



Emergency Response Information System

Problem 5
Final Project Proposal
v.5.4

IST 420
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I. Introduction

1. Introduction

Events like the tragedy of September 11 and the I-80 vehicle disaster have called our attention to the importance of emergency response planning. Emergency response organizations on the local, state and federal levels all have emergency response systems. However, the emergencies are first handled by the local emergency response personnel. It is also the fiscal responsibility of the local county for emergencies that occur. Therefore, it is important that the local emergency response personnel have the best available knowledge, expertise, training, equipment, and support. It is the goal of this team to ensure that the information available to the Centre County emergency response personnel is accurate and timely to ensure the proper decisions can be made.

Therefore the, the coordination between organizations, units and individuals will be focused on because it is of critical importance at an emergency response scene. Without efficient coordination, response efforts may be hindered, endangering the lives of both emergency response personal and victims alike. With technology integration “‘Those of us at the Fire Department command center will be able to get a whole city picture, and decide how to allocate resources,’ said Deputy Assistant Chief Joseph W. Pfeifer” of Brooklyn’s Fire Department, who lost 20 men on September 11th, and stated “ ‘I want this [the new technology] yesterday’” [8]. Because of statements like the above, ERIS has been charged with the task of analyzing Centre County’s current response system, and recommending an integration plan that brings together new and emerging technologies to supplement and improve the search and rescue operations of FEMA.

The ERIS project has evolved since its inception. The project was originally designed to integrate real-time location data from the scene of an incident, weather information, and maps in a single view that would allow FEMA to view the situation and coordinate efforts of the emergency personnel. Since then, the team has realized that the context for this problem was off its mark. From speaking to subject matter experts at the Centre County Office of Emergency Management, the team learned that the system designed would best be suited for use by the local emergency personnel. Therefore, the scope of

this project was reduced greatly from the Federal Emergency Management to the Centre County Emergency Management Agency in Pennsylvania.

The revised project will continue to use a tracking system to obtain real-time location data about assets in the field as well as the layered views. However, the new system will be integrated with the Centre County's existing GIS system.

As shown in **figure 1** below, the new ERIS system will allow devices attached to personnel and other assets at the scene of an incident to send location data to the Emergency Operations Center (EOC) at the Centre County's Emergency Management Office via a cellular network. The location information will be received by a server and processed into a form readable by the ESRI Geographic Information System (GIS). A suite of ESRI applications will be used to retrieve the existing map data and overlay the real-time location data. The data will also be converted to static images, be sent to a web application running on a web server that compresses and encrypts the images, and sent to a PDA used by the Incident Commander (IC) on the scene.

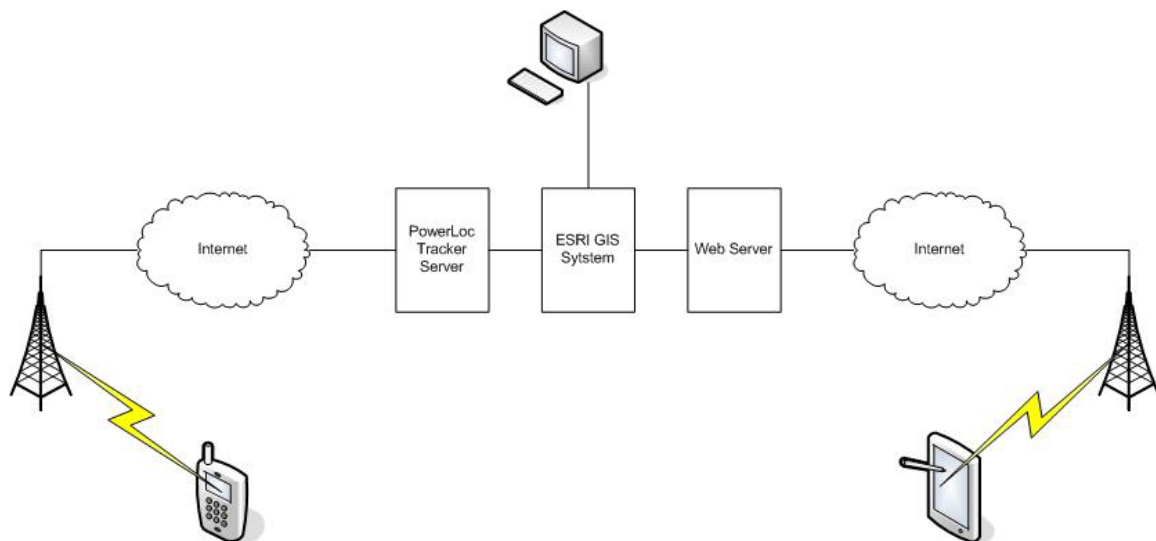


Figure 1: System Overview

As shown above, the system will allow the emergency management personnel at the EOC to monitor the situation from a remote location. In addition, the Incident Commander will

be able to access the same information via the PDA or tablet PC. This diagram is not intended to be a full representation of the system. Rather, it is a high level overview of the revised ERIS system. Hardware and network diagrams may be found later in this document, along with application and data diagrams.

II. Context Analysis

1. Overview

According to Centre County's website <http://www.co.centre.pa.us/>, "The mission of the Centre County Office of Emergency Services is to plan for the prevention of, mitigation of, preparation for, response to, and recovery from any disaster situation. The primary objective of the Service is to reduce the vulnerability of Centre County citizens and communities to damage to, or loss of life or property resulting from disasters by making maximum use of all available resources, both public and private." The focus of this integration effort will be to focus on the needs of the Centre County Office of Emergency Services, hopefully proposing more effective ways to leverage their existing process and infrastructure.

The EMC becomes involved in any event where there is significant need based on the scale of the incident, or the involvement of multiple departments or counties. The may include joint efforts between police, fire and or medical.

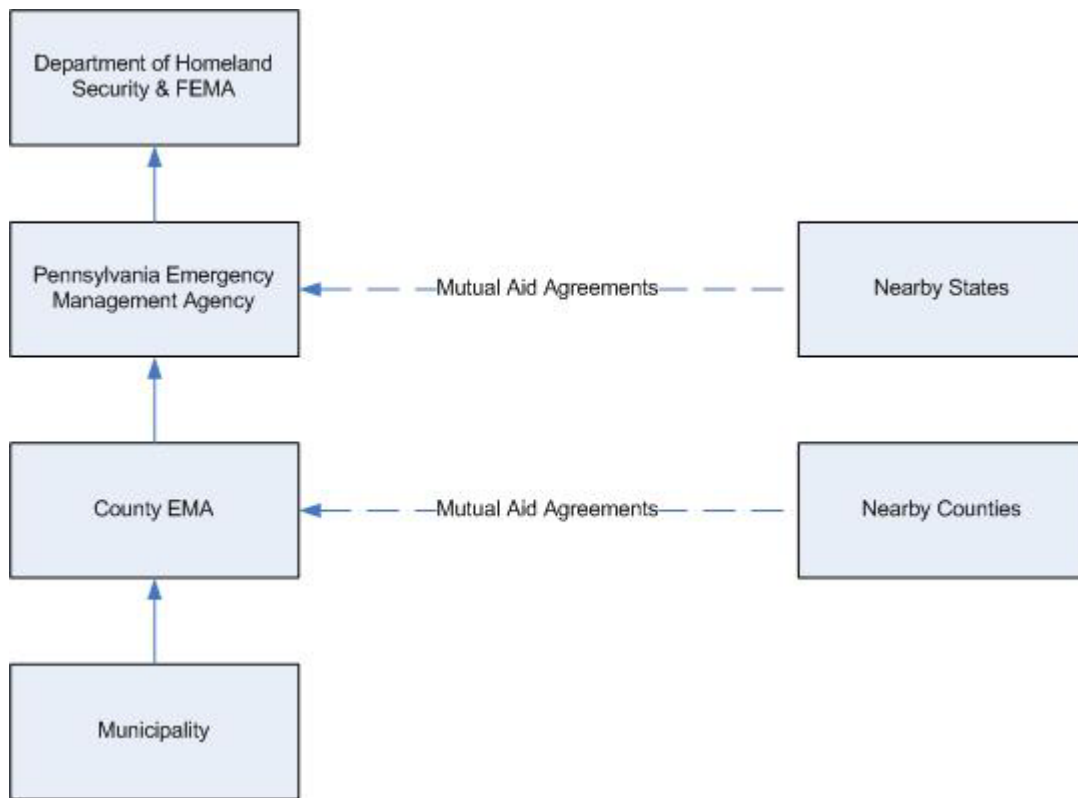
1.1 Responsibility

According to Mr. Rockey, Emergency Management Coordinator for Centre County, mostly all responsibility in an emergency situation falls to the county where the situation is occurring. The majority of the physical resources available consist of local fire departments, police and medical support units. States and the federal government don't have the same number of these resources, although they are helpful in providing disaster relief and funding. But as Mr. Rockey makes clear, it is a long and complicated process to get state or federal aid. The majority of the time, the county foots the bill.

Figure 1 explains the structure of responsibility in an emergency situation. Once a situation occurs, the municipality or county in which it occurs responds with their own resources. If they become overwhelmed, and do not have sufficient resources, the county can turn to other counties. Centre County has Mutual Aid Agreements with many

surrounding counties, such as Blair County. If these counties are also overwhelmed, and their resources are depleted, the state and eventually federal government can become involved. However, as Mr. Rockey informed us, most situations that have arisen in the past in Centre County haven't gone to the state or federal level. Obtaining support for all but the largest and most critical situations is unlikely.

