THEMATIC SESSION F
ROLE OF ICT IN DISASTER MANAGEMENT

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ABSTRACTS

ROLE OF GARUDA GRID TOWARDS BUILDING UP NATIONWIDE 'INTEGRATED DISASTER MANAGEMENT SYSTEM'

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Present day disaster prediction & forecasting techniques mainly uses the computational power of high end servers and clusters for performing various complex simulations which mainly depends on the integrated modeling of voluminous Spatial & Non-Spatial digital data sets. Many organizations are working towards the predication & forecasting of natural & man induced disasters and each type of disaster needs to undergo unique type of complex simulation techniques. Still today across the nation there is no well developed common platform, which is capable enough to perform high end complex simulations of various disasters in an integrated way. Working towards this Virtual Organization setup i.e establishing the Nationwide Integrated Disaster Management System is a meaningful effort through which the knowledge and efforts of various scientific organizations can be utilized at right time to solve many real time national

problems. Development of this common scientific computational platform for the Prediction, Forecasting & Managing of all types of disasters is yet another complex process which mainly comprises the following seven major components i). Setting up the nationwide HPC Grid, ii). Integrating/Interfacing HPC & Satellite resources iii). Bringing together various Disaster Strategic User Groups iv). Sharing voluminous Spatial & Non Spatial data v). Addressing Security & IPR issues vi) Collaborative development of parallel stimulations and vii). Pre & Post disaster information dissemination to the decision makers & end users. This paper conceptually elaborates the role of C-DAC's GARUDA Grid which is an integrated collaborative HPC environment that can act as a foundation platform for the establishment of 'Integrated Disaster Management System' which is an unavoidable necessity in this 21st Century.

LIDAR DEM APPLICATIONS IN INDIA

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Digital Elevation Model (DEM) is an important parameter for improving the Flood Forecast Models and Hazard Zoning operation, Flood Damage Assessment, Determination of the Friction Coefficients on Flood Plains, Coastal Erosion Monitoring, and Topographic data input to GIS based relief, Rescue and Flood Simulation operations etc. DEM can be derived from various channels such as Ground survey methods, Aerial Photogrammetry and Interferometric Synthetic Aperture Radar. But each method has its limitations in Accuracy, Cost, Timing, Weather and Feasibility etc.

Airborne Scanning Laser Altimetry is the State-of- Art technology for providing very accurate DEM up to 15cm with very less ground information support. LiDAR data can also be acquired in inaccessible moderate vegetated terrains like forests both day and nights even in semi-bad weather conditions. LiDAR system broadly consists of Laser Scanning Assembly. Laser Range Finder, Global Positioning System (GPS) and Inertial Measurement Unit (IMU).

LiDAR technology has been implemented for the first time in India by NRSA for the project entrusted by National Water Development Agency (NWDA) to divert surplus waters of Godavari from the proposed Inchampalli reservoir to Nagarjunasagar and Kinnerasani reservoirs for

irrigating dry lands of Warangal, Nalgonda and Khammam in A.P. This vegetation covered terrain has inaccessibility problem where other methods are difficult to do. The objective of this project is to derive DEM of an accuracy of less than 50 cm within 100m corridor along the above two proposed canals of lengths 300 km and160 km.The raw input coming from LiDAR survey is referenced to WGS84 datum. For applications like hydrology, reducing WGS84 heights to MSL is to be additionally carried out after filtering for bare earth points. The paper reports the bench marking (BM) exercises and typical applications carried out in the fields of river linking, forestry and urban studies.

APPLICATION OF ICT IN DISASTER MANAGEMENT - AN OVERVIEW

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Disaster whether natural or man-made play havoc with the lives of millions of people every year around the globe. Their aftermath is nothing but a grim picture of death, destruction, and sufferings. It is not always possible to avoid disaster but the sufferings can be minimized by proper disaster management through appropriate disaster management tools. One of the disaster management tools is Information and Communication Technology (ICT). The advancement in Information and Communication Technology in the form of INTERNET, GIS, Remote Sensing, Space Technology etc.

can help a great deal in planning and implementation of disaster reduction measures.

This paper highlights how Information and Communication Technology can be applied effectively in different stages of disaster management process to reduce or avoid the human, physical and economic losses suffered by individual/nations and to reduce personal sufferings to speed up recovery with a few case studies.

