

GIS Based Emergency Planning and Response Systems

Indrani Chendrasekharan

Project Leader and Director
NIC and MEF, NCT of Delhi
indusekh@hotmail.com

ABSTRACT

The rapid industrialization, increased usage, production, transportation and handling of chemicals have resulted in number of serious chemical accidents such as Bhopal gas tragedy– the worst chemical disaster in history. Ministry of Environment and Forests (MoEF), Govt. of India, has done tremendous efforts to minimize such accidents and to improve emergency preparedness at district, state and center levels. To further improve the preparedness level a GIS based system has been developed to aid emergency planning for MAH Industries in India. The work envisages in developing comprehensive user-friendly software with database of Major Accident Hazard (MAH) units, hazardous chemicals stored, resources available to combat emergency. Exact location of the unit, vulnerable zonation (through CAMEO suit and ARCHIE), resources available with the authorities for emergency management- fire, medical, police, shelters etc along with their locations and data on surrounding of MAH units has been studied for major clusters of industries in forty districts (fourteen states) of India.

1. Overview

Geographical Information System (GIS) based emergency planning and response system has been developed for major cluster of industries in selected industrialized states in the country. The system integrates critical information in a spatial form under a single banner through GIS (Geographical Information Systems) and incorporates computer modeling for major chemical accident scenarios. The project, funded by the Ministry of Environment and Forests, Government of India, addresses industrialized clusters in the 14 industrialized states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu, Karnataka, Kerala, Delhi NCT, Rajasthan, West Bengal, Assam, Haryana and Madhya Pradesh.

GEPR front-end software is supported by data on Major Accident Hazard or MAH units, first responders (fire, police, hospitals, etc.), sensitive areas, chemical accident scenarios, spatial data (detailed digitized maps with data in 'layers'), Response Information Data Sheets or RIDS packed in a database all under a single banner. Locations of industries, responders and sensitive

areas as recorded by GPS are shown on these maps. For any chemical accident scenario, one can view the template (generated through Aloha and Cameo s/w) on the base map and logical queries can be handled.

GEPR can greatly assist response agencies at the local level during both pre-emergency state for planning and rehearsing and also during actual emergency situation.

2. Vision and Objectives

To develop a national level chemical emergency planning and response tool that is kept fully up-to-date, web-based and able to assist stakeholders at the local level to ensure the most effective mechanism in a user friendly and dynamic fashion at a single point, fully self contained. The s/w will assist planners, first responders, district crisis group as well as chemical industry in off site planning, preparedness and response.

Major Project Components

The major components are as

- Identification of chemical industries in the study area covering major states of India.
- Collection of data pertaining to chemical storage and handling from identified industries.
- Collection of resource data in terms of fire fighting equipment and stocks, Personal Protective Equipment (PPE), transportation facilities, etc., from industries
- Collection of data on resources available with government authorities such as police, fire and medical departments
- Collection of spatial data with the help of GPS handsets for chemical industries, first responders– police, fire and medical and sensitive areas such schools, cinemas, etc.
- Identification and procurement of SOI toposheets for the study area
- Geo-referencing and digitization of toposheets
- Chemical accident simulation using computer models for all the identified chemical accident scenarios
- Database design
- Development of front-end menu-driven software linking spatial data, scenario templates, industry data, resource data and response information data sheets (RIDS) for each chemical.

3. Goals and Milestones

The application on off-site emergency planning for MAH Industries in India is a unique approach, first of its kind integrating Spatial and non-spatial data

on to a single GIS-based system. The application has successfully delivered a highly interactive menu driven, user-friendly customized package for non-specialist end users at local level. Also it has delivered a Powerful versatile digital geo-referenced database of maps, images, MAH data (locations, contact personnel, chemicals etc), vulnerability zones, district resource data (fire, hospitals, police, etc.) as national asset. The project needs to cover remaining additional clusters with high concentration of MAH units for national perspective. Training was imparted to Crisis Group and other users at State and district level. The goals and milestones against each activity and sub activity, their progress were continuously tracked by project management administration system. Any area of concern was brought to management attention and remedial actions taken up in a time bound manner. Constraints report has also been prepared.