Figure 1: Structure of Responsibility in an Emergency Situation



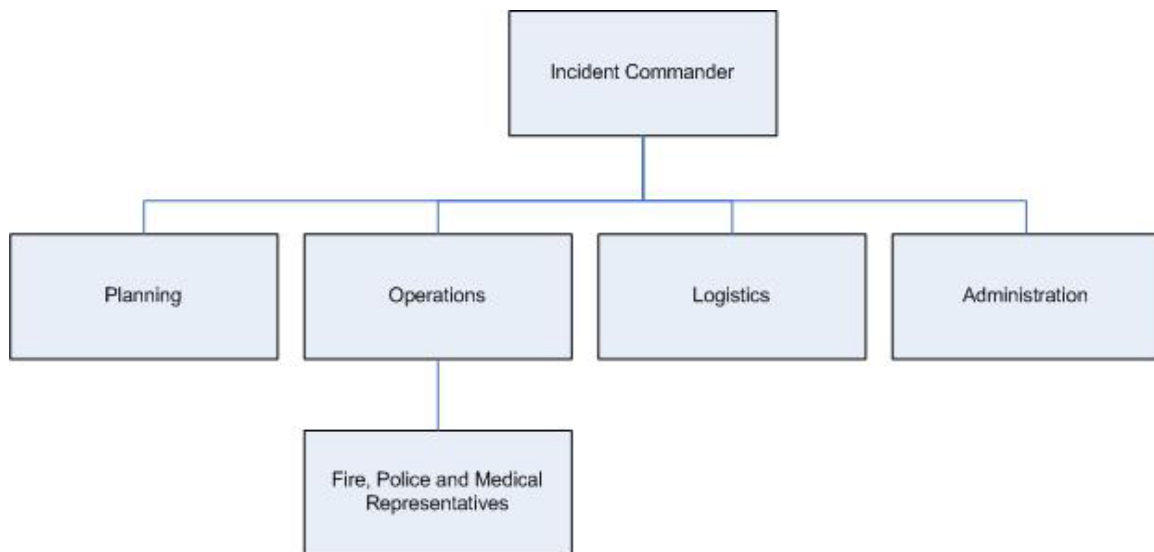
1.2 Types of Emergencies

While there is a variety in the type of emergencies that occur in Centre County, most are on a relatively small scale, with the exception of weather related events. Car accidents, fires, etc. are the norm. Winter weather on the other hand can become quite a big event crippling roadways, and causing many secondary emergencies, such as water main breaks, accidents, etc. However, on certain occasions there have been rather large scale

emergencies, such as the recent I-80 multiple vehicle accident involving over 50+ vehicles.

1.3 Operating Procedures

Every situation has an Incident Commander (IC) assigned to it. The IC is an ad hoc position assigned on a per incident basis. The IC may be a commanding officer who is in the fire, police or medical services. The IC is responsible for the coordination and tactical control on the scene of the incident. For small incidents, the IC may not actually be involved in the situation or may just assist from a remote location; however, for situation of larger scale the IC is normally at the scene of the situation or in the EOC. There is an IC or every event.



1.4 Infrastructure and Equipment

At any given emergency incident, communication is a key element in providing emergency response services. To facilitate this, Centre County has a variety of communication equipment at their disposal.

At the EOC, or Emergency Operations Center, there are multiple phones with a variety of connectivity options, including land lines, cellular, encrypted land lines, hot lines, and satellite. The EOC also has access to radio and Internet. However, the EOC is only activated for extremely large scale emergencies, in some cases a partial EOC is activated if a full EOC is not needed.

In the field, connectivity is somewhat more limited, consisting of cell phones and handheld radios.

In addition to communication, tracking what's going on is extremely important. At any given time, the Incident Commander should be able to know where personnel and equipment are currently located. This is accomplished with very detailed maps and push pins to represent different assets. When an asset moves, they are required to radio their new position. This process leads to non-real time information and a lot of excess radio traffic to report position changes. Mr. Rockey estimates that up to 70% of radio communication is comprised of position related information. Furthermore, he stated that different counties often operate on different and incompatible radio frequencies. For example, Centre County and Blair County don't operate on the same radio frequency. Thus for personnel from different counties to communicate between each other, they must radio through a chain of individuals until they find someone with two radios that relays the message. And as we probably all know from childhood, after passing a message around many times, it can often become distorted.

Mr. Rockey also said that there is a need for better information about that scene of an emergency situation. For example, the IC and other personnel should know the location of water lines, gas lines, electric, valves, etc. where are not currently on one single map. He also adds that it wouldn't be beneficial to have so much information on one map anyway. Mr. Rockey informed us that he is currently looking into a GIS solution that would allow him to layer different views.

Centre County currently has a GIS system which is primarily used for tax collection and zoning purposes.

2. Scenario

One of the most recent and largest emergency situations in the history of Centre County was the I-80 multi-vehicle accident. “On January 6, 2004, during a heavy snowfall, not one but three multi-vehicle accidents took place on both sides of Interstate 80 between Exit 158 and Exit 178. The first accident occurred in both the eastbound and westbound lanes between Exit 158 and Exit 161 at 11:15 AM. It involved approximately 30 tractor-trailers, around 20 passenger vehicles, and resulted in six fatalities. There were still four or five vehicles, including a semi, still burning come sunrise on January 7 in the westbound lanes, and prevented investigators from beginning their work. Pennsylvania State Trooper David White said 17 people had been taken to Mount Nittany Medical Center and Lock Haven Hospital, and one who was flown to the trauma center at Altoona Hospital. Ambulances and fire crews were brought in from four counties to attend to the injured and extinguish the fires. White added, "They can't get the fires out -- or they thought they had them out and they're back -- so they're still blocking the eastbound lanes with emergency vehicles, and the smoke is still billowing." The eastbound lanes opened on January 7, and the westbound lanes in the evening of January 8 after PENNDOT inspected the highway. Excavation began on Monday, January 12 along the site of the accident. Employees of Eagle Towing and Recovery began removing contaminated soil from the roadside.” (<http://www.pahighways.com/IHwys/I80.html>)

During our interview, Mr. Rockey spoke quite a bit about this incident. According to him, there were multiple counties and departments involved in the emergency response. Communications were an issue at the incident. Since multiple counties were involved, they weren't all using the same radio frequency. Therefore, to relay messages between personnel from different counties, someone had to have two radios to relay the message physically to someone from another county. Along with this, tracking where personnel and supplies were located was an issue. If the IC needed personnel to respond to a fire

that had just broken out, they would have to radio multiple personnel, ask their location, compile the information and make a request for personnel to relocate.



Smoke billowing from the pileup as seen the day of the accident. (Associated Press)

III. Market Analysis

Understanding the current emergency response market is vital before making any recommendations to the Center County Office of Emergency Services, this also allows for a more informed decision. The goal is to show how organizations/areas are dealing with emergency response management, and other current emergency response technologies available.

1. Major Elements of Market

1.1 Technology use in Organizations

There are other organizations similar to Centre County, which deal with emergency response on a local level. We looked at other counties on a smaller level, such as Lewis and Clark County of Montana, and other cities, such as Portland, OR and Philadelphia, PA. We selected these areas because they are using similar technologies that we are proposing for Centre County, which we feel could be expanded. Each of these organizations contributes to the efforts during an emergency response, although they may each serve a unique function. However, most of them include education, training, prevention, recovery, and rescue and relief in times of crisis and disaster as top priorities.

The Global Disaster International Network (GDIN) is a non-profit group committed to assist disaster managers find the information they need, particularly when other means have failed, to develop unique information sharing procedures that augment the existing system, to foster the development of new disaster information technologies and to foster professional development. [20]

Presently, GDIN is partnered with ReliefWeb. ReliefWeb is an Internet site where information of disasters is posted. As of now, GDIN is trying to make a more flexible system to increase the amount and quality of essential information posted on ReliefWeb while also providing a useful formation to all relief organizations. To keep the system flexible while having a standardized format GDIN will collect only core data, this includes: displaced populations, health facilities, personnel involved, roads, etc. By posting this data on ReliefWeb, core data about the disaster could be accessed from anywhere with an internet connection [15]. GDIN is also researching and looking in to is EMAdvantage. EMAdvantage has many features including, threat and risk identification, evacuation modeling, facility/resource management, activity tracking, and incident/personnel tracking [16].

The city of San Diego, CA uses its own system, the emergency response management system (ERMS), to manage routing and allocation analyses—mostly during earthquakes. The system divides the city into 3,200 smaller regions, called Fire Demand Zones (FDZ). Within each zone, fire department stations are identified in order to calculate proximities and response time estimates. Also, all road information (street width, traffic directions, slopes, and curvatures) is recorded to provide routing information to emergency personnel and equipment.

The ERMS takes all the information about each FDZ (fire station location and road information) then uses ArcInfo network to perform routing between desired sources and destinations, provides allocation analyses, and point-to-point routing. When responding to an emergency, ERMS calculates time of arrival to a destination for personnel, and provides with directives to a location and alternative route information if

primary routes are hindered. Overall, the ERMS is an effective system that provides routing and allocation analyses in order to better coordinate the response and rescue efforts [22].

The Office of Canadian Infrastructure Protection Emergency Preparedness (OCIPEP) works to improve the safety and security of Canadians. [17] OCIPEP is currently researching GeoConnections, which is a national initiative to provide Canadians with geospatial information over the Internet.[18] Emergency services can use geospatial information to chart the quickest routes to accidents or disaster areas. GeoConnections collects GeoSpatial Data to create topographic maps, aerial photography and satellite imagery. [19]

These examples utilize geospatial information in some way, but fail to take advantage of location tracking or any other GPS services. In the next section, we will discuss a few examples that integrate GIS information with a location based tracking system.

1.2 Current Technology Solutions

Currently, many types of technologies can aid in an emergency response situation. Tracking personnel at the scene of a disaster is the main issue. Many solutions use the Global Positioning System (GPS) providing precise location positioning information, and Geographical Information System (GIS). GIS provides map services, used for planning and condition tracking, for personnel, equipment and current conditions (flood, fire, weather). One solution that uses both of these technologies is available from PowerLOC. They provide a real-time personnel and equipment tracking monitor device, which relays

location information back to a control center. Location information is then overlaid onto GIS maps, and distributed to laptops, PDS and possibly other devices. If the tracked user enters a defined danger zone, the device will alert both the user and the control center. [6]

In a case study Louisiana State Police (LASP) incorporated PowerLoc into their daily work. The solution would utilize navigation in the patrol cars, server-based tracking, and allow interactive communication with headquarters and other officers. They wanted the system to use GPS to document incident locations, provide real-time navigation and rerouting, and display officer locations to headquarters. Each patrol car was equipped with Mobile Data Computers (MDC) which have the officers all of the above information—in a way it gave them the same functionality as headquarters with the use of PowerLOC and the MDC. Overall, the LASP reported high satisfaction with PowerLOC. Initialization was easy and the system accommodated other LASP vehicles. The system did everything they wanted it to do, thus enhancing their tasks [21].

