined in the software for some tasks or in the rules for the other tasks.

There are a limited number of possible tasks in the EMCAT simulation: laying a line to a hydrant, putting water on an area, ventilating an area, trenching an area, search and rescue, and communications. The resource and time requirements for these tasks are defined in the database for each scenario, as discussed in the previous section. For each task, the operator must provide certain parameters to the software such as the line size to use, the area being affected, and the number of firefighters to perform the task.

Note that if the operator selects a company with insufficient idle firefighters assigned to a task, the software will allow the operator to reassign those firefighters. If a firefighter is reassigned, the effects of the task he/she was previously involved in are negated and the firefighter will begin performing the new task after a "backout" period of time.

2.2.2.4 Rules

In order to define the effects of actions of the operator on the fire status, a set of rules is developed for each scenario. Rules are incorporated into the software as a series of conditional (IF) statements. A rule can have conditions such as time, water status, and ventilation status. If a rule's conditions are true, the rule can change the amount of water, the "slow coefficient," or the water or fire coefficients of various areas. Rules are also used to end a simulation based on the current video scene and to switch from one scene to the next.

2.3 Video Scenes

The most challenging aspect of developing the EMCAT system was the development of a low cost method of generating the realistic and dynamic visual fire scenes. This section lists the scene requirements and describes the method used for generating the images.

2.3.1 Requirements

The contractual requirements for the visual scenes are:

1. Visual sequences shall be limited to an affordable number while providing sufficient variety for meaningful scenarios.

2. The images of burning structures shall be as realistic as possible. Flame shall grow or diminish in a natural way. Smoke shall change from dark to light (steam) at the appropriate time.

3. Stylistic representations of fire and smoke are unacceptable.

4. Simulation depth and realism shall be achieved in such a way that production doesn't become prohibitively expensive, for it is anticipated that users will demand many affordable, perhaps even customized, scenarios.

2.3.2 Implementation

In order to meet the requirements for the visual scenes at an affordable price, several concepts were considered. These are listed below along with the advantages and drawbacks of each:

1. The use of a Chromakey system to electronically superimpose fire and smoke on an image of the structure was considered. This method allows the "stock" fire and smoke footage to be electronically scaled and positioned over the structure. A photograph of the structure would be sufficient for this method.

There are three disadvantages to the Chromakey method. The first is the "halo" effect which is evident on the overlayed objects which gives the objects a "pasted on" look. The second, and most serious, disadvantage is the prohibitive cost of renting the required electronic editing equipment. The third disadvantage is the scene degradation resulting from the editing the dynamic elements onto the scene one at a time.

2. The use of real scale models of the structure with real fire and smoke was considered. This method permits the realistic geometry of the structure and the capability to incorporate structural damage.

   The main disadvantage to this concept is again one of cost. A model of the larger and more complex structures could cost several thousand dollars. Another disadvantage is the problem of scaling the fire and smoke effectively.

3. The generation of the images using only software graphics and animation was considered. This concept would provide for very flexible scene generation since little or no real imaging is required. If carried to an extreme, this system would even allow for the elimination of the video disk, with the software electronically generating flame and smoke on an image.

   Again, the major disadvantage of this concept is cost. Systems capable of generating the required scenes are very expensive and the process is labor intensive, at least initially. Current systems also lack the ability to generate completely realistic images and animate them convincingly. Current scenes tend to look cartoonish.

4. The method considered and ultimately developed for generating the EMCAT visual scenes is the optical overlay concept shown in Figure 2. In this concept a photograph of the structure is cut to allow smoke to pass through the windows, door, vents, etc. Two black templates with the shape of the structure are made. Behind one template fire is generated in the windows, doors, vents, etc. White smoke (steam) is pumped through the windows, doors, vents, etc, of the other template. The three images are optically overlayed by using a half-silvered mirror.

   This method offers the advantage of being inexpensive, since little specialized equipment is required. It also provides for realistic geometry of flames and reasonably realistic flame and smoke.

   The disadvantages of this method mainly stem from the problems of scaling flame and smoke down to the required size. Both fire and smoke tend to move too quickly at this scale and the fire tends to be unrealistic and difficult to control. The speed problem was resolved by slowing down the image to one-half the original speed. The fire problem was resolved by using simulated flames created by fast-moving segments of cellophane.

