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USE OF GIS IN THE FEDERAL EMERGENCY MANAGEMENT INFORMATION SYSTEM (FEMIS)

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DISCLAIMER

Use of GIS in the Federal Emergency Management Information System (FEMIS)[1]

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Abstract

The Federal Emergency Management Information System (FEMIS) is a decision support system that integrates all phases of emergency management. FEMIS is designed to support the emergency manager in planning, coordination, response, training and exercise.

FEMIS uses a classic client-server architecture. The FEMIS component modules include a Human-Computer Interface (HCI), a relational database management system (RDBMS), an electronic mail system, a report generator, a project management system, a geographic information system (GIS), and hazard specific modeling and analysis tools. Of these systems, the RDBMS and the evacuation model reside on a UNIX platform while all the other software reside on networked personal computer (PC) workstations.

ArcView 2.0 is the GIS product used to support FEMIS at each PC workstation. ARC/INFO is loaded on the UNIX-based server and is used to prepare the spatial data. This paper describes the way GIS support for FEMIS was built using Avenue scripts and the inter-process communications available through ArcView 2.0. It also identifies the limitations encountered and the way the HCI was built to overcome them. The final product is a fully integrated responsive, user-oriented decision support system, capable of linking the planning, response, recovery, and mitigation phases of emergency management.

1.0 Introduction

The Federal Emergency Management Information System (FEMIS)[1] is a client-server based decision support system that automates and integrates the planning, coordination, response, training, and exercise phases of emergency management. FEMIS provides the planner with integrated tools to generate and distribute emergency plans, track resources, collect and use real time data from weather monitors, generate event logs and status boards, display the location of real or potential hazard events via a geographical information system, model and display plumes of hazardous material releases, animate

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plume movement over time, determine and display areas at risk, automate the formulation of protective action recommendations and decisions, generate and display evacuation routes, simulate anticipated traffic conditions during emergency evacuation, and more. FEMIS speeds response when time is critical, permitting planners and operators to quickly evaluate and implement emergency response plans, thereby reducing the risk to the population.

FEMIS is designed to be a decision support tool with applications across a broad range of disaster planning and response activities. The U.S. Army's Chemical Stockpile Emergency Preparedness Program (CSEPP) and its associated requirements, functionality, and interfaces provided the target application environment for the initial FEMIS system implementation.

This paper briefly discusses the implementation philosophy and functionality of FEMIS as a background for a more detailed discussion of the spatial data model and functionality of the GIS portion of FEMIS as implemented in ArcView Version 2.0. The paper concludes with a discussion of implementation issues and lessons learned.

2.0 FEMIS Architecture

FEMIS uses a client-server architecture as shown in Figure 1. ORACLE, a relational database management system, is used to implement the FEMIS database (FDB). As installed at a given site, the FDB may be distributed logically among multiple Emergency Operations Centers (EOCs) and physically among multiple networked Unix server workstations. The Arc/Info Geographic Information System (GIS), used for spatial data preparation and conversion, also resides on a Unix server, along with electronic mail services, an event notification system, and an evacuation network simulation model.

A communications server, implemented on a dedicated personal computer (PC) workstation, is used to acquire meteorological (met) data. The communications server receives met data over a serial port from a Handar weather system during actual operations, or from a met simulator (a PC workstation dedicated to sending canned weather data previously captured from a Handar system) during training exercises. The communications server can also be interfaced to other external communication systems and devices.

The controlling FEMIS application and user interface, the end-user GIS (ArcView 2.0), and other supporting subsystems and models operate on each client PC workstation under Microsoft Windows. The FEMIS application software is implemented in Visual Basic and controls access to the subsystem software and the relational database. The subsystems are built upon commercial off-the-shelf (COTS) software products and industry standard models as listed in Table 1. The FEMIS application communicates with its subsystems through shared Dynamic Link Libraries (DLL), Object Linking and Embedding (OLE), Dynamic Data Exchange (DDE), or a custom messaging service, depending on the interprocess communication options available in each subsystem.

All GIS interactions are performed through DDE calls from the FEMIS application to ArcView Version 2.0. The FEMIS application sends a DDE "execute" request to ArcView with the name of the Avenue [2] script to be executed and a parameter string. ArcView executes the script and sends back a DDE message with the results from the script execution and a status code.

3.0 FEMIS Functionality

FEMIS employs a windows-based user interface that facilitates the selection and use of emergency information, analysis, and planning tools without unnecessarily restricting the user to a monolithic sequence of choices. At the heart of the FEMIS application is the navigator screen, shown in Figure 2. The navigator screen provides systematic access to the FEMIS subsystems and application models. The appearance of the navigator screen, the options available to the user, and the actions resulting from those choices are dependent upon the current emergency management mode (e.g., planning, operations, exercise/training) and other prior user selections, external events, and conditions which may be present.

Planners at an EOC will use FEMIS in the ***Planning*** [3] mode to develop a suite of emergency plans based on various potential accident (event) scenarios. For any given scenario, a user may elect to apply an existing emergency plan (***Select Plan***), modify a plan (***Edit Plan***), or create a new plan (***Generate Plan***). If the EOC were notified of a real emergency event (e.g., a hazardous material release), EOC personnel would need to immediately switch to the ***Operations*** mode of FEMIS so that they could begin to analyze and respond to the emergency situation at hand. The ***Run Hazard*** option allows emergency personnel to run a hazard dispersion model (see Section 4.2) and plot the extent of the predicted plume, as shown in Figure 3. Emergency personnel may choose to view the ***Threatened Area*** (Figure 4) and obtain estimates of the population at risk and the time when the hazard is expected to reach each of the affected zones and facilities. They may then select a specific emergency plan and make the appropriate protective action decisions (e.g., evacuation or sheltering). ***Operational Tracking*** (Figure 5) may be invoked to track the overall status of emergency operations. Detailed information on the event, weather conditions, casualties, evacuees, and other topics can be obtained from status boards under the ***Status*** option.