Another location tracking solution is A-GPS (Assisted GPS), which makes use of GPS satellites when available, and also uses cell phone tower triangulation to determine location. While not as precise as GPS, AGPS provides location tracking abilities in many situations in which GPS would fail to function, such as in a large building. [12]

Mesh Networks Inc. has also developed a unique system, where every device at an emergency response scene, personnel with radio, vehicles, computers, to act as a hub. The hubs link together, to form an instant mesh network for data transmission. This overcomes loss of signal issues, and allows devices to triangulate their positions relative to other devices. The system is capable of providing extremely accurate location tracking, but is proprietary and still in testing. [13] The Orange County Firefighters have also used

this technology for a demonstration, using wireless broadband to track movement of firefighters and emergency personnel inside a building. The device is small, light weight and transmits signals to the command post, which would be located outside of the structure. [14]

MapInfo's Critical Area Response Manager (CARM), identifies where power lines, gas lines and other utilities are located using their mapping system. CARM can greatly assist response organizations in their efforts. ArcInfo's software, similar to MapInfo called ArcGIS StreetMap USA, is a nationwide address location and mapping system. ArcInfo also makes ArcPad for mobile use on a PDA, which has the same functionality as ArcGIS StreetMap [4].

Aether Systems Inc. has also developed a JAVA application, Fire RMS, for use on a PDA or any other wireless device that gives fire fighters instant access to information, such as building maps, electrical plans, shut off valves, occupancy data, hydrant locations and other information that give the fire fighter on site instant information using satellites [5].

2. Comparisons and Explanations of Selected Organizations and Technologies

2.1 Comparisons

After researching other organizations that handle emergency management, there were similarities found in the organizations' solutions, the most obvious was that all focused on improving communications. Coordinating different emergency response groups can become difficult as the scale of the disaster and number of emergency response personnel increase. Using GIS information to communicate geospatial data is

crucial to aid in response efforts, which is why each system incorporated real-time routing for efficient dispatching of personnel and equipment. Allowing GIS data to be available on the scene in real-time gives them the ability to make quick decisions and reactions during the chaos of the disaster. Maps was another commonality, used to locate specific land features, engineering landmarks, and resource tracking. Another similarity in each of the organizations was end-user/personnel real-time information and instruction onsite.

2.2 Explanations

Each of the current technology solutions is similar because they improve coordination between a control center and onsite personnel, allowing the command center to locate, manage, and provide information to different response teams. We specifically chose to emphasize San Diego and The Louisiana State Police because San Diego uses the ESRI software, which Centre County already uses, but does not use any location based tracking. San Diego has a routing system, but if it could track locations of responding personnel in real-time, response time would be reduced, because personnel would not need to report their location by radio. This will provide a more efficient way to dispatch personnel because it would reduce the risk of communication delays and duplicating dispatch calls to a specific location.

Our choice to emphasize the Louisiana State Police was to give an example of a system that relies more on tracking, rather than using GIS data. Location is used to help dispatching, aide in reporting incidents, and provide safety for the police officers. The system did provide the officers with basic road information for routing purposes, but

nothing on the scale of what we are proposing for Centre County, such as geospatial layers including pipelines and electrical lines.

The following table is a summary of the features found among these solutions.

Similar Features	Description
Global Positioning System	Allows Real-Time tracking and information of rescue teams which will improve search and rescue by recording specific locations, and coordinating efforts of rescue teams.
Real-Time Information	For keeping personnel information up to date and improving coordination efforts.
Mobile Data Transfer	In order to provide information to onsite emergency response personnel from the command center over a wireless network.
PDA's/Hand Held Device	For Emergency Response Personnel to send and receive data from the control center
Tactical Mapping	Using PDA's, the command center can send detailed maps of building, areas, and weather conditions.
Advanced Mathematical Algorithms	To predict unfavorable conditions that could potentially cause harm to the rescue efforts
Routing	Using road conditions to efficiently move emergency personnel and equipment from destination to source.

3. Issues for Centre County and Conclusion

3.1 Issues

Common organizational trends and emerging technologies that relate to emergency response have become apparent through our research. One of the problems that Centre County may face is that many organizations are reluctant to share specific details of organizational plans due to privacy and security reasons. To resolve this issue, or to gain more information from other organizations, Centre County could create partnerships with other organizations and counties to share resources, techniques and evaluations.

Centre County may also face technical issues that could interfere with the development of the system, because some technologies that may be too new and have not been fully tested may have many glitches. In addition, tracking personnel will be an issue that Centre County will have to evaluate, because tracking personnel is not emphasized in any other organization. Centre County could have wireless issues onsite also, where some spots may not have strong enough signals for personnel to communicate with the EOC. Because of the differences of signals throughout the county, the system must be flexible in order for the system to work, even under weaker signals.

The integration effort is another issue, since there is no one technology solution available currently would meet Centre County's needs, we would have to integrate different technologies to create a solution. This may become timely and expensive because glitches and development problems might delay the progress of developing the system. To relieve these issues, Centre County must undergo extensive planning and testing to ensure that the integration effort is going to be feasible and effective.

Social issues will affect Centre County's development of the system. Will their system require local agencies to restructure their agency in order to meet federal guidelines? Any change could result in confusion within the local agency's department. Learning a new system is another issue, which will take a lot of time for Centre County to invest in. Careful training must be available for users and personnel to learn how to use the system effectively. If users are provided with improper training, time will be wasted, delaying response and recovery onsite—this is where time is most crucial.

For system administration and development, Centre County may have to hire more people. This economic issue may help decrease unemployment, but will be costly

for Centre County to pay its new employees. Another issues the county may face is attaining enough capital to implement a new system. Because Centre County's budget is controlled by the government, and does not contain a major city, the county will not get as much funding as Pittsburgh or Philadelphia, thus, it may be impossible for the country to receive money for the system, unless it becomes a national standard.

Overall, Centre County must consider the legal and regulatory, technical, integration effort, social and economic issues to plan and implement a new system. The issues provide a better understanding of the work environment. If these issues are left ignored, Centre County's solution could hinder emergency response rather than help it.

3.2 Conclusion

After conducting our market analysis, we have learned that many systems are currently using ArcGIS for mapping an geospatial data. What these current systems however, are not using ArcGIS concurrent with tracking. With both tracking and ArcGIS, we feel that Centre County's emergency management system would benefit more greatly.

IV. Needs Analysis

1. Requirements

1.1 Compliment existing emergency response procedures

Emergency response organizations including Centre County Office of Emergency Services, fire, police and medical, already have existing procedures and protocols in place for emergency response situations. Individuals in these organizations are well trained in these methods and do not need to be modified. More importantly, since these procedures are already proven, the system should compliment these procedures and allow them to be performed more effectively.

1.2 Operates consistently even in adverse conditions

The system must have the ability to operate consistently. This includes operation in adverse conditions, commonly found in emergency response situations. This includes but is not limited to the presence of high temperatures, water, or smoke. This may also be the failure of existing telecommunication and utilities. Lastly, the system must also be able to be used under high stress conditions.

1.3 Tracking system for personnel, vehicles and supplies

Each individual, supply, and other pieces of relevant equipment needs to be tracked. The system must be able to locate resources with precision in a two or three-dimensional space. The system must also be able to uniquely identify each resource and provide basic status information.

1.4 System must be mobile

The equipment and technology needed on-site must be able to travel to the site of an emergency. It must also function properly within the conditions of the various sites that may be encountered.

1.5 Adequate field communications infrastructure

Centre County's GIS system needs to send data between devices without the risk of data loss. The IT infrastructure should support adequate bandwidth for a communications network in field situations. The network should have self-sustaining capabilities.

1.6 Secure data transmission

As with any Emergency Management System, information assurance is a high priority. The system must provide a means of sending and receiving information over a secure network.

1.7 Overlay resource locations with maps

The system must be capable of overlaying resources and environmental conditions onto street maps and three-dimensional structural schematics. This will allow for a reference to the relative locations of the resources being tracked and allow decisions to be as specific as possible with regard to geographic locations.

1.8 Allow for quick and effective data manipulation and analysis

Because of the real-time nature in which Incident Commander must make decisions, the system should provide real-time information. The system must allow for the quick and effective manipulation and analysis of the available data coming from multiple locations.

1.9 Leverage existing infrastructure when possible

This system will require the investment of resources. However, when possible, existing resources should be reused. This should not be an impediment to providing an effective system; however, it is a way to make the system more attainable.

2. Justification for Prioritization

The reasons for the ordering of our needs are based on our interviews and communications with Mr. Rockey, and other Centre County management personnel.

3. Gap Fit

	San Diego, CA	LA State Police	Orange County, FL	ERIS
Compliment existing emergency response procedures	x	x	x	x
Operates consistently even in adverse conditions	x		x	x
Tracking system for personnel, vehicles and supplies		x	x	x
System must be mobile		x	x	x
Adequate field communications infrastructure	x		x	x
Secure data transmission			x	x
Allow for quick and effective data manipulation and analysis	x	x	x	x
Leverage existing infrastructure when possible		x		x

4. Rationale for Gap-Fit analysis

4.1 San Diego

The missing link for San Diego's ERMS is that it does not track personnel. It is effective for routing procedures and analysis of a situation in which traffic needs to flow. It also did not leverage the infrastructure, because the city had to install nodes in many of their neighborhoods for the system to function reliably. We cannot say that it will operate in adverse conditions, or that there is secure data transmission.

4.2 LA State Police

The LA State Police system uses PowerLOC, but not combined with a robust GIS system. Because PowerLOC itself uses commercial bandwidth, there is no guarantee about secure data transmission, or that the service will operate under adverse conditions.

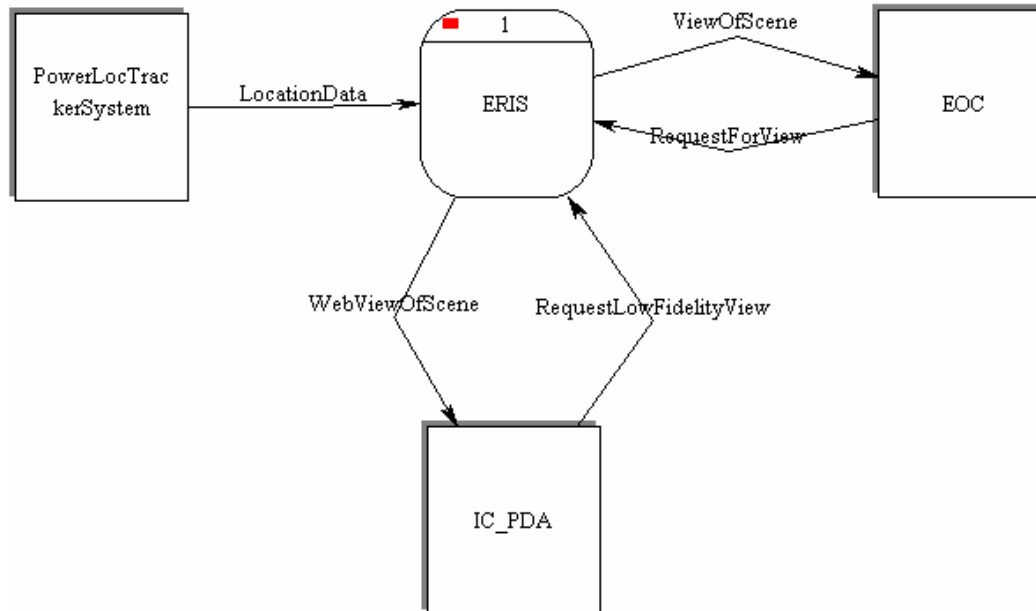
4.3 Orange County, FL

Orange County, FL uses a Mesh Network, which our team initially looked at for ERIS. We feel, though, that because it does not utilize an existing infrastructure, that it would not be as viable as a solution. Also, because the system is still new and in testing, we feel that a proven technology and company would be beneficial.