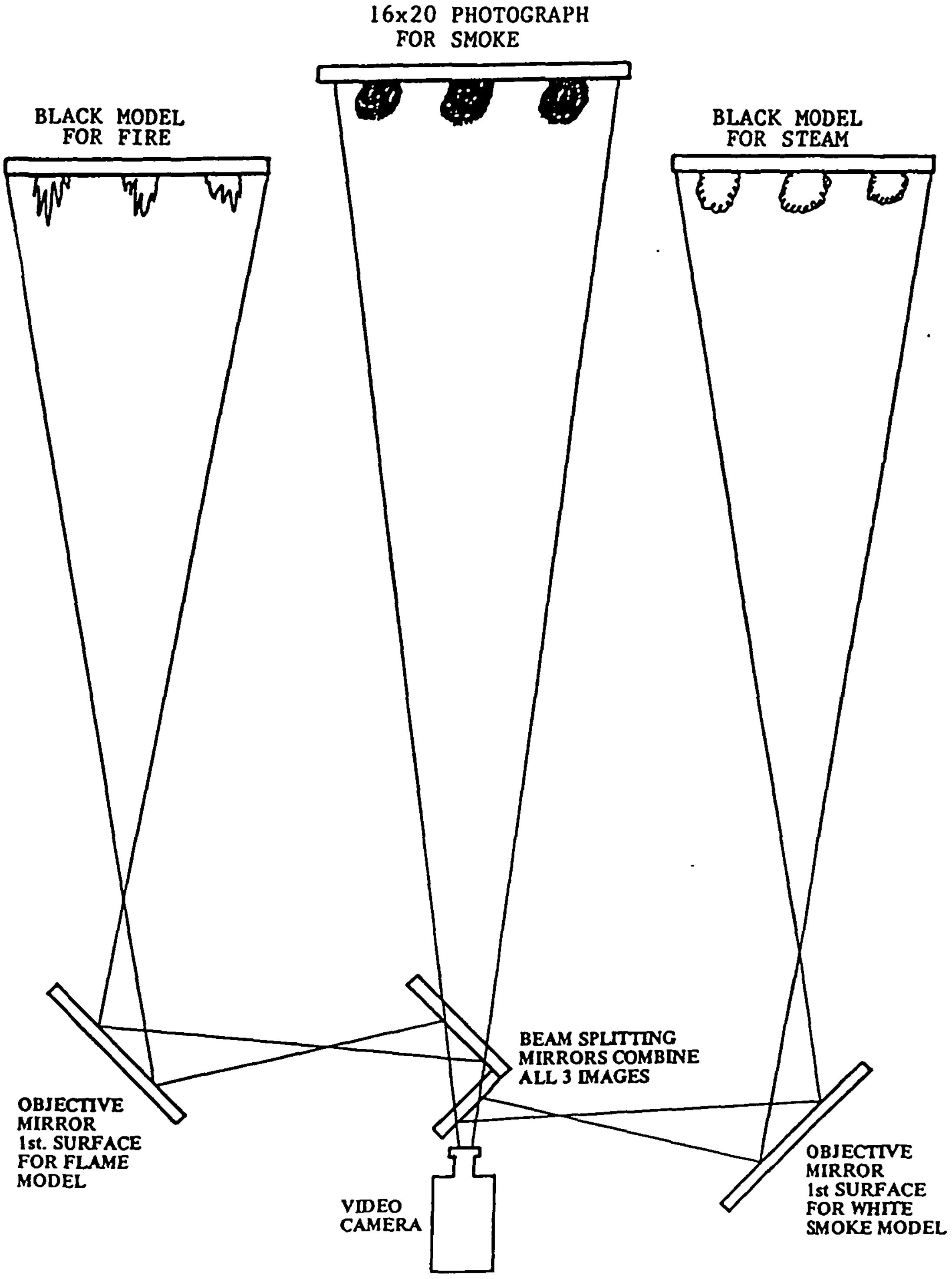

FIGURE 2 - OPTICAL OVERLAY CONCEPT FOR EMCAT SCENE GENERATION

3.0 METHODOLOGY OF SCENARIO DEVELOPMENT

This section describes the steps used in developing each scenario for the EMCAT system. This development methodology was a key design goal of the EMCAT development contract. The development process assumes that a technical consultant for fire progression and fire fighting is involved to provide all the required information.

3.1 Incident Definition

The first step in the development of a scenario is the selection of the training objective, i.e., fire situation to be simulated. Once this is known, the following information must be generated.

1. A structure is selected and photographed from the appropriate vantage point. Other photographs showing exposures, other sides of the structure, or other pertinent views can also be taken for inclusion in the pre-fire section of the video disk.

2. The structure layout and construction is determined. As long as the external features are not violated, the real floor plan can be altered to fit the fire progression desired.

