Control of industrial accidents in Saudi Arabia

Loughborough University

Control of Industrial Accidents In Saudi Arabia

by

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Abstract

An information-based solution is proposed that will aid fire-fighters and other emergency service personnel in their control of industrial accidents in Saudi Arabia. The integration of databases and geographic information systems (GIS) through dynamic data exchange (DDE) creates an informatics tool with more general usability. Further, web enabled information exchange about hazardous materials is interfaced with the proposed information system. The resulting 'Industrial Incidents Administration System' (IIAS) is a paperless, user-centred, secure method for information exchange able to preserve information between the Civil Defence and Industrial Sectors in Saudi Arabia using state of the art electronic sources and resources.

Three main needs were identified in the design phase of IIAS: the information architecture of the data repositories in a form that retains semantic and syntactic values; a rapid-access database for planning decisions; and, an online transactional database for frequent updating. In order to achieve the IIAS, the following technologies were exploited and integrated. Online data exchange through the use of an Information Bus system architecture; a local database which contains five sub-systems; and the GIS application. Interoperability was an important feature of the proposed solution.

In order to better understand and satisfy user needs, the prototype system was implemented and evaluated. The purpose of this prototype was to receive feedback from users to understand their needs. The feedback received helped to improve, as well as add, new functionalities to the IIAS. In this study, we presented results and experiences of conducting two well known evaluation techniques: heuristic evaluation and cognitive walk-through. The two methods employed complemented each other very well, the first giving feedback from end-users needs, and the second revealing deficiencies in usability in the system. The study provided convincing information for improving the current version of IIAS.

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I dedicate this work to my father and mother.

I also dedicate this work to my beloved wife F. Al-Gahtani and my sons Saeed, Ali and Abdullah, and to my daughters Mohra, Asma and Atheer.

I am saying for them: Thank you

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API	Application Programming Interface
ASIT	Safety and Information Systems in Transport Ltd., Switzerland
AUDMP	Asian Urban Disaster Mitigation Project
BARPI	Bureau for Risk and Industrial Pollution Analysis
CAD	Computer-Aided Dispatch
CAS	Chemical Abstract Service
CCSFC	Central Committee for Storm and Flood Control
CD	Civil Defence
CDCC	Civil Defence Command Centre
CDIC	Civil Defence Information Centre
CDIC	Civil Defence Information Centre
CHEMTREC	Chemical Transportation Emergency Centre
CODISC	Operational Centre of the Directorate for Civil Defence
CPI	Chemical Process Industry
CW	Cognitive Walkthrough
DBMS	Database Management Systems
DDE	Dynamic Data Exchange
DMIS	Disaster Management Information System
DMT	Data Management Team
DOI	Department of the Interior
DRIRE	Regional Bureau for Industry, Research and the Environment
EAS	Emergency Alert System
EPA	Environmental Protection Agency
ESRI	Environmental System Research Institute
ESS	Environmental Software and Services

FCC	Federal Communications Commission
FCCN	Foundation for National Scientific Computing
FEMA	Federal Emergency Management Agency
FOSC	Federal On-Scene Coordinator
FSB	Federation of Small Business
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GIIC	Global Information Infrastructure Commission
GIS	Geographic Information System
GMD	German National Research Centre for Information Technology
GNP	Gross National Product
GUI	Graphic User Interface
HARIA-2	Handling Algorithms for Risk Evaluation in Industrial Activities
HE	Heuristic Evaluation
HITERM	High-Performance Computing and Networking for Information Management and Decision Support
HPCN	High-Performance Computing and Networking
ICM	Information Centre Manager
ICT	Information and Communication Technology
IFB	Industrial Fire Brigade
IFBO	Industrial Fire Brigade Officer
IFIP	International Federation For Information Processing
IIAS	Industrial Incidents Administration System
IMS	International Media Support
IS	Information System
ISDR	International Strategy for Disaster Reduction

ISO	International Standards Organisation
ISP	Internet Service Provider
ISU	Internet Service Unit
IUDMP	Indonesian Urban Disaster Mitigation Project
IUPAC	International Union of Pure and Applied Chemistry
KACST	King Abdulaziz City for Science and Technology
KSU	Kansas State University
LAN	Local Area Network
LEPC	Local Emergency Planning Committee
MCIT	Ministry of Communications and Information Technology
MIE	Ministry of Industry and Electricity
MOI	Ministry of Interior
MOP	Ministry of Planning
Nanadisk-Net	National Natural Disaster Knowledge Network
NCEC	National Chemical Emergency Centre
NCP	National Oil and Hazardous Substances Contingency Plan
NDCC	National Disaster Coordinating Council
NDMC	National Disaster Management Centre
NFDC	National Fire Data Centre
NII	National Information Infrastructure
NRC	National Response Centre
NRSC	National Radio Systems Committee
NRT	National Response Team
ODBC	Open Data Base Connectivity
OIC	Officer in Charge
OOA	Object-Oriented Approach

OSC	On-Scene Coordinator
PC	Personal Computer
RBDS	Radio Broadcast Data System
RCP	Regional Contingency Plan
RDS	Radio Data System
RRT	Regional Response Teams
SA	Saudi Arabia
SABIC	Saudi Arabian Basic Industries Corporation
SAGA	Saudi Arabian General Investment Authority
SAMIS	Saudi Arabian Ministry of the Interior System
SANCST	Saudi Arabian National Centre for Science and Technology
SAR	Synthetic Aperture Radar
SDLC	System Development Life Cycle
SIACEDPC	Service for Civil and Economic Affairs, Defence and Civil Protection
SIAR	Sistema Informativo Aziende a Rischio
SIPBI	Indonesia Disaster Management Information System
SME	Subject Matter Experts
SMEs	Small and Medium Enterprises
SOMIS	Social Management Information System
SPSS	Statistical Package for Social Science
SQL	Structured Query Language
SSM	Soft System Methodology
STC	Saudi Telecommunication Company
SUMI	Software Usability Measurement Inventory
UK	United Kingdom

UN	United Nation
UNDP	United Nation Disaster Program
UNECE	United Nation Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
US	United State
USA	United State of America
USFA	United State Fire Administration
VSAT	Data Internet Service via Satellite
WAN	Wide Area Network
WWW	World Wide Web
χ^2	Chi-square
XML	Extensible Markup Language

1.1 Background

In the last decade, there has been a considerable increase in the number of disasters, including natural, man-made and hybrid types of disaster. A significant increase has been noticed in the man-made category particularly in chemical, transport and nuclear installations (Martin, 1999). As a direct result of this, there has been an increasing trend of exerting more social, political, legal and economic pressure to create better policies and practices in disaster preparedness, planning, management, mitigation, response and recovery (Kara-Zaitri, 1996). There has also been, at the same time, significant advances in science and technology. These advances have been specifically noticed in four main areas: namely, computer hardware and software, human-computer interfaces, communications, and scientific tools and techniques. It is fair to say that the advances in these areas should help in reducing the vulnerability of humans and the environment to disasters.

According to Kara-Zaitri (1996), there are two main barriers that continue to hinder technologies from being transferred to disaster management to cope with disaster reduction and mitigation. These are:

a. *The failure of scientists and engineers to communicate the new tools and technologies to other scientists researching in, and practitioners working in areas related to disaster management and emergency planning.*
b. *The failure of disaster management practitioners and decision-makers to take ownership of the new technologies. This can be attributed to the fact that these practitioners have not been involved in the process and therefore suffer a lack of understanding and confidence in the use of these new technologies in disaster management.*

Thorburn and Langdale (2003) mentioned that the main barriers to implementing change and to developing disaster management plans are having the people and the skills to do it. Bourn (2000) identified the main barriers and incentives for risk taking as follows:

- Lack of expertise in risk management;
- Lack of formal systems, processes and procedures for managing risks;
- Unclear responsibilities for the management of risks;
- Time and funding constraints; and
- Fear of project failure thus reducing the scope for innovation.

In the 21st century, emphasis has shifted towards the communication aspects of information technology, ensuring the continued dominance of information and communication technologies (ICT). It is indisputable that information and communication technology (ICT) is becoming increasingly important in every sector, but particularly it is becoming one of the most important services in information networks, enabling information to be accessed easily and speedily. In the context of disaster management, the revolution in ICT is changing the nature of economies and societies around the world; we are only just catching up with the amazing capabilities of how information and communication technologies (ICT) can affect business (Jack Hilary and Associates, 1996). The emergency planning world will most certainly benefit from such advances in information and communication technologies.

Currently, information networks play a major role in controlling and directing the flow of huge amounts of information. Many countries have now established a series of national networks, which link different public and private sectors with the aim of sharing and exchanging information. However, not all organisations adopt IT systems. Among almost four million UK small and medium-sized companies, for example, the Federation of Small Businesses (FSB) in 1999 estimated that 65 percent did not even own a PC. Moreover, a large number of organisations that exist in Saudi Arabia, for example, have not taken full advantage of these new technologies (AL-Turki, 2001).

Implementation of ICT is often expensive and risky. Decisions about the technology needed to build information systems are difficult to make for several reasons and some technology may fail to provide the expected services. First, companies find it difficult to keep up with rapid advances in hardware and software. Second, technology decisions can make or break companies. Third, the window of time to make decisions regarding technology is limited. Finally, and most importantly, technology is about people and how they adapt to change (Gupta, 2000).

In Saudi Arabia, the importance of information for all sectors of the Kingdom cannot be overemphasised. As a result of this, the Ministry of Planning decided to implement an information network for all government agencies in the Kingdom (Ministry of Planning, 1995). The objective of this plan was to emphasise and encourage public and private organisations to adopt modern technologies, managerial skills and business practices. A corollary of these objectives was to reduce the country's dependence on expatriates and foreign technical assistance (Ministry of Planning, 1997).

The Saudi Arabian government has taken steps in the past several years towards diversification and to achieve greater private sector participation in the economy. The number of production factories in the Kingdom of Saudi Arabia reached 3,481 by the end of 2001 (Ministry of Industry and Electricity, 2002). The possibility of unpredictable industrial disasters, like those in Bhopal and Chernobyl, is more likely to occur with this increasing number of factories and therefore it becomes imperative to plan and establish information networks.

Planning while circumstances are normal is necessary to manage and react to emergencies and this planning requires the active participation of both government and non-government organisations. One of the most important government organisations in Saudi Arabia that is directly involved in disaster management in the Kingdom is the Civil Defence organisation.

Civil Defence is one of the most important sectors in Saudi Arabia and this importance stems from the fact that it provides protection and help to all sectors including the Industrial Sector. The Civil Defence protocol defines Civil Defence as follows:

'Civil Defence is defined as a number of necessary procedures for the protection of the population, public and private properties from fire, disasters or war risks, various accidents, relief of the inflicted and to ensure the public communications, performance of public utilities and protection of national resources during peace and war time. This also includes restoration of natural life to areas subjected to disasters'.

As a result of this definition the functions of the Civil Defence sector can be summarised as:

- Protecting the civil population against the effects of hostilities or disasters;
- Assisting the civil population in recovering from the immediate effects of hostilities or disasters; and
- Providing the conditions necessary for the survival of the civil population.

Civil Defence planning and implementation requires extensive information about natural and industrial hazards. To achieve this, it should aim to use the most up to date information and technology available.

Consequently, the establishment of a national information network, which links both the Civil Defence organisation and the Industrial Sector, has become extremely important for dealing with industrial disasters. This necessitates a study of the dangers that may be initiated and the extent of the impact of such dangers on human lives and property. It is also important for the Civil Defence department to be aware of safety measures and other issues related to the Industrial Sector.

1.2 Aim of the Study

The principal aim of this study is to design, implement and evaluate an information management system that links the Civil Defence and Industrial Sector in Saudi Arabia, in order to control industrial accidents.

1.3 Objectives

To gain a better understanding of how to provide a fast, efficient and easy-to-use service via information networks that will link these two sectors, the following objectives have been established:

1. To investigate the current use of ICT in the Civil Defence department and the Industrial Sector in Saudi Arabia in the management of industrial accidents.

2. To investigate the benefits that arise from the use of current ICT systems available in Saudi Arabia:

    a. To study users' needs, expectations and attitudes towards information technology in the Civil Defence department and the Industrial Sector.

    b. To study the information flows and use of information among the employees of the Civil Defence organisation and the Industrial Sector in Saudi Arabia.

3. To study the benefits of designing an information network for dealing with potential disasters.

4. By using an appropriate systems-based methodology, to develop a model for a proposed high-speed information network for sharing and exchanging information between the two sectors concerned.

Figure 1.1 shows the flowchart of how these objectives will be implemented through this research.

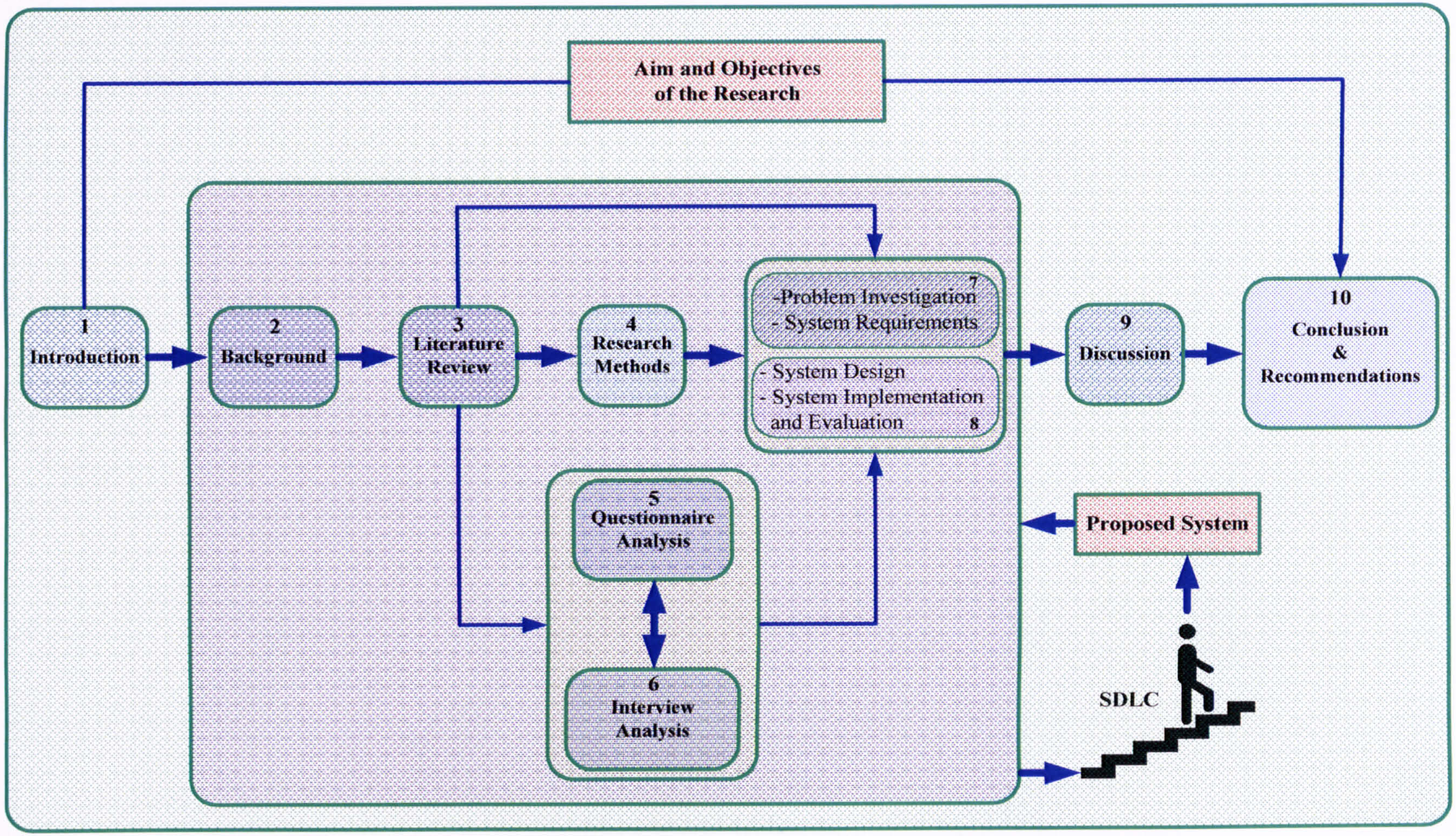

Figure 1.1 Roadmap of the implementation of the research objectives

1.4 Significance of the Study

It is indisputable that information and communication technology (ICT) is becoming increasingly important in all sectors, particularly in managing risk. The results of this research will be of interest, not only to researchers, but will also have important practical implications. In terms of its contribution to ICT research, the current work will provide new insights on the organisational implementation of ICT in the Civil Defence and Industrial Sector.

This study considers the use of information networks between these sectors to improve the services and to deal efficiently and effectively with disasters when they occur. The study provides recommendations and suggests an action plan for the development of information networks.

1.5 Organisation of the Thesis

The thesis is divided into ten chapters. The layout of these chapters is illustrated in Figure 1.2. A brief description of each chapter is included here to serve as the thesis' summary.

In Chapter 1, a brief introduction to the thesis is presented. It examines the need for this research, its aims and objectives, and its significance. Chapter 2 discusses the definition of disaster management, its phases, and the impact of ICT. The importance of information flow and a geographic information system (GIS) is discussed. Furthermore, some brief background information about the Civil Defence department and the Industrial Sector in Saudi Arabia is offered. The role of the Civil Defence sector in protecting lives and property, the various industrial cities, and the public and private Industrial Sector are also discussed. Chapter 3 presents the results of a literature review in the area of the development of ICT in disaster management in developed and developing countries, and in Saudi Arabia. This is to make the reader aware of the great progress that has been made in disaster management. In Chapter 4, a general review of research methods is presented. A discussion of the appropriateness of the selected methodology for this research and the System Development Life Cycle (SDLC) are also presented. In Chapters 5 and 6, the results of the survey which was conducted are presented and discussed.

Chapter 7 implements Stage One and Stage Two of the SDLC approach. These stages are: identifying the problems and opportunities (Stage One) and the analysis of the system requirements (Stage Two). Chapters 8 and 9 discuss Stages Three and Four in more detail. The design and implementation of the proposed model (IIAS) are presented. The system's conceptual framework, architecture, database sub-system, the GIS sub-system and the Web-based sub-system are discussed. Also presented in this chapter is a summary of the system evaluation that was conducted for each of the three sub-systems.

Chapter 10 presents an overall summary and discussion of the results. The benefits of designing an information network and adopting the system model are also discussed. The contributions to knowledge as a result of the research study are outlined. Chapter 11 presents the conclusions of the main findings and recommendations regarding the implementation of IIAS. In addition, suggestions for future work.


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Layout of the Thesis

2.1 Introduction

This chapter is aimed at reviewing the relevant developments concerning information infrastructure and network applications for the adoption of ICT in disaster management. The importance of emergency planning and operational centres in the field for dealing with disasters will be identified, together with the emerging role of communication technologies in the mitigation, preparedness, response and recovery phases of disaster management. The emerging challenges in making the application of these technologies effective will also be described. The importance of GIS as a disaster control tool will be discussed while the chapter will give a general overview of Civil Defence and the Industrial Sector in Saudi Arabia.

2.2 Disaster Management

2.2.1 Definitions

The International Strategy for Disaster Reduction defined disaster as a function of the risk process. It results from a combination of hazards, conditions of vulnerability, and insufficient capacity or measures to reduce the potential negative consequences of risk (UN/ISDR, 2004). Such events can be earthquakes, landslides, floods, hurricanes, volcanic eruptions and industrial disasters. The most important characteristic of industrial accidents is that they have effects off-site from their original location. As a result, the extent and severity of the accident may significantly affect the population of the adjacent areas (Tudor, 1997).

The US Federal Emergency Management Agency (FEMA) defined risk as*: the potential losses associated with a hazard and defined in terms of expected probability, frequency, magnitude, severity, exposure, and consequences. Hazards include natural disasters and accidental or man-caused events, including any natural catastrophe as:*

hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, and drought, fire, explosion, or other catastrophe, including radiological ones, that cause, or may cause, substantial damage or injury to civilian property or persons (FEMA, 2000).

Compared to natural disasters, industrial accidents are typically of shorter duration, entail less warning, evoke a less coordinated response, less central government, involvement, and greater local and private involvement (Impact Assessment, Inc., 2001; Kelly, 1989). Awareness of the frailty of our environment has increased concern about both the immediate and long-term dangers of industrial disasters. Both are now part of the public agenda in many countries (Granot, 1998).

The international community has become aware of the necessity to reduce the impact of disasters and to increase the work on disaster management. The decade 1990-2000 was designated the "International Decade for Natural Disaster Reduction" by the general assembly of the United Nations (Verstappen, 1998). To reduce the impact of natural disasters, a complete strategy for disaster management is required, involving the aspects of disaster prevention (hazard, vulnerability and risk analysis applied to planning), disaster preparedness (warning and monitoring of disasters) and disaster relief operations. In each of these aspects the use of Information and Communication Technology (ICT) can play an important role.

In such cases, appropriate action to protect the affected population should be based on rational and quantitative information that would lead to appropriate and efficient decisions (Markatosa *et al.*, 2002). Computer-integrated tools and information networks for managing large-scale industrial accidents are important facilities that provide a quantitative estimation of the accident's consequences and propose, under the circumstances, a reliable course of action to be undertaken automatically.

2.2.2 Phases of Disaster Management

According to the Federal Emergency Management Agency (FEMA, 2003), the phases of disaster management that reduce the loss of life and property and protect our institutions from all hazards by leading and supporting the nation in a comprehensive, risk-based emergency management programme are mitigation, preparedness, response and recovery.

Mitigation is the taking of sustained action to reduce or eliminate long-term risk to people and property from hazards and their effects. Its actions involve supporting the efforts of local government officials to: promote the construction or siting of structures so that the chances of them being affected by disasters are reduced; develop, adopt and enforce appropriate building codes and land use planning standards; and to take action to minimise industrial hazards. Mitigation is achieved primarily through community actions, which can be greatly enhanced by the support of individuals, public-private partnerships, and any relevant agencies. Its strategy is to make it as easy as possible for communities and their citizens to take informed and effective mitigation actions. FEMA mitigates hazards by leading a national effort to:

- Identify and improve the understanding of the nation's hazards and their risks, by community;
- Develop or improve techniques which mitigate those risks;
- Provide an environment conducive to applying those techniques;
- Provide financial and technical assistance (both pre- and post-disaster) to facilitate the application of those techniques; and
- Support the development of incentives and disincentives which make the application of those techniques a social, political and/or economic priority.

Preparedness is the building of the emergency management profession to prepare effectively for, mitigate against, respond to, and recover from any hazard by planning, training and carrying out drill exercises. FEMA's preparedness strategy seeks to foster innovation and improvement to reduce the gap between the capabilities required to respond to disasters and those capabilities that are in place. The focus of the preparedness strategy is on risk identification; emergency management professional development; the establishment of capability performance measurements and assessment through tests, exercises and real world experiences; planning and public education; and partnerships with the private sector and other nations.

Response is the conducting of emergency operations to save lives and property by positioning emergency equipment and supplies, evacuating potential victims, providing food, water, shelter, and medical care to those in need, and restoring critical public services.

Recovery is the rebuilding of communities so individuals, businesses and governments can function on their own, return to normal life, and protect against future hazards.

Response and recovery require the efforts of government and many agencies, including private, public, and non-profit organisations, and individuals. To implement more efficient and effective response and recovery strategies, FEMA integrates high-performance technology into its data collection and programme management activities. Resources in use, or being completed, include GIS, a sophisticated mapping technology to enable high-quality imaging of areas affected by disasters (FEMA, 2000).

Yodmani and Hollister (2001) stated that the role of communication technology has been recognised as integral to disaster management for a long time. In addition, the application of communication technology has a role in all the four phases of disaster management. The new communication and information technologies that have emerged over the last two decades lend themselves to greater possibilities of integration into different communication systems. The interoperability of various communication systems including the Internet, mobile phones, fax, e-mail, radio and television is becoming increasingly more functional. As a result, the possibilities for the application of communication technologies in the mitigation and prevention of disasters are also increasing. There are also both social and technical aspects to the application of communication technologies in disaster management. The effective application of these technologies for disaster management depends greatly upon their appropriateness for the social and economic context in which they are applied.

2.3 ICT in Disaster Management

2.3.1 Information Needs in Disaster Management

Rego (2001) mentioned that the information needs of disaster managers fall into two distinct but closely related categories of activities. These are:

- *Pre-disaster activities*: analysis and research (to improve the existing knowledge base), risk assessment, prevention, mitigation and preparedness;
- *Post-disaster activities*: response, rehabilitation and reconstruction.

Accordingly, there are two categories of disaster-related data:

- *Pre-disaster baseline data* about the country and risks;
- *Post-disaster real-time data* about the impact of a disaster and the resources available to combat it.

There are two essential preliminaries to establishing a disaster management information system (Rego, 2001):

- *Defining the purpose of the system:*
  To define the purpose of the system, questions such as "who will be the main users and what end product do they require?" should be addressed. The system must be appropriate to the level of management at which it is used. Failure to have a very clear idea of the purpose of the system is likely to lead to the creation of an unnecessarily elaborate one which attempts to do more than is

really necessary, with the attendant risks of it being costly, time consuming to maintain, the data being out of date, and the system itself being inappropriate to the real needs of its users.

- *Investigating the existing databases and integrating with them:*
  Often the information needs of disaster managers overlap those of other organisations and the data may therefore already be stored elsewhere. Disaster managers should resist the temptation to establish their own all-embracing database. An example of a disaster-related international database is a commercially developed one on hazardous substances. UNEP is planning to introduce a similar one for environmental matters.

According to Ayyangar (1999), the components of a national disaster management information system (DMIS) would be a database of:

a) Hazard Assessment Mapping,
b) Vulnerability Assessment,
c) Demographic Distribution,
d) Infrastructure, Lifelines and Critical Facilities,
e) Logistics and Transportation Routes,
f) Human and Material Response Resources,
g) Communication Facilities.

The DMIS would be used in all the four phases of disaster management. The hazard and vulnerability assessments and mapping components of a DMIS are the cornerstone of preparedness planning, as well as planning and implementation of a mitigation programme. All data is of critical use in the preparedness plan as well as in the actual response operations (Ayyangar, 1999).

2.3.2 Information Flow

Without a carefully planned, well-organised approach to data gathering, the information flow in an emergency can be very slow and may force decision makers to take action based on minimal information.

Jegillos (2000) identified some problems that need to be solved in order to improve the information flow during emergency situations. These problems are:

- The lack of a monitoring system and information dissemination coordinating councils;
- Non-synchronisation of disaster assessment reports;
- Lack of communication and transportation facilities.

Communication is one of the most critical components in an emergency because information flow is essential. The status of conditions must be current because decisions must be made quickly. The more information that is available and the more accurate it is, the better the decisions are likely to be. There should be a command centre to lead emergency operations. Emergency management communication for planning, response and relief efforts are currently being addressed by emergency managers and organisations who are joining forces with various communication networks with the intention of providing relevant, reliable and survivable communication in the Pacific areas (Klenk, 1997).

Disasters are the ultimate test of the capability of emergency response. The ability to effectively deal with disasters is becoming more relevant because of factors that tend to increase risk. Unfortunately, there are recurring difficulties with disaster response. Lessons learned in previous disasters are not always being applied in other communities. Heide (2000) stated that one of the reasons that lessons about disasters are not learned is because it is difficult for emergency responders and planners to get accurate information about what actually happen in disasters so that they may profit from the lessons learned by others. Sometimes this is because accurate information regarding the basic underlying causes of the difficulties is not readily available to emergency and disaster responders.

In Saudi Arabia, an exchange of information between the Civil Defence department and the Industrial Sector already has been established. The Civil Defence administration and fire brigades in each region collect the information, with the main method of collecting such information being paper-based. When collected, the information is then stored in files and archived. The Civil Defence Information Centre (CDIC) has, in the past, provided electronic data for emergency situations. Such information includes the names of local hospitals, the number of beds, and the location of evacuation centres and places of shelter for the victims. This information requires constant updating as most of the institutions are dynamic. In addition, new ones are set up and need to be added to the database. However, the existing method of storing information makes this task almost impossible.

At present, the information flow is performed in a 'conventional' way by exchanging paper forms. The information flow is obviously abundant but the quality of information being disseminated requires improvement. As a result, information coverage is not integrated and more effort is needed in redesigning the information flow between these two sectors.

Through the current situation, it has been found that the information flow between the Civil Defence department and the Industrial Sector is limited and that a joint Geographic Information System (GIS) programme may bring improved and new planning and executing capabilities in disaster management. Such a system will provide new capabilities that will benefit the organisations by providing improved information flow from field and information suppliers to end users (BlueChip, 1999).

GIS can be defined as a computer-based system to collect, store, analyse, retrieve and display geographic information. It consists of at least four main components, namely: hardware/software, information, people who operate the system, and the organisational context (work and information flow, number of hierarchical levels, etc)

(Traub, 1998). GIS consists of tools that can analyse, store, manipulate and display geographically referenced information, such as data identified according to their locations. GIS can use information from many different sources and in many different forms. The primary requirement for the data is that the locations of the variables are known. Locations may be shown by coordinates of longitude, latitude and elevation, or by attributes such as ZIP codes. GIS is a database system with software that can analyse and display data using digitised maps and tables for planning and decision-making. A GIS can assemble, store, manipulate, and display geographically referenced data, tying this data to points, lines and areas on a map or in a table. GIS can be used to support decisions that require knowledge about the geographic distribution of people, hospitals, schools, fire stations, roads, weather events, the impact of hazards/disasters, etc. Any location with a known latitude and longitude or other geographic grid system can be a part of a GIS.

GIS technology is a valuable asset for government. It can be used for scientific investigations, the planning of land use and urban growth, zoning, permit tracking, transportation planning and management, emergency management, school bus routing and taxation analysis. For example, GIS would allow emergency planners easily to calculate emergency response times in the event of a disaster or might be used to find wetlands that need protection from pollution.

The importance of GIS in an emergency response was highlighted in New York after the World Trade Centre bombings in September 11, 2001. In the first four days of the rescue attempts, no GIS equipment was available. Rescue workers had to create maps on cardboard or use shopping guides to draw maps of unstable buildings. Once GIS equipment arrived, the rescue operations team was able to create maps that included the location of command and first aid centres, food stations and hazards such as fires or debris hanging from buildings. Images from heat sensing cameras were used to detect fire patterns in the rubble and, combined with locations of underground fuel tanks, were used to find the source of the fires. Based on these maps, rescue workers could then plan their work each day (Greenman, 2001). Also, posted after the attack was a relief and rescue map of Manhattan. It included locations and links for information on subjects such as hospitals, missing persons, blood donation centres, closed roads, telephone and electrical outages, grief counselling centres, relief organisations and damaged areas (Strayhorn, 2001).

Other state and local governments have used also GIS in emergency planning and response. For example, Pennsylvania developed a GIS database to help in its emergency planning and in Salt Lake City, Utah, GIS has been used to analyse the effect of an earthquake on the response time of fire and rescue squads. By combining information about the road networks, fire stations, and the types of soil around the fault line, analysis showed how fast areas within the city could be served, the areas most likely to be affected by accidents or disasters, and where the worst damage could be expected. For example, during an earthquake in San Francisco, police and fire department personnel were able to use GIS to create visual images and maps from volumes of disaster reports. This allowed emergency vehicles and repair crews to be dispatched quickly and efficiently around the bay area (Strayhorn, 2001a).

Esri (2003) defined a GIS as computer software that links geographic information (where things are) with descriptive information (what things are). Unlike a flat paper map, where "what you see is what you get," a GIS can present many layers of different information. GIS is a very useful tool for many aspects of emergency management, including emergency response, planning, exercises, mitigation, homeland security and national preparedness. In addition to its ability to manage and display data, GIS has robust modelling capabilities, allowing its users to adjust data and scenarios for prediction, planning and estimation. Moreover, GIS is used as an interface for integrating and accessing massive amounts of location-based information in the public safety market. GIS allows public safety personnel effectively to plan for emergency response, determine mitigation priorities, analyse historical events, and predict future events. GIS can also be used to get critical information to emergency responders upon dispatch or while en route to an incident to assist in tactical planning.

Data are probably the most important component of a GIS and can prove to be the most expensive part of the GIS system to maintain. Geographic data can be collected in-house or obtained from commercial data providers. A GIS will integrate this spatial data with other data sources which can be directly held in the GIS system or in external proprietary databases such as ORACLE, INGRES, INFORMIX, DBASE, ACCESS etc. GIS distinguishes itself from other text-based database systems by being able to answer questions like: 'What is at a particular location, place name or post code?' For example, it can show if an accident has occurred at a specified location, or where a particular item or certain features exist. It can also outline the type of accident, whether it is fatal, involves serious injury, slight injury or damage only, and show what has changed in a particular area over a period of time, for example, what is the accident record at a site over three years (Road Accident Analysis Systems, 2003).

A GIS has the ability to display large amounts of data in new and meaningful ways and can be merged with existing systems to provide improved operator interfaces and analysis tools. GIS allows large amounts of data to be presented in a clear and straightforward manner.

The benefits derived from having coordinated data that can be merged with other datasets and used by different users for a variety of different purposes can be immense. Integrating the GIS system with operational front ends can replace lengthy textual database queries with digital maps for getting information quickly.

2.4 Saudi Civil Defence

The Saudi Arabian Civil Defence sector is part of the Kingdom's Ministry of the Interior. The purpose and goals of the Civil Defence department is to protect the population, national resources, property and vital national functions from destruction caused by war or other hazardous circumstances. It is also responsible for limiting the damage a hazardous incident may cause, as well as alleviating its consequences.

The main units of the Saudi Civil Defence organisation are: the Civilian Protection unit, the Fire unit, the Rescue and Safety unit, and the Information Centre. The performance of the Civil Defence sector depends on the performance of the following bodies, according to the rules and regulations issued by the Civil Defence Council in conjunction with other parties (Al-Oseemy, 1986):

1. Ministries, government bodies, legal personnel, corporations, enterprise proprietors, and the owners of vehicles, other vehicles and drivers.
2. Civil Defence forces, internal security forces, the National Guard and the Armed Forces.
3. Civil Defence volunteers.

The Civil Defence sector is made up of the following:

1. The Civil Defence Council.
2. The General Administration of Civil Defence.
3. The Civil Defence Committee.

The Civil Defence department, according to the regulations, has the following responsibilities:

1. Leading and managing Civil Defence.
2. Monitoring hazards and risks.
3. Alerting and telecommunications.
4. Structuring Civil Defence.
5. Evacuation.
6. Rescue services: fire fighting, rescue, relief and recovery.
7. Training and education.

The Civil Defence organisation recognises the problems involved with industry and the serious consequences which an accident might cause. It has therefore established the necessary legislative instruments, control arrangements and co-operative measures in order to reduce both the probability of an accident and the consequences should an accident involving hazardous substances occur.

However, the main emergency response force, which will be involved in accidents concerning hazardous substances, is the fire brigade. The duties of the fire brigade are to:

a. Carry out information and motivation activities in the municipality to cover fire dangers, fire prevention measures, and the manner of behaviour should a fire or other acute accident occurs.

b. Carry out fire prevention and control inspections.

c. Carry out accident prevention duties in connection with the handling of hazardous substances and the transport of dangerous goods by road and rail.

d. Perform more explicit prevention and emergency preparedness duties during times of war and crisis.

e. Be a task force in case of fire.

f. Be a task force in case of other acute accidents when this is decided in accordance with the risk and vulnerability analysis of the municipality.

The fire brigade must also identify and keep records of constructions, stores, sites, tunnels, enterprises etc. where fire may lead to the loss of many lives or cause great damage to health, the environment or materials.

The Civil Defence Command Centre (CDCC), manned round the clock, is responsible for mobilising all fire-fighting brigades and for receiving complaints about fire hazards and dangerous goods. It also acts as an emergency co-ordinator for other government departments and public utilities in the event of major incidents. The centre is equipped with maps for the entire municipality, and also has some computers which are using for storing and retrieving information. The directive system is manual and depends on the experience of the worker.

The following sections discuss the three main units in the Civil Defence department which participate in disaster management.

2.4.1 Civilian Protection

This is one of the main departments in Civil Defence organisation and conducts scientific research in the field of civil protection. For this purpose, a department for risk analysis has been established within this unit to evaluate the potential risks involved in Civilian Protection and to report to the technical department.

The threats faced by the Civil Defence department have been classified into different categories. First, direct and indirect war: the Ministry of Defence and Aviation, the Ministry of the Interior and the National Guard play important roles in preparing emergency plans. Second, expected risks due to technology and industry: Saudi Arabia has witnessed a significant increase in industrial development, so it is to be expected that this category is prone to risks, especially in the field of petrochemical industries and scientific research centres. Measures are being taken to address this escalation in the level of risk in the industrial cities. The role of Civilian Protection in industrial disasters is mainly thorough warning, evacuating and sheltering the civilian populace. In addition, this department receives information and transmits it when necessary to other related departments. Third, natural disasters such as earthquakes and flash floods can cause great loss in terms of life and property, while dam collapses or land slides can affect the construction of buildings or firms in certain regions as the earth's crust will not bear the load. Excessively high temperatures are also accompanied by risk, especially during the pilgrimage (Hajj) season, due to the presence of a very a large number of people in one place. This requires special efforts and arrangements on the part of the Civil Defence department in order to meet these risks.

2.4.2 The Information Centre

The Civil Defence Information Centre (CDIC) was set up in 1984 as a provider of computer services and information needed by decision-makers. The CDIC is intended to support the development of information technology and to distribute the results of information technology to all Civil Defence departments. The most important aims of CDIC have been identified as follows (Al-Shomrani, 1993):

- To offer information technology and computer services to all Civil Defence departments.
- To offer consultancy services on matters of concern to organisations using or intending to use computer resources.
- To develop training and educational plans for users.
- To prepare all application programs that are needed to keep users up-to-date with information.
- To promote awareness of recent advances and future directions in information technology and applications.
- To co-operate with other interested organisations in the development and maintenance of a professional code of conduct.

2.4.3 Industrial Fire Brigade (IFB)

The Civil Defence organisation has at least one fire station serving each industrial city. Each day (24-hour shift), there is a total of 64 personnel on duty that make up the fire suppression, rescue and special teams of the fire department. All on-duty personnel are under the supervision of one Officer in Charge (OIC). The OIC is on duty for 24-hour periods and is responsible for directing all operations and emergencies. OICs are readily identifiable at fire scenes as they are positioned inside the command vehicle with the chief's aide. At all emergency incidents, department procedure calls for a command centre to be set up at the scene. The Command Centre is responsible for the overall direction of emergency activities. A diagram depicting the current organisational structure of the IFB is shown in Figure 2.1.

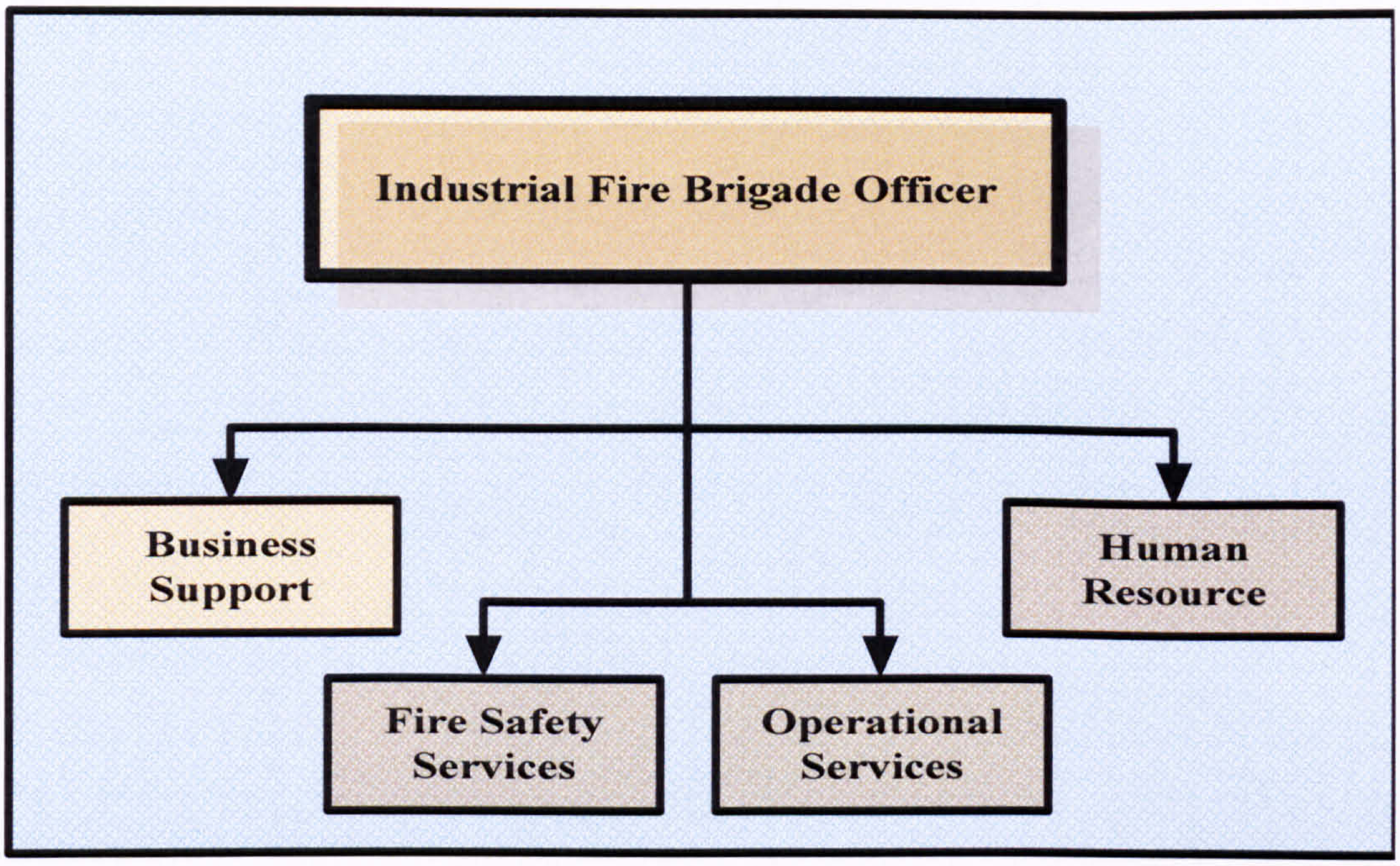


Figure 2.1 IFB organisational structure

In addition to responding to emergency incidents, extensive preparation, training and community outreach is required to meet the challenges of a modern and growing industrial city. Some of the activities a fire brigade undertakes each week include:

- **Inspection** - Crews work with the Fire Prevention Unit in the inspection of businesses and factories to help eliminate fire hazards and to acquaint the fire-fighters with the general layout of places in the event a fire should occur.
- **Drills** - Each week, drills are conducted on fire fighting operations. Drills are essential in keeping the skills of fire-fighters at the highest level of readiness. Drills include practice with the following: ladder work, pump operations, breathing apparatus, hose layouts, rescue techniques, emergency medical care, practice fires, dealing with hazardous materials accidents, etc.
- **Apparatus Maintenance** – The maintenance of apparatus is the continuous task of preparing fire apparatus and equipment to operate under the most

adverse conditions. Inspection, cleaning, and preventative maintenance are performed daily.

- **Pre-Fire Plan** - A pre-fire plan involves developing a familiarity with the characteristics of a building or a business that is vital in a fire fighting operation. Such characteristics include layout, content, location of electrical panels and sprinkler systems, standpipe locations and operation, stairways, elevators, exits, false ceilings, and any special hazards that may be present.
- **Post Incident Analysis** - These involve in-depth discussions of previous fires and operations, the problems that may have occurred, and suggestions for improvement.
- **Classes** - During class periods, subjects for discussion range from the hazards of gases and chemicals to factory construction. Many specialised classes dealing with fire suppression tactics, hazardous materials, emergency medical techniques, etc. are scheduled throughout the year.
- **Community Education** - In conjunction with the Community Education Unit, the Industrial Fire Brigade visits factories to present fire safety information and explain safety procedures. They participate in community activities such as safety and fire prevention days. All the fire-fighters are active in fire prevention throughout the community.

The use of ICT in an emergency situation will have a significant effect on the working environment of the fire-fighters. The most important communication link, actioned by a telephone call, is the one used between the Civil Defence department and the Industrial Sector in the case of a joint emergency. The CDCC receives emergency calls from throughout the Kingdom. Figure 2.2 shows a data flow diagram for an emergency call.

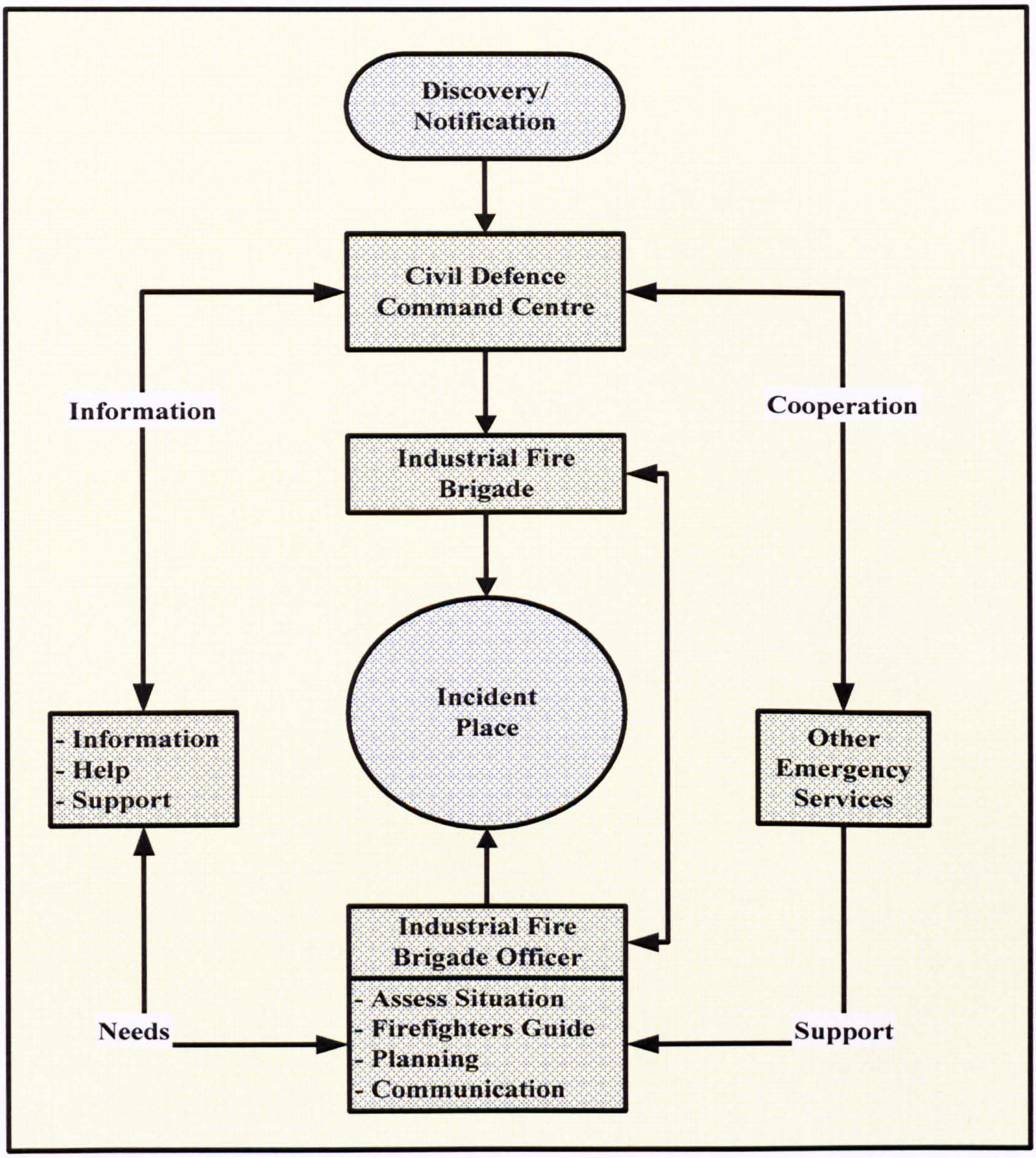


Figure 2.2 Data flow diagram for an emergency call

The CDCC will normally be the first to be notified and be in charge at the scene of a fire incident. The CDCC dispatches all fire and emergency calls via a radio network system which incorporates the use of portable or stationed radios. When an emergency call is received, basic information, such as name and address, are required, whereas the phone number is automatically displayed on the computer-aided dispatch (CAD) console. The call-taker then routes the information to the appropriate fire brigade via radio. Once the call district has been determined, fire and rescue personnel are notified via a tone alert system. The dispatcher is responsible for tracking the status of the agencies and equipment, responding to and assisting with requests, such as mutual aid or additional medical personnel or equipment, from the field. Other emergency services use various types of portable, mobile and base station radios to communicate with the dispatch centres and in order to coordinate incidents.