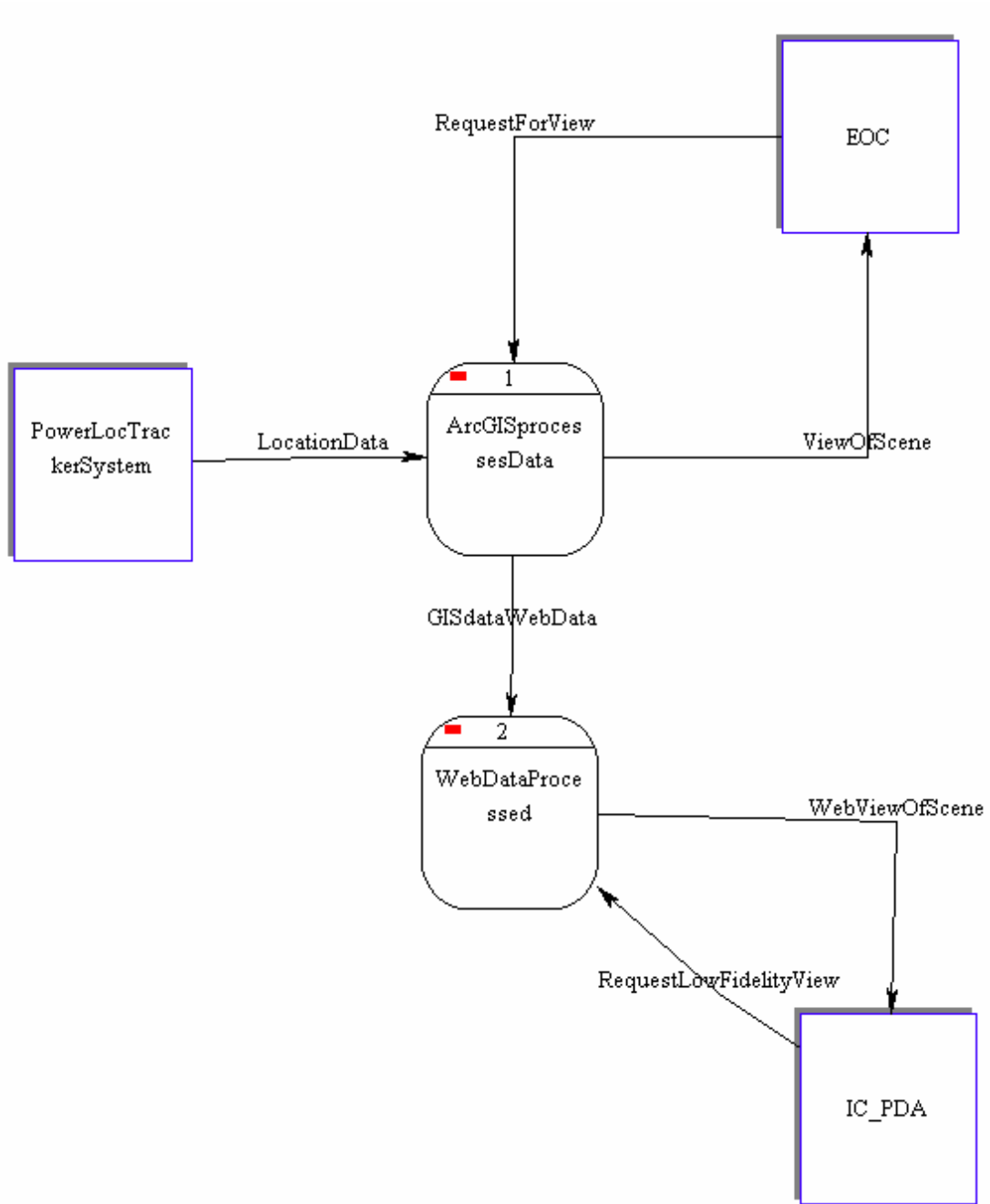
V. Process Analysis

1. Dataflow Diagrams

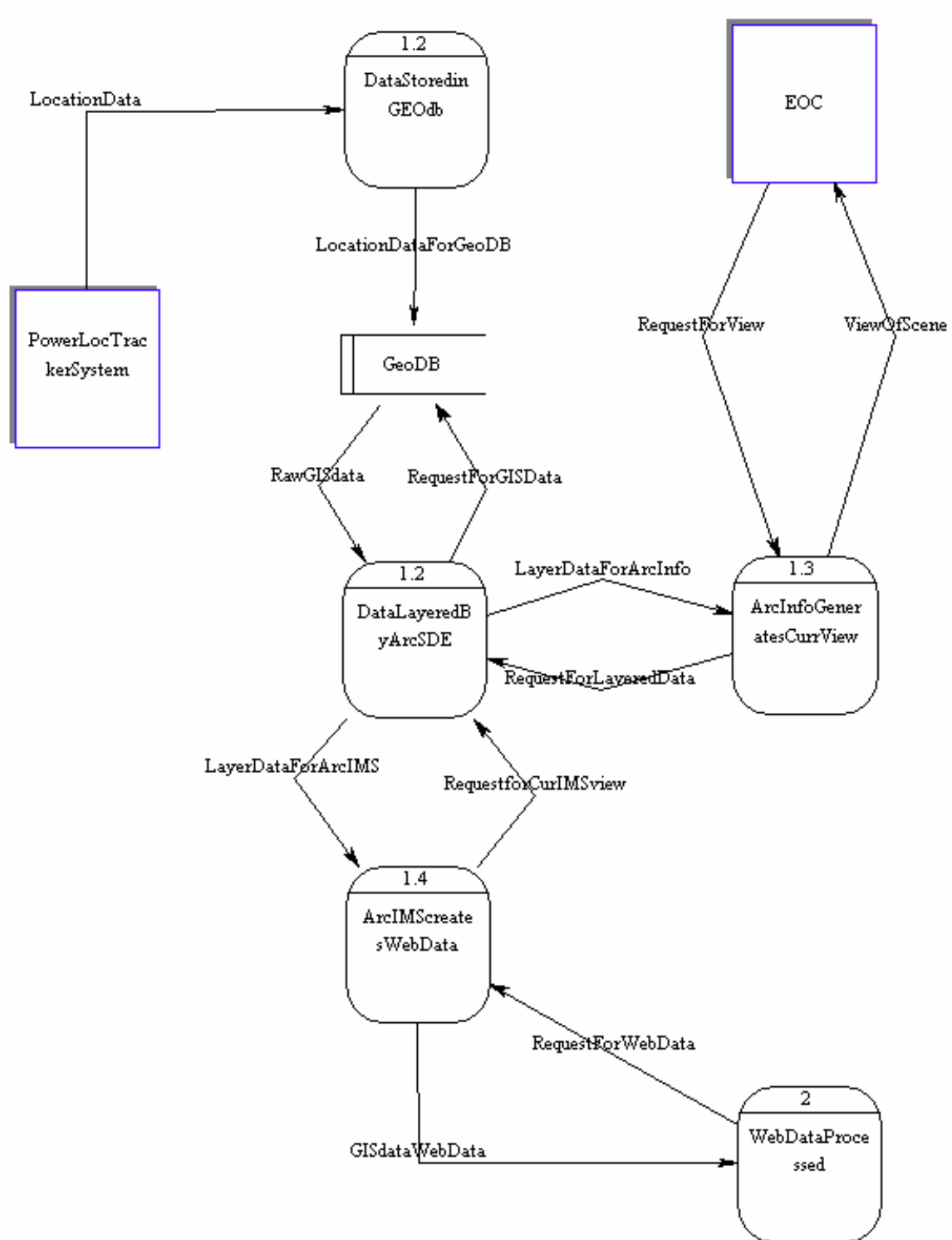
1.1. Context Diagram:



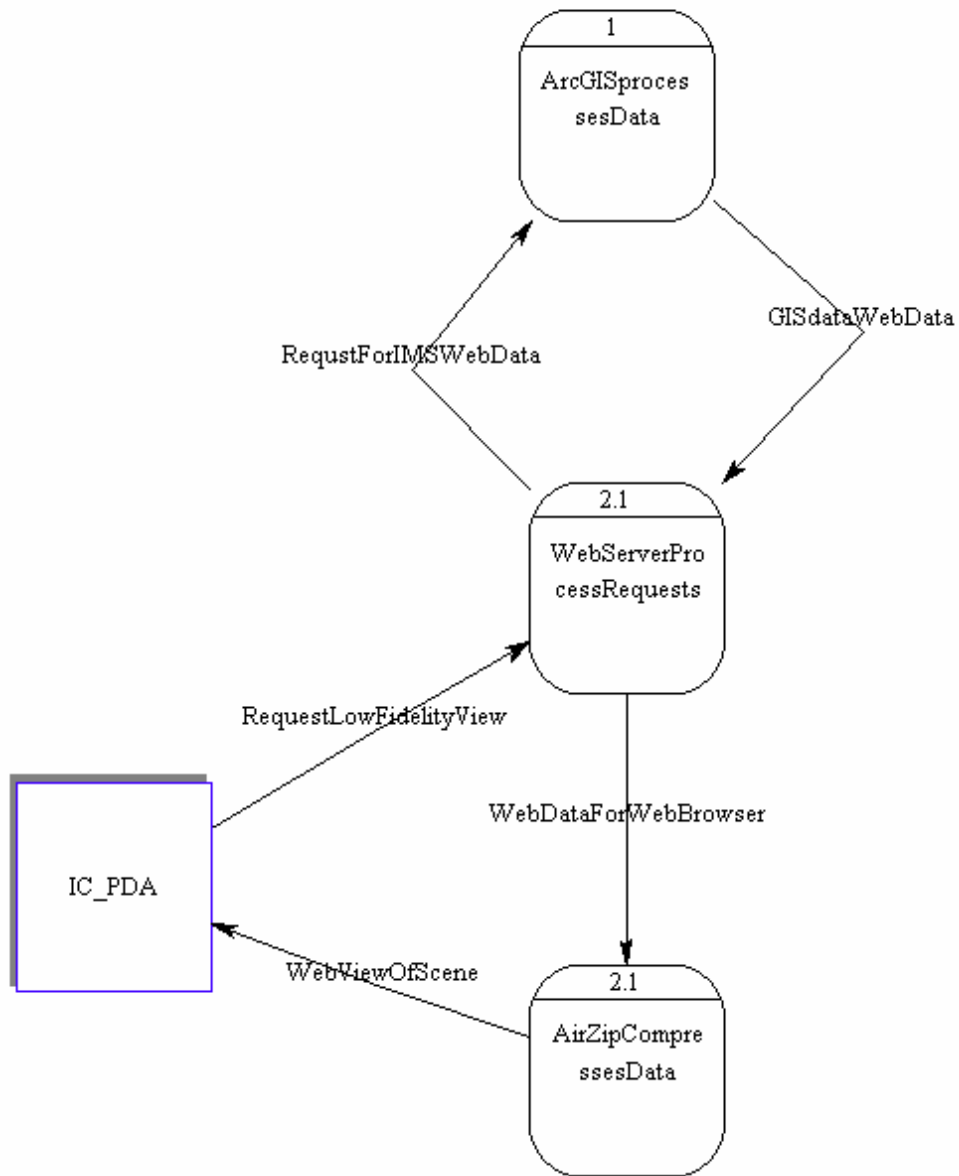
1.2. Level 0:



1.3. Level 1 – Arc GIS Processes Data:



1.4. Level 1 – Web Server:



2. Data Dictionary

2.1. External Entity Definition

External Entity Name: PowerLocTrackerSystem
Description: PowerLoc Tracker system that sends locations

External Entity Name: IC_PDA
Description: Incident Commander on scene with a PDA

External Entity Name: EOC
Description: Emergency Operations Center at Bellefonte

2.2. Datastore Definition

Datastore Name: GeoDB
Description: Geospatial DB used by ArcGIS

2.3. Dataflow Definition

Flow Name: LocationData
Description: LocationData from PowerLoc in GPS

Flow Name: ViewOfScene
Description: View of scene in ArcGIS format

Flow Name: RequestForView
Description: Request from EOC for current view

Flow Name: WebViewOfScene
Description: Low fidelity view of scene

Flow Name: RequestLowFidelityView
Description: Request from IC for low fidelity view

Flow Name: GISdataWebData
Description: GIS sent from ArcGIS to web process

Flow Name: LocationDataForGeoDB
Description: Location data for the Geo DB

Flow Name: RawGISdata

Description: Raw GIS data from GeoDB

Flow Name: LayerDataForArcInfo

Description: Layer data for ArcInfo for graphics

Flow Name: LayerDataForArcIMS

Description: Layer data for ArcIMS for web data

Flow Name: RequestForWebData

Description: Request for web data from ArcIMS

Flow Name: RequestforCurIMSview

Description: Req for the current view from IMS

Flow Name: RequestForGISData

Description: Request for Raw GIS Data from DB

Flow Name: RequistForIMSWebData

Description: Request for data from ArcIMS

Flow Name: WebDataForWebBrowser

Description: HTML and image data from web server

Flow Name: RequestForLayeredData

Description: ArcInfo request for layered data

2.4 Process Definition

Process Name: ERIS

Description: Emerhency Response Information System responsible for handling location-based emergency data

Process Name: ArcGISprocessesData

Description: Processes GIS Location Data

Process Name: WebDataProcessed

Description: Converts GIS data to web format

Process Name: DataStoredinGEOdb

Description: Data entered into GEO DB from PL

Process Name: DataLayeredByArcSDE

Description: ArcSDE converts GIS into layers

Process Name: ArcInfoGeneratesCurrView

Description: Graphical data generated from layer

Process Name: ArcIMSCreatesWebData

Description: Web data generated from layer data

Process Name: WebServerProcessRequests

Description: Web server receives ArcIMS data

Process Name: AirZipCompressesData

Description: AirZip compresses data for small file

3. Design Rationale

3.1. PowerLoc Tracker System

The PowerLoc tracker system is a complete, out of the box solution for tracking objects and people through a combination of GPS and cellular signals. The only information pertinent to this system is only the location data of assets that are being tracked. Therefore, the PowerLoc devices, data, and processes are considered outside the ERIS system and thus treated as an external entity in the diagrams. The only point of contact between PowerLoc and ERIS is the Location Data sent from PowerLoc to ERIS. No feedback is required from ERIS because PowerLoc is a passive, continuous system.

3.2 Web Server and AirZip

The process of getting data ready to be sent to the wireless PDA is handled by the web server and AirZip. The request is sent to the web server, which pulls information from ArcIMS. The new data is then intercepted by AirZip before it is sent to the PDA, compressed on the fly, and sent back to the PDA in a smaller, more secure file.

3.3 Possibility of Additional External Observers

The team decided against adding external observers (such as state emergency personnel, federal agencies such as FEMA or the FBI, and other counties' Emergency Management Coordinators) because there was not a need explicitly determined. However, the possibility could exist for these external organizations and personnel to act as observers and receive a live view of the scene. The web server would be an excellent place to allow

outsiders to view the ERIS views generated because the server is within the control of the county (meaning they can determine content and access privileges), would not require outsiders to have GIS software (only a web browser and internet connection required), and would not add a noticeable load to the web server.

3.4 Weather data

Weather information was removed from the initial dataflow diagrams. This was due to time constraints on the project. If the weather data is needed at the scene of an emergency, it would be possible to quickly integrate this into ERIS. The National Weather Service is capable of providing weather data for GIS systems and could be added to the GeoSpatial database in the same way location data is collected and updated. ArcSDE would then be able to add another layer for weather. This would be helpful when dealing with environmental threats such as chemical spills, fires, and explosions when wind direction and precipitation runoff is important to consider.

VI. System Architecture

1. Overview

1.1 Introduction

ERIS will incorporate the use of cellular networks, wireless GPS tracking, geographical information systems (GIS), and portable computing devices.

Location base technologies will be used to locate and track emergency response personnel, equipment, and resources. The locations will be determined through the use of a GPS location based technology called PowerLoc, and through manual input from the workers in the field (who are not yet equipped with PowerLoc devices), the Incident commander will be able to track and supplies and personnel onsite. The data will be transmitted from the site of the disaster to the Emergency Operations Center wirelessly through the available cellular service in Centre County.

Once workers in the field are equipped with the PowerLoc device, the device determines it's location via GPS and then sends the information about the disaster wirelessly to a tracker server that will locate the worker. A GIS system called ESRI will retrieve digital maps of the area, overlay the tracked workers, and send these maps to the Incident Commander (IC) and the Emergency Operations Center (EOC). The system will use AirZip a built in security which compresses and encrypts files from the GIS system to the PowerLoc devices. This will allow the IC and EOC to view important information, allowing him/her to make critical decisions quickly during the event of an emergency, and also dispatch personnel and supplies effectively.

1.2. Tradeoffs

The ERIS solution may very well benefit Centre County; however there are some tradeoffs which should be discussed.

Since the ERIS system will be using the existing cellular network in Center County, it may create some problems when using the system to track personnel. The issue is that the cellular coverage in Center County is limited, and when workers in the field are trying to communicate with the Incident Commander, the area where the worker may be may have no cellular coverage. Alternatives to using the existing cellular network would be to use a landline, or a private cell network.

ERIS will also face issues with delays. In the process of tracking and sending information from the PowerLoc Device to the EOC, it takes time to transmit data and also process the information in the GIS system. The time it takes to transmit data may vary depending on how strong the cellular signal is, and can take from 30 to 45 seconds. ERIS will also be updating the maps every 15 seconds because there is not enough bandwidth to support real-time maps. When considering both of these delays, there should be no more than a one minute delay. Having a delay could be problematic, because during a disaster in one minute many things can change and new issues may arise. However, an IC should have a clear picture of everyone's location as of one minute prior, giving a close estimate to their current location. It is assumed that assets will not be traveling very far within the one minute period.

The battery life of the PowerLoc devices is another tradeoff. On stand-by the battery can last for up to 10 days. When using sporadically, on average the battery life is up to 24 hours. This will be a problem, because recovering after a disaster may take more than 24 hours, and the PowerLoc devices may run out of battery and become useless. But, the devices should have enough power to last a shift before new personnel take over. Battery changes or charges can be conducted as personnel end and begin active duty.

One final tradeoff is that the ERIS system will not be using weather in the integration. Not having information about the weather could be problematic, because if weather conditions are unfavorable during the disaster which could make managing the disaster even more difficult. However, at this time, a reliable weather data source that could integrate with the proposed system could not be fully determined.

2. Application Integration

2.1. Overview

As shown in figure 2 below, the applications used within the ERIS system will be a PowerLoc tracker server software, an ESRI GIS system, and a web server. The data from the devices will be accepted by the PowerLoc tracker server and the location data will be updated in the geospatial database. The GIS system will use this database to draw the geographical information from and process it to make a coherent picture of the scene. The layered data will then be processed by the web server and compressed and encrypted to be sent to the IC's wireless PDA.