3. The fire progression is determined by selecting a point of origin and determining the fire flow paths. Technical input is required to determine fire growth rates, the time to burn through an obstacle, etc. For each area in the structure, the fire start time, burn rate, and extinguishment rate need to be determined.

4. An initial assessment is made of the occupancy rate and the location of the victims, as well as the resource availability. This information is in the database and can be updated later as desired.

3.2 Responses and Effects Determination

Once the basic incident has been determined, the possible fire fighting and rescue responses can be determined. The effect on the fire progression for each response is also determined. Note that each response needs to be assessed individually. The following types of responses need to be considered.

1. Application of water for each area or groups of areas. How will it affect the fire in that area and how will it affect the fire progression into other areas?

2. Ventilation of an area. If done in the correct place, this could greatly slow the fire spread. If done incorrectly, it could greatly increase the fire spread.

3. Search paths for each group of areas need to be determined.

4. Any areas which can only be reached through another area need to be determined. The simulator will allow the scenario to be defined with these "paths" which must be extinguished before another area can be reached.

3.3 Scene Story Board Development

Using the fire progression and responses developed above, the scenes for the scenario can be determined. These are drawn on simple outline drawings of the structure to create a story board which is used during filming. The location of fire, smoke, and steam is shown for each scene in the story board. The process of development is as follows:

1. The fire progression assuming no action, or "default" progression, is drawn. This is normally between 5 and 10 scenes long. Each time a major change in the smoke, fire, or steam occurs, a new scene is required. The progression should end when all major areas are involved.

2. For each scene in the default progression, determine the visual effect, if any, for each possible response. Water application on each area which shows smoke or flames will require a new scene. Ventilation of an area will require a new scene (by showing fire appearing through the vent). Fire appearing due to alternate progressions or due to the removal of water will require a new scene. As new scenes are developed, these are also drawn on the story board if they do not already exist.

3. The process in step 2 is repeated for each scene developed until an "end" scene is reached. An end scene will usually show all areas extinguished, major areas protected while others are extinguished, or major areas burning out of control while other areas are protected or extinguished.

4. When all scenes have been illustrated on a story board, the number of scenes may be excessive. Since only about 100 scenes will fit on a video disk (assuming 15 second scenes and overhead for pre-plan information, etc.), the scenes may need to be reduced.

Some factors which will help in reducing the number of scenes are:

a. Eliminating transition scenes. For instance, fire will immediately turn to steam in the simulation.

b. Combining similar scenes, especially those which are the result of second or third generation responses.

c. Limiting the extent of the incident simulated. Once an attack has been established and depicted, the simulation should end.

5. Once the story board is completed, the scenes can be filmed and edited. Each scene should be filmed at least 10 seconds longer than required to allow for editing and video disk overhead. Since the order of the scenes on the video disk is not important, it should be selected for ease of filming and editing.

3.4 Database and Software Programming

In this phase of scenario development the information generated during the previous phases is used to develop the scenario specific software and the database. The database is developed from the structure definition, fire progression and resource availability information defined in the Incident Definition phase. The scene change rules in the database can be directly transferred from the information developed for the scene story boards. The rules and any other special software required for the scenario can be determined from the information determined in the Responses and Effects phase. This includes areas where firefighter actions can be taken, any limitations on accessibility, and the effect of ventilation and water application in the various areas.

4.0 ASSUMPTIONS

This section documents the assumptions which are built into the software, as well as those made during development of the software. A list of those assumptions follows.

1. During search and rescue operations:

   a. If area is greater than 50% involved, it will not be searched and will result in a "Too Hot to Search" message.

   b. One firefighter is required to rescue each victim found.

   c. If the number of firefighters searching is less than the number of victims found, excess victims will be left unrescued.

   d. If the number of firefighters searching is greater than the number of victims found by more than one (i.e., 2 or more firefighters), then the victims will be rescued and the search will continue with the remaining firefighters.

   e. Firefighters will not re-enter the structure after rescuing operations unless commanded.

2. During water application:

   a. Any time water is being used from an engine, a pump operator will be assigned automatically by the software.

   b. The turret is assumed to be pre-connected.

c. The water application rates for the various line sizes are:

3/4" Line =	15 GPM
1" Line =	30 GPM
1-1/2" Line =	80 GPM
1-3/4" Line =	200 GPM
2-1/2" Line =	250 GPM
Turret Line =	500 GPM.