2.5 The Industrial Sector

The Kingdom's policy for ensuring the growth of the non-oil Industrial Sector focuses on establishing industries that use the country's abundant and inexpensive supplies of petroleum products, petrochemicals and minerals. Petrochemical and other oil-based industries are concentrated in the new industrial cities. These plants use natural gas and natural gas liquids that were previously flared, as well as refined products from the oil industry to manufacture products that will, in turn, feed non-oil industries. The concentration of industrial plants in specific areas also facilitates the provision of vital support services, such as water, power and transportation.

Thirteen industrial cities have been built, with the two principal ones at Jubail on the Arabian Gulf and Yanbu on the Red Sea. Others are scattered across the Kingdom, as shown in Figure 2.3. These sites were chosen for their proximity to sources of raw materials and ease of access to major domestic and international consumer markets. All have been built with emphasis on environmental and wildlife conservation.

Jubail is the largest industrial city. It accommodates more than 30,000 workers and has 15 major plants and other industrial facilities, as well as a dedicated desalination plant and a busy seaport. It also has a vocational training institute and a college.

Yanbu is a major industrial site with a modern port from which products manufactured locally and in other areas of the Kingdom are exported. There are three major refineries, a petrochemical complex, and many manufacturing and support enterprises.

The Saudi Arabian Basic Industries Corporation (SABIC) plays a central role in encouraging the participation of the private sector in the nation's economic growth. Established in 1976 by the government as a shareholding company with an initial capital of 2.66 billion U.S. dollars, SABIC quickly became the backbone of Saudi Arabia's successful industrialisation. By 1994, SABIC had 15 major plants operating in the industrial cities of Jubail, Yanbu and Jeddah, with a 16th under construction, and had an annual production of 13 million tons of chemicals, plastics, industrial gases, steel and other metals. Some of these products are sold in domestic and international markets while others are used as feedstock by secondary and support industries to produce consumer goods. These industries, all owned and operated by the private sector, produce a variety of consumer and industrial goods.

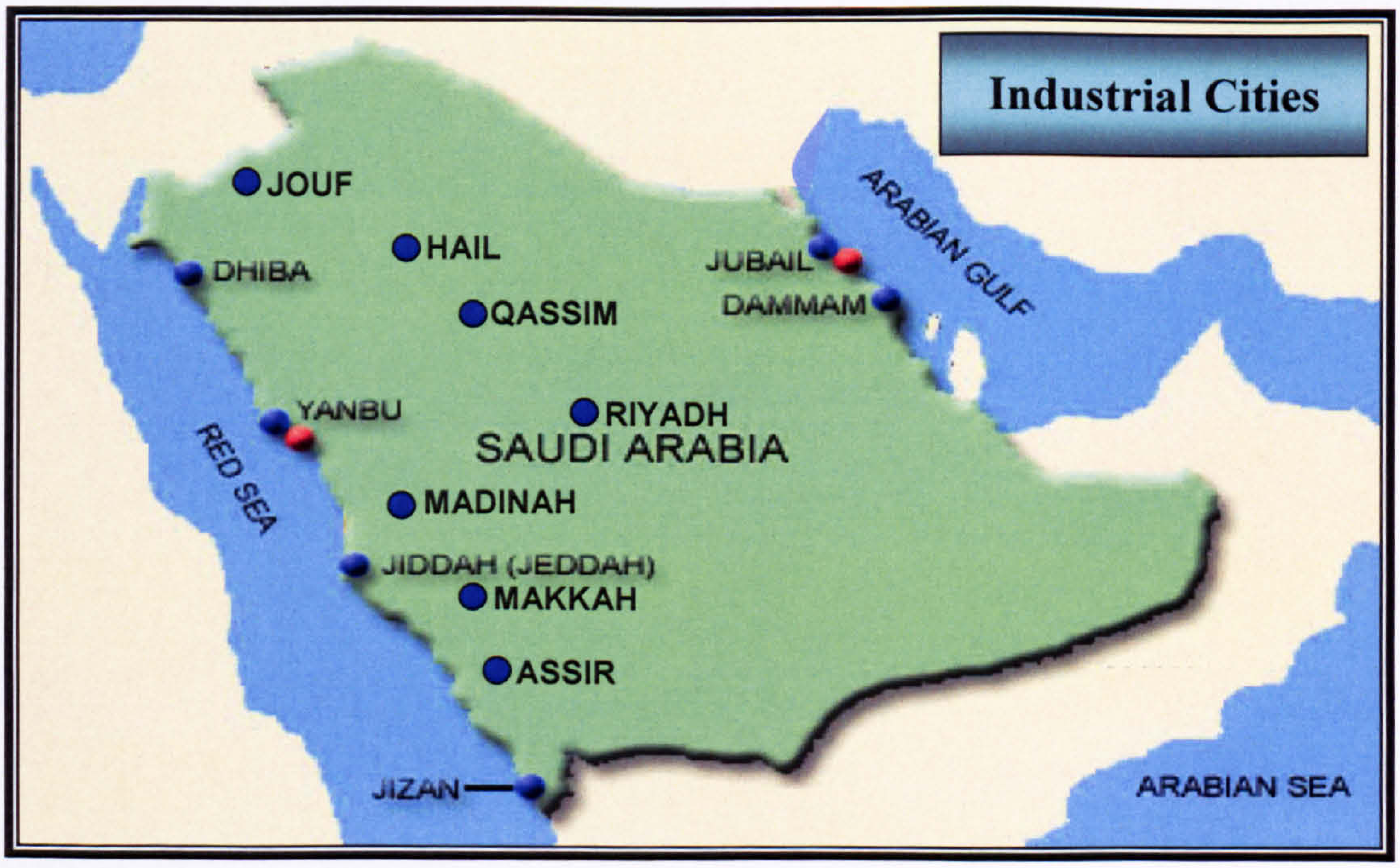


Figure 2.3 Industrial cities in Saudi Arabia

2.6 The Private Sector

A combination of loans, incentives, subsidies and information, and the government emphasis on strengthening the role of the private sector especially during the course of the Fifth Development Plan (1990-94), have clearly had the desired result. Between 1972 and 1992, the private sector's value of output rose from 2.08 billion dollars to 44.26 billion dollars. Industrial goods produced by this sector totalled 10.6 billion dollars, 2.6 billion dollars of which was exported. During the past decade, the private sector has contributed more to the country's gross domestic product (GDP) than has the oil sector. Also, the country has seen a decrease in imports, directly proportional to an increase in domestic production.

Saudi Arabia's thirteen industrial cities, comprising 90 million square metres, are managed by the Ministry of Commerce and Industry. Each industrial city has an on-site administration to handle the day-to-day needs of investors and oversee the site development process (SAGA, 2004). Figure 2.4 shows Riyadh Industrial Area. The researcher aims to implement the prototype of the proposed system here.

About 90 % of enterprises in the Saudi Arabian manufacturing sector are small and medium enterprises (SMEs) and their share in the total employment in the manufacturing sector is 54 % (International Finance Corporation Report, 2001). For this reason, long-term programmes targeting SMEs are expected to be very beneficial in instituting the principles of sustainable development. Efforts to help SMEs to acquire environmental management systems will constitute one of the milestones of 'sustainability' in Saudi Arabia.

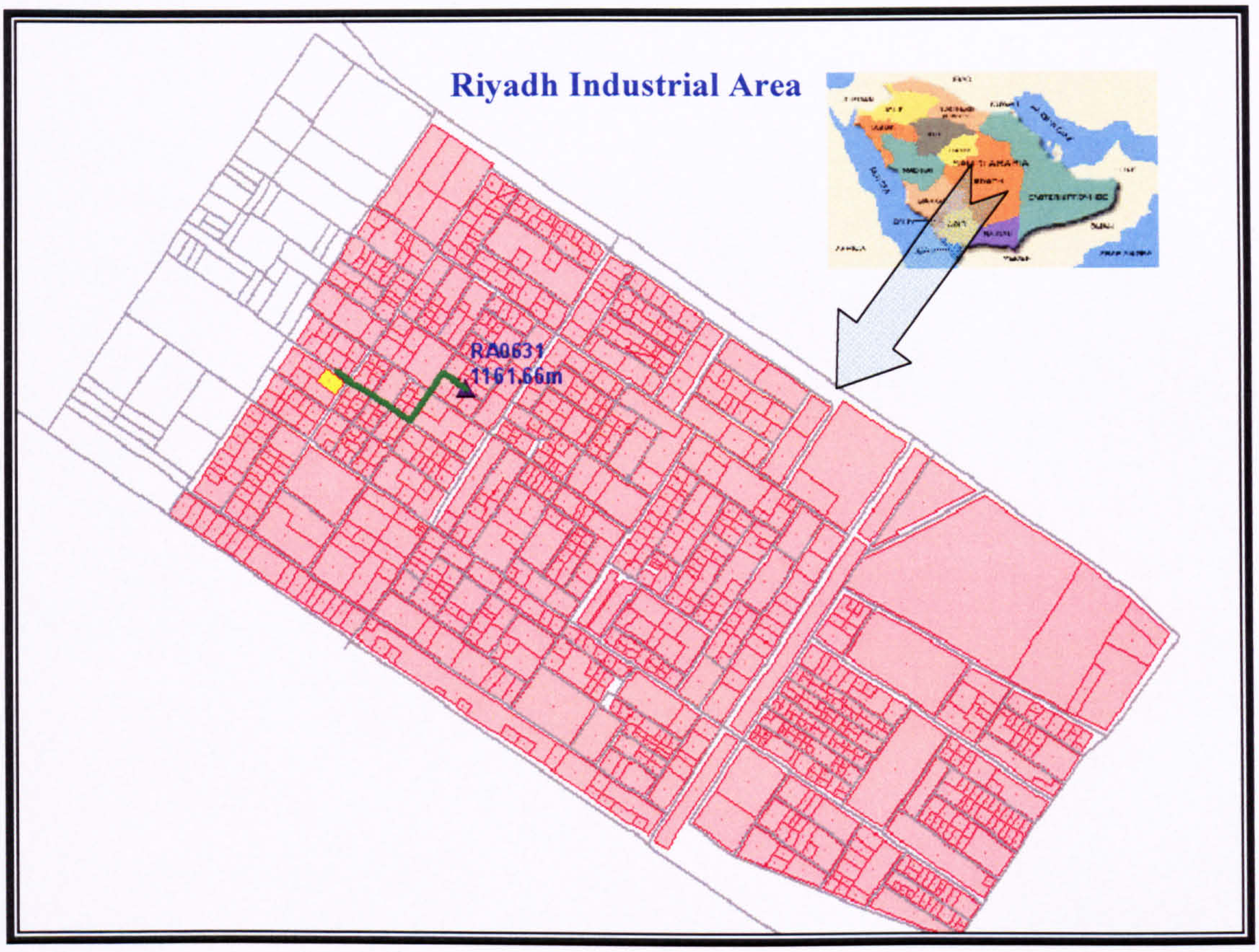


Figure 2.4 Riyadh industrial area

2.7 Summary

This chapter has provided a review of the adoption of ICT in disaster management. A definition and the phases of disaster management and emergency plans have been discussed. The chapter has also given an overview of the current information flow between the Civil Defence department and the Industrial Sector in Saudi Arabia.

Some background information was also offered about Civil Defence and the Industrial Sector in general in Saudi Arabia in order to give a clear picture about the current information management between these two sectors; a brief description of some of the main information services was supplied.

The next chapter discusses the literature review of this research.

3.1 Introduction

This chapter aims to review the relevant developments regarding information infrastructure and network applications for the adoption of ICT in disaster management. Clearly, studies which consider ICT services in disaster management are most relevant to this work and therefore a large percentage of the literature reviewed here has concentrated on this area. The development of ICT in disaster management in both developed and developing countries is reviewed and there then follows a discussion of disaster management issues in such countries. ICT in Saudi Arabia currently and in the future is then considered, with more attention being paid to ICT in disaster management.

3.2 The Development of ICT in Disaster Management

Information and Communication Technologies (ICTs) are well recognised as tools in disaster management and the effectiveness of ICT for the management of natural, human or technology-induced disasters has been unquestionably established. Hak-Su (2002) reported that harnessing modern technology and increasing regional cooperation in disaster preparedness could save lives and help prevent property damage. Many lives could be saved and tragedy mitigated, if effective disaster management measures were undertaken.

Disasters are a tragic interruption of the development process. Lives are lost, social networks are disrupted, and capital investments are destroyed and, when development plans are laid and disaster strikes, development funds are diverted to the emergency. Menon (2003) defines disaster management as the process by which the uncertainties that exist in potentially hazardous situations can be minimised and public safety maximised. This is achieved through a range of strategies from hazard management and prevention to speedy restoration of the affected community.

With ICT penetrating into all disciplines, the management of information and knowledge is becoming more efficient, cost effective and almost in real time. ICT applications, such as the design and development of databases, relational database management systems, management information systems, decision support systems, expert systems, knowledge bases, simulation models etc, make disaster management more effective.

Another major breakthrough of information technology applications in disaster management is the design and development of Geographical Information Systems (GIS) which permit the development of base maps with district boundaries, village locations and their access to critical infrastructure like primary health centres, blood banks, hospitals, police stations, fire brigades, transport depots, etc. This facilitates more efficient decision-making, policy analysis and problem solving both during an emergency and during normal times (Esri, 2003).

The developments on the World Wide Web and the Internet have opened up the possibility of creating Web sites for specialised institutions which work in various domains of disaster management. The potential of the Internet and the World Wide Web has been tapped by specialised institutions in the developed countries, allowing people to browse the content on their sites.

Even in developing countries, the details of disasters are now available almost instantaneously on the World Wide Web due to the user-friendly tools available for web hosting and uploading content. In each specialised discipline, there are user networks and list servers that allow the exchange of information across the world on a real time basis.

In recent years, however, the developed communities have been making links between disasters and development. Disasters impact on developing countries in other ways than on developed countries. Disaster losses include, not only the shocking direct impacts, such as the loss of life, housing and infrastructure, but also indirect impacts such as the interruption in the production of utility services, transport, labour supplies, suppliers, or markets. Secondary losses include impacts on such macroeconomic variables as economic growth, the balance of payments, public spending and inflation (World Bank, 2004).

This has created a growing realisation that, in addition to post-disaster relief and recovery measures, greater attention needs to be focused on pre-disaster measures to prevent negative impacts from hazard events and to be better prepared for those that cannot be prevented. As the future is characterised by limited predictability, pre-disaster mitigation approaches face considerably more uncertainty than do post-disaster approaches that react to situations as they unfold. Pre-disaster management is risk management and risk management has three components: risk identification, risk reduction and risk transfer.

This section provides a brief overview of current practices and the perceived benefits of ICT applications in disaster management in both developed and developing countries.

3.2.1 ICT in Disaster Management in Developed Countries

In developed countries, demand for ICT products and services comes predominantly from manufacturing industries, the government, the telecommunications industry, and the financial services sector.

ICT can make a valuable contribution to sustainable disaster management by improving monitoring and response systems and enabling the more efficient use of resources. The scarcity of relevant and reliable information has always been a substantial obstacle to more effective disaster management. Used to collect, process and disseminate information, ICT enables a better understanding of issues, such as hazardous materials incidents, and helps to monitor ecological conditions so that prevention and mitigation measures can be activated (UNDP, 2001).

The Health and Safety Executive, for example, indicates that in the United Kingdom, about five accidents per month involve exothermic runaway reactions, of which approximately 45% occur in batch or semi-batch reactors. Each accident in a chemical plant resulting from a thermal runaway produces a chain of undesired direct consequences to the population, the environment, the chemical facilities and the product. In addition, but no less important, are the consequences to the process itself and to the commercial strategy of the global chemical industry. Since 1976, the year of the Seveso accident, the European chemical industry is experiencing increasing social and environmental pressures. The population is particularly sensitive to any environmental or safety problem associated with activities with which they are not very familiar (Etchells, 1993). Thus, the prevention of runaways and their consequences has the highest priority for the chemical industry (Barton & Nolan, 1992). Because of this, an important number of chemical companies, both small and large, universities, and research centres have created the thematic network, *HarsNet*, financially supported by the European Commission (Nomen & Sempere, 2000).

As mentioned above, the European Commission has funded the *HarsNet* project, focussing its effort on the safety of chemical plants, especially the small ones and on those that cannot afford many of the required studies. The acronym *HarsNet* means the thematic network on hazard assessment of highly reactive systems. This kind of thematic network is a platform to exchange and create knowledge that joins specialists in a specific field, in this case experts from the European research environment and industry. The importance of *HarsNet* is highlighted by the number of partners: 26 from 11 countries in the European Union. Also, approximately 60% of the chemical industry participates and *HarsNet* also enjoys economic support from the European Union. The main objectives of *HarsNet* are:

- To examine, establish and develop knowledge about the hazard assessment of reactive chemicals in order to ascertain recommended techniques and methodologies.
- To exchange knowledge and transfer technology in order to develop techniques and methodologies for hazard assessment. These should be able to be applied step by step and should be designed to reveal the occasions on which more sophisticated tests should be performed by external laboratories or specialised experts.
- To promote the co-ordination of research amongst the participants, identifying complementary areas and synergies.
- To define and to execute a strategy of technology dissemination and transfer to the chemical industry, including the possibility of introducing the subject of thermal hazard assessment into the curricula of chemical engineering courses.

The *HarsNet* Forum contains two subsections: the *HarsBase* and *HarsGuide* that together cover all the work and exchanges carried out inside the network. *HarsBase* is made up of two main areas. The first is a series of links, all of which have very rich resources on risk assessment and safety analysis. Through these links, information about material safety data sheets, list of accidents that have occurred in the past, as well as the main available literature (books, journals or handbooks) can be accessed. A second area contains a commented list of instruments available in the market for data acquisition. *HarsGuide* was recently changed to *HarsBook*. This consists of a guide for experts and is the "state-of-the-art" for hazard evaluation methodology accepted by the whole consortium of experts. It is written for those who are knowledgeable in this field of work and is an internal working document available for the exclusive use of the *HarsNet* partners.

The European Commission, Directorate-General III funds the High-Performance Computing and Networking for Information Management and Decision Support (HITERM). It supports risk assessment and planning, emergency response training, and eventually emergency management. It involves participants from Austria, Italy, Portugal, Switzerland and Germany. The project aims at reaching better than real time performance for the simulation of accidental release of hazardous substances into the atmosphere, or into ground and surface water. This information is used in the framework of on-line decision support and advisory systems (Lux, 1997). HITERM is based on a client-server architecture that links easy-to-use front end (clients) with powerful high-performance computing and networking (HPCN) as the main server. The basic architecture of the system is organised around a central HITERM server that coordinates the various information resources, including the HPCN components, such as parallel computers or workstation clusters, for better-than-real-time simulation of demanding models, potential links to monitoring equipment, and user interface clients (HITERM, 2002).

Software tools for risk analysis and risk management within HITERM can be grouped into a number of categories:

- Simulation models
- GIS based tools
- Decision support tools
- Different tools and their compatibility with different development environments (languages, libraries, data formats)
- Different platform diffusion
- Tools, libraries, data bases and information sources
- Communication protocols and networking.

Figure 3.1 shows the basic architecture of the system, organised around a central HITERM server. Within the framework of High Performance Computing and Networking (HPCN), HITERM aims at expanding the application of HPCN to offer decision support in new domains. The central focus is the interface between technological risk management and the environment, providing a complex and demanding testing ground. This information is used in the framework of on-line decision support and advisory systems for:

- The adaptive routing of hazardous transports, integrating environmental risk criteria with other road information;
- The support of emergency management tasks (and related staff training) for transportation accidents involving hazardous substances and for hazardous installations, as foreseen by the amended Post-Seveso Directive (82/501/EEC, 87/216/EEC, COM (94) 4).

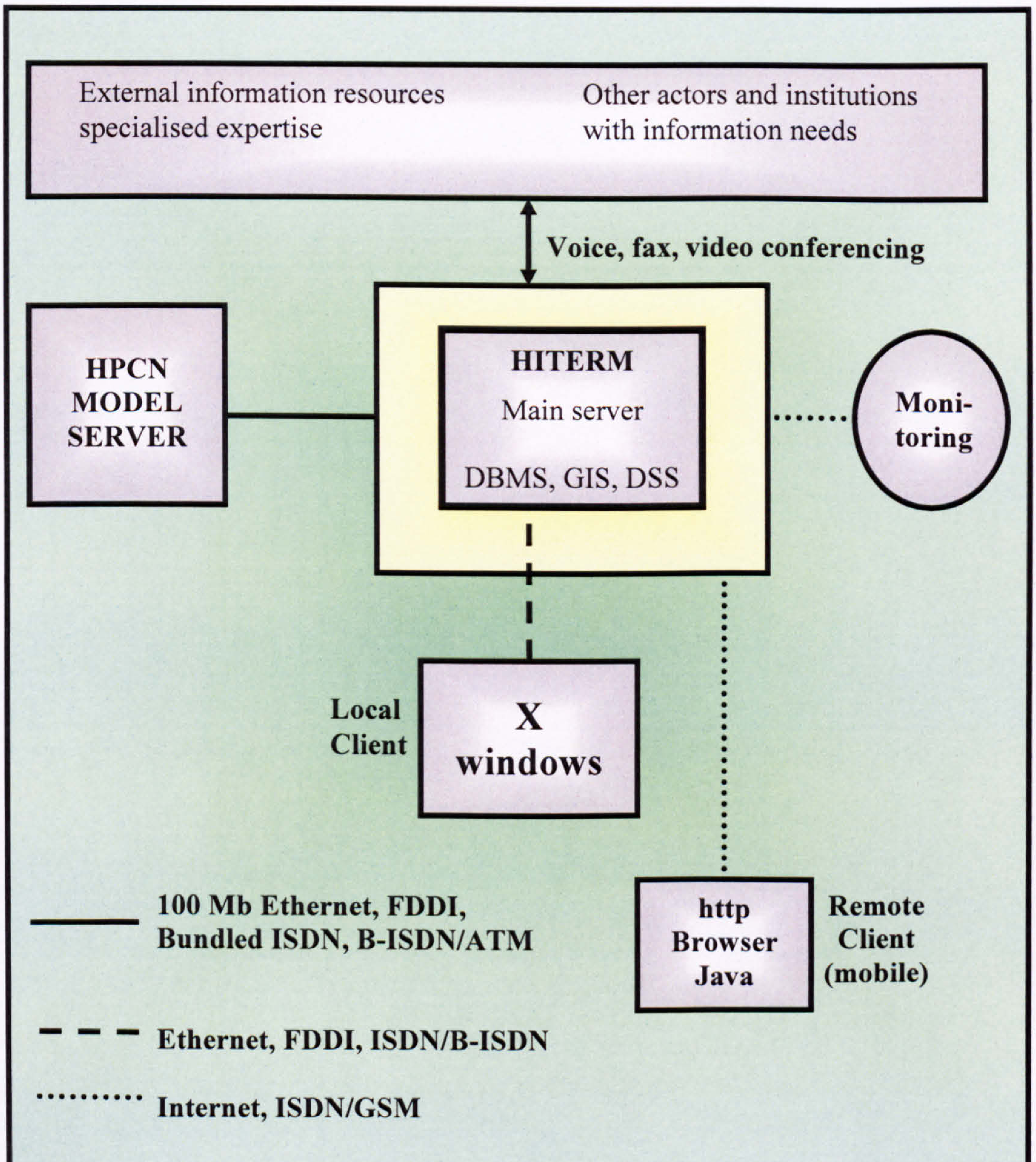


Figure 3.1 The basic architecture of the HITERM server

The main objectives of HITERM are to design and develop HPCN methods and tools for time-critical environmental applications that are related to technological risk and emergency management. A prototype system, based on client/server distributed parallel computing, was produced for the on-line adaptive routing and safety analysis of hazardous transports. This includes dynamically updated environmental risk criteria and the simulation of accidents (release scenarios of hazardous substances) for the support of emergency control measures and staff training for emergency management, both for transportation accidents and Seveso-class chemical process and storage plants.

The project consortium includes:

- An Subject Matter Experts (SME) (Environmental Software & Services (ESS), Austria) specialising in environmental information and decision support systems, model and GIS integration, and multi-media user-interface design;
- An SME consulting group (SYRECO, Italy), specialising in risk assessment for the chemical process industry;
- An information technology SME (LNEC Informatics, Portugal), specialising in data communication and distributed applications, in collaboration with FCCN (Foundation for National Scientific Computing), the Portuguese National Foundation for Scientific Calculus and its supercomputing group as an associated partner;
- A major industrial end-user, PETROGAL, (the largest Portuguese company) that operates a large number of chemical installations and more than 200 vehicles for the transport of hazardous goods (about 5,000 tons on the road at any point in time), with an annual mileage of about 15 million kilometres;
- A large national research institution with considerable experience in high-performance, parallel computing and environmental applications (GMD: the German National Research Centre for Information Technology);
- And a Swiss consulting group, specialising in transportation safety, with considerable experience in transportation telemeters, and a large set of

application projects (ASIT: Safety and Information Systems in Transport Ltd., Switzerland).

The Radio Data System (RDS) for FM broadcasting was first specified by the European Broadcasting Union in 1984 (RDS, 2000). It has been used in most European countries since 1987, with some modifications in 1990. Digital codes are transmitted at 1187.5 bits per second on a sub-carrier that is added to the stereo multiplex signal (or monophonic signal as appropriate) at the input to the FM transmitter. On appropriate receivers, the codes can be displayed showing the station name, programme information, precise time, advertisements, paging messages, traffic conditions and emergency alerts. Furthermore, the codes can be used to turn on the receiver, set the volume, stop any tape cassette or CD, and issue a warning. Most FM radio stations in Western Europe transmit on RDS, and car radios with RDS functionality are available from 50 different manufacturers (Dietmar & Marks, 1998).

In UK, the National Chemical Emergency Centre (NCEC) provides information on the physical and chemical properties of chemicals (e.g. flammability, explosivity and oxidising properties); environmental and health effects; emergency response, including medical response (first aid), evacuation approaches and decontamination or clean-up and services for on-site assistance; emergency preparedness; risk evaluation management and communication; equipment development; and advice to other centres. The Centre is manned during regular working hours only. Emergency calls can be made, however, via the police and fire brigades 24 hours a day.

The Safety and Reliability Directorate provides the same services, gives advice to other centres and prepares case-studies. It operates during regular working hours only: from 8.30 a.m. to 5 p.m. (Monday to Thursday) and from 8.30 a.m. to 4 p.m. (Friday). Emergency calls can be made via the police and fire brigades 24 hours a day.

The Health and Safety Executive keeps an inventory of hazardous activities, a list of hazardous substances, and a list of all industrial premises identified to the Health and Safety Executive with details of their activities. In Northern Ireland, it is the

Department of Economic Development which keeps these lists and provides advice on health and safety matters; it also carries out inspections. Methods have been developed by the Health and Safety Executive to assess the consequences to people of major industrial accidents, taking into account all the main scenarios. Its qualified and trained inspectors inspect industrial installations.

The competent authority for the purposes of the convention is the Health and Safety Executive mentioned above. In the event of an industrial accident, it is the duty of the emergency services, the police, the fire brigade and the ambulance service to respond. The Health and Safety Executive provides advice as necessary to the emergency services and initiates investigation into the causes of the accident. Much of this work is carried out as a collaborative effort between the Health and Safety Executive, the Department of the Environment, industry and the Home Office (UNECE, 2004).

In France, The Ministry of the Environment and the Ministry of the Interior are responsible for the prevention of, preparedness for, and response to industrial accidents. The Industrial Environment Service draws up and monitors the application of rules relating to installations which are listed for environmental protection purposes and, to that end: (a) keeps inventories of hazardous activities and a register of experts on such activities; (b) develops scenarios for preventive, preparedness, and response measures for industrial accidents; (c) coordinates the activities of the regional inspectors of installations which are listed for environmental protection purposes; and (d) analyses hazards and industrial pollution and maintains the ARIA computerised data bank (Analysis, Research and Information on Accidents), these being functions of the Bureau for Risk and Industrial Pollution Analysis (BARPI).

At the local level, the prefect, the chief administrative officer of a district, is involved in the implementation of the preventive and response measures at this level. The Regional Bureau for Industry, Research and the Environment (DRIRE) assists the prefect in the implementation of preventive measures, and the Inter-ministerial Service for Civil and Economic Affairs, Defence and Civil Protection (SIACEDPC) assists the prefect in the event of an accident. In such an event, or if there is an imminent threat, the prefect requests assistance, in particular from the Operational Centre of the Directorate for Civil Defence (CODISC), which is under the supervision of the Ministry of the Interior. CODISC and the prefect of the region concerned receive industrial accident notifications. CODISC also acts as a point of contact for receiving and requesting assistance from other countries. General action plans, based on industrial risk evaluation, are prepared by SIACEDPC under the supervision of the prefect and in consultation with other local services, such as fire brigades, the police and DRIRE. Industrial sites with hazardous activities are covered by specific intervention plans which are implemented and led by the prefect (UNECE, 2004).

According to national legislation in Italy, the Ministries of the Environment and of Health are the central authorities responsible for the prevention of, preparedness for and response to industrial accidents. The regions transmit the results of safety report analyses to the central authorities, which supply directives and coordinate the activities relating to the law on major hazards of industrial activities. The prefect, the Civil Protection Department (Presidence of the Council of Ministers) and the Fire Service National Body (Ministry of the Interior) are responsible for the preparedness for and response to industrial accidents. The prefect, in cooperation with the local committee for emergency, prepares an off-site contingency plan for each hazardous activity and submits it to the Civil Protection Department. The prefect is also responsible for providing information to the public, including information on the possible risks from hazardous activities, preventive safety measures, the external emergency intervention to be undertaken, and public behaviour in the event of an industrial accident. Such information is also submitted to the Ministries of the Environment and of Health.

The Civil Protection Department organises rapid intervention in the event of an accident at national and local levels. The Fire Service National Body, in cooperation with the Civil Protection Department, takes part in emergency management and provides services for on-site assistance in the event of an industrial accident. Both these bodies are also responsible for planning and for the plant licensing of hazardous activities, equipment development and training. Two emergency systems deal with emergency situations in Italy.

The first one is called Handling Algorithms for Risk Evaluation in Industrial Activities (HARIA-2). This approach was set up for external emergency planning, analysis and response, taking into account, not only the physical phenomena, but also sociological aspects of the emergency. This is the main characteristic of the research project (Mazzini *et al.*, 2001). The methodology is transferred to a software package, which allows a fast simulation of various accident scenarios. It can also be used for training of rescue services and as a support to emergency decision-makers. The prototype has been developed on a commercial GIS platform (Contini *et al.,* 2000). It integrates all databases and models, including those simulating population behaviour and evacuation plans, albeit in a simplified mode. Emergency planning and management are the responsibility of the Public Administration, particularly that in charge of civil protection, in collaboration with the companies owning the dangerous plants. In Italy, about 400 plants are registered as hazardous installations according to article 5 of the Seveso Directive. The focus of the HARIA project is on emergencies that could arise in an area of a maximum of 20x20 km^2 around one of these plants, as a consequence of a major accident. In most cases, the area affected by the physical consequences of an industrial accident is expected to be smaller (a few km^2), but the social impacts can easily extend beyond the limits of the physical effects. Therefore the boundaries for the modelling of accident scenarios can be chosen case by case.

In Italy, the obligation to provide external emergency plans for industrial activities is the responsibility of the prefecture, while that of giving the necessary information to the public is the responsibility of the leader of the community. The objective of the HARIA-2 project is primarily to assist the implementation of this important public responsibility. In particular, HARIA-2 organises the information needed for the preparation of the emergency plan, the simulation of the physical evolution of an accident scenario, and the simulation of the efficiency and effectiveness of various rescue strategies. Essentially, the project aims at optimising the preventive and preparation phase of an emergency.

The second system is the Sistema Informativo Aziende a Rischio (SIAR). It is the information system in the Region of Piemonte that collects data on establishments which are covered by the Directive 96/82/EC (Seveso II). The aim of this Directive is to prevent major accidents involving dangerous substances and to limit their consequences for people and the environment. The SIAR Database contains up-dated information provided by operators in their safety reports, while the GIS component allows the visualisation of installations in their geographical context, characterising more sensitive elements, like main infrastructures such as schools, office buildings, hospitals, department stores and other locations frequented by the public (Ariano *et al.,* 2000). Operators are required to send a notification to the competent authority, reporting the quantities of hazardous substances involved, and then describing the processes, possible accidents and safety measures taken to prevent them. Also, the competent authority must ensure that the safety reports that are submitted are accurate and complete; they must organise a system of inspections in order to audit safety measures.

SIAR can be a powerful tool during ordinary activities and, in the case of accidents and in carrying out external emergency actions, it offers an up-to-date inventory and a quick exchange of information between different authorities (Ariano *et al.*, 2001, p.1). SIAR uses an Oracle database, containing all data provided by operators, and a GIS that allows the presentation and analysis of geographical data. It is possible to mark the establishments' locations on a map, showing features around them, such as residential areas, schools, hospitals, other locations frequented by the public and sites of particular natural sensitivity or interest. Links to mathematical models and software for consequence analysis promise interesting developments to manage emergencies in real time. Finally competent authorities could use SIAR to take into account the objectives of preventing major accidents in their land-use policies and to draw up external emergency plans.

From the synergy of these two components (database and GIS) there is the possibility of representing accidental scenarios using different themes for different effects (fires, explosions and toxic releases) and evaluating their impact on particularly sensitive receptors, such as hospitals and schools, which can be represented together with hazardous sources and calculated damage distances.

The Ministry of Housing, Physical Planning and the Environment in the Netherlands has launched an information system called XENVIS. The system is in daily operational use. It offers a national level GIS with linked databases for risk objects like Seveso-class chemical process plants; a hazardous chemicals database is linked to the plant's safety audits and risk evaluations. Models for the selection of transportation routes, tracing spills into surface water systems, and continuous and accidental atmospheric releases, support the risk assessment. Figure 3.2a-f shows an interactive java demo that illustrates the emergency response model integrated into XENVIS (ESS, 2000).

In the USA, the Chemical Transportation Emergency Centre (CHEMTREC) handles all types of chemical emergencies. Upon receipt of a call identifying an accidental chemical release, CHEMTREC provides chemical-specific emergency response information to the caller. CHEMTREC also obtains other information, such as the chemical(s) involved in an accident, the exact location of the incident, shipping information, information regarding the nature of the incident, and the name(s) of the shipper. CHEMTREC links the shipper or manufacturer of the product to the responders at the scene of the incident, in order to give responders the proper information to handle the incident safely.

The role of the National Response Centre (NRC) is to facilitate notification to all levels of government; to facilitate communication between federal agencies in the event of an accidental release of hazardous substances; to assist state and local governments, as necessary; to ensure that response actions protect public health and the environment; to provide resources and expertise when the magnitude of an accident is beyond the capabilities and resources available locally; and to ensure that responsible parties are held accountable for conducting appropriate clean-up actions and/or reimbursing the federal government for clean-up costs (NRC, 2002).

Figure 3.2a Regional Development

Figure 3.2b Hourly Monitoring

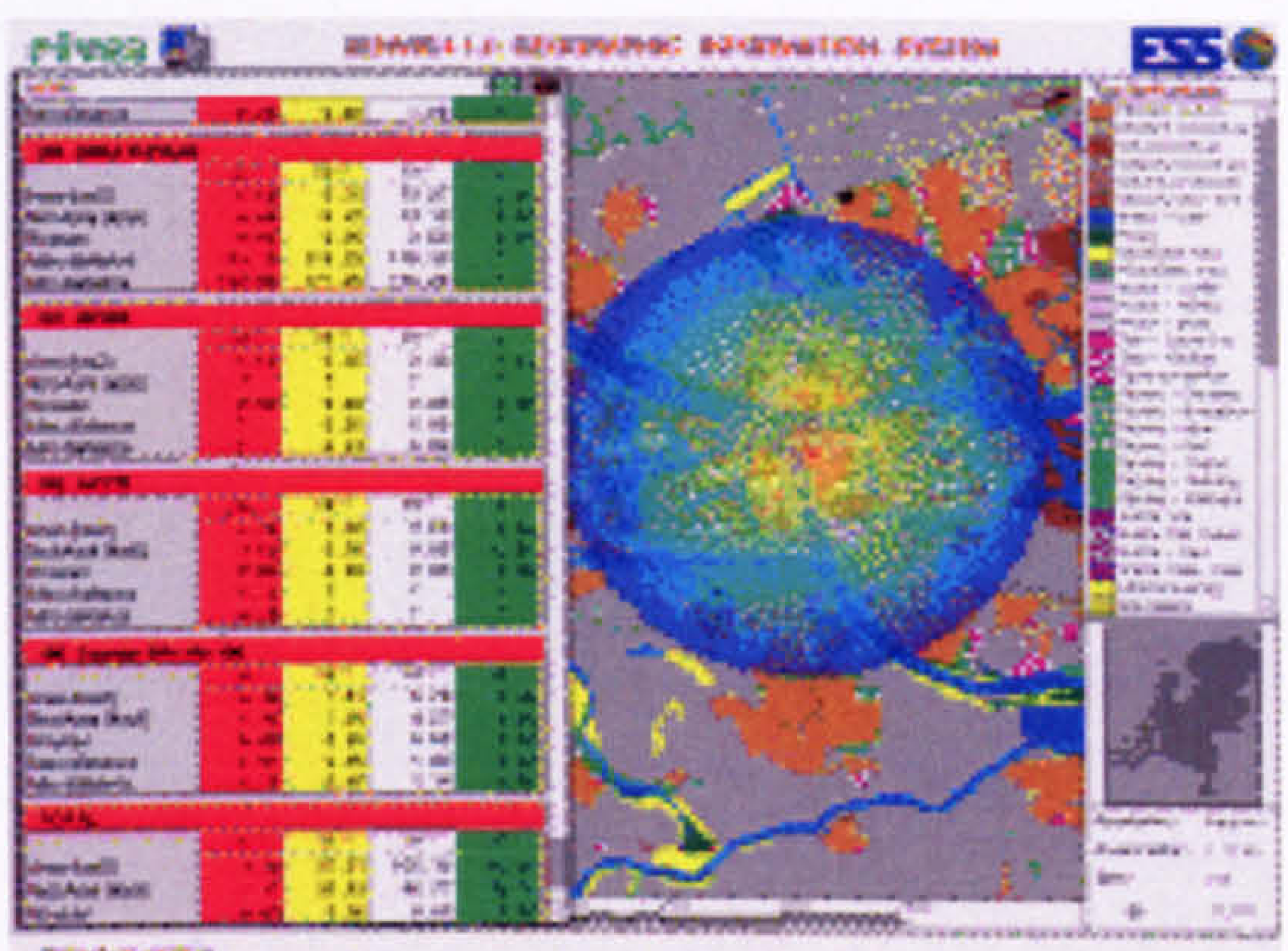


Figure 3.2c Accidental Release Models

Figure 3.2d Spatial Data

Figure 3.2e Accidental Release Boundaries

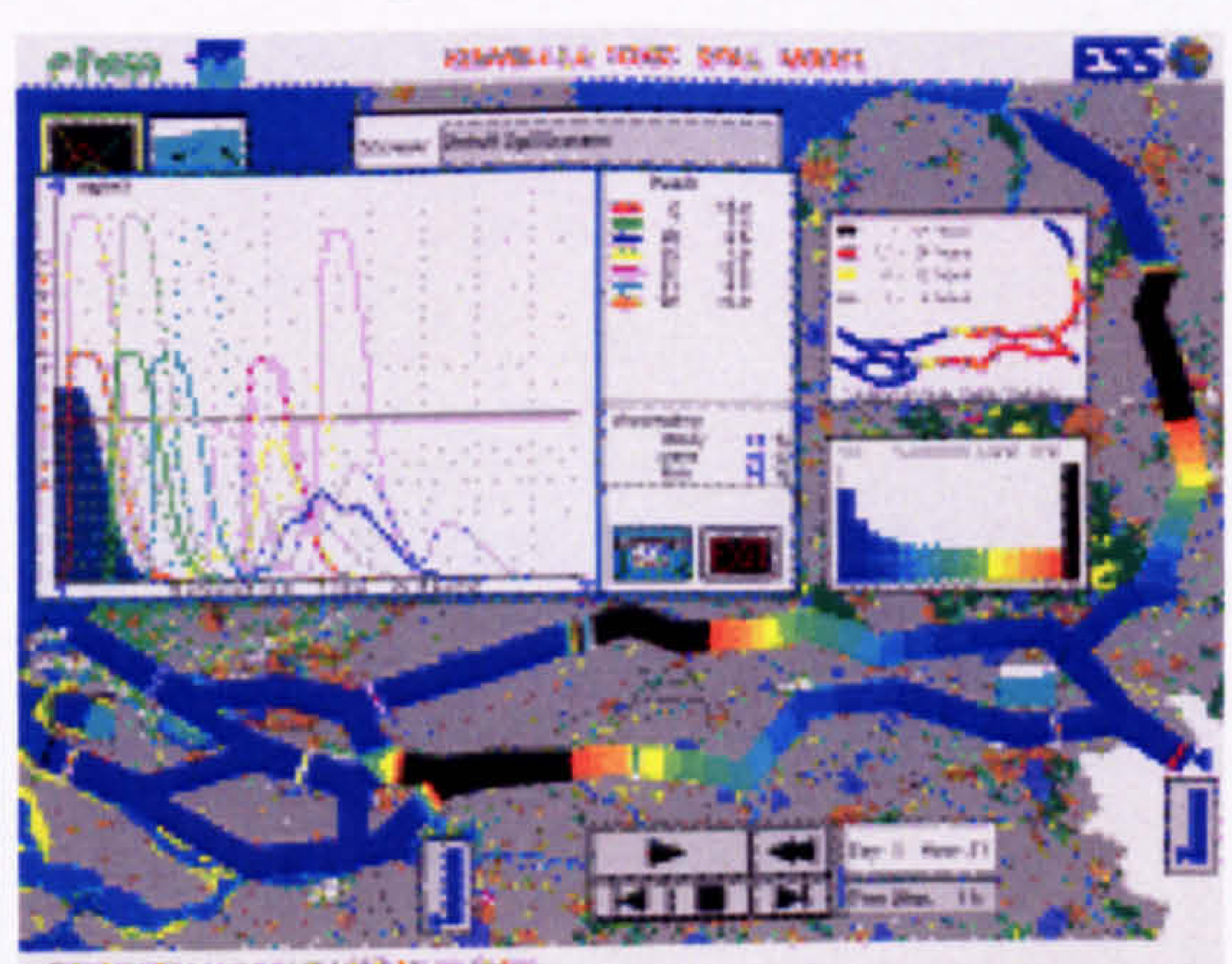


Figure 3.2f Accidental Release Analysis

The National Response Centre keeps a 365-day, 24-hour watch and processes approximately 15,000 calls per year. Telephone reports of incidents are entered into a computer database and immediately relayed to the predesignated On-Scene Coordinator (OSC). The National Response Centre is also the contact point for the

National Response Team (NRT) during a response. It provides facilities for the NRT to use when coordinating a national response action and provides emergency response support to the OSCs. Notification systems also exist at state and local levels (NRC, 2000).

The National Oil and Hazardous Substances Contingency Plan (NCP) outlines the National Response System. This is the federal government's mechanism for a coordinated emergency response to releases of hazardous substances. The NCP has three organisation levels: the National Response Team (NRT), Regional Response Teams (RRTs), and federal On-Scene Coordinators (OSCs).

The National Response Team's membership consists of 15 federal agencies. The Environmental Protection Agency (EPA) serves as chair and the United States Coast Guard serves as vice-chair of the NRT. One of the NRT's objectives is to strengthen and enhance coordination among members at both national and regional levels during a chemical incident. There are 13 RRTs, one for each of 10 federal regions, plus one for Alaska, one for the Caribbean, and one for the Pacific Basin. Each RRT keeps a Regional Contingency Plan (RCP). Like the NRT, RRTs are planning, policy and coordinating bodies and do not respond directly to the scene. The RRT, however, provides assistance as requested by a federal On-Scene Coordinator (OSC) during an incident. The federal OSC coordinates all federal containment, removal and disposal efforts and resources during an incident. The OSC is also the point of contact for the coordination of federal efforts with those of the local response community. The OSC has access to extensive federal resources, including the Special Forces: the Coast Guard's National Strike Force, EPA's, the Environmental Response Team, the Coast Guard's Public Information Assist Team, and Scientific Support Coordinators (UNECE, 2004).

The Department of the Interior's (DOI) bureaus and offices, based on its extensive land and resource management responsibilities, provide scientific expertise to Federal On-Scene Coordinator (FOSC) to help protect sensitive natural, recreational and cultural areas and resources and to facilitate environmental recovery. Expertise is also available in remote sensing; mapping (including GIS); surface and ground water contamination and contaminant transport; oil, gas, and mineral development; and oil spill response research and development.

The Emergency Alert System (EAS) is a joint government-industry response to a Presidential requirement to have the capability to address the entire nation at very short notice in the case of a grave threat or national emergency. At a national level, only the President or his constitutional successor can activate EAS. White House Communications Agency Trip Officers accompany the President at all times. At the direction of the President or his successor, they contact the Federal Emergency Management Agency (FEMA) to activate the national-level EAS. The EAS is the principal system that allows the President to address the nation during or immediately after a disaster. All stations are required to retransmit federal messages with appropriate priority. Industry participants in EAS include over 14,000 radio and television stations that were required to have EAS equipment by January 1, 1997. Currently, all radio and television stations and cable systems with 10,000 or more subscribers (and in 2002, all cable and wireless cable systems) are mandated by the Federal Communications Commission (FCC) to have EAS equipment and to issue national alerts and conduct tests (Bureau, 2001).

Future objectives of the EAS include:

- Continuing to study alternative ways (including new technologies) to disseminate Presidential messages to the public.
- Completing development of all State and local EAS plans
- Developing EAS educational and training packages such as video training tapes for government and industry personnel.
- Encouraging the development of new consumer devices using the EAS/SAME technology to alert the public of emergency situations.

The National Fire Data Centre (NFDC) administers a national system for collecting, analysing and disseminating information on fire and other emergency incidents to the fire community. The NFDC provides a national analysis of the fire problem, identifying problem areas for which prevention and mitigation strategies are needed. It is responsible for gathering, analysing and organising the publication and dissemination of data related to the prevention, occurrence, control of fire (NFDC, 2002).

The RDS standard used by European countries has been slightly modified by the National Radio Systems Committee (NRSC) in the United States, and is called the Radio Broadcast Data System (RBDS) (Wright, 1998). The main objectives of RBDS are to enable improved functionality for FM receivers and to make them more user-friendly by incorporating features such as program identification, program service, name display, open data application and, where applicable, automatic tuning for portable and car radios. The open data application allows for the retransmission of emergency information sent by the EAS. Unlike EAS, RBDS does not interrupt programming for all listeners, only for those with appropriate receivers with the warning function enabled (EAS, 2000). There are many commercial uses for the RBDS signal that might compete for bandwidth with emergency messages but would also provide payback for the small costs of implementing RBDS at the transmitter. Several hundred U.S. FM stations are using RBDS. Cadillac was the first U.S. automaker to offer RBDS receivers built in to some 1998 models.

There were more than 86 million wireless telephone subscribers in the United States in 1999 (The Business, 2001). Wireless telephones provide the capability to call a person rather than simply a location, but they also allow broadcast to all telephones within a cell or specific location without knowing which specific telephones are currently there. Individual cells are typically 10 miles in radius for analogue systems and only 3 miles in radius for digital systems. This unique ability to reach any mobile receivers within a specific cell at a given time makes wireless telephones an excellent method to deliver warnings to only those people at risk. This means, for example, that, as a tornado sweeps through a given community, people within the telephone cells at highest risk could be alerted (Working Group on Natural Disaster Information Systems, 2000).