The ***Evacuation*** option provides access to an evacuation network model (see Section 4.6) for evaluating the consequences of evacuation decisions. The evacuation simulator model ESIM[2] forecasts the loading of the evacuation network links based on traffic loading and roadway network topology. Traffic loading is determined by weather, population distribution, and other conditions at the time of the emergency event. The

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[2] Avenue is the programming language of ArcView.

[3] Key words in italics indicate actual FEMIS button labels or menu items.

network topology can be quickly modified to account for road closures, accidents, or other problems. The results are best depicted through ***Animation*** of the evacuation network, synchronized with animation of the hazardous material dispersion. Figure 6 shows an animation snapshot.

4.0 GIS Functionality

The FEMIS GIS map display, implemented as a view within an ArcView project, includes a scanned image map of the area of interest, together with themes that represent readily identifiable features, such as roads, streams, water bodies, and political and administrative boundaries. These features provide a background and spatial frame of reference for the display of features and events (e.g., facilities, traffic control points, emergency planning zone boundaries) that are relevant to the emergency management process.

The FEMIS application, written in Visual Basic, controls the programmatic interface to the GIS. A ***Map*** button on the toolbar of the main FEMIS screen is always visible and provides access to ArcView to perform general ad hoc mapping functions. In addition, context-sensitive map buttons found in many of the application screens invoke the GIS to perform special map display and selection functions that are specific to the FEMIS application.

The GIS is used to create and display graphic representations of the potential dispersion of hazardous substances following an accidental release to the environment. Emergency planners can use the GIS to display, identify, and analyze the spatial relationships among possible event locations, shelters and other emergency management facilities and resources, transportation routes, and population at risk. The GIS can also animate the progression over time of both the hazard plume and the evacuation of the affected area. These and other GIS functions currently implemented in FEMIS are discussed in the following paragraphs.

4.1 Location Identification and Spatial Analysis

By selecting the map button located on many of the FEMIS screen forms, the user activates the FEMIS GIS map display. The user may then perform various selection, identification, and spatial analysis functions. The map button of each form invokes an Avenue script which provides context-sensitive functionality. In some situations the user is presented with a "view-only" map on which the desired information (e.g., a plume) has been plotted. In other cases the user is asked to graphically interact with the map by selecting individual objects or by drawing a polygon enclosing the map objects for which specific information is requested. In all cases in which the user is expected to pick an object, choose a location, or draw a polygon, the ArcView cursor is a bull's eye.

The user may activate the GIS at any time from the map button on the toolbar in the parent FEMIS window. A standard base map of the current site is displayed, with access to most of the functions available in ArcView's default graphical user interface (GUI). Some special-purpose functions are also provided. For example, an "area" button allows the user to select a theme and graphically identify a subset of polygons for which the total surface area is desired. A "population" button provides a summation of the population within the census blocks that are intersected by one or more user-selected polygons.

4.2 Hazard Condition Identification

FEMIS uses D2PC[3], the PC version of an atmospheric dispersion model called D2, to predict the extent of a real or hypothetical release of hazardous materials to the environment by computing a dispersion plume. The area covered by the plume varies with time and depends on a variety of input conditions such as wind direction, wind speed, atmospheric stability, and the quantity and type of the hazardous material released.

The user may specify or modify the input conditions by editing the D2 input form. Selection of the ***Run and Plot*** option causes the D2 model to execute. The plume contours predicted by the model are then passed to ArcView for plotting.

For each plume, multiple contour polygons are built and shaded according to the values of the contour level attribute (concentration or dose). A separate theme is created for each set of polygons that constitutes a D2 plume. Up to ten dosage or concentration levels may be plotted for each model run. Outputs from multiple D2 runs may be displayed simultaneously by using different colors and/or shade patterns for each theme.

4.3 Risk Area Identification

The geographical area of interest surrounding the potential hazard site is divided into emergency planning zones. For a given hazard event, the "risk area" is the set of zones that are at risk of exposure to the hazard plume, as determined by one of the following methods:

- Plume Intersection. The user picks one of the D2 plume contours, and all zones that are partially or fully intersected by the selected contour polygon make up the risk area.

- Risk Wedge. The user selects a point on the map (usually the hazard release point) and specifies the central direction, arc width (angle), and length for plotting a wedge-shaped area called a risk wedge. The risk wedge accounts for possible variations over time from the basic wind direction used by the D2 model. The zones intersected by the risk wedge form the risk area. The risk wedge is created dynamically in ArcView and stored with other wedges in a "wedge" theme for subsequent retrieval and analysis.

- Ad Hoc Selection. The user picks the zones to be included in the risk area from a list or from the map by clicking with the mouse. The user may also modify an existing risk area by adding or deleting zones.

The zones at risk are displayed with different shading to distinguish them from the remaining zones. ArcView's theme-on-theme selection function can be used to identify objects of interest (e.g., facilities) within the risk area.

4.4 Facility Updates

Locations and attributes of facilities that are relevant to emergency planning and operations are stored in the FDB. Updates to the facility attributes may occur rather frequently and need to be reflected in the GIS facility theme. Each time there is a modification to the facility information stored in the FDB, a text file containing the relevant facility locations and attribute values is created and stored on the Unix server. This file is then downloaded to the client PC's and used within ArcView to create an event theme that replaces the existing facility theme.