Methodology

Identification of Chemical Industries

As per the Manufacture Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989 and as amended in 2000, Major Accident Hazards (MAH) installations, means: isolated storage and industrial activity at a site handling (including transport through carrier or pipeline) hazardous chemicals equal to or, in excess of the threshold quantities specified in the rules. Chief Inspector of Factories at state level maintain a list of such factories in their states and such industries in short listed districts were identified based on the latest data maintained by them.

4. Database Design

Database design was undertaken to facilitate data storage and easy retrieval. Data of all the chemical industries, their chemicals and resources; data of first responders, data of sensitive areas; data on output of computer models in terms of .pas files, RIDS data, spatial data on locations; raster data as images of toposheets, etc. have been stored in databases, and linked through front end menu driven software.

Database design has been done taking into consideration the following:

- Information on MAH units
- Resources available with MAH units for emergency management
- Data on response agencies
- Resources available in District/clusters
- Vulnerable areas

Chemical and Resource Data from MAH industries

With the help of chemical experts questionnaires were developed to collect chemical and resource data from MAH industries. All the information

required for developing the package was collected through visit to identified industries so that first hand, factual and correct data is collected. Information related to handling of hazardous chemicals, their storage and processing conditions, quantities, safety measures, etc. formed the content of this questionnaire. A separate section of the questionnaire dealt with the information on resources available with the industries to manage chemical accidents. Such resources mainly include fire fighting equipment and stocks, spill control equipment, PPEs, etc.

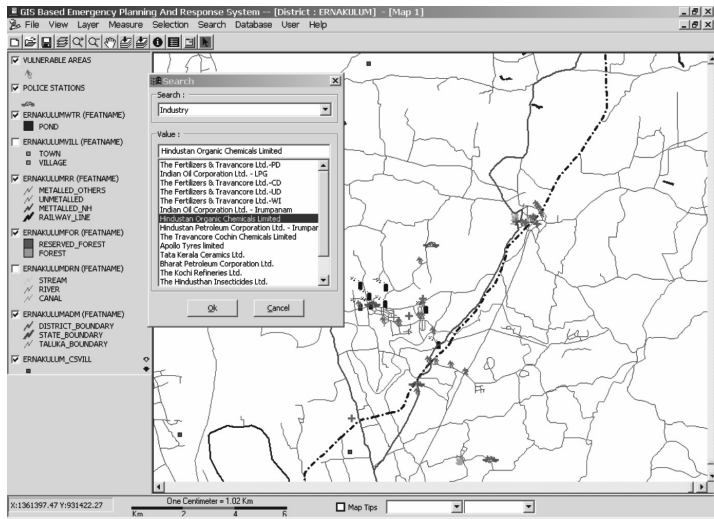
Resource Data from Government Authorities

For any chemical accident, police, fire and medical services at local level are considered to be first responders. Therefore it is important to collect data in terms of their location and resources available with them for emergency planning. Separate questionnaires were developed to collect resource data and their contact information for local authorities. Based on the location of MAH industries, police stations, fire stations, government and private hospitals in the vicinity were identified and data was collected from them through the questionnaire. Such data include the number and type of fire tenders, PPEs, etc. with fire services and facilities available at hospitals for treatment of burn patients and chemical poisoning patients, etc.

Collection of Spatial Data

Spatial data in terms of latitude and longitude was collected for all the MAH industries, police stations, fire stations, hospitals, sensitive areas such as schools, colleges, cinemas, etc. Such data was collected through physical survey of the area using hand-held GPS instrument.