The mission of the Agency for Toxic Substances and Disease Registry (ATSDR), as an agency of the U.S. department of health and human services, is to serve the public by using the best science, "taking responsive public health actions, and providing trusted health information to prevent harmful exposure and disease related to toxic substances" (Gosa, 2001). ATSDR's Hazards Substance Release/Health Effects Database is a scientific and administrative database developed to provide access to information on the release of hazardous substances from Superfund sites or from emergency events. It also contains information on the effects of hazardous substances on the health of human populations. Its goals are as follows (ATSDR Strategic Plan (2002-2007), 2003):

- To evaluate human health risks from toxic sites and releases and take action in a timely and responsive public health manner.
- To ascertain the relationship between exposure to toxic substances and disease.
- To develop and provide reliable, understandable information for people in affected communities and tribes, and for other stakeholders.
- To build and enhance effective partnerships.
- To foster a quality work environment at ATSDR.

Japan used to be troubled from disasters such as earthquakes. Although Toyama prefecture is known for its extremely low number of natural disasters, nonetheless it takes every possible measure to prevent them from occurring. Toyama has a number of advanced communication networks which function as an information core. These networks cover the entire country and help to ensure the safety of its citizens when disasters strike. The networks also vitalise local areas by giving them opportunities to send information to other areas (Commerce and Industry Planning Section of Toyama Prefectural Government, 2000).

As can be seen from the review presented in the preceding section, a number of technologies are in place in the developed countries. The suitability or otherwise of these technologies and methodologies to the Saudi scenario is discussed at the end of this chapter. In the next section, the application of ICT in disaster management in developing countries is reviewed.

3.2.2 ICT in Disaster Management in Developed Countries: The Issues

The first step in preparing a disaster management plan for any chemical process industry (CPI) is to identify and mitigate the conditions that might cause them. In practice, such a plan should start early in the design phase of the chemical facility and continue throughout its life. The objective is to prevent emergencies by eliminating hazards wherever possible. In spite of the advances made in knowledge and technology, failure-free design and devices have remained elusive. Even the most well designed and inherently safe chemical facility must prepare to control potentially hazardous events that are caused by human or mechanical failure, or by natural forces such as floods or earthquakes.

Boppana and Swaminathan (2000) indicated that disaster management in the chemical process industries is an integral and essential part of a loss prevention strategy. A good communication system, training and understanding of emergency procedures, regular interaction between government agencies and industries, education of the public, and a high level of availability of emergency equipment are the key areas for effective emergency preparedness. Regular drill exercises enable the industry and the various agencies involved in disaster management to have confidence that their task force will grow into an effective operational team and will be a positive expression of continuing emergency planning and analysis.

Mouginis-Mark *et al.* (2001) mentioned that disaster managers are increasingly using satellite observations for the mitigation, response and recovery activities associated with many different types of natural disaster. However, cloud cover remains an issue for optical sensors in many parts of the world and few unobstructed views of many areas prone to hazards exist despite the higher temporal coverage provided by the Landsat 7 and Terra spacecraft. However, some solutions have been suggested for this problem, such as using multiple Landsat 7 images to produce cloud-free mosaics. To retrieve the images and information is, however, very costly.

In the USA, after September 11 2001, the emergency services faced certain problems during their recovery efforts after the incident. Roper (2002), in his articles on the use of remote sensing systems in providing planning advice to support the ground operations at the World Trade Centre site and the related debris processing and disposal sites in the New York area, stated that:

> This was the largest most complex recovery effort of this nature ever to occur in the United States. Remote sensing was only a part of the total recovery activity but did provide important assistance throughout the recovery operation.

He recommended developing the infrastructure and updating the disaster management procedures, as well as developing the training skills of the staff.

To a great extent, the fire problem in America remains as severe as it was 30 years ago (FEMA, 2000). Nonetheless, today's fire departments, rescue squads, emergency service organisations and other first responders face expanded responsibilities and broader assignments than the traditional fire response and suppression. The primary responsibility for fire prevention and suppression and action with respect to other hazards dealt with by the fire services rests with state and local governments. Nevertheless, a substantial role exists for the federal government in providing funding and technical support.

The responsibilities of today's fire departments, as mentioned above, extend well beyond coping with traditional fire hazards. The fire service is the primary responder to almost all local hazards, protecting a community's commercial, as well as human, assets and firehouses are the closest connection government has to disaster-threatened neighbourhoods. Fire-fighters, who too frequently expose themselves to unnecessary risk, and the communities they serve, would all benefit if there was the same dedication to the avoidance of loss from fires and other hazards that exist in the conduct of fire suppression and rescue operations.

A reasonably disaster-resistant America will not be achieved until there is greater acknowledgment of the importance of the fire service and a willingness at all levels of government to fund adequately the needs and responsibilities of the fire service. The lack of public understanding about fire hazards is reflected in the continued rate of loss of life and property. Without the integrated efforts of all segments of the community, including city and county managers, mayors, architects, engineers, researchers...etc, as well as the fire service, there is little reason to expect that a proper appreciation of the critical role played by the fire service will materialise, in which case the necessary funding will continue to be lacking.

However, FEMA and the US Fire Administration (USFA) have not pursued many of the preventive measures authorised by the enactment of the Federal Fire Prevention and Control Act of 1974; Congress has not made available the funds necessary to carry them out; they have not been adequately advocated by USFA; and if implementation is the test, they have not been widely accepted by the fire service at large. In addition, FEMA has not applied to the fire problem those lessons which it learned with respect to other natural hazards, including earthquake, flood and hurricane and has failed to exercise all of its powers under the 1974 Act.

To tackle these problems, Congress should increase its involvement in fire loss prevention in America and exercise more fully its oversight responsibilities. Congress should also make available appropriate resources for the fire problem commensurate with those it provides to community policing or for highway safety.

FEMA should exercise its full authority and should apply the same prevention emphases and strategies to the fire hazard that it has applied to other natural hazards, the Agency's objective being an all-risk, multi-hazard loss prevention programme.

In Canada, risk information about on-site companies is far less developed. Denis (2001) conducted a study on the management lessons learned from disasters involving hazardous materials. She stated that, while large corporations are usually inclined to give out such information, depending in part on the restrictions due to competition, the major risks in the area involve small or medium-sized businesses and their fear of revealing the risks their operations represent for a community. In addition, they may fear feeling forced to take risk mitigation measures if the risk is known to the community. She argued that, in order to avoid such conflicts of interest, a mandatory process is the best option, as long as it is applied. This will ensure that the relationships between emergency services and those in factories or businesses at the time of a disaster will not be routine but will, at least, constitute a good effort.

In Japan, Ebisui (2004) examined the gaps between the civil services, current legislation, and practice in the public emergency services. The issues covered include (1) employment and human resource development (employment level, employment diversity and training, including gender issues); (2) working conditions; (3) occupational safety and health; (4) social dialogue and rights at work, covering both the content and structure of social dialogue; and (5) coordination in the public emergency services.

He suggested that this would result in enhanced communication between labour and management, as well as promoting a mechanism to tackle the issues which would be expected to arise upon implementing the emergency services. Furthermore, to deliver quality services, the fire services should be granted their demand for new technologies to provide personnel with the necessary skills and competencies to maintain a high degree of performance. High-level skills of in terms of education and training for fire personnel and fire brigade members are required.

3.2.3 ICT in Disaster Management in Developing Countries

In the Asian region, there is significant disparity in the communication infrastructure across countries and across different kinds of user groups. While there is a good deal of enthusiasm among the scientific and technical community to make use of emerging communication technologies to share real-time information as well as local knowledge and experiences, the decision-makers most responsible for managing disasters have to rely on rather conventional means of communication. Low bandwidth and a poor computing infrastructure pose serious constraints. On a national and regional level, this calls for conscious integration of emerging and conventional communication technologies (Yodmani and Hollister, 2001).

While disparities in communication infrastructure do exist, there is a lot of local innovation in the Asian region which needs to be harnessed and integrated with new technologies. The use of local cable television for Internet access, the use of phone booths for Internet kiosks in India, and wireless Internet access in Lao are some of the examples of local innovation that can be exploited for communications in disasters.

However, growing emphasis on the devolution of disaster management to community level and greater recognition of the effectiveness of community-based disaster management would require that the disaster management community looks into innovative approaches for the application of emerging communication technologies in disaster management.

While new communications technologies have made the sharing of knowledge and information much faster and more reliable, language is going to be a major barrier in the effective application of these technologies in the Asian region. Translation software does not yet address the needs of Asian communities. In the coming years, overcoming this language barrier will be a major challenge and will require a combination of high-tech, as well as more down to earth human-based systems.

In the section which follows, examples of the application of ICT in disaster management in Asia are reviewed. Particular countries discussed include Indonesia, India, the Philippines, Vietnam and Sri Lanka.

The National Disaster Management Coordinating Board (Bakornas PB) in the context of the UNDP has developed a program on Strengthening Disaster Management in Indonesia. This is called the Indonesia Disaster Management Information System (SIPBI). SIPBI is aimed at enhancing Bakornas PB's decision-making capability besides increasing and ensuring flows of reliable and up to date information on various disaster events and related disaster management measures. The main objectives of the SIPBI component are:

- To formulate concept and design,
- To establish operational mechanisms on a pilot basis at a national level and in four project areas,
- To standardise disaster management information/data,
- To formulate standard operating procedures for system operations,
- To facilitate the development of similar systems in other disaster-prone districts and provinces.

The scope of SIPBI's development includes the development of a computer networking system, a geographic information system (GIS), and a database for disaster management.

The GIS component aims at developing risk maps at national, provincial and district levels. Under this project, a number of modules are underway on forest fires, earthquakes, tsunami, volcanic eruptions and social unrest, for building a database system in an Internet mode (UNESCAP, 2002).

Bahasa in Indonesia has formed a community called Kompak. It is a forum for concerted national disaster mitigation organisations, and for research, training and community organisations in order to acquire a basis for common understanding and implementation of sustainable urban disaster mitigation. It is a part of the information and networking programme of the Indonesian Urban Disaster Mitigation Project (IUDMP) which itself is part of the country's ADPC's Asian Urban Disaster Mitigation Project (AUDMP). Kompak also aims at enhancing public awareness and preparedness through information dissemination and by building public and private networks as a forum for exchanging information and experience on urban disaster management. It has both an Internet-based communication network, as well as a newsletter, for communication among members. The Internet-based communication network has two components: an intranet and an extranet. The intranet is a restricted site to member organisations and individuals in Bandung, as well as national and provincial agencies, while the extranet is an open-access site for all, particularly NGOs, individuals and institutions in other parts of the country (AUDMP, 2003).

In India, the National Natural Disaster Knowledge Network (Nanadisk-Net) is being planned as a "network of networks". It has to be so because India badly needs a platform to facilitate an interactive, simultaneous dialogue with all the players dealing with natural disasters, major or minor, both in India and abroad. It will be a platform to facilitate an interactive dialogue with all government departments, research institutions, universities, community-based organisations and even individuals. The network will act as a digital library service and will facilitate access to global databases and early warning systems in a significant way. The Knowledge Network is designed to give a boost to technical cooperation among developing countries and to expand international relationships to include the exchange of information and the transfer of technology (Bhandari, 2000).

In the Philippines in 2000, the National Disaster Coordinating Council (NDCC) started to install an emergency management information system that will link up all their regional centres electronically and make available vital information to the public through the Internet. The new system will have four components: emergency reporting and monitoring, emergency logistics management, emergency fund management, and a geographic information system. The advanced geographic information display system has been established at the Philippines National Disaster Management Centre (NDMC) in Camp Aguinaldo, Manila. It is linked to all member organisations of the NDCC as well as the regional offices of the department of Civil Defence, which form the Secretariat of the Regional Disaster Coordinating Councils. The integrated database comprises spatial information, consisting of digitised maps, aerial photos and satellite data, while the non-spatial data on display offers a history of disasters, a demographic database, response teams and a directory of key contacts and resources. NDCC is also assessing the existing systems for early warning to identify areas for upgrading and enhancement (ADPC, 2001).

Vietnam's main disaster co-ordination body, the Central Committee for Storm and Flood Control (CCSFC) is located in the Department of Dyke Management and Flood and Storm Control in the Ministry of Agriculture and Rural Development. Its Standing Office, the SOCCFSC, is the agency with the main responsibility for monitoring the effects of storms and floods, gathering damage data, providing official warnings, and co-ordinating and implementing disaster response and mitigation measures. It relies on the administrative structure of the Dyke Department to carry out its disaster assessment, disaster reporting and emergency co-ordination duties. When a flood or storm occurs, the officials at district level are responsible for sending a district disaster assessment report to the provincial level officials who collate and verify them and then forward them to SOCCFSC. Personnel here, in turn, collate the provincial reports to produce a national damage assessment report.

To expedite the transmission of this information, SOCCFSC has set up a disaster communications system. This is an emergency electronic mail network that links provincial Dyke Department offices with the SOCCFSC. It has created a department-wide intranet, accessible both to central disaster management authorities and to officials in the localities in Vietnam. The intranet is regularly updated with essential corporate information and serves as a general reference tool for disaster managers in their day-to-day work (Rego, 2001).

Sri Lanka has established a disaster management information system called the Social Management Information System (SOMIS). The National Disaster Management Centre (NDMC) of Sri Lanka is developing a database which will incorporate various aspects of disaster management integrated with SOMIS; the software will be compatible to commonly used operating platforms (ADPC, 2001).

Overall, due to the rapidly changing nature of information technology and because of increasing international competition, alliances across national and regional borders have become an inevitable trend. According to the Global Information Infrastructure Commission (GIIC) (1995), while many Asian countries have made outstanding achievements in heir national information technology and information infrastructure, the Asian region as a whole still has a long way to go in achieving the levels of informatisation in Europe and America. Xinkui (GIIC, 1995) calls for a common and joint effort of all the Asian countries to work on an equal and symbiotic basis, helping each other out in terms of a National Information Infrastructure (NII) (Cordeiro & Al-Hawamdeh, 2001).

3.2.4 ICT in Disaster Management in Developing Countries: The Issues

Evaluation of the management of emergencies needs careful and wider attention. As the populations exposed to hazards increase world wide, and as risks multiply, there is more that needs to be known in order to manage such risks. Although some tools have been used for many years in developed countries, new approaches are needed for developing countries. Many developing countries are characterised by a weak central planning and management capacity, a lack of a strong, decentralised emergency response capacity, and by dependence on international organisations for a response. Robust tools that will work in this environment are needed (Burnham, 2001).

From a disaster management perspective, greater urban population density concentrates populations at risk. A classic example is the greater number of casualties that occur when an earthquake strikes an urban area, particularly when buildings are densely concentrated and building occupancies are high. In many developing countries, rapid urbanisation outstrips the development of an adequate public health infrastructure, predisposing populations at risk, such as the poor, women, and children, to human-conceived disasters like complex-emergencies (Burkle, 1999).

Masser (2004) summarised that disaster management is essentially a dynamic process that includes the traditional management functions of planning, organising, staffing, leading and controlling. Its main objective is the reduction of the effects of a disaster and it involves many organisations working together in one or more of the phases of the disaster cycle. Unfortunately, until very recently, disaster management was seen as the process of co-ordinating relief and reconstruction activities following an event. This has proved inadequate as these tasks yield only temporary results at very high costs. The consequences of natural disasters pose a major problem in developing countries; it is estimated that per capita losses of the Gross National Product (GNP) are 20 times greater in developing countries compared to those of developed countries.

The role of a GIS in disaster management should focus on the processing of interdisciplinary information to produce interactive products for decision-makers. The literature shows that two of the biggest challenges ahead relate to cost recovery of data production and its dissemination. It is essential to ensure that data providers recover the costs of data production, as well as making it possible to share and transfer both the raw and the interactive products amongst urban stakeholders by means of the Internet. The success of a disaster management plan depends, to a great extent, on informed decisions and therefore on the availability of accurate information presented in a timely and appropriate manner. In Armenia, for example, decision-makers had been provided with maps of hazard zonation, population density, urban growth and land-use, on which to base their decisions. However, as little attempt had been made to integrate the data sets, the implications of the information were not immediately visible, causing confusion and, in the worst cases, the formulation of inadequate policies.

A report from UNESCAP (2004) mentioned a number of factors that affect the efficacy of remote sensing and GIS. These are:

- Gaps in the quality of the product delivered and information content vis-à-vis the specific needs of the end-users down the line; the gaps in the case of floods and agricultural drought are listed in boxes 1 and 2 (some countries have their own airborne synthetic aperture radar (SAR) to address this gap);
- Not enough real-time information dissemination to end-users;
- Lack of institutionalization and inadequate organizational mechanisms to integrate space applications for decision-making by end-users.

Developing countries are often worst hit, socially and economically, by different types of disasters. A number of factors explain why developing countries suffer most. The key reason is that proper quantification tools and risk modelling techniques do not exist to explain why planning and management of risk transfer would benefit emerging economies vulnerable to natural hazard events. The second is a lack of insurance traditions in these countries. Finally, a central agency responsible for assessing, collecting and transferring risk is absent. Infrastructure is owned by the state, which must bear the costs of repair and reconstruction after a major catastrophe. The obligation of the government to pay for catastrophe losses would be less if a well-established insurance market existed that assumes partial responsibility for the damage to infrastructure.

In developed countries, dealing with risk retained by the government is often handled by a specialised governmental agency, such as the NCEC in the UK or the NRC in the USA. In developing countries, however, most risk arising from disasters is borne by the central government since no specific government agency exists to pay for the cost of catastrophes.

The details of disasters are now available almost instantaneously on the World Wide Web due to the user-friendly tools available for web-hosting and uploading content on the net. In each specialised discipline, there are user networks and list servers, which allow exchange of information across the world on a real time basis. The greatest problems regarding information networks are financial support and developing sufficient skills for their staff in using and dealing with these networks efficiently (World Bank, 2004).

3.2.5 ICT in Disaster Management: Conclusion

The 21st century has begun to see the convergence of technologies and the consequent process of globalisation. Information and Communication Technology (ICT) has been instrumental in speeding up the process of economic growth. Future societies will be knowledge-based and ICT will revolutionise products, processes and services. In order to reap the benefits of ICT, it is essential that people should be able to absorb technology and enhance their knowledge generation capabilities.

ICT is a tool: it cannot improve conditions or create systems by itself. ICT has to be linked with efforts to improve programs and systems, whether in education, business, health or government. Like other systems or equipment, ICT needs a complete life cycle designed for sustainability. People should be trained to be responsible for the proper operation and maintenance of ICT systems, otherwise these systems will fail and will prove costly to restore. What works in developed countries may not necessarily work in developing countries. Like all other development tools, ICT will have to adapt and fit properly within the environment in many areas, including language, user training and capability levels, and culture, in addition to its having sufficient financial support. If the objective is to change or improve the existing environment of which ICT will become a part, then a comprehensive change management process is needed for the proposed system to have a chance to succeed.

Disaster management is nothing but the employment of skilful ways and methods to control a disaster. Disaster management techniques or methods are based on the economic status of the country and hence these vary from country to country. Any disaster management technique involves a certain amount of investment. Hence, the process of managing disasters and thus increasing safety, involves a balancing act between the cost of reducing the risk of a disaster and the benefits arising from the amount of risk reduced. Thus, developed countries manage disasters better than developing countries.

However, while the widespread adoption of ICT in developed countries has brought productivity benefits, this is still largely to materialise in the developing countries. Part of the problem may be that the adoption rates have not reached a threshold that will allow this yet.

3.3 ICT in Disaster Management in Saudi Arabia

In the past thirty years Saudi Arabia has witnessed huge developments in ICT and in all aspects of its economic, industrial and social life. Therefore, computers and communications systems have become the cornerstone of progress in both the public and private sectors. From the early years of its development plans, the Saudi government has spent billions of pounds to build and improve its national infrastructure in the fields of computing and telecommunication. The official Saudi policies and development plans were designed and implemented to facilitate and promote the adoption and application of knowledge, skills and information technology (Ministry of Planning, 2000).

In addition, the Saudi government has encouraged public and private organisations to utilise Information and Communication Technology (ICT) systems to facilitate and improve the efficiency and effectiveness of their functions. The government's encouragement has been accompanied by huge investments to build national computer and information centres. Saudi Arabia is now among the most advanced users of information technology in the world (IMS, 2003), and yet it is still considered to be a developing country, regardless of the fact that it is one of the richest developing countries. However, Siddiqui (1997) reported that, although Saudi Arabia is still relatively young in terms of implementing ICT systems, it has become an active player in recent years. ICT policy in Saudi Arabia is based upon the assumption that the application of ICT leads to higher productivity (KACST, 2001). Therefore, most organisations have introduced ICT in some form or another to support and improve the efficiency and effectiveness of their operations.

The Internet is an international network of organisational, national and regional computer networks around the world linked up to exchange information. It is an invaluable business tool for everyday communication, marketing products, providing support, inviting customer feedback and for publishing. Approval was given in 1997 for KACST to introduce the Internet into the Kingdom of Saudi Arabia, and to make it available to research establishments, academic institutions, and both the public and private sectors. The preparation of organisational procedures by KACST with co-operation and co-ordination from STC was attained, and the Internet was launched in January 1999. The project was expected to be finished by the end of 2000 but was a little late in its completion. Now all regions in Saudi have embraced the Internet.

The Internet offers a number of benefits to organisations. This is confirmed by many researchers and writers such as Shikhar (1998) and Fishenden (1997). Organisations that adopt the Internet can use its systems to:

a. Build direct connections to customers;
b. Personalise interactions with their customers;
c. Build customer loyalty;
d. Deliver new services;
e. Bypass intermediaries;
f. Speed up business transactions;
g. Cut the costs of marketing, sales and advertising;
h. Receive revenue faster than by some traditional methods.

KACST and the Saudi Telecommunication Company (STC) provide the official regulatory and technical requirements for Internet services in Saudi Arabia. The STC was directed by the Ministers' Council to enhance its telecommunications infrastructure to meet the expected demand for Internet services. STC will be the gateway for this service and provide the international connection to big international ISPs. According to the official arrangement, STC is supposed to provide the necessary physical infrastructure while KACST will be responsible for providing the know-how and the technical support to government agencies wishing to have their own space on the Internet. Monitoring access to the Internet services will also be the responsibility of KACST.

The Internet project has been completed but suffers from a number of problems (technical, financial, and organisational). KACST and STC are responsible for developing and implementing the necessary standards and specifications for the computers and the software that will be connected to the Internet. They will continue to lead the development of the Internet in the Kingdom to provide eventually a service that will become a benchmark in the developing world (KACST, 2001).

The Internet service indices in 2002 indicated that the number of Internet subscribers was 1,250,000 (5.7% of the population). The number of personal computers in the year 2002 totalled around 1,425,000, a percentage that is roughly 6.5% of the total population. The government has also encouraged the private sector to provide communication services, and four companies have been recently been licensed to provide Data Internet Service via Satellite (VSAT) services. The number of local information technology companies rose to 1650 in 2003. This clearly indicates that there is an increasing need for information technology products and that the local market is ready to absorb such products (MCIT, 2004).

In 1977, the Saudi government also established the Ministry of the Interior's National Computer Centre to help the Ministry improve its administrative, public and national security functions, and to manage vital and sensitive information (Al-Turki, 2001). The system is called the Saudi Arabian Ministry of the Interior System (SAMIS). It is a facility of several hosts connected to hundreds of terminals throughout SA. In parallel with the establishment of this centre hundreds of Saudi high school and university graduates were sent to the USA for training and education courses to prepare them to run and maintain this centre. This researcher was one of these students who were sponsored through this project.

The Ministry of the Interior's computer centre is considered the biggest of its kind in the Middle East; it has about 10 branches scattered in the main Saudi cities and covers the whole geographical area of the Kingdom. Some of SAMIS' active systems are:

- The Traffic System, which keeps records of all vehicles, driving licences, drivers, traffic accidents, and other related information in SA.
- The Civil Affairs System, which keeps records of the births, deaths, and personal data of citizens.
- The Immigration and Passports System, which keeps records of all Saudi citizens' passports, and expatriates' registrations and stay permits. This system is also used to keep records of people entering and leaving the country.
- The Criminal Records System, which keeps detailed records of all criminal incidents in the country. This system also contains the Finger Prints System.
- The Administrative and Financial System, which is used to improve the Ministry's administrative functions.
- The Arms Registration System, which is used to keep records of all arms sold and licensed in SA.
- The Provinces' Governments System, which is used to help run Saudi provincial government.

Today, most Saudi public organisations have computerised many of their functions and are equipped with the latest hardware and software systems available for their type of business. This is why about 70% of the mainframes and about 40-50% of the microcomputer installations are in public organisations (Al-Turki, 2001).

3.3.1 National Network Development in Saudi Arabia

The Saudi government started to plan for a national network infrastructure in the mid-1970s when it decided to establish a central campus site to support research and development (R&D) projects in Saudi Arabia. Because of the vast amount of information and the difficulty of handling it in the traditional way, the Saudi government established the Saudi Arabian National Centre for Science and Technology (SANCST) in 1977 as an independent organisation supporting science and technology. In 1985, SANCST was renamed King Abdulaziz City for Science and Technology (KACST) and its responsibilities were expanded to include its involvement in developing a national network infrastructure in Saudi Arabia. It was expected to be responsible for the formation of national science and technology policies, for the support and encouragement of scientific research, and for the coordination of the research activities of other organisations.

Since its establishment, KACST has provided very important academic and research services to the academic community in SA. Furthermore, KACST has established some units which deal with environmental hazards as part of the national development plans. These units are:

(a) Radiation Protection Unit

The unit undertakes all responsibilities in relation to protection from radiation hazards in SA. It has a database which contains all sources of radioactive substances in SA and details of all workers and experts in the field of radiation. This database is used as part of the national radiation emergency plan.

(b) Radiation Monitoring and Early Warning Unit

The responsibility of this unit is continuously to monitor radiation levels in all cities and border areas of Saudi Arabia. During radiation incidences, the unit will receive an alarm from its system, which will start to deals with hazards and call for assistance from responsible departments and organisations.

(c) The Seismic Observation Unit

The seismic observation unit contains 23 substations for the observation of earthquakes. These sub-stations are distributed in different areas in Saudi Arabia but especially in the Arab armour area. Twelve seismic observation sub-stations have been completed (five in the Tabuk area, five in the Gizan area and two stations in Riyadh). These stations are connected by circuit telephones to the information analysis centre in KACST and are helping in seismic observation via the national network. This network depends on the new digital technology to achieve greater accuracy when dealing with hazards.

The sub-stations obtain electrical power from solar cells in each station and send information hourly through specific telephone lines. An advanced analysis centre, which undertakes the reception and analysis of information, was established in KACST. As an addition, five digital stations have been completed in the Al-akabba

Gulf area so that the total number of national network stations now comprises 40 subsidiary stations.

The national network for the observation of earthquakes is one of the newest national networks and is situated in the east. This network consists of thirty two sub-stations, which supply the centre with immediate information about the daily seismic activities in all areas of the world, as well as in the Middle East area with a concentration on the Arab peninsula. The unit uses telephone circuits, transmitters and reception devices. They have three mainframes with a UNIX operating system and reception devices linked to seismic databases. This system helps to control and mitigate seismic hazards.

(d) National Net

The National Net connects KACST with governmental and non-governmental institutions to make use of the databases available within KACST. It is also connected to certain countries and international institutions via GULFNET; this will be replaced with an Internet connection in the near future (KACST, 1994; AL-Zoman & Al-Bader, 1998). In addition, KACST has developed KACSTNET as a national data communication network to provide scientific and technical information for researchers and the academic community in the Kingdom. KACSTNET is a dial-up service that connects many research institutions and libraries in SA with the KACST computer which is linked to the computers at the National Computer Centre (NCC) in Riyadh through a leased line.

KACST has developed its own communication and information systems through Sun SPARC 2000 using the UNIX operating system. According to KACST officials, PASSTHRU software allows users of the KACST computer to communicate with NCC computers as if they were locally connected to that system (KACST, 1994). In addition, KACST has established the Electronic and Computer Research Institute, which conducts and sponsors research and studies relating to the application and development of IT. The research institute consists of the following units: The Programming Unit, the Electronic Equipment Unit and the Communication Unit.

KACST is the host site for GULFNET and BITNET and the most recently adopted Internet services in SA. This will be discussed in the next section. GULFNET is a store-and-forward network and not a distributed processing facility. It was used during the 1980s and 1990s by many universities in Saudi Arabia, Kuwait and other countries in the region to transfer files, text, data and programs (KACST, 1994). GULFNET's main purpose was to provide academic and research facilities, as well as services, to stimulate research co-operation between Saudi academics and their counterparts in the region and around the world (KACST, 1989).

Because of the growing role of ICT in the nations' economies, Saudi Arabia has given it top priority and has carried out some drastic changes. Considering the great importance which the sector of communications and information technology holds for progress and development in Saudi Arabia both at present and in the future, a number of significant initiatives have been launched in this domain since last year. The most prominent of these initiatives include the following (MCIT, 2004):

- Establishing the Ministry of Communications and Information Technology in 2003.
- Establishing the Communications and Information Technology Authority in 2003.
- Establishing the Industrial Cities' and Technology Zones' Authority in 2003.
- Approving the Electronic Government Programme by virtue of a Royal Decree in 2003.

A report from MCIT (2004) mentions that the number of local information technology companies rose to 1650 in 2003, making an average annual growth rate of 37% during the last five years. This clearly indicates that there is an increasing need for information technology and its products.

3.3.2 Disaster Management in Civil Defence

The primary responsibility of the Civil Defence department is to save lives and protect the property of the people. When accidents happen, the Command Centre receives an emergency call informing it of about the type, place and time of the accident. The Command Centre, after gathering data, will immediately pass the information to the most suitable fire brigade. The fire brigade officer will then direct his team to manage the accident. The effectiveness of these officers depends on experience, training and skill. In the case of large accidents, a Command Centre operator will make an emergency communication to send out more than one brigade and emergency team.

Because fire departments are often the first to respond to a hazards emergency, they must be involved in every aspect of emergency planning. Depending on the size of the disaster, the Civil Defence department calls Local Emergency Planning Committees (LEPCs) for outside help before significant damage is done. Local Emergency Planning Committees (LEPCs) must consist of representatives of all of the responsible organisations mentioned in the Civil Defence protocol. The LEPC's initial task is to develop an emergency plan to prepare for and respond to all types of emergency. These plans are reviewed, tested and updated annually. Because the LEPC's members represent the community, they should be familiar with factors that affect public safety, the environment, and all hazards that may affect their community.

An emergency plan must include the identity and location of hazardous material; procedures for immediate response to a chemical accident; ways to notify the public about actions they must take; names of coordinators at plants; and schedules and plans for testing the plan.

In addition to participating in emergency planning, the Civil Defence department needs information about all types of disasters to help it in controlling them. Having access to this information will help Civil Defence personnel responding to an emergency to know which type of disaster, as well as its severity and location, to expect at the scene. Civil Defence personnel can request more specific information about chemical inventories at a plant and can also request an on-site inspection. The plant must provide specific information regarding the hazardous chemicals in order to prepare the fire-fighters dealing with such industrial accidents more effectively.

3.3.3 The Future of ICT in Disaster Management in Saudi Arabia

ICT can play important roles in the reduction of disasters. The use of such technologies can be particularly useful in the risk assessment, mitigation and preparedness phases of disaster management. These technologies are also vital to the early warning and management of the effects of disasters. In order for Saudi Arabia to be able to incorporate the routine use of effective ICT in disaster management, there is a need to increase awareness, build the national capacity to respond, and also to develop solutions that are customised and appropriate to the needs of the emergency control.

ICT is particularly important for disaster management at present to facilitate the control of incidents. For example, ICT in disaster management offers many opportunities for acquiring and processing data and information as part of the emergency planning process, and for preparing decisions and informing key personnel by means of ICT.

From the literature and the current situation in Saudi Arabia in this area, it is evident that there is a need to develop and adapt disaster management by using ICT. Furthermore, this is also complemented by nationwide awareness of the usefulness of ICT and the involvement of the public and private sectors, especially in telecommunications, communications and information.

Concerning the use of ICT for disaster management and emergency control, it seems to be important to differentiate between the internal (within administrations and for professional planning) and external use of ICT. Within professional planning, ICTs are used as working and controlling tools so in this context planning becomes more and more dependent on ICT. External uses of ICT, for example, the Internet, aim at spreading planning information, as well as enhancing planning participation and communication.

ICT as a working and controlling tool for professional planning can offer the following advantages:

- Provision of information systems: Geo-spatial databases, as well as digital maps, are often used to provide environmental and planning information and to control the cohesion of data. The use of geographical information systems eases the analysis of complex planning data and contributes to a better quality of information. Additionally, the Internet is a source of planning information of all kinds.
- Scenarios / simulations / forecast of planning outcomes: ICT facilitates the creation of different planning alternatives as well as the forecast of their outcomes. This includes the prognosis of trends (e.g. risk dispersion), as well as the development and evaluation of alternative options for future developments. Thus planners are able to choose the most suitable emergency plans on the basis of complex analysis.
- Monitoring: ICTs are used to monitor industrial cities and the achievement of disaster management.

To bridge the gap in coordinating activities of agencies working for emergency services, an information network system needs to be developed. Such a system will link Civil Defence departments, industrial fire brigades and the Industrial Sector in Saudi Arabia to help them to control and deal effectively with industrial accidents. Furthermore, it will prevent data shortages concerning hazardous materials, present the best ways for dealing with incidents, and facilitate a combination of efforts among other emergency services.

3.4 Summary

This chapter centres on how technological developments, and information and communication technology in particular, are used in disaster management in developed as well as developing countries. In Europe, particular systems identified include the HarsNet, HITERM and RDS. The HarsNet, as discussed in Section 3.2.1, centres mainly on disaster management technologies, particularly in the chemical industry. It helps in bringing experts and resources together to combat chemical disasters. This is very important, especially where hazardous materials are manufactured. A network such as this would be useful in the Saudi scenario. However, due to limitations in technology as well as exposure, its application would not be feasible.

The HITERM system, also a network of experts from various countries of the European Union, aims at providing an interface between technological risk management and the environment. By its nature, HITERM is a very sophisticated system with adequate models, tools and communication protocols for effective disaster management.

Other European countries also have sufficient management systems that are utilised in the event of disasters. These have proven to be very effective tools.

Also discussed are technologies in use in developing countries. These technologies, although useful in their isolated environments, may not be sufficient or suitable in the Saudi scenario due mainly to technological exposure as well as the availability of skilled labour effectively to manage these technologies. In addition, the ICT infrastructure is not yet up to the desired level to accommodate these technologies. For it to be sufficient, an integrated technology that incorporates remote sensing equipment, GIS, digital maps and similar resources, is required to provide adequate information to disaster managers.

It is in this regard that the researcher feels that an approach suitable to the environment needs to be devised. A system that will help in bringing together the two main sectors, the Civil Defence department and the Industrial Sector in some sort of a communication platform, is necessary. This is leads to the idea of proposing an integrated database, a GIS and the Internet combined to provide a framework for the system. This system, the researcher hopes, will utilise most of the benefits of systems in Europe, America and Asia, at the same time making it relevant to the region.

A detailed discussion of the system requirements is given in Chapter 7 and the proposed system is discussed in Chapter 8.

In the next chapter, a general review of research methodologies, as well as those of software development, is offered. The selection of the methodology to be applied in this research is discussed and the reasons for this choice are outlined.

4.1 Introduction

Research studies are conducted for the purpose of obtaining data that are not available from other sources regarding a specific area of knowledge. Obtaining empirical data can be done using many different techniques. The most common techniques include interviews, observations, case studies and questionnaire surveys. The method selected depends on the goals and objectives of the research, the sample of respondents involved, the time set for the completion of the study, and financial considerations.

In social science and information systems, there are two main types of empirical research: the quantitative approach and the qualitative approach. The quantitative approach is characterised by research methods of formulating hypotheses, which are tested through controlled experiment or statistical analysis (Kaplan & Duchon, 1988). This approach uses techniques such as experiments, surveys and analysis of archival information. The qualitative approach, on the other hand, utilises techniques such as case study, participant observation and interviews. It emphasises an interpretative method that uses data to both pose and resolve research questions. This approach gives a narrow but more detailed focus.

This chapter reviews a number of research methods used in the field of information systems (IS) research. The discussion will also highlight the advantages and disadvantages of each method; this will help in their applicability to the current study and this will be covered in Section 4.2. This section also discusses certain concepts related to Stages One and Two of the Hard Systems Methodology which will be used as a framework for this study. This concept includes the System Development Life Cycle approach. After that, and in the same section, SDLC will be discussed in detail, in addition to the rationale behind its selection and development. Section 4.3 will involve the selection, design and procedures involved in the data collection techniques. Finally, Section 4.4 will include the overall conclusion of this chapter.

4.2 Research Methods

IS studies involve the adoption of a number of research strategies. Galliers (1992, p.50) identified eight major research strategies that are used. These are:

1. Laboratory experiments;
2. Field experiments;
3. Case studies;
4. Forecasting and future research;
5. Simulation;
6. Phenomenological studies;
7. Action research;
8. Surveys.

An overview of each of these strategies is presented in the following subsections.

- **Laboratory Experiments**

  Laboratory experiments can test and clarify theories about how things work in the real world (Bernard, 2000, p124). The importance of this method is that it is based on the identification of the precise relationship between variables in a designed and controlled environment (i.e. the laboratory) (Robson, 2002, p80). In this approach the researcher has to create conditions where he/she can control the variables with the intention of formulating suitable measurements while keeping other pertinent factors unchanged (Sekaran, 1984, p97). The most significant characteristic of laboratory experiments is the identification of the exact relationships between selected variables by implementing quantitative analytical approaches in a well-devised environment (Galliers, 1992, p50). The weakness of this method includes the difficulty of creating the necessary environment for results to be measurable, and manipulating a number of variables at the same time (Festinger & Daniel, 1966, p141). Lack of similarity to the real world is a further limitation of this method; this will affect any attempt to generalise the results. Also, under certain conditions, the laboratory study may be a costly technique to employ. Since the current research is concerned with obtaining data in natural settings, where the variables are difficult to control, laboratory experiments are clearly inappropriate.

- **Field Experiments**

When experiments are done outside the laboratory, they are called field experiments (Bernard, 2000, p125). This is an extension of the previous method but in its natural environment (Robson, 2002, p83). Benbasat (1985) defined field experiment as 'an information systems research technique in which the investigators select the sample (persons, groups or organisations) to receive the experimental "treatment" randomly or by matching them through some key variables'. The major strengths of this method are that it provides instant feedback and information on the usefulness of the experiment determining the influence that certain conditions have on particular behaviours and allowing the experimenter to segregate and control a small number of variables that can be later studied thoroughly (Phillips, 1971 & Lewis-Beck, 1993). The major advantage of this approach is that it enables the researcher to isolate and control a small number of variables, which can then be investigated intensively. However, the main limitations, besides those already stated for laboratory studies, relate to the difficulties in finding volunteers willing to participate in the field experiment. Also, there may be difficulties in repeating the experiment with adequate controls since this is not usually possible just by changing the study variables. Moreover, the field experiment may sometimes be considered both unethical and time-consuming (Mitchell & Janina, 2001). In practice it is difficult to identify organisations that are prepared to be experimented on and still more difficult to achieve sufficient control to make replication viable.

- **Case Studies**

Case studies are defined in various ways and a standard does not exist. However, a definition compiled from a number of sources (Benbasat, 1985; Kaplan & Duchon, 1988; Yin, 2003) stated that: A case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups or organisations). The boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used. The case study approach is particularly appropriate for individual researchers because it gives an opportunity for one aspect of a problem to be studied in some depth. Analysis can be carried out through interviews or group discussions of a number of cases from which conclusions can be drawn within a limited time scale (Bell, 1993). Case studies involve an attempt to describe relationships that exist in reality, very often in a single organisation. Case studies may be positivist or interpretivist in nature, depending on the approach of the researcher, the data collected and the analytical techniques employed. Reality can be captured in greater detail by an observer-researcher, with the analysis of more variables than is typically possible in experimental and survey research. Case studies can be considered weak as they are typically restricted to a single organisation and it is difficult to generalise findings since it is hard to find similar cases with similar data that can be analysed in a statistically meaningful way. Furthermore, different researchers may have different interpretations of the same data, thus adding research bias into the equation (Gordon & Langmaid, 1988). The case study is considered by Benbasat (1985, p.370) to be a viable method in three settings:

- It is necessary to study the phenomenon in its natural setting;
- The researcher can ask "how" and "why" questions, so as to understand the nature and complexity of the processes taking place;
- Research is being conducted in an area where few, if any, previous studies have been undertaken.

For the aim of this study, and to collect data from a large number of respondents in the Civil Defence organisation and in the Industrial Sector, case studies are not appropriate for use in this research.

- **Forecasting and Future Research**

Forecasting and future research is the systematic exploration of what might come to be. The advantage of this method is to provide an early prediction about problems that might lie ahead and this can increase the probability of avoiding these problems. However, these insights are dependent on the precision of past data and the expertise of scenario builders (Galliers, 1992). Since, however, the aim of this study is to investigate the existing situation, this method is deemed inappropriate.

- **Simulation**

Simulation is a method used to solve problems, which are difficult or impossible to solve analytically, by copying the behaviour of the system by generating appropriate random variables. It attempts to carry over the essential structural elements of some real world phenomenon into a relatively well-controlled environment. Simulations commonly call for participants to play an explicit role. One noteworthy advantage of simulation is its use as a teaching tool, and in intervention studies, where the intention is to modify behaviour (Robson, 2002, p286). This approach was deemed inappropriate for this study because of the difficulties associated with devising a simulation that accurately reflects the real world situation it is supposed to model.

- **Phenomenological Studies**

Vogel and Wetherbe (1984) suggested that phenomenological studies are based more on opinion and speculation than observation. This method tends to be more or less a structured process and is more likely to be an individual, rather than a group activity. This type of creative process makes a valuable contribution to the building of theories, which can subsequently be tested by more formal means. The advantage of this method is the creation of new ideas and insights. Its disadvantages arise from the unstructured and subjective nature of the process. Since the aim of phenomenological studies is to analyse the individual experience, it was deemed inappropriate for the present purpose of examining particular industries.

- **Action Research**

Burns (2000, p252) defines action research as: "the application of fact-finding to practical problem-solving in a social situation with a view to improving the quality of action within it, involving the collaboration and cooperation of researchers, practitioners and laymen". Thus it might be viewed as a subset of the case study and field experiment methods (Antill, 1985). This relates to the fact that action researchers know that their very presence will affect the situation they are researching. The advantages of this method include the very practical benefit of engaging the client organisation in the research method and the fact that the researcher's biases are made overt in undertaking the research. Its disadvantages include the fact that its application is usually restricted to a single organisation or single type of organisation. The strength of this kind of technique is that it gives professionals more chance to take advantage of their practice as a research opportunity (Dick, 2003). It allows researchers, through its recycling steps, to redefine the problem being studied, together with its hypotheses, which may lead to changing and re-evaluating the research strategies. The limitations of this technique are that the different perceptions of researchers will inevitably lead to different interpretations; the results generated by researchers cannot be generalised (Birley & Neil, 1998); and the lack of control over individual variables will affect any attempts to differentiate between cause and effect (Galliers, 1992, p150). This approach cannot be used in the present study because the researcher wants to collect data from different firms and different organisation in Saudi Arabia.

- **Survey**

The survey is the most widely used method of data collection in information science. There are two main types of survey methods: the interview and the questionnaire. Each includes a number of subtypes. The interview method may be conducted in group settings, by telephone, or in a face-to-face private encounter between interviewer and respondent. Questionnaires may be administered to large groups in a suitable setting, they may be mailed to respondents who fill them out in private and return them by mail, or be hand-delivered to respondents who are instructed to treat the questionnaire as if it were a self-administrated interview (Chadwick *et al*, 1984). It requires a lot of time and effort to be spent in designing and implementing the questionnaire (Saunders *et al*, 1997).

Major forms of survey are descriptive and explanatory surveys. The descriptive survey aims to estimate as precisely as possible the nature of existing conditions or the attributes of a population. The explanatory survey seeks to establish cause and effect relationships but without experimental manipulation (Burns, 2000). Thus, surveys may vary in their levels of complexity, from those that provide simple frequency counts to those that involve correlation analysis.

There are a number of advantages of survey research. First, information on such a topic as the attitudes and beliefs of large numbers of respondents is difficult to obtain by any other means. Second, survey methods can be used to obtain information about events that have occurred previously and that now exist primarily in the memories of those to be studied. A third advantage of survey methods is that they permit the collection of data from large numbers of respondents in relatively short periods of time and at a relatively low cost (Chadwick *et al.*, 1984).

There are some problems with the survey method, however. Great care has to be taken to ensure that the sample is truly representative. In surveys, all respondents will be asked the same questions and wording questions is not as easy as its seems. Therefore careful piloting is necessary to make sure that all questions mean the same to all respondents. Surveys can provide answers to questions such as what, where, when, and how? However, it is not easy to find responses to "why?" questions from surveys. If a survey is well structured and piloted, it can be a relatively cheap and quick way of obtaining information (Bell, 1993).

The key reason for using the survey is to enable the researcher to obtain data about practices, situations or views at one point in time through questionnaires or interviews. Quantitative analytical techniques are then used to draw inferences from this data regarding existing relationships. The use of surveys permits a researcher to study more variables at one time than is typically possible in laboratory or field experiments, whilst data can be collected about real world environments.

This researcher chose the survey and interview techniques for the following reasons. The survey was an appropriate research instrument to begin the investigation because it is able to reach a large number of geographically dispersed organisations; it is also the least time-consuming and the most effective data collection procedure. Interviews can help to gather valid and reliable data, which are relevant to the research question(s) and objectives.

4.2.1 Selection of Research Strategies

After reviewing the various types of research strategy discussed in the previous section, and based on a systems science approach to problem understanding, it was decided to use both a positivist and an interpretive approach. The former is used when collecting data that can be used to predict and control the current and future needs of ICT; the latter is adopted in this research for understanding and interpreting the findings from the interviewees concerning the role and impact of ICT on their departments. The main purpose of combining a qualitative research method with a quantitative one was to achieve one or more of the following (Morgan, 1998):

(1) Arrive at better understanding of the topic being studied;

(2) Design a research methodology;

(3) Learn from specialists about certain issues related to the subject matter;

(4) Become acquainted with problem areas or constraints;

(5) Assess the feasibility of the topic being researched.

The mail questionnaire was the most appropriate research instrument to begin the investigation for a number of reasons. Firstly, it can reach a large number of geographically dispersed organisations, it is also the least time consuming and the most effective data collection procedure. Secondly, respondents may consult with others, review records, think about a question before answering, and interrupt the process of completing the instrument if necessary (Chadwick *et al.*, 1984). Thirdly, some researchers argue that the questionnaire survey is a useful way to obtain information about sensitive topics because it is anonymous. Moreover, respondents can freely report attitudes and behaviour without embarrassment or fear of reprisal (Sudman & Bradburn, 1982).

The interview is one of the most basic forms of data gathering and can be described as "a two-person conversation, initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him on content specified by research objectives of systematic description, prediction, or explanation". Interviews can be both structured and semi-structured in nature.

Structured interviews will usually contain a series of very specific questions that are to be read to the respondent, along with a set of predetermined response categories. The working form and order of the questions is designed to be exactly the same for all respondents (Chadwick *et al.*, 1984).

Semi-structured interviews are a popular and effective method which can be used to assess views when the target sample is small. If this uses a non-standard set of questions, the interviewer will have a list of themes and questions may vary from interview to interview; the order of questions might also vary. The interviewer may omit some questions and add others when it is required.

The main aim of the interview is to gather evidence about the organisations concerned, and to obtain opinions, feelings and exceptions relating to co-operation activities. Therefore, this study has employed semi-structured interviews.

4.2.2 The Population and Sample Size

Population refers to the target population or the group of individuals of interest to the study. The idea behind adequate sampling, however, remains the same: to gather a sample of subjects that is representative of the greater population. The ideal research sample is therefore often referred to as a representative sample.

While the population is the entire group of organisations, people, events, or things of interest that the researcher wishes to investigate, the population frame is a listing of all elements in the population from which the sample is to be drawn (Sekaran, 1992).

In this study, the aim is to design information network in terms of industrial incident control in Saudi Arabia. Therefore, the target population for the questionnaire is limited to Civil Defence and Industrial Sector employees in the three main industrial regions in Saudi Arabia (Riyadh, Jeddah and Dammam). This population was chosen for two principal reasons: (1) its importance to the national economy as a means of diversification; and (2) its potential for investigating the issue of ICT implementation in a sector that has seen very limited studies of this kind.

