University of Redlands

A Web-Based Application for the Redlands Fire Department

A Major Individual Project submitted in partial satisfaction of the requirements
for the degree of Master of Science in Geographic Information Systems

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by
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The report of Yusuf Albanki is approved.

A handwritten signature in black ink, appearing to read 'Douglas Flewelling', written over a horizontal line.

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A handwritten signature in black ink, appearing to read 'Fang Ren', written over a horizontal line.

Fang Ren, Ph.D., Committee Chair

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Abstract

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The Redlands Fire Department wanted to use Geographic Information System (GIS) technology in their analysis processes, to improve and enhance their services. Thus, a web-based application was developed to satisfy their needs. The main goal of the application was to help incidents analysts in studying fire incidents. Four objectives were set to meet this goal. The first objective was to show different summary statistics using a dashboard design. The second objective was to add different network analysis functions to help it understand the nature of its coverage areas. The third objective was to visualize the incidents using different mapping techniques. The fourth objective was to allow the user to determine and analyze the incidents that had a long emergency response time. Using this application, the Redlands Fire Department can manage its resources, identify the needs of its stations, understand the road networks, visualize performance history, predict coverage capacity, determine the locations that have a high concentration of incidents, and improve its services.

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List of Acronyms and Definitions

GIS	Geographic Information System
API	Application Programming Interface
Esri	Environmental Systems Research Institute
SDK	Software Development Kit
IDE	Integrated Development Environment
UML	Unified Model Language
HTTP	Hypertext Transfer Protocol
HTML	Hypertext Markup Language
URL	Universal Resource Locator
XML	Extensible Markup Language
WWW	World Wide Web
FTP	File Transfer Protocol
NFIRS	National Fire Incident Reporting System
RIA	Rich Internet Application
CSV	Comma-Separated Values
EMR	Emergency Response
ANI	Automatic Number Identification
ALI	Automatic Location Identification
SWC	Shockwave Flash Component

Chapter 1 – Introduction

Data and the process of deriving information from data are important for organizations. The information helps the organizations to discover the positive and negative indicators such as risks so they can take appropriate actions and make critical decisions to increase their productivity. Because information is valuable in the emergency response field, the Redlands Fire Department wanted an application that could turn their archived incidents data into useful information, and display the information using charts and maps. They also wanted functions like determining the nearest fire stations to a selected point and calculating the estimated coverage area for the fire stations to help them in minimizing their emergency response times.

An executive summary of the project is provided in this chapter. The first section introduces the project client. The problem addressed in this project is defined in the second section. The third section describes the goals, objectives, and methods used to implement the project. The fourth section addresses the report audience. The final section outlines an overview of the rest of the report.

1.1 Client

The client of this project was the Redlands Fire Department which is responsible for the public safety and firefighting in the City of Redlands. The point of contact for the project was Mr. Philip Mielke, who is the City of Redlands GIS Administrator. The client was interested in developing an online mapping application to analyze fire incidents to improve their performance in serving the citizens of Redlands.

1.2 Problem Statement

Time is extremely crucial for firefighting and rescue services. Many lives could be saved, and a lot of damages could be minimized by a quick response. Because of that, the Redlands Fire Department wanted a tool to help them to understand and minimize emergency response time. Currently, the Redland Fire Department stores and manages their incident records in a computer-aided dispatch system, which does not allow them to visualize the incidents on a map and conduct various analyses such as evaluating the distribution of the incidents and determining the locations that have a high response time. As such, it was difficult to make decisions about placement of resource. In addition to incidents analyses, the Fire Department also needed to identify the best routes for emergency response and evaluate the coverage areas of their fire stations. This could not be done with their current system. Thus, a better system were in demand that can help the Redlands Fire Department to understanding and evaluating the factors like incident locations, emergency response times, peak hours, and incident types, because understanding these factors and their relationship are crucial for the decision makers to better manage their resources to enhance their services.

1.3 Proposed Solution

In order to meet the client's requirements, the goals and the objectives were clearly identified. Project creep was avoided by determining the project scope precisely. These elements and techniques are described in the following sections.

1.3.1 Goals and Objectives

The primary goal of this project was to help the Redlands Fire Department minimize their emergency response time by developing a web-based application to analyze incidents. Three objectives were set to meet this goal.

The first objective was to show different summary statistics using a dashboard design. These incidents statistics summarized in the forms of tables and charts can help the client better understand the data. For example, the client can identify the workloads on each fire station, or the average emergency time of each fire station. Based on this information, the client can make plans to deal with the incidents.

The second objective was to add different network analysis functions to help them understand the nature of their coverage areas. Choosing wrong routes or assigning wrong fire stations to deal with an incident will increase the emergency response time. Using network analysis, different plans can be created to deal with roads conditions and to assign further incidents to the correct fire station.

The third objective was to map the incidents on a map using different mapping techniques. For example, clustering mapping can allow the client quickly identify where the fire incidents concentrated. Linking the map with the charts and tables for the summary statistics will further enhance client's understanding of selected incident records.

By meeting these goals and objectives, the Redlands Fire Department can use the application to make critical decisions, like resources redistribution and requesting new resources.

1.3.2 Scope

The project scope was composed of three components. The first component was an ArcSDE SQL Server geodatabase to store incidents data. The second component was a tool to import incidents data to the created geodatabase. The final component was a web-based application where the client can view the incidents in the form of linked graphs, tables, and maps. The application should allow the client to conduct analyses such as finding the closest fire station, calculating the service area of a fire station, and examining the spread of incidents over a specified time frame.

1.3.3 Methods

Several techniques and methods were used in each phase of the project's development life cycle. In the system analysis and design phase, similar projects were studied and multiple meetings were held with the client to define the requirements. The collected requirements were then classified into functional requirements and non-functional requirements.

The conceptual data model and logical data model were then designed to determine the needed data and build the database schema. The geodatabase was created on ArcSDE SQL Server, and a tool to import incidents data was implemented using model builder and Python script.

A web-based application was developed using Flex SDK 4.6 and ArcGIS API for Flex version 2.5 in the implementation phase. The required map services were published to ArcGIS Server 10 using ArcGIS Desktop 10. Different analyses were added to the developed application, such as network analysis. Finally, a dashboard design was used to display the required incidents statistics using different elements such as charts, tables and maps.

1.4 Audience

The intended audience of this report is the Redlands Fire Department employees. This project could also be useful to an audience with an introductory knowledge in GIS, programming, public safety, and the emergency response fields.

1.5 Overview of the Rest of this Report

The rest of this report describes how the main project components were implemented. Chapter 2 outlines the background and literature review. Chapter 3 describes the analysis and design of the project. The database design, data scrubbing, and loading are discussed in Chapter 4. The implementation of the import incidents tool and the web-based application is described in detail in Chapter 5. Chapter 6 illustrates several use cases of the application. Finally, the conclusions and future works are discussed in Chapter 7.

Chapter 2 – Background and Literature Review

A literature review was conducted before the project development phase, and three topics that are relevant to this project were reviewed. The first topic discussed in this chapter is how GIS technology became one of the essential technologies in the public safety field and has been used in most of the public safety areas, such as emergency management, disaster management, and decisions making (Section 2.1). The concept of dashboard design is introduced in Section 2.2, and Section 2.3 shows the role of web GIS in facilitating the spatial data sharing and accessing.

2.1 GIS and Public Safety

The term “public safety” includes any actions or procedures that are taken to protect people and their property from current and future threats. These threats could be natural or human made, and their effects could be direct or indirect on the surrounding areas (Caplan, 2010). Today, public safety systems are used by public safety agencies to help them in responding to the threats and events. The mission of public safety agencies is to respond quickly to reduce the losses in lives and properties (Leitinger, 2004). Due to the current increase in population, economic development, and urban development the mission of public safety agencies has become harder to accomplish. To improve public safety agencies’ services and speed up the emergency response process, GIS technology has been included in many public safety systems. This is because GIS is capable of analyzing spatial and tabular data, like populations, disasters, and critical infrastructure that are critical for decisions making in an emergency situation. Different kinds of information can also be generated and displayed on the map using queries and analysis tools. In addition, showing live data feeds—that are coming from different sources—on the map provides a common operational picture to the commanders, and this helps them in decisions making as well (Esri, 2008).

Common GIS functions used in the public safety systems include geocoding function, which is used to find incidents locations, and cartographic visualization, in which the necessary data are displayed on the map with appropriate symbologies. Some public safety systems contain the models for determining the areas that may be affected by a specific threat, such as a simulation of atmospheric dispersion of hazardous materials (Caplan, 2010). In addition, various spatial analyses and network analyses can be used to assess the distribution of the resources. For example, allocation analysis examines the efficiency of the service area for the resources under certain constraints like time. This information is important for public safety agencies because it allows them to evaluate the coverage area for their facilities.

The other type of commonly used analysis is location-allocation analysis where a set of facilities to be optimally sited under certain objectives and constraints like distance or time (Chang, 2011; Waters, 1999). Hotspot analysis is also used to identify the concentration and the spatial pattern of geographic objectives of interest, such as crime incidents and traffic accidents. This analysis is used by public safety agencies to study hotspots to take appropriate actions to reduce the number of the incidents.

The benefits of GIS to public safety could be enhanced by integrating it with other technologies (Esri, 2007). For example, the integration of GIS with automatic number identification (ANI) and automatic location identification (ALI) technologies speeds up the call taking process because the caller information and the location are detected directly when the call is received by the operators. Moreover, the integration between GIS with the automatic vehicle location helps the dispatcher send the closest resources to the incidents and track them. Thus, the integration between GIS and other technologies provides situational awareness to decision makers.

GIS also plays an important role in disaster management that is another essential subject in public safety. In order to minimize the effects of disasters, five phases should be considered and studied (Leitinger, 2004). The first phase is planning, in which the potential risks and disasters are analyzed to evaluate their possible effects. In this phase, GIS has been used for risk assessment, such as natural hazard assessment and vulnerability assessment (Cova, 1999). The second phase is mitigation, which includes the activities that should be performed to minimize the effects or to avoid the identified disasters. In this phase, GIS can be used in risk mapping and determining priorities (Cova, 1999). The contingency plans to minimize the damages are developed in the preparedness phase, and they are executed in the response phase. In these phases, GIS can be used for emergency vehicle routing, evacuation planning, and zoning planning. After the disaster, several activities should be taken to recover from the disaster. In this phase, GIS can be used to make damage assessments and recovery analyses (Cova, 1999).

2.2 Dashboard Design

An effective representation of needed information is very important for decision makers. Thus, choosing an appropriate design to show the data and information is an essential issue to be address in the development of decision support systems. Many systems fail because their designers focus on the beauty of the design more than on the goal of the system (Few, 2006).

According to Pousman and Stasko (2006), the design patterns for information systems can be classified into four categories: the Symbolic Sculptural Displays which uses water, light and others to view very few pieces of information; the Information Monitor Displays, a peripheral part of a computer desktop; the High Throughput Textual Displays, where the information is represented by using text and simple graphics; and the Multiple Information Consolidators which combine pieces of information from different sources on one screen and use techniques like blinking to inform the user about the changes in the information. The dashboard can be classified in this last category.

Few (2006) defines dashboard design as a “visual display of the most information needed to achieve one or more objectives which fits entirely on a single computer screen so it can be monitored at a glance” (p.34). Few’s definition of dashboards means dashboards should use graphics, gauges, charts, and maps more than using text. In doing so, the user can understand the information quickly and clearly. To make the design fit the computer screen, scroll bars should be avoided. The definition also indicates that dashboards should be designed to meet specific goals. Without addressing the goals and objectives, a dashboard will be merely an artwork.

Among different types of dashboards, the performance dashboards “translate the organization’s strategy into objectives, metrics, initiatives and tasked customized to each group and individual in the organization” (Eckerson, 2011, p. 4). Unlike other dashboard types, performance dashboards are developed based on performance matrices and performance indicators like risks indicators and activity matrices that are used to measure business achievements by comparing the current status to business goals. The performance dashboards allow users to monitor their work, analyze the problems based on various data, and manage their resources. There are three types of performance dashboards: the operational dashboards, which focus on monitoring and give alerts if something wrong is happening; the tactical dashboards, which are used to analyze the information to solve problems; and the strategic dashboards, which focus on management more than analysis or monitoring and they are used by executives to manage the implementation of the strategic plans (Eckerson, 2011).

The concept of dashboard design has been included in many applications in the public safety field. For example, a web-based dashboard was implemented by Esri North Africa (Esri NeA) in 2009 to control and manage the emergency response processes (EsriNeA, n.d.). Another example was the fire view dashboard that was implemented by The Omega Group. This application allows the user to analyze fire incidents and provide the information in different views, such as charts, maps, and reports (The Omega Group, n.d.).

2.3 The Development of Web GIS

Web technologies have been a huge revolution in most of industries. They change the way of sharing, accessing, and using data. Many workflows are improved by using the web. Like other technologies, GIS was influenced by this revolution. Today, web GIS is one of the most important divisions in GIS industry, together with other related divisions such as Internet GIS, and Internet distributed GIS services (Dragičević, 2004). In fact, web GIS is a subset of Internet GIS. Unlike web GIS that is limited on using World Wide Web (WWW) and HTTP to manipulate spatial data, other protocols like File Transfer Protocol (FTP) and Telnet can be used in Internet GIS (Peng, 1999).