These figures were provided by Mr. Blair of the National Fire Academy.

d. If firefighters are assigned to put water on an area which is not on fire, no water will be applied (no water damage) but the effects of water will be applied.

e. While applying water, firefighters will search the areas and, if victims are found, will abandon their hoses to perform rescue.

f. If the water supply runs out ("TANK EMPTY"), any firefighters applying water will automatically back out and will have to be reassigned when the water supply is restored.

3. Regarding the water supply:

a. The water in the tanks of all the engines or tankers on the scene is assumed to be available to all firefighters.

b. As soon as one engine is hooked to a hydrant, all engines are assumed to have access to an unlimited supply.

c. A hydrant is assumed to be able to supply as much water as needed unless it is failed.

d. When firefighters lay to a failed hydrant, they will report it and stop. They must be assigned to lay another line to an unfailed hydrant.

4. For ventilation and trenching:

a. If the area to be vented or trenched is above the third floor, an aerial ladder can be used to speed up the process, if available.

b. *If a saw fails, the firefighters will automatically return* to get another saw.

5.0 SYSTEM REVIEWS AND RECOMMENDATIONS

This section presents the results of the various demonstrations and reviews of the system. In the original contract, an evaluation period was provided whereby the system would be made available to various agencies for review. This was not performed as specified due to time and money constraints. However, an extended evaluation of the system has been conducted on the system by the National Fire Academy, since they have had access to an EMCAT system for almost 11 months due to an early delivery. A system has also been purchased by the Kentucky Vocational Education system and has undergone extensive evaluation over an 8 month period. These extended evaluations have allowed many of the problems found to be corrected in later versions of the software, a capability which would not have been possible under the original contract.

5.1 Reviews

Listed below are the demonstrations and reviews of the EMCAT system which have been conducted during the contract period. Note that those demonstrations which were held using the prototype EMCAT system developed by NASA are not listed.

1. National Fire Academy - Two review/discussion visits to the NFA January 15-16, 1985 and December 9-10, 1985. Two review/discussion visits by Mr. Blair to Essex on February 14-15, 1985 and July 15-16, 1985. During these visits requirements for scenarios and software and problems with the system were discussed. Most of these requirements have been implemented and most of the problems have been solved in the final EMCAT system.

2. Kentucky - The Public Safety Occupations division of the Kentucky State Vocational Education system has purchased a system for the purpose of evaluation. On August 22, 1985 several demonstrations of the EMCAT system were arranged for Essex personnel to attend and gather comments. The system was also used during the Lake Cumberland Regional Fire School held on August 24-25. The details of these reviews and the results are provided in Appendix A.

3. The system was demonstrated as part of the National Fire Academy presence at the Fire Department Instructors Conference held in Cincinnati during March 20-21, 1985.

4. The system was demonstrated at the U. S. Navy's Southeast Regional Fire Officer's Training Course at Whiting Field in Milton, Florida during December 3-5, 1985.

Although most of the problems or discrepancies which were uncovered during the various reviews have been incorporated into the final version of EMCAT, some of the comments were not within the scope of the development effort.

5.2 Recommendations

Several recommendations have been made for the EMCAT system which would greatly enhance the EMCAT but were not within the scope of the original contract. These are listed below.

1. Make the EMCAT system available for IBM and IBM compatible equipment. It was also mentioned during the Navy review that the U. S. Navy and Air Force have selected the Zenith Z-151 personal computer, which is IBM compatible.

2. An input mode easier to operate than the current keyboard had been requested many times. The touchscreen software, which will greatly simplify user inputs, has been developed as part of the development effort. If found to operate as expected during subsequent testing, this version of the system will probably be the version which is marketed by Essex.

3. Multiple fire situations for a scenario were requested in order to increase the factors available to training officers. The database makes this capability currently available in software, the only limit being the scenes available on the video disk. This could be made possible by generating more fire progressions on one video disk (limited to 2 or 3 fire progressions) or on multiple video disks (unlimited fire progressions).

4. Various suggestions have been made for providing a "difficulty factor" in the software which could be set by the instructor prior to each simulation session. This factor could be incorporated by simply increasing the speed of the fire spread or could involve adjusting many or all aspects of the simulation.

5. Many reviewers have complained about the inability to see any of the hardware or personnel fighting the fire. Suggestions include showing trucks as they arrive, showing personnel going into the structure when assigned, and showing lines that are put into a building. These could be accomplished with digital graphics overlayed over the video image.