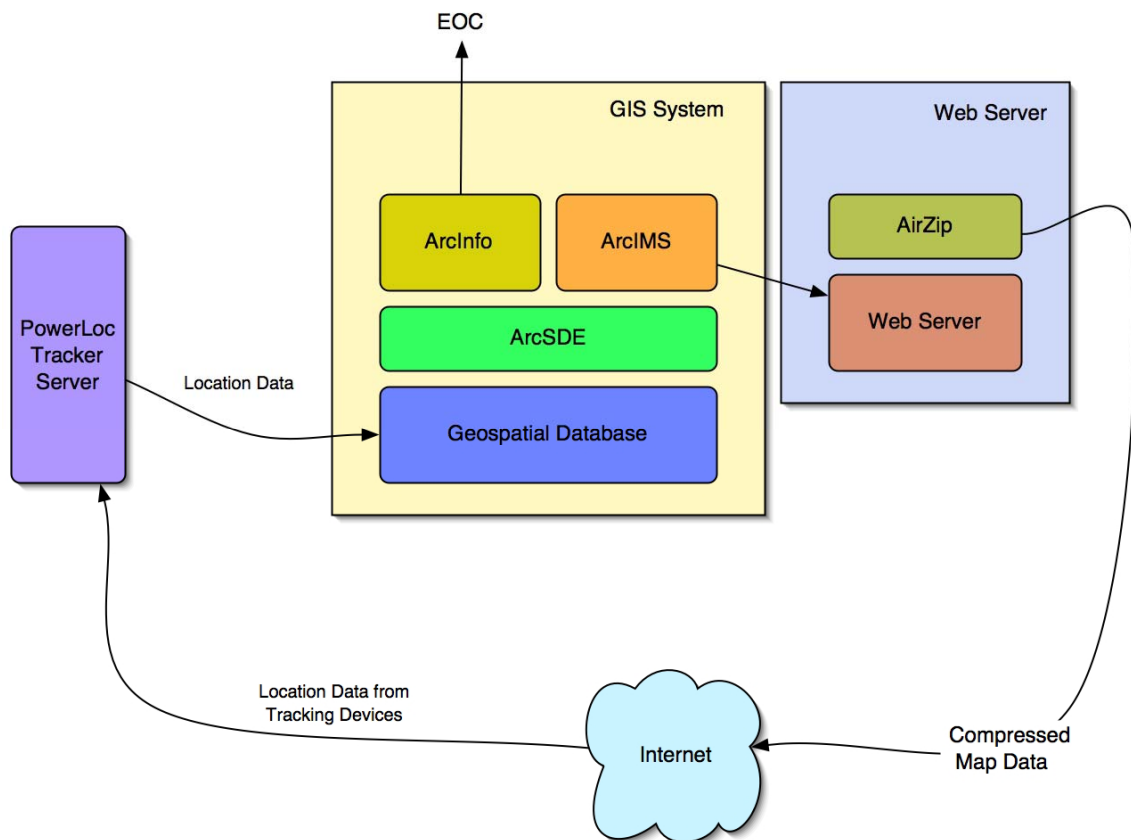


Figure 2: Application Overview

Currently, Centre Country has fully functional existing ESRI GIS system that uses a geospatial database, ArcInfo, ArcIMS, ArcSDE, and a variety of other Arc products. The county also has existing web servers running IIS.

The new applications being introduced in this system are the PowerLoc Tracker Server and the AirZip server module. The tracker server is necessary to receive and process the location data being sent by the many devices on the scene of an incident. AirZip is a web server application that compresses and encrypts image files before being sent over the Internet. This will allow smaller files to be sent to the PDA, conserving bandwidth, while also increasing security.

2.2. PowerLoc Tracking System

The PowerLoc system is designed to allow mobile devices to be carried in the field by personnel, equipment, or any other asset desired to be tracked. There are a variety of applications available in the PowerLoc suite. A command and control application allows users to interact with a GIS map system to define zones, danger areas, off limits areas, boundaries, and other such areas. Additional software includes a client application and a PDA based mobile command and control application.

For this project, the only application necessary from PowerLoc is the Tracker Server software.

2.2.1 Tracker Server

Built as a scalable and open architecture server system designed for wireless carriers and Location Service Providers, the tracker server is used to accept the data from the mobile tracking devices. The server can handle up to 1,000 devices simultaneously. The software is designed to interface with a variety of cellular and wireless networks, including GSM.

The tracker server can also interface with a GIS database. As the location information from the devices is received, the tracker server recognizes which device the signal came from, the coordinates of the device on the Cartesian plane, and any other information sent with the location. The server then updates the geodatabase with the new locations.

2.3. GIS Applications

2.3.1 Geodatabase

The Geodatabase is the physical location where the geographic maps and spatial information (spatial data, business rules, relationships, and behavior) inside a database management system (DBMS).

The geodatabase allows for the creation of data models that capture real world information inside a spatial database. The following image is an example of the ArcGIS Address model, and how Centre County stores information about address data.

As shown in **figure 3** below, the geodatabase can store image files, vector coordinates, single points, and all other attributes that accompany these. By using ArcSDE, the data is placed in context by a geo-location process that aligns coordinates on the Cartesian plane. Different types of information can then be layered and viewed separately.

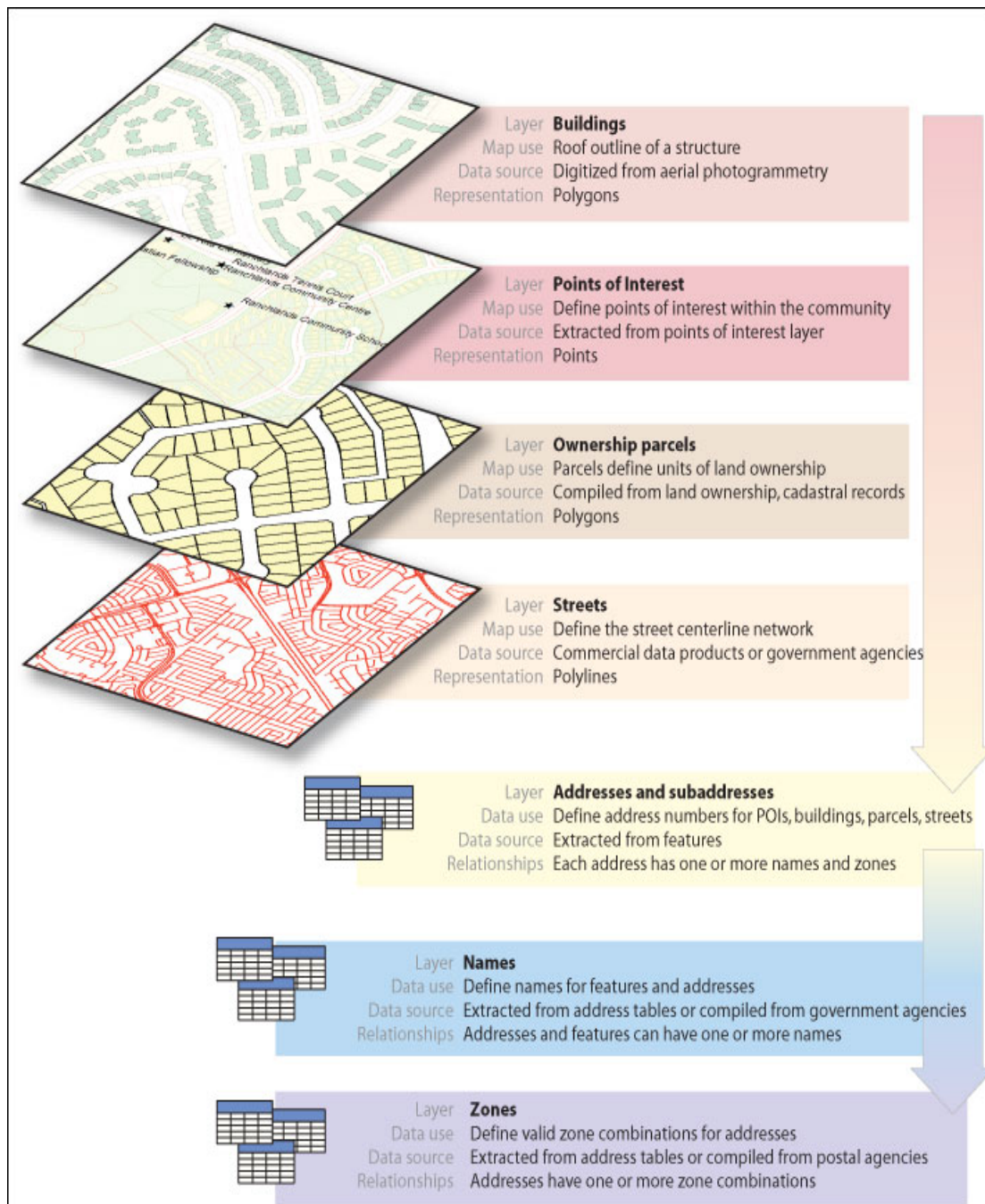


Figure 3:<http://www.esri.com/news/arcnews/fall03/articles/introducing-arcgis-address.html>

world with GIS information. Currently, ArcIMS is being used by service providers to deliver maps to cell phones or PDA's, such as to provide traffic reports, asset management, alerts, and personnel dispatching.

ArcIMS is the application between the ArcSDE and the web interface. Working together, they provide for a fast Internet access point to GIS data stored in the database. With this interaction, ArcIMS is able to manage, store, access, and analyze data at any location by creating a web application.

Figure 5 below represents the framework of how ArcIMS functions at different levels. On the client, or users', side, the client requests GIS data through HTML, Java, Active X, or some other custom/other methods that are custom developed. The Data Access Gateway in the image is ArcSDE, which acts as the gateway to the DBMS.

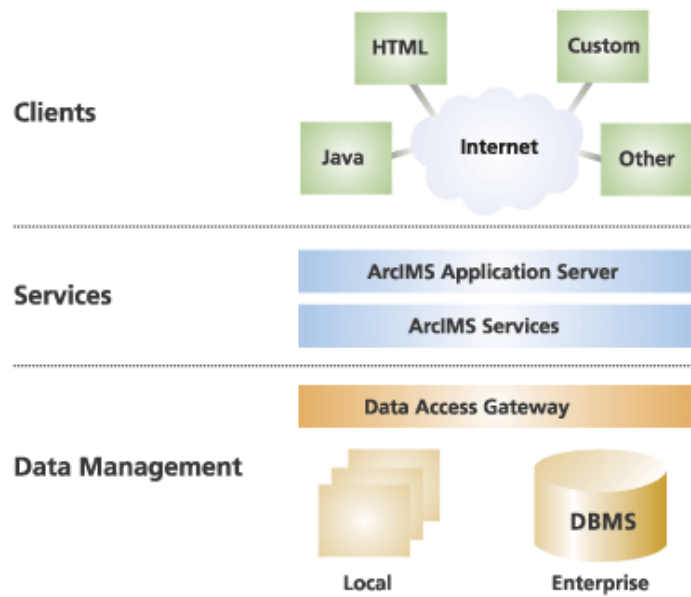


Figure 5: <http://www.esri.com/software/arcims/architecture.html>

2.3.4 ArcInfo

Within the ArcGIS software family, ArcInfo is the most comprehensive GIS available. It was built to combine some of their previous software, ArcView and ArcEditor, into one application that took it to a higher level. ArcInfo allows users with freedom to creation, update, query, map, and analysis GIS data on their desktop, workstation, or mobile devices. On top of providing data visualization, query, analysis, multi-user geodatabase editing, and the ability to create and edit geographic data, it also adds advanced geoprocessing and data conversions (statistical calculations, situational generalization data, overlaying maps). The image below is an example of how to view the different layers within the database.