Web GIS offers GIS functions on the web so that spatial data can be stored, analyzed, and visualized using HTML and HTTP (Penev, 2006). This minimizes the restrictions, such as the time and location of distributing and processing spatial data (Alesheikh, Helali, & Behroz, 2002).

Since web GIS is a combination of web and GIS, this gives it many advantages over the traditional GIS. First is the simplicity of its applications compared to the desktop applications. Most of web interfaces are not as complex as the desktop GIS interfaces, so the audience is a wide range of users including professionals and the public. Second, the updating process is done only on the application server. This feature reduces the time required for applications updates, since there is no need to update the clients’ machines. Third, unlike with desktop applications, many users can use and access applications at same time, which greatly facilitate information dissemination. This is done by using web browsers with necessary plug-ins, and the end users do not need to have expensive commercial software. In general, using web GIS can reduce the costs of training, licenses, and the required criteria of the client’s machine (Fu & Sun, 2010).

An example of web GIS is the E-government project implemented by UK's government to integrate local authorities' systems, services, and spatial data. Many benefits were gained from using web GIS. Each department can have access to the spatial data owned by other departments and can create mashup applications to display the data from different sources. Having access to all data supports the decision making process. The management and maintenance problems were solved by dedicating servers to store all the data. Ultimately, this architecture saves time and cost because all information is available and there is no need for searching or buying new data (Stachowicz, 2004).

The main challenging in web GIS is the speed, since a large amount of data need be exchanged between clients and server (Alesheikh, Helali, & Behroz, 2002). This problem can be solved by using appropriate web GIS architecture. The choice depends on the requirements and the available environment. The first architecture is called "Thick Client/ Thin Server." In this architecture, all processing is completed on the server side and the client can display the results. Any machine can be used on the client side. However, the response time will be long. The second architecture is "Thin Client/ Thick Server." In this architecture, the processing is done on the client side and the server sends the needed data. This architecture is influenced by network speeds, since a large amount of data need be transferred in the processing. Also, this architecture requires a powerful client machine to handle all processes. The last architecture is "Medium Client and Server." The processes are done on both sides (Ewald, 2004). This architecture becomes favorable when the processing loads are balanced between the client side and server side.

2.4 Summary

The goal of this project was to implement a web GIS application to support the client in the decision making process by providing different analysis tools and showing the statistics using dashboard design concept. Since this project will be used in the public safety field, many custom functions and analyses were added, such as closest facility analysis and service area analysis. Finally, the project was implemented based on web GIS technology, so that the application can be used by many users at the same time with low costs. The next chapter describes the system analysis and design of this project.

Chapter 3 – Systems Analysis and Design

The analysis and design phase is very important in the project's development life cycle because the following phases will highly depend on that phase. This chapter discusses the various elements of the system analysis and design. First, it highlights the client problem that was solved by the proposed system. Then, it explains the functional and non-functional requirements that were considered in the system development and how these requirements were met. Finally, it shows the project plan that identifies the major tasks which were done to implement the system.

3.1 Problem Statement

The Redlands Fire Department wanted a web-based GIS application to analyze fire incidents, and to improve their services. By using this application, proactive actions can be taken to decrease the emergency response time. Also, critical decisions like resources redistribution, ordering new resources, and building new fire stations can be made. In order to make this web application useful for the decision makers, the client wanted to examine several factors related to their services, such as the distribution of the fire incidents in relation to the fire stations, the incidents types, the peak hours, the areas that have a high concentration of incidents, and emergency response time. Moreover, these factors should be represented by interactive charts and map.

3.2 Requirements Analysis

Several meetings with the client were held to understand their requirements. The results of these meetings were divided into functional requirements and non-functional requirements. Non-function requirements consist of technical requirements, operational requirements, and transitional requirements (Table 3-1).

Table 3-1 Requirements Analysis Overview

Functional Requirements	
Displaying the information and the distribution of the incidents using tables, charts, and map	
Searching for incidents that have emergency response times greater than specified time	
Examine the spread of the incidents	
Service area analysis	
Closest facility analysis	
Non-Functional Requirements	
Technical Requirements	Using the Esri software suite
	Using an Adobe Flex framework
Operational Requirements	Operational environment updates
	Geodatabase archiving
Transitional Requirements	A tool to import the exported incidents data to a system geodatabase

3.2.1 Functional Requirements

The functional requirements determine the capabilities the system should have to solve the client's problem. According to the client, the system should allow the user to see the distribution of the incidents—based on the selected duration—over fire stations, months, days, hours, and areas using charts, tables, and maps. The system should also allow the user to determine the incidents that have emergency response times greater than the specified time. In addition, the system should allow the user to examine the spread of the incidents over time, find closest fire station to a selected point, and identify the coverage area of their fire stations.

3.2.2 Non-Functional Requirements

The technical requirements focus on the required technologies to build the system. Based on the client's requirements, the system was developed using the Esri software suite, so the web services were authorized using ArcGIS Desktop 10 and published using ArcGIS Server 10. The web application was developed using Flash Builder 4.6 with Flex SDK 4.6 and ArcGIS API for Flex version 2.5 was used as the Integrated Development

Environment (IDE). Since the application was developed using the latest version of Flex SDK, the client web browsers need Flash Player 11 or higher to access the application.

The operational requirements state the required processes to keep the system up and running. The archiving process will be done by the client either daily or weekly, based on their plan. The client is also responsible for operational environment updates. Data conversion can be categorized as transitional requirements. Since incidents data was provided in its original text format, a tool was developed to load these incidents to the geodatabase developed for the web application. The validation process, geocoding process, and adding the valid incidents into the geodatabase were the main functions of this tool.

3.3 System Design

The system design was dependent on the results of the requirements analysis. This section illustrates the system architecture and the design of the user interface.

Figure 3-1 shows the system architecture that consists of two tiers. The first tier is a server tier or web server, which contains the ArcGIS Server and application server. This connects to the system geodatabase. The second tier is the client tier; the client can access the application using any web browser with Flash Player 11 or higher.

Figure 3-1 System Architecture

As for the interface design, several required components were laid out during the design process and refined during the implementation phase. For example, the incidents map was designed to include a tool tip that shows incident type and a popup window that shows the incident information, such as incident ID, emergency response time, and clear time. After discussion with the client, a world topographic map, one of the Esri web services, was used as a basemap.

An important function of the web application is to show statistics about the retrieved incidents. The Show Statistics window was designed to include five sections (Figure 3-2).

First, incidents types are represented using a pie chart. Different levels of incidents details can be viewed using the pie chart, the user can navigate from one level to another by clicking on the incident type. Second, the fire stations section is a column chart showing the distribution of the incidents over the fire stations. The third section shows the distribution of the incidents over the months using a column chart. Fourth, a calendar of the selected month shows the distribution of the incidents over the days. The last section shows the distribution of the incidents over the hours of the selected day. The charts are interactive. When the user changes their queries by incidents or by fire stations, the charts, tables, and the map will be automatically updated. The title bar shows the average emergency response time of the selected incidents.

Figure 3-2 Show Statistics window

The Analyze Emergency Response Time window was designed to allow the user to search for the incidents that took more emergency response time than specified. Figure 3-3 shows the Analyze Emergency Response Time window.

Figure 3-3 Analyze Emergency Response Time window

The Service Area window was designed to generate a service area for one or multiple fire stations based on the specified time intervals (in minutes). Figure 3-4 shows the Service Area window layout.

The 'Service Area' window contains a section titled 'Select Fire Station(s)' with four checkboxes labeled 261, 262, 263, and 264. Checkboxes 261 and 264 are checked. Below this is a section titled 'Enter Travel time (in Min)' with three input fields containing the values 3, 5, and 7. At the bottom are two buttons: 'Solve Service Area' and 'Clear'.

Figure 3-4 Service Area window

Figure 3-5 shows Closest Facility window layout, which helps the user to find the nearest fire stations to a selected point. Its interface allows the user to add point and barriers to the map.

Figure 3-5 Closest Facility window

To analyze the temporal changes in incident distribution, a time slide bar was designed as shown in Figure 3-6. Once the user selects a timeframe, the incidents occurring within the timeframe will be animated by month. The total number of the incidents within selected timeframe will be displayed.

Figure 3-6 Incidents Time Slider window

The Options window (Figure 3-7) was designed to give the user more control on the application. The Option window allows the user to show or hide the all incidents layer, show or hide the selected incidents layer, auto zoom to selected incidents, and use or not use cluster option to view selected incidents.

Figure 3-7 Options window

Finally, the Street View window was also included to the application to help the user better understand the local environment. Figure 3-8 shows the Street View window which allows the user to view contents from different sources, such as Bing maps, Google maps, street view, or a combination from these sources (Dual Viewer). This window was designed based on the Street View window which was created by Frank Roberts for Flex Viewer.

Figure 3-8 Street View window

The implementation of all these components/functions will be described in details in Chapter 5.

3.4 Project Plan

Time was a critical factor in the project development life cycle, because losing control of time would affect the project quality. To avoid this situation, the project plan identifying the major tasks and their required time was created. The plan of this project consisted of five major tasks.

The first task was requirement analysis and design. The main objective of this task was to understand the client's needs and the scope of the project. Also, the functional non-functional requirements and system design were determined as the outcome of this task.

The second task was geodatabase development; during this task the client data were received. The goal of this task was creating the geodatabase and loading the client data. This task took longer than expected, because the data were received as a text file. To insure the data quality and integrity, a tool was developed to perform several validations and load valid data into the created geodatabase.

The third task was training. Learning the basics of the development using Flex and ArcGIS API for Flex was an essential task before starting the implementation task.

System implementation and testing, which was the fourth task, was based on the outcome of the requirements analysis and design tasks. The system was developed and several test cases were conducted to find the bugs and errors.

The final task was system delivery which included submitting the system and documentation to the client.

During the project development life cycle, some modifications in the plan were made. For example the ArcGIS API for Flex was chosen over ArcGIS Viewer for Flex because it provides more flexibility in customization. The project scope was also changed based on available data. For example, the usage of each fire truck was removed from the scope, because this information was not provided.

3.5 Summary

The output of the system analysis and design process was a blueprint for the project development. With good system analysis and design outcomes, many risks and problems that can influence projects development can be avoided. Moreover, identifying the required tasks that should be accomplished to deliver the system and put them within the appropriate time frame is important to insure implementing the system within the specified duration. This chapter focused on the system analysis and design and project plan. The next chapter will describe the system database design.

Chapter 4 – Database Design

The purpose of a well-designed database is to determine and organize the required data for the project and to avoid data duplication. This reduces the database size and speeds up the search process. This chapter describes the steps that were performed to create the system database, starting from the conceptual data model and ending with data loading.

4.1 Conceptual Data Model

The conceptual data model was an effective way to determine the required data for the project. It was used to identify the necessary entities to solve the client's problem and shows how these entities are related.

Figure 4-1 shows the conceptual data model of the project. There are three main entities in this project: *Fire_Stations*, *Incidents*, and *Fire_Trucks*. The relationship between the *Fire_Station* and *Incidents* is “responds to” which is a one to many relationship. The *Fire_Trucks* and *Fire_Stations* are related by an “assigned to” relationship which is one to many. In addition to these main classes, *Service_Area* class is connected to the *Fire_Stations* via an aggregation relationship. The goal of this class is to store the service areas of each fire station on different times, to minimize the calculation time. Finally, the *Fire_Trucks* and *Incidents* are related by the association class “Dispatch.” This class stores details about the dispatching action, such as the arrival time of the dispatched fire trucks.

Since the network analyses will be done based on the fire stations, two functions were added to the *Fire_Stations* class. The first function is *ClosestFacility* which is used to determine closest fire station to a selected location. The second function is *ServiceArea* which is used to calculate the service area for fire stations based on a given time.

Figure 4-1 Conceptual Data Model of the project

4.2 Logical Data Model

Unlike the conceptual data model, the logical data model shows more details about the identified entities. Thus, the required attributes and their data types are specified in that data model.

The database of this project has two feature classes —*Incidents* and *Fire_Stations*— and two main tables, which are *Incidents_Types* and *Fire_Trucks*. In addition to these tables, *standard* table, which is based on the schema that was given from the client, is used in the loading incidents process.

Figure 4-2 shows the logical data model of the project database. Some modifications were made on the conceptual model based on the available data and the client's actual needs. Because client was interested in when the first fire truck arrives at the incident location, the information on this truck is stored in the *incidents* class instead of in the association class. In addition, a new class was created to store incidents type information. This class works as a lookup table for incidents types. Moreover, *Service_Area* class was removed, since there are no needs to store the service areas because the time is not critical since the application will not be used in the emergency response, but it will be used in the analysis process. In addition, storing the service area of each fire station will make difficult to handle the overlaps between the service areas in the application, because they should be clipped to remove the overlapped portions.