6. The addition of sound effects has been mentioned as a worthwhile enhancement to the realism of the simulation. These include both background sounds of the fire scene and voices to simulate radio transmissions. The current system will not support sound because the video disk player shuts off the sound during slow-speed play modes, which are used for all EMCAT scenes. Newer technology players, or external sound sources such as synthesizers, would provide the capability for future development.

7. Many requests have been made by potential users in other fields for similar systems. Applications which have been considered

include police and security force training, plant operations training, driver training, and command post operations training and management. Essex is considering the development of other systems and is seeking funding for this purpose.

8. In order to eliminate the limiting aspects of the video disk in terms of the number of scenes and the unvariability of the simulation, it is becoming apparent that the newly emerging computer graphics technology will provide some exciting breakthroughs. Using software very similar to that already used in the EMCAT system, a simulator using this technology could generate an unlimited number of fire progressions for a given structure. The small amount of realism lost would be offset by an increase in fidelity of transition scenes, variability of smoke and flame density, and even structural damage due to fire.

In summary, the EMCAT system has been demonstrated to be an effective device for training fire scene commanders in the allocation and deployment of resources and real-time decision making. The system also appears to be marketable in the fire fighting training community, and Essex plans to pursue additional development and sales activities.

APPENDIX A

EMCAT DEMONSTRATIONS AND REVIEW COMMENTS

A listing of the demonstrations and reviews conducted in Kentucky during August 22-25, 1985 and a listing of the comments and problems recorded during those reviews follow. Note that the "new version" of the software referred to in the text is the final version delivered at the end of the EMCAT contract.

A. Demonstrations and reviews of the EMCAT System:

1. Campbellsville-Taylor County Fire Department; August 22.

2. Elizabethtown Fire Department; August 22.

3. Cave City Fire Department; August 22.

4. Lake Cumberland Regional Fire School; August 25.

B. Comments and problems recorded during the reviews listed above:

1. Develop an EMCAT System on the IBM Personal Computer.

2. Provide an audio track of fireground sounds during the simulation.

3. Output status messages, which currently appear on the status screen, via an audio system.

4. Provide a status monitor, currently provided only for the operator, for the trainees. This is possible with the current system by "splitting" the video signal for this display.

5. Show equipment and personnel on the video scene to help in tracking resources. Other alternatives to this concept include providing a plot plan of the fire scene with some means of tracking available resources. This can either be a digital, computer-controlled scene; a table-top, three dimensional model; or a magnetic, manually controlled "simulation board" (as currently used with the sand-box systems).

6. Provide standard pre-fire plan information in the scenario manual. Also provide information about the time of day, weather, and other factors which affect the incident. These provided in the scenario manuals.

7. Develop a Tanker/Chemical Spill/Hazardous Materials scenario.

8. Several comments were received which would make EMCAT more useful for volunteer departments:

   a. Randomize the number of firefighters available for each scenario.

   b. Stagger the arrival of firefighters at the scene. This is supported by the new version being developed.

c. Provide for drop tanks, ponds, or other water sources. Some of these sources, such as ponds, can be supported in the current system by using hydrants.

d. Provide the capability of calling for additional companies rather than calling for the next alarm.

e. Provide the capability to assign any firefighter to any task, regardless of which company to which they belong.

9. Several comments were received about the printout provided by the system:

   a. Print the line size used when water is applied. This is supported by the new software version.

   b. Print the total amount of water used during the simulation session.

   c. A problem exists with the determination of water damage which will be corrected in the new software version.

10. The effect of smoke inhalation on victims is not supported. However, the new version of the software automatically injure the victim when the fire starts in the area and kills the victim when the fire reaches about 50% involvement in the area.

11. Provide a flag by which the use of breathing apparatus must be requested or the firefighter will be injured. Currently, the operator can disable a firefighter manually.

12. Support the ability of firefighters to search a room with a line. This is supported by the new version of the software. It was also noted that replacements for a water crew that had abandoned their lines to perform a rescue would have a decreased setup time.

13. It was pointed out that one firefighter was usually assigned to protection with a charged line when ventilation was being performed. This can be supported in the current system by setting the minimum number of firefighters required to perform the ventilation task.

14. Provide some method to injure or kill firefighters if utility support is not requested or if the power and gas lines are not disconnected.

15. Currently, if a firefighter is sent to an area with a line, water will be applied even if the area is not on fire. This is changed in the new version of the software.

16. The question of the EMCAT system use in the one-on-one training mode versus the classroom mode (with an instructor and/or operator) arose. The current system requires some prior operator knowledge. However, it has been designed for both modes of training. A touch screen was subsequently implemented to make the system easier to operate. A light pen input system could also be implemented.