The advantages of drawing a sample that represents the characteristics contained in the population are that data are often cheaper to collect, it requires fewer people to collect and analyse the data, the sample size allows more information to be obtained about fewer cases, and time is saved in analysing and processing a sample (Stroh, 2000, p207). The reasons for selecting a sample rather than the whole population is because of the large size of the population under investigation, inadequate time on the part of the researcher to examine the whole population at once, and lack of knowledge of the total number of the population. De Vaus (2002) mentioned that there are two processes by which samples may be obtained. Firstly, non-random sampling can be defined as a rational approach that typically gives the researcher no clear indication of who will be selected in the sample and who will be excluded; this sampling depends on the researcher's judgment. The major weakness of this type of sampling lies in the danger of bias on the part of the researcher in the selection of units or cases for study and the difficulty in estimating the accuracy of the sample (Burton, 2000, p313).

Random sampling is the second category. It is scientifically more acceptable than non-probability sampling because an estimation of sample precision can be attained mathematically and it eliminates any risk of bias in the selection of the sample on the part of the researcher (Burton 2000, pp.312-315). It gives each member of the target population an identical probability of being selected in the sample. Salant and Don (1994, p.33) identified four major types of probability sampling: simple random sampling, systematic sampling, stratified sampling and cluster sampling. These techniques are briefly defined and their potential advantages and disadvantages pointed out in the following paragraphs (KSU, 2000).

- **Simple Random Sample**

  Every unit in the population has an equal chance of being selected in the sample. Each unit in the population is assigned a number. A set of numbers is then randomly selected with units assigned to those numbers being included in the sample. Using simple random sampling may be very difficult if the size of the study population is very large as it could be very cumbersome and time-consuming to assign a number to every unit in the study population, especially if it has to be done by hand.

- **Systematic Random Sample**

  The sampling fraction (k) is calculated by dividing the study population size by the desired sample size. A random number is selected between 1 and k. Beginning with the randomly selected number, every k^{th} unit in the population is selected for inclusion in the sample. The primary reason for using a systematic sample is that it may be more practical in terms of time and resources compared to a simple random sample, particularly when the size of the study population is large and it would be too difficult to assign a number to each unit. A primary danger of systematic sampling is that this design can produce a biased or non-representative sample if the sampling frame from which the sample is selected is ordered in some kind of systematic fashion that will influence the composition of the sample.

- **Stratified Random Sample**

The population is divided up into subgroups or "strata." A separate sample of units is then selected from each strata. There are two primary reasons for using a stratified sampling design. The first reason is potentially to reduce sampling error by gaining greater control over the composition of the sample, particularly concerning variables where it is important that the sample be representative. Stratification variables by which a study population is divided up into strata (or groups) in order to select a stratified sample. A second reason for using a stratified sampling design is to ensure that a small group within a population is adequately represented in a sample in order to compare it to a large group. This type of design does not work as well when the goal is to draw inferences about the population as a whole as the sample is not representative of the population on the stratification variable. However, weighting can be used to attempt to correct this problem.

- **Cluster Random Sample**

The population is divided up into subgroups or "clusters" that represent aggregates of individual units. A sample of clusters is then selected. All individual units that are contained within a cluster that is selected are included in the sample. A major advantage of cluster sampling is that it can be used on very large populations and it is not necessary to have data on important variables for the entire population. Rather, it is just necessary to be able to divide the population up into clusters of some type. A major disadvantage of cluster sampling is that this method tends to produce less representative samples compared to other probability sampling designs, particularly when the clusters contain large numbers of units within them and only a few are needed to meet the desired sample size.

In order to achieve the objectives of the study it was considered desirable to involve a diverse collection of private organisations. The sample organisations will be selected from different business sectors using stratified random sampling because this technique is an efficient research sampling method. The sample of industrial organisations for this research will be selected from the database of the Ministry of Industry and Electricity. This Ministry represents the main link between industrial organisations. To accomplish this study, the number of questionnaires that will be distributed is 900 (see Appendices 1-3).

Two main groups are typically considered for collecting data related to fire-fighting and ICT activities in the two organisations. These are: fire-fighters and ICT managers/ officers, and users. This study aims to find out the opinions, user needs and expectations of the users of the new information network in dealing with disasters.

4.2.3 Design of the Questionnaire

The survey was developed in response to the need for a simple tool that both staff sectors could use to assess how they are dealing with industrial accidents by using ICT. At the commencement of the research no reliable information was available on the establishment of an information network in the field of industrial disasters in Saudi Arabia. The aim of the survey is to explore the current situation regarding the use of an information network in dealing with industrial disasters. Furthermore, the questionnaire will test users' needs, expectations and attitudes towards information technology in the Civil Defence and Industrial Sector.

Most of the questions in this research instrument were closed and simply required the respondent to tick an appropriate box (√). Additionally, the respondents were given the chance to add other information and add comments. This process enabled the respondents to indicate their answers to most questions.

The questionnaire was Arabised. The purpose of the Arabic version of the questionnaire was to permit respondents with little or no knowledge of English, yet who were actively involved in IT implementation in their organisations, to participate in the survey.

The questionnaire was split into three main sections, each encompassing a different theme, as follows:

Part One: Personal Details

Part One consists of 6 questions (Q1-Q6) which focus on collecting information about the respondents' characteristics that were thought might influence ICT implementation. They were directed to classifying the positions the respondents held, their nationality, age, educational qualifications, etc.

Part Two: Computer Background and Use

Part Two consists of 15 questions (Q7-Q21) and focuses on collecting information about a respondent's background in computer use and the organisation's characteristics such as its ICT support. In this part, an attempt is made to explore to what extent the organisation supports its staff members in increasing their computer skills and getting benefit from the use of ICT in their jobs.

Part Three: Computer Attitudes

This part contains three main questions (Q22-Q24), although Q22 contains 9 sub-questions, while Q23 contains 16 sub-questions. This part attempts to find out about the importance of using ICT from the point of view of the users, as well as their competence, in an attempt to find out their attitudes to using ICT in their jobs.

4.2.4 Semi-Structured Interviews

The interview is perhaps the most widely used elicitation technique simply because it is what occurs normally when people want to find out information from someone else. The interview should be scheduled in advance. A list of questions should be prepared by the interviewer in an attempt to elicit specific information.

The advantages of using the interviewing technique are several. It is very simple, it has a low cost, needs less administration time, is confidential, increases return rates, and it is easy to score. The interviewer has more control over the interviewing situation and circumstances of answering the questions, and the flexibility of the interview technique allows the interviewer to explain, clarify and modify questions in accordance with the situation whenever it is needed to elicit in-depth information. In addition, it assists the interviewer in obtaining additional information about the situation being studied (Robson, 2002, p229).

It also has a number of inherent disadvantages, however. These include the fact that data are collected from a small number of people, and results cannot be generalised or even be said to be representative. Interviews can also be time-consuming, particularly when potential respondents are spread over a large geographic area. On sensitive issues, interviewees may hesitate to provide the interviewer with in-depth information, such as that regarding personal behaviour.

The main idea of the interviews is to get rich information about the current situation which cannot be gathered by using a questionnaire. In this study interviews were carried out with industrial fire brigade officers (IFBOs), director of Civil Defence Command Centre, the manager of the Civil Defence Information Centre, ICT professionals in the Industrial Sector (ICT managers), ICT professional at the King Abdulaziz City for Science and Technology (KACST), and network service manager at the Saudi Telecom Company (STC). The following elements were considered for the interviewing process.

Figure 4.1 show the relationship between questionnaire and interviews in gathering data stage.

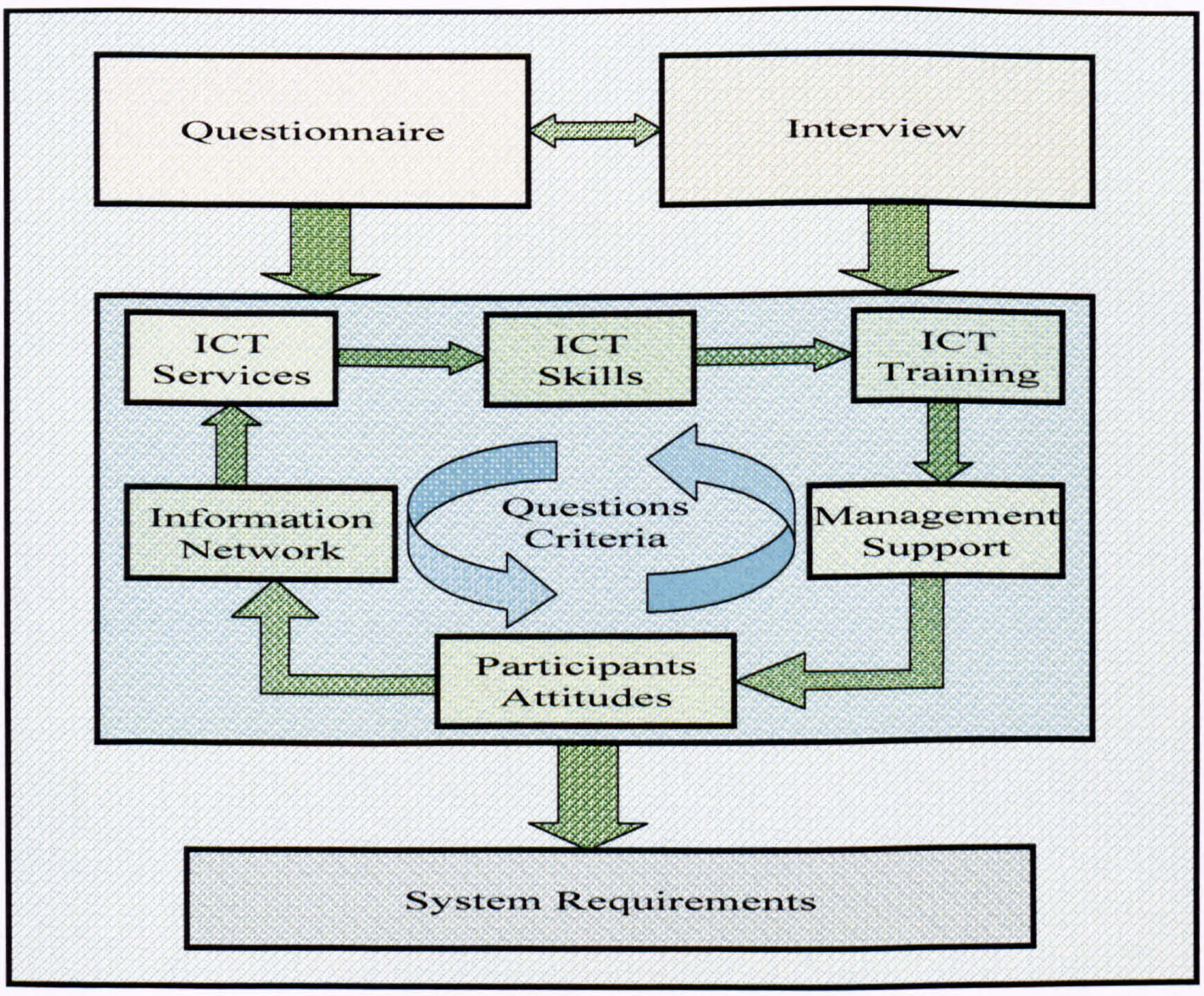


Figure 4.1 Relationship between questionnaires and interviews in gathering data

4.2.5 Pilot Study

Researchers argue that it is absolutely essential that a pilot study be conducted to establish that the proposed questionnaire is intelligible and that the meaning of the questions is clear to the recipients. Also, it must be ensured that the questionnaire is unambiguous, reliable and valid for the purpose for which it is to be used (Remenyi and Williams, 1995). For this reason, a pilot study was conducted prior to the final distribution of the questionnaire to the target population. The purpose of the pilot study was to capture the comments of both inexperienced and experienced users. These comments were used to refine the questionnaire design and to identify errors or any misunderstood sentences that might be apparent.

The pilot sample comprised 26 research staff and research students taken from Loughborough University, Leicester University and King Saud University in Riyadh. All recipients had Arabic as their first language.

The questionnaire for the pilot study was translated into Arabic. The purpose of the Arabic version of the questionnaire was to permit respondents with little or no knowledge of English, yet who were actively involved in the implementation of ICT in their organisations, to participate in the survey.

The pilot study was distributed to recipients on 15 May 2002. Of the 26 questionnaires distributed, ten were given to research students in the department of Information Science at Loughborough University and the Management Centre at Leicester University. The remaining 16 questionnaires were sent via e-mail to research staff in King Saud University in Saudi Arabia. The overall response rate was 88.5% (n=23), which comprised a 100% return from UK-based respondents and 81% of Saudi respondents. The outcome of the pilot phase was to make minor modifications in the order that questions appeared and to split one of the questions into two components. (See Figure 4.2)

Original Question:

7. What is your computer background level?

- ☐ Good: I can use computer and software packages without any assistance.
- ☐ Bad: I have a little knowledge but I need assistance.
- ☐ None: I don't use a computer at all.

Modification:

Change scale from (Good – Bad – None) to scale from 0 –to- 10, where 0=no experience, 1=little experience then the scale goes up to 10=high experience.

no experience	little experience									High experience
0	1	2	3	4	5	6	7	8	9	10

Original Question:

8. Do you use a computer in your job?

☐ Yes ☐ No

Modification:

8. Do you currently use a computer in your job?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

Add Three Questions:

9. Do you have the opportunity to use a computer in order to obtain the information?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

10. Do you think it is necessary to use a computer in order to obtain information to complete your duties?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

15. Does your organisation give you support to take computer courses?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

Delete Question:

19. Do you think the availability of an information network between Civil Defence and Factories will help to control industrial accidents?

☐ Yes ☐ No

Figure 4.2 Modifications to the questionnaire

a. Content Validity

The survey has high face-validity for both academics and researchers groups who completed the survey; that is, people who have reviewed and completed the survey indicate that measures are important dimensions for this research.

The review of context validity was undertaken by 16 academics staff based in Saudi Arabia and 10 research students from Loughborough and Leicester Universities in the UK. Findings from these reviewers include:

It was easy to follow and complete.	97%
It was easy to answer most of the questions based on my experience.	93%
I think this survey has a lot of useful information.	90%
It asked about things that were important to me.	87%
It was interesting.	84%
It was too long.	37%
I got tired of working on it.	31%
It was difficult to read and understand.	8%
It used a lot of words I didn't know.	5%

b. Development of the Final Questionnaire

1. Small modifications were made to make the questionnaire clearer.
2. The questionnaire was designed to be as respondent friendly as possible to make its completion easy and less time-consuming.
3. The number of questions was limited to fit a four-page layout.
4. Only necessary and relevant questions were asked to avoid redundancy and to maintain reliability.

4.2.6 Data Analysis Methodology

Data were analysed after conducting the qualitative and quantitative research. Each stage of the research was analysed separately and then comparisons were made. The normal first step in analysis, especially in surveys, is the editing and coding of collected data. The researcher checked the data to make sure it was as accurate as possible, consistent with other facts secured, uniformly entered, as complete as possible, and arranged to facilitate coding and tabulation. The analysis of responses was carried out on a personal computer using the Statistical Package for Social Science (SPSS), popular statistical software often used in social studies. This is a descriptive study, so the statistical analyses used were frequencies, cross-tabulations, the Chi-square test and the T-test to verify the research objectives. More details about the data analysis of this study and the different techniques and tests carried out are found in Chapters Seven and Eight.

4.3 System Methodology

Information systems development methodologies differ in the techniques they recommend, the contents of the development phases they specify and, in some cases, their whole perspective on IS (Nandhakumar & Avison, 1999). They are intended to improve many aspects of IS development, such as understanding the development process, communicating the knowledge acquired, improving productivity of the programming task, and making IS easier to maintain (Avison & Fitzgerald, 2003). New methodologies and approaches are often proposed as solutions to problems in IS development (Fitzgerald, 2000).

Avison and Shah (1997) define a methodology as a collection of procedures, techniques, tools and documentation aids which will help the systems developers or systems users in their efforts to implement a new IS. The methodology will consist of phases, themselves consisting of sub-phases, which will help in choosing the techniques that might be appropriate at each stage of the project. Techniques and tools feature in each methodology. A technique is a way of carrying out a particular activity in the systems development process and any particular methodology may recommend techniques to carry out many of these activities. Each technique may involve using one or more tools, which represent some of the artifacts that might be used. In the context of IS methodologies, tools are normally computer-based but a methodology is more than merely a collection of these tools. It is usually based on some philosophical view: otherwise it is a method, like a recipe (Avison & Fitzgerald, 2003).

According to Bellinger (2002), a system is an entity that maintains its existence through the interaction of its parts; a model is a simplified representation of the real system; and a simulation is the manipulation of a model in such a way to compress it, enabling one to perceive the interactions that would hardly be systemically visible. Since models are simplifications of the reality, there should always be a low complexity and high accuracy solution. Systems Theory has two main approaches, the original hard systems approach (more relevant to technical, engineered systems) and the more recent soft systems approach (more relevant to human and social systems) (Clayton & Radcliffe, 1996). In selecting a methodology for problem-solving, a distinction between hard and soft problems is very important. Hard problems are problems characterised by the fact that they can be well defined. It is assumed that there is a definite solution and a number of specific goals that must be accomplished can be defined. Hard approaches to systems analysis and design have been very successful in developing computer systems that, viewed from a technical perspective, are efficient and effective information providers.

The hard systems approach starts with a basic acceptance of the objectives, problem specification, and organisational needs. Hard systems engineering aims to provide a solution to a defined problem in the terms in which the problem is posed, so these factors are generally taken as given. Hard systems approaches (or structured approaches) assume that the problem is known and well defined and that what is needed is an automated solution. There have been cases however, when new information systems have not had user acceptance or seem to be misplaced as solutions to spurious problems. This indicates that an alternative approach is required to capture the human element of a system design (Edwards, 2000).

Soft systems methodologies (SSMs) are thought to be valuable for enterprises that are undergoing rapid change and are becoming increasingly information focussed. Checkland & Holwell (1998) and Jackson (1997) examined soft systems methodologies which support the provision of information systems to support human activity systems. Soft systems methodologies seek to create a system of enquiry (Checkland & Scholes 1999) which may be used to examine problem situations and lead to action decisions at both the level of what is required, and how the requirement can be met. SSM applies the concept of the whole entity and is a learning process methodology. It helps decision-makers understand the messy real-world problematic situations by comparing people's perception with constructed theoretical models. The basic concepts of SSM help to: define clearly a system's purpose; check connectivity between activities; create measures of performance and mechanisms to collect/monitor/control activities; establish decision-making procedures; define the system boundaries; establish and control resources; clarify system and sub-system hierarchies; and guarantee continuity.

Checkland (1999) believes that the main difference between the 'hard' and 'soft' approaches is that where the former can start by asking what system has to be engineered to solve this problem, or what system will meet this need and can then take the problem or the need as 'given', the latter has to allow completely unexpected answers to emerge at later stages. He thinks the 'soft' methodology is seen to be the general case of which 'hard' methodologies are special cases. Thus, by definition, soft problems are difficult to define.

It is often stated that the 'hard' system thinking is appropriate for well-defined technical problems and 'soft' system thinking is more appropriate in fuzzy, ill-defined situations involving human beings and cultural considerations (Checkland & Scholes, 1999). Different approaches have different strengths and weaknesses, different areas of applicability and differing objectives. Table 4.1 below shows what can be considered as the main criteria that distinguish hard and soft problems (Harry, 1994).

Hard Problem	Soft Problem
Defined	Undefined
Clearly bounded	Fuzzy-edged
Separable problem	What is the problem?
Clear who ought to be involved	Not sure who ought to be involved
Information needs known	Unsure what information is needed
Know what the solution would look like	Not sure what the solution would look like

Table 4.1 Main criteria that distinguish hard and soft problems

4.3.1 Selecting the Methodology for this Study

Avison and Taylor (1997) classified information systems development according to the problem situation. The classification divides the methodologies into four main types for four different problem situations as follows:

Class 1. Well-structured problem situations with well-defined problem and clear requirements. The appropriate methodologies for these situations include methodologies based on the traditional systems development life cycle (SDLC), frequently referred to as the waterfall model.

Class 2. Well-structured problem situations with clear objectives but uncertain user requirements. Methodologies such as those based on data modelling, process modelling or prototyping are likely to be appropriate in these situations.

Class 3. Unstructured problem situations with unclear objectives. Soft systems approaches, in which the perspectives of those involved are stressed, are likely to be appropriate in these situations.

Class 4. Situations where there is a high user interaction with the system. These situations require approaches that stress the needs of the people who will interact with the system. Socio-technical approaches will be most appropriate in these situations.

Class 5. Complex problem situations, combining two or more of classes 1± 4, requiring a contingency approach to information systems development. A Multi-view is the more appropriate approach in this class.

The aim of this study is to design, implement and evaluate an information system that links Civil Defence departments and the Industrial Sector in Saudi Arabia, in order to control industrial accidents. The problem is well structured, well defined and has clear objectives. The requirements need to be well known and understood and easily communicated. Users are only given a limited say in the decision-making and analysts are not expected to question why a system should be developed or its objectives as the new computer system is expected to reflect the status quo. The system development life cycle (SDLC) is typical of this situation.

4.3.2 System Development Life Cycle (SDLC)

The Systems Development Life Cycle (SDLC) is a conceptual model used in project management that describes the stages involved in an information system development project, from an initial feasibility study through maintenance of the completed application. It was designed in the late 1960s and is often described as a 'hard' approach since it attempts to find the best solution for a clearly defined problem (Avison & Taylor, 1997). It provides a consistent framework of tasks and deliverables needed to develop systems. The methodology may be modified to include only those activities appropriate for a particular project, whether the system is automated or manual, and whether it is a new system or an enhancement to existing systems. It tracks a project from an idea developed by the user, through a feasibility study, system analysis and design, programming, pilot testing, implementation and post-implementation analysis. Documentation written during project development is used in the future when the system is reassessed for its continuation, modification or deletion. Various SDLC methodologies have been developed to guide the processes involved, including the waterfall model, rapid application development (RAD), the fountain model, the spiral model, and build and fix model (Turban *et al.*, 2004).

The waterfall model is a popular version of the SDLC for information systems. Often considered the classic approach to the systems development life cycle, the waterfall model describes a development method that is linear and sequential. The advantage of waterfall development is that it allows for departmentalisation and managerial control. A schedule can be set with deadlines for each stage of development and a product can proceed and be delivered on time. Development moves from concept, through design, implementation, testing, installation, troubleshooting, and ends up at operation and maintenance (Satzinger *et al.*, 2004).

Rapid application development (RAD) is the merger of various structured techniques (especially data-driven information engineering) with prototyping techniques and joint application development techniques to accelerate systems development. A RAD project typically includes gathering requirements through workshops or focus groups, building or generating prototypes using high-powered computer-aided software engineering (CASE) tools, and using time boxes to help manage the project scope and delivery times (McConnell, 1996). It is usually chosen in cases where a large user community will have significant input to the system, the requirements of the new system are unclear, or there is a high degree of possibility that the requirements and feature set will change as the project proceeds (Cordova, 2001). Advantages of RAD are in saving time and effort, and the fit between user requirements and system specifications. Disadvantages of RAD are that the faster development associated with lower cost may lead to lower overall system quality, thereby making it easy to ignore some issues. Examples may include: missing information on underlying business processes; inconsistent internal designs with and across systems; lack of scalability, and lack of attention to later systems administration built into the system (Hoffer *et al.*, 2001).

The fountain model depicts a highly iterative and recursive approach that is especially suited to an object-oriented software development. It recognises that although some activities can't start before others -- such as the need for a design before you can start coding. There is a considerable overlap of activities throughout the development cycle. Just as in a fountain, where water rises up and falls back to the pool below, in object-oriented software development, the general workflow from analysis through design to implementation is overlaid with iterative cycles across two (or all three) of these phases.

The spiral model is an iterative development approach in which each iteration may include a combination of planning, analysis, design, or development steps (Satzinger *et al.*, 2004). The evolutionary process begins at the centre position and moves in a clockwise direction. Each traversal of the spiral typically results in a deliverable. For example, the first and second spiral traversals may result in the production of a product specification and a prototype, respectively. Subsequent traversals may then produce more sophisticated versions of the software. An important distinction between the spiral model and other software models is the explicit consideration of risk. There are no fixed phases such as specification or design phases in the model and it encompasses other process models. For example, prototyping may be used in one spiral to resolve requirement uncertainties and hence reduce risks. This may then be followed by a conventional waterfall development. The disadvantages of this model are that it does not work well with contract work, relies on the ability of software engineers to identify sources of risks, and requires considerable expertise in risk assessment (Boehm *et al.*, 2000).

The build and fix model is the crudest of the methods. Write some code, and then keep modifying it until the customer is happy. Without planning, this is very open-ended and can be very risky.

The waterfall model was adopted for this study; because one of the fundamental aspects of the waterfall model is that each step is assumed to stand alone and must be completed 100% before moving to the next step. This type of model is comfortable in large, formal organisations and on projects that have high risk in the areas of budget and schedule predictability and control. Since the 1960s several variations to the waterfall model have been used for design projects throughout the information sciences (Kendall & Kendall, 2001; Donaldson & Siegel *et al.*, 1997). Kendall suggested six stages for the waterfall model listed below (Kendall & Kendall, 2001):

1. Identifying the problems, opportunities and objectives;
2. Analysing the system requirements;
3. Designing the recommended system;
4. Implementing and evaluating the system;
5. Developing and documenting the system and processes;
6. Testing and maintenance.

Because this is an explorative study, the waterfall model would be modified to focus only on the first four stages in a design project. Although each step is presented discretely, it is never accomplished as a separate step. Instead, several activities can occur simultaneously and activities may be repeated (Kendall & Kendall, 2001). It is also possible to complete some activities in one step in parallel with some activities of another step (Hoffer *et al.*, 1999). The original model did not allow for returning to earlier stages and making modifications. Later, when this was found to be too restrictive, a feedback cycle was incorporated which allowed the team to revisit and modify earlier phases. The iteration was allowing the development team to demonstrate results earlier on in the process and obtain valuable feedback from system users. Figure 4.3 shows the SDLC stages and highlights their output for each stage. Stages One and Two are discussed in detail in Chapter 7, while Stages Three and Four are discussed in more detail in Chapter 8 and 9 respectively.

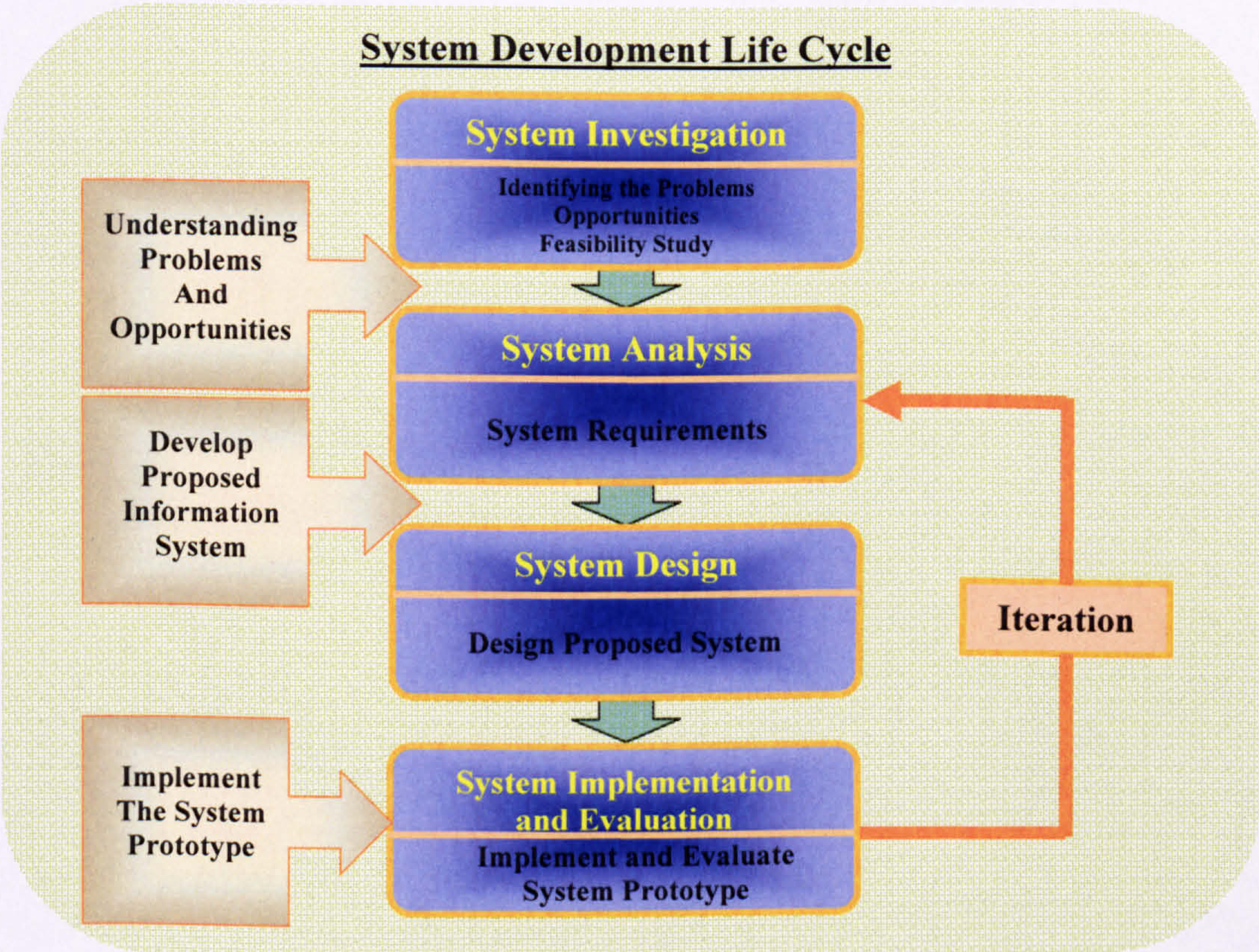


Figure 4.3 System Development Life Cycle (SDLC) stages

4.3.3 Description of System Development Life Cycle Stages

The four stages of SDLC that will be used in this study are (Kendall & Kendall, 2001):

1. **Identifying the Problems and Opportunities:** The first phase of the SDLC design process calls for an identification and clarification of the problems, and opportunities. The problem will be defined through the data collection process. Also, to aid the problem definition phase, a comprehensive review of the literature will be conducted. Interviews with experts in the field of industrial accidents and information technology will be conducted, and questionnaires will be distributed to Civil Defence and Industrial Sector employees for the purpose of defining the problem. Opportunities are situations that the analyst believes can be improved on through the use of computerised information systems.

2. **Analysis of the System Requirements:** The analysis phase will help the researcher to establish and clarify the relationship between the problem and the needs of users and various stakeholder groups. Data-gathering methods will be used to identify the required data. The system requirements will be translated into technical specifications and functional needs for the system during the third stage of the SDLC process. Two major tasks are required to complete this phase. The first is translating the problem requirements for the proposed system into a set of technical needs and functional specifications that will need to address the problems stated in SDLC Stage 1. The second task requires a decision-making process about whether the proposed system or one of several alternative systems would be better suited for meeting the requirements.

3. **Designing the Recommended System:** The intended outcome of this phase is a narrative description and schematic representation of the model system. The design of the model system will depend on the data that will be collected from the previous stages. The goal of this stage is to translate the analysis of the

needs, requirements and technical specifications into a model for a system and a conceptual framework that can address the problem in a highly effective way.

4. **System Implementation and Evaluation:** The purposes of this stage are to implement the system prototype in the real world, to elicit the comments and remarks of end users on the proposed system, and to evaluate the prototype to find the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction.

4.3.4 Potential Strengths and Weaknesses of the SDLC

Avison and Fitzgerald (2003) stated that this methodology has a number of features to commend it:

- It is a series of phases starting from a feasibility study to review and maintenance. The phases are expected to be carried out as a sequential process. Each of these has sub-phases and the activities to be carried out, along with the outputs of each sub-phase, are spelt out in some detail. Deliverables may include documents, plans or computer programs.
- It offers a series of techniques, which include ways to evaluate the cost and benefits of different solutions and methods to formulate the detailed design necessary to develop computer applications.
- It encompasses a series of tools, which might include project management tools, as control of the overall project is vital as a way of improving the likelihood of meeting deadlines.
- It offers a training scheme so that all analysts and others new to their roles and responsibilities could adopt the standards suggested.
- It contains a philosophy, perhaps implied rather than stated, which might be that 'computer systems are usually good solutions to clerical problems'.

Avison and Fitzgerald (2003) also remarked on some weaknesses of the SDLC approach as follows:

- **Failure to meet the needs of management**: systems developed by this approach often successfully deal with operational processing, while middle management and top management are sometimes ignored by computer data processing.
- **Models of processes are unstable**: the conventional methodology attempts to improve the way that the processes in businesses are carried out. However, businesses do change and processes need to change frequently to adapt to new circumstances. It could be said therefore that computer systems are unstable because the real world processes themselves are unstable.
- **Lack of control**: despite the methodological approach enabling estimates to be made of the time, people and other resources that are needed, these estimates may prove to be unreliable because of the complexity of some phases and the inexperience of the estimators. Computer people may be seen as unreliable and some disenchantment may ensue in relation to computer applications.
- **Problems with the ideal approach**: The SDLC model assumes a step-by-step, top-down process. This is somewhat naïve. It is inevitably necessary to carry out a series of iterations when, for example, new requirements are discovered or sub-phases might prove unnecessary.

A hard system approach often gathers quite specific data and/or information, and is generally looking for facts. It assumes that we know where we are going, and hence what sort of changes are required in order to improve the situation, so all we have to do is affect these changes in the most effective and efficient ways. In contrast, the soft systems approach accepts that we do not always know what changes are needed, as well as there being no final solution but rather the stand of an iterative process to improve the problem situation (Hicks, 2004).

Satzinger *et al* (2004) stated that system development projects are organised around the SDLC and its phases must be completed for any system development. In the hard system approach, the two main approaches to system development are SDLC and the object-oriented approach (OOA). OOA views an information system as a collection of interacting objects that work together to accomplish tasks. The SDLC is a phased approach to building a system, dividing systems development into formal stages (Laudon & Laudon, 2005). The SDLC approach was adopted in this study because it is used for building large complex systems that require a rigorous and formal requirements analysis, predefined specifications, and tight controls over the systems-building process.

4.4 Summary

This chapter reviews various quantitative and qualitative research methods in the IS field. To obtain information relating to the research objectives, the researcher chose a combination of the questionnaire, followed by a number of mini-focus interviews, to ask for opinions relating to a particular problem and its likely solution from the sample population that was chosen for the study.

Additionally, this chapter reports on the procedures adopted in the design and development of the questionnaire and interview techniques. It also explains the sampling techniques used and how these were conducted. Finally, it provides details of the questionnaire and interview fieldwork procedures.

To carry out research effectively that will result in the implementation of an information system, the selection and application of a specific methodology is required. A number of methodologies are reviewed in this chapter and the System Development Life Cycle (SDLC) was found to be the most appropriate methodology to be applied. The features of this methodology, its strengths and weaknesses are also highlighted. In the next two chapters, the results of the survey and interviews that were conducted are discussed in detail.

5.1 Introduction

The first stage of SDLC investigates the situation and problems of the current system. This investigation phase is used to gather information from the users in order to understand fully the problems in submitting data to the information personnel. The purpose of this is to seek to enhance the existing system, to correct problems, or to develop an entirely new information system. It is important to involve end users in this process to ensure that the new system will function adequately and meets their needs and expectations.

This chapter is aimed at presenting the analysis of the data collected from the questionnaire surveys conducted in Saudi Arabia. The chapter is divided into four sections. The first section discusses the questionnaire's distribution and the data collection, and is aimed at analysing the demographic distribution of the respondents. The second section discusses the breakdown of the respondents' computer background and their use of computers. Issues discussed include the level of respondents' computer background, years of experience, opportunity to use a computer in order to obtain information, types of computer at work, training and ICT training. The third section discusses the respondents' attitudes towards computer use and the use of a computer (information) network. The fourth section explores respondents' perceptions concerning the level of importance of the use of ICT in their job and their perceptions of their own competence in using ICT. Table 5.1 shows the different variables in SDLC.

5.2 Questionnaire Distribution and Data Collection

A total of 900 questionnaires were distributed in October 2002 and collected on various dates in November 2002. 350 questionnaires were distributed to Civil Defence staff, and a further 550 questionnaires were distributed to Industrial Sector staff in

Variable	Variable Examined
ICT	• Background • Skills • Use • Availability
Training	• Management Support • ICT Courses • DM Courses
Attitude	• Manual and Computerised Systems • ICT Change • Information Network
Staff Perception	• ICT Competence • ICT Importance

Table 5.1 Variables in the SDLC

Riyadh, Jeddah and Dammam. Table 5.2 shows the questionnaire distribution and the response rate.

Sector	Number issued	Number returns	% of returns	Overall %
Civil Defence	350	306	87.4%	**49 %**
Industrial Sector:				
Riyadh	200	138	69%	22.12 %
Jeddah	150	77	51%	12.34 %
Dammam	200	103	51.5%	16.50 %
Total	550	318	57.8%	**51%**
Total	**900**	**624**	**69.3%**	

Table 5.2 Response rate of respondents

The largest percentage of respondents (306 out of 624, 49%) came from Civil Defence departments, followed by 138 (22.12 %) from the industrial zone in Riyadh, and 103 (16.5 %) from industrial zone in Dammam. Finally, 77 (12.34 %) came from the industrial zone in Jeddah, which gives a total of 318 (51%) responses from the Industrial Sector.

It is interesting to note that the data collected from the two sectors is almost equal (49% and 51%). This further shows the credibility of the data as they are not skewed to either of the two sectors. This, therefore, suggests that the data can be taken as an equal representation of the two sectors.

5.3 Data Analysis

The data collected were coded and analysed using the Statistical Package for Social Science Studies (SPSS). 624 questionnaires were returned, giving a response rate of 69.3%. Descriptive statistics, including cross-tabulations, were used to characterise the responses to each question in the questionnaire, after which an analytical test (χ^2 test) was used as a test of significance. The purpose of using descriptive analysis is to present the data in an understandable and less complex form.

5.3.1 Personal Details

The respondents were asked to which sector they belonged. The intention was to group respondents according to location and to get a clear picture of the number of Saudi and non-Saudi participants in this study. The majority of the respondents (N=318, 51%) came from Industrial Sector and the rest of the respondents (N=306, 49%) came from Civil Defence departments.

Within each sector, the questionnaires were distributed in different departments. The respondents were asked to specify their job description. The result was divided into five parts as follows: Civil Defence Officers, Civil Defence Soldiers, Industrial Sector Managers, Industrial Sector ICT Professionals and Industrial Sector Staff. Figure 5.1 shows a graphical representation of these results.

It can be seen from Figure 5.1, that most of respondents were Civil Defence Soldiers (45.8%) followed by ICT Professionals in the Industrial Sector (24.9%). This was then followed by Industrial Sector staff (18.3%), then Industrial Sector Managers (7.8%) and lastly, Civil Defence Officers (3.2%).

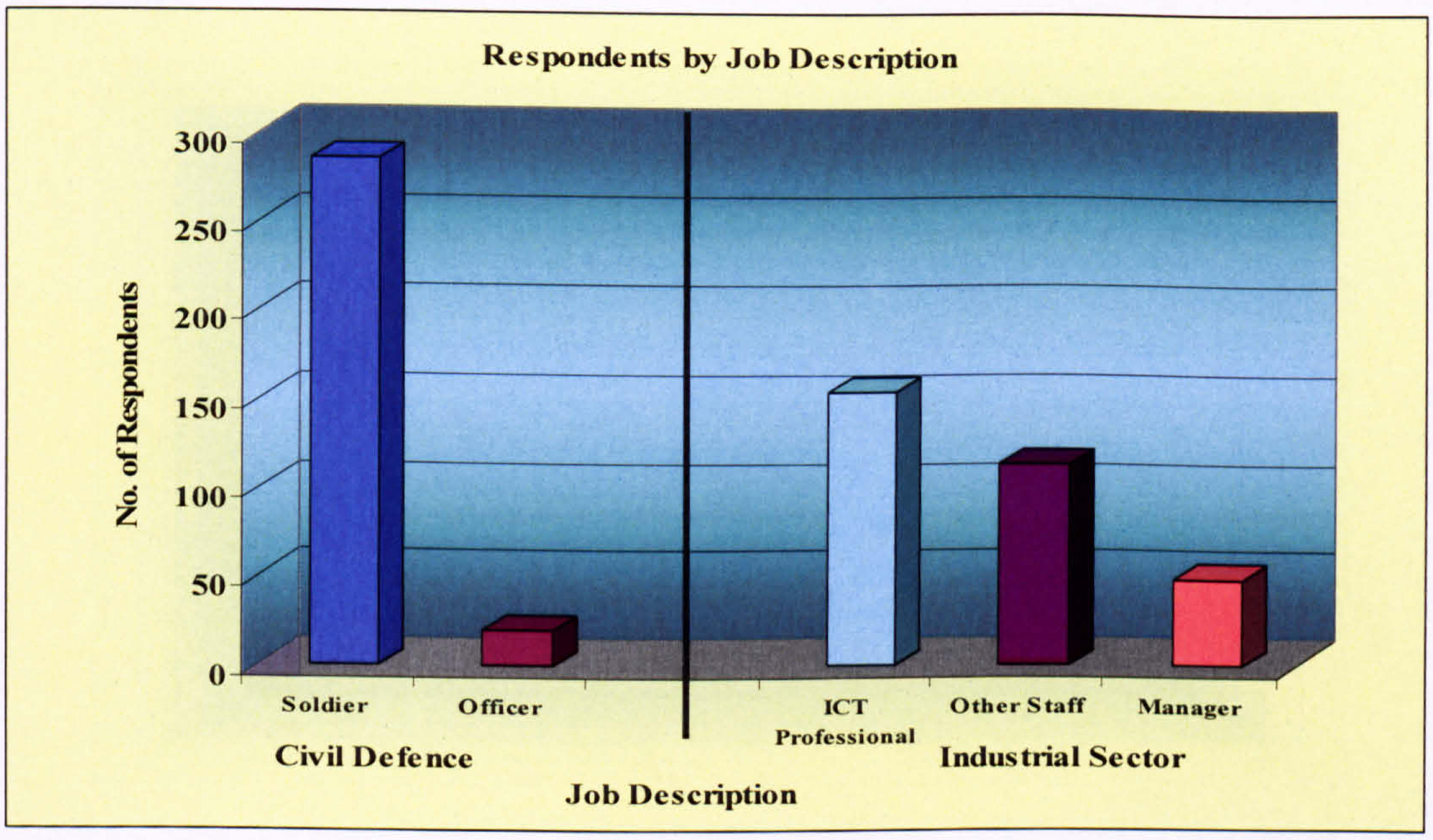


Figure 5.1 Percentages of respondents by job description

To test the availability of ICT in the two sectors, a χ^2 test was used to test the significance of the association between Civil Defence staff and Industrial Sector staff in using of computer at work. Table 5.3 shows that result indicates a significant relationship (χ^2=309, df=4, P<0.001, N=624). This supports the finding that computers are more available for use in the Industrial Sector than in the Civil Defence sector.

	Use of computer at work					
Sector	**Never**	**Rarely**	**Occasionally**	**Often**	**Always**	**Total**
Civil Defence	190	46	46	15	9	**306**
Industrial Sector	22	15	62	70	149	**318**
Total	**212**	**61**	**108**	**85**	**158**	**624**

Table 5.3 Using computers at work in both sectors

Respondents were asked about their nationality. The findings show that all staff from the Civil Defence sector are Saudi nationals as it is a government establishment with a military wing. In contrast, the Industrial Sector comprises different nationalities, as there is still a need for highly skilled foreign workers to be employed in Saudi Arabia. In fact, from the questionnaires returned, 151 respondents (47.5%) were Saudi nationals, while foreign workers totalled 167 (52.5%).

Respondents were asked about their final educational qualifications. The responses were grouped into five classes. From the results, it can be seen that a third of respondents (33%) completed their education with a secondary school certificate, followed by those at under secondary degree level (30.6%). In addition, 23.6% of the respondents completed their formal education with a university degree, while only 6.7% of respondents carried on successfully to complete postgraduate qualifications. The rest of the respondents (6.1%) had other professional qualifications. Figure 5.2 shows the relationship between these results graphically. These data were investigated by using a χ^2 test to test the significance of association between place of work and educational qualifications. Educational qualifications and place of work showed a high level of statistical significance (χ^2=231.998, df=4, P<0.001, N=624). This finding seems to be related to the high educational standards required for employment in the Industrial Sector.

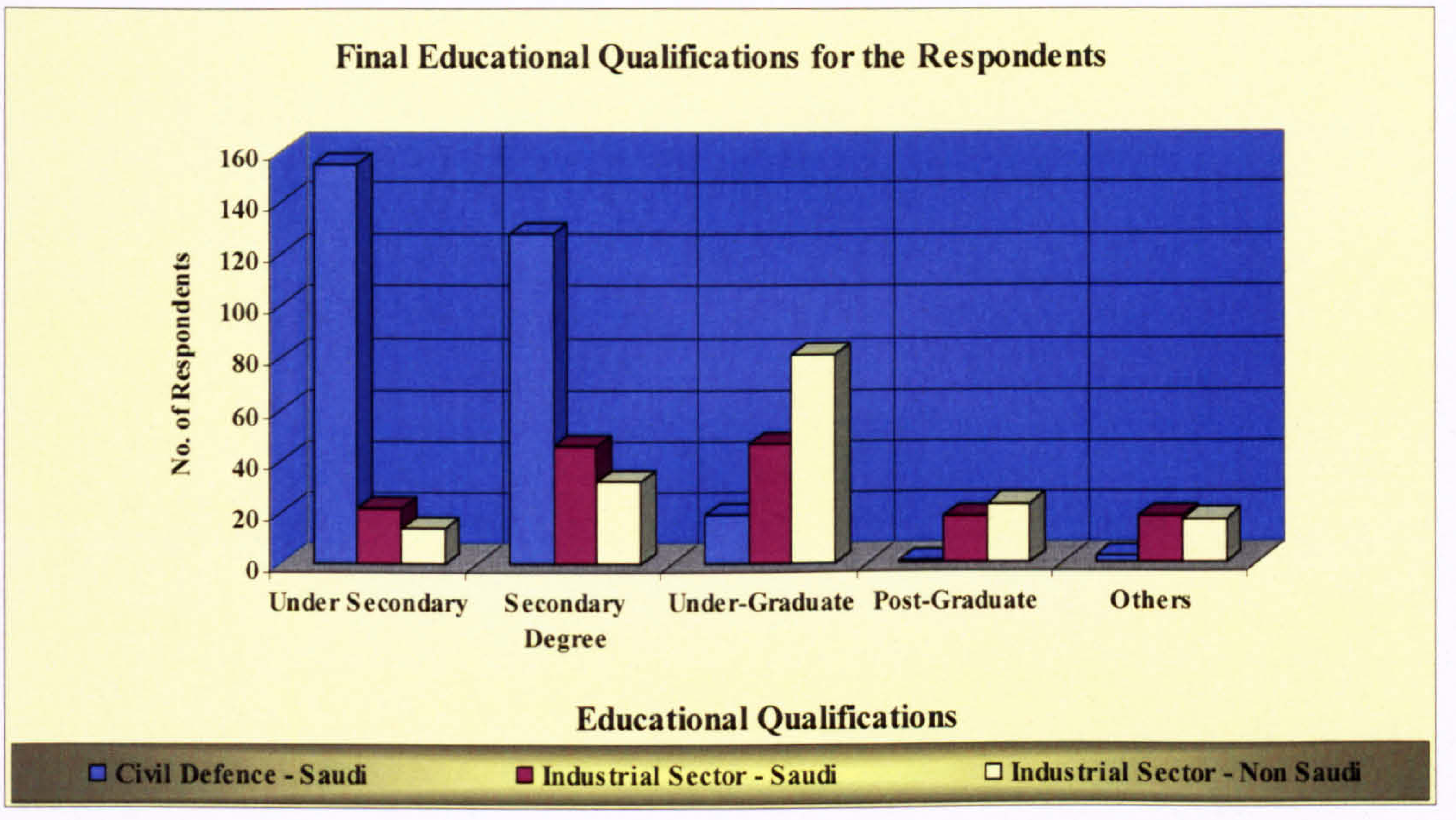


Figure 5.2 Percentage of final educational qualifications of the respondents

Respondents were asked to specify the number of years they had worked in their current job. The results were grouped into six classes. Most respondents (43%) had been in their current jobs between one to five years (the first group). This is followed by the second group (6-10 years), which constitutes about 23.4%. Table 5.4 shows the frequency and percentage for each group.