Figure 4-2 Logical Data Model of the project

The *Fire_Stations* feature class contains the fire station names and their addresses, and the primary key is STATION_NO. The *Incidents_Types* table stores incident type codes and their descriptions, and the primary key is Incident_Type. The *Incidents* feature class stores information about the incidents, such as Inc_Key, address, and clear time. The Inc_Key is the primary key of this feature class. The Inc_Station, Inc_Type, and Inc_1stFireTruck are foreign keys used to connect the incident with its related fire

station, incident type and Fire_Trucks, respectively. Finally, the primary key of the *Fire_Truck* table which stores fire trucks information is FT_Name

4.3 Data Sources

A sample of incidents data was provided in a comma delimited text file, which was exported from the client's existing system. To understand the data and their structure, the file was converted to an Excel file. Table 4-1 shows the main fields in the provided text file. The file contained incidents records between 31 December 2009 and March 2011. In addition, the fire stations data were provided in a shapefile format.

Table 4-1 Main fields in the provided text file

Field name	Description
INC_Key	Incident ID
INC_AlarmTime	Incident informed time
INC_1stCompany	First fire truck arrived to the incident location
INC_GISAddress	Incident address
INC_City	City
INC_ZipCode	Zip code
INC_Station	Fire station
INC_IncType	Incident type code
INC_IncDesc	Incident Description
INC_DispatchTime	Dispatch time
INC_EnrouteTime	En route time
INC_ArrivalTime	Arrival time
INC_ClearTime	Finish time

The Redlands Fire Department follows the National Fire Incident Reporting System (NFIRS). Since the standard incidents types and their descriptions were not provided, the website of the NFIRS (<http://nfirs.fema.gov/>) was used to get this information, which was found in an Excel sheet named NFIRS_Spec_Tables_2009 that contains all codes that are used in NFIRS. After approval from the client, these data were used as the source for the Incidents_Types table.

Finally, The World Topographic map service was used as basemap of the application.

4.4 Data Scrubbing and Loading

Before the beginning of the data loading process, the geodatabase schema was created based on the conceptual and logical data models. The fire stations data and the incidents data were tested before loading them to the geodatabase to ensure the integrity and the accuracy of the data. Several validations were performed, like testing if there were incidents records that had missing attributes. Some fields were calculated before data loading, such as emergency response time, arrival time, and total time. After all that, a geocoding process was done on the valid incidents.

Since the scrubbing and loading process for the incidents data will be done frequently based on the client needs for the future use of the application, a tool was implemented to handle this process. This tool is described in detail in Chapter 5. About 78.9% records from the total records were successfully added to the database, and the other data were removed due to various reasons that will be further discussed in Chapter 5. These records added to the geodatabase were used for testing and building the application.

All tables and feature classes were exported into the ArcSDE geodatabase, since the client has ArcSDE geodatabase in their environment. ArcSDE geodatabase can store a large amount of data without affecting the performance of data manipulation.

4.5 Summary

This chapter discussed how the project database schema was generated using the conceptual data model and the logical data model. Both data models were used to identify the necessary entities and their attributes to meet the client's needs. The second part of this chapter focused on the database implementation.

Chapter 5 – Implementation

Two components were developed to meet the client’s requirements: an Import Incidents tool which was implemented using ModelBuilder and Python scripts; and a web-based application, which was used to analyze the fire incidents. This chapter discusses the implementation of these components.

5.1 Import Incidents Tool

The Import Incidents tool was developed in the project to import the data provided by the client to the system. Moreover, it will be used frequently on a large number of new incident data in the future when the client needs to update the system database. This tool consists of multiple processes to check data integrity, and ModelBuilder and Python scripts were used to implement this tool.

Figure 5-1 shows the workflow of importing incident data using the Import Incidents tool. In this project, data were exported from the existing system as a text file, and then converted to an Excel file before using the tool. The tool uses the converted file as input and its output is an Excel file that contains the status of each incident. The user can view which items were inserted successfully, and which could not be inserted. For the items that were not inserted successfully, a reason will be given. The user can then fix any errors and repeat the process using the output file.

Figure 5-1 Import incidents data workflow

Figure 5-2 shows the interface of the Import Incidents tool. This tool allows the user to set the input table; match the fields; specify the output file format, which is either comma separated values (CSV) or Microsoft excel file format (XLS); and set the location of the output file.

Figure 5-2 Import incident tool interface

The tool performs several tasks, including copying incident data, validating records, geocoding, performing field calculations, and exporting the results into an Excel file or CSV file. The following sections describe how these tasks were accomplished in this project. The tool model is provided in Appendix 1.

5.1.1 Copy incident data

The data import process started by creating a test table based on the standard table schema that was used in the client's existing database. The Append tool was used to copy the data from the input Excel sheet to the test table based on the field matching that was specified using the field map section in the tool interface. Subsequently, status and description fields were added to the test table to store the status of each incident record.

5.1.2 Validations

Many validations were performed on the imported data to avoid data inconsistency and to ensure the data integrity and quality. Because most fields were used in the application, these fields (such as Inc_key, Inc_address, and Inc_AlarmTime) should not be empty.

The first step in the validation process was to check if there were empty fields. The second step was to check if the Inc_key followed the standard format. The Inc_key should consist of 25 characters; it must start with "CA", and the rest of the characters

should be numbers. The third step was to check if the incident ID already exists in order to avoid the duplication of incidents.

To maintain the relationship between the incident and its incident type, the fire station, and the fire truck that dealt with it, the existence of these attributes were checked across other related tables.

Finally, the time fields, which are incident time, incident arrival, and incident clear time, were checked to verify their sequence and their date and time format.

5.1.3 Geocoding

Once validated, the incidents records were geocoded. The Import Incidents tool uses an online address locator: the North American Address Locator. After this process, the tool selected the matched records with a score of 90 and inserted them into the incidents feature class using InsertCursor. On the other hand, the tool wrote the status of unmatched records in the status and description fields in the test table.

5.1.4 Fields Calculation

Several fields that were used in the web application were calculated: the emergency response time, which is the difference between the arrival time and the incident time; the handle time, which is the difference between the clear time and arrival time; and the total time, which is the difference between the clear time and the incident time. This process was accomplished by selecting the inserted records from incidents feature class using MakeFeatureLayer, and using Calculate Field to calculate the value. This process was repeated to calculate each value separately, since Calculate Field tool is used to calculate one value at a time. Table 5-1 shows the equations that were used to calculate the emergency response time, handle time, and total time. These times are measured in minutes.

Table 5-1 The Field Calculations Equations

Field	Equation
Emergency Response Time	([Inc_ArrivalTime]- [Inc_AlarmTime]) * 24 * 60
Handle Time	([Inc_ClearTime]- [Inc_ArrivalTime]) * 24 * 60
Total Time	([Inc_ClearTime]- [Inc_AlarmTime]) * 24 * 60

5.1.5 Results Exporting

Finally, the test table was exported to an Excel file by using a Table to Excel script that was downloaded from ArcGIS Resource Center. The exported file contains the status codes and the description of each record. The status code of each record indicates whether the record was successfully added into the system database and what problems had occurred if it was not. Each record will have only one status. Table 5-2 provides the

descriptions of these status codes. The codes were designed in that way to allow the user to group the results based on their category. Also, several new codes can be added in the future without affecting the sequence of the current codes. After exporting the results, all intermediate tables like test table will be deleted.

Table 5-2 Status Code and Description

Code	Description
9	Incident was added successfully
1	Checking if one of the mandatory fields is empty
1.1	Incident ID is empty
1.2	Incident Time is empty
1.3	Arrival Time is empty
1.4	Clear Time is empty
1.5	Incident Address is empty
1.6	Fire Station is empty
1.7	Incident Type is empty
1.8	City is empty
1.9	Zip Code is empty
2	Checking if the Incident ID follows the standard
2.1	The Incident ID is more than or less than 25 characters
2.2	The Incident ID does not follow the standard 'Not start with CA'
2.3	The Incident ID does not follow the standard 'it has letters other than CA'
3	Checking if the incident ID already exists
3.1	The Incident ID exists in the incidents
3.2	The incident ID exists in the imported file more than once
4	Checking the relations with other tables
4.1	The Fire Truck is not in the FireTrucks Table
4.2	The Fire Station is not in the FireStations Table
4.3	The Incident Type is not in the IncidentType Table
4.4	Incident Description not matched with existing incident descriptions for the incident ID
5	Checking the date and time fields
5.1	Problems in time sequence
5.2	The Incident Time is not in the standard format '%m/%d/%Y %I:%M:%S %p'
5.3	The Arrival Time is not in the standard format '%m/%d/%Y %I:%M:%S %p'
5.4	The Clear Time is not in the standard format '%m/%d/%Y %I:%M:%S %p'
6	Checking the geocoding results
6.1	Address Unmatched
6.2	Score Below 90
6.3	Zip Code or City not in the matched address

This tool was used to load the incident data that were received from the client. The data were grouped based on the month, and then the tool was used to import the incidents data. Table 5-3 summarizes the results of this process. Since the main problem in the data was the inaccuracy of the addresses in most of the incidents records, the client was notified about the problem to avoid it in the future. The total incidents number of records was 10408, the total number of successfully saved records was 8211, and the total number of unsaved records was 2197.

Table 5-3 Results of Data Loading

Code	Type	Total
1.1	Incident time is empty	6
1.3	Arrival time is empty	1
1.4	Clear time is empty	1
1.5	Incident address is empty	2
4.1	The Fire Truck is not in the FireTrucks Table	10
6.1	Address Unmatched	10
6.2	Score Below 90	1507
6.3	Zip Code or City not in the matched address	660

5.2 The Web Application Development

Developing the web application to meet the client requirements was the main focus of this project. In order to develop an interactive Rich Internet Application (RIA), a Flex framework was chosen for the development process. This section focuses on how the web application was developed.

5.2.1 Publishing the Map Services

Map services are one of the major components in web GIS applications because the application communicates with the database through them. In this project, three map services were published: incidents that included all incidents' locations details like occurrence times and fire stations that were dealt with these incidents , incident types that was a table that stores incident codes and their description, and fire stations containing all fire station locations and names.

The first step in publishing map services is authoring the map documents. In this step, three map documents were prepared. Each map document had a layer that points to the required data. The symbology was set for both incidents layer and fire stations layer.

Because temporal analysis function was one of the client requirements, temporal animation was enabled in the incidents layer property and the time attribute that indicated when the incidents occurred was specified (Figure 5-3). So after selecting the analysis duration, the user can use the Time Slider window to visualize the incidents by months. When the Time Slide window opens, start and end dates are generated. The user can then select the time slider stops. When the user changes the time extent, the time definition property of the feature layer that is used to display incidents changes to the new extent.

Unlike the incidents and fire stations map documents, the incident type did not have symbology, because it only points to the incidents types table.

Figure 5-3 Time properties of the incidents layer

After authoring the map documents, the second step was to use the Map Service Publishing toolbar to analyze the map documents. This step was to fix any errors or to avoid warnings that could affect the performance of the map services. This step was completed using ArcMap 10.

The final step was to publish the map documents to ArcGIS Server 10 using ArcCatalog 10. The default maximum number of records returned by the server was 1,000 for each service. This number was changed to "1,000,000,000" for the incidents map service, to accommodate the large number of incidents that can be selected by the user. This change was done by stopping the service, changing the value from service properties, and then restarting the service.

5.2.2 Building the Web Application

The proposed application was developed using the Flex environment because it has extensive libraries of components, such as charts and data grids, that were used to meet the project goals. Flex SDK 4.6 was used with ArcGIS API for Flex version 2.5. Flash Builder 4.6 was also used as the IDE for the application development. The first step was to install the latest version of Flash Builder, and then imported the Shockwave Flash Component (SWC) file of the ArcGIS API for Flex to the created Flex project. Generally, SWC files are used to store classes, components, and assets to distribute and reuse them in other applications (Ahmed, Hirschi, & Abid, 2009). This section details how the main functions and components were developed in this environment.

5.2.2.1 Map Component

The map component is very important in the web GIS applications, because it holds the layers that are used to show map features.

Because the application is focused on the city of Redlands, the initial extent property of the Map component was set as follows: `xmax="-13043827.765"`, `ymax="4036937.772"`, `xmin="-13045738.691"`, and `ymin="4035504.578"`. These settings ensure that the map component shows the City of Redlands when the application is opened.

Three types of map service layers were used in the project: Graphic Layer, Feature Layer, and ArcGISTiledMapServiceLayer. The first type (ArcGISTiledMapServiceLayer) was used to view the basemap, because it is used to display the cached map services. The second type (Graphic Layer) was used to show the results of the analyses (such as service area analysis), and the parameters of some functions (such as the barrier points for closest facility analysis). The symbology of the graphic layers should be set manually, so the renderer property was used. There are two types of renderers. A simple renderer was used to set the same symbology for all features, such as barriers graphic layer so all barriers will have the same symbol. A unique value renderer was used to set different symbologies for different features; an example of this would be setting different colors for the results of closest facility analysis. Table 5-4 shows all graphic layers that were used in the application.