4.5 Impact Time

Impact time is the time from the beginning of an emergency event (hazard release) until the hazard reaches a protective action unit (e.g., a facility). This is the amount of time available to notify emergency officials, warn the public, and implement protective actions. One method used to estimate impact times in FEMIS is to perform a theme-on-theme selection within the GIS to identify the facilities at risk, then compute the distance to each facility from the location of the emergency event, and finally provide this information as input to another model, PARDOS. The PARDOS model estimates impact times at discrete distances from a chemical dispersion source. Within FEMIS, PARDOS predicts impact times to zones and facilities. It is also used in the generation of plume animation time steps.

4.6 Evacuation Network Generation

The ESIM evacuation model provides both initial time estimates for evacuation and time-step animation to evaluate the evacuation feasibility and consequences. An evacuation network must be specified before ESIM can be run.

The evacuation road network is depicted as a Link-Node Diagram (LND). The LND, generated from information in the FDB, is represented in ArcView with link, node, and centroid themes that are stored as ArcView shape files on the user workstation. These themes are generated by the following process:

a. The link and node data are manipulated to create an ArcView table that stores the coordinates of the beginning and ending node of each link. This table, called the link table, has one record for each link.

b. The link and centroid themes are created by looping through all the records in this link table.

c. The node theme is generated directly from the node coordinate information stored in the FDB.

Each link is represented as an arrow that is slightly offset from the centerline between the beginning and ending node. Bi-directional links are thus shown by two non-overlapping arrows so that the user can identify (pick) either link using the mouse.

FEMIS provides the capability to edit the link-node diagram by adding, deleting, or modifying links, nodes, or centroids. Records are added or deleted in the FDB and in the corresponding ArcView theme attribute table. Modifications that do not affect the LND object locations (e.g., changes in the allowable turns at a node) are performed only in the FDB.

The user is notified of possible consequences of an "add" or "delete" action. For example, deleting a node will also delete all the links connected to the node. These links are highlighted and the user is requested to confirm the delete request. If adding a link would exceed the number of links per node allowed by the ESIM model, the user is notified and the "add" request is denied.

4.7 Animation

Both the predicted location of the dispersion plume over time and the loading of the evacuation network can be animated in synchronization and displayed in the GIS. Both animations are controlled by the FEMIS application to depict the evacuation network status in relation to the plume movement.

Plume animation starts with the drawing of an animation wedge as a GIS theme. The dispersion polygons are drawn as soon as they are received through DDE calls from the FEMIS application. An animation "play box" controls the animation methods/choices: step forward, fast forward, stop, step backward, reset (restart).

The evacuation animation starts with the generation of a graphic object list containing a clone of the link arrows. At each of the animation steps, ArcView receives a DDE call with the list of colors for each of the links. The colors vary with the link traffic loading. A play box controls the animation mode in a manner similar to plume animation.

5.0 FEMIS Spatial Data Model

FEMIS spatial datasets consist of themes that are accessed and displayed with ArcView running on the user's PC in stand-alone mode or under the control of FEMIS applications. Some themes are relatively static and are created and pre-loaded from various data sources, using a variety of data import processes. Other themes that are

dynamic in nature are created or modified by Avenue scripts that are invoked by FEMIS applications. Each theme represents a coherent set of similar geographic features, such as roads, facility locations, emergency planning zone boundaries, or predicted hazardous material concentration contours.

The FEMIS spatial datasets contain attribute information which characterizes the geographic features that make up the themes. Some of these attribute values are stored and maintained in the FDB.

5.1 Theme Characterization

Table 2 lists the FEMIS spatial themes along with their data sources and other characteristics. The FEMIS themes can be divided into four categories:

1) Static themes are background map layers and other themes that change infrequently and are managed and controlled by the system administrator at the FEMIS site. Users are not permitted to modify the spatial or attribute information contained in these datasets. Examples of static themes are roads, census blocks, and image maps. All of these themes are pre-loaded into the FEMIS spatial database.

2) Themes with user-modifiable attributes are themes with attributes that can be modified by users from within certain FEMIS modules. Updates are restricted to the temporary addition or modification of designated attributes of existing theme features. The emergency planning zones theme is an example of a theme with user-modifiable attributes. The operator/planner can insert or modify a protective action recommendation or decision status (evacuation or sheltering) for each emergency zone within the risk area.

3) Themes with user-added features are existing themes which allow users of FEMIS to add new geographic features. These themes are currently restricted to point (event) themes and include facilities and other known points. The facilities theme is initially loaded with the locations of buildings and other facilities of interest for emergency planning purposes. Users can then add other facilities to this theme. Known points are other locations that users may wish to include as named reference points, such as the location of a hypothetical or real emergency event, or potential traffic control points during the evacuation of an area.

4) Model-generated themes are created by applications that are linked to the hazard dispersion and evacuation models. A separate theme is created and stored on the user's PC for each model case that is run. Because these themes are generated dynamically in response to calls from the FEMIS application software, they are not loaded initially.

5.2 Data Sources and Import Processing

Arc/Info is used to process the raw spatial data and convert it into ArcView themes. Associated attribute data must also be prepared for loading into the FEMIS relational database. The five primary sources of FEMIS spatial data are listed below.

1) IBS[4] (Integrated Baseline System). IBS was developed by PNL for the U.S. Army as an interim off-post emergency management system. IBS stores and manages spatial data and related attributes of off-post geographic features and modeling results.

2) EMIS[5] (Emergency Management Information System). EMIS was developed by Applied Computer Systems, Inc., for the U.S. Army as an interim on-post emergency management system. EMIS stores and manages spatial data and related attributes for on-post geographic features, modeling results, and raster image background maps of the area surrounding the CSEPP site.

