EGG 11265-1123
UC-708
Conf-950430--4

APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM FOR RADIOLOGIC EMERGENCY RESPONSE

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SUMMARY

Data and information are not synonymous. By definition **data** are "...a series of observations, measurements, or facts." Information implies that knowledge is obtained from the instruction, investigation, or study of data. A Geographic Information System (GIS) is a multifunctional analytical tool that can be used to compile available data and derive **information**. A GIS is a computerized database management system for the capture, storage, retrieval, analysis, and display of spatial (i.e., locationally defined) data. Maps are the most common type of spatial data, but any type of data that can be referenced by an x-y location or geographic coordinate can be used in a GIS. Vertical aerial photos and electro-optical images can also be georeferenced and used as base maps. Data are often available from different sources, at different scales, and in different projections. In a radiological emergency, it is critical that data of all types be rapidly compiled into a common format in order to make accurate observations and informed decisions.

For emergency situations that require rapid response, base layers should be preprocessed for quick implementation. Scenario-dependant information can be entered into the GIS as data become available. Developing a baseline GIS for nuclear facilities would offer a significant incentive for all organizations to contribute to and utilize this powerful data management tool. The system being developed could integrate all elements of emergency planning, from the initial protective actions based on models through the emergency monitoring phase, and finally ending with the complex reentry and recovery phase.

INTRODUCTION

Comprehensive and timely radiological, cultural, and environmental data are required in order to make informed decisions during a radiological emergency.

One of the responsibilities of the DOE Nevada Operations Office, under the Federal Radiological Emergency Response Plan (FRERP) and the Aerial Measuring System (AMS) program, is the acquisition and analysis of these data. Much of the data are in the form of maps, tabular summaries, and vertical imagery. During an emergency it is critical that these data be rapidly compiled into a common format. This data management task is large and complex and is ideally suited for automated processing.

Within the Federal Radiological Monitoring and Assessment Center (FRMAC), there is a continuing effort to improve the data management and communication process. The most recent addition to this essential function has been the development and testing of the **F**ield **A**nalysis **S**ystem for **E**mergency **R**esponse (FASER). The system is configured with commercially available off-the-shelf hardware and software components. This facilitates the sharing of much of the data with all state and Federal agencies which may be involved. It is an integrated system with compatible digital image processing (ERDAS, Inc. 1994) and GIS (ESRI 1992) software. All hardware is mounted in containers designed for shipment on overland carriers or commercial airlines.

The GIS provides an integrated platform for the input, archival, query, and analysis of spatially referenced data. The integration of digital image processing capabilities with the GIS permits digital map products to be registered and overlaid onto satellite and aerial imagery. The GIS is multi-functional with input, analysis, and output capabilities. Most use data structures that store points, lines, or polygons as strings of coordinates or vectors. A true GIS will also have an associated set of attributes stored in an accessible, relational database.

This ability distinguishes a GIS from more common engineering CAD/CAM systems. The analytical capabilities of GIS include, but are not

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limited to: overlay, aggregation of map units, feature extraction by attribute, proximity analysis, modeling, area/length measurements, feature enumeration, and network analysis.

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DATA BASE DESIGN AND IMPLEMENTATION

To support FRMAC deployments and field exercises, geographic databases consisting of co-registered "layers" of cultural, radiological, aerial photographs, satellite imagery, and environmental data are being compiled for the areas around commercial nuclear power plants and DOE facilities. Data were encoded into ARC/INFO, a commercially available GIS that operates on personal computers, work stations, and mainframe computers (ESRI 1992). The library of layers may include the following data:

- Administrative Boundaries

    State Boundaries
    County and/or Township Boundaries
    Emergency Planning Zones (EPZ)
    Protective Action Sectors (PAS)

- Transportation

    Roads
    Railroads
    Utility Corridors
    Evacuation Routes

- Surface Hydrology

- Landcover

- Emergency Response and Public Facilities

    Emergency Operations Centers (EOC)
    Decontamination Centers
    Shelters and Reception Centers
    TLD Locations
    Schools
    Police and Fire Stations
    Hospitals
    Nursing Homes
    State Institutions
    Major Industries
    Recreation Areas