Table 5-4 Applications' Graphic Layers

Graphic Layer Name	Usage	Renderer Type	Image
resultsGraphics_Layer	Show the results of the service area analysis	Uniquevaluerenderer
glFindAddress	The results of the geocoding process	Simple
routeGraphics_Layer	The results of closest facility analysis	Uniquevaluerenderer
barriersGraphics_Layer	Show barriers for closest facility analysis	Simple
graphicsLayer	Show the selected location for using street view	Simple
incidentsGraphics_Layer	Show the selected location for closest facility analysis	Simple

Unlike graphic layers, feature layers use the symbology of the original map document, so there is no need to specify the symbology. Since the feature layers have a definition query property, the queries can be done directly. In addition, feature layers come in three modes: Snapshot mode, On demand mode, and Selection mode. Snapshot mode is used to retrieve all features at once, On demand mode is used to retrieve features that are within the viewing extent, and Selection mode is used to retrieve the selected features. Table 5-5 shows all feature layers that were used in the application.

Table 5-5 Applications' Feature Layers

Feature Layer Name	Usage	Mode	Image
fireStations	Show fire stations	snapshot
fAllIncidents	Show all incidents	snapshot
fSelectedIncidents	Show the selected incidents	selection
fLayer	Show the incidents which are within the timeframe of the timeslider	snapshot

Because there are more than 200 potential incident types, using different colors to symbolize the incidents by types could potentially confuse the user. Thus, a tooltip was set for each incident to show the incident type. The tooltips were set in “add graphic event” which is one of the feature layer events.

The popup menus were used to provide the user with more information about the incidents. The information shown in the popup menus are: Incident ID, Alarm Time, Arrival Time, Clear Time, emergency response time, Handle Time, Total Time, Fire Station, and Address. The popup menus were configured using the InfoWindowRenderer property of the feature layers.

5.2.2.2 Data representation

When the selected duration contains a high number of incidents, the map will be unreadable because these incidents overlap. A clustering process, provided by ArcGIS API, was used to solve this problem. The clustering process groups the nearby points into a single point. The grouping distance is dynamic depending on the map scale. Figure 5-4 shows the difference clustering makes in the map display. In the map on the left, clustering has not been used. In the map on the right, clustering has been used.

Figure 5-4 Map without Clustering and Map with Clustering

A WeightedClusterer component was used to implement the cluster process by assigning it to the Feature Layer using clusterer property of the Feature Layer. To remove cluster, a null value should be assigned to the clusterer property of the Feature Layer. Cluster is used in selected Incidents Feature Layer and all Incidents Feature Layer. The FlareSymbol component was used with WeightedClusterer. Figure 5-5 shows the effect of using FlareSymbol with the WeightedClusterer component. The FlareSymbol component was assigned to the WeightedClusterer component using the symbol property of the component. Several properties were used to configure FlareSymbol. backgroundAlpha, was set to 0.6. backgroundColor was set to 0x66FFCC. flareMaxCount, was set to 30; this means that the maximum cluster size that can be flared is 30. flareSizeIncOnRollOver was set to 3. Weights was set to [30, 60]; this was used to set breaks and the size for each break was set using size property [20, 30, 60]. Therefore, the size of the cluster from 2 to 30 will be 20, the size of the cluster from 31 to 60 will be 30, and the size for a cluster whose value is greater than 60 will be 60. This feature helps the user imagine the amount of the incidents in the cluster.

Figure 5-5 Flare Cluster

5.2.2.3 Find Address

The find address function was based on an online address locator, provided by Esri that can be changed using the application configuration file. The function accepts three parameters: the address, an array of values that are needed in the output (for example, loc_name), and AsyncResponder (which is used to define the onresult and onfault functions).

If the address is successfully returned, a new graphic will be created and added to the glFindAddress graphic layer. Based on the results of the geocoding (Table 5-6), the map scale will be changed correspondingly.

Table 5-6 Map Scales for the Geocoding results

Result Type	Scale
Street Number	10000
Street	15000
Zip code	20000
City	150000

5.2.2.4 Street View

Visiting the sites that have a high concentration of incidents is an important task that needs to be completed by the incident analyst in order to understand the causes of the concentration. In order to assist the incident analyst in performing this task, a window that provides a connection to the Google Street view was included in the application. Using this window, the user can select a point on the map and view panoramic images of the selected point. This was created based on the Street View widget that was created for Flex Viewer by Frank Roberts. The source code was downloaded from the code gallery of ArcGIS API for Flex in the ArcGIS Resource Center. The widget views the data from different sources, such as Google maps, Street View, and Bing. The data is displayed using mapchannels.com which defines the interface and the arrangement of display. The Street View window allows the user to select different views, such as Dual Viewer, Bing Maps, Google Map, and Street View. Figure 5-6 shows examples of different interfaces that are provided by mapchannels.com.

Figure 5-6 Different Interfaces for Street View

These interfaces were determined using the URL, so there is URL provided for each interface. The coordinates of the selected point were included in the specified URL based on the selected interface.

In order for the code to work on the standalone application outside of Flex Viewer, some modifications were made to replace the parts related to the Flex Viewer. The WebForm.mxml component that is used to display the images and interfaces was imported to the project. Also, flex-iframe-1.4.6.swc library was downloaded from Google Code and imported to the application library.

5.2.2.5 ActionScript Classes

ActionScript is an object-oriented programming language that is used to develop applications in Flex platforms with MXML. MXML is based on XML and is used to implement the application interface. ActionScript is the main language in that platform, so all MXML tags will be converted to ActionScript statements in the process of compiling the code of the application (Labriola, Tapper, & Boles, 2011).

Displaying incident statistics using charts, tables, and map was one of the most important requirements of the project. This was implemented by developing ActionScript Classes. The idea was to create basic classes that store essential information about the objects and methods, such as increment and reset count values, to access the stored data. Instead of dealing with each object individually, collection classes were created to store the created objects in ArrayCollection, which contain methods to access all stored objects. At the end, all collections classes were stored in a parent class named ChartsDataCollection to manage the requests for collection classes (Figure 5-7).

Figure 5-7 ActionScript Classes

FireStationDataObj class was used to create fire station object that has the fire station name and the number of the incidents that were dealt with by this fire station. Because the Redlands Fire Department has four fire stations, four objects from this class were created. IncidentsDataObj class was implemented to create incidents objects which contain incident code, incident type, code level, and total number of the incidents of this type. One object from this class was created for each incident type. The TestEMSDataObj class was used to store the number of incidents that had an emergency response time above and below the specified value in the Analyze Emergency Response Time window. So when the user uses the Analyze Emergency Response Time window, two objects will be created, based on this class, in order to store above and below counts.

All objects are stored in ArrayCollection. Thus, the objects of FireStationDataObj are stored in the FireStationCollection, IncidentsDataObj objects are stored in IncidentsDataCollection, and TestEMSDataObj objects are stored in TestEMSDataCollection. These collection classes contain methods that are used to determine the value of the object that should be incremented. Also, they contain methods to reset the count of all objects.

The same concept was applied on DateTimeDataCollection, except the data needed to be stored in a different time and date level. Thus, different DataObj and DataCollection classes were created. For example, YearDataCollection has an ArrayCollection to store YearDataObj objects. Each YearDataObj has an ArrayCollection to store the year's months, which are stored in MonthsDataCollection and so on. YearMonthCountDataObj

is a special class that is used to connect to the distribution of the incidents over months, so it contains the year, month, and count.

ChartsDataCollection is a parent class that stores the objects of collection classes. Also, it serves as data provider for the charts and tables that are used in the Show Statistics window. The ChartsDataCollection methods receive the data, and then it calls the appropriate functions in the Collection Classes.

This data structure was useful in the development of the Show Statistics window, because handling and managing all the data with different user actions separately is very difficult. Moreover, this structure is reusable, so the functions can be used multiple times in different events. The code can also be extended easily by adding more functions without affecting the other functions or classes. Finally, managing and tracing the errors is simple because of the encapsulation feature of the object-oriented programming language, so the changes are done on the functions but not on the entire code.

The fire stations and the incident types data are retrieved when the system is being initialized. On the other hand, the incident data are retrieved after specifying duration. The calculations and the user selections are handled using ChartDataCollection methods.

5.2.2.6 Show Statistics and Analyze Emergency Response Time windows

In order to retrieve data from the map services, two query components were used: Query and QueryTask. The Query component was used to specify the parameters for QueryTask, such as the where statement and returned fields. The QueryTask component was used to execute queries based on the Query components and handle the queries results.

Because incident types and fire stations are static, their queries are executed at the beginning of the session, and their results are handled using ActionScript classes as described in Section 5.2.2.5. Unlike incident types and fire stations, incidents are dynamic, and different types of queries will be executed based on the user selection. All incident queries should be within a specified duration, so a time extent property of Query component was used for this purpose.

The Show Statistics window consists of several visual elements, such as a pie chart, column bars, and tables. The pie chart was used to show the percentage of the selected incidents based on the incident types. Since the incident types have three levels of detail, this was implemented by allowing the user to click on the chart to navigate from one level to the next level. Figure 5-8 shows the navigation from fire incident to the details of structure fire incident type. Figure 5-8a shows the first level, which contains the main incident types. Figure 5-8b shows the details of fire incident type, which was displayed after clicking on fire segment. Figure 5-8c shows the sub categories of the structure fire incident type, which was viewed after clicking on the structure fire incident type.

Figure 5-8 Navigation between Incident Types Levels

This process was implemented by using the structure of the incident code. The incident code consists of three digits. The leftmost digit represents the first level; for example, 1 is used for fire. The leftmost digit and the middle digit represent the second level; for example, 11 is used for structure fire incident type. The whole code represents the detail level; for example, 111 represent a building fire.

In addition to the navigation between the different levels of the incident types, the user can focus his analysis on one incident type. This is done by double clicking on the incident type (Figure 5-9), which will refresh all components based on the selected incident type.

Figure 5-9 Selecting Incident Type

The fire stations column bar chart (Figure 5-10) shows the distribution of the incidents over the fire stations based on the selected incidents and duration. The user can focus on one fire station by clicking on that particular fire station, and the values of all charts and other components will be recalculated based on the selected fire station.

Figure 5-10 Fire Stations Column Bar Chart

The Months Column Bar Chart (Figure 5-11) shows the number of incidents in each month within the selected duration. This was accomplished by determining the months within the selected duration, then calculating the amount of incidents within each determined month using ActionScript Classes. This component will be populated with the data when the user specifies the duration, selects the incident type, or selects the fire station.

Figure 5-11 Months Column Bar Chart

The user can select a month from Months Column Chart, to show the distribution of incidents by each week in that month. Figure 5-12 shows the calendar for December of 2010. The number of incidents is classified into three groups. The first group is green. This group includes days in which there were 1-14 incidents. The second group is yellow. This group includes days in which there were 15-24 incidents. The third group is red. This group includes days in which the number of incidents was greater than 24. These ranges were determined after the discussion with the client.

SU	MO	TU	WE	TH	FR	SA
			19	19	22	23
20	14	13	22	17	19	26
13	19	22	15	20	20	17
15	22	46	34	26	18	18
11	16	20	18	24	13	

Figure 5-12 Distribution of the Incidents by Weeks

Figure 5-13 shows an example the distribution of the incidents by hours. This component shows the number of incidents in each hour for the selected day from incident week's calendar. The hour cells are colored based on the values of the incidents, so the range of the green color is from 1 to 2, the range of the yellow color 3 to 5, and the cells with incident value greater than 5. These ranges were specified by the client.

	00	01	02	03	04	05	06	07	08	09	10	11
AM	0	1	0	3	0	2	2	1	1	2	1	3
PM	1	0	1	1	1	0	0	2	1	3	5	15

Figure 5-13 Distribution of the Incidents by Hours

The other window is Analyze Emergency Response Time which is used to determine the incidents that had emergency response time greater or smaller than the specified time. The minimum and maximum emergency response time will first be calculated for the incidents under consideration. The system will not accept values greater than or less than the calculated minimum and maximum ranges. Figure 5-14 shows an example of the range, so the user cannot enter value smaller than zero or greater than 729 minutes.

Min: 0

▲
▼

Max: 729

Figure 5-14 Minimum and Maximum Emergency Response Time

The user can specify the test value and the system will calculate how many incidents were above and below this value using ActionScript Classes. Figure 5-15 shows an example of the incidents that had emergency response time above and below seven minutes. This tool can facilitate the user to study the incidents that had emergency response time greater than the specified value, figure out what problems may have occurred, and finds ways to avoid those problems in the future. The details of those particular incidents will be displayed in the Show Statistics window, and those incidents will also be selected on the map.

Figure 5-15 Analyze Emergency Response Time Window

5.2.2.7 Closest Facility

One of the client's requirements was to show the fire stations closest to a selected point. This was achieved by using closest facility analysis. An online closest facility solver, which is provided by Esri, was used to meet this requirement, but the client can change this solver by changing the service URL in the configuration file. Two components were declared to implement the closest facility analysis: closest facility task and closest facility parameters. The closest facility task was used to specify the request properties, such as request time out and the URL of the published closest facility solver. Table 5-7 shows the configuration of the Closest Facility Task. The concurrency determines how multiple requests will be handled; the "Last" value means to solve the last request only.