3) TIGER/Line Data. The U.S. Bureau of the Census provides TIGER/Line data files that contain location and attribute information for a variety of physical and non-physical features such as roads, railroads, streams and water bodies, landmarks, state and county boundaries, and census unit boundaries.

4) Site Configuration Data. Some spatial data related to planning decisions made at the site (e.g., accident-based planning category boundaries) may not be available from any other existing data system. This data must be obtained directly from site personnel and must be entered into ASCII files or digitized from USGS maps or other printed maps prior to FEMIS import processing.

5) FEMIS Application Models. The FEMIS application uses the model outputs from the dispersion and evacuation models to generate ArcView themes via calls to Avenue scripts.

6.0 Implementation Issues

One of the major challenges in building FEMIS was to integrate the commercial software packages with the FEMIS application in such a way that the entire system has a reasonably consistent "look and feel" as a single integrated product. ArcView provides limited flexibility in the positioning and appearance of the user interface. In addition, Arcview does not use standard Open Database Connectivity (ODBC) drivers to access the Oracle relational database. To compensate for these limitations, we built a shell of Visual Basic around ArcView to access the database and handle most of the user dialogue. This Visual Basic shell facilitated the customization of the user dialogue to present a "look and feel" that is similar to the remainder of the FEMIS application.

Other specific issues and problems encountered in using ArcView to implement the GIS subsystem of FEMIS are described in the following paragraphs.

6.1 GIS Application Interface

All GIS interactions with the FEMIS application are performed through DDE calls to ArcView, in which ArcView is the server and the FEMIS application is the client. All DDE calls pass to ArcView the name of the script to be executed and a parameter list. The first three parameters are always the name of the FEMIS executable application that makes the DDE call, the link topic, and the link item. These parameters are used to create a DDE client to send back the results from the ArcView script execution. The remaining parameters are used as inputs to the ArcView script to be executed.

One limiting factor of this approach is the maximum length of the parameter string in the DDE call (currently 255 characters), a DOS limitation. This limitation, encountered in spatial analysis requests, in polygon creation, and in animation, was circumvented by storing the actual parameter string in a file and passing the file name in the DDE call.

Given the choice, we would have preferred a more robust and efficient interprocess communication mechanism such as that provided by an application programming interface using dynamic link libraries (DLL). However, ArcView does not currently support a DLL interface.

6.2 Feature Attributes and Display Characteristics

Attributes of features contained in FEMIS themes are currently stored as columns in the ArcView theme table. Some of the themes also have attributes that are stored and managed in the relational database. If a change is made to a theme's feature locations or attributes within the relational database, the change is communicated to ArcView through a DDE message to initiate modification or regeneration of the ArcView theme.

Display characteristics of a theme are currently loaded from legend files or initialized during the setup process based on parameters in an initialization file. In future FEMIS releases, these characteristics will be stored in GIS data dictionary tables in the FDB. The GIS data dictionary will define default display characteristics (legend parameters) for each theme. It will also permit the definition of optional display characteristics based on attribute classification.

6.3 Set-up and Configuration Management

ArcView provides a development environment in which the script editor is integrated with the graphical user interface (GUI). The ArcView project file is a snapshot of the ArcView system as of the moment the project is saved. The project status, as represented by the ArcView GUI, scripts (Avenue code), views, charts, tables, and associated data pointers, is captured in a project file characterized by the ".apr" extension. When the project is started again, it presents the user with the same environment as of the moment the project was saved.

The project file is a powerful development vehicle. It allows the developer to write new scripts, compile them, and execute them without having to re-compile and re-link the existing scripts or modify the GUI. However, there are some drawbacks: 1) the data are not separate from the code, 2) the same GUI is presented to all users, and 3) code configuration management is difficult. The following paragraphs describe some of the steps that were taken to minimize these problems.

6.3.1 Separation of Data from Code (Data Independence). FEMIS is intended to be used in a number of geographically disparate locations with different data characteristics and requirements. The same code must be applicable to all of the spatial datasets. Although it would be easy for a user to enter ArcView and add or delete datasets (themes), it is not obvious how this should be done to ensure that the GIS code will operate properly and consistently on the specific set of themes that are included in the project. Our solution to this problem was to store appropriate metadata (theme names, legend parameters, and other descriptive information) in the FDB for all of the site-specific spatial datasets. As part of the on-site installation, the spatial metadata for the site are accessed from the relational database, and the relevant themes are loaded into the project under control of an Avenue script, as specified by the information in the metadata. The ArcView GUI is then customized for FEMIS use; the project file, with its pre-loaded themes and Avenue code, is stored; and the project is then ready for use by the FEMIS application.

6.3.2 GUI Regeneration. The FEMIS requirements for simplicity of use and minimal training created the need for a simplified ArcView graphical user interface. A simplified interface is less confusing to first-time users, but it imposes restrictions on the expert user or developer. Therefore, ArcView scripts were written to modify the default ArcView GUI to meet the FEMIS requirements, and to optionally restore the full GUI for the expert user or developer. The usual cloning of a GUI was not adequate here because a GUI is tied to a document, and FEMIS requires the same interface for all documents of the same type (e.g., all tables should be presented with the same GUI).

6.3.3 Configuration Management. Developing code within an ArcView project has at least two risks: 1) a code error may corrupt and destroy the entire project file; and 2) a second developer may be in the process of making some changes that are incompatible with the first developer's modifications. Storing the project file in a code control system does not help because if one developer needs to modify a script, he has to check out the entire project file, and this prevents other developers from working with any of the code components contained in the project. Both problems are due to the fact that the project file contains both the source code and the "executable" software. To solve these problems without losing the advantages of the project file, we automated a script back-up and restore process that allows the project file to be rebuilt from the text files of the scripts. If the script text files are saved in a code control system, they can be checked out with the proper locks that would let fellow developers know that a specific script is being worked on by another person. Furthermore, the script text files can now be archived for each major code release and treated as traditional code.