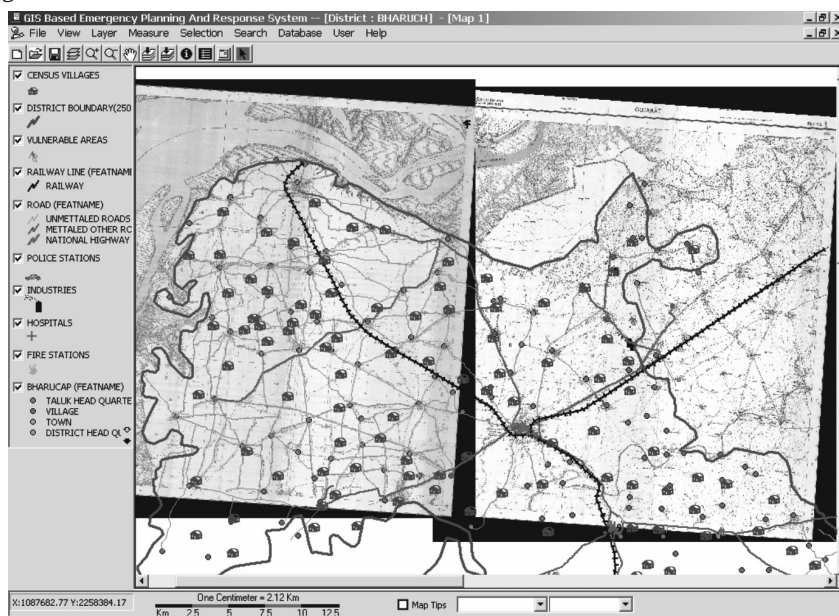
Fig. 1



Procurement, Geo-referencing and Digitization of Toposheets

All the required toposheets were procured, scanned, digitized and mosaiced to create district-wise profile as shown. Geo-referencing was done for synchronization of vector and raster data for authentication.

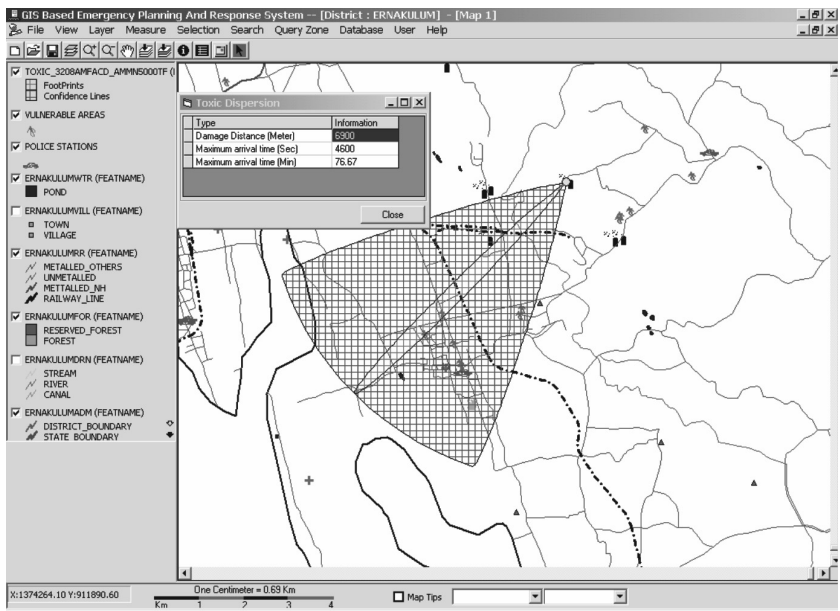
Fig. 2



5. Computer Simulation Modeling

Chemical data collected from MAH units formed the basis of this activity. Data sets were compiled chemical wise along with their quantities and storage conditions. Based on the characteristics of the chemicals various possible Maximum Credible Loss (MCL) scenarios were listed and computer simulation was carried for such scenarios. The following criteria as laid down by the MoEF is considered, viz: catastrophic rupture (release of Inventory within a minute or so from a single container for toxic chemicals and for the grouped inventory in case of flammable material), IDLH value cutoff for toxic chemicals (NIOSH values, based on half hour exposure), 4 kw/m² heat radiation cut-off for fires, 0.1 bars peak over-pressure for explosions. Whenever multiple offsite scenarios are present, the model would provide predetermined hazard zones chemical-wise. The MCLs are mainly worked out for the storage scenarios and also for process scenarios, if necessary. Various identified computer models such as ARCHIE, ALOHA, CAMEO, etc., are used for delineation of vulnerable zones chemical wise. The consequence calculations were performed as per the guidelines of the MoEF, using worst-case meteorological conditions (stability class D with 3

Fig. 3



m/s of wind speed and stability class F with 1.5 m/s of wind speed). This allows highly realistic hazard zone mapping depending upon the wind conditions at the time of incident.