GIS TECHNOLOGY FOR DISASTERS AND EMERGENCY MANAGEMENT

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Natural disasters are inevitable, and it is almost impossible to fully recoup the damage caused by the disasters. But it is possible to minimize the potential risk by developing disaster early warning strategies, preparing and implementing developmental plans to provide resilience to such disasters, and helping in rehabilitation and post disaster reduction. Disaster response and recovery efforts require timely interaction and coordination of public emergency services in order to save lives and property. Today, IT is used in this field only to a limited extent, but there is a tremendous potential for increasing efficiency and effectiveness in coping with a disaster. The prime concern during any disaster is the availability of the spatial information, and the dissemination of this information to all concerned. GIS has emerged as a very important tool for effective planning, communication, and training in the various stages of the disaster management cycle. This paper describes the role of remote sensing and

Geographical Information System (GIS) in evolving a suitable strategy for disaster management and occupational framework for their monitoring, assessment and mitigation. We illustrate how GIS can fulfill data requirement needs for planning and emergency operations and how GIS can become the backbone of emergency management. We discuss how the increase availability of Remote Sensing data and GIS during the last decades has created opportunities for a more detailed and rapid analysis of natural hazard.

STRENGTHENING COMMUNICATION DURING DISASTER USING AMATEUR WIRELESS OPERATORS

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Floods, earthquake, super cyclone are very common in our country. Lots of lives took place, properties are damaged. The people who are in distressed due to natural calamity, they are evacuated by the rescue teams. The state police, civil defence personnel are employed. Even Indian Armed forces personnel also deployed if situation arise. It is reported in most of the cases that rescue teams reached the site quite late.

Each district, sub division & block levels civil authorities plan and review the same in a regular manner how to tackle the disaster .The probable shelters are identified before hand where people can move in case of real situation arise. In each area there are young volunteers who are keen to help the distressed people. It will be of great help if these people can be given proper training. It is like Civil Defence's Warden, Casualty services training.

Communication is one of the vital set up, which is urgently to tackle the situation. The prompt communication is the better relief, rescue and rehabilitation. At present the communication set up is developing very fast in our country, but the flood, earthquake disturb the communication.

During such emergency communication from Police and Civil Defence may extent their cooperation in a restricted manner for providing wireless communication.

There are amateur wireless operators and stations that are very active, helpful during various natural calamities. These operators are individually and also as societies. The Ministry of Communication, Government of India, and issues the licensees, this is issued after written and practical test. The various educational institutes, state offices of Bharat Scouts & Guides are also having such stations. The communications are made radiotelephony and radiotelegraphy as per the Indian Wireless Telegraph (Amateur Service) Rules 1978 (as amended in 1984).

THE NATURAL HAZARDS LOCATOR SYSTEM– DATABASE MAPPING SOLUTIONS FOR HAZARDS RECORDS IN JAMAICA

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Simultaneous natural hazard information retrieval and placement of this on a common geographic location allow for rapid overlays and correlation of similar and diverse datasets. This engages different users, ranging from academic specialists to stakeholders and elected and appointed officials seeking general information about natural hazards and examining local vulnerabilities. The assembly of this information results in multiple hazards occurring over different geographic areas and over different time scales to be collected in a single common environment.

As a relatively small island, Jamaica is exposed to many different types of natural hazards, ranging from the spectacular (1692 Port Royal earthquake; 1988 Hurricane Gilbert) to the more common landslide and flood events that cause much damage to lives and property. With a diverse geological character, different parts of the island are at varying degrees of risk to these hazards. However, with continued growth in population and demand on land resources, developments have increasingly placed more people and infrastructure at direct risk from natural hazards, and their impacts have become more severe.

Developers, insurers, government authorities, private stakeholders, and academics all have vested interests in understanding the nature and character of natural hazards in Jamaica, probing their causes and effects, as

well as means of mitigating their impacts. Many researchers and government agencies have created different maps on the different hazards, at different scales, ranging from regional to local scales. As a result, much information exists. However, this does not exist within a single common database, nor does this have a capacity for the simultaneous overlay of the information on a common base map, resulting in users having to sift through many different maps and reports.