7.0 Conclusions and Lessons Learned

ArcView proved to be a dynamic and flexible environment for implementing the required GIS functionality for FEMIS. This environment and the object orientation of Avenue, ArcView's scripting language, allowed rapid prototyping and implementation and helped to make the development process enjoyable. A more versatile debugger could have made the process even more productive and enjoyable.

The most significant limitations encountered were:

- the inability of ArcView to use the standard Microsoft Open Database Connectivity (ODBC) drivers to access the Oracle database. The drivers made by Q&E and recommended by ESRI for use with ArcView were not compatible with some aspects of the Visual Basic code used in the FEMIS application. This inadequacy made it impossible to access the FDB directly from ArcView.

- the lack of a robust inter-process communication mechanism such as that provided by an application programming interface (API) using Dynamic Link Libraries (DLL).

- the limited ability of ArcView to customize the user interaction dialogue and style. It was thus difficult to make the ArcView dialogue appear similar to that used in the remainder of the FEMIS application.

To compensate for these limitations, we built a shell of Visual Basic around ArcView to access the relational database and handle most of the user dialogue. This helped to make the user interface more uniform throughout the FEMIS application. In retrospect, building the Visual Basic shell was a fortunate decision because there will be very little reprogramming required to convert the ArcView DDE calls to DLL calls when future ArcView releases provide for the integration of DLLs.

Acknowledgements

FEMIS is the product of the FEMIS project team. Many members of this team provided comments and suggestions that helped to make this a better paper. The contributions of J. Bower, M. Burford, T. Coonelly, T. Downing, D. Millard, and J. Williams are especially appreciated.

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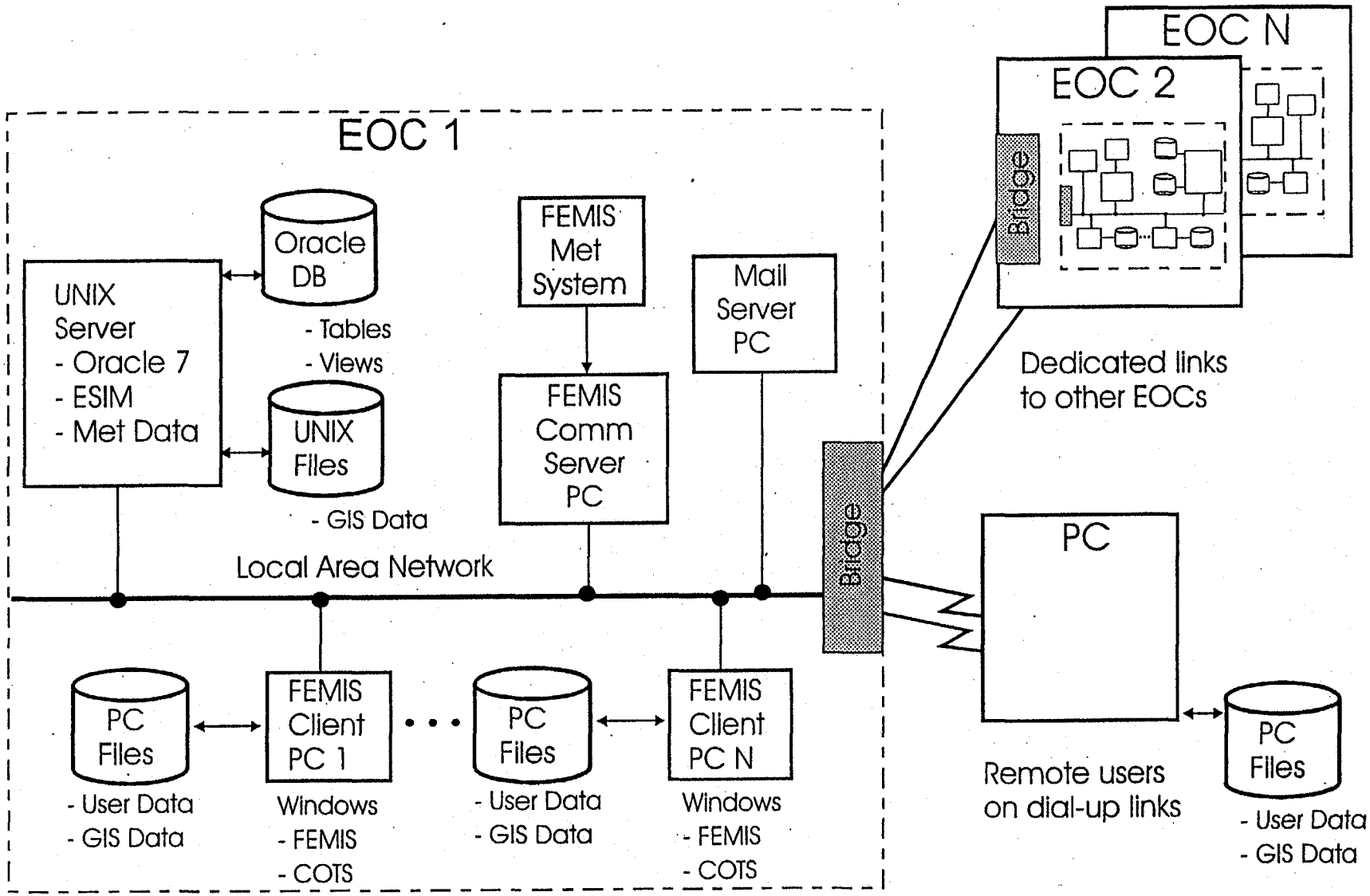