- Radiation Fallout Patterns

    Exposure Rate
    First-Year Dose
    Ingestion Pathways
    Baseline Radiation

- Dispersion Model Outputs

    RASCAL
    ARAC

- Imagery

    Satellite Images
    Aerial Photographs

The variety of source materials (including maps, tabular summaries, and satellite imagery) is collected from Federal, state, and commercial sources. The transportation and hydrology layers are produced from Digital Line Graphs (DLG) acquired from U.S. Geological Survey in a system-compatible format. Landcover is derived from an unsupervised spectral clustering and maximum likelihood classification of Landsat satellite Thematic Mapper (TM) data. This layer is maintained as a raster image layer and converted to a system-compatible vector layer. Radiation data can be entered from hand-drawn maps, or gamma data acquired with EG&G's Aerial Measurement System (AMS) in a format that can be entered directly into the GIS. Most of the remaining data layers are manually automated from existing maps and reports. All data are co-registered and transformed into a common geographic coordinate system. Creation of this comprehensive data base is very labor intensive. It is recommended that base layers be preprocessed for quick implementation during an emergency so that all efforts could be concentrated on the automation and processing of scenario-dependant data.

To demonstrate the potential of GIS for emergency response, the system has been utilized in interagency FRMAC exercises. An interactive GIS system has been deployed and used to analyze the available spatial data to help determine the impact of a hypothetical radiological release and to develop mitigation plans. For this application, both hardcopy and real-time spatial displays were generated with the GIS. Composite maps with different sizes, scales, and themes were produced to support the exercises. The number of possible maps that can be derived from this data base is limited only by the users' needs.

FIELD ANALYSIS SYSTEM FOR EMERGENCY RESPONSE (FASER)

The Field Analysis System for Emergency Response (FASER) is a modular system designed to be deployed and used in direct support of emergency response situations. The modular nature of the system allows for maximum flexibility in that the system can be field configured to fit the situation encountered. This system is based on a RISC-based workstation.

The system is configured with commercially available off-the-shelf hardware and software components. This facilitates the sharing of much of the data with all state and Federal agencies which may be involved. It is an integrated system with compatible digital image processing (ERDAS, Inc. 1994) and GIS (ESRI 1992) software. All hardware is mounted in containers designed for shipment on overland carriers or commercial airlines.

Modularity is a major consideration. This provides redundancy in the field, particularly if more than one system is deployed. It also allows for systems to be customized easily for specific tasks, simply by connecting disk drives with desired software and ample free disk space, along with the desired peripherals. To be most effectively modular, "live insertion" should be supported as fully as possible. "Live insertion" refers to the ability to insert and remove individual boards and disk drives within a system without powering the system down, eliminating lengthy reconfiguration delays associated with switching the system off. This capability is also known as "hot swapping" or "hot plugging."