Though not an independent natural hazards modeling or predictor service, the Natural Hazards Locator System brings together this information, converting hard-copy reports, photographs and maps to digital format, and extracting the information, creating a digital archive of the data. Maps will be georeferenced and digitized using Geographic Information Systems (GIS), while reports and photographs are tied to their locations on a single Jamaica base map. Dialog commands will allow the user to use the service to search for information by location (select a place and view the different information that are provided), or by type of hazard, with the requested information appearing on the base map.

Users are now able to see a map or photographic record associated with a location to evaluate that place's natural hazards history. Associated GIS data layers, such as topographic and geological maps, also provide background information about the local geoscape of the users' area of interest. The service can now be used to provide the background knowledge to inform them about the location, and guide further decisions associated with it.

CHANNEL CHANGES OF THE BRAHMAPUTRA RIVER DURING 1990-2004 BASED ON MULTI DATE SATELLITE DATA

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Hardly a year passes when Assam does not experience floods. Associated with the floods the problem of erosion has assumed serious proportions in the region. The dynamic nature of the Brahmaputra River is one of the major causes of floods and erosion. In order to understand morphological changes of the Brahmaputra river a study of river channel changes of the Brahmaputra river has been jointly taken up by the Space Applications Centre (ISRO), Ahmedabad and the Brahmaputra Board, Guwahati. A study of the Brahmaputra River – its entire course in Assam from Dhola near the confluence of the river Lohit, the Disang and the Dihang up to the town Dhubri using an integrated approach of Remote Sensing and Geographical Information System (GIS) has been carried out. The channel configuration of the Brahmaputra River has been mapped for the years 1990, 1998, 2000, 2003 and 2004. Integration of the thematic maps led to the identification of areas of aggradation, degradation, areas occupied by sandbars, vegetation, main and secondary active channels, etc. The analysis of satellite data has provided not only the information on the channel configuration of the river system on repetitive basis but also has revealed several significant facts about the changes in river morphology, erosion pattern and its influence on the land, channel bars and their spatial variation, stable and unstable reaches of the river banks, changes in the main channel of the Brahmaputra river, etc. Continuous increase in the erosion of the banks of the Brahmaputra River is observed. Mapping of sandbars also have brought out much needed data over their stability and trend of shifting. It is noticed that the areas occupied by the sandbars and

vegetation in the river is progressively increasing. It is envisaged that the data generated will contribute vital inputs towards flood management aspects.

TECHNOLOGY, COMMUNICATIONS AND EARLY WARNING: BUILDING "ALIVE" SYSTEMS

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Globally climate change has a more visible face than ever as observed over last one decade and more so from the beginning of the new millennium. Never has been debate stronger on climate change issues and disasters in developed as well as developing world. South Asia is one of the most vulnerable disaster prone regions in the world and in last five years it has witnessed large and long-term impact on lives and livelihoods of people in this region particularly in India.

Ekgaon technologies over last one year has been looking into various aspects of climate change impacts and role that communication can play. The critical questions which ekgaon is looking into are; Impact & Vulnerability; impacts also depend on the degree to which vulnerable populations are able to get, correctly interpret and act on advance warning of impending disaster (flood or cyclone). The research during the first phase of ekgaon's work aims to assess the existing global/national/regional/state/village level communication policies and systems in general as well as specific focus towards their role in early warning, disasters and building adaptive capacities. It would look into climate/weather forecasting products and their ability to provide early warning inputs under different climate change scenarios.

To make communication systems "alive" they need to be based in community. Traditional knowledge base of ancient communities even today contains examples/methods/techniques of early warning, although most for slow onset disasters but many for sudden onset disasters also. A communication system based on socially accepted values and processes would have greater "life" and "longevity". Technology should be able to meet the need rather then become central vehicle to be adapted too; the role of institutions is to enable this facilitation for better adaptation of communication systems. This presentation looks into issues of adaptability, institutional roles and technological options (for infrastructure and delivery) for community based disaster preparedness to effectively manage eventualities and evolve coping mechanisms.