A χ^2 test was used to test the existence of an association between the number of years worked in their current job and the use of computers in their work. The result shows that there is significant relationship between number of years in the current job and use of computer in their work (χ^2=156.559, df112, P<0.003, N=624). This result indicates that the longer respondents stay in their current job the more they will have an opportunity to use a computer. Perhaps this demonstrates the degree of maturity of the use of computers in the workplace in Saudi Arabia.

No. of years	Frequency	Percent %
1-5	268	42.95
6-10	146	23.40
11-15	111	17.79
16-20	64	10.25
21-25	28	4.49
26-30	7	1.12
Total	**624**	**100**

Table 5.4 Frequency and percent of number of years in job

5.3.2 Identifying Existing Components of the Information Network

To identify the existing components of the information network, a number of questions were asked which varied in the level of detail of the response. Respondents were asked to rate themselves in terms of their computer background. The scale ranged from no experience (0) to high experience (10). The majority of the respondents (N=105) had no experience in using computers, and this came mainly from the Civil Defence sector (N=97). This is closely followed by those with little experience (N=95). Figure 5.3 shows the levels of computer backgrounds in percentage form for both sectors.

From Figure 5.3 it can be seen that the results from the Industrial Sector exhibit a near normal distribution. This is so because the Industrial Sector is predominantly owned by private individuals. It is also a highly skilled sector and relies, to some extent, on the use of computers in accomplishing tasks. As a result, one would expect a wide range of experience in the level of computer use by the employers in such a sector. The responses from the Civil Defence sector show a negative exponential distribution, again showing the degree of maturity of computer-based skills among poorly educated Saudi nationals.

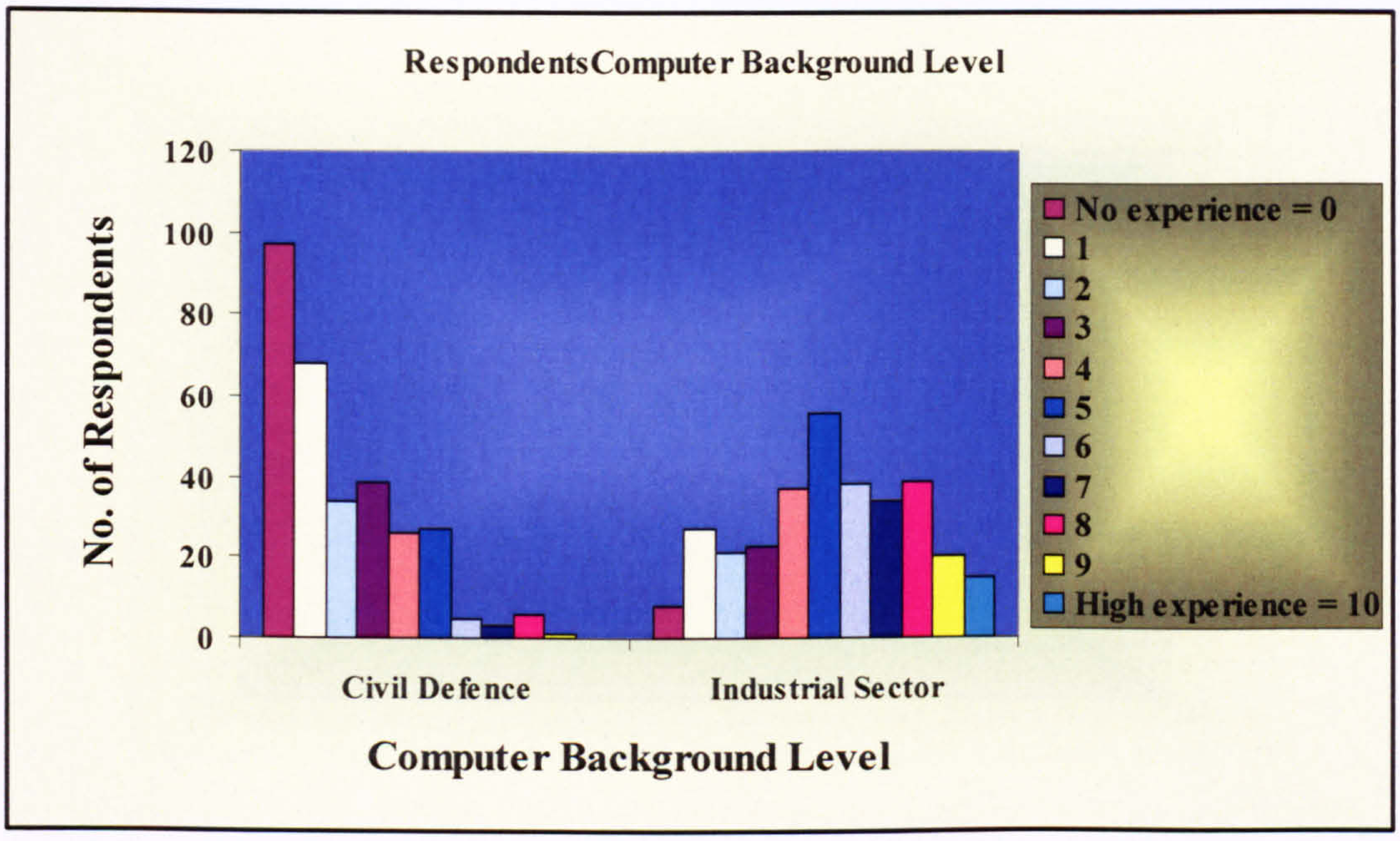


Figure 5.3 Percentages of computer background level for both sectors

In order to identify the presence of information network components within both the Civil Defence and Industrial Sector, some questions were asked to find out to what extent these are available in both sectors. For a meaningful response in the context of the research questions of this study, respondents were asked to choose a scale of their perception of the importance of and their competence in using ICT in their job.

Respondents were then asked to indicate if they used a computer at work. The results show that the majority of respondents from the Civil Defence sector (n=190) never use a computer at work where as in the Industrial Sector the largest percentage of respondents (149 out of 318, 47%) always use a computer at work. These results support the analysis above. Table 5.5 presents a summary of this result.

Place of work	Use of computer at work					
	Never	Rarely	Occasionally	Often	Always	Total
Civil Defence	190	46	46	15	9	**306**
Industrial Sector	22	15	62	70	149	**318**
Total	**212**	**61**	**108**	**85**	**158**	**624**
Percent %	**33.97**	**9.78**	**17.31**	**13.62**	**25.32**	**100**

Table 5.5 Use of computers for both sectors

Respondents were asked if they had an opportunity to use computers in order to obtain information. In this way it was hoped to find out how necessary it was to use a computer to complete their duties. The biggest percentage of the respondents from the Civil Defence departments (36.3%) never use a computer to obtain information. This is understandable since, by the nature of their work, fire-fighters and soldiers have no demand for the use of computers in accomplishing their tasks, and as already has been seen, the level of computer use is low.

Respondents were asked what types of computer connection were in use in their organisations. In this way it was hoped that the extent to which networked computers have penetrated both sectors could be identified. Moreover, it offers a way to assess the ability of staff in both sectors to access information.

The majority of respondents (32.9%) indicated that they have no computer at their place of work and most of these came from the Civil Defence sector (n=186). This is closely followed by those that have networked computers (27.1%), then those that have stand-alone and networked computers (22.9%), and lastly those that have stand-alone computers only (17.1%). Table 5.6 shows these results.

Types of computer at work					
Place of work	**No Computer**	**Stand-Alone**	**Networked Computer**	**Both**	**Total**
Civil Defence	186	53	57	10	**306**
Industrial Sector	19	54	112	133	**318**
Total	**205**	**107**	**169**	**143**	**624**
Percent %	**32.9**	**17.1**	**27.1**	**22.9**	**100**

Table 5.6 Types of computer at both sectors

From the responses it appears that the Industrial Sector is mostly networked. This gives an indication that Civil Defence staff are lagging behind in the use of computers as part of their everyday work, based on the number of computers available and the number of people actually using the computing facilities.

Respondents were asked whether they have information networked between these two sectors. In this way it was hoped to find the extent to which information networks have penetrated these two sectors. All the respondents from both sectors indicated the non-existence of an information network between the Civil Defence departments and the Industrial Sector.

Respondents were asked how they exchange information. In this way it was hoped to discover what methods of exchanging information were used and how these methods affect this exchange. All respondents from both sectors indicated that they exchange information only by manual means. All respondents agreed that this method of information exchange causes delay and hence affects the delivery of services from both sectors. This further shows the necessity for the existence of an information network between the two sectors.

5.3.3 Identification of ICT Training Support

Training is one of the most important aspects of an organisation. For the purpose of this study, respondents were asked to point out if they received computer training. The purpose of this question was to assess the efficiency of training programmes and the level of user satisfaction with computer training and, moreover, to find out if there was any computer training in the use of ICT that deals with industrial accidents.

Respondents were asked whether their organisations give them support to take computer courses. A total of 168 respondents from the Civil Defence sector (about 55% of this sector) indicated that they had never undertaken any computer training. In addition, a large proportion of the respondents from the Industrial Sector (about 28% of this sector) also indicated that they had never taken any computer training, these results in a combined total of 41% of respondents. The result is likely because of the level of education of the respondents.

As discussed in previous sections, workers within the Civil Defence sector are less computer literate, indicating a training gap that can be exploited to enhance skills, thereby contributing towards moving the balance to "information rich" rather than "information poor". On the other hand, most of the workers within the Industrial Sector are already sufficiently skilled and have possibly had training on the use of ICT prior to joining the sector, thereby no longer requiring training. A detailed breakdown of the results is shown in Table 5.7.

Computer courses supported						
Place of work	**Never**	**Rarely**	**Occasionally**	**Often**	**Always**	**Total**
Civil Defence	168	58	53	14	13	**306**
Industrial Sector	89	61	79	49	40	**318**
Total	**257**	**119**	**132**	**63**	**53**	**624**
Percent %	**41.2**	**19.1**	**21.1**	**10.1**	**8.5**	**100**

Table 5.7 Computer courses supported

To investigate the availability of computer courses aimed of increasing the workers' skills in the use of ICT in dealing with industrial accidents, respondents were asked about accident control and risk analysis courses that were supported by their organisations. Tables 5.8a and 5.8b show the responses to these questions cross-tabulated with the training support offered by organisations.

Computer Courses in Accident Control						
		5	**4**	**3**	**2**	**1**
Organisation Training Support	**Never**	14	18	48	84	93
	Rarely	5	9	18	32	55
	Occasionally	13	11	26	37	45
	Often	6	13	8	21	15
	Always	13	12	6	11	11
	Total	**51**	**63**	**106**	**185**	**219**

Table 5.8a, Accident control courses

Where (5= strongly available, 4= available, 3= neutral, 2= not available, 1= strongly not available)

Computer Courses in Risk Analysis						
		5	**4**	**3**	**2**	**1**
Organisation Training Support	**Never**	15	21	45	78	98
	Rarely	4	7	20	40	48
	Occasionally	8	14	29	37	44
	Often	4	12	9	24	14
	Always	13	10	6	10	14
	Total	**44**	**64**	**109**	**189**	**218**

Table 5.8b, Risk analysis courses

Where (5= strongly available, 4= available, 3= neutral, 2= not available, 1= strongly not available)

It is very clear from the respondents' answers that there is not sufficient support from these sectors for their workers to use computers in dealing with industrial accidents. The results from these two tables give more evidence that the two sectors do not support their workers enough with regard to taking computer skills courses. Figure 5.4 shows the results in more detail, indicating that more effective management of the computer training programmes in disaster management is needed.

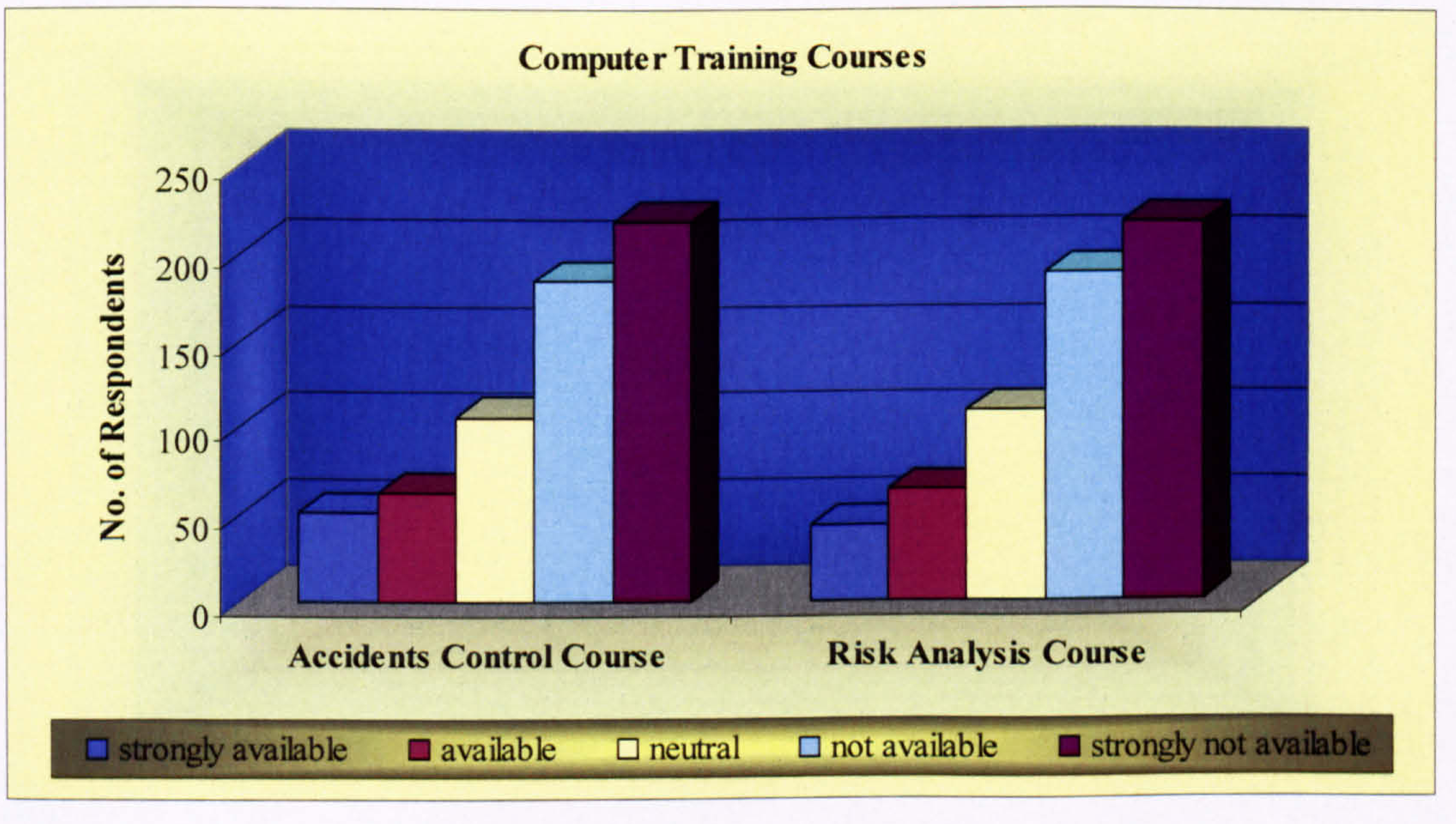


Figure 5.4 Computer training courses

To go deeper and be more precise, respondents were asked if they had taken courses that deal with industrial accidents and if they had taken these courses on-line. The result shows that majority of the respondents (n=441) had not taken any courses that dealt with industrial accidents, while a total of 183 respondents indicated taking 'disaster management' courses; 13 indicated they had taken these courses on-line. Figure 5.5 shows these results graphically in the form of a histogram. Again, this demonstrates the lack of these two sectors in providing enough disaster management courses; more training support is needed.

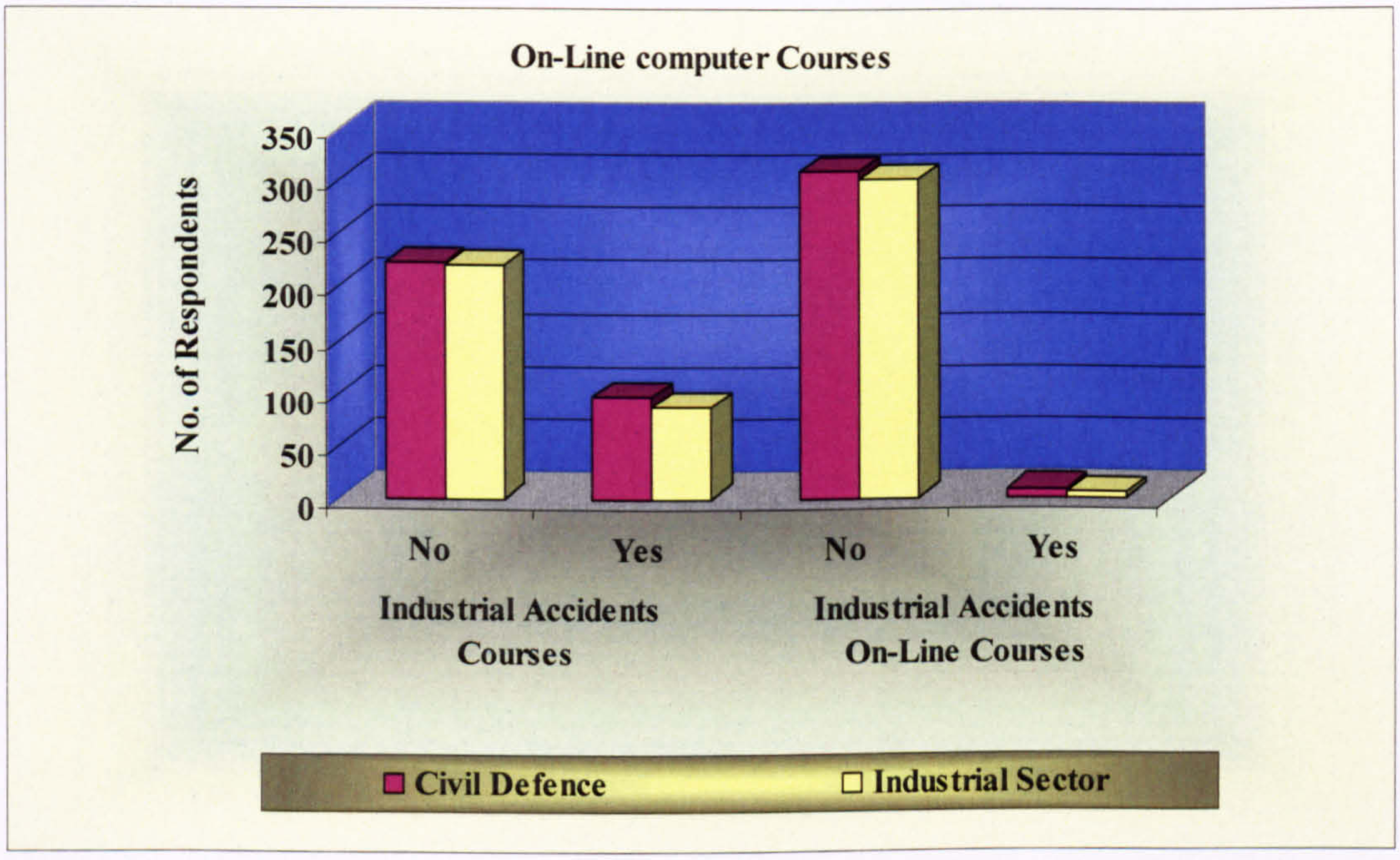


Figure 5.5 Responses regarding on-line computer courses

5.4 Attitudes to Computers

Attitude is an important concept that is often used to understand and predict people's reaction to an object or change and how their behaviour can be influenced (Fishbein and Ajzen, 1975; Allport, 1966). Human factors are important elements in the implementation of any information system.

This section of the study summarises the results regarding users' needs, expectations and attitudes towards information technology within the Civil Defence and Industrial Sector. The analysis of results from each sector have been separated because significant differences have already been reported between them in terms of computer availability and use. The responses of the Civil Defence workers are presented first. This is followed by the responses from the Industrial Sector workers. A final discussion on the overall results is also presented.

Respondents were asked to rate the importance of nine factors in their organisations' decision to implement ICT systems. Responses were recorded on a five-point Likert-type scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

5.4.1 Attitude of Civil Defence Personnel in Using ICT

Respondents were asked to rate the importance of nine factors in their attitudes towards the use of ICT. Responses were recorded on a five-point Likert-type scale ranging from 1=Strongly Disagree to 5=Strongly Agree. As noted in Table 5.9, the most important factor is '**Use of computer**' where 33% of the respondents strongly agreed that it is the most important factor, while 13.5% of the respondents agreed that it is the most important. This was followed by '**Attitude to IT**' where 27.6% strongly agreed and 18.8% agreed. The third factor was '**Attitude to the existence of an information network**' where 36.2% strongly agreed and 9.8% agreed. '**Attitude to replacement of paper-based system**' was considered to be the least important factor, with 26.8% strongly agreeing and 14.9% agreeing to this.

Generally, these findings indicate that the Civil Defence staff are keen to use ICT in their duties. Table 5.9 shows the results in more detail. Figure 5.6 shows the attitude of Civil Defence staff in using ICT (Agree & Strongly Agree Vs Disagree & Strongly Disagree). The results in Table 5.9 suggest that using computers for prestige had a relatively greater significance to service organisations and it was the most important motive for adopting IT. It is very clear from this figure there is no comparison between the groups that strongly agree and agree and those who disagree and strongly disagree with these statements.

#	Description		5	4	3	2	1
1	**Use of computers**	F	206	84	9	6	1
		%	33.0	13.5	1.4	1.0	0.2
2	**Attitude to IT**	F	172	117	11	4	2
		%	27.6	18.8	1.8	0.6	0.3
3	**Use of new technology**	F	177	90	31	7	1
		%	28.4	14.4	5.0	1.1	0.2
4	**Attitude to replacement of paper-based system**	F	167	93	32	13	1
		%	26.8	14.9	5.1	2.1	0.2
5	**Attitude to IT-based systems**	F	164	103	32	3	4
		%	26.3	16.5	5.1	0.5	0.5
6	**Attitude to change**	F	177	94	25	8	2
		%	28.4	15.1	4.0	1.3	0.3
7	**Developing job procedures**	F	197	86	17	3	3
		%	31.6	13.8	2.7	0.5	0.5
8	**Attitude to Arabiasation of computer programs**	F	184	96	19	5	2
		%	29.5	15.4	3.0	0.8	0.3
9	**Attitude to existence of information network**	F	226	61	16	2	1
		%	36.2	9.8	2.6	0.3	0.2

Table 5.9 Attitude of Civil Defence staff in using ICT

Where: (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree)

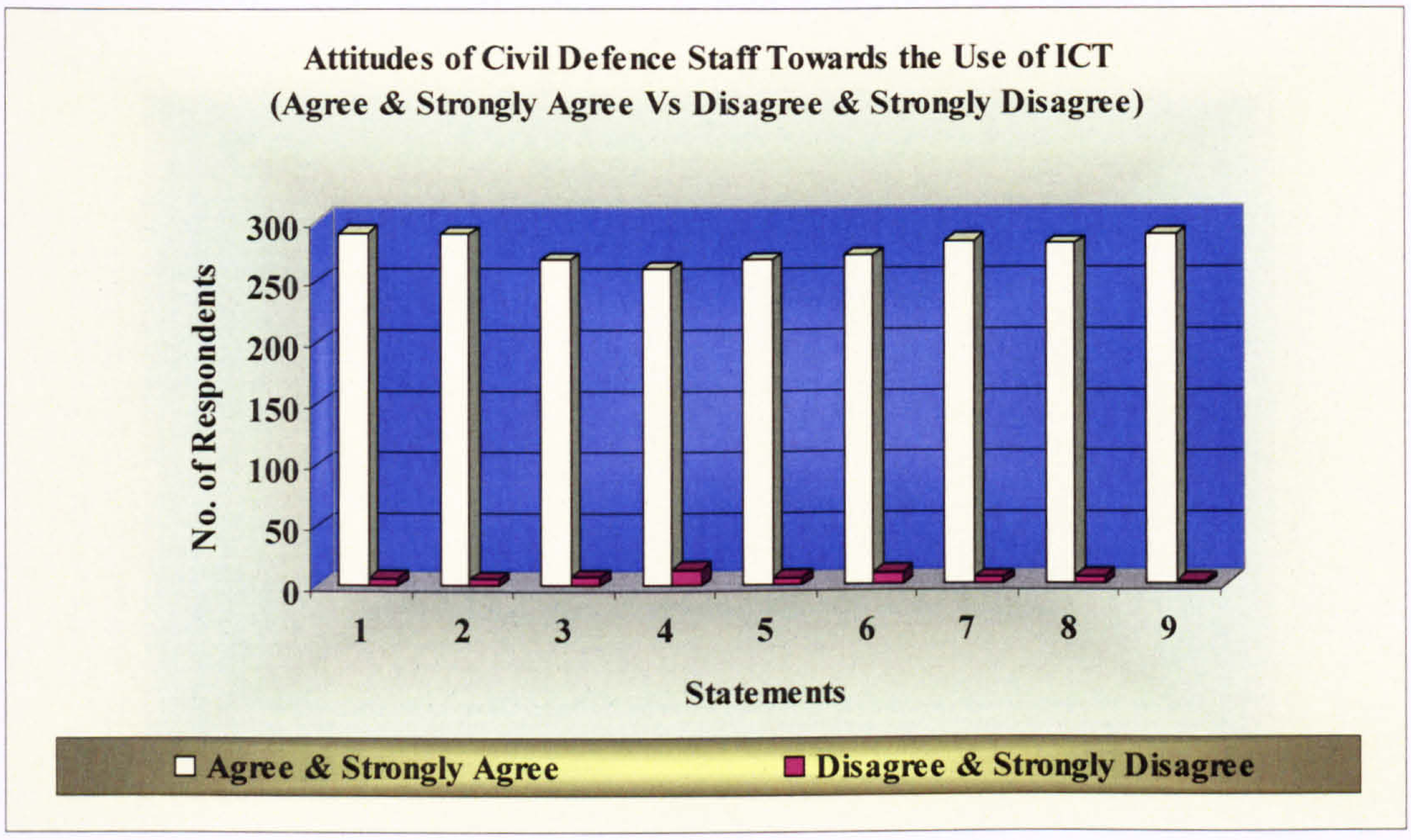


Figure 5.6 Attitudes of Civil Defence staff towards the use of ICT

5.4.2 Attitude of Industrial Sector Staff in Using ICT

As noted in Table 5.10, the most important factors were '**Attitude to ICT**' where 32.5% of the respondents strongly agreed and 17.9% agreed respectively. This was then followed by the need to use the computer where 35.1% strongly agreed and 15.2% agreed. The third factor was '**Developing job procedures**' where 36.7% strongly agreed and 13% agreed. The fourth most important factor was '**Use of new technology**', where 34.8% strongly agreed and 14.7% agreed. The factor that turned out to be considered the least important factor was the '**Attitude to Arabiasation of computer programs**'. Table 5.10 shows the result in greater detail.

The results in Table 5.10 suggest that adopting ICT has a relatively greater significance to service organisations as this was the most important motive for using computers. Figure 5.7 shows the attitudes of Industrial Sector staff for using ICT (Agree & Strongly Agree Vs Disagree & Strongly Disagree). It is very clear from this figure there is no comparison between the groups that strongly agree and agree and those who disagree and strongly disagree with these statements.

#	Statement		5	4	3	2	1
1	**Use of computers**	F	219	95	3	1	0
		%	35.1	15.2	0.5	0.2	0
2	**Attitude to ICT**	F	203	112	3	0	0
		%	32.5	17.9	0.5	0	0
3	**Use of new technology**	F	217	92	9	0	0
		%	34.8	14.7	1.4	0	0
4	**Attitude to replacement of paper-based system**	F	168	122	21	7	0
		%	26.9	19.6	3.4	1.1	0
5	**Attitude to ICT based systems**	F	164	136	17	1	0
		%	26.3	21.8	2.7	0.2	0
6	**Attitude to change**	F	187	122	9	0	0
		%	30.0	19.6	1.4	0	0
7	**Developing job procedures**	F	229	81	7	0	1
		%	36.7	13.0	1.1	0	0.2
8	**Attitude to Arabiasation of computer programs**	F	124	152	35	4	3
		%	19.9	24.4	5.6	0.6	0.5
9	**Attitude to existence of information network**	F	193	86	37	2	0
		%	30.9	13.8	5.9	0.3	0

Table 5.10 Attitude of Industrial Sector staff in using ICT

Where: (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree).

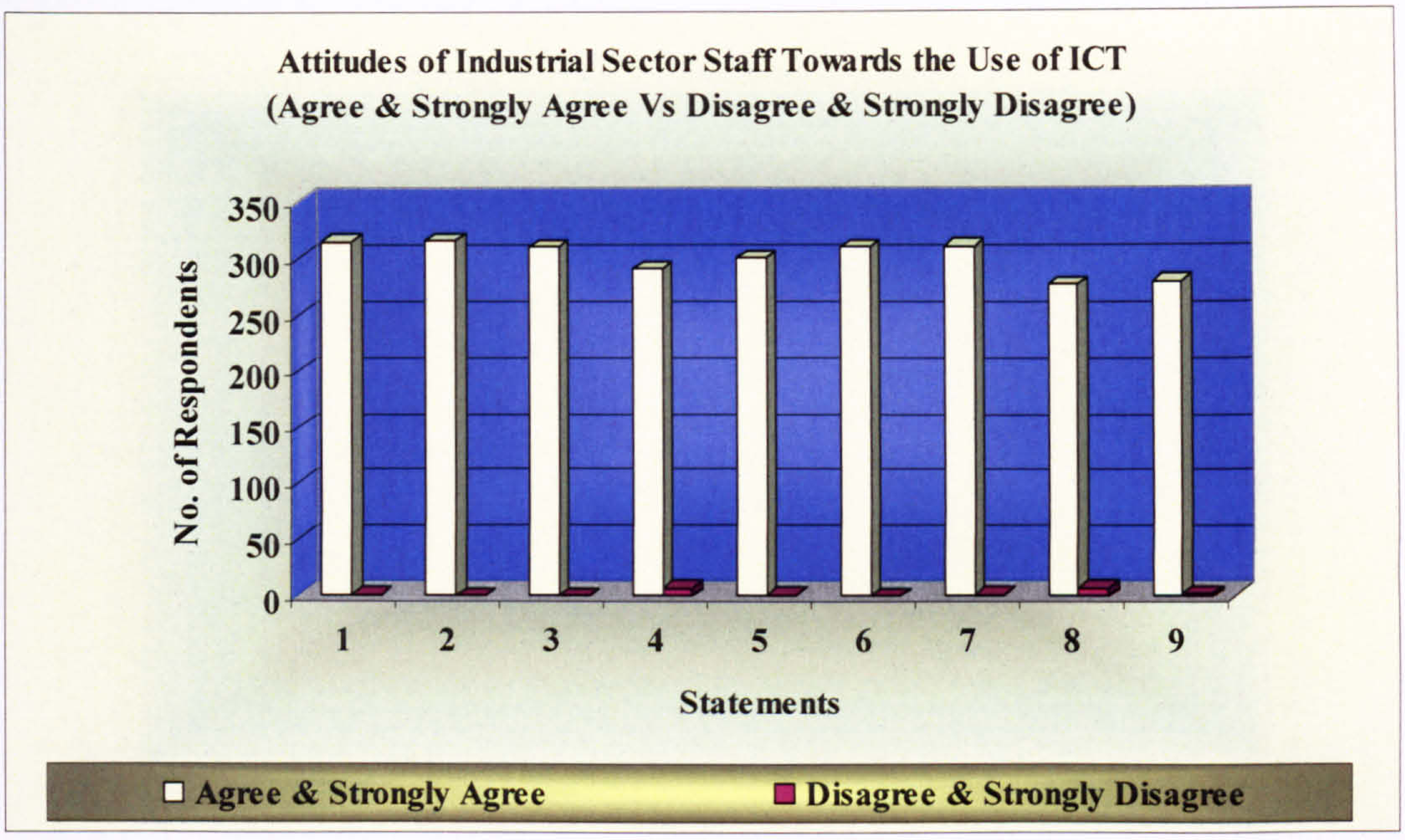


Figure 5.7 Attitudes of Industrial Sector staff towards the use of ICT

A t-test was conducted to calculate whether the means of two independent samples for a single variable differ significantly from each other. This was used to ascertain whether the mean attitude of the Civil Defence staff towards Information and Communication Technology in dealing with industrial accidents differs from that of the Industrial Sector respondents.

Firstly, the reliability coefficients for these statements were tested. These statements were found to be a reliable measure of competency (Cronbach [Alpha] = 0.88).

Means and standard deviations were calculated for the attitudes to computers between the Civil Defence and Industrial Sector staff. The test was carried out to see the differences between these two groups in terms of nine statements, which were used to represent the respondents' attitudes towards the use of computers.

Table 5.11 shows a summary of the results of the comparison between the Civil Defence and Industrial Sector in terms of the use of computers.

1. Use of Computers				
Mean & S.D. Civil Defence	Mean & S.D. Industrial Sector	t-value	df	Sig. (2-tailed)
4.5948 0.6769	4.6730 0.5086	-1.626	565.725	0.104

Table 5.11 *t*-test for use of computers

There was no significant difference in attitudes towards the use of computers between the Civil Defence and Industrial Sector. In other words, they both have highly positive attitudes towards use of computers; this gives a good indication that Civil Defence staff want to use computers in their work.

Table 5.12 shows a summary of the results of the comparison between the Civil Defence and Industrial Sector staff in terms of their attitudes to IT.

2. Attitudes to ICT				
Mean & S.D. Civil Defence	Mean & S.D. Industrial Sector	t-value	df	Sig. (2-tailed)
4.4804 0.6928	4.6289 0.5030	-3.055	555.429	0.002

Table 5.12 *t*-test for attitudes to ICT

There exists a significant difference in attitudes to ICT between Civil Defence staff and staff in the Industrial Sector. This result shows that Industrial Sector staff have more positive attitudes concerning the need for ICT in their work than Civil Defence staff.

Table 5.13 shows a summary of the results of the comparison between Civil Defence and Industrial Sector staff in terms of the use of new technology.

3. Use of new technology				
Mean & S.D. Civil Defence	Mean & S.D. Industrial Sector	t-value	df	Sig. (2-tailed)
4.4216 0.7906	4.6541 0.5327	-4.292	532.016	0.001

Table 5.13 *t*-test for the use of new technology

The Civil Defence and Industrial Sector respondents do have significantly different attitudes towards the use of new technologies in their jobs, with respondents from the Industrial Sector showing more positive attitudes. This is probably because they may have been exposed to new technologies. It is also likely that they have already experienced the importance of new technology in enhancing their work.

Table 5.14 shows a summary of the results of the comparison between respondents from the Civil Defence and Industrial Sector in terms of their attitudes to the replacement of their paper-based system.

4. Attitude to replacement of paper-based system				
Mean & S.D. Civil Defence	Mean & S.D. Industrial Sector	t-value	df	Sig. (2-tailed)
4.3464 0.8556	4.4182 0.7135	-1.137	593.891	0.256

Table 5.14 *t*-test for attitudes to the replacement of the paper-based system

There was no significant difference in attitudes to the replacement of the paper-based system between Civil Defence and Industrial Sector respondents as both had highly positive attitudes towards such a replacement. This result indicates the importance of developing job systems.

Table 5.15 shows a summary of the results of the comparison between Civil Defence and Industrial Sector staff in terms of their attitudes to IT based systems.

5. Attitudes to IT based systems				
Mean & S.D. Civil Defence	**Mean & S.D. Industrial Sector**	**t-value**	**df**	**Sig. (2-tailed)**
4.3725 0.8129	4.4560 0.6124	-1.444	566.539	0.149

Table 5.15 *t*-test for attitudes to IT based systems

There was no significant difference in the attitudes to IT based systems between the Civil Defence and Industrial Sector. They both have highly positive attitudes towards improving their work procedures by using ICT. This result indicates the importance of using ICT in each sector.

Table 5.16 shows a summary of the results of the comparison between Civil Defence personnel and Industrial Sector staff in terms of their attitudes to change.

6. Attitudes to change				
Mean & S.D. Civil Defence	**Mean & S.D. Industrial Sector**	**t-value**	**df**	**Sig. (2-tailed)**
4.4248 0.8032	4.5597 0.5514	-2.437	537.889	0.15

Table 5.16 *t*-test for attitudes to change

There was no significant difference in attitudes to change between Civil Defence and Industrial Sector respondents. They may be motivated to change, not for their professional enhancement, but in order to acquire a better system.

Table 5.17 shows a summary of the results of the comparison between Civil Defence and Industrial Sector staff in terms developing job procedures.

7. Developing job procedures				
Mean & S.D. Civil Defence	**Mean & S.D. Industrial Sector**	**t-value**	**df**	**Sig. (2-tailed)**
4.5392 0.7333	4.6887 0.5451	-2.881	562.513	0.004

Table 5.17 *t*-test for developing job procedures

There was a significant difference in attitudes to developing job procedures between the Civil Defence and Industrial Sector. This result revealed that Industrial Sector staff have a more positive attitude towards developing job procedures than Civil Defence staff. This significance may stem from the fact that Industrial Sector staff are more highly educated and trained than those in the Civil Defence department.

Table 5.18 shows a summary of the results of the comparison between Civil Defence and Industrial Sector staff in terms of their attitudes to the Arabiasation of computer programs.

8. Attitude to the arabisation of computer programs				
Mean & S.D. Civil Defence	**Mean & S.D. Industrial Sector**	**t-value**	**df**	**Sig. (2-tailed)**
4.4869 0.7432	4.2264 0.7654	4.314	621.949	0.001

Table 5.18 *t*-test for attitudes to the Arabiasation of computer programs

There was a significant difference in attitudes to the Arabiasation of computer programs between respondents from the Civil Defence and Industrial Sector. This result shows that Civil Defence staff have a more positive attitude to the Arabiasation of computer programs than those in the Industrial Sector. The result also indicates that Civil Defence staff who have an Arabic system have a significantly more positive attitude than those in the Industrial Sector.

Table 5.19 shows a summary of the results of the comparison between the Civil Defence sector and the Industrial Sector in terms of their attitudes to the existence of an information network.

9. Attitudes to the existence of an information network				
Mean & S.D. Civil Defence	**Mean & S.D. Industrial Sector**	**t-value**	**df**	**Sig. (2-tailed)**
4.6634 0.6385	4.4780 0.7222	3.401	617.604	0.001

Table 5.19 *t*-test for attitudes to the existence of an information network

There was significant difference in attitudes to the existence of an information network between respondents from the Civil Defence sector and those from the Industrial Sector. This result shows that Civil Defence staff have a more positive attitude to the existence of an information network than staff from the Industrial Sector. This stems from the fact that Civil Defence personnel need an information network to support their duties in dealing with industrial accidents.

5.5 Summary

This chapter presents the findings of the questionnaires analysis. The data that were collected and analysed will form the basis of Stage One (Identifying the Problems and Opportunities) of the SDLC technique (explained in detail in Chapter 7). The findings in this chapter also support the research objectives (1 & 2). A number of potential issues related to ICT were identified and explored. These include: access, use, skills, and training needs.

The results of the survey show that there are weaknesses regarding the use of ICT. The absence of good ICT provision, the weakness of ICT services and training courses, and the lack of qualified staff are regarded as major factors that have an impact on the use of ICT in disaster management. Other issues include the fact that executive management in both sectors do not encourage their staff to use and retrieve information by using ICT. Overall, the findings reveal that there are significant skills gaps. There are no training opportunities and staff in both sectors need ICT training programmes in terms of disaster management.

There are some problems in the Civil Defence sector regarding the provision of ICT services. Firstly, the shortage of ICT training support must be regarded as the major problem affecting the use of ICT. This shortage comes about because the budget of the Industrial Fire Brigades (IFBs) goes to training in traditional fire control. Secondly, most IFB staff did not use the Internet, because accessing the Internet is still not effective because the provision of terminals to IFBs is still very limited. Thirdly, there is a lack of qualified ICT staff in the IFBs. Because there is no electronic information service for IFBs, the survey gives a strong indication that most of the respondents used manual-based systems for obtaining or retrieving information. Most of IFB staff want to increase their computer skills. Workshops and seminars are regarded as two useful methods for providing information to users, especially when undergoing a long training period. A major problem here is the lack of management support for computer training programmes, because management concentrates on increasing the skills of fire-fighters through traditional training. The lack of training opportunities in ICT was regarded as a major problem.

The highest positive indication from users regarding the ICT services available in their departments came from the Industrial Sector. This may suggest that their staff were better trained than staff from the Civil Defence sector. All staff in the Industrial Sector were better educated and their ICT skills are good. In addition, most of them had more experience than Civil Defence staff and so they could handle and provide ICT services more efficiently. More staff training in the use of ICT is needed in disaster management; this can be seen from the responses to the questionnaire.

It is clear from the findings that training in the two sectors in terms of disaster management still needs to be explored and the benefits of ICT should be harnessed to make training more effective and to prepare workers to meet the changing needs of the future. Both sectors need to evaluate their ICT services in terms of disaster management training by testing out the benefits of these services. To do this, they must consider the views of the users of these facilities. The weaknesses surrounding the use of ICT services must be discussed as the less these facilities are used, the more likely it is they will be scrapped or never installed at all. When they evaluate their services to obtain feedback about the shortcomings of what they offer, they often discover that there is a shortage of equipment such as terminals, PCs, etc. or there is a need to upgrade the system. This problem will not be solved if there is not enough support.

Developments in ICT mean that both sectors are looking for new ways of upgrading their services. Advances in technology offer more options for delivering and managing services differently and better than before. From the findings, all participants want instant access to information and they require good quality services, especially since electronic products are becoming cheaper and, at the same time, are offering better quality. Moreover, an information network between these two sectors in terms of disaster management should be designed.

In next chapter, the results of the interviews that were conducted are discussed in detail.

6.1 Introduction

In order to gather as much data as possible in relation to the research objectives, it was decided to conduct interviews with a number of key people that have a direct connection with the overall subject. The interviews, as explained in detail in Chapter Four, were designed for two groups. The first was prepared for the members of the Civil Defence and Industrial Sector who were given similar questions. The second was designed for the ICT Professional at KACST and the Network Service Manager at STC.

This chapter is divided into two parts. The first part presents the results of the interviews while the second part discusses these results in more detail. The findings are grouped into four main sections. The first section deals with the data collected from the Saudi Civil Defence employees and the second section deals with the data collected from ICT professionals in the Industrial Sector. In order to structure the interview responses for these two sections, topics were grouped together to examine the current situation and resultant problems as follows:

- Current status of ICT services;
- The role of ICT in emergency situations;
- Future plans and expectations for using ICT in dealing with industrial accidents;
- Training issues;
- The current situation of LAN/WAN connections on the computers.

The third section deals with the data collected from ICT professional in KACST and fourth section with a Network Service Manager at STC. The importance of KACST stems from its supervision of the international connection point in Saudi Arabia with the Internet network. The importance of STC stems from its responsibility for the Internet Service and its duty to ensure the adequacy and appropriateness of the available technological infrastructure. The last two sections focus on the assistance of these respondents in establishing an information network to link the Civil Defence and Industrial Sector (see Appendix-4 for interview questions).

To investigate the current status and use of ICT services, a number of interviews were carried out. The sample interviewed included twelve officers from Civil Defence departments, seventeen key figures from different factories, an ICT Professional from KACST and a Network Service Manager at STC. This chapter presents an analysis of the results of the data collected from the interviews and outlines the main issues of concern raised by the interviewees.

Part One: Results of the Interviews

I.1 Civil Defence

As mentioned in Chapter 4, interviews were carried out with Industrial Fire Brigade Officers (IFBOs), personnel at the Civil Defence Command Centre (CDCC), and the Civil Defence Information Centre Manager (ICM), as shown in Table 6.1. The main idea of conducting interviews with different levels of management was to obtain rich information about the current situation which could not be gathered through the questionnaire. A total of twelve officers from different departments and different levels of management were selected.

Description	No. of Respondents
Fire Brigade Officers	8
Civil Defence Command Centre	3
Civil Defence Information Centre Manager	1
Total	12

Table 6.1 The Civil Defence interviewees

a. The Current Status of ICT Services

ICT and its applications enable people and organisations to coordinate activities with other people and organisations in different locations, regions or countries. Successful organisations increasingly will be those that are able to use and support ICT in their organisations and to help their staff to increase their skills by providing them with sufficient training and courses.

All departments use PCs and ICT as part of the daily routine. However, many Civil Defence staff have poor skills in using ICT. The skills needed to manage and operate ICT successfully are basic when the staff that may be needed should have good ICT skills. The respondents mentioned that the skills of staff in using ICT should be improved as an essential task to improve the ICT services. One of the IFBOs stated:

> The increasing of skills of those people who are dealing with ICT definitely will help to develop ICT services.

Another IFBO mentioned:

> A lack of awareness of the importance of ICT among the staff make the ICT services improvement slow.

Ensuring access to ICT-based services is emerging as one of the key developments in any organisation. All of the interviewees reported that their departments are using word-processing software in daily business activities as the main use of ICT. They are, however, suffering from a lack of ICT to support the needs of staff; this comes from the weakness of the ICT infrastructure. One IFBO said:

> We need more updated PCs connected directly to the Internet to help us to search, retrieve, and communicate on-line with others.

The Civil Defence Command Centre (CDCC) plays an active role in the control of all types of incident. It needs highly trained people to provide them with developed ICT facilities. CDCC is the bridge to help people in the case of an emergency. It uses a Local Area Network (LAN), which connects PCs together to aid the exchange of information between end-users. CDCC require staff who are familiar with a wider range of technology applications. In addition to providing the basic set of services that deal with incidents, staff who are trained in basic computer operations are required. In fact, the CDCC staff need to be well trained in using ICT to ensure the delivery of a high standard of service during emergencies but often this is not the case because staff training is not sufficient to use these facilities. The CDCC director expressed concern that the centre is not using ICT for reaching and dealing with emergency cases. CDCC staff are dissatisfied with the current situation in dealing with emergencies which depends on manual maps and the prior experience of workers. Figure 6.1a-b shows a screenshot of CDCC.