2.4. AirZip Accelerator

AirZip is a company that partners with ESRI and makes applications that sit over web servers to secure and accelerate the file transfer over the Internet to mobile devices. AirZip Accelerator is an advanced web server filter function that optimizes image files, speeding the delivery of web pages from web servers to web clients over dialup or wireless connections, and improving performance by up to 800%. AirZip Accelerator intercepts incoming http image requests from web clients, retrieves the requested images, and returns an optimized image to the web client. Accelerator works with or without AirZip Accelerator software installed on the client.

This application will allow the map data being sent as image files from the web server to the wireless PDA to be much faster. As bandwidth over a cellular network may not be very fast, and while it is also important that the IC receive the most current information, this application will allow the data to be sent faster, decreasing the overall turnaround time from the time at which the device sends a location signal to the time at which the IC receives the location information.

2.5. Application Integration Strategies

The major application integration areas will occur between the PowerLoc server and the geodatabase, the ArcIMS application and the web server, and the web server and AirZip. Because the ArcGIS applications are part of a suite and designed to work with each other seamlessly, and because they are already in place and working, the integration among them will not be discussed.

The Tracker Server and the geodatabase will be integrated by allowing the server appropriate privileges to the Oracle database running the geodatabase. The server will then update, delete, or add records as it receives or stops receiving data from the mobile devices. The data will be inserted in the database using a structure defined in the ArcSDE users' manual. This will ensure that ArcSDE, and in turn the rest of the ArcGIS applications, will be able to access the data.

The ArcIMS application is also already in place at Centre County and is currently used to allow remote access to the GIS system via a web application. ArcIMS will be used to create a new web application that pushes image files of the requested data over a TCP/IP connection. The AirZip filter will be installed as an application over the web server to help speed up this process. As described previously, the filter takes any http request to the web server, intercepts the image file, and optimizes it before sending it out. In this case, the filter will only apply to requests made to the web application created by the ArcIMS.

2.6. Design Tradeoffs

2.6.1 ArcGIS Applications

ESRI offers a suite of ArcGIS applications. The applications used were selected because they represent what is available and/or in use at the Emergency Operations Center in Bellefonte. Additional ArcGIS applications could have been used (such as ArcXML to create XML data from GIS data), but would create additional overhead. Therefore, the team decided to use the applications above.

3. Data Integration

The major data elements of this system are the change in location data from the generation at the device to the transfer to the wireless PDA. Additional data may be generated by the ERIS system, but is either negligible or handled by another system outside the scope of this project.

3.1. Data Processing

3.1.1. Data Origination

The location data will originate from the mobile devices. The devices will be using a GPS receiver to determine the current location at fifteen second intervals. The devices will receive the location data in a Rinex format (a string based format that uses very small packet sizes). The devices will then re-transmit that Rinex data via the cellular network to the PowerLoc Tracker server. Because the data is being sent over a GPRS network, it will pass through a WAP gateway where the data is converted to a TCP/IP connection.

3.1.2. PowerLoc Data Processing

When the Rinex data arrives at the Tracker Server, the Cartesian coordinates are extracted. The server also takes into account the device ID number and recognized the device as belonging to a specific asset. That asset has a description already stored in an internal database. These descriptions are pre-loaded and can reflect the department, functions, specialties, and other details about the asset. The server then inputs the data into the geodatabase, an Oracle DBMS. **Table 1** shows a possible table layout for the database.

Name	Data_Type	Null?
device_id	SE_FLOAT_TYPE	NOTNULL
xcoord	SE_FLOAT_TYPE	NOTNULL
ycoord	SE_FLOAT_TYPE	NOTNULL
dept_id	SE_FLOAT_TYPE	NOTNULL
county_id	SE_FLOAT_TYPE	NULL
agency_id	SE_FLOAT_TYPE	NULL
date_time	SE_INTEGER_TYPE	NOTNULL
base_layer_id	SE_INTEGER_TYPE	NOTNULL

Table 1: Possible Table Layout

3.1.3. ArcGIS Data

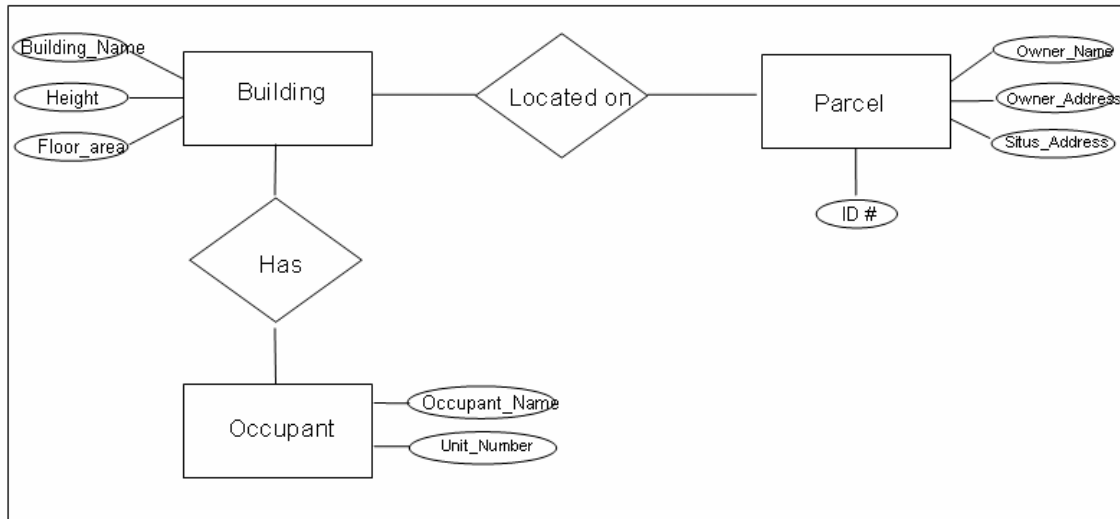
Once the data is stored in the geodatabase, ArcSDE allows ArcIMS and ArcInfo to view the location data as a layer within the GIS system. Therefore, the points representing assets will be overlaid onto the map and/or other data present in the GIS system.

ArcIMS will connect with a web server by processing any requests for map data on a continuous basis. Requests made by the mobile devices (or any computer on the Internet) will be sent via an HTTP request. When the request is made for the image file, ArcIMS generates a snapshot of the layers desired and converts the image into JPEG or PNG files. Currently, Centre County uses PNG files because of their higher quality. However, for requests made by mobile devices, the images will be converted to JPEG format to reduce file sizes.

When the JPEG file is created by ArcIMS, it is sent to the web server. As the requested data is about to be sent back to the mobile PDA, the AirZip filter intercepts the transfer,

optimizes the image to reduce file size, and sends the optimized JPEG file to the PDA via a cellular network connected to the Internet by a WAP gateway.

The following diagram is an entity relationship diagram for the geospatial database. The parcels are properties. Buildings are structures on the parcel and occupants are owners of the parcel or occupants of the structure.



3.2. Issues with Data Integration

Some issues regarding this type of data integration are:

- Some descriptions may not be accurate. There needs to be a way for the users at the EOC to verify that the people using the devices align with the pre-loaded descriptions. This can be achieved by assigning each department a range of devices and not allowing personnel to exchange devices.
- PowerLoc is not entirely clear on how the tracker server can export data or update a database. This issue will be resolved on April 16, 2004 during a conference call with Mike Stack of PowerLoc.

- Loss of data during travel over the public Internet or cellular networks. This can cause fragmented pieces of location data to arrive and deem them unusable, resulting in a location not being updated correctly.

4. Network and Hardware Architecture

4.1. Introduction

To support the functionality requirements of ERIS it is critical that a network infrastructure support the system in both terms of hardware and connectivity. Furthermore, both of these must be redundant or have a low risk of failure. Lastly, the infrastructure must be secure, keeping appropriate data in the hands of the proper people. The following sections will outline how ERIS meets these requirements and supports the overall project objectives.