DISASTER MANAGEMENT SUPPORT (DMS): IN PURSUIT OF ENHANCING NATIONAL RESPONSE MECHANISMS TO THE NATURAL DISASTERS

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India, characterized by the unique geodynamics, typical monsoon behaviour, flood prone river basins coexisting with semi-arid & arid regions and long coastlines, is amongst the nations most vulnerable to natural disasters. While the country has administrative response mechanisms in terms of a three-tier hierarchical organizational set-up connecting centre, state and district level functionaries, there are also networks of knowledge institutions mandated to provide the operational scientific and technological solutions towards disaster management. Non-availability of timely and reliable assessment of the damage to aid in response and recovery operations, absence of hazard zonation maps,

vulnerability analysis, risk assessment of the potential population on desirable scale, inadequacy of appropriate tools and techniques (GIS, simulation models, decision support system, and lack of reliable and effective communication systems) have been the constraining factors to strengthen disaster management efforts.

In the above context, Department of Space (DOS) in the 10th Five Year Plan has launched a Disaster Management Support (DMS) programme. Using synergistically space (mainly INSAT and IRS satellites) and airborne systems in conjunction with the conventional technologies, the programme commits providing space-enabled products and services on a reliable and timely basis to strengthen the resolves of disaster management in the country. Based on GIS based comprehensive database, enabling technologies - including space modeling and networking systems, the programme has responded comprehensively to some of recent disasters the country has faced - including 26 December 2004 Tsunami, monitoring of artificial lake in Sutlej basins impending to flash floods in Himanchal Pradesh and the Floods of 2005 in different parts of the country.

To organize DMS programme, DOS has developed the critical mass in terms of institutional infrastructure, project management skill and domain expertise. In fact, DOS has placed all its technological and organizational strength in support of DMS programme. While DOS has created a single window delivery system – Decision Support Centre (DSC) to disseminate all space enabled products and services to the end users, it has also got a separate Disaster Management Support (DMS) programme office to develop the institutional interface with policy makers, international organizations and user agencies. DMS programme of DOS is therefore developed as a mission oriented and project based endeavour providing the

critical technological and institutional support towards disaster management in the country. DMS programme, apart from an integral component of National systems, is also integrated well with other space agencies through International Charter.

VULNERABILITY ANALYSIS BASED ON SYSTEMATIC DISASTER DATABASES

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It is globally recognized that development and disaster risk are inter-linked; but the exact nature and extent of these linkages are yet to be defined. Detailed analysis of the databases i.e. data of existing hazards, historic disasters and development indicators needs to be performed at various levels to find out how the development projects and changes in the socio-economic factors contributed to the reduction or accumulation of risk. Though a large number of databases exist in India, they are often scattered and the databases are not systematic and difficult to collate for comparative analyses.

A methodological tool called 'DesInventar' was developed by the Network for Social Studies on Disaster Prevention in Latin America (LA RED) to build systematic disaster inventory databases. This methodology has been tested and adapted in many countries in Latin America and the Caribbean. Similar initiative of developing disaster databases and vulnerability analysis has been adapted by many countries in Asian region (Nepal, Sri Lanka, Maldives, Philippines, Indonesia) as well. Based on a relational database structure and a disciplined expert assisted structure for data

collection, query analysis and presentation, DesInventar permits the homogeneous capture, analysis and graphic representation of geo-referenced information on disaster occurrence and loss. Online version of DesInventar permits multiple users to access the database simultaneously and assures data security by providing various levels of accessibility.

This paper is based on the methodology, results and challenges of the initiative to build a historical database on disasters and vulnerability analysis in 5 States (Orissa, Uttranchal, Uttar Pradesh, Delhi and Tamil Nadu) of India. A systematic geo-referenced inventory of small, medium and large-scale disasters for past has been built. The analysis of the database helped in revealing the new dimensions of hazard risk and vulnerability against the accepted notions.

SPACE TECHNOLOGY FOR DECISION SUPPORT IN NATURAL DISASTER MANAGEMENT – DECISION SUPPORT CENTRE INITIATIVES

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Decision Support Centre (DSC) was established under Disaster Management Support Programme by Department of Space to use the space technology for better management of natural disasters. DSC is an operational service provider exploring the synergy and convergence of space and contemporary technologies in pre-disaster, during disaster and post-disaster phases.

Space technology provides critical and timely information on various disasters, which play a vital role in disaster management. Floods, cyclones, drought, landslides, tsunami, earthquakes and forest fires are the natural disasters addressed by DSC. Among these, floods are the most widespread and frequent disasters occurring in country. Suitable satellite optical or microwave data was used in generating information on floods in the form of maps and damage statistics. Drought situation was monitored by using NOAA data through biweekly vegetation index for 14 states of the country, IRS WiFS for Andhra Pradesh and Karnataka states. Forest fires are monitored by utilising the multi-resolution, multi-temporal and multi-spectral satellite remote sensing data. Presently mapping and monitoring activities of all the disasters are being carried out on regular basis.