Table 5-7 Closest Facility Task Configuration

Property	Value
Concurrency	Last
Requesttimeout	60 second
Showbusycursor	True
URL	Specified in the configuration file

The closest facility parameters component was used to specify the required parameters for the solver, such as target facility count, barriers, incidents, and facilities. All these values are determined by the user using the Closest Facility window.

The process starts when the user selects a point so the closest facility task will be executed based on the specified parameters. When the results are received, another process is executed to display the results and show tooltips for the results.

The routes drawing effect was implemented using a SWC library file called “Extended Polyline Effects” that was downloaded from the code gallery of the ArcGIS Resource Center.

5.2.2.8 Service Area

Service area analysis is very important to emergency response services, since it shows the coverage area for the selected facilities within the specified times. This information helps the fire department assess the locations of their facilities, and determining the areas that are out of coverage.

Two components were defined to implement the service area function in the project. The first component was service area task, which was used to specify request properties, (such as the URL of the published service area solver, which can be changed using the application configuration file), concurrency, and request time out. Table 5-8 shows the configurations of service area task component.

Table 5-8 Service Area Task Configuration

Property	Value
Concurrency	Last
Requesttimeout	120 second
Showbusycursor	True
URL	Specify in the configuration file

The second component was a service area parameters component, which was used to specify the required parameters for the solver, such as facilities and default breaks (travel intervals).

The user can use a Service Area window to generate the service area. This is achieved by specifying the travel time intervals and selecting one or multiple fire stations. The tooltips are specified, after receiving the results.

5.2.2.9 Configuration File

A configuration file was created to increase the flexibility and usability of the application. This file is an XML file that was used to define the URLs of the services that were included in the application. The administrator can change the solvers, like closest facility and service area, without changing the code. This can be achieved by changing the URLs in the configuration file. Like solvers, the map services can also be changed. An HTTPService was used to read the URLs from the configuration file and set the services at the application initialization. As shown in Figure 5-16, the configuration file contains three sections, which are basemap, operationallayers, and services.


```

1 <?xml version="1.0" ?>
2
3 <configuration>
4
5   <essentials>
6
7     <basemap>
8
9       <layer id="baseMap" url="http://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer"/>
10
11     </basemap>
12
13     <operationallayers>
14
15       <layer id="allIncidents" url="http://msgis-ags-1/arcGIS/rest/services/C20-yusuf_albanki/incidents/MapServer/0"/>
16
17       <layer id="selectedIncidents" url="http://msgis-ags-1/arcGIS/rest/services/C20-yusuf_albanki/incidents/MapServer/1"/>
18
19       <layer id="fireStations" url="http://msgis-ags-1/arcGIS/rest/services/C20-yusuf_albanki/fireStations/MapServer/0"/>
20
21       <layer id="incidentsTypes" url="http://msgis-ags-1/arcGIS/rest/services/C20-yusuf_albanki/IncidentsTypes/MapServer/0"/>
22
23     </operationallayers>
24
25     <services>
26
27       <service id="closestFacility" url="http://sampleserver3.arcgisonline.com/ArcGIS/rest/services/Network/USA/NAserver/Closest%20Facility"/>
28
29       <service id="serviceArea" url="http://sampleserver3.arcgisonline.com/ArcGIS/rest/services/Network/USA/NAserver/Service%20Area"/>
30
31       <service id="addressLocator" url="http://tasks.arcgisonline.com/ArcGIS/rest/services/Locators/TA_Address_NA_10/GeocodeServer"/>
32
33       <service id="geometryService" url="http://sampleserver3.arcgisonline.com/ArcGIS/rest/services/Geometry/GeometryServer"/>
34
35     </services>
36
37   </essentials>
38
39 </configuration>

```

Figure 5-16 Configuration File

5.3 Summary

The main objective of this chapter was to shed light on the implementation process. The importance and the steps of developing the Import Incidents tool were discussed in section 1. Section 2 described the main components of the web-based application. The next chapter provides scenarios and use cases of the application.

Chapter 6 – Use Cases

The main purpose of the application is to provide different analysis tools to the incidents analysts of the Redlands Fire Department, and to help them in analyzing the fire incidents. This chapter demonstrates different use cases in using the system.

6.1 Exploring Incidents within a Specific Duration

Suppose an incidents analyst wants to study the fire incidents that happened between October 2010 and March 2011. After selecting this duration, all incidents falling in this period are retrieved and displayed on the map (Figure 6-1). Each incident has a tooltip that shows its type and information window that can be displayed by clicking on the incident.

Figure 6-1 Incidents between October 2010 to March 2011

To help the incidents analyst in understanding these incidents, a Show Statistics window, which contains dynamically linked graphs and maps, is used (Figure 6-2). The pie chart on the top of the window displays the types of incidents given a period specified by the user. Underneath the pie chart are two bar charts displaying the number of incidents for each fire station and the distribution of incidents by months respectively. A more detailed distribution of the incidents by days and by hours is also provided at the bottom the window.

Figure 6-2 Show Statistics Window

During October 2010 and March 2011, there were a total number of 3420 calls received by the Redland Fire Department and these incidents fall into 8 categories as indicated by the pie chart. Rescue and Emergency Medical Service Incident, Service Call, and False Alarm and False Call are the top three categories of incidents during that period of time. The average response time to these incidents is 6.5 minutes (shown on the top of the window). To help the incidents analyst better interpret the pie chart, the colors associated with different categories of incidents are fixed.

Since the types of incidents contained in the data are organized in a 3-level hierarchical structure, they are displayed hierarchically as well. The pie chart shown in Figure 6-2 only displays the top level of the incidents types. If the analyst wants to explore more refined incidents types, he/she can click on a particular type and the nested incident types in that type will show up in a pie chart as well. On the pie chart at any level, the analyst can double click on it to select all incidents of a specified type. For example, the user can double click on the fire, the red part of the chart, and all the fire incidents are updated in the map and other charts (Figure 6-3).

Figure 6-3 Select Fire Incidents

In addition to viewing the incidents by their types, the incidents analyst can also explore the incidents by months and by fire stations. For example, when the analyst clicks on Fire Station 263 on the fire station chart, all the incidents handled by this fire station are highlighted in the map and updated in all rest of graphs (Figure 6-4).

Figure 6-4 Select 263 Fire Station

Detailed information like the distribution of incidents over weeks and hours for each month can also be displayed using the interactive feature of this window. For example, the incidents analyst may want to examine how the incidents were distributed over October 2010. By clicking on the Oct 2010 in the month chart, the number of incidents on each day is shown in the bottom left chart. Apparently, Monday and Tuesday had the highest number of incidents in the month. . To view the hourly distribution of the incidents on Oct 1st 2010, the incident analyst can click on that day (Figure 6-5).

Figure 6-5 Distribution of the Incidents over Days and Hours

Besides getting some statistics about the incidents for a specified period, the analyst can also use the Find an Address to find a location. For example, if the analyst is interested in exploring the incidents in the neighborhood of 1111 East Central Avenue, Redlands, he/she can quickly identify the target location by entering the address (Figure 6-6).

Figure 6-6 Find an Address Window

The analyst can also use the Street View to know more about the nature of the target location. Figure 6-7 shows that the analyst can explore 360 degree pictures of the specified location.

Figure 6-7 Street View Window

Sometime, the study area may contain a large number of incidents that may overlap each other. This will confuse the incidents analyst, so he/she cannot figure out the exact number of incidents or identify the incidents pattern. This problem can be solved using cluster option for the selected incidents. Thus, the incidents analyst can select an incident

type or fire station and select cluster option from Options window (Figure 6-8). The cluster process groups nearby incidents into one symbol. The size of the symbol indicates the number of incidents that it contains. The cluster process is dynamic, so the cluster process will activate when the map scale is changed.

Figure 6-8 Using Cluster Option

The individual incidents within cluster symbol can be accessed by hovering the mouse over that symbol. In addition to use cluster for selected incidents, the Options window allows the incidents analyst to control the visibility of all incidents layer and the layer of the selected incidents.

Finally, the Incidents Time Slider window can be used by the incidents analyst to see the distribution of the incidents in each month (Figure 6-9). The time slider is flexible, so the incidents analyst can specify start month and end month.

Figure 6-9 Distribution of the Incidents by Months

6.2 Analyzing Emergency Response Time

In addition to viewing and exploring the incidents, another important function provided by the application is to analyze emergency response time, as it is critical for fire departments to improve their services. Suppose the incidents analyst wants to analyze incidents that had emergency response times greater than 10 minutes. This analysis can be done using the Analyze Emergency Response window (Figure 6-10). After the analyst enters 10 minutes, all incidents that had an emergency response time greater than the specified time are displayed on the map. The incidents analyst can then further explore the statistics of these incidents using the Show Statistics window.

Figure 6-10 Analyze Emergency Response Time Window

6.3 Finding Service Areas and Closest Fire Station

The service area of a facility is often represented by a specified travel zone and people living within the zone are taken as the potential demand for the service provided by the facility. This analysis is commonly conducted to analyze the customers' profiles. Suppose the incidents analyst wants to find the service areas of Fire Station 261 and 262 for 3, 5, and 7 minutes. In this case, the analyst chooses all the fire stations under consideration, and enters the time parameters. The application then calculates the requested service areas for the specified fire stations as shown in Figure 6-11.

Figure 6-11 Service Area Analysis

Another popular analysis that is often conducted in facility management is to find the closet facility, which will be very important for dispatching fire trucks. The Closest Facility window can be used to display the closest fire stations to a selected point. This window can also be used to add road barriers to represent closed roads, which should be avoided by closest facility solver. Suppose incidents analyst wants to find the nearest fire stations to the Redlands Mall if there are road constructions around the mall. Figure 6-12 shows the results of using closest facility analysis with barriers; each route has a distinct color and a tooltip that shows the required time to reach to the specified location. Based on that result, 261 station can reach to the mall within 1 minute. This type of analysis help the incidents analyst to study the impact of closing roads, so he/she can put plans to avoid having a high emergency response.

Figure 6-12 Closest Facility Analysis

6.4 Summary

The process of incidents analysis is very important, since it allows the fire department to discover any weak points or problems that can affect their critical services. This strategy helps in reducing the impact of the incidents on people and property. To make analysis process effective, several functions and statistics should be used and studied.

This application provides the incidents analyst with the necessary functions to help them in the analysis process. The closest facility and service area analyses can be used to evaluate the coverage of the fire stations, and identified the effects of closing roads on their services. Moreover, Show Statistics window provides a dynamic statistics about the incidents. Since graphics and maps are used to show statistics, the incidents analyst can quickly figure out the variations and identified the incidents patterns. In addition, Analyze Emergency Response Time window can be used to help the incidents analyst to study the causes of high emergency response for some incidents. Different supportive tools were added to the application to increase the accuracy of analysis process, such as Street View window and Incidents Time Slider window. Several use cases was discussed in this chapter to show how to use these tools and functions.

Chapter 7 – Conclusions and Future Work

The primary goal of this project was to provide a web application for the Redlands Fire Department in order to help them analyze fire incidents and make decisions for enhancing their services. The application was developed based on their requirements that were analyzed in the early stages of the project. Their main problem was that they do not have a GIS-based system, although the nature of their work is highly dependent on determining and analyzing locations of incidents, like studying the distribution of the incidents throughout the city, in order to take appropriate actions.

After studying the requirements and similar systems, several analysis functions were added to the developed application to allow them to evaluate the performance of their fire stations and identify the causes for having a high emergency response for some incidents. Service area and closest facility network analyses were added to the application to help study the coverage area for the fire stations within specified time intervals, and identify the closest fire stations for selected incidents. Using these functions can help the Redlands Fire Department management make important decisions, such as building new fire stations or using specific routes when responding to incidents in specific locations. Generally, closed roads have a great impact on the fire department's response time. Using the closest facility function in the application can minimize this problem. The user can add barriers, and the application will find the best alternative routes.

By studying previous incidents, the fire department can work to avoid mistakes and identify the needs and shortages in order to enhance the services they provide. There are a huge number of recorded incidents, which makes the analysis process very difficult. An interactive dashboard window was developed to solve this problem. It displays the incident statistics using dynamic charts, tables, and maps. This feature helps the user identify the incident patterns by examining incident locations, types, and times. It also helps the user evaluate the performance of each fire station. Critical decisions can be made by studying the incidents. The fire department may discover that they need to increase the number of firemen for a specific fire station, buy new fire trucks, or redistribute resources among fire stations.

Most fire departments have a standard emergency response time for responding to incidents. A tool was added to the application to allow the Redlands Fire Department to determine the incidents that had a high emergency response time. Studying these incidents can help them discover the causes of the delay in response time, and put a plan into place to solve them.

Although the available functions cover the project scope, additional functions can be added to the application to maximize its benefits. First of all, there are different types of fire trucks, such as tower ladder, hydraulic platform, and turntable ladder. Each type has a specific task and role in firefighting. Statistics about the usage of the current fire station's fire trucks can be added to appear in the Show Statistics window. This information helps management recognize the shortages of each fire station; this could also explain why services need to be made by one station in another station's area.