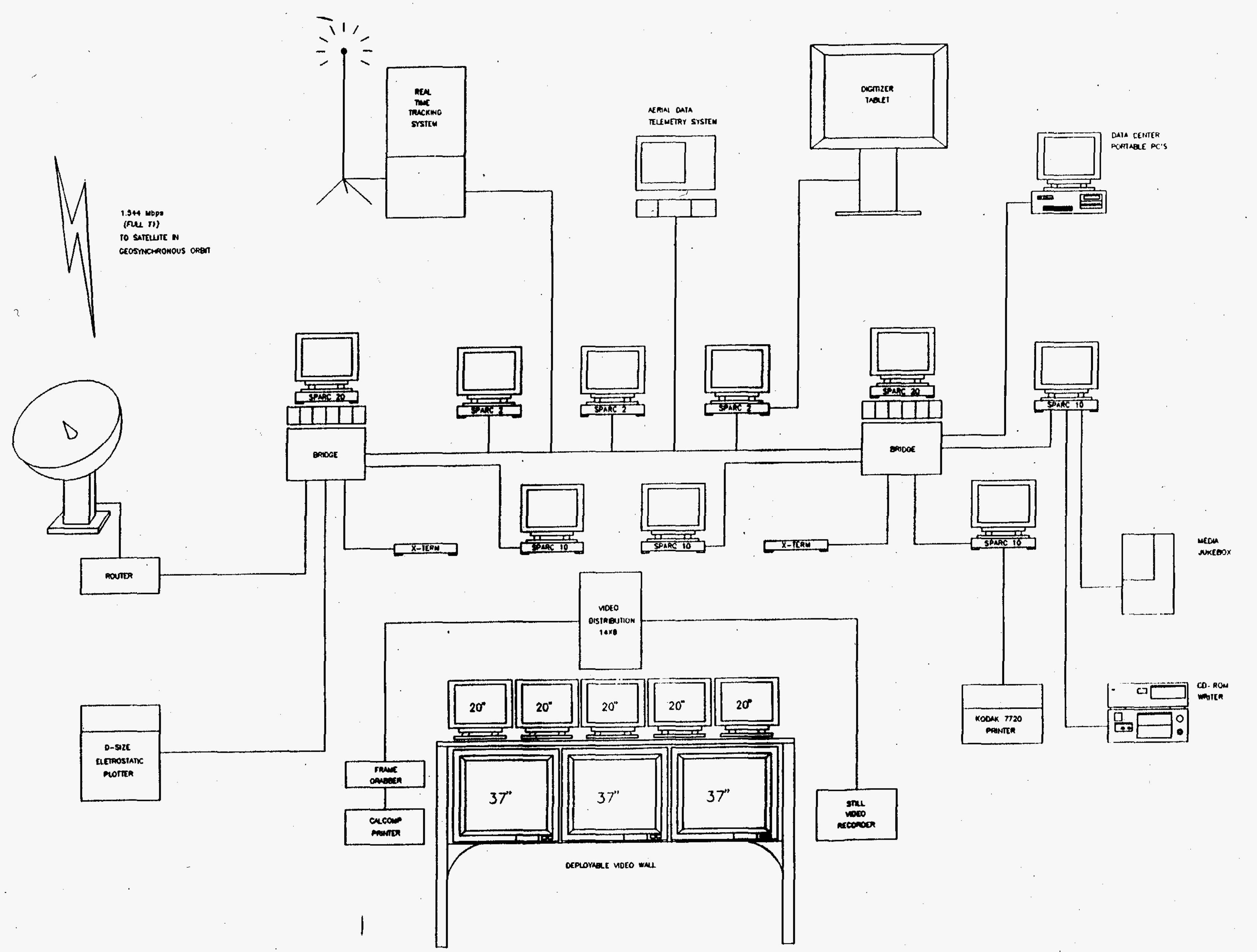
The FASER system (see attached diagram) will include a "server" workstation unit and several networkable standalone workstations. The "server" workstation will be similar to the individual workstations, different only because it will be configured with considerably more storage capacity and a range of peripherals. The server will not serve code; it will merely provide an on-line data library and input/output access to various media. It will also function as a workstation.

Each standalone workstation in the FASER system (which includes the "server"), will include the following minimum features:

* Sun SPARC compatible processor and operating system
* A 19" high-resolution multifrequency monitor
* A 24-bit graphics adapter
* An external peripheral enclosure that will support high-capacity removable SCSI disk drives, erasable magneto-optical drives, and other media.
* Network connectability to interface the workstation to the rest of the system
* Removable/Hot Pluggable SCSI devices("hot pluggable", meaning they can be removed and replaced without shutting down or powering down the workstation.
* The ability to function as an NFS server, allowing the workstation filesystems to be mounted by other workstations and by PCs running PC/NFS connectivity software.

The "server" workstation will include all the functionality of the individual workstations plus several gigabytes of additional disk space, an 8mm tape drive module, a quarter-inch tape module, a CD-ROM module, and an erasable magneto-optical disk jukebox. The server includes a networking/communications module that integrates a bridge, a 10baseT network hub, and a patch panel to manually connect devices to perform specific communications tasks. The workstations will be compatible with existing and planned video routing schemes that will be used to allow workstation output to be displayed on the workstation monitor and a separate, larger display simultaneously. A D-sized electrostatic plotter and a dye sublimation printer are included for map and image output, respectively. A Postscript laser printer is used for ASCII text file printing and can be used to produce hardcopy of vector data in black and white. The data storage media are fully modular, employing 3.5" form factor removable SCSI devices. The system accommodates all the common media, including rewritable optical drives, CD-ROM, 8mm,

FIELD ANALYSIS SYSTEM FOR EMERGENCY RESPONSE (FASER)



4mm, and quarter-inch tape drives.

Complex general purpose GISs have a reputation for being difficult to use and for requiring experienced, well-trained operators. One of the goals of this system is to provide a simplified user interface for implementing routine processes. With the interface, the user has the option of selecting any site and overlaying any combination of the available data layers. The user selects line widths, shade patterns, and colors for display. The interface also provides utilities for the integration of digital images into the GIS displays. The functionality of the interface can be customized to meet additional requirements.

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Work supported by the U.S. Department of Energy, Nevada Operations Office, under Contract No. DE-AC08-93NV11265.

Prepared for the Department of Energy under Contract No. DE-AC08-93NV11265.