Actions were initiated for development of support tools required to utilize the available data for hazard zonation and the vulnerability maps of various disasters. Interfaces are in the process of development for exchange of data / information from the concerned departments through well established protocols. Feasibility studies were also carried out to utilize the data from ALTM and airborne SAR and other future EO missions. The procedures for generation and transmission of the information was streamlined and automated to a significant extent for meeting the required performance, in terms of user-friendly format, information content and turn-around-time. DSC will respond to the disaster situation depending upon the nature of the disaster in providing timely information.

It is envisaged that the DSC will be connected to National Emergency Operation Centre (NEOC), State Emergency Operation Centres, selected knowledge institutions and Shadnagar Earth station through satellite based Virtual Private Network (VPN). Thus, DSC will have online interface

with these agencies to effectively use the ground observations and the data in conjunction with the space data to derive updated information on disaster events and provides decision support.

NATIONAL EMERGENCY COMMUNICATION NETWORK

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The National Emergency Communications Plan envisages a reliable National Emergency Communication Network (NECN) for efficient management of law & order, crises and disaster situations. The NECN will interconnect National, State and District Emergency Operations Centres (EOC) as well as Mobile and Transportable EOCs, that can be deployed at emergency / disaster sites. The NECN will provide voice and data links between all EOCs and also support setting-up of video conferencing facilities on demand from all sites.

The selection of technologies for Emergency Communication equipment is made on the basis of their suitability for reliable operation in disaster / emergency situations, when communication infrastructure facilities as well as mains power supplies are interrupted.

The NECN is mainly dependent on satellite based communication facilities because mobile / transportable satellite based communication equipment can be installed at any site within a short time, to provide (or restore) essential communication facilities with input power requirements which can be meet by portable generators. Equipment operating in High

frequency / Very High frequency bands including HAM radios is also suitable for emergency communications networks.

The NECN will be set-up using existing Government owned networks. There is also a proposal to establish Early Warning System (EWS) for issuing alert in cases of Cyclones, floods and Tsunami.

DEVELOPMENT OF A GIS BASED FLOOD HAZARD MODEL TO PREVENT DISASTERS

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Flooding is one of the most common natural disasters, with adverse consequences on socio-economic activities and great damage to land and water-related infrastructures both short-term and long-term. The combination of higher exposure, a potential increase in hazard, and change in insurance conditions makes development of sophisticated risk analysis model a necessity. Accurate delineations of both extent and depth of probable flooding allows flood management officials to make judicious decisions regarding constructions, insurance and other regulated practices on or near potential flood prone areas.

The RMS Belgium River Flood Model represents the first step in RMS's development of a pan-European flood model. Extensive spatial analysis during hydrodynamic model development includes generation of a modeled river network, hydrologically corrected Digital Elevation Model, catchments delineation, rainfall to run-off modeling, developing flood extent and flood depth information.

Based on mathematical calculations, the model comprises of four different modules viz., event definition, hazard data development, vulnerability functions and financial module.

With its high-resolution capabilities, this model provides users with the tools needed to price and underwrite new and existing risks, assess the impact of these risks on their portfolios, and effectively manage their exposure evolution over time. In addition, the model can be used by insurers, re-insurers, and brokers to make decisions related to reinsurance pricing and purchasing, as well as capital allocation.

REMOTE SENSING AND GIS APPROACH FOR FLOOD MANAGEMENT

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India, on account of its geographical position, climate and geological setting is one of the worst affected centre of natural disasters like floods, cyclone, drought, earthquakes, forest fires, landslides and tsunami in the South Asian region. River flood most devastating disasters in India are mainly caused due to the variations in rainfall, climate and topography. Annually flood affected area, flood damages and people affected are increasing with the flood magnitudes varying from year to year and region to region. Though disasters cannot be stopped, it is possible to minimize the flood damages with efficient flood disaster management by application of modern technology tools. Space technology plays a potential role in flood disaster management in the forecasting, warning, relief, rescue,

rehabilitation and mitigation phases. The role of satellite remote sensing data in these phases of flood disaster is discussed here in this paper along with a few case studies.