Second, kernel density and hotspot analyses can be added to the project analysis functions. With this, the user can weigh the incidents based on several factors, such as the loss in lives and property, the number of the resources that were used to deal with the

incidents, and the time that was spent to handle the incident. This function would help the user assess incidents based on their real impacts.

Third, the overlay analysis can be done between fire stations' service areas, and an incidents layer can be used to determine the incidents that had an emergency response time that was greater than the expected time. This feature would help the user discover if there are locations that should be assigned to different fire stations to decrease the emergency response time, or if there is a shortcoming at a fire station.

Fourth, a function to study the distribution of the incident types with demographic data could be added to the application to identify a relationship between the occurrence of certain incidents and a specific category of the population, such as age and education. This analysis could help the fire department provide appropriate awareness and training.

Fifth, integration between the fire department's existing system and the new application could be implemented to exchange the incident data directly between these systems. This would ensure that the system geodatabase is always updated. This would mean that the analysis process could be done at any time, without needing to load incidents every time analysis needs to be done.

In summary, this project successfully met the client's functional and non-functional requirements. Also, several improvements and functions were identified and could be added in the future. Finally, this project shows how GIS technology can be used in the public safety field.

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Appendix A. Import Incidents Tool Model

Appendix B. Incidents Types based on NFIRS

No.	Incident Code	Description
1	1	Fire
2	10	Fire, other
3	100	Fire, other
4	11	Structure Fire
5	110	Structure fire, other (conversion only)
6	111	Building fire
7	112	Fires in structure other than in a building
8	113	Cooking fire, confined to container
9	114	Chimney or flue fire, confined to chimney or flue
10	115	Incinerator overload or malfunction, fire confined
11	116	Fuel burner/boiler malfunction, fire confined
12	117	Commercial Compactor fire, confined to rubbish
13	118	Trash or rubbish fire, contained
14	12	Fire in mobile property used as a fixed structure
15	120	Fire in mobile prop. used as a fixed struc., other
16	121	Fire in mobile home used as fixed residence
17	122	Fire in motor home, camper, recreational vehicle
18	123	Fire in portable building, fixed location
19	13	Mobile property (vehicle) fire
20	130	Mobile property (vehicle) fire, other
21	131	Passenger vehicle fire
22	132	Road freight or transport vehicle fire
23	133	Rail vehicle fire
24	134	Water vehicle fire
25	135	Aircraft fire
26	136	Self-propelled motor home or recreational vehicle
27	137	Camper or recreational vehicle (RV) fire
28	138	Off-road vehicle or heavy equipment fire
29	14	Natural vegetation fire
30	140	Natural vegetation fire, other
31	141	Forest, woods or wildland fire
32	142	Brush or brush-and-grass mixture fire
33	143	Grass fire
34	15	Outside rubbish fire
35	150	Outside rubbish fire, other
36	151	Outside rubbish, trash or waste fire
37	152	Garbage dump or sanitary landfill fire
38	153	Construction or demolition landfill fire
39	154	Dumpster or other outside trash receptacle fire

40	155	Outside stationary compactor/compacted trash fire
41	16	Special outside fire
42	160	Special outside fire, other
43	161	Outside storage fire
44	162	Outside equipment fire
45	163	Outside gas or vapor combustion explosion
46	164	Outside mailbox fire
47	17	Cultivated vegetation, crop fire
48	170	Cultivated vegetation, crop fire, other
49	171	Cultivated grain or crop fire
50	172	Cultivated orchard or vineyard fire
51	173	Cultivated trees or nursery stock fire
52	2	Overpressure Rupture, Explosion, Overheat(no fire)
53	20	Overpressure rupture, explosion, overheat, other
54	200	Overpressure rupture, explosion, overheat other
55	21	Overpressure rupture from steam (no ensuing fire)
56	210	Overpressure rupture from steam, other
57	211	Overpressure rupture of steam pipe or pipeline
58	212	Overpressure rupture of steam boiler
59	213	Steam rupture of pressure or process vessel
60	22	Overpressure rupture from air or gas (no fire)
61	220	Overpressure rupture from air or gas, other
62	221	Overpressure rupture of air or gas pipe/pipeline
63	222	Overpressure rupture of boiler from air or gas
64	223	Air or gas rupture of pressure or process vessel
65	23	Overpressure rupture, chemical reaction (no fire)
66	231	Chemical reaction rupture of process vessel
67	24	Explosion (no fire)
68	240	Explosion (no fire), other
69	241	Munitions or bomb explosion (no fire)
70	242	Blasting agent explosion (no fire)
71	243	Fireworks explosion (no fire)
72	25	Excessive heat, scorch burns with no ignition
73	251	Excessive heat, scorch burns with no ignition
74	3	Rescue & Emergency Medical Service Incident
75	30	Rescue, emergency medical call (EMS), other
76	300	Rescue, EMS incident, other
77	31	Medical assist
78	311	Medical assist, assist EMS crew
79	32	Emergency medical service (EMS) Incident
80	320	Emergency medical service, other (conversion only)
81	321	EMS call, excluding vehicle accident with injury
82	322	Motor vehicle accident with injuries

83	323	Motor vehicle/pedestrian accident (MV Ped)
84	324	Motor vehicle accident with no injuries.
85	33	Lock-In
86	331	Lock-in (if lock out , use 511)
87	34	Search for lost person
88	340	Search for lost person, other
89	341	Search for person on land
90	342	Search for person in water
91	343	Search for person underground
92	35	Extrication, rescue
93	350	Extrication, rescue, other
94	351	Extrication of victim(s) from building/structure
95	352	Extrication of victim(s) from vehicle
96	353	Removal of victim(s) from stalled elevator
97	354	Trench/below-grade rescue
98	355	Confined space rescue
99	356	High-angle rescue
100	357	Extrication of victim(s) from machinery
101	36	Water or ice-related rescue
102	360	Water & ice-related rescue, other
103	361	Swimming/recreational water areas rescue
104	362	Ice rescue
105	363	Swift water rescue
106	364	Surf rescue
107	365	Watercraft rescue
108	37	Electrical rescue
109	370	Electrical rescue, other
110	371	Electrocution or potential electrocution
111	372	Trapped by power lines
112	38	Rescue or EMS standby
113	381	Rescue or EMS standby
114	4	Hazardous Condition (No Fire)
115	40	Flammable gas or liquid condition, other
116	400	Hazardous condition, other
117	41	Combustible/flammable spills & leaks
118	410	Combustible/flammable gas/liquid condition, other
119	411	Gasoline or other flammable liquid spill
120	412	Gas leak (natural gas or LPG)
121	413	Oil or other combustible liquid spill
122	42	Chemical release, reaction, or toxic condition
123	420	Toxic condition, other
124	421	Chemical hazard (no spill or leak)
125	422	Chemical spill or leak

126	423	Refrigeration leak
127	424	Carbon monoxide incident
128	43	Radioactive condition
129	430	Radioactive condition, other
130	431	Radiation leak, radioactive material
131	44	Electrical wiring/equipment problem
132	440	Electrical wiring/equipment problem, other
133	441	Heat from short circuit (wiring), defective/worn
134	442	Overheated motor
135	443	Breakdown of light ballast
136	444	Power line down
137	445	Arcing, shorted electrical equipment
138	45	Biological hazard
139	451	Biological hazard, confirmed or suspected
140	46	Accident, potential accident
141	460	Accident, potential accident, other
142	461	Building or structure weakened or collapsed
143	462	Aircraft standby
144	463	Vehicle accident, general cleanup
145	47	Explosive, bomb removal
146	471	Explosive, bomb removal (for bomb scare, use 721)
147	48	Attempted burning, illegal action
148	480	Attempted burning, illegal action, other
149	481	Attempt to burn
150	482	Threat to burn
151	5	Service Call
152	50	Service call, other
153	500	Service Call, other
154	51	Person in distress
155	510	Person in distress, other
156	511	Lock-out
157	512	Ring or jewelry removal
158	52	Water problem
159	520	Water problem, other
160	521	Water evacuation
161	522	Water or steam leak
162	53	Smoke, odor problem
163	531	Smoke or odor removal
164	54	Animal problem or rescue
165	540	Animal problem, other
166	541	Animal problem
167	542	Animal rescue
168	55	Public service assistance

169	550	Public service assistance, other
170	551	Assist police or other governmental agency
171	552	Police matter
172	553	Public service
173	554	Assist invalid
174	555	Defective elevator, no occupants
175	56	Unauthorized burning
176	561	Unauthorized burning
177	57	Cover assignment, standby at fire station, move-up
178	571	Cover assignment, standby, moveup
179	6	Good Intent Call
180	60	Good intent call, other
181	600	Good intent call, other
182	61	Dispatched and canceled en route
183	611	Dispatched & canceled en route
184	62	Wrong location, no emergency found
185	621	Wrong location
186	622	No incident found on arrival at dispatch address
187	63	Controlled burning
188	631	Authorized controlled burning
189	632	Prescribed fire
190	64	Vicinity alarm
191	641	Vicinity alarm (incident in other location)
192	65	Steam, other gas mistaken for smoke
193	650	Steam, other gas mistaken for smoke, other
194	651	Smoke scare, odor of smoke
195	652	Steam, vapor, fog or dust thought to be smoke
196	653	Smoke from barbecue, tar kettle
197	66	EMS call where party has been transported
198	661	EMS call, party transported by non-fire agency
199	67	HazMat release investigation w/no HazMat
200	671	HazMat release investigation w/no HazMat
201	672	Biological hazard investigation, none found
202	7	False Alarm & False Call
203	70	False alarm and false call, other
204	700	False alarm or false call, other
205	71	Malicious, mischievous false alarm
206	710	Malicious, mischievous false call, other
207	711	Municipal alarm system, malicious false alarm
208	712	Direct tie to FD, malicious false alarm
209	713	Telephone, malicious false alarm
210	714	Central station, malicious false alarm
211	715	Local alarm system, malicious false alarm

212	72	Bomb scare
213	721	Bomb scare - no bomb
214	73	System or detector malfunction
215	730	System malfunction, other
216	731	Sprinkler activation due to malfunction
217	732	Extinguishing system activation due to malfunction
218	733	Smoke detector activation due to malfunction
219	734	Heat detector activation due to malfunction
220	735	Alarm system sounded due to malfunction
221	736	CO detector activation due to malfunction
222	74	Unintentional system/detector operation (no fire)
223	740	Unintentional transmission of alarm, other
224	741	Sprinkler activation, no fire - unintentional
225	742	Extinguishing system activation
226	743	Smoke detector activation, no fire - unintentional
227	744	Detector activation, no fire - unintentional
228	745	Alarm system activation, no fire - unintentional
229	746	Carbon monoxide detector activation, no CO
230	75	Biohazard scare
231	751	Biological hazard, malicious false report
232	8	Severe Weather & Natural Disaster
233	800	Severe weather or natural disaster, other
234	811	Earthquake assessment
235	812	Flood assessment
236	813	Wind storm, tornado/hurricane assessment
237	814	Lightning strike (no fire)
238	815	Severe weather or natural disaster standby
239	9	Special Incident Type
240	90	Special type of incident, other
241	900	Special type of incident, other
242	91	Citizen complaint
243	911	Citizen complaint
244	UUU	Undetermined incident type (conversion only)

Appendix C. ActionScript Classes Code

CalendarWeeksDataObj.as

```
package Classes
{
    // This class is used to handle days of month

    public class CalendarWeeksDataObj
    {
        public var sun:String;

        public var mon:String;

        public var tue:String;

        public var wed:String;

        public var thr:String;

        public var fri:String;

        public var sat:String;

        public var month:uint;

        public var year:uint;

        public function CalendarWeeksDataObj(arr:Array,month:uint,year:uint)
        {
            sun=arr[0]

            mon=arr[1]

            tue=arr[2]

            wed=arr[3]

            thr=arr[4]

            fri=arr[5]

            sat=arr[6]

            this.month=month;

            this.year=year;
        }
    }
}
```