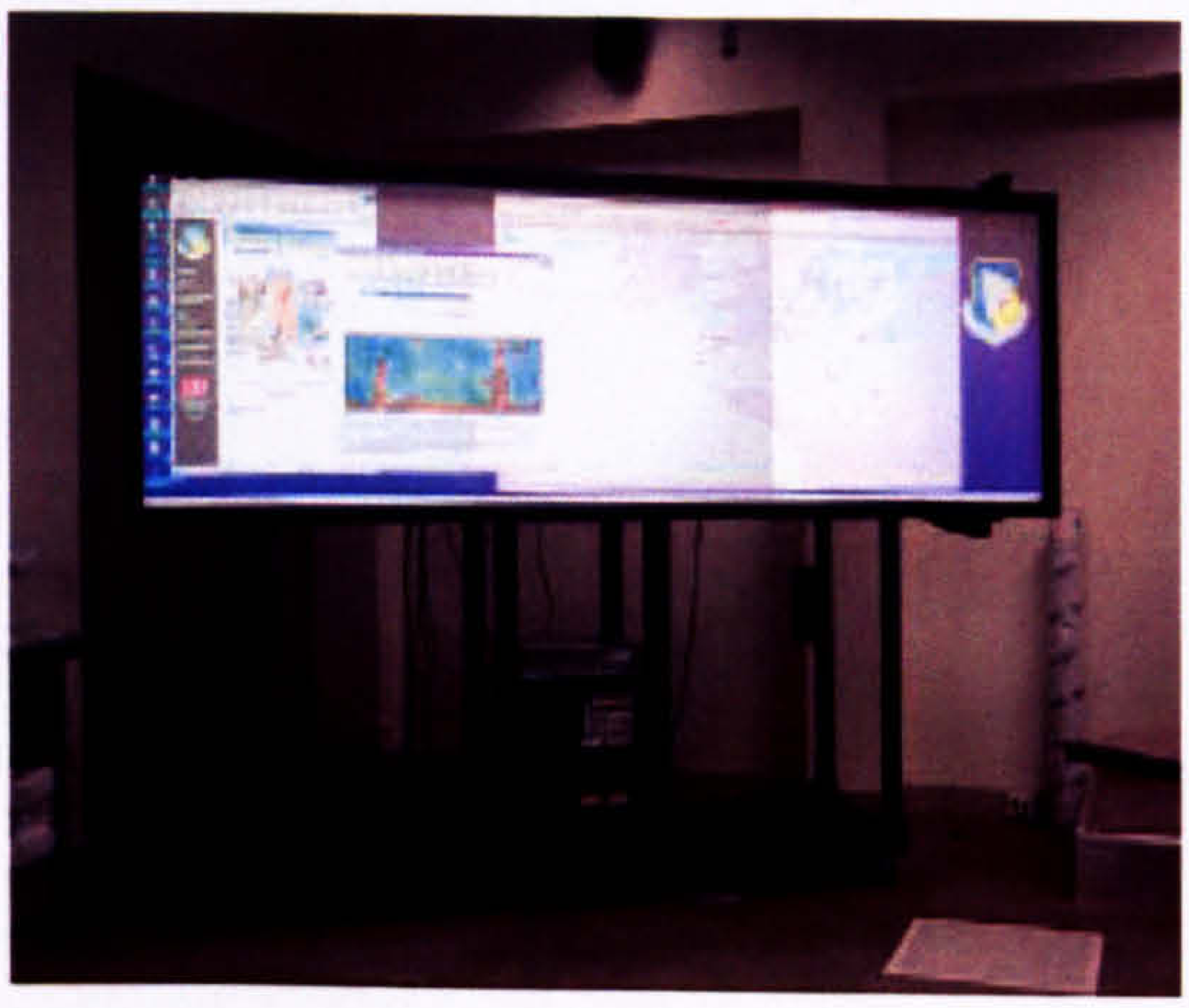


Figure 6.1a Manual maps stand

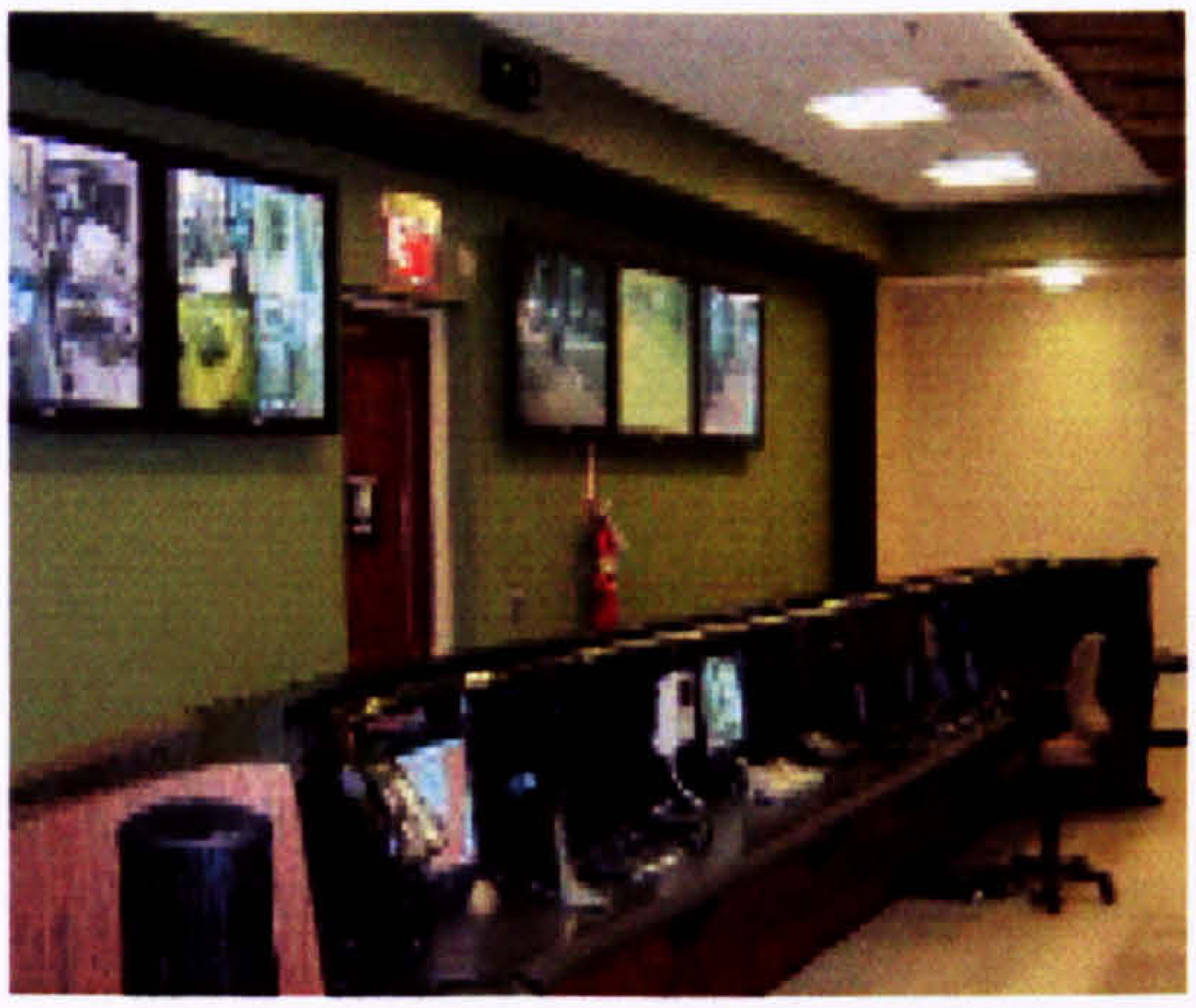


Figure 6.1b Front View of CDCC

The CDCC director stated that:

> We need a combination of different forms of ICT training courses to be made available to the trainees with an increased use of updated ICT facilities.

The use of ICT resources is demanded by these departments as departments which do not use ICT facilities will be less able to access information; be less able to use computer operations and Internet applications, such as e-mail communications; will not be able to carry out information search techniques and basic Web site maintenance; and will be less able to take advantage of computer training and perhaps more advanced functions such as Internet telephone and video conferencing.

The respondents indicated that they do not have an implementation strategy to adopt ICT in their departments. They mentioned that when they want to update their ICT, they write to the establishment's senior management and inform them of the need to update their ICT and any other application. They will then be invited for a discussion: sometimes it is a long time before this discussion takes place and sometimes the senior management does not take up the recommendation or request. One IFBO stated:

> We do not have any strategy to adopt ICT in our department and the updating of PCs takes a long time. We are looking for improving the current situation and increasing the financial support.

The Information Centre Manager indicated that their duties include developing ICT services in all Civil Defence departments. The Manager was asked to what extent he thought that the ICT infrastructure and computing services were sufficient to meet the needs of Civil Defence departments. He indicated that the ICT infrastructure and computing services within the Civil Defence departments had a reasonable ICT infrastructure and computing services, considering the financial support. The Manager identified numerous challenges facing ICT development within Civil Defence institutions including:

- Budget constraints and lack of professional human resources.
- Lack of an ICT adoption strategy.
- An insufficient number of updated PCs.
- Lack of adequate Internet access for a large number of staff.

The general ICT services provided by this centre are almost identical in the following functions:

- Administrative software applications for the departments.
- Hardware and software installations, maintenance and technical support.
- Internet services.
- ICT training programmes that are offered for the Civil Defence staff.

Industrial Fire Brigades (IFBs) play an active role in controlling industrial accidents. However, every IFB needs resourcing to a high level, especially in ICT. Moreover, they need certain hardware and software applications to perform their jobs as expected. The IFB needs to be in contact with internal sources (i.e. Civil Defence departments) and external sources (i.e. factories) to exchange information.

The interviewees were dissatisfied about the current situation of ICT because the computer applications did not match all their information needs, and they too complained about poor services and maintenance for PCs. All respondents wished to have more advanced computer systems, and advanced applications and networking which could help staff to improve their work. For example, one IFBO said:

> I think the information network is necessary for daily work, because, it will provide us with immediate information that we need.

Another IFBO mentioned:

> There is no updated information about hazardous materials. As well, databases of hazardous materials are not available.

The Information Centre Manager stated that:

> ICT resources frequently change and are being upgraded very rapidly so it is hard to satisfy both our needs and the needs of our end-users.

Clearly, an opinion has been expressed that there are issues with the current ICT services. The executive management do not give enough support to ICT development. This may be a result of the limited financial support for ICT services. These issues increase the extent of the complexity of the problem for which a way forward must be found. A solution would enable the Civil Defence organisation to be fully functional and take its place in controlling incidents effectively. The Civil Defence's future development plans should concentrate on increasing the ICT experience of all workers and bring up-to-date all computer hardware. Moreover, Civil Defence plans should increase the competence of all fire-fighters in carrying out their duties.

b. The Role of ICT in Emergency Situations

The role of ICT in improving the way incidents are dealt with concerns the provision and structuring of information. ICT can assist fire-fighters and emergency call takers in making better choices on the basis of the information provided. The use of ICT in emergency services will improve and help in the control of incidents everywhere.

Respondents mentioned that ICT plays an important role in hazard control and in improving efficiency in dealing with disaster management processes. ICT in emergency services, for example, will help fire brigades to find the incident's location and give information on how to control the incident. The nature of emergency planning and response means that the emergency service providers rely heavily on ICT services and equipment for communication and administration.

The emergency call taker is the first person to whom citizens speak when they dial 998 to report an emergency. It was found that the most important communication facility that is in use between the Civil Defence and Industrial Sector in the case of an emergency is a telephone call. The CDCC Director mentioned that:

> This is the only communication facility we have at present with factories during incidents. Sometimes, we are faced some problems because the callers do not provide us with enough information about the situation or give the wrong address.

He stated that, to develop ICT in emergency management, CDCC should be:

> ...equipped with updated technologies such as: wireless communications, environmental and weather information, and remote alarm systems, and this is just a few examples of the services the CDCC needs to execute its duties for protecting human life, habitats, land and properties.

The procedures that respondents follow when an accident happens are described as below:

> CDCC is always receiving emergency calls from everywhere. As soon as a call is received, it sends a call to the nearest Fire Brigade from the accident location and provides it with available information.

Communication is a necessary tool for the operation of emergency management control, as well as for calling other emergency services. The development of communication capacity will help to improve CDCC's services. The CDCC Director said:

> We need access to the Internet to communicate with others and to permit our staff to retrieve on-line information about the hazardous materials. Moreover, this will increase their knowledge about emergency management.

In answering the question regarding the difficulties that fire-fighters face when dealing with industrial accidents, both respondents answered that the shortage of information about hazardous materials in factories is the most important factor. In addition, because of the factories' distant location, it is often difficult for fire brigades to reach a scene quickly; planners should determine in advance approximately how much time would elapse before they could arrive at the scene. Keeping the plan current is a difficult task but can be achieved by scheduling reviews regularly. However, because of the slow response from the factories this takes longer than expected. One IFBO mentioned:

> The shortage of the availability of updated information about hazardous materials that are in factories is the greatest problem we are faced with at present.

The respondents also indicated that they do not use any ICT facilities in the case of dealing with industrial accidents; they follow the CDCC's instructions and the experience of workers to reach the location of the accident. One IFBO said:

> We are living in a high tech era, but we have still not got the benefit from this development.

He added:

> We need updated hardware and computer applications to help us to improve our services.

The Information Centre Manager said:

> The use of ICT in emergency response is becoming increasingly important and the provision of facilities potentially very demanding, but there is no capital budget and insufficient support for the replacement or development of ICT services.

The purpose of IFBs is to protect the industrial cities from industrial accidents. Therefore, to get a top level of service quality in industrial cities, the Civil Defence has distributed a hazardous materials data sheet to all factories to identify all hazardous materials in order to keep the service up-to-date. This, in conjunction with training, gives high quality service in dealing with industrial accidents. One IFBO mentioned that:

> We spend a long of time updating the information about hazardous materials in industrial cities, because we are still using manual-based system.

c. Future Plans and Expectations for Using ICT in Dealing with Industrial Accidents

It is true to say that to be successful in fire-fighting, fire-fighters must have effective arrangements with the Industrial Sector in terms of the availability of hazardous materials data. The purpose of these arrangements is to facilitate and promote liaison between fire brigades and factories through guidance which will identify the problems which they may face during industrial accidents. The interviewees mentioned that emergency plans are one of the most important arrangements that are made with factories. The CDCC Director mentioned that:

> There are emergency plans in each installation, which are obligatory to implement and they must have regular drills for their staff to be familiar with these plans.

One IFBO stated that:

> The emergency plan is the guide on the setting up of internal and external equipment at the establishment, previously inventoried, and of actions to be taken when there is an accident situation.

Therefore, the emergency plan forms part of a policy of prevention and protection for people and property, and it contains all information that must be followed during the emergency. The emergency plan is formalised by the drawing up of documents which are collected together in an 'Emergency Plan' manual; this contains all the information necessary to manage an accident situation. This manual is drawn up by the establishment's manager who is responsible for updating it as a function of the evolution of:

- Risks or knowledge;
- The organisation's structures;
- The environment;

- Means of intervention.

The establishment's staff member who is asked to organise or take decisions in the case of an accident must know and have mastered the contents of these manuals, particularly the classes of compulsion. The emergency plan manual must be sent to those responsible in the Civil Defence department to check and give permission for this plan to be implemented.

The Civil Defence organisation is responsible for reviewing such emergency plans and participates in carrying out certain training courses for the factories' staff. These courses include:

- Fire fighting.
- Safety procedures.
- Evacuation.
- Using fire extinguishers.
- Making emergency calls.

In the case of an emergency, the Civil Defence instructions for all factories are as follows:

- To start to implement their emergency plan;
- Call Civil Defence, and
- Evacuate the personnel to suitable assembly points.

In the case of co-operation and collaboration with the Industrial Sector, the Civil Defence organisation believes that it is important that both sectors are aware of each other's activities. IFBOs mentioned that:

> Management of hazardous chemicals has still not gained the desired attention it should receive.

Co-operation between organisations will help to improve the services, particularly in industrial cities, for controlling industrial accidents. To reveal to what extent there is co-operation between the Civil Defence and Industrial Sector, interviewees were asked whether there is any co-operation between Civil Defence departments and factories. They remarked that, in order to cope with technology and improve the fire-fighters' services, the management of the factories should help Civil Defence personnel to update their information which relates to hazardous materials to keep fire-fighters aware of all dangerous materials in industrial cities. The IFBOs stated that:

> We must update our information regarding the hazardous materials but unfortunately, there is little co-operation from factory managements regarding this matter, because they do not give these data sheets any thought unless Civil Defence asks them to do it through inspection processes.

Another added:

> Lack of co-operation from factories to provide us with information about all dangerous materials causes delay in providing good services.

Moreover, IFBOs called on factories to:

> ...increase their attention regarding co-operation and collaboration with Civil Defence because the current situation is not working effectively.

One IFBO added:

> We need more co-operation from factories to provide all the information that the Civil Defence needs.

Another one said:

> When we need to update the hazardous materials' information from the Industrial Sector, this takes a long time and sometimes we are aware that this information is not corrected or not completed. I think the existence of an information network with factories will solve a lot of problems.

The importance of co-operation on these issues is clear. Interviewees concentrated on the following points: updating hazardous materials data, response times, and more effective co-operation.

When the interviewees were asked whether they thought it is time to develop communications between their organisation and the Industrial Sector to control industrial accidents quickly and effectively, their responses were positive. They indicated that:

> Now is the time to establish the information network to exchange information with factories and there are more advantages from establishing the information network with factories and they support it strongly.

One of the interviewees stated that:

> Yes, it is not before time to develop the communication with factories.

The interviewees additionally asserted that all factories should have a connection with this network and should take advantage of its database contents. They mentioned identifying tasks and assigning responsibilities for action and following up the updating of the information network so it could be used as expected.

Regarding the respondents' responses concerning how they evaluated their work in dealing with industrial accidents, they said that they do their best in controlling accidents and that there were times when they needed longer to control the accidents effectively because they had to collect information and evaluate the accident first before deciding on the best way to control the accident. IFBOs mentioned:

> Sometimes we spend a long time till we control the incident because of facing unknown hazardous materials. This comes from the shortage of information and data and weakness in the co-operation from factories about the hazardous materials they have.

They hope to improve fire-fighting equipment, use ICT properly, and cooperate effectively with the Industrial Sector; this will come through the support of the upper levels of executive management and decision-makers.

Communication and co-operation regarding the creation of an information network between the Civil Defence organisation and the factories should be established. This cannot be achieved without the support of executive management in each organisation. The attitude of fire-fighters towards this is positive. An information network should facilitate the communication and co-operation between these two organisations in terms of emergency management and fire safety. Almost always, in order for the fire brigades to respond effectively to any emergency, all emergency services must be involved.

d. Training Issues

In order to succeed in ICT, the computer knowledge of staff in any organisation needs to be updated and be able to match the continuous evolution of the information technology. To assist the organisation to excel in this information age, the training department can provide staff with training and assistance to take full advantage of computing technologies.

Respondents were asked whether any emergency control training involving the use of ICT was available for staff and whether there existed any computer training plan to develop staff skills and keep them up-to-date with ICT. The purpose of training on response to chemical emergencies is to provide information that should be common to all the professionals from both sectors, particularly those involved in planning for or responding to chemical incidents.

All respondents indicated that they did not take part in any training for emergency control by using ICT, and that there is no computer training plan to develop staff skills. This comes from:

- Insufficient finance and difficulty in getting financial support via high management to manage and purchase new computer equipment (hardware and software);
- Shortage of computer staff;
- Lack of skilled people who have a background in computers;
- Difficulties regarding training due to the high cost of training and a lack of ICT specialists.

One IFBO said:

> There is not enough time to spend on ICT training because of the time taken up with fire brigade duties.

Interviewees expressed concern over the lack of training opportunities and the lack of the training department initiatives to organise training on emergency management by using ICT. One IFBO said:

> User training is still important when people want to get up and running as soon as possible, and the management should support them.

The Fire Brigade Officers mentioned that there was training for fire-fighters in Civil Defence training centres as part of basic training on Civil Defence duties. In industrial cities there is some co-operation with certain factories and some short training courses to increase the competence of workers in both sectors.

Respondents highlighted the importance of increasing their staff's skills in using ICT, but there are some problems that minimise the benefits of training. These are the lack of funding, a shortage of technical staff, and the maintenance of hardware and software. It was clear that well-qualified and skilled staff were needed to operate these systems and to train fire-fighters to exploit computers effectively and efficiently.

According to the interviewees, different types of skills and knowledge are needed to help staff know how to use ICT effectively during emergency management. The Information Centre is responsible for providing courses and on-site training for fire-fighters. However, while the Information Centre provides its services to all Civil Defence staff, it does not have time to train all of the staff in fire brigades. The Information Centre Manager stated that:

> Our responsibilities include providing and maintaining top-quality services for Civil Defence staff, and assisting in developing and maintaining ICT to ensure maximum service levels within the available budget. We are responsible for installing all ICT equipment in the Civil Defence. Areas of responsibility include information systems, computer operations, telecommunications, office automation, end-user computing/information centre as well as strategic planning for information resources. Therefore, to solve the lack of staff skills in using ICT, we are setting up a new training programme for the Civil Defence which will be utilised to educate staff according to department needs.

Civil Defence staff require awareness level information on how ICT can benefit their work, as well as acquiring a working knowledge of how ICT works. This information is basic to the planning for, acquisition of, and effective use of various technologies. Technology planning in the Civil Defence often neglects issues of ICT hardware, software use and ongoing training. IFBs are suffering from a lack of training and technical assistance, both in the operation and integration of the technology, and a lack of appropriate and specialised software for emergency management.

e. The Current Situation of LAN/WAN Connections

The importance of LAN/WAN network management has been growing as the foundation of information sharing. In turn, information systems are required to meet the needs for job innovation. Therefore, network management must be converted to an optimal, efficient form. Information systems must keep adapting. Network technologies are developing every day and corporate network systems need to incorporate these technologies to keep improving their flexibility and functions. The CDCC Director said:

> We have a LAN in our centre and all the PCs are connected. The LAN is connected with the Civil Defence Information Centre, and they mainly use it to fill up the database using daily inspection reports.

Some departments in Civil Defence are trying to organise their terminal equipment to allow information to be shared throughout the organisation. IFBOs mentioned:

> We have a terminal connected with the Information Centre but rarely do we use it because it is not updated and there is a shortage of skilled staff.

Regarding the possibility of using this network to communicate with the Industrial Sector, IFBOs clarified that the IFBs are part of the Civil Defence organisation. Typically, the Civil Defence has its Information Centre and this has the ability to establish a network with Industrial Sector. Some of the respondents indicated that they do not know about possibility of communication with factories because they are not specialists, while others indicated that it is not possible to connect with factories because of weaknesses in the infrastructure.

The Information Centre Manager answered this question:

> Yes, we can communicate with the Industrial Sector and other emergency services but we need a budget and support from the decision-makers in the Civil Defence.

Exchanging information with external sources is important and the Civil Defence staff appreciate this point; they are asking for the LAN to be activated and that a WAN is established to connect them with others. The CDCC Director emphasised the importance of the network and said:

> The network architecture must be deployable to any utility in the Civil Defence. This will help us to access information and to exchange information with others.

All respondents mentioned that there are some problems that need to be faced when implementing ICT systems. These include:

- Shortage of ICT personnel (e.g. programmers, software specialists, engineers),
- Inadequate technical support and advice on selecting ICT resources,
- Lack of funding and difficulties in obtaining financial support from high levels of management,
- Difficulties regarding training due to the high cost of training and a lack of ICT specialists.

One of the respondents stated that:

> I think there will be no problems when we decide to establish this information network, because it is very important and will improve and increase the level of services provided by the Civil Defence.

Concerning problems that they will face when they decide to communicate with factories, they answered that there will be no co-operation from factories, especially if there any high costs that they will have to pay.

I.2 The Industrial Sector

As mentioned in Chapter 4, interviews were carried out with ICT professionals in the Industrial Sector (ICT managers). The main idea of the interviews was to gather rich information about the current situation, which could not be gathered via the questionnaire. A total of seventeen ICT professionals from different factories and different areas (Riyadh, Jeddah and Dammam) were selected. The interviewees included seven ICT managers from Riyadh, five ICT managers from Jeddah (in the Western Province of Saudi Arabia) and five ICT managers from Dammam (in the Eastern Province of Saudi Arabia), as shown in Table 6.2. The criteria for choosing these factories stem from the fact that these factories deal with different quantities of various hazardous materials.

a. The Current Status of ICT Services

ICTs are now playing a significant role in enhancing the productivity of the Industrial Sector and in improving the precautions taken to avoid industrial accidents. The most significant ICT applications improve both production levels and productivity, primarily through better process controls. This results, in turn, in changes which increase safety precautions. All respondents indicated that they have ICT departments and use it in their functions. These departments offer a number of services such as:

- Operating the computer systems,
- Developing the computer applications for organisation departments,
- Developing and maintaining business applications.

Concerning the use of ICT facilities for reaching and dealing with industrial accidents, some of the respondents said that they do not have these facilities. One of them stated that:

> We do not have these facilities because the Civil Defence does not have it.

	Description	Area
1	Riyadh Oxygen Plant	Riyadh
2	Odwan Chemical Industries	Riyadh
3	Saudi Carbonates Co.	Riyadh
4	Agricultural and Industrial Chemicals Factory	Riyadh
5	Al-Sharq Plastic Factory	Riyadh
6	Saudi Paint Company Ltd. "Paintco"	Riyadh
7	Saudi Vetonit Co. Ltd. "Saveto"	Riyadh
8	Pharmaceutical Solution Industries	Jeddah
9	Modern Luggage Industries	Jeddah
10	Al-Faisal Plastic Factory	Jeddah
11	Badreig Melamine Factory	Jeddah
12	Al-Sama Factory for Printing Ink & Sundries	Jeddah
13	Saudi Industrial Detergent Co.	Dammam
14	Al-Hayat Factory for Medical Products	Dammam
15	Gulf Melamine Factory	Dammam
16	Saudi Company for Chemical Products	Dammam
17	Plastic Sheets Factory	Dammam

Table 6.2 The interviewees from the Industrial Sector

In addition, some of them answered that they have a safety department to deal with accidents when they occur and that they have a warning system. Figure 6.2a-c shows some of the warning systems that available in Industrial Sector.

They indicated that, in the case of major accidents, they mainly use the basic form of communication – the telephone – to call for Civil Defence assistance. Seven of the respondents indicated that:

> In the case of accident we mainly use the telephone to call to the Civil Defence and try to follow their instructions.

Figure 6.2a Fire control panel

Figure 6.2b Fire alarm system

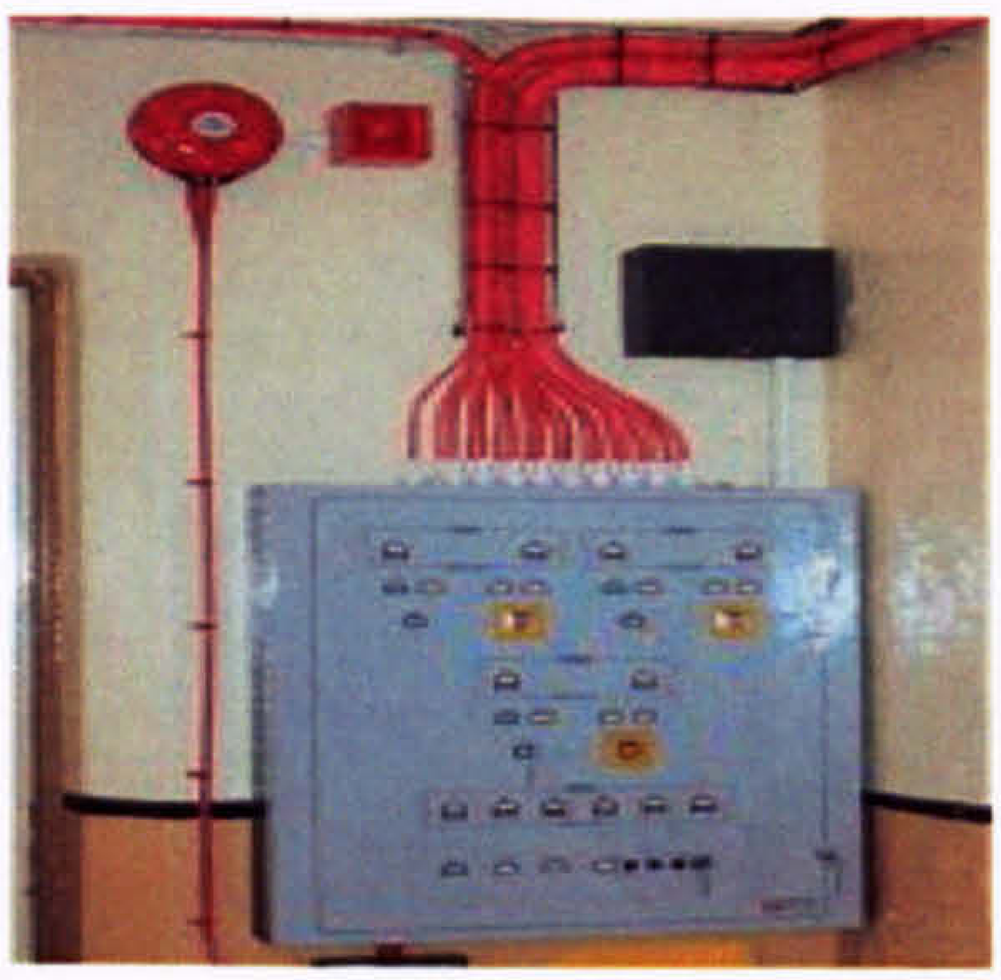


Figure 6.2c Halon control system

Nonetheless, efforts to further improve and upgrade the capability and professionalism of fire prevention, protection and control, as well as rescue work, are demanded. Furthermore, they are aware of the importance of ICT in helping the organisations to overcome the problems they may face.

Regarding whether the factories have a strategy to adopt ICT, six of the interviewees answered that they did not have any ICT strategy, while the rest indicated that they have strategies for adopting ICT. One of the respondents stated that: 'we have regular investigations of our systems and we evaluate all computer applications. If we find any need to change or develop our computer applications, we do it immediately'.

Regarding ICT strategy, the respondents mentioned that:

> We in the private sector know our future success in business will depend on the development of technologies that can be commercialised and produce

> revenues. So, our strategies are to develop key devices, components, and related process technologies essential to information input, signal processing, and output of information as part of ICT development plans.

Concerning the regular development of ICT applications, all respondents answered that they have plans to develop their computer applications depending on their needs. Some of them mentioned that:

> As part of our strategy to development and improve ICT, the improvement of information needs will be considered. The good use of information and computer applications considered as standard will be incorporated into the development of ICT applications by computer departments.

ICT will play a crucial role in the development of safety procedures in this era. The Industrial Sector should take an active role in this and the financing of high tech for safety projects should be encouraged.

b. The Role of ICT in Emergency Situations

A communication system that will link organisations with emergency services is very important and should be available 24 hours a day. Immediately after an incident occurs, there is a high demand for information. Whether the incident is large or small, a natural disaster or man-made, the media and public, as well as responders, require accurate and timely information. The Industrial Sector should use ICT in such situations. One of the factory managers said:

> We still not take the full benefit from ICT in terms of emergency management. It is important to know that the result of the lack of adequate communications with emergency services will affect the speed of response of the emergency operations.

Reviews of emergency plans in terms of preparedness and readiness will provide comprehensive fire safety. These reviews should be conducted annually and the involvement of line management and co-operators, where applicable, is critical. Reviews are designed to assist the factories in preparing for operating during an emergency. They also serve as a mechanism to identify deficiencies, recommend corrective actions, and establish the need for follow-up to corrective actions.

Regarding the procedures they follow in the event of an accident, all respondents indicated that they follow the Civil Defence's instructions. These instructions are that, when the warning system starts, they must:

- Implement the installation's emergency plan,
- Evacuate workers to assembly points,
- Call the Civil Defence.

Two of the respondents stated that:

> We have an industrial accident department which has the ability to evaluate the accident and then will implement the emergency plan and call the Civil Defence.

Concerning the use of ICT in the case of controlling industrial accidents, two of the respondents indicated that they did not use ICT in controlling accidents, while the rest indicated that they have a warning system to detect and control fire incidents; this is connected to the control panel to help workers know where the accident is. One of the respondents stated that:

> We should use ICT such as a hazard alarm system connecting with the control panel in our plant because they are simple and indicate that there is danger imminent. This will advise people to protect themselves and will inform them on the character of the hazard. This is particularly important for industrial hazards when fast and well-founded reactions are needed in order to protect the plant from damage.

Regarding the use of ICT in the case of dealing with industrial accidents, that is, calling fire brigade automatically using automated directional systems, the respondents indicated that they did not have such a system but they have warning systems and control panels which help in determining an accident's location.

Regarding the difficulties they face when accidents happen, the respondents indicated that their workers sometimes deal with accidents erroneously. This, they said, can be overcome by increasing the workers' training in emergency cases. One of them said:

> Particularly problematic are structures and buildings, which may present difficulties in the event of evacuation such as multi-storey hotels or high-rise office buildings.

Another respondent added:

> Insufficient training has produced workers who could not adapt to the demands of an emergency which the system did not anticipate.

ICT can be applied to connect the Civil Defence and Industrial Sector, thus enabling them to share information and to establish an effective warning system. ICT can sort, collate and relate data to assist the emergency services in managing emergency situations. The interviewees indicated that the phone call is the only way to communicate with the emergency services. They did not use ICT in dealing with emergency situations, despite the tremendous usage of ICT in this era. Moreover, ICT could support key people in improving communications in terms of dealing with industrial accidents.

c. Future Plans and Expectations for Using ICT in Dealing with Industrial Accidents

Effective arrangements between organisations are a key tool in enhancing the control of industrial accidents. The need for co-operation and co-ordination arises from a growing awareness of the importance of incident control. All respondents indicated that some arrangements with Civil Defence departments exist. Firstly, each factory has to prepare an emergency plan and then send it to the Civil Defence for approval. Secondly, the main co-operation between the Civil Defence and the factories is in training. The Civil Defence organises courses for factory staff and trains them on how to deal with accidents and fire-fighting. Also, during accidents, factories mainly follow Civil Defence instructions and call the Civil Defence by telephone.

In terms of co-operation and co-ordination with Civil Defence, the respondents answered that they usually comply with what the Civil Defence needs i.e. the completion of the hazardous materials sheets regularly and the preparation of emergency plans. Concerning keeping information up-to-date (mainly the hazardous materials information), they mentioned that they give the Civil Defence all the information but sometimes this takes a long time because, according to one of the respondents,:

> We have other duties and updating information needs more time, because this has to be done manually.

Concerning their co-operation with the Civil Defence organisation on updating their information regularly, the respondents indicated that they follow the Civil Defence's instructions, give them any data they want and do their best to inform the Civil Defence about any hazardous materials they have. When discussing with them the existence of delays when co-operating with the Civil Defence departments, as well as the lack of up-to-date information, they mentioned that they try to do what the Civil Defence needs because this will provide a high level of safety.

Regarding the role played by fire-fighters in controlling accidents, the respondents mentioned that:

> Sometimes fire brigades reach the place of the accident and take a long time to control the accident.

Respondents were asked what they think when fire-fighters respond to an emergency call and find unknown hazardous materials. The answer was clear: they must disengage from the immediate threat until they can identify the type and degree of the hazard. The correct information and up-to-date data are very important for fire-fighters in dealing with accidents effectively and sufficiently. The respondents were in agreement that the need for an information network cannot be overemphasised; this would, they felt, help to overcome these problems. They also stated that it is time to develop an effective communication channel with the Civil Defence because this will increase the performance of fire-fighters as well as decreasing the time taken to reach the accident site.

Co-operation does not mean immediate integration. It can take several forms, with various degrees of arrangement and co-ordination. Besides, there is no compulsory sequencing between these organisations. They need an effective arrangement to improve their readiness for emergency situations.

d. Training Issues

As mentioned in last section concerning training issues in Civil Defence departments, this section presents comments regarding training issues in the Industrial Sector. Human resources development is one of the most important factors in any organisation and ICT has great potential to promote this effectively. The Industrial Sector should therefore make ICT utilisation a priority for training in the control of emergencies. However, it should be noted that each organisation has its own needs from such training and this is something of a supplementary tool, e.g., using computers in specific jobs, for design programmes etc. Thirteen of the respondents indicated that they do not have any emergency control training using ICT techniques. One of the respondents stated that:

> We hope there are training courses in emergencies by using ICT, but unfortunately this is not available at the moment.

The rest indicated that they try to offer their staff some training courses in conjunction with the Civil Defence organisation and other emergency services to increase their skills in dealing with accidents. Concerning the existence of any special training courses for emergency control using ICT, all respondents answered that there are no special courses but they try to do their best to increase the safety skills of their staff.

Regarding whether or not they have computer training plans to develop staff skills and keep them up-to-date with ICT, five of the respondents indicated that they do not have any plans, while the rest highlighted that they ran basic training courses and offered a general guide to the computer facilities for end-users on operating systems to help them to use their desktop computers effectively and to carry out their daily tasks. Furthermore, they have plans to continue with this in future and they hope that all end-users will benefit from these courses. Some of these courses are shown in Table 6.3.

The possibilities for ICT utilisation and training can be seen in improving the existing training programmes; support for providing training on dealing with emergencies by using ICT; system development for on-site training; support for training with the Civil Defence; and participating in drill exercises.

No.	Types and topics of end-user training courses
1	Basic computer skills
2	General guide to computer facilities
3	Training to use the Internet
4	Programming language

Table 6.3 Computer training courses

e. The Current Situation of LAN/WAN Connections

The development of infrastructure plays an important role in the promotion of ICT. Such developments, however, have to be carried out in a planned and co-ordinated manner. More importantly, the dissemination of current and planned development information to other sectors would be required. This would enable other organisations that use ICT for their activities to be able to plan their own e-strategies that are commensurate with the available infrastructures and other resources. The ICT policy should address the need for such coordination and information sharing. It should recognise the importance of the network as an essential prerequisite to information exchange. Three respondents indicated that they do not have any type of network, while the rest indicated that they have a LAN in their units. This LAN, they said, is mainly used for business processing and to link the central branch with the other branches to exchange information.

In respect of the possibility of using this network to communicate with Civil Defence departments, three of the respondents answered that they do not have any type of network, but if any link with the Civil Defence is organised in the future they will. Furthermore, two of the respondents answered that they have a LAN but it is not ready to communicate with Civil Defence departments at the moment. The remaining respondent indicated that there is a possibility for them to connect with Civil Defence departments the information network existed.

In the intensifying competition among companies, there are growing expectations over job innovations based on information systems. Each company is striving to organise its terminal equipment to allow information to be shared throughout the company. This will help to establish a WAN between different organisations.

Interviewees were asked about the main problems that their organisations face when implementing ICT systems and what these are. In responding, six respondents indicated that they did not face any problems when they implemented their ICT systems, while the rest indicated that they had some problems when carrying out the implementation. These problems included:

- Non-cooperation from end-users,
- Training new staff,
- Choosing the ICT applications
- Lack of funding and difficulties in obtaining financial support from senior management.

One of them added:

> We are expected to solve ICT problems such as designing a suite of computers for particular needs.

The respondents discussed many problems in describing their use of ICT. Here the researcher organised the problems emerging from the research according to categories that reflect the key source of the problem:

- Technical faults,
- Knowledge, skills and the user interface,
- Learning,
- Problems with commercial services,
- Social relationship issues,

- Everyday usage problems and frustration with the limits of the technology,
- Uncertainty over innovation and upgrading.

Some of these problems are one-off events, others are continual and associated with the everyday usage of the technology.

Concerning problems that they are likely to face when they decide to communicate with Civil Defence departments, eight of the respondents indicated that they do not envisage any problems; they think that it is a good idea and will increase the safety of industrial installations. The rest indicated that the main problems are likely to be funding and staff training for the new system. One of the respondents mentioned that:

> The automation of emergency services will revolutionise the way rescue missions are carried out. Then, fire brigades will be able to reach a specific site, deploy their equipment and control the emergency quickly and effectively.

Another added:

> One of the benefits of the communication system is that all needed data will be stored in the computer-aided dispatch system. This will help dispatchers to perform their duties during emergency situations. After the emergency, this system will help in studying what happened, how the situation unfolded, what problems were encountered, what deficiencies were present and other details that can be used to refine the emergency response plan.

It is clear that there are some issues concerning ICT implementation. Awareness of the importance of ICT in emergency control and positive attitudes towards ICT will help to overcome these issues.

I.3 The ICT Professional in KACST

In order to get the full picture about organisations that provide information services in Saudi Arabia, KACST was given consideration. This is mainly because KACST is one of the biggest organisations in information provision and this research seeks to investigate the current situation regarding ICT and to understand the kind of services and assistance KACST provides.

The interviewee was asked about the kind of services that KACST provides for controlling emergencies. The interviewee stated that there are various information services and facilities that are available to academic institutes, universities and to the public as well. There are some services that KACST provides for academic and research purposes. These are:

- Basic services: remote access, e-mail and file transfer,
- Databases that can be searched by academics and which are divided into four separate databases, and,
- On-line database services, nationally and internationally.
- KACST is the only national Internet connection point (gateway) in Saudi Arabia and, for the continuity of its services, it has constructed another gateway in Jeddah.

When the interviewee was asked whether these services would support the establishment of a new system (an information network) that would link the Civil Defence and Industrial Sector, he indicated that the type of services that KACST provides is mainly for academic and research purposes. This implies that the desired system will not be supported directly by KACST. However, he indicated that KACST would provide all the assistance required by the researcher in establishing the new system, as this is within their main aim: supporting scientific research and all studies that are within the remit of KACST.

The interviewee was asked about the problems that are likely to be encountered in establishing the desired information network. He mentioned that these projects need good management, sufficient funds and high-skilled personnel to work with such networks. High quality communications and up-to-date hardware and software must be used in order to present high-quality information.

I.4 The Network Service Manager at STC

The Data Network Planning and Internet Services Manager was interviewed in order to understand the role of STC in industrial disaster control in Saudi Arabia. At the beginning of the interview he summarised the tasks of his department as:

- Participating in identifying the necessary ICT infrastructure and related technical requirements for providing effective telecommunications to facilitate Internet services throughout Saudi Arabia;
- Hooking up the beneficiaries of the Internet services in terms of individuals, ISPs and government and non-government organisations with KACST-ISU;
- Overseeing all types of procedure to designate modem ports and leased lines to the ISPs, handling related financial issues, and providing the required technical and support services.

The interviewee was asked about the kind of services that the STC provides for the control of emergencies. The interviewee stated that the role of the STC is to build the infrastructure that supports data transfer in all formats including the Internet, tele-medicine, e-commerce and other data transfer-related networks.

The interviewee was asked about the kind of assistance that the STC will provide towards establishing the new system. The interviewee answered that the STC is developing a high-speed network connecting most parts of the Kingdom. Currently, the main regions of the Kingdom are covered by this backbone with expansion planned for the remaining regions. The Internet Services Unit (ISU) and all Internet Services Providers (ISPs) are connected to the national backbone that carries Internet traffic inside the Kingdom and to the international link. On the other hand, the role of the ISPs is to sell services to the end-users and to authenticate and validate their access to their router and other applications such as data hosting, web page design, promotional advertisements, etc.

The interviewee was asked whether he thinks that the STC will support the new system as apart from the national network. He answered that the STC would support this information network as well as the national network.

The interviewee was asked about the problems that might be encountered in establishing the information network. He mentioned that this project needs highly qualified staff as well as ICT skilled workers to help in success of this project.

Part Two: Interview Discussion

This section discusses the results of the interviews which were examined in the previous section. The responses of Civil Defence and Industrial Sector interviewees were discussed. At the Civil Defence, the Director of the Command Centre (CDCC), the Manager of the Information Centre (ICM) and Industrial Fire Brigade Officers (IFBOs) were interviewed. Interviews in the Industrial Sector were carried out with ICT professionals. It was also decided to interview an ICT professional at KACST and a Network Service Manager at STC to understand their present activities and their perceptions of future plans to improve the current situation.

II.1 Interview Discussion with Civil Defence and Industrial Sector Respondents

a. Current Status of ICT Services

It was found that ICT services in the Industrial Sector were more advanced than those in the Civil Defence organisation. The results of the questionnaire and interview survey found that the utilisation of ICT in the Industrial Sector was regarded as more optimal than in the Civil Defence sector. This reflects the fact that staff in the Industrial Sector used computers in their work more than Civil Defence staff. The use of ICT services in industrial fire brigades is not fully exploited because most staff do not have enough ICT skills to use these facilities. The interviews revealed that most IFB staff have poor qualifications and do not use computers regularly. The use of computers in the Industrial Sector was better because:

- The Industrial Sector encourages their staff to use this facility and provides them with updated hardware and software.
- There are more training courses in ICT on how to use the latest technology in computer and network facilities.
- There are more qualified staff than in Civil Defence departments.

A lack of using ICT services in the Civil Defence sector and a lack of qualified ICT staff were seen as major problems regarding the provision of effective services to staff in industrial fire brigades. The use of ICT applications in both sectors differed one form the other. The computer application most used by IFBs was the word processing application whereas workers in the Industrial Sector used different applications depending on their needs, such as word processing, databases, graphics, design applications ...etc.

The CDCC was found to be more computerised than IFBs. It uses a LAN to help its staff to exchange and retrieve information that is available in databases. The CDCC Director mentioned that the centre is trying to increase the skills of staff in using ICT facilities and to train them to ensure they are sufficiently qualified to deal effectively with emergency situations. The current situation in the CDCC is not as expected because the ICT training of staff is not sufficient. The CDCC Director indicated that there were no digital maps available in the CDCC and that manual maps were still used to determine the locations of incidents. The researcher believes that there was a lack of precise address data for the location of incidents; a lack of a sophisticated GIS, which was an expensive and rapidly changing technology; and a lack of an infrastructure for digital maps of Saudi Arabia. All these factors contributed to a failure to use digital maps properly.

The Information Centre Manager indicated that the financial support to ICT services depends on the annual financial support received from executive management. All Civil Defence departments are asked to prepare and provide estimates of the financial support required to run their ICT programmes. The Information Centre will execute its programmes according to the financial support that is received from executive management. The ICM mentioned that the budgets which are allocated to ICT are not sufficient to acquire all the necessary ICT equipment, such as PCs and software, or to allow the replacement or upgrading of the map system, etc. All interviewees from Civil Defence departments indicated that the lack of financial support is a major factor that affects their ability to keep up with the updated ICT.

In contrast, most of the factories have a computer department and its function is to support the factory's needs in terms of its ICT services. Each factory gives good financial support to this department to enable it to run ICT effectively. There were therefore obvious differences in the financial support for ICT in these two sectors because the Civil Defence organisation asks for support from the government, whereas the Industrial Sector is self-supporting since it is part of the private sector.

No ICT plans and infrastructure were found in IFBs so if there was a slight problem with any equipment, software or hardware, these brigades had to inform the Information Centre in order for repairs to be carried out. More attention should be given to IFBs to allow them to use ICT properly. For instance, computer hardware, software, databases...etc, should be available in each IFB to help them in their daily work and to help them to communicate with others. The researcher believes that IFBs still need certain hardware and software applications to meet the needs of their staff because these have not been developed consistently. Therefore, the lack of an adoption strategy and financial support are problems that need to be overcome by key personnel in the organisations.

Factories have ICT strategies. They are more advanced than the Civil Defence sector in this regard. The interviewees indicated that they undertake regular examinations of their need for ICT services. The researcher believes that the ICT situation in the

Industrial Sector is better than that in the Civil Defence sector because the former is part of the private sector looking to improve its business to obtain a high profit.

It was found from the interviewees in both sectors that there are programmes which have been planned to enhance the ICT services in all departments by such means as providing a computer network, databases, and giving more attention to ICT.

b. The Role of ICT in Emergency Situations

The interview survey showed that the only ICT system used in emergency situations is the telephone. The researcher believes that ICT-based applications to support emergency situations take advantage of the developments in computing, telecommunications and associated technologies (such as display technology and sensor technology) that have taken place over the past decade. Up until now, these developments have given us computers, the Internet and information networks. In dealing with disasters, these are enabling technologies and the challenge is to use them in ways that complement and extend existing service delivery. Product development in the computer and telecommunications sectors is still rapid. The telephone system is, however, adequate to carry the telecommunications traffic involved in emergency situations at the moment. This means that the Industrial Sector still uses this system to contact the Civil Defence organisation. There is, however, a need for significant improvement in the current contact system with the advent of computer-based systems.

The Director of CDCC stated that they are looking to develop the skills and efficiency of 998 operators. This development comes from improving and using updated ICT facilities. Among the interviewees there was agreement on the importance of putting industrial accidents in focus and a strong commitment when it comes to realising this. The researcher believes that there is a need to build bridges between the person receiving the call and the dispatcher. Furthermore, the design of an information network will offer more information that will be provided automatically on a screen and help the call-taker to deal with incidents. A GIS could provide maps and the operator could be helped by a decision support system during emergency situations.

c. Future Plans and Expectations for Using ICT in Dealing with Industrial Accidents

The interviewees in the Industrial Sector indicated that all factories have emergency plans and follow the Civil Defence safety instructions. None of these had made any evaluative comparisons between their emergency plans and those of other highly advanced factories. The researcher believes that such an evaluation would clarify the strengths and weaknesses of emergency situation plans and then safety specialists could use this evidence to promote safety procedures to provide more control for the organisation.

Co-operation between the Civil Defence and Industrial Sector could solve problems such as the weakness of information exchange. The researcher believes that co-operation between these two sectors is very important, especially since all interviewees in both sectors confirmed that their organisations are still not providing successful electronic services. Some of interviewees who have high-level qualifications from the UK or the USA focussed on the importance of increasing awareness regarding co-operation to achieve the automation of all operations and to take lessons from the developed countries.

To activate such co-operation between these two sectors, a strong system needs to be created to use and obtain the most benefits from ICT facilities. The goal of this system would be to study operational procedures and ways of sharing information, computer aided dispatch systems and radio networks. In the case of large disasters, this could ensure more efficient handling. There is also a need for compatible technical standards for communication and a need for rules that make it possible to act more easily across networks.

d. Training Issues

The interview results show that both sectors indicated that there were training programme courses available in their organisations. The results from the survey show that the main problem was that the quality of these courses was still insufficient effectively to promote staff skills in using ICT. A further difficulty which faces these sectors is that most organisations did not provide or support training courses in how to use ICT in emergency situations.