Figure 1. Conceptual View of FEMIS Phase I

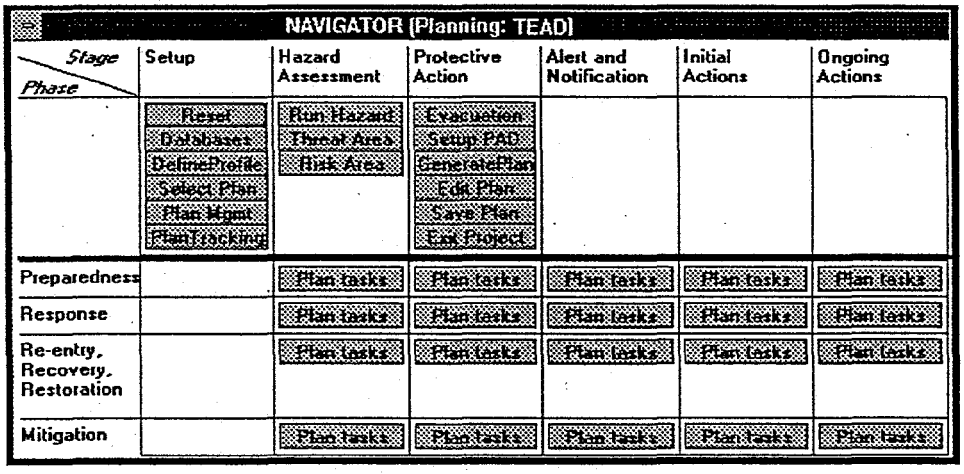

Figure 2. FEMIS Navigator Screen.

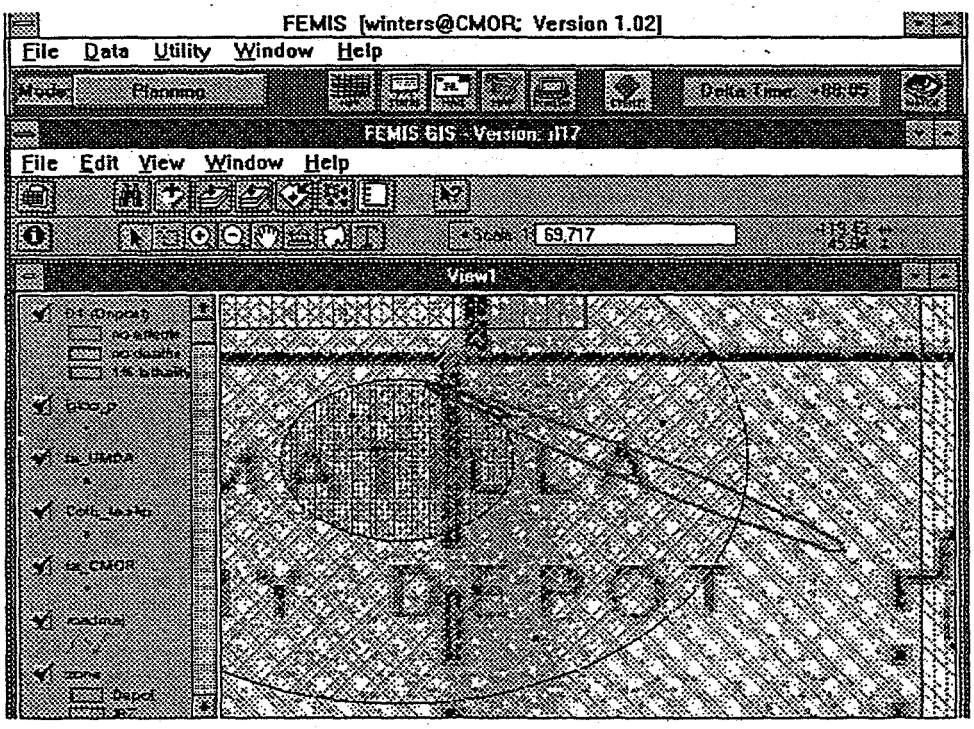

Figure 3. Hazard Dispersion Plume.