Computer modeling has been done for all the hazardous chemicals stored at the MAH units so that vulnerable zone for each chemical is delineated under different combinations of meteorological conditions. Whenever multiple offsite scenarios are present, the model provides hazard zones chemical wise. The MCLs are mainly worked out for the storage scenarios and process scenarios. Where clusters of MAH Units are present, the Vulnerability template indicates units, which could cause knock on effect onto the MAH Unit in a 2-way mode.

The computer model provides complete interactivity to emergency management authorities to find the actual hazard zone and how it can change with time and meteorological conditions, by minimum data input.

This Vulnerable Zone data is mapped onto the base map, both as text in box and also graphically, to allow visual display.

Development of Front-end Menu-driven Software

To provide the user friendliness to the whole package, a front-end menu driven software has been developed using Map Objects interface. It has been designed and customized keeping in mind the type of information required by the response agencies at district emergency control centers and also the skill level of the expected users at the district and state level. It is a very powerful tool for strategic planning and resource identification

for responding to chemical accidents. Three types of accidents have been envisaged viz. Fire, Explosion (BLEVE/UVCE) and Toxic Vapor Dispersion. The package has been provided with a password to prevent unauthorized use.

Response Information Data Sheets (RIDS)

The software provides separate tool for accessing response information on each of the identified chemicals for every district. RIDS provide complete information about that particular chemicals such as its physical and chemical properties, fire hazards and fire fighting measures, health hazards and PPEs, etc. RIDS is available under the help button, the user can select the desired hazardous chemical from the list available and view its complete information. The user can also access RIDS by double clicking the desired chemical under chemical information of any industry.

6. Implementation

The project was implemented in the four most industrialized states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu in Phase-I. Due to the tremendous response and acceptance at the local level, the project was extended to 20 clusters in another 10 industrialized states (Karnataka, Kerala, Delhi NCT, Rajasthan, West Bengal, Assam, Haryana and Madhya Pradesh) in Phase-II. It is now in the process of up gradation to a web-based structure with more refinement in all aspects (modeling, real time application, dynamic modeling menus, etc.) since June 2007 a prototype for Maharashtra and Gujarat is being developed, featuring the upgrades.

GEPR has been implemented and persons trained at the local level for Phase-I and Phase-II and the package has been officially handed over to the local level authorities.

7. Targeted Beneficiaries

Local level administrators (District Crisis group)—more effective mechanism and emergency response systems and practices in place

Emergency Responders (local fire, police, hospitals, etc.)- more co-ordinated and planned response. Ability to foresee upgradation of resources, better planning, etc.

Industries and their emergency teams—better understanding of offsite hazard potential. Reduction in incidents.

Members of the public residing close to the industrial pockets—more participation in information dissemination, mock drills, etc., and involvement in planning phase.

The Government administration at large (information, etc.)—promotion of industrial safety and hazard mitigation, emergency response, etc.

The public at large (information dissemination over the web, etc.)

8. Geographical Spread

Major Accident Hazard Units are spread across the length and breadth of the country. These MAH units are often found in clusters located within notified Industrial estates though some are outside in isolated locations. To manage chemical emergencies arising out of hazardous material releases from such clusters of MAH units requires great planning and co-ordination between several agencies simultaneously. The response to possible chemical emergencies is a subject of great concern to the nodal ministry for co-ordination of chemical emergencies, namely the Ministry of Environment and Forests (MoEF), Government of India.

Project application is at the 'local' or pocket/district level, where it is intended to act as a tool for emergency planning and response. It has covered so far the four most industrialized states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu in Phase-I. Also the project cover districts with major industrial clusters in ten states, namely Rajasthan, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Assam, West Bengal, Kerala, Karnatka and NCT. These ten states comprise those with the bulk of MAH industries in the country.

9. Challenges

- Evolving a unique hazard modeling approach for such a wide variety of industrial operations
- To ensure simplicity without loss of resolution, particularly in consequence modeling phase
- Identifying a suitable system for conversion of modeling data into the GEPR platform. This entailed marrying outputs from commercial simulators with unique front end software.
- Satisfying so many varied stakeholders from all over the country, each with unique approaches to hazard management