According to all interviewees, both sectors provide training courses to their staff but these may or may not be adequate to fulfil the needs of staff members, especially in terms of using ICT when dealing with accidents. For instance, IFBs are concentrating on providing training for their staff. This training consists of basic fire-fighting and how to deal effectively with emergency situations. The results from the survey show that there are no training courses on using ICT in emergencies. Another problem which faces the IFB staff is that decision makers do not let them attend or undertake these courses because no time is available. Furthermore, the Industrial Sector does not provide any ICT courses for use in emergency situations because these courses are not available, as interviewees mentioned. They added that they do, however, have access to a variety of ICT training courses depending on their needs.

The researcher believes that both sectors should evaluate the present situation regarding dealing with industrial accidents and should try to provide effective training courses by using ICT. One of the ways in which these sectors could improve staff skills is to make arrangements with the ICT professional or specialist companies to provide advanced training programmes. Then, it is important that sufficient time is allowed for training in order to educate staff in the use of this technology.

The training courses should contain valuable information and useful techniques for those dealing with incidents. They should contain, for instance, the information that a fire officer needs at the accident scene, the information that an operator in the alarm centre needs, and the information that is expected by such professionals in order for them to provide an efficient service. Such courses should enable staff to evaluate the situation at the accident scene and make tactical decisions and prognoses. This information is valuable for the operator at the command centre and enables him/her to work efficiently. Staff should be encouraged to attend these courses in order to improve their skills and to keep them up to date with ICT services.

e. The Current Situation of LAN/WAN Connections

The interview survey showed that there are LANs in some organisations. These LANs have limited functions to execute organisations' needs. The computer network at CDCC is connected to all PCs within the centre. The Director of the CDCC indicated that they have a LAN for the exchange of information among their staff. IFBs also need to be connected by computer networks. The use of electronic services in Civil Defence departments is not fully exploited because most departments and fire brigades do not have access this facility. Some factories have LANs and use them within the organisations. The use of electronic services in the Industrial Sector, however, is better than that in the Civil Defence sector. This is because of the superior financial support for these facilities from the Industrial Sector compared with the Civil Defence organisation.

A lack of access to the network and qualified ICT staff were seen as the major problems regarding the provision of effective services to staff in the Civil Defence sector. The results of the interviews showed that there was neither a WAN nor computer networks to connect these sectors to each other. The researcher believes that these two sectors need to be connected through computer networks. As the Information Centre Manager mentioned, the Civil Defence departments were in the initial stages of developing ICT and recently considerable advances have been made towards building up an effective WAN and computer networks for all departments. The researcher understands that the Civil Defence organisation will improve its computer networks, especially since the majority of respondents indicated a wish to use the Internet and communicate with others. Furthermore, the Industrial Sector, as all interviewees mentioned, will support the computer network that will link with Civil Defence departments.

II.2 Interview Discussion with ICT professionals at KACST and STC

The interviews with the ICT professional at KACST and the Network Manager at STC show that these departments have their own duties and that they cannot participate in emergency control in industrial cities. The ICT professional at KACST indicated that KACST provides information services and facilities to academic institutes, universities and also to the public. The situation at STC is the same at KACST where the Network Manager indicated that the role of the STC is to build an infrastructure of communications all over Saudi Arabia; they cannot provide specific services for emergency control.

They stressed that, in the future, if the Civil Defence and Industrial Sector intend to obtain support, such as information or consultancy; KACST and STC will try to offer their experience and knowledge to them.

The researcher believes that the role of these departments is very important in ICT services in Saudi Arabia. However, designing an information network to link the Civil Defence and Industrial Sector should be started and then these departments should be asked to evaluate the network and provide more effective services.

6.2 Summary

The interviews were conducted with a number of key people who have a direct involvement in the overall aims and objectives of this research. They revealed that those interviewees who were decision-makers in their various positions confirmed that the non-existence of an information network between the Civil Defence and

Industrial Sector is considered to be one of the most fundamental issues currently faced in dealing with industrial accidents.

From the interviews with Civil Defence officers, it was very clear that they needed support for all fire brigades in industrial cities, particularly with ICT equipment and computer hardware and software. They suffer from a lack of availability of ICT training, especially in dealing with industrial hazards, and this makes the provision of ICT training and equipment an important issue.

In a similar manner, the lack of availability of LANs in Industrial Fire Brigades made the use of computer applications developed by the Civil Defence Information Centre (CDIC) very poor and ineffective. In instances where LANs exist, there is an urgent need for the development of computer applications to support their staff.

The interviews revealed that all respondents indicated that they want to increase their co-operation and co-ordination to overcome all difficulties that they face during emergency situations. The attitude of the interviewees was very clear; they strongly agree with the idea of establishing an information network between the Civil Defence and Industrial Sector. They believe that this network will increase the efficiency of fire-fighters and increase the quality of services during accidents.

Most of the respondents thought that there would be no problems in the use of ICT to allow communication between the Civil Defence and Industrial Sector, so long as both sectors will obtain maximum benefits from such an information network. Some of the respondents, however, thought that insufficient funding could be an obstacle in implementing this network and were doubtful as to whether the Industrial Sector would cooperate in giving true and accurate information about the hazardous materials they have.

All respondents believed that the importance of co-operation and collaboration between could not be overemphasised. They agreed that the existence of updated information would help fire brigades in dealing with and controlling industrial accidents effectively. However, in the absence of an information network, co-operation and collaboration is still rare and updating information takes a long time.

It is sad to note that, although all responsible staff are interested in taking ICT training, particularly courses that deal with the use of ICT in accident control, no such courses are available. It would be useful if such courses could be provided to support the staff from both sectors.

All respondents supported the idea of establishing of information network because they believed that it will improve Civil Defence services and increase the skills of fire-fighters in dealing with industrial accidents. Moreover, they stressed that they should take advantage of the benefits of Internet technology to exchange information; they would be ready to give Civil Defence departments any information necessary and would support the establishment of databases of such information.

In the next chapter, the first and second stages of the SDLC are discussed in accordance with the research findings from Chapter Five and this chapter.

Stage One: Identifying the Problems and Opportunities

Stage Two: Analysis of the System Requirements

7.1 Introduction

The previous chapters highlighted the current situation and noted the most important issues in the field of dealing with industrial accidents in Saudi Arabia. This chapter applies the SDLC technique introduced in Chapter 4 to establish an information network between the Civil Defence and Industrial Sector in Saudi Arabia. This technique defines the current situation, highlights issues associated with the establishment of an information network, and considers the importance of a new system. In this chapter, Stages One and Two of the SDLC technique are discussed. The first stage identifies the problems, scope and opportunities; a feasibility study is also defined in more detail, together with a discussion of the nature of the problems and opportunities of the proposed system. In the second stage, an analysis of the system requirements is defined from the principle requirements extracted from the fieldwork in order to fulfil the research objectives. Figure 7.1 shows the SDLC stages and highlights their output for each of the stages, together with the effect of these stages on the fulfilment of the research objectives. The figure is divided into two parts: this chapter deals with the first part, while the second part is discussed in the next two chapters.

Part One: Identifying the Problems and Opportunities

I.7.1 Identifying the Problems

According to the SDLC approach, Stage One is concerned with finding out as much as possible about the problem situation and from as many people as possible. The

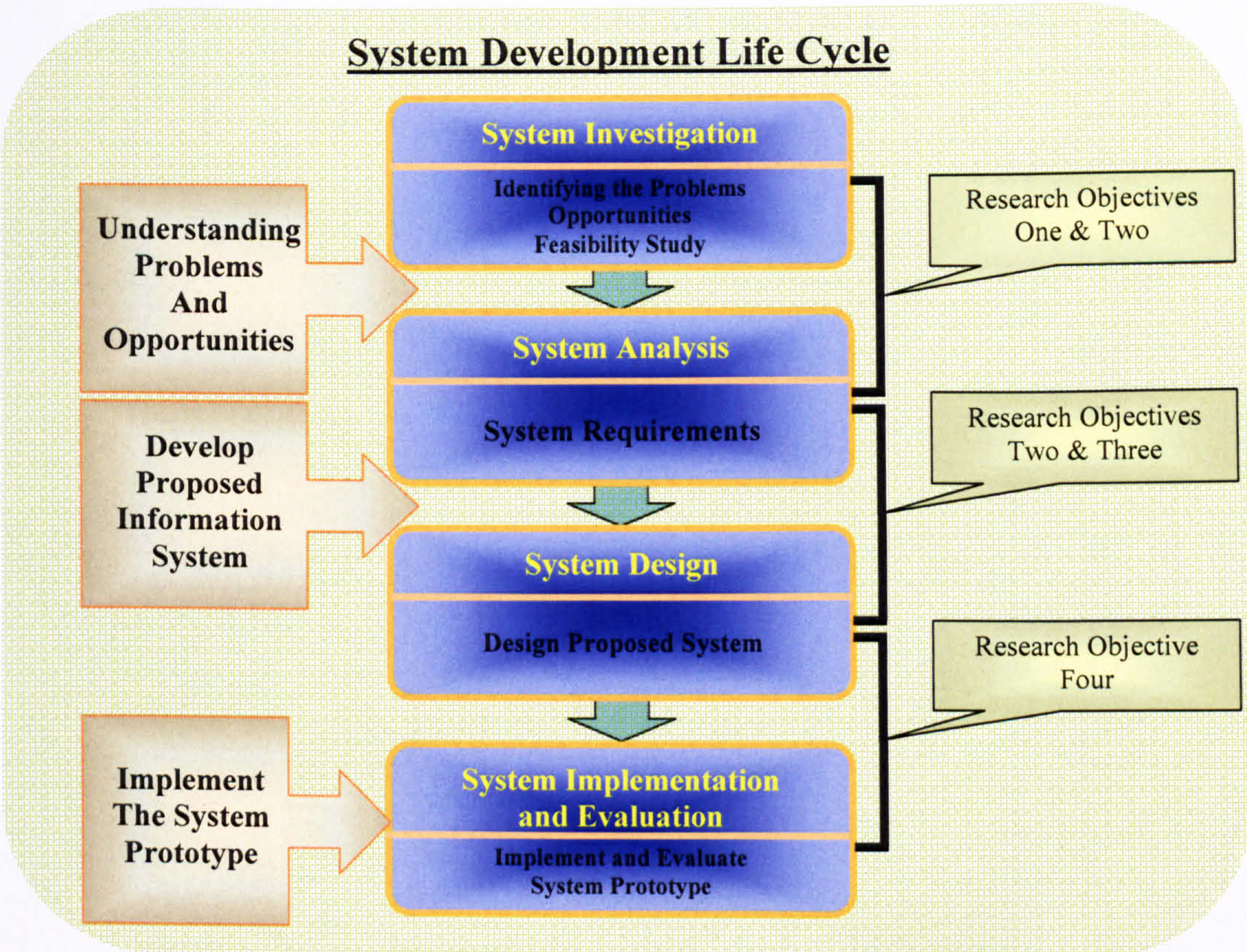


Figure 7.1 SDLC stages and their effect on the research objectives

perspectives or views of individuals or organisations concerning the problems is related to whether they are involved primarily with outcome-related activities, such as disaster management, or whether they are looking at potential solutions for emergency control. In this research, both perspectives of the problem are related to the lack of an advanced information system that is sufficiently capable of improving disaster management.

The problem from the first perspective is that people such as fire-fighters or factory staff are primarily concerned with the control of industrial accidents. These people focus on outcome problems or the disasters-related conditions that a model system is designed to target, influence or improve. In this study, the outcome aspect of the disaster management problem is defined as the lack of using ICT in emergency services, the shortage in updated data about hazardous materials, and the lack of cooperation and coordination.

From the process perspective, the problem is defined as how best to design a system that will operate optimally, efficiently and effectively. Process-related problems were identified, described and discussed throughout the data collection process, as well as in detail in the literature. However, because of the nature and complexity of the system that is envisioned, it is impractical to provide a detailed listing of all of the issues, elements and sub-problems that are within the scope of this study. Therefore, only a few of the most significant problems and issues that were prominent at one or more of the decision-making stages of the design process are highlighted below:

- The development category problems and issues, many of which are shared with several other categories, include project and team management issues; system and software design issues, such as standardisation, portability and the interoperability of code and systems; and the prototyping of systems.
- Data management and informatics is a category that includes many issues and problems such as data integrity, flow and management; data optimisation; and user interface and control concepts.
- There are many problems in the computer science, information technology and telecommunications domain including software, hardware and issues such as performance and interoperability, as well as security concerns.

From the information sharing perspective, the current information flow between Civil Defence departments and the Industrial Sector is shown in Figure 7.2. Other emergency services which help in the management of industrial disasters are also added. The context diagram below shows three main entities and what they currently share in the way of information.

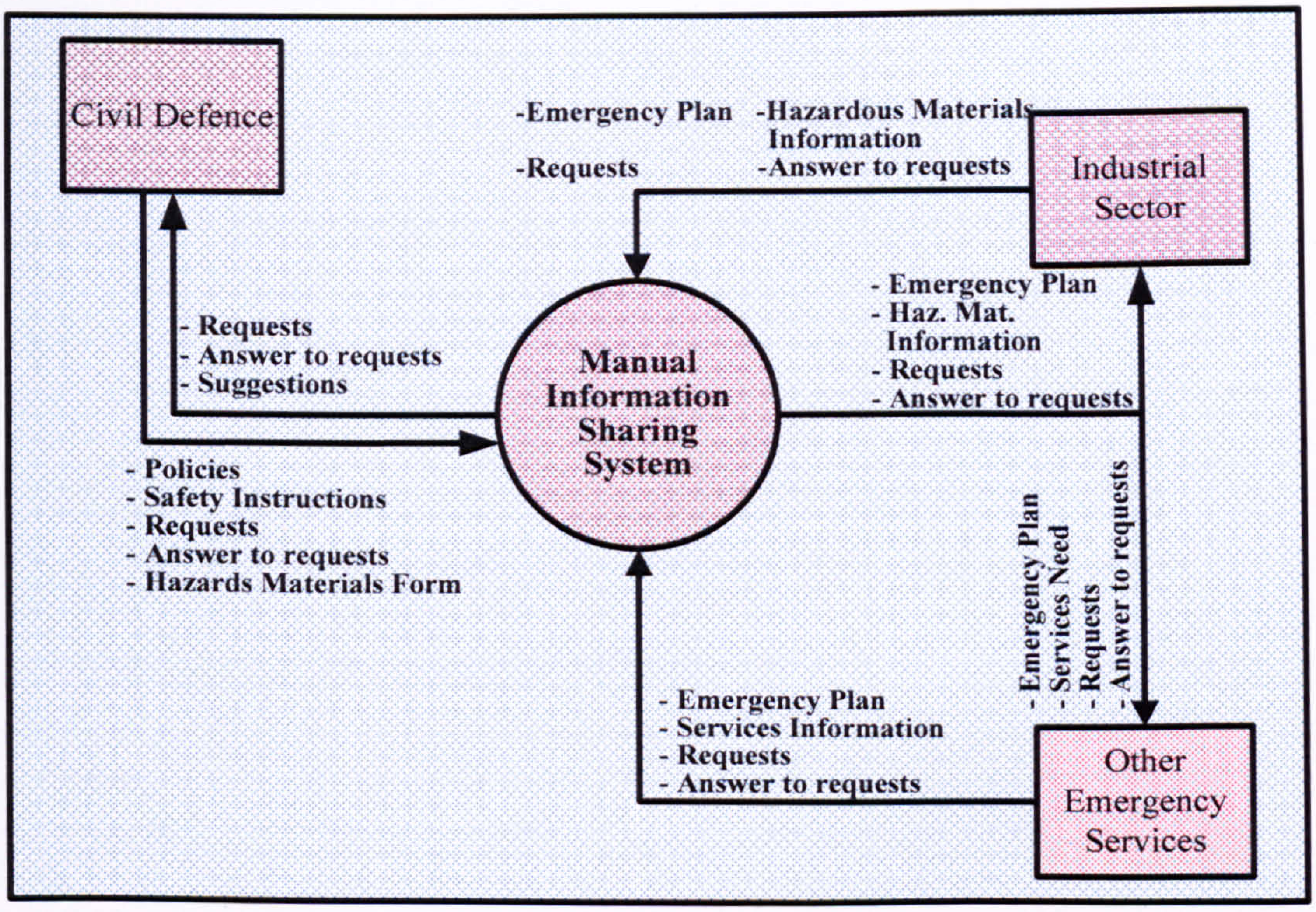


Figure 7.2 Manual information sharing system context diagram

The information exchange process between the Civil Defence and factories is manually performed using a paper-based system. This process is prone to error as it is not accurate and is time-consuming to maintain. The current process is also hampered by the slowness of the factories' responses. The Civil Defence sends monthly hazardous material data sheets to factories to update their data about industrial hazards. Sometimes some factories do not respond, so the Civil Defence departments need to remind them. This is time-consuming. Figure 7.3 shows the data flow diagram of a hazards materials data sheet.

I.7.2 Scope and Opportunities

The scope of this study will be limited to the development of an information network and an advanced communication system by using appropriate ICT to link the Civil Defence departments with the Industrial Sector to enhance the information sharing abilities of all related sectors.

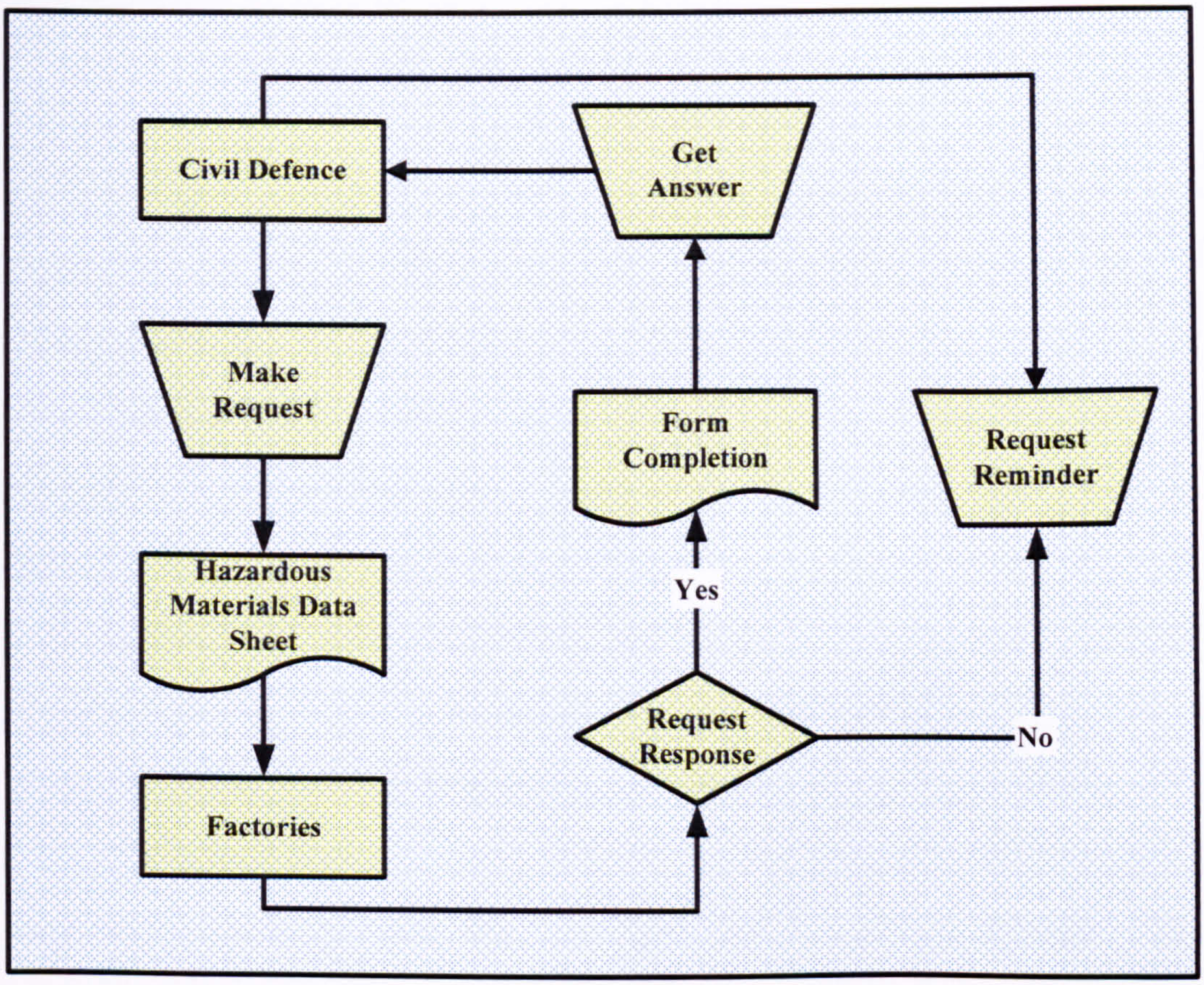


Figure 7.3 Data flow diagram of a hazardous materials data sheet

A host of potential opportunities were identified during the data collection process. The data were collected from multiple sources including a review of the literature and interviews with leaders in the field. The opportunities and benefits that could be realised from the development and deployment of an advanced information network system have been grouped according to three groups:

a. Fire-fighters:

- To be able to achieve improvements in dealing with industrial accidents and the quality of services through informatics change.
- To empower fire-fighters to increase their ICT experience.
- To help fire-fighters obtain updated information.
- To help decision-makers.

- To reduce the time consumed in accident control.

b. Industrial workers:

- To develop and improve the relevant emergency plans.
- To re-engineer safety procedures by integrating technology throughout the spectrum of informatics and emergency planning.
- To ease documentation exchange procedures.

c. Technologies and informatics:

- To provide new technology and informatics systems in fire-fighting vehicles.
- To develop and help in responding to industrial accidents.
- To help both sectors use ICT in accident management.

The stated mission for developing an information network to link the Civil Defence organisation and the Industrial Sector is to provide a highly innovative, efficient and effective technology for the improvement of the quality of Civil Defence services and for dealing with industrial accidents. This will form a set of fundamental principles for the proposed system and the conceptual framework. These principles are:

- Locate potential hazard sites;
- Automate an audit of potential hazards on each site identified;
- Automate information gathering and retrieval about hazards and how to deal with them;
- Provide automated information to the Civil Defence sector (including, for example, the fire brigades) at the point of need via suitable devices;
- Operationally reduce the time delay between the hazardous incident and the response by Civil Defence employees;

- Operationally reduce the time between Civil Defence employees arriving at the hazardous incident and the control of the situation.

As can be seen, the first two objectives relate to the physical identification of hazardous locations and to the provision of a log. The second two objectives relate to the use of information gained, and the final two objectives indicate the operational advantage of having an innovative, integrated information system. To summarise, there are ample opportunities for addressing the problems and achieving the aim of designing a model system. The system design that is envisioned for this study would fill part of the void that currently exists.

I.7.3 Feasibility Study

The implementation of ICT systems is costly and cannot be carried out without planning; a system cannot be installed on a trial-and-error basis. Feasibility studies based on cost-benefit assessments must be conducted to help organisations in their decisions to implement ICT and cost assessment techniques must be used in planning. To be able to predict present and future ICT costs, organisations should understand the likely cost escalation and put processes in place to manage such costs. The purposes of these processes, as Mutsaers *et al.* (1998) and Meek (1999) point out are:

- To collect and maintain information about all major developments under way within the organisation.
- To report to the top management the predicted development, operations, applications, support and maintenance costs for all major projects.
- To collect and maintain historical data regarding standstill costs generated by developments in the organisation's specific environment.

Therefore, it makes sense to utilise some kind of cost assessment tools such as cost-benefit analysis or cost-effectiveness analysis when deciding on adopting a new or updating an existing system. Doherty and King (1998) found that undertaking cost-benefit analysis was noted as the most important issue addressed by organisations when deciding on implementing an IT system.

From these discussions it becomes very clear that correct estimation of the costs of implementing ICT systems will help the organisation to direct sufficient financial and human resources for the implementation; this clearly will increase the chance of the system's success and consequently the benefits will be realised.

Because this study is an empirical study to test the importance of establishing the information network, and from evidence from the literature, the feasibility study of the system can be evaluated in terms of three major categories:

A. **Hardware:** The system will be developed and implemented using hardware currently available in both sectors.

B. **Software:** The Web site will be developed and implemented with:

   - Databases; and
   - A Geographic Information System (GIS).

   The database provides logged information for the audit of hazards and the GIS provides crucial information about the point of need.

C. **Cost and benefits of this study:**

   There is an intangible cost involved with the new system which will be the training of the end users. The training programmes will be conducted in the Civil Defence Institute where the facilities are available and free. The expected benefits that could be gained from the new system are: setting up a network that would allow both sectors to exchange information; setting up a Web site so users can update their information; and giving access to information to those people who need it so they can make the right decisions at the right time.

In summary, in the first step of the SDLC process, the two types of problem to be addressed in the model system design are: first, improving the system of information exchange and, second, addressing the technology and design process problems. These problems serve as the basis for defining the system requirements in Stage Two of the SDLC.

Part Two: Analysis of the System Requirements

II.7.1 System Requirements

The second step in the SDLC technique calls for a detailed assessment of the requirements for an effective system. It is important to study the system that will be improved or replaced (if there is one). Data were collected, a requirement analysis process completed, and experts in the field asked to evaluate the requirements list.

System analysis involves asking the users and managers to identify problems with the current system. Most users have a very good idea of the changes they would like to see and most will be quite vocal about suggesting them. The development of the new system will improve the users' efficiency or the ease of use of the new system compared with the current system (Dennis *et al.*, 2002).

In this stage a detailed analysis is made of the systems to be built to help create a clear understanding of the problems and requirements, together with the reasons for developing a new system. The data in this section correspond to and partially fulfil the first three research objectives.

II.7.2 The Principal Requirements

The principal requirements that emerged from the requirements definition process are:

- ICT planning: Currently, no central administrative structure exists to provide the necessary leadership and vision to manage most effectively ICT in both sectors. Such a structure must be established so that a long term ICT plan can be developed, maintained and implemented. It should also provide a mechanism for the approval, coordination and arbitration of major ICT activities across all departments. The system should encourage both sectors to prepare an effective ICT plan and take full advantage of the opportunities that ICT affords for teaching, research and information services.

- Management support: The fieldwork identified a lack of management support in terms of using ICT in disaster management. In order to improve the support for ICT, the perspective of management should change as the proposed system must promote and improve the disaster management services.

- ICT training: Without ICT training, the effective use of ICT within the IFB cannot be guaranteed. It is one of many sectors recognising that a lack of skills and training is a fundamental factor in limiting the use of ICT. The lack of a programme for training fire-fighters on computers and other multi-media utilisation has been identified as a major reason for the slow take-up of computer experience and skills, and for the absence of an ICT strategic training plan. From the collected data, 65% from the respondents asserted that there is insufficient support from the organisations for their workers to use computers in dealing with industrial accidents. This proves that the two sectors do not provide enough support for their workers to take computer courses. Because of the importance of ICT training, the value and impact of enhancing the training environments, and the need to improve efficiency within the emergency services, the system must promote and provide good training and increase the ICT skills of users.

- User participation: Because of the requirements that the system be designed to accommodate users, optimise the user-centric interface and experience, and minimise barriers for all users of the system, the system must be designed to be intelligent and dynamic. It must be possible to tailor the interface, interactions and output to accommodate the preferences and tastes of each user.

- Efficiency of the proposed system: Because of the importance of providing an information exchange system with high standards, the system must use intelligent tools to execute tasks that will enable the system to achieve its goals and objectives in order for the user to gain maximum benefit from the system.

These system requirements were translated into the technical specifications and functional needs for the system during the third stage of the SDLC.

7.2 Summary

The requirements that emerged from the fieldwork represent all types of requirement that are necessary for a comprehensive examination of the system design. The analysis and synthesis process produced five fundamental requirements that clearly will help in improving the current system. These requirements served as a framework for defining the needs of the system in the third phase of the SDLC.

In the next chapter, Stage Three of the SDLC are discussed in detail.

Stage Three: System Design

8.1 Introduction

New technologies, such as high-speed networks and inexpensive massive storage, along with Internet expansion, have led to a considerable increase of the amount and availability of on-line text (Kopanaki *et al.,* 2001). However, information is only valuable to the extent that it is accessible, easily retrieved and structured (Koniger & Janowitz, 1995). The growing volume of data, the lack of structured information, and the diversity of information have made its retrieval and management even more difficult (Kalakota & Whinston, 1996). Thus, there is a strong need for improved means of controlling the information explosion (Rowley, 1998). Moreover, from the data collection exercise reported in Chapters 5 and 6, there is a need to provide electronic information exchange that will assist both sectors in exchanging their information. To this end, remarkable efforts have been made towards the design of an advanced technique for accessing, retrieving and manipulating electronic data. This technique includes electronic data feeding and the retrieval of selected information from on-line sources.

Aiming to address problems concerning the manual-based system of information exchange, an integrated system has been designed and given the name IIAS (The Industrial Incidents Administration System). This system is aimed at keeping information between both sectors up-to-date using electronic sources. IIAS would facilitate the provision of personalised content adapted to each user's profile from the Industrial Sector. The co-operation of the aforementioned technologies provides an integrated system of information processing. In order better to understand and satisfy users' needs, a prototype has been created and evaluated. The purpose of the prototype is to get feedback and understand end-users' needs. Users' remarks will help to improve, as well as add new functionalities to, the system.

The database needs of the Civil Defence and Industrial Sector in Saudi Arabia are large and complex. Three main needs were identified in the system design phase. These are:

- Data stored in this form must not lose any of the quality of information collected.
- A rapid-access database is needed for planning decisions.
- An online transaction database is required to provide facilities for frequent updating.

The design of the required application utilises the benefits from a spread of established programming environments in building a complete and integrated application, working as a single entity.

This chapter is aimed at describing the integrated computer-based information system which was developed to fulfil the functional requirements described in Chapter 7.

8.2 System Overview

The current process of information exchange between the Civil Defence and the Industrial Sector is manual-based. This process has a number of problems, which have been discussed in previous chapters. To tackle these problems effectively, a computer-based system needed to be designed which could be used easily, quickly, and efficiently in terms of information exchange by linking the Civil Defence and Industrial Sector. The proposed system is called an Industrial Incidents Administration System (IIAS). Figure 8.1 shows a proposed architecture framework conceptual model of IIAS. The information network model for the IIAS was constructed to highlight the method by which data is transferred between the two sectors, as well as other emergency services responsible for handling and controlling industrial accidents.

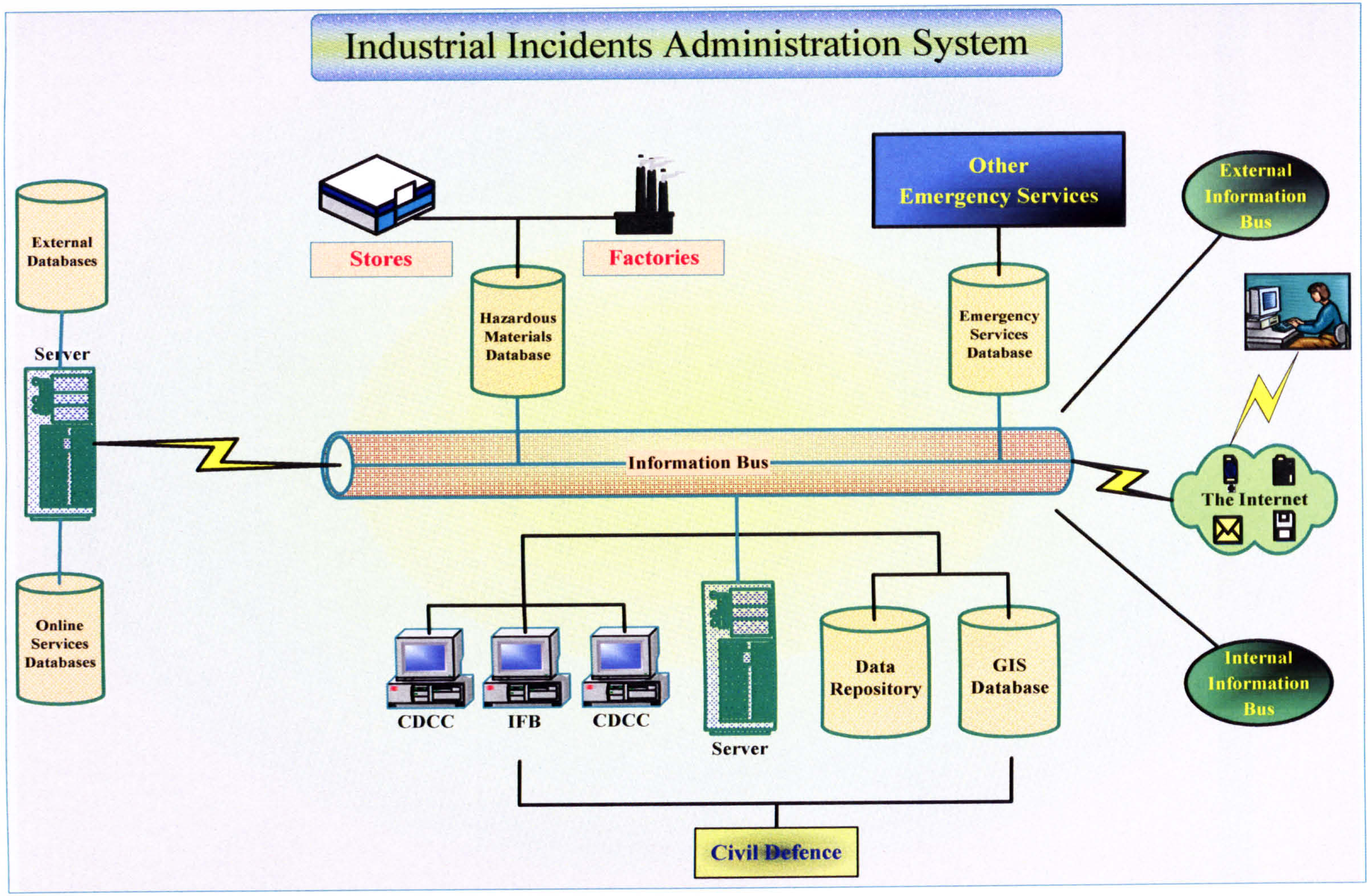


Figure 8.1 Proposed Architecture Framework Conceptual Model of IIAS

The objectives of this system were to develop a Web-based information system and to design a database connected with a GIS application. Their integration is based on data coming from Web sources to a database server to allow optimal speed of information exchange. IIAS will help in producing an integrated system for efficient information management, exploiting the cooperation between sectors in controlling industrial accidents. IIAS aims to provide:

- Information according to the users' needs;
- Information according to the hazardous materials in the Industrial Sector;
- Automatic exchange of information in various ways, enabling the users from both sectors to select the information of interest, as well as to send queries;
- Automatic warning of updated information for each user.

In order to achieve these objectives, IIAS exploits and integrates the following technologies:

- Online data exchange through the Information Bus;
- A local database, which contains five sub-systems;
- A GIS application.

Online data exchange through the Information Bus: This provides for the exchange and retrieval of information electronically in order to provide and present updated and correct information to both sectors. The concept of the information bus is that all data that passes through it is represented in standard XML formats (Zisman *et al.,* 2003). The Web site was developed to provide information about hazardous materials, industrial accidents and emergency plans. The Information Bus contains two sources: internal and external. The internal part is used by the Civil Defence organisation. From this, personnel can download hazardous materials data and upload it to the GIS application. The external part is used to support the exchange of information with the Industrial Sector and other emergency services.

Local database: This provides techniques for categorising information in various thematic domains and retrieving information matching a user's query. The IIAS database sub-system is developed and exploited to collect specific data about the Industrial Sector, taking into account the Civil Defence requirements concerning the control of industrial accidents.

GIS application: The purpose is to integrate GIS with a database system to develop a technical method for sustainable industrial accidents control based on the availability of information. The application will use the following techniques:

- The GIS, using ARC/INFO and ArcView, is also run on the Windows operating system and provides ArcView scripts which are macros written in Avenue, ArcView's programming language and development environment, to support DDE and Open Data Base Connectivity (ODBC) (Wilken and Honekamp, 1991).

- ODBC (Open Data Base Connectivity) is a widely accepted application programming interface (API) for database access. ODBC technology provides a common interface for accessing heterogeneous Structured Query Language (SQL) databases. ODBC is based on SQL as a standard for accessing data. This interface provides maximum interoperability: a single application can access different SQL Database Management Systems (DBMS) through a common set of code. Database drivers are then added to link the application to the user's choice of DBMS. ODBC applications are not tied to a proprietary vendor API. Therefore, a wide variety of database management systems (DBMS) can be accessed with the same ODBC source code that is directly incorporated into an application's source code.

8.3 IIAS Proposed Infrastructure

The system was designed to support the functions of industrial accidents control. The requirements of the IIAS are identified in Chapter 7. It is composed of a local database, GIS application, and online data exchange. The exchange of information will take advantage of the benefits of Internet technology. People from different factories will generate documents and information in different formats and through applications available on the Internet. The local database is composed of five sub-systems:

- Factories' general information;
- Hazardous materials sub-system;
- Safety devices sub-system;
- Fire detection and warning systems sub-system; and
- Best locations of fire-fighters sub-system.

The database will belong to the Civil Defence and will be hosted on main server in CDCC and it will be available on an Internet Web server. The CDCC will be responsible for the maintenance of server by performing the monitoring and management tasks for providing access to the database. The server is used for tasks like Database Consistency Checks (DBCCs) and backup and restore. DBCCs offer one of the earliest opportunities to detect consistency problems within the production and system databases. Since the database will be subjected to heavy workload it is imperative to constantly ensure that the database has not been corrupted. DBCCs can be performed from the maintenance server on a copy of a database stored in the backup system without any additional overhead on the database servers.

Factories are responsible for correcting, updating and maintaining their associated information sent to the database through the Internet. Staff from each factory would type or fill out the required data and send it on-line to the database. The subsystems in the database are integrated for optimal performance and they belong to the IIAS domain with a centralised control.

After data has been fed, transformed, and validated, it is ready to be posted to the production environment where users can see and query the data. Because of the importance of the security requirements, extensive data validation must occur before the data is moved to production. This validation may involve some manual data comparisons as well, depending on the importance and sensitivity of the data. In such a scenario, data must be validated each time it is moved into the production environment (for example, every week or every month).

The GIS application will use the digital data available to build an information database about each factory and how to reach accident sites. The updating and modifying or deleting process is automatically captured and recorded by the system. Also, the time the process takes place is captured automatically. This is necessary for future reference.

From studying the information flow between the two sectors, and from the results of fieldwork, the researcher found the exchange of information between the Civil Defence and Industrial Sector to be manual-based. This causes a number of problems which are discussed in detail in Chapter 7. Figure 8.2 shows the framework of the current system.

During peaceful times, information collecting and exchange is manual-based. The Civil Defence sector sends surveyors to fill in the required information sheets. These are then kept in archives. During emergencies, this information is not normally available directly to the emergency call-taker and it takes a long time to get any useful data from industrial fire brigades; sometimes no information is available. In the figure, the blue arrows show that there is contact between these organisations, but that this is still slow and via a manual-based system. The red arrows mean that there is very limited contact between these organisations.

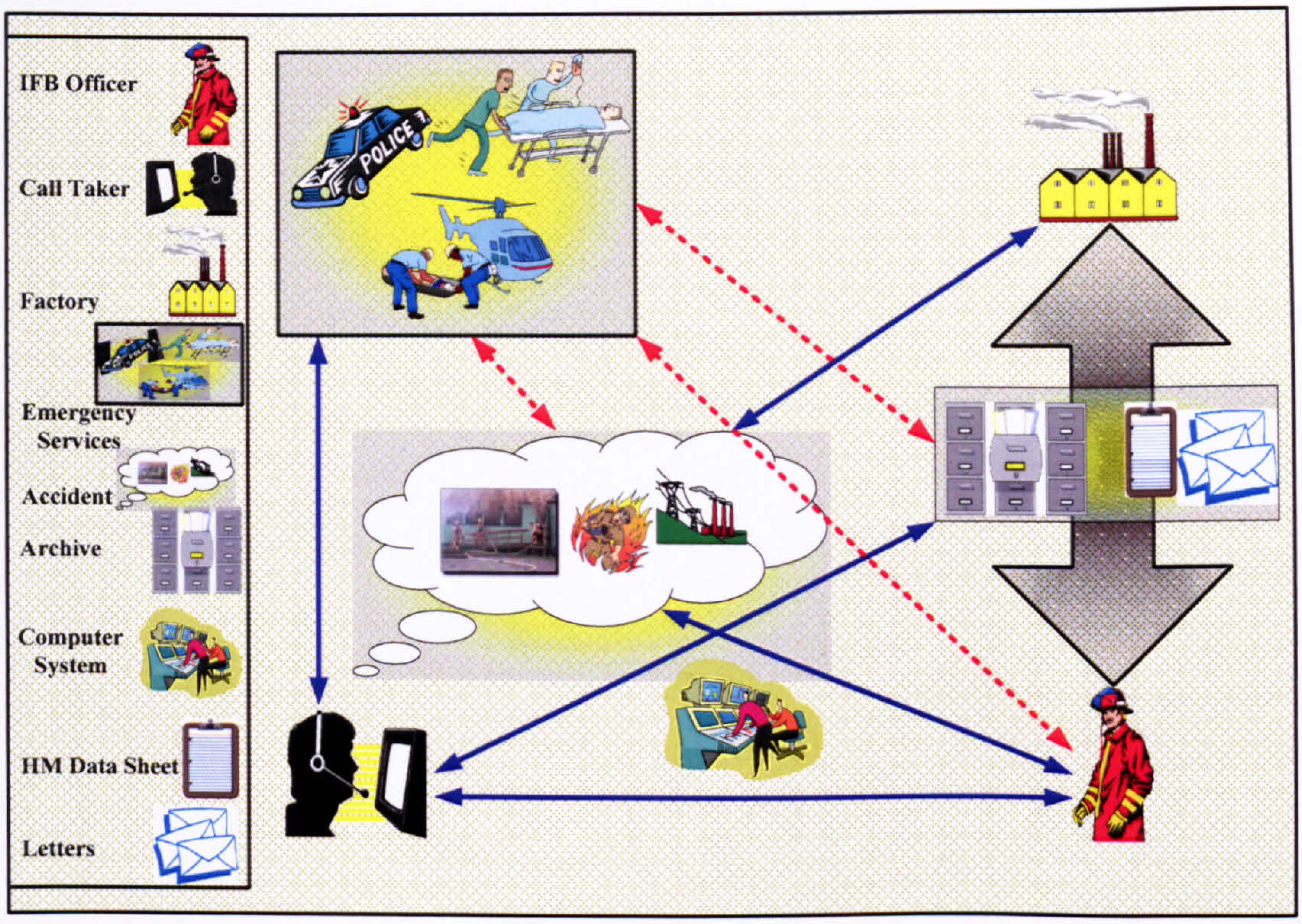


Figure 8.2 Framework of the current system

The researcher's design of the IIAS, as a proposed system followed from the result of the survey mentioned in chapters (5 and 6). This showed a lack of ICT knowledge in the industrial fire brigades, therefore the system was designed so that the IFBs did not need to interact directly with the system, rather the CDCC staff would use the system and control the IFBs. Therefore the system was designed to meet primarily the objectives of the CDCC. This system will connect all organisations on-line that should interact with each other during accidents. It is composed of Civil Defence systems, Industrial Sector systems, a data channel and a browser as shown in Figure 8.3.

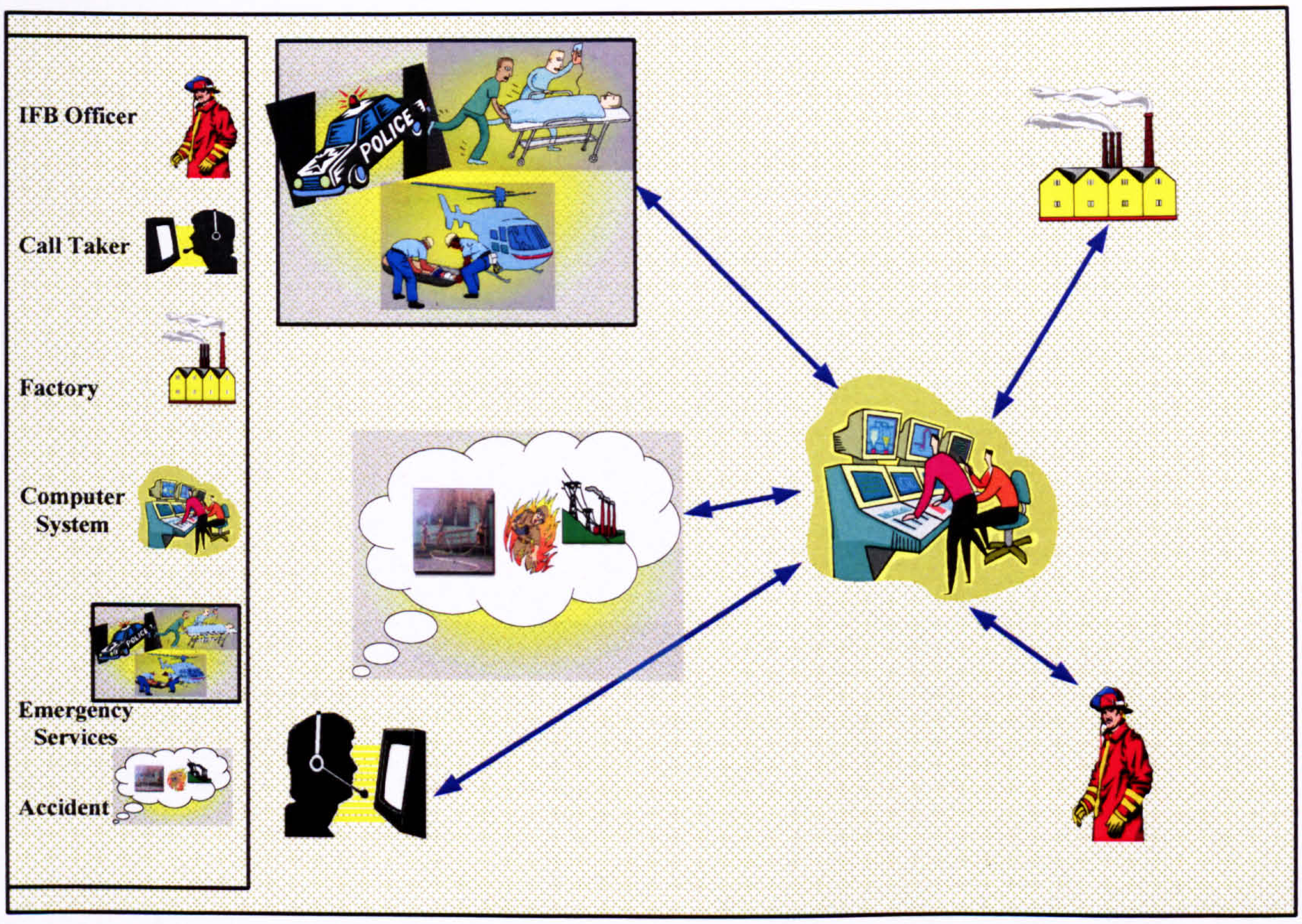


Figure 8.3 Framework of the proposed system

The IIAS system comprises a database with 5 sub-systems, a GIS application, and a server that also act as a data repository. The Industrial Sector interacts with the five sub-systems mentioned on (page 189). A data channel management process checks whether or not the data channel is linked to the on-line database. It also controls synchronisation between sub-systems automatically.

8.4 IIAS Functions

The local database system contains five sub-systems, as in outlined Section 8.3. These form the basis and starting points for the process that deals with industrial accidents. These sub-systems are described below:

a. Factory General Information sub-system

The purpose of the factory general information sub-system is to provide general information about factories. The importance of this information stems from the fact that, during accidents, there is an urgent need to be in contact with the factory's management. Furthermore, this sub-system contains a field that helps to determine the geographical boundaries for each factory and its relationship with other factories. This will help decision-makers to take the right decision and to ease the control of accidents. Another field shows the main departments in the factory such as: the main gate, offices, the production area, and the stores area, which will help to identify detailed information about each department. These details include the type of hazardous materials, safety devices, fire detection and warning systems. Figure 8.4 shows the factory general information sub-system process.