ChartsDataCollection.as

```
package Classes
{
import com.esri.ags.FeatureSet;
import com.esri.ags.SpatialReference;
import com.esri.ags.TimeExtent;
import com.esri.ags.layers.FeatureLayer;
import com.esri.ags.tasks.supportClasses.Query;

import flashx.textLayout.formats.Float;

import mx.collections.ArrayCollection;
import mx.controls.Alert;
import mx.controls.DateField;
import mx.formatters.DateFormatter;

import spark.formatters.DateTimeFormatter;

// This class is used to handle the calling to other classes "It is a parent class", also it has collections that are used as data providers for charts

[Bindable]
public class ChartsDataCollection
{
public var incidentsPieChart:IncidentsDataCollection;

public var fireStationColumnChart:FireStationCollection;

public var testEMSDataCollection:ArrayCollection=new ArrayCollection();

public var avgEMR:Number=0;

public var startDate:Date;

public var endDate:Date;

public var mainMapSpatialRefernce:SpatialReference;

public var datetimeDataCollection:DateTimeDataCollection;

// Constructor, define data providers for incidents pie chart, and fire station column chart

public function ChartsDataCollection(incidentsTypes:Array,fireStations:Array)
{
incidentsPieChart=new IncidentsDataCollection(incidentsTypes);

fireStationColumnChart = new FireStationCollection(fireStations);

}

public function
IncidentsNavigation(incidentsArr:Array,flselectedIncidents:FeatureLayer):void
{

var dateTimeFormatter:DateTimeFormatter = new DateTimeFormatter();

dateTimeFormatter.dateTimePattern="yyyy-MM-dd HH:mm:ss";

avgEMR=0;

ResetAll();
```

```

for each (var incident:Object in incidentsArr)
{
    incidentsPieChart.IncrementCount(incident.Inc_Type);

    fireStationColumnChart.IncrementCount(incident.Inc_station);

    avgEMR=avgEMR + incident.Inc_EmergencyResponseTime;

    datetimeDataCollection.IncrementDate(incident.Inc_AlarmTime);

}

datetimeDataCollection.RefreshYearMonthCountDataCollection();

avgEMR=avgEMR/incidentsArr.length;

incidentsPieChart.refreshDataProvider("111");

flselectedIncidents.clearSelection();
}

public function
LoadIncidents(incidentsArr:Array,startDate:Date,endDate:Date,flselectedIncident
s:FeatureLayer):void
{

    var dateTimeFormatter:DateTimeFormatter = new DateTimeFormatter();

    dateTimeFormatter.dateTimePattern="yyyy-MM-dd HH:mm:ss";

    avgEMR=0;

    this.startDate=startDate;

    this.endDate=endDate;

    datetimeDataCollection= new DateTimeDataCollection(startDate,endDate);

    ResetAll();

    for each (var incident:Object in incidentsArr)
    {
        incidentsPieChart.IncrementCount(incident.Inc_Type);

        fireStationColumnChart.IncrementCount(incident.Inc_station);

        avgEMR=avgEMR + incident.Inc_EmergencyResponseTime;

        datetimeDataCollection.IncrementDate(incident.Inc_AlarmTime);

    }

    datetimeDataCollection.RefreshYearMonthCountDataCollection();

    avgEMR=avgEMR/incidentsArr.length;

    incidentsPieChart.refreshDataProvider("111");

    flselectedIncidents.clearSelection();
}

```

```

}

// To populate the data providers with data based on the selected firestation
public function
FireStationSelected(firestation:String, incidentsAttribute:Array, flselectedIncidents:FeatureLayer):void
{
    ResetAll();

    var dateTimeFormatter:DateTimeFormatter = new DateTimeFormatter();
    dateTimeFormatter.dateTimePattern="yyyy-MM-dd HH:mm:ss";

    var count:uint=0;

    for each (var incident:Object in incidentsAttribute)
    {
        if (incident.Inc_station == firestation)
        {
            incidentsPieChart.IncrementCount(incident.Inc_Type);

            avgEMR=avgEMR + incident.Inc_EmergencyResponseTime;

            datetimeDataCollection.IncrementDate(incident.Inc_AlarmTime);

            count++;
        }
    }

    //Fill all FireStation with the data
    fireStationColumnChart.IncrementCount(incident.Inc_station);
}

datetimeDataCollection.RefreshYearMonthCountDataCollection();

avgEMR=avgEMR/count;

incidentsPieChart.refreshDataProvider("111");

var qselectFirestation:Query = new Query();

qselectFirestation.timeExtent = new TimeExtent(this.startDate, this.endDate);
qselectFirestation.outSpatialReference=this.mainMapSpatialReference;

qselectFirestation.returnGeometry=true;

qselectFirestation.where="Inc_station like '"+firestation+"'";

flselectedIncidents.selectFeatures(qselectFirestation);
}

// To populate the data providers with data based on the selected incident type
public function
IncidentsSelected(incidentCode:String, incidentsAttribute:Array, flselectedIncidents:FeatureLayer):void
{

```

```

ResetAllExceptIncidents();

var dateTimeFormatter:DateTimeFormatter = new DateTimeFormatter();

dateTimeFormatter.dateTimePattern="yyyy-MM-dd HH:mm:ss";

var count:uint=0;

for each (var incident:Object in incidentsAttribute)
{
if (String(incident.Inc_Type).substr(0,incidentCode.length) == incidentCode )
{
fireStationColumnChart.IncrementCount(incident.Inc_station);

avgEMR=avgEMR + incident.Inc_EmergencyResponseTime;

datetimeDataCollection.IncrementDate(incident.Inc_AlarmTime);

count++;

}

}

datetimeDataCollection.RefreshYearMonthCountDataCollection();

avgEMR=avgEMR/count;

var qselectIncidents:Query = new Query();

qselectIncidents.timeExtent = new TimeExtent(this.startDate,this.endDate);

qselectIncidents.outSpatialReference=this.mainMapSpatialRefernce;

qselectIncidents.returnGeometry=true;

qselectIncidents.where="Inc_Type like '"+incidentCode+"%";

flselectedIncidents.selectFeatures(qselectIncidents);

}

// To reset all data providers

public function ResetAll():void
{
incidentsPieChart.ResetCount();

fireStationColumnChart.ResetCount();

datetimeDataCollection.RestAll();

avgEMR=0;
}

// To reset all data providers except incidents

public function ResetAllExceptIncidents():void
{
fireStationColumnChart.ResetCount();

datetimeDataCollection.RestAll();

```

```

avgEMR=0;
}

// To handle test emergency response time, so the above and below number of incidents will be determined

public function
EMRtest(incidents:Array,featureLayer:FeatureLayer,EMR:Number):void
{
// Reset Count

testEMSDataCollection=new ArrayCollection();

// Declare variables to calculate the avg

var countAbove:uint=0;
var countBelow:uint=0;

// Reset All other components

ResetAll();

var txt:String="";

for each (var incident:Object in incidents)
{
txt=txt+" "+String(incident.Inc_EmergencyResponseTime)+"\n";

if(Number(incident.Inc_EmergencyResponseTime) > EMR)
{
countAbove++;

// Increment other components

incidentsPieChart.IncrementCount(incident.Inc_Type);

fireStationColumnChart.IncrementCount(incident.Inc_station);

avgEMR=avgEMR + incident.Inc_EmergencyResponseTime;

datetimeDataCollection.IncrementDate(incident.Inc_AlarmTime);

}

else
{
countBelow++;

}

}

datetimeDataCollection.RefreshYearMonthCountDataCollection();

testEMSDataCollection.addItem(new TestEMSDataObj("Above",countAbove));

testEMSDataCollection.addItem(new TestEMSDataObj("Below",countBelow));

incidentsPieChart.refreshDataProvider("111");

var qaboveEMS:Query = new Query();

```

```

qaboveEMS.timeExtent = new TimeExtent(this.startDate, this.endDate);
qaboveEMS.outSpatialReference=this.mainMapSpatialRefernce;
qaboveEMS.returnGeometry=true;
qaboveEMS.where="Inc_EmergencyResponseTime > " + EMR.toString();
featureLayer.selectFeatures(qaboveEMS);
avgEMR = (avgEMR/countAbove);
}

// Return maximum and minimum emergency response time, to be used in test emergency response window

public function EMRtestGetBoundries(incidents:Array):Array
{
var max:Number=Number(incidents[0].Inc_EmergencyResponseTime);
var min:Number=Number(incidents[0].Inc_EmergencyResponseTime);

for each (var incident:Object in incidents)
{

if(Number(incident.Inc_EmergencyResponseTime) > max)
{
max=Number(incident.Inc_EmergencyResponseTime);
}

if(Number(incident.Inc_EmergencyResponseTime) < min)
{
min=Number(incident.Inc_EmergencyResponseTime);
}

}

var Boundries:Array= new Array();

Boundries.push(Math.round(max));
Boundries.push(Math.round(min));

return Boundries;

}

// To handle the rest of test emergency response time

public function ResetEMRTest():void
{
testEMSDataCollection=new ArrayCollection();
}

public function returnIncidentType(incidentCode:String):String
{
return incidentsPieChart.returnIncidentName(incidentCode);
}
}
}

```


DateTimeDataCollection.as

```
package Classes
{
import Classes.CalendarWeeksDataObj;
import Classes.DaysDataObj;
import Classes.MonthYearDataObj;
import Classes.MonthsDataCollection;
import Classes.MonthsDataObj;
import Classes.YearDataCollection;
import Classes.YearDataObj;

import mx.collections.ArrayCollection;
import mx.controls.DateField;

import spark.formatters.DateTimeFormatter;

// This class contains the data providers for date and time charts

[Bindable]
public class DateTimeDataCollection
{
public var yearDataCollection:YearDataCollection;

public var yearMonthCountDataCollection:ArrayCollection=new ArrayCollection();

public var calender:ArrayCollection=new ArrayCollection();

public var hoursGridProvider:ArrayCollection=new ArrayCollection();

private var dateTimeFormatter:DateTimeFormatter = new DateTimeFormatter();

public function DateTimeDataCollection(startDate:Date,endDate:Date)
{
dateTimeFormatter.dateTimePattern="yyyy-MM-dd HH:mm:ss";

var startYear:uint= startDate.fullYearUTC;

var endYear:uint=endDate.fullYearUTC;

yearDataCollection=new YearDataCollection(startYear,endYear);
}

public function RestAll():void
{
yearDataCollection.YearRest();
}

public function IncrementDate(incidentDate:Object):void
{
var
year:uint=DateField.stringToDate(dateTimeFormatter.format(incidentDate),"YYYY-
MM-DD").fullYearUTC;

var
month:uint=DateField.stringToDate(dateTimeFormatter.format(incidentDate),"YYYY-
MM-DD").monthUTC + 1 ;

var
day:uint=DateField.stringToDate(dateTimeFormatter.format(incidentDate),"YYYY-
MM-DD").dateUTC;
```

```

var hour:uint = uint(dateTimeFormatter.format(incidentDate).substr(-8,2));

yearDataCollection.IncrementYearCount(year,month,day,hour);
}

public function RefreshYearMonthCountDataCollection():void
{
yearMonthCountDataCollection.removeAll();

for each (var year:YearDataObj in yearDataCollection.yearDataCollection)
{

for each (var month:MonthsDataObj in
year.monthsDataCollection.monthsDataCollection)
{
if (month.monthCount!=0)
{

var monthLabel:String = month.monthName + " " + year.yearName.toString();

yearMonthCountDataCollection.addItem(new
MonthYearDataObj(monthLabel,year.yearName,month.monthIndex,month.monthCount));

}

}

}

calender.removeAll();

hoursGridProvider=new ArrayCollection();

}

public function buildCalendar(year:uint,month:uint,
monthData:MonthsDataObj):void
{

calender=new ArrayCollection();

hoursGridProvider=new ArrayCollection();

var arr:Array=new Array();

var date>Date=new Date(year,month,1);

for (var i:int = 0; i < 7; i++)
{
var str:String="";

arr.push(str);
}

while(date.month == month)
{
var index:uint = date.dayUTC;

arr[index]=String(date.dateUTC) +"+"+
String((monthData.daysDataCollection.daysDataCollection.getItemAt(date.dateUTC-
1) as DaysDataObj).dayCount);

```

```

if (index ==6)
{
    calender.addItem(new CalendarWeeksDataObj(arr,month,year));

    for (var j:int = 0; j < arr.length; j++)
    {
        arr[j]="";
    }

}

date = new Date(date.fullYearUTC,date.monthUTC,date.dateUTC+1);
}

calender.addItem(new CalendarWeeksDataObj(arr,month,year));

}
}
}

```

DaysDataCollection.as

```
package Classes
{
import mx.collections.ArrayCollection;
import Classes.DaysDataObj;

// This class contains the data collection of days

[Bindable]
public class DaysDataCollection
{
public var daysDataCollection:ArrayCollection = new ArrayCollection();

public function DaysDataCollection()
{
for (var i:int = 1; i <= 31; i++)
{
daysDataCollection.addItem(new DaysDataObj(i));
}

}

public function ResetAllDays():void
{
for each (var day:DaysDataObj in daysDataCollection)
{
day.RestCount();
}

}

public function IncrementDay(day:uint, hour:uint):void
{
(daysDataCollection.getItemAt(day-1) as DaysDataObj).dayCount++;

(daysDataCollection.getItemAt(day-1) as
DaysDataObj).hoursDataCollection.AddTime(hour);
}
}
}
```

DaysDataObj.as

```
package Classes
{
import Classes.HoursDataCollection;

// This class define days data object

[Bindable]
public class DaysDataObj
{

public var dayIndex:uint;

public var dayCount:uint=0;

public var hoursDataCollection:HoursDataCollection = new HoursDataCollection();

public function DaysDataObj(dayIndex:uint)
{
this.dayIndex=dayIndex;
}

public function RestCount():void
{
dayCount=0;

hoursDataCollection.ResetAllTime();
}
}
}
```