DISASTER MANAGEMENT – A GIS APPROACH

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A Geographical Information System (GIS) over the topography can help in many ways like planning, development and management to meet various needs of human kind. Survey of India can perform an effective and important role in developing the Geographical Information System (GIS) with the help of its enormous resources of topographical database specifically in the field of Disaster Management. Remote sensing data can add flavors to a Geographical Information System (GIS) application. It is also possible to depict the fast changes occurred during or after the disaster relief mission in the form of Geographical Information System (GIS) with the help of remote sensing data. In view of Survey of India's past experiences in the field of Disaster Management, an attempt has been made in this paper to describe how Geographical Information System (GIS) technology along with topographical and remote sensing data can be helpful to assess the extent of damage, planning of relief operation as well as reconstruction and development activities in case of Natural calamities.

GIS Centric Emergency Operations Centre for Disaster Management

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Disaster is a geographic phenomenon. A GIS is a computer-based tool that helps us visualize information (both maps and tabular data), see patterns and relationships that aren't otherwise apparent. The ability to ask complex questions about data and analyze many geographic features at once, then instantly see the results on a map makes GIS a powerful tool for creating and visualizing events and scenarios.

Emergency disaster management requires response, incident mapping, establishing priorities, developing action plans, and implementing the plan to protect lives, property, and the environment. GIS allows disaster managers to quickly access and visually display critical information by location. The GIS deployed in the Emergency Operations Centre (EOC), the nerve centre of all activity in case of a disaster, facilitates the development of action plans that are transmitted to disaster response personnel for the coordination and implementation of emergency efforts and for real time monitoring.

GIS facilitates online monitoring of status of ongoing work. As work is completed and identified, GIS can visually display current project status. As status changes, information can be quickly updated and reports generated. Current status can be easily viewed and accessed at the centralized GIS interface in the EOC.

Key advancements in GIS technology which play an important role in GIS based information systems being the main stake of EOCs are Geoprocessing, Geovisualization, and Geodatabase.

Every user of GIS today performs using most if not all of these 3 views.

1. The Geodatabase view: A GIS is a spatial database containing datasets that represent geographic information in terms of a generic GIS data model (features, rasters, topologies, networks, etc).
2. The Geovisualization view: A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Various map views of the underlying geographic information can be constructed and used as windows into the database to support queries, analysis, and editing of the information.
3. The Geoprocessing view: A GIS is a set of information transformation tools that derive new geographic datasets from existing datasets. These geoprocessing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets.
Together, all three are critical parts of a complete GIS and are used at varying levels in all GIS applications including those deployed in EOCs.

Today, GIS technology that supports distributed networks of shared web services, and even the networking of networks- like the linking of Federal, State, and Local web services, is growing dramatically. Many are interested in combining their enriched GIS datasets into comprehensive coverages for larger areas that are multipurpose and can serve the needs of numerous organizations and applications.
GIS software technology has aligned with and adopted five fundamental information technology strategies. It is…..
-- Engineered to modern IT standards: multi-tier architectures (data and application servers, many clients), supports low-cost hardware and grid configurations with logical partitions.
-- Wide open supporting data interoperability, types, formats, sources, used on the fly.

-- Wide open for multi-participant access, users collaborating on maps, data, and spatial information via the web is a 'federated' workflow.

-- Cross-platform-- logic can run anywhere, data can reside anywhere, Windows, UNIX, Linux.

-- Integratable in other business systems also, best practices, data models, scripts, can be shared.

Additionally there would be 4 broad categories of users:

- GIS 'professionals', who understand the technology and fundamental concepts
- GIS 'developers', who build and integrate GIS applications and logic into more focused workflows
- IT 'professionals', the core IT administrative staff of organizations, particularly larger organizations and enterprises, who are emerging as critical to supporting GIS in the enterprise,
- GIS 'consumers', a broad description for generally non-technical users, managers, including emergency response staff, administrative staff, etc., who utilize Embedded, Server-based, Desktop and Mobile applications that contain GIS functionality.

These strategies are the context for how modern, comprehensive GIS technology can be deployed in Emergency management and hence the core of any Emergency Operations Centre's Information System.