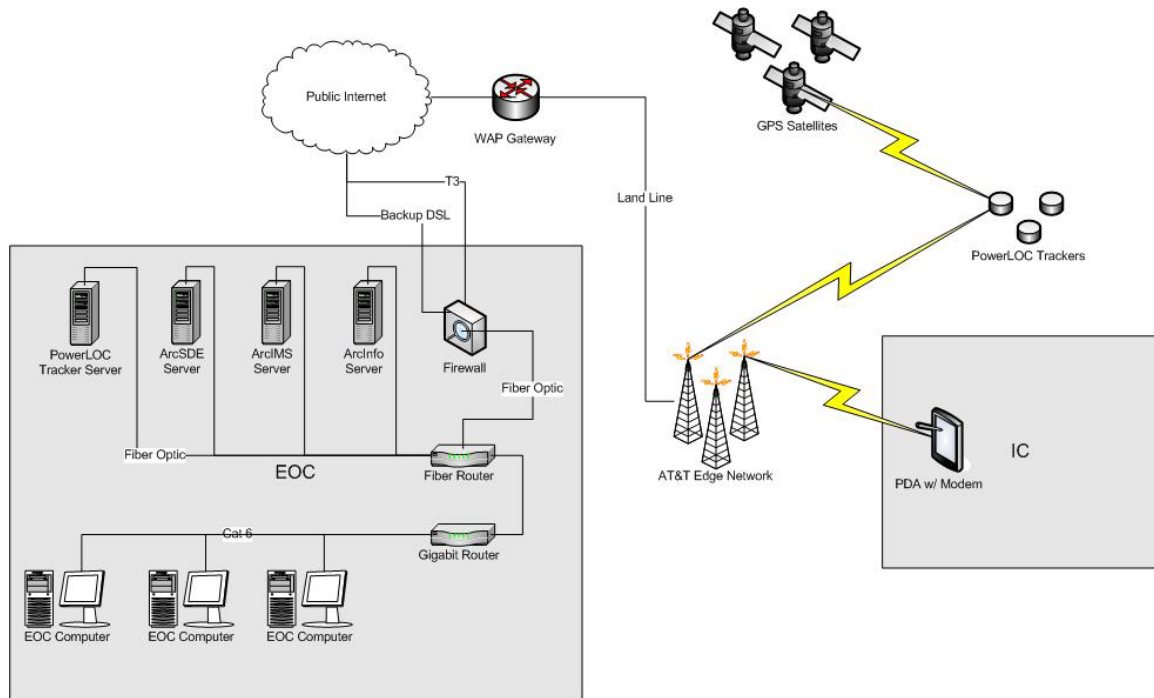


Figure 6: Overall Network Diagram w/ Hardware

4.2. Hardware Integration

4.2.1 Major Hardware Elements

- **GPS Satellite:** At any time, four GPS satellites are needed to allow the GPS receiver within the PowerLoc Tracker to determine its location. These GPS satellites are maintained by the United State Military and are considered to be at a low risk for service interruption. Furthermore, GPS is an established technology that has been proven for many years. However, GPS location determination does require that a GPS receiver have a line of site to GPS satellites. Therefore, this should be seen as a potential risk for interruption of ERIS service.
- **PowerLoc Tracker:** These units determine their location based on an internal GPS receiver. Each until has a GPS precision of +/- 10 feet. Under normal use each unit has a batter life of 24 hours. Up to 400 of these units can be distributed at any one time. These units are cellular, GMS, and GPRS compatible for a variety of connectivity options. Capable transmission rate: 155 Kbps. Each of these units has a unique publicly accessible IP address. As hardened tactical devices, these units are designed for adverse conditions much like those encountered in emergency response situations. This unit encrypts its data transmission.
- **AT&T Edge Network:** Developed, maintained and operated by AT&T Wireless. This is a next generation Edge GPRS (GSM) network is capable of high speed data transmission: 110 - 130 Kbps download, 50 – 80 Kbps upload. AT&T has a nationwide deployment of their Edge technologies, which is proven and tested within the industry. The WAP Gateway within this network translates publicly addressable IP address into the cell network, matching up Internet data with mobile Edge devices.
- **Server Cluster (4):** These servers handle all GIS and PowerLoc Tracker information. With redundancy in mind, these servers are configured with redundant RAID arrays, dual hot swap Xeon processors, and hot swappable power supplies. All servers are surge / UPS protected. Additionally the EOC has backup generator incase of power disruption.

- **Firewall:** This firewall is designed to block all unauthorized access in and out of the EOC. Since actual location tracking and other GIS data will be available from within the EOC, it is important that it is not be allowed to exit the facility or be tampered with. When data does enter or exit the facility, it must be encrypted for security purposes.
- **Fiber Router and Gigabit Router:** These routers provide high speed connectivity within the EOC.
- **EOC Computers:** These are high end workstations that are used to access ArcINFO information. These computers are surge / UPS protected. Additionally the EOC has backup generator in case of power disruption.
- **PDA with Edge Modem:** This is a hardened PDA with an AT&T Edge Network modem. This unit has a publicly accessible IP address. This unit encrypts its data transmission.

4.2.2 Topology

From the standpoint of the field devices, the PowerLoc Trackers and hardened PDAs, all connectivity takes place wirelessly. Each of these connections takes place in a point to multipoint configuration, with the connectivity infrastructure being multipoint. For example, each PowerLoc Tracker can connect to one of multiple AT&T Edge Network towers. Also, each PowerLoc Tracker has the ability to use any four of the available GPS satellites for location determination.

While redundancy does exist in this configuration, it should be noted that the loss of a GPS satellite or AT&T Edge Network tower would still decrease the reliability of ERIS. For example, failure of the nearest Edge tower would most likely result in a loss of signal strength, because the next tower would be farther away than the initial tower.

The connectivity required from the AT&T Edge Network towers to the public Internet is handled by AT&T Wireless via land lines. Information is then sent into the public Internet which acts as a highly redundant mesh network.

To access information from the Internet, the EOC is primarily connected via a T3 line, which meets or exceeds ERISs bandwidth requirements (see below). In case of failure, a DSL 1Mbps line is available for connectivity purposes, which still meets all but the most bandwidth intensive scenarios for ERIS. These connections go through a firewall before entering the EOC for security purposes.

Within the EOC, all servers are connected via fiber optic cables to a fiber optic switch. The external Internet connection enters the EOC network at this router. Another Gigabit router is connected to the fiber optic router. This secondary router handles information from the EOC Workstations. The topology within the EOC is a non-redundant tree topology.

4.2.3 Connectivity and Bandwidth Requirements

AT&T GPRS Edge Network

At any one time there may be up to 400 PowerLoc Tracker units operating. Each of these units will send location data every 15 seconds. Each transmission will require that 2 Kb of data be sent to the AT&T GPRS Edge Network. Therefore, the maximum throughput needed at any one time is 800 Kbps. However, the PowerLoc devices will not all be transmitting at the same time. By staggering transmissions, the total throughput used at any one time will more realistically be well below 800 Kbps. To send and receive information from the ArcIMS Server to the PDA in the field, there will be a maximum need for 56 Kbps. Therefore assuming up to 5 PDAs are in use at any one time, a maximum of 280 Kbps are needed. Therefore, the total required rate of transmission at any one time at peak rate is 1080Kbps.

When looking for a connectivity solution for these devices, wireless ability, current availability, bandwidth and reliability were all considered. Since the PowerLoc devices already support GPRS, using such a networked had added appeal. Additionally, PDAs and other future uses of ERIS might need higher speed wireless data transmission rates. When considering the available connectivity solutions in Centre County, PA the best balance between speed, availability and reliability was found with the AT&T Edge Network. This network has fairly widespread coverage and an average sustained bandwidth 110 - 130 Kbps download and 50 – 80 Kbps upload per device. Therefore, with the highest demand of any device being 56 Kbps, this more than adequately provides enough bandwidth for ERIS operations.

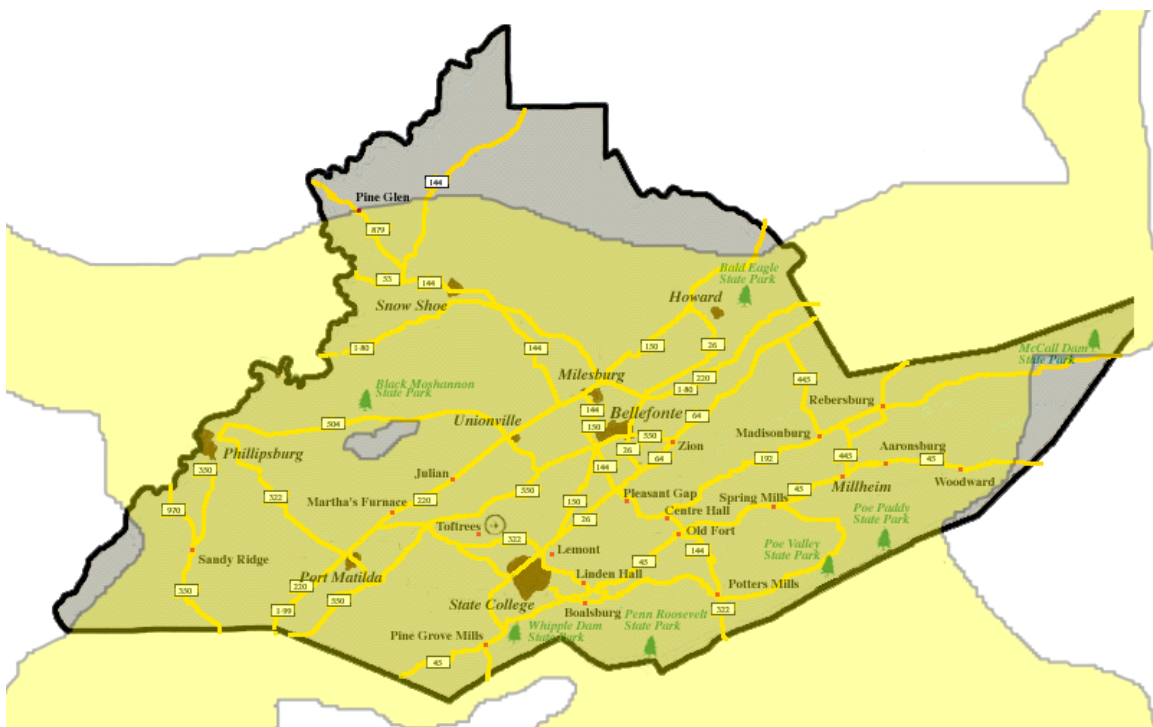


Figure 7: AT&T Edge Network Coverage in Centre County, PA

Emergency Operations Center (EOC)

In the case of the Centre County, PA EOC, there would be an estimated 20 or less individuals accessing GIS or location tracking information during any given situation. In fact, this number would most likely be much lower. However, even given the limited number of users, GIS systems deal with a great deal of information in the form of raw database data and processed imagery. As such the EOC's Workstations are connected via Gigabit Ethernet to a Gigabit Router. This Router is connected to a Fiber Optic Router. From this Router all servers are connected via Fiber Optic. This will ensure that no bottleneck situations arise.

Information going in and out of the EOC is limited to data from the PowerLoc Tracker units and ArcIMS information. Since the maximum data rate for these combined at peak was determined to be 1080 Kbps, a T3 will provide more than adequate support. In the case of T3 failure, a backup 1 Mbps DSL line will provide redundant connectivity.

Public Internet

By using the AT&T Edge Network and giving each wireless field device a publicly accessible IP address, these devices can technically be accessed from anywhere in the world. While this does bring raise some security concerns, this also means that if there were an issue at the EOC, the GIS and PowerLoc tracking hardware could theoretically be deployed at another location at still have access to field data. Also, but using the public Internet, the system benefits from the extensive mesh redundancy of the public Internet.

4.2.4 Security Considerations

Considering the critical nature of ERIS, it is important to ensure that data flowing to and from the field to the EOC is not misused. Varieties of security methods are used throughout ERIS to ensure a secure working environment. For example, the EOC and all servers reside within the Emergency Management Coordinator's office building,

protected by a firewall. Only data being sent from the devices and out to the PDA via HTTP connections will be exposed to the public Internet. To increase security in these areas, cellular encryption will be used between the devices and the cellular network. Also, AirZip will increase the security of the map image files by encrypting them before being sent out over the public Internet.

4.2.5 Portability and Setup

One of the major advantages of the ERIS solution is that most of the hardware and connectivity needed for operation are already in place and operational on a daily basis. The AT&T Edge Network is already in place and fully operational on a daily basis. And the majority of the hardware needed at the EOC is already operational. Field devices, the PDAs and PowerLoc Tracker units, must be distributed to emergency workers before they go onto the scene. However, this is a simple process as they can be distributed and kept in emergency vehicles, such as fire trucks, police cars, and ambulances. The units are hardened for tactical use and have a fairly lengthy battery life. Therefore, ERIS should have no negative impact on the day-to-day operating procedures of emergency workers.

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