FireStationCollection.as

```
package Classes
{
import mx.collections.ArrayCollection;

import spark.collections.Sort;
import spark.collections.SortField;

// This class holds the firestation data collection that contains the
firestations and number of incident that they dealt with

[Bindable]
public class FireStationCollection
{
public var fireStationCollection:ArrayCollection= new ArrayCollection();

public function FireStationCollection(array:Array)
{
for each (var arr:Object in array)
{
fireStationCollection.addItem(new FireStationDataObj (String(arr.STATION_NO)));
}

//Create the sort field
var dataSortField:SortField = new SortField();

//name of the field of the object on which you wish to sort the Collection
dataSortField.name = "fireStation";

dataSortField.numeric = true;

var dataSort:Sort = new Sort();

dataSort.fields = [dataSortField];

fireStationCollection.sort = dataSort;

//refresh the collection to sort
fireStationCollection.refresh();
}

public function IncrementCount(fireStaion:String):void
{
for each (var station:FireStationDataObj in fireStationCollection)
{
if(station.fireStation == fireStaion)
{
station.count++;
break;
}
}
}

public function ResetCount():void
{
for each (var station:FireStationDataObj in fireStationCollection)
{
station.count=0;
}
}

}
}
```

FireStationDataObj.as

```
package Classes
{
    // Define firestation data object

    [Bindable]
    public class FireStationDataObj
    {
        public var fireStation:String;

        public var count:uint=0;

        public function FireStationDataObj(fireSation:String)
        {
            this.fireStation=fireSation;
        }
    }
}
```

HoursDataCollection.as

```
package Classes
{
import mx.collections.ArrayCollection;
import Classes.HoursDataObj;

// Provides the hours data collection

[Bindable]
public class HoursDataCollection
{
public var hoursDataCollection:ArrayCollection=new ArrayCollection();

public function HoursDataCollection()
{
hoursDataCollection.addItem(new HoursDataObj("AM",0));

hoursDataCollection.addItem(new HoursDataObj("PM",1));
}

public function AddTime(hour:uint):void
{
if(hour<12)
{
(hoursDataCollection.getItemAt(0) as HoursDataObj).IncrementHour(hour);
}

else
{
(hoursDataCollection.getItemAt(1) as HoursDataObj).IncrementHour((hour-12));
}
}

public function ResetAllTime():void
{
(hoursDataCollection.getItemAt(0) as HoursDataObj).ResetCount();

(hoursDataCollection.getItemAt(1) as HoursDataObj).ResetCount();
}
}
```


HoursDataObj.as

```
package Classes
{

    // Define the hours of a day data object

    [Bindable]

    public class HoursDataObj
    {

        public var hourTypeName:String;

        public var hourIndex:uint;

        public var HH0:uint=0;

        public var HH1:uint=0;

        public var HH2:uint=0;

        public var HH3:uint=0;

        public var HH4:uint=0;

        public var HH5:uint=0;

        public var HH6:uint=0;

        public var HH7:uint=0;

        public var HH8:uint=0;

        public var HH9:uint=0;

        public var HH10:uint=0;

        public var HH11:uint=0;


        public function HoursDataObj(hourTypeName:String, hourIndex:uint)
        {
            this.hourTypeName=hourTypeName;

            this.hourIndex=hourIndex;
        }

        public function ResetCount():void
        {
            HH0=0;

            HH1=0;

            HH2=0;

            HH3=0;

            HH4=0;

            HH5=0;

            HH6=0;
```

```

HH7=0;

HH8=0;

HH9=0;

HH10=0;

HH11=0;
}

public function IncrementHour(hour:uint):void
{
    switch(hour)
    {
        case 0:
        {
            HH0++;

            break;
        }

        case 1:
        {
            HH1++;

            break;
        }

        case 2:
        {
            HH2++;

            break;
        }

        case 3:
        {
            HH3++;

            break;
        }

        case 4:
        {
            HH4++;

            break;
        }

        case 5:
        {
            HH5++;

            break;
        }

        case 6:
        {
            HH6++;

            break;
        }
    }
}

```

```
}  
  
case 7:  
{  
HH7++;  
  
break;  
}  
case 8:  
{  
HH8++;  
  
break;  
}  
case 9:  
{  
HH9++;  
  
break;  
}  
case 10:  
{  
HH10++;  
  
break;  
}  
case 11:  
{  
HH11++;  
  
break;  
}  
}  
}
```

IncidentDataObj.as

```
package Classes
{
    // Define incident data object, it contains code, type, level of detail, and
    // incidents count

    [Bindable]
    public class IncidentDataObj
    {
        public var code:String;

        public var type:String

        public var level:uint;

        public var count:uint=0;

        public function IncidentDataObj (code:String,type:String)
        {
            this.code=code;

            this.type=type;

            this.level=code.length;
        }
    }
}
```

IncidentsDataCollection.as

```
package Classes
{
import flash.sampler.NewObjectSample;

import mx.collections.ArrayCollection;
import mx.collections.IViewCursor;
import mx.controls.Alert;
import mx.messaging.AbstractConsumer;
import mx.olap.aggregators.CountAggregator;

import spark.collections.Sort;
import spark.collections.SortField;

// Contains incidents datacollection, and the functions that is used to handle  
this data collection

[Bindable]
public class IncidentsDataCollection
{
public var incidentsCollection:ArrayCollection= new ArrayCollection();

public var level:uint=1;

public var selectedIncident:String="";

public var incidentsChartDataProvider:ArrayCollection=new ArrayCollection();

public function IncidentsDataCollection(arr:Array)
{
for each (var type:Object in arr)
{
incidentsCollection.addItem(new
IncidentDataObj(type.Incident_Type,type.Incident_Description));
}

//Create the sort field
var dataSortField:SortField = new SortField();

//Name of the field of the object on which you wish to sort the Collection
dataSortField.name = "code";

dataSortField.numeric = true;

var dataSort:Sort = new Sort();

dataSort.fields = [dataSortField];

incidentsCollection.sort = dataSort;

//Refresh the collection to sort
incidentsCollection.refresh();

}

public function ResetCount():void
{
for each (var type:IncidentDataObj in incidentsCollection)
{
type.count=0;
}
}
```

```

}

public function IncrementCount(type:String):void
{
    var cursor:IViewCursor = incidentsCollection.createCursor();

    var code:IncidentDataObj = new IncidentDataObj(type,"");

    //Low Level
    if (cursor.findFirst(code) == true){
        (cursor.current as IncidentDataObj).count++;
    }

    //Medium Level
    var mediumtype:String=type.slice(0,2);

    code.code=mediumtype;

    if (cursor.findFirst(code)){
        (cursor.current as IncidentDataObj).count++;
    }

    //Higher Level
    var hightype:String=mediumtype.slice(0,1);

    code.code=hightype;

    if (cursor.findFirst(code)){
        (cursor.current as IncidentDataObj).count++;
    }
}

public function returnIncidentName(incidentCode:String):String
{
    var cursor:IViewCursor = incidentsCollection.createCursor();

    var code:IncidentDataObj = new IncidentDataObj(incidentCode,"");

    if (cursor.findFirst(code) == true)
    {
        return (cursor.current as IncidentDataObj).type;
    }

    else
    {
        return "";
    }
}

```

```

public function refreshDataProvider(selectedIncident:String):void
{
    incidentsChartDataProvider= new ArrayCollection();

    var level:uint=uint(selectedIncident.length);

    level=(level%3)+1

    for each (var incidentType:IncidentDataObj in incidentsCollection)
    {
        if (incidentType.level==level && incidentType.count != 0)
        {
            if (level == 1)
            {
                incidentsChartDataProvider.addItem(incidentType);
            }

            else if (level ==2)
            {
                if(incidentType.code.slice(0,1) ==selectedIncident)
                {
                    incidentsChartDataProvider.addItem(incidentType);
                }
            }

            else if (level == 3)
            {
                if(incidentType.code.slice(0,2) ==selectedIncident)
                {
                    incidentsChartDataProvider.addItem(incidentType);
                }
            }
        }
    }
}

```

MonthsDataCollection.as

```
package Classes
{
import mx.collections.ArrayCollection;
import Classes.MonthsDataObj;

// Define Month datacollection, that will be assigned to year

[Bindable]
public class MonthsDataCollection
{

public var monthsDataCollection:ArrayCollection=new ArrayCollection();

public var monthArray:Array= new
Array("Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug", "Sep", "Oct", "Nov", "Dec");

public function MonthsDataCollection()
{
for (var i:int = 0; i < monthArray.length; i++)
{
monthsDataCollection.addItem(new MonthsDataObj(monthArray[i],i+1));
}

}

public function MonthsReset():void
{
for each (var month:MonthsDataObj in monthsDataCollection)
{
month.ResetMonth();
}

}

public function IncrementMonthCount(month:uint,day:uint,hour:uint):void
{
(monthsDataCollection.getItemAt(month-1) as MonthsDataObj).monthCount++;

(monthsDataCollection.getItemAt(month-1) as
MonthsDataObj).daysDataCollection.IncrementDay(day,hour);
}
}
}
```


MonthsDataObj.as

```
package Classes
{
import Classes.DaysDataCollection;

// Define month data object that has month name and index and month count

[Bindable]
public class MonthsDataObj
{
public var monthName:String;

public var monthIndex:uint;

public var monthCount:uint=0;

public var daysDataCollection:DaysDataCollection=new DaysDataCollection();

public function MonthsDataObj(monthName:String,monthIndex:uint)
{
this.monthName=monthName;

this.monthIndex=monthIndex;
}

public function ResetMonth():void
{
this.monthCount=0;

this.daysDataCollection.ResetAllDays();
}
}
```

MonthYearDataObj.as

```
package Classes
{
    // To arrange the data collection based on month

    public class MonthYearDataObj
    {
        public var monthLabel:String;

        public var year:uint;

        public var monthIndex:uint;

        public var monthCount:uint;

        public function
        MonthYearDataObj(monthLabel:String,year:uint,monthIndex:uint,monthCount:uint)
        {
            this.monthLabel=monthLabel;

            this.year=year;

            this.monthIndex=monthIndex;

            this.monthCount=monthCount;
        }
    }
}
```

TestEMSDataCollection.as

```
package Classes
{
import mx.collections.ArrayCollection;

// Define data collection for test emergency response, to define below and above

[Bindable]
public class TestEMSDataCollection
{
private var testEMSDataCollection:ArrayCollection = new ArrayCollection();

public function TestEMSDataCollection()
{
var testObj:TestEMSDataObj=new TestEMSDataObj("Above");

testEMSDataCollection.addItem(testObj);

testObj=new TestEMSDataObj("Below");

testEMSDataCollection.addItem(testObj);
}
}
}
```

TestEMSDataObj.as

```
package Classes
{
    // Define the data object of below and above

    [Bindable]
    public class TestEMSDataObj
    {
        public var name:String="";

        public var count:uint=0;

        public function TestEMSDataObj(name:String,count:uint)
        {
            this.name=name;

            this.count=count;
        }
    }
}
```

YearDataCollection.as

```
package Classes
{
import mx.collections.ArrayCollection;
import Classes.YearDataObj;

// To handle year data collection

[Bindable]
public class YearDataCollection
{
public var yearDataCollection:ArrayCollection=new ArrayCollection();

public function YearDataCollection(startYear:uint,endYear:uint)
{
for (var year:int = startYear; year <= endYear; year++)
{
yearDataCollection.addItem(new YearDataObj(year));
}

}

public function YearRest():void
{
for each (var year:YearDataObj in yearDataCollection)
{
year.YearReset();
}

}

public function YearIndex(year:uint):uint
{
return (year-(yearDataCollection.getItemAt(0) as YearDataObj).yearName);
}

public function
IncrementYearCount(year:uint,month:uint,day:uint,hour:uint):void
{
(yearDataCollection.getItemAt(YearIndex(year)) as YearDataObj).yearCount++;

(yearDataCollection.getItemAt(YearIndex(year)) as
YearDataObj).monthsDataCollection.IncrementMonthCount(month,day,hour);

}
}
}
```

YearDataObj.as

```
package Classes
{
import Classes.MonthsDataCollection;

// To define year data object, it contains the data collection of months

[Bindable]
public class YearDataObj
{
public var yearName:uint;

public var yearCount:uint=0;

public var monthsDataCollection:MonthsDataCollection= new
MonthsDataCollection();

public function YearDataObj(yearName:uint)
{
this.yearName=yearName;
}

public function YearReset():void
{
yearCount=0;

monthsDataCollection.MonthsReset();
}
}
```

YearMonthCountDataObj.as

```
package Classes
{
    // Provides the year and incidents count for each month

    [Bindable]
    public class YearMonthCountDataObj
    {
        public var yearName:uint;
        public var janCount:uint;
        public var febCount:uint;
        public var marCount:uint;
        public var aprCount:uint;
        public var mayCount:uint;
        public var junCount:uint;
        public var julCount:uint;
        public var augCount:uint;
        public var sepCount:uint;
        public var octCount:uint;
        public var novCount:uint;
        public var decCount:uint;

        public function YearMonthCountDataObj(yearName:uint, arr:Array)
        {
            this.yearName=yearName;

            janCount=arr[0];

            febCount=arr[1];

            marCount=arr[2];

            aprCount=arr[3];

            mayCount=arr[4];

            junCount=arr[5];

            julCount=arr[6];

            augCount=arr[7];

            sepCount=arr[8];

            octCount=arr[9];

            novCount=arr[10];

            decCount=arr[11];
        }
    }
}
```