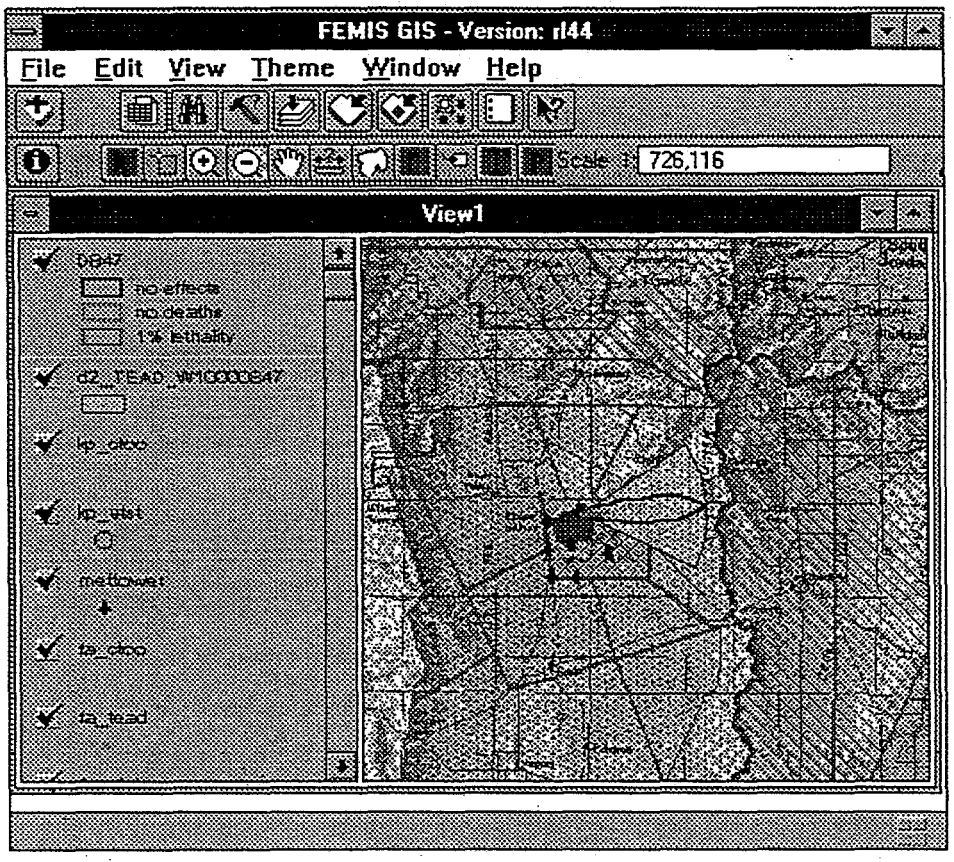

Figure 4. Threatened Area Display.

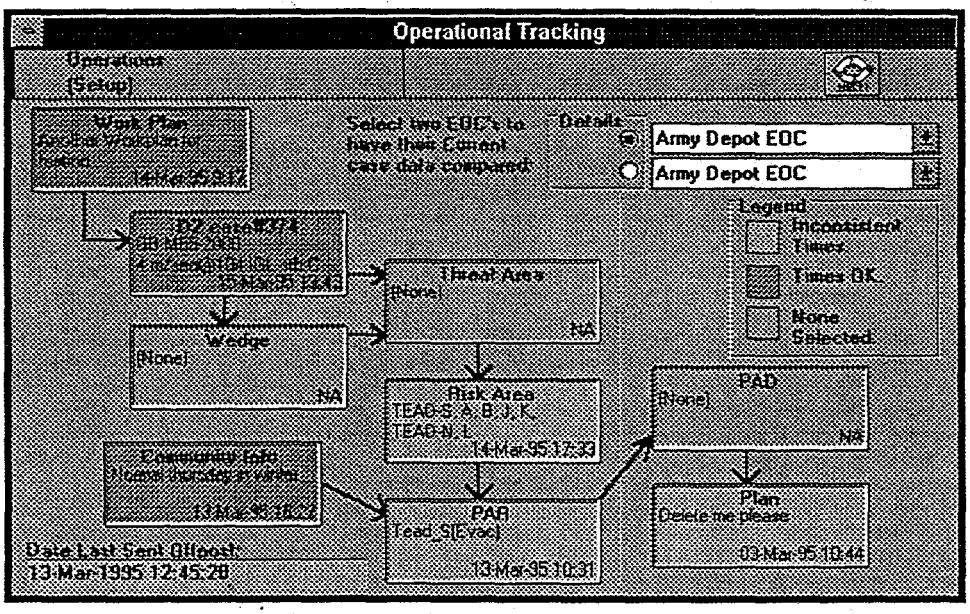

Figure 5. Operational Tracking Screen.

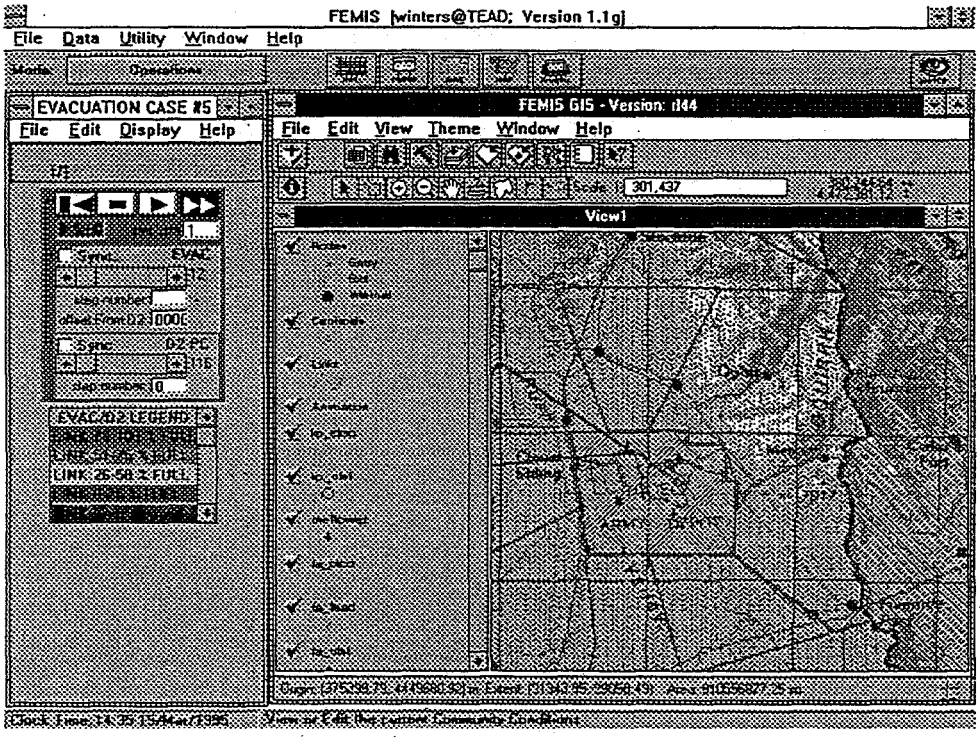

Figure 6. Animation Snapshot.

Table 2. GIS Theme Dictionary

Generic Theme Description	Legend	Data Source	Data Type	User Modifiable	Number of Themes
Facilities	<eoc> Facilities	IBS/FEMIS App	Vector Point	Yes	1 per EOC
Known Points	<eoc> Known Pts	IBS/FEMIS App	Vector Point	Yes	1 per EOC
Accident Based Planning Wedges	<eoc> ABP Wedges	FEMIS App	Vector Polygon	Yes	1 per EOC
D2 Track (dose)	<eoc>_dose<case_id>	FEMIS App	Vector Polygon	Yes	1 per EOC, case
D2 Track (conc.)	<eoc>_conc<case_id>	FEMIS App	Vector Polygon	Yes	1 per EOC, case
D2 Wedge	<eoc>_wedg<case_id>	FEMIS App	Vector Polygon	Yes	1 per EOC, case
Evacuation Nodes	<eoc>_node<case_id>	FEMIS App	Vector Point	Yes	1 per EOC, case
Evacuation Centroids	<eoc>_cent<case_id>	FEMIS App	Vector Point	Yes	1 per EOC, case
Evacuation Links	<eoc>_link<case_id>	FEMIS App	Vector Line	Yes	1 per EOC, case
Census Subdivisions (MCD/CCD)	Census Subdivs	TIGER/Line	Vector Polygon	No	1
Census Tracts	Census Tracts	TIGER/Line	Vector Polygon	No	1
Census Blocks	Census Blocks	TIGER/Line	Vector Polygon	No	1
State & County Boundaries	State/County Bnd	TIGER/Line	Vector Polygon	No	1
Accident-Based Planning Categories	ABP Categories	Site Config	Vector Polygon	Yes	1
Igloos (point)	Igloos (point)	EMIS	Vector Point	No	1
Igloos (area)	Igloos (area)	EMIS	Vector Polygon	No	1
Emergency Planning Zones	Emerg Plan Zones	IBS/Site	Vector Polygon	Yes	1
Met Towers	Met Towers	Site Config	Vector Point	No	1
Administrative Boundaries	Admin Boundaries	IBS	Vector Polygon	No	1
All Roads	All Roads	TIGER/Line	Vector Line	No	1
Major Roads	Major Roads	TIGER/Line	Vector Line	No	1
Streams, Water Bodies	Streams, Lakes	TIGER/Line	Vector Line, Poly	No	1
Image Maps	Image Map 1:<scale>	EMIS	Image	No	1 per scale

<eoc> = <eoc_code> -- Example: CUMA (County of Umatilla, Oregon)
<site> = <site_code> -- Example: TEAD (Tooele Army Depot, Utah)
<case_id> = 7-digit D2 or evac. case id (least significant 7 digits, including leading zeros) -- Example: 0000341
<scale> = map scale factor -- Example: 500K (1:500,000)

Table 1. COTS Software and FEMIS Models	
RDBMS	ORACLE v7.1
GIS	Arc/Info v7.0.2 (Unix) ArcView v2.0 (PC)
Plan Management	Microsoft Project v4.0
E-mail	Novell Groupwise v4.1
Word Processor	WordPerfect v6.0
Office Applications Graphics Spreadsheet	 MS PowerPoint v4.0 MS Excel v5.0
Dispersion Model	D2PC (July 1994)
Dosage Model	PARDOS v2.1
Evacuation Model	ESIM/OREMS (February 1994)

Table 2. GIS Theme Dictionary

Generic Theme Description	Legend	Data Source	Data Type	User Modifiable	Number of Themes
Facilities	<eoc> Facilities	IBS/FEMIS App	Vector Point	Yes	1 per EOC
Known Points	<eoc> Known Pts	IBS/FEMIS App	Vector Point	Yes	1 per EOC
Accident Based Planning Wedges	<eoc> ABP Wedges	FEMIS App	Vector Polygon	Yes	1 per EOC
D2 Track (dose)	<eoc>_dose<case_id>	FEMIS App	Vector Polygon	Yes	1 per EOC, case
D2 Track (conc.)	<eoc>_conc<case_id>	FEMIS App	Vector Polygon	Yes	1 per EOC, case
D2 Wedge	<eoc>_wedg<case_id>	FEMIS App	Vector Polygon	Yes	1 per EOC, case
Evacuation Nodes	<eoc>_node<case_id>	FEMIS App	Vector Point	Yes	1 per EOC, case
Evacuation Centroids	<eoc>_cent<case_id>	FEMIS App	Vector Point	Yes	1 per EOC, case
Evacuation Links	<eoc>_link<case_id>	FEMIS App	Vector Line	Yes	1 per EOC, case
Census Subdivisions (MCD/CCD)	Census Subdivs	TIGER/Line	Vector Polygon	No	1
Census Tracts	Census Tracts	TIGER/Line	Vector Polygon	No	1
Census Blocks	Census Blocks	TIGER/Line	Vector Polygon	No	1
State & County Boundaries	State/County Bnd	TIGER/Line	Vector Polygon	No	1
Accident-Based Planning Categories	ABP Categories	Site Config	Vector Polygon	Yes	1
Igloos (point)	Igloos (point)	EMIS	Vector Point	No	1
Igloos (area)	Igloos (area)	EMIS	Vector Polygon	No	1
Emergency Planning Zones	Emerg Plan Zones	IBS/Site	Vector Polygon	Yes	1
Met Towers	Met Towers	Site Config	Vector Point	No	1
Administrative Boundaries	Admin Boundaries	IBS	Vector Polygon	No	1
All Roads	All Roads	TIGER/Line	Vector Line	No	1
Major Roads	Major Roads	TIGER/Line	Vector Line	No	1
Streams, Water Bodies	Streams, Lakes	TIGER/Line	Vector Line, Poly	No	1
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