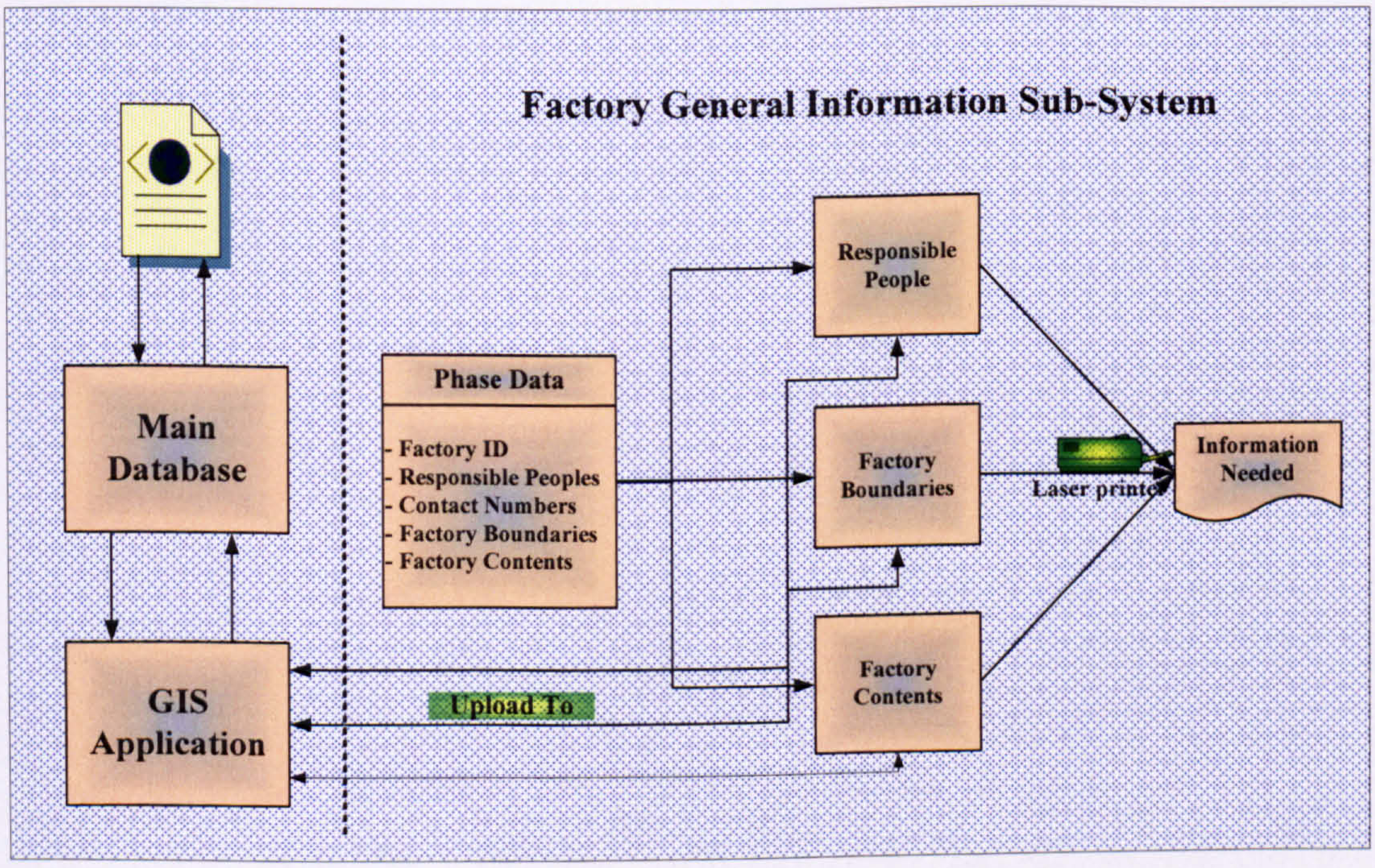


Figure 8.4 Factory general information sub-system

b. Hazardous Materials Sub-system

The purpose of the hazardous materials sub-system is to provide correct and accurate information during accidents. The factory should be able to provide detailed information about all hazardous materials that are used in the workplace. The database needs comprehensive information about hazardous materials in the form of chemical substances or mixtures for use in a workplace setting. Both employers and workers in both sectors can use it as a source of information about hazards, including environmental hazards, and to obtain advice on safety precautions. The information in the database acts as a reference source for the management of hazardous material accidents in the industrial cities. The information in the hazardous materials sub-system contains the following fields:

1. Hazardous material ID;
2. Type of hazardous materials;
3. Degree of hazard;
4. Fire control;
5. Health implications;
6. First aid.

The first step leading to the safe use of chemicals is to know their identity, their hazards to health and the environment, and the means to control them. Chemical identity means a name that will uniquely identify a chemical; this can be a name that is in accordance with the nomenclature systems of the International Union of Pure and Applied Chemistry (IUPAC), or the Chemical Abstracts Service (CAS), or a technical name (UNITAR, 2001). Furthermore, this inherently complex knowledge must be organised by depending on international standards and in such a way that essential information about the hazards and corresponding protective measures can be identified and conveyed to different types of users.

The hazardous materials sub-system provides a number of benefits and possible uses for the Civil Defence and Industrial Sector, and other emergency services. The system can make a significant contribution towards reducing the incidence of chemical-related injuries.

The hazardous materials sub-system can provide the following benefits: fewer chemical accidents and incidents; lower health care costs; improved protection of fire-fighters, workers and the public from chemical hazards; and an improved corporate image for both the Civil Defence and the Industrial Sector.

Industrial Fire Brigades (IFBs) also benefit from this sub-system by the provision of updated information on hazardous materials. With this information, along with appropriate training, education, and a review of safety instructions, there can be: decreased health risks in the workplace and for the public at large; and improved levels of knowledge regarding chemical hazards, especially for fire-fighters. Figure 8.5 shows the hazardous materials sub-system process.

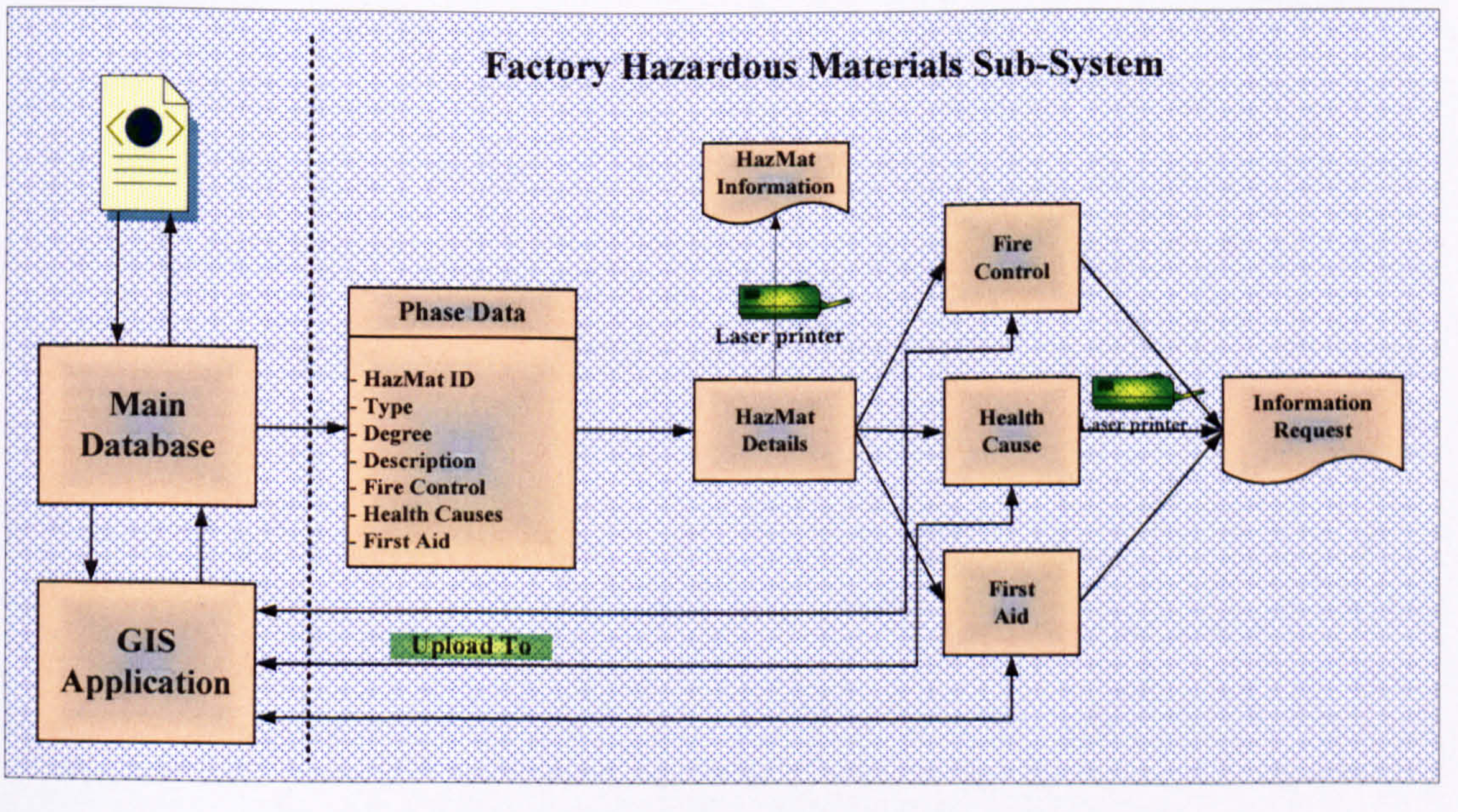


Figure 8.5 Factory hazardous materials sub-system

c. Safety Devices Sub-system

The purpose of this database is to provide computerised data to the ultimate resource for safety devices in each department in the factory. It will allow the user to find any particular device and its availability. These data will be useful to fire-fighters, emergency services, and factories in order to know the quantities of safety devices that available in Industrial Sector especially during the industrial accidents. A full description is included for each device to help in understanding its functions and usage. Figure 8.6 shows the safety devices sub-system process.

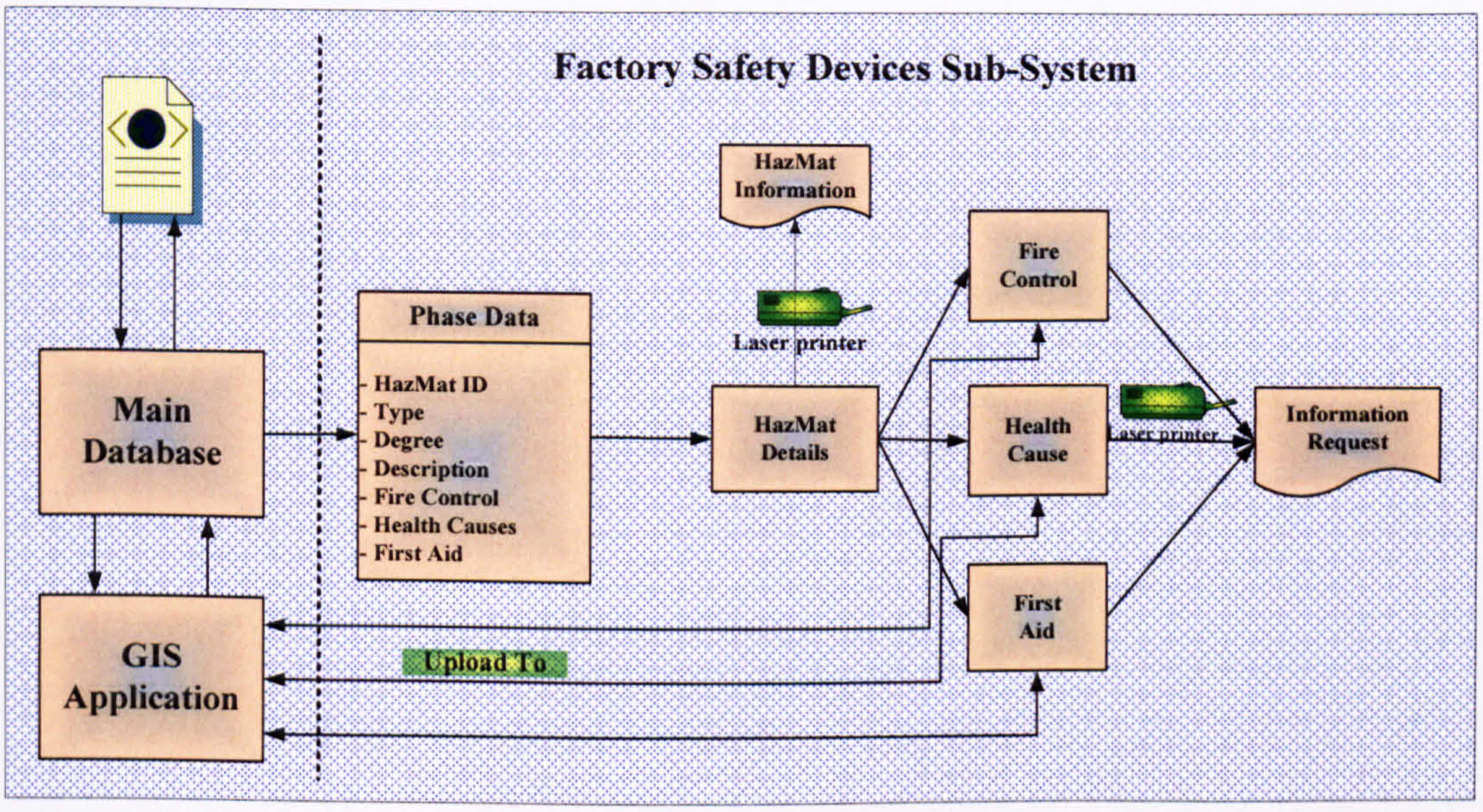


Figure 8.6 Factory safety devices sub-system

d. Fire Detection and Warning Systems Sub-system

This database is similar to that discussed in (c) above. The purpose of this database is to provide the ultimate resource for fire detection and warning systems devices in each department in the factories. It allows the user to find any particular device and its availability. A full description is included for each device to help in understanding its functions and usage. Figure 8.7 shows the fire detection and warning systems devices sub-system process.

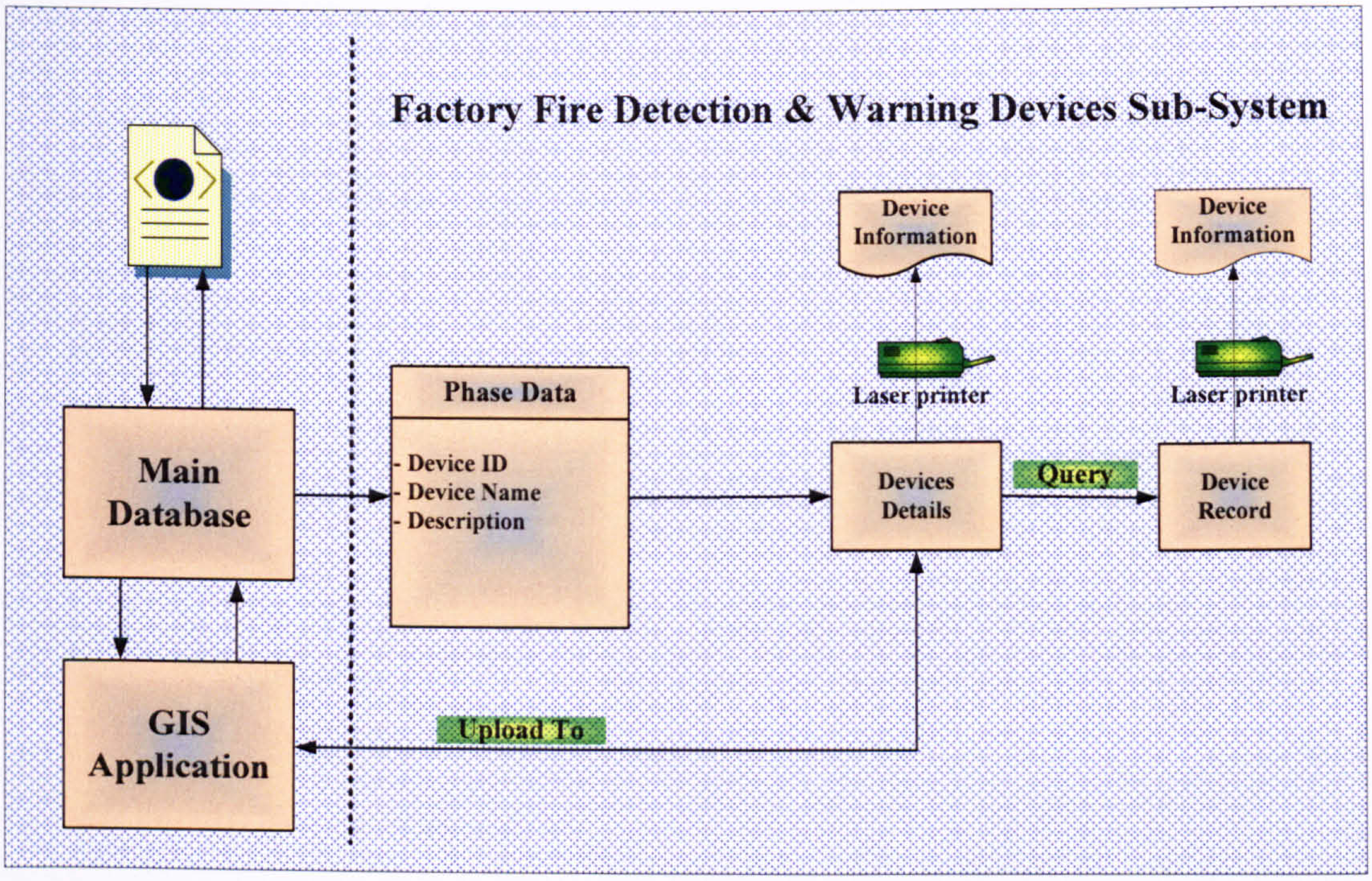


Figure 8.7 Factory fire detection and warning systems devices sub-system

e. Best Locations of Fire-fighters Sub-system

The purpose of this database is to provide full information for the user to guide fire-fighters for the best locations for fire stations. This will help IFB to know the exact locations of fire-fighters and other emergency services on a fire scene. It permits the dispatcher to provide the officers with information on the accident scene and where the fire brigades must be localised. Figure 8.8 shows the best location of fire-fighters sub-system process.

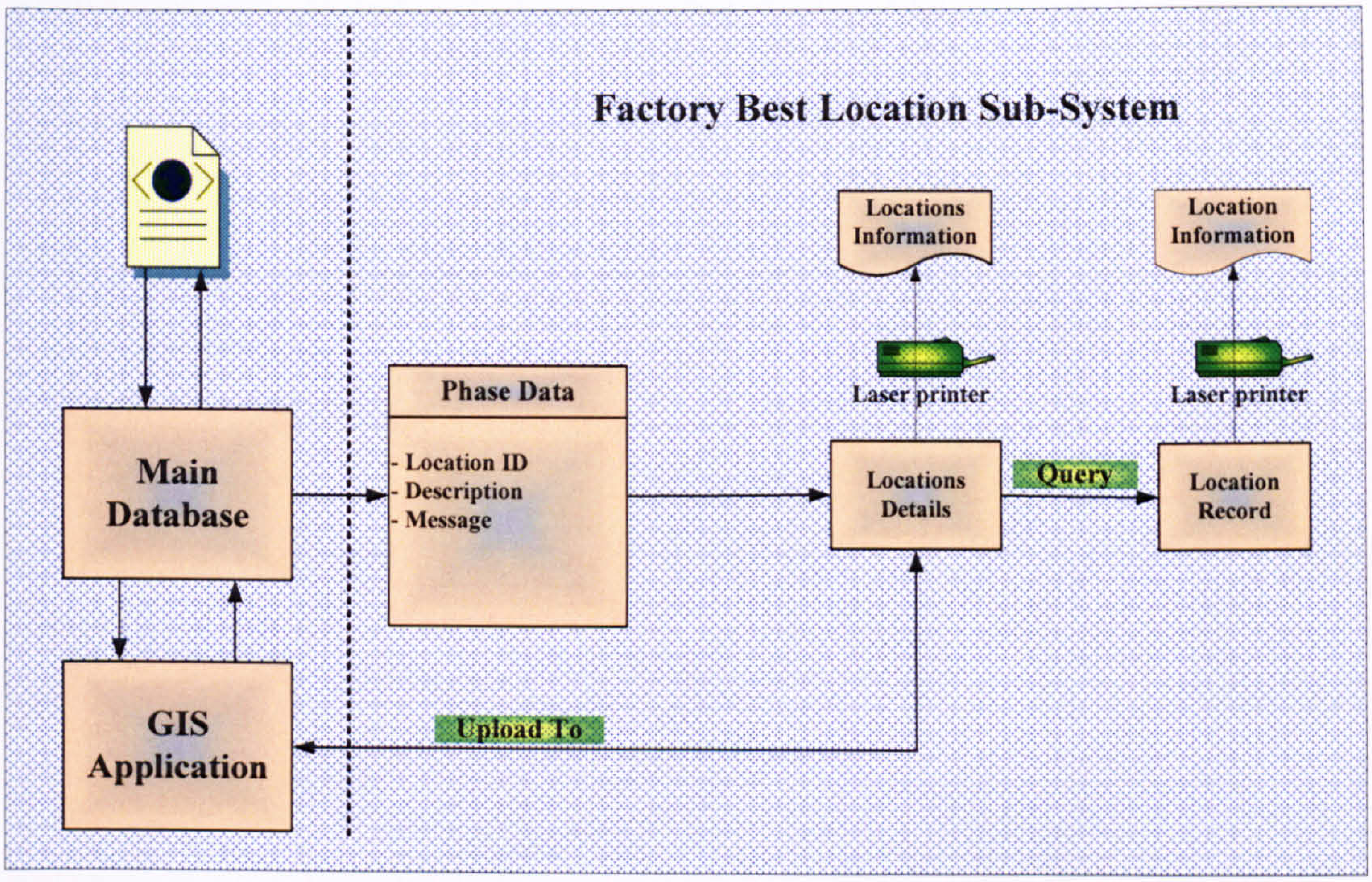


Figure 8.8 Factory best location sub-system

8.5 IIAS – GIS

The GIS and databases are interfaced through ODBC. An SQL establishes a connection to databases. The commands received from the GIS are transformed to SQL, sent through ODBC, and, after this, GIS will exchange information to text form for sending to the end-users.

The script is an object-oriented language named Avenue. An Avenue script can be used to control how and when requests get sent to ArcView objects, as discussed in Chapter 7. Through Avenue, ArcView's look and functionality can be customised. Avenue can be used to send requests to objects of pre-defined classes.

Using ArcView's SQL connection feature, a database server can be connected and run an SQL query to retrieve records from it. The records accessed become a table that can be used like any other ArcView table. Using Windows, SQL connections are based on Microsoft's ODBC standard. Therefore, ODBC SQL is used when communicating with an SQL database on Windows. Five new buttons were added to ArcView for specific purposes. Table 8.1 shows these application buttons and their functions.

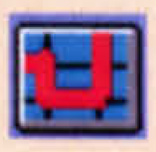
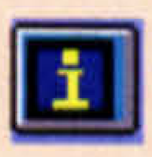
Button	Name	Description
	**Search Factory**	Allows the selection of a factory location by entering NAME or ID of the factory.
	**Show Directions**	Allows user to view the path and direction of a selected fire station.
	**Factory Information**	Provides access to the factory database. User can view different information (general, materials, safety devices and fire detection system and warning systems.)
	**Delete Graphics**	Deletes all graphics generated by the applications from the "Search Factory".
	**Options**	Provides the user to set different values as parameters to searching nearest station analysis.

Table 8.1 Application buttons and their functions

These buttons, represented as a graphic user interface (GUI), have been developed to integrate GIS and databases for providing decision-making aid during incident situations by providing the information suitable for each industrial incident.

The GIS in this study consists of three main components:

- A spatial and attribute database, based on GIS software (Arc/Info), to generate and analyse spatial data;
- Databases are developed in the Microsoft Access shell and stored as rules and facts in the database server; and
- Five new buttons, to be used as a graphic user interface (GUI), were developed to facilitate the interface between the GIS, databases, the display results, and either maps, documents, or reports to aid decision-making.

These components are shown in Figure 8.9.

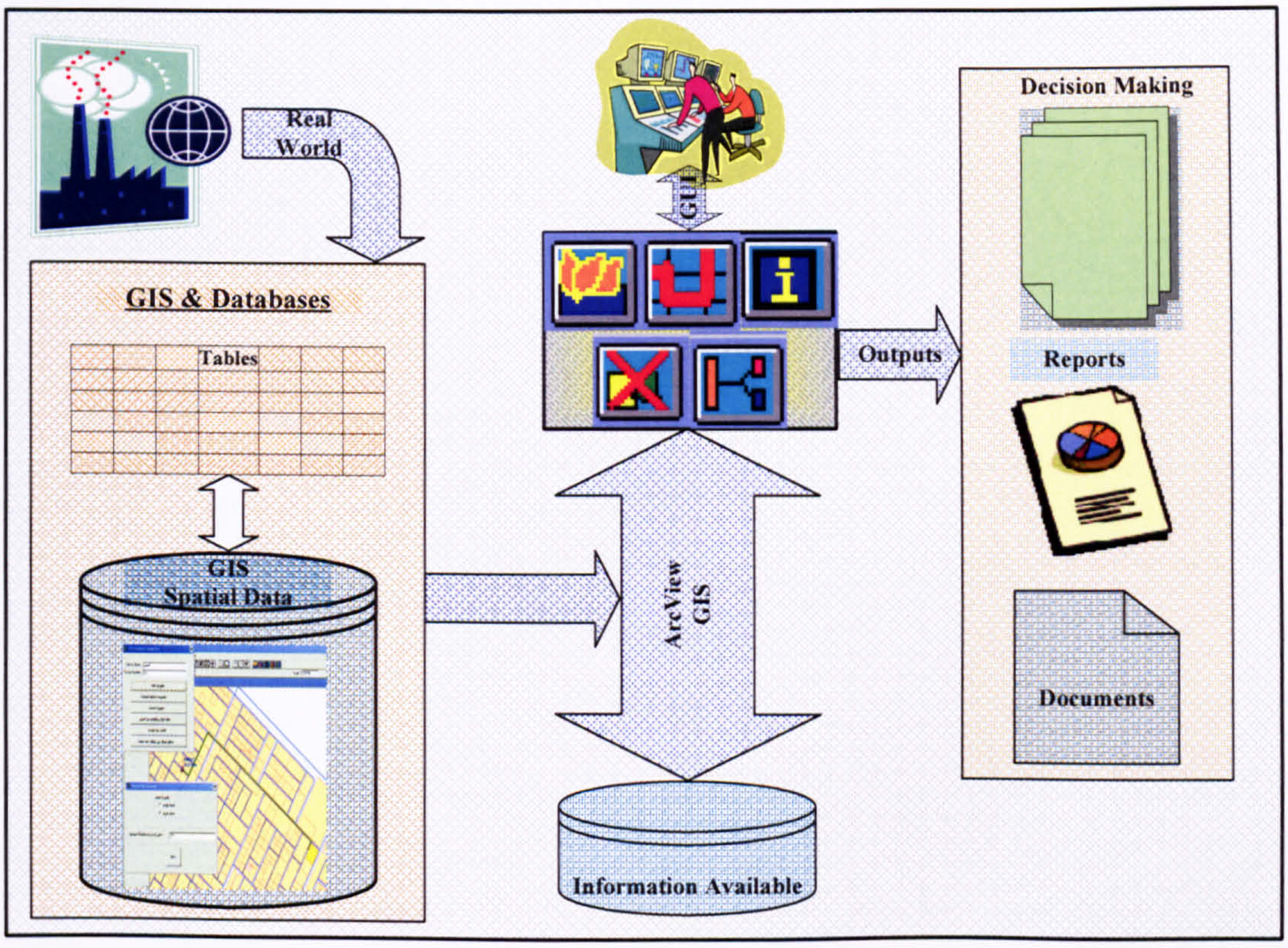


Figure 8.9 The GIS and databases and their functions

Spatial data are designed to store and manage digital maps for industrial cities. These spatial data are initially generated and stored, based on the ArcView GIS. The tables are linked to the relational tables which store data for each factory and hazardous material stores. The available information will allow users to make a query on the specific data, such as the nearest fire stations, and this information can be transferred and exported as input data for the decision-making process during incidents. The inference engine starts after receiving an emergency call and then the call-taker moves through a sequence of rules until he/she finds all data that can be sent to fire-fighters. Appendix – 5 shows the GIS documentation of use the ArcView GIS.

8.6 IIAS – Security System

Information is one of the most important assets in an organisation. For any organisation, information is valuable and should be appropriately protected (BS 7799-2, 1999). Security involves combining systems, operations and internal controls to ensure the integrity and confidentiality of data and operation procedures in an organisation (Hong *et al.,* 2003).

The increased accessibility to information has not come without a price. Any time information is distributed on any type of network, there is the potential that unauthorised persons will access such information (Michener, 1999). Users are concerned about the level of security present when providing sensitive information on-line (Warrington *et al.*, 2000) and will perform transactions only when they develop a certain level of trust.

With the serious threat of unauthorised users on the Internet, information security is facing unprecedented challenges, and effective information security management is a major concern (Eloff & Solms, 2000; Schultz *et al.*, 2001). For all that, site security is required to take all necessary steps to protect their users' personal information.

ICT must deliver reliable Internet services to corporate users while ensuring that systems and information stay secure from outside threats. An organisation using an information network must install firewalls to prevent outsiders from accessing its own private data resources and for controlling to what outside resources its own users must have access (Mayur *et al.,* 2002, p.135).

The proposed security system adopted for IIAS is firewalls. A firewall is the most effective preventative method to protect internal network resources from external attack (Norifusa, 1998, p.70). Firewalls can constitute an effective type of network security. They prevent the dangers of the Internet from spreading into the internal network by restricting access at a centrally managed point (Skoularidou & Spinellis, 2003, p.85).

Network firewalls are hardware/software barriers between a corporate network and the Internet (Kokka, 1998, p.36). They are intelligent devices that control traffic between two or more networks for security purposes. Basically, a firewall, working closely with a router program, filters all network packets to determine whether to forward them to their destination. A firewall is a set of related programs, located at a network gateway server that protects the resources of a private network from users from other networks (McCollum, 1997, p.21).

A firewall usually consists of a UNIX or Windows NT computer running special firewall software. Other hardware platforms such as routers can also run firewall software. Although this software is usually associated with Internet connections, it can be used to control traffic between parts of an intranet or between networks of different corporations. A firewall is often installed in a specially designated computer separate from the rest of the network so that no incoming request can get directly at private network resources. Typically, firewalls employ one of three architectures known as screen routers, proxy servers and stateful inspectors. By combining the strengths of more than one approach, the firewall can be more effective (Mayur *et al.,* 2002, p.135).

8.7 Summary

The main purpose of this chapter was to discuss the design of the Industrial Incidents Administration System (IIAS) for the exchange of information and control of industrial accidents in industrial cities in Saudi Arabia. The aim of the system was to provide up-to-date information and improve communications between the Civil Defence and Industrial Sector to help dealing effectively with industrial accidents.

The prototype was developed through a highly interactive geographical user interface. When an application is built, one of the most important considerations is how the users can use the application. This study also uses Avenue script of a customised ArcView GIS to design five new buttons as a graphic user interface (GUI) to enable the use of spatial features, such as maps, in the display functions. GUI has many different screen objects which can be collected and grouped to perform the user interface. Each object has different characteristics and is used to convey different types of information. Interfaces are used to transfer data from one component to another. GUI is designed to link the spatial database with other databases in order to facilitate the extraction of relevant information. This prototype can be used by the industrial cities in Saudi Arabia. The proposed security system for IIAS was discussed as well.

In the next chapter, Stage Four of the SDLC are discussed in detail.

Stage Four: System Implementation and Evaluation

9.1 IIAS – Implementation Overview

The prototype was experimentally tested in the Civil Defence Command Centre (CDCC) in order to evaluate the efficiency of IIAS in the case of industrial accidents. After testing the prototype, a number of issues were observed and the required alterations were carried out.

The final implementation of the new system will be carried out in two phases. The first phase, an IIAS Web interface, will become part of the official Web site of the Civil Defence organisation in Saudi Arabia and will be available at (http://www.998.gov.sa). The second phase, an IIAS database and a GIS application, will be installed at the CDCC.

One of the most important factors to help the success of the system is training. Initially, each factory will receive a full document containing all the information needed about the new system. After completing system installation, the special training programme will be produced to cover all personnel at CDCC and members from all factories. This programme will cover a period of three days for each session, and will continue to cover all members. The training required will be divided into three sections:

I. An introduction and overview of the system, its role and importance;
II. A description of the database and GIS application and how data can be entered;
III. A description of the system's Web interface and how the various information forms can be used.

Data Management Team (DMT) at CDCC would be responsible for developing, supporting, and maintaining IIAS applications and the common data access portal which access the distributed data warehouses. It will also support the ICT functions within the command centre and manage the disaster information system. DMT includes those groups and individuals that are collectively responsible for the effective use, protection, and maintenance of data assets within the IIAS. It is responsible for coordination of data management activities across IIAS as well as implementing data management principles, policies, standards, and for establishing the overall data architecture.

In support of the IIAS, the Data Team will establish a core Data Architecture, to include:

- Develop and maintain data management policies, standards, procedures, and shared utilities and tools for data management.
- Coordinate the collection and management of metadata for spatial and tabular data.
- Establish a framework or structure for data administration processes.
- Facilitate sharing and re-use of common data in Civil Defence and Industrial Sector.
- Implement and manage a Change Control function for common and shared data in consultation with the Data Steward and Executive Sponsor.
- Perform Data Administration functions for applications, to include:
    - Resolution of conflicting data names, establishing common lookup tables, setting common domains for sharable data elements, and establishing unique keys and identifiers.
    - Coordinating data administration/management training.
    - Maintain a shared, central metadata repository for use by the external sources to store and provide access to metadata.
- Establishing standard and sharable data elements to promote data reuse.

The external sources, such as factories, are currently responsible for the production and maintenance of their own data sets through their approved member. Rather, each factory would have the option to be responsible for ensuring that their data is available and conforms to the standards established by the Data Team. Each approved factory can be given access to their own private password protected member pages. They will access these pages by entering their username and password which they select at the time of their membership application. In their member area they can perform a number of useful member functions (i.e. updating data, upload and download of information, sharing documents, etc.).

Through this research, it is suggested that the databases on the IIAS website will have a major role in facilitating the communication among the emergency services and factories and providing a central reference point for authorities. Keeping the information up to date is of course important; the website facilitates this by allowing factories to change their own records and add relevant notes. Factories should therefore be playing their part by updating their own contact details and adding/deleting factory information as and when necessary. DMT will keep monitoring and controlling of these databases and will revise the log of each member for be sure they are feeding the system with correct data.

9.2 IIAS – Prototype Implementation

> *"Prototyping is about people. Users are not often able to articulate what they want an information system to do, and they cannot visualise it from written specifications. Prototyping enables them to see a system, "play" with it and modify it before it is implemented" (Kenneth Lantz, 1997).*

Prototyping is the building of a model (prototype) that can be modified before the actual system is installed. Crinnion (1991, p17) defined the prototyping process as "building a physical working model of the proposed system, and using it to identify weaknesses in our understanding of the real requirements".

There are two different approaches to the practice of prototyping. These are known as Throw-away prototyping and Evolutionary prototyping. Throw-away prototyping is where the objective of the prototype is to understand the users' requirements and hence to develop a better requirements definition for the system. The prototype concentrates on experimenting with those parts of the user requirements which are poorly understood. Evolutionary prototyping, on the other hand, is where the objective of the prototype is to work with the users to explore their requirements and deliver a final system. The development starts with the parts of the system which are understood. The system evolves by adding new features as they are proposed by the users (Sommerville, 1996, p.11).

The benefits of developing a prototype are, according to Sommerville (1996, p.138):

1. Misunderstandings between developers and users may be identified as the system functions are demonstrated.
2. Missing user services may be detected.
3. Difficult-to-use or confusing user services may be identified and refined.
4. Developers may find incomplete and/or inconsistent requirements as the prototype is developed.
5. A working, albeit limited, system is available quickly to demonstrate the feasibility and usefulness of the application to management.
6. The prototype serves as a basis for writing the specification for a production quality system.

Prototypes have also other uses (Ince & Hekmatpour, 1987):

1. User training: a prototype system can be used for training users before the final system has been delivered.
2. System evaluation: this is the most important stage of prototyping because this stage will discover the requirements, errors and omissions of the system.

9.2.1 The Importance of Prototyping

The success or failure of a project lies, not with the elegance of its code, but in its analysis of the system and end-user requirements. System analysts have the difficult job of eliciting knowledge from end-users and communicating this knowledge to many different parts of the application development team. Therefore, what system analysts need is a way to communicate requirements. The most appropriate method for communicating requirements with end-users is through prototyping.

Prototyping is a means of communication. More importantly, it is an additional means of communication, designed to provide an additional dimension to application analysis and design: it involves the visualisation and simulation of requirements documentation. Prototyping does not replace requirements documentation and the like; instead, it is meant to communicate them more efficiently.

The visualisation of application features and requirements, and the simulation of application behaviour enables both buy-in and feedback. The result is well-grounded validation, a more complete grasp of the project's complexity and scope, and insurance that the application is one that will successfully answer user needs. High fidelity, functional prototyping is the means to that end (Conallen, 2002).

9.2.2 Prototype Development

Most development techniques that specify prototyping do so within the larger context of a traditional SDLC (Beauregard, 2001). In these cases, the prototype takes the place of, or supports and clarifies, some of the steps in those cycles. Dearnley and Mayhew (1983) expanded an SDLC by inserting a prototyping stage after the requirements definition, leading on to analysis, design or final design depending on the outcome of the prototype.

Wilson (1997) stated that prototyping is usually applied within a traditional SDLC; it can only be as viable as the SDLC which encapsulates it. While prototyping serves to enhance the performance of these models, due consideration must still be given to this. Prototyping applied well can assist in clarifying user requirements, resolving technical or architectural issues, and demonstrating viability. Prototyping increases the viability of managing projects by assisting in clarifying user requirements, resolving technical or architectural issues, demonstrating viability, or documenting the system.

Prototyping assumes that better systems are built by "trying out", and that the time and expense of developing a prototype is justified by the benefits. Prototyping can enhance the viability of the SDLC of which it is a part by clarifying user requirements, resolving technical or architectural issues, and demonstrating viability. The methodology embraces adaptation as part of its very model and the means, method and management controls applied to the use of prototyping will differ for every project (Beauregard, 2001).

For the proposed system, prototyping will be used to support the SDLC approach to achieve the proposed system. There are two main and inter-related concerns about the SDLC. The first concern is the extended time required to go through the development life cycle. The second concern about using the SDLC is that user requirements change over time. During the long interval between the time user requirements are analysed and the finished system is delivered, user requirements are evolving. Thus, because of the extended development cycle, the resulting system may be criticised for inadequately addressing current user information requirements. It is apparent that the concerns are interrelated, since they both pivot on the time required to complete the SDLC and the problem of falling out of touch with user requirements during subsequent development phases. If a system is developed in isolation from users (after initial requirements analysis is completed), it will not meet their expectations. To overcome these problems, some analysts propose that prototyping be used. When prototyping is used in this way, the analysts effectively shorten the time between the ascertainment of information requirements and the delivery of a workable system.

Additionally, using prototyping can overcome some of the problems of accurately identifying user information requirements. The three major advantages of prototyping are: the potential for changing the system early in its development, the opportunity to stop development on a system that is not working, and the possibility of developing a system that more closely addresses users' needs and expectations (Kendall & Kendall, 1995, p.203).

Because application development is largely a human activity and humans are not infallible, iteration is needed. Iteration is a common technique consisting of the repetition of a work unit on an existing work product in order to improve it. An important, fundamental principle of iterative development is that each iteration delivers a functional version of the final system. It is a properly engineered, fully working portion of the final system and is not the same as a prototype. In this study, iteration was done among the various phases of the Waterfall lifecycle several times (see figure 4.3, p.103).

It is absolutely necessary that a system is developed to provide accurate and up-to-date information, and one that will satisfy the information needs of both sectors. Specifically, there is a need to provide electronic data on hazardous materials that will assist fire-fighters in controlling industrial accidents. Because of the explosion of Internet-related technologies and their capability to support this type of information service, a Web information system prototype was developed.

9.2.3 Prototype Objectives

As Shneiderman states, the web design process must begin by asking: "Who are the users and what are the tasks?" (1998, p.565). Visitors to the IIAS website may be fire-fighters, industrial workers or hazardous controllers looking for information through a web search. Each of these three groups needs to be able to find what it needs quickly and easily without having to wade through information that does not serve their purpose. It is also important that the site be visually appealing while meeting the standards of good web site design.

The purpose of designing this prototype was to achieve the following objectives:

- Obtain a better understanding of the new system and effectively communicate this amongst both sectors;
- Look for potential problem areas or areas that may require further work before the new system is commissioned;
- Work out the best approach to implement the new system.

9.2.4 Prototype Database Design

A database is a logically coherent collection of data with some inherent meaning and is designed, built and populated with data for a specific purpose (Elmasri & Navathe, 2000). As far as this study is concerned, a critical objective of database modelling is to develop a centralised database involving the integrated historical information that covers all the factories in all industrial cities, so that the IIAS principles can be achieved.

Corresponding to the requirements for the database, addressed in Chapter 7, an initial mock-up database was developed, as shown in Figure 9.1. On this page the user will enter the relevant factory information into the database for the first time. After this, the update will be carried out regularly by the user who has being assigned the responsibility, as well as given the necessary authorisation, to enter data into the system. All data that are entered into the database will automatically be downloaded to another server for two purposes: to use it with another application (GIS) and for security.

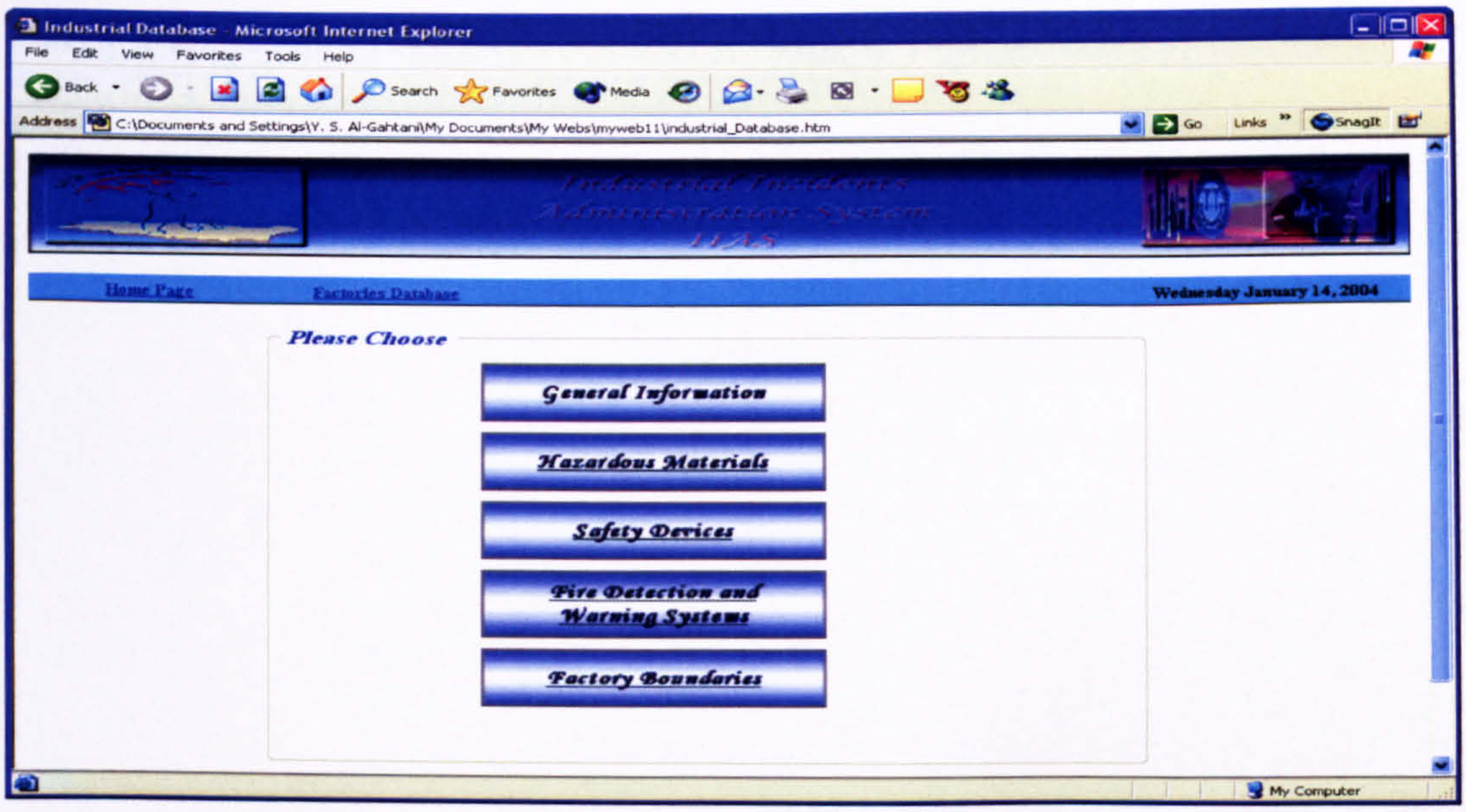


Figure 9.1 Database page

When the above scenario is considered, it is imperative that security is addressed. If information about a certain "factory" is stored in a database, it must be protected. Service providers will need to maintain high levels of security to prevent the interception of this information during communication or the acquisition of this information by non-authorised parties such as identity thieves, hackers and stalkers. The safe storage of data is critical for the safety and security of a factory. The security aspect will be dealt with during the implementation of the proposed system in the real world, not in the mock-up prototype.

The purpose of other components in the database page is to present useful information and to let factories look at it electronically instead of via a manual-based system. These components are:

- **Reports:** to find some special reports published by the Civil Defence and related to industrial affairs.
- **Accident Control:** to give information and instructions about how to deal effectively with accidents and support the factory administration to implement the right procedures on how to control different industrial accidents.

- **Expert People:** it is very important to be aware of experts in dangerous materials and industrial accidents. They will give their support during any accidents in how to control or mitigate accidents. This page will provide a list of expert volunteers, especially in industrial accident control.
- **Civil Defence Forms:** The Industrial Sector needs some forms from Civil Defence departments such as the hazardous materials declaration. This page will provide all the forms that will be required by the Industrial Sector and these can be downloaded in the required format electronically.
- **Safety Instructions:** to give factories all safety instructions that are provided by Civil Defence departments and international standards. Specific safety instructions will be provided for each safety class.
- **Emergency Plans:** It is a reasonable assumption that every factory will, at some point, experience some sort of crisis or emergency. Emergency preparedness and planning activities will help to minimise human, property, and economic loss due to any hazardous event. Industrial Emergency Plans will be designed for small- to medium-sized factories with little or no experience on emergency planning. These plans will be designed to be user friendly and to proceed step by step through a process for developing an appropriate emergency plan. This page will contain different emergency plans related to different industrial hazards.
- **Training Courses:** All workers working in factories should be aware of the required safety training for dealing with industrial accidents, including emergency response training. The Civil Defence will organise training courses relevant to industrial workers and these can be found on the web site. Emergency training applies to factory evacuation procedures during fires and explosions, recognition of system alarms, and appropriate action in the event of spills of hazardous materials.

9.2.5 User Interface Design

Corresponding to the presentation layer of the overall architecture, the interface connects users with system application and background data sources. The quality of the user interface directly determines the effectiveness of users' interactions with the system and their perceptions of it. As far as this project is concerned, web-based interface design is adopted because it provides global access and abundant interactive information, which is particularly appropriate to meet different user requirements. The general design principles are as follows:

- **Layout Design**

  The layout design for the system interface follows the consistency principle, which means the layout organisation and component location are generally consistent with the web house-style of industrial hazardous control. Moreover, the interface can also show other styles corresponding to the specific systems it links to.

- **Navigation**

  The navigation design of this system applies a hierarchical web structure. This means each level is logically and vertically linked with other levels and the elements within the same component at the same level are connected with each other (Mandel, 1997). The hierarchical structure is very helpful with regard to security issues in that the users cannot jump across different levels at will; the unauthorised areas are protected automatically.

Figure 9.2 illustrates the typical layout of the prototype system using the homepage of the prototype as an example. Corresponding to the application layer, functionality design is the core portion of the whole system design process. For this study it aims at achieving the objective of designing an information network for exchanging information between the Civil Defence and the Industrial Sector to help fire-fighters to deal effectively with industrial accidents.

Generally speaking, the main functions involved in this system are an ad hoc industrial database, which contains a factory database, reports, accident control, expert people, Civil Defence forms, safety instructions, emergency plans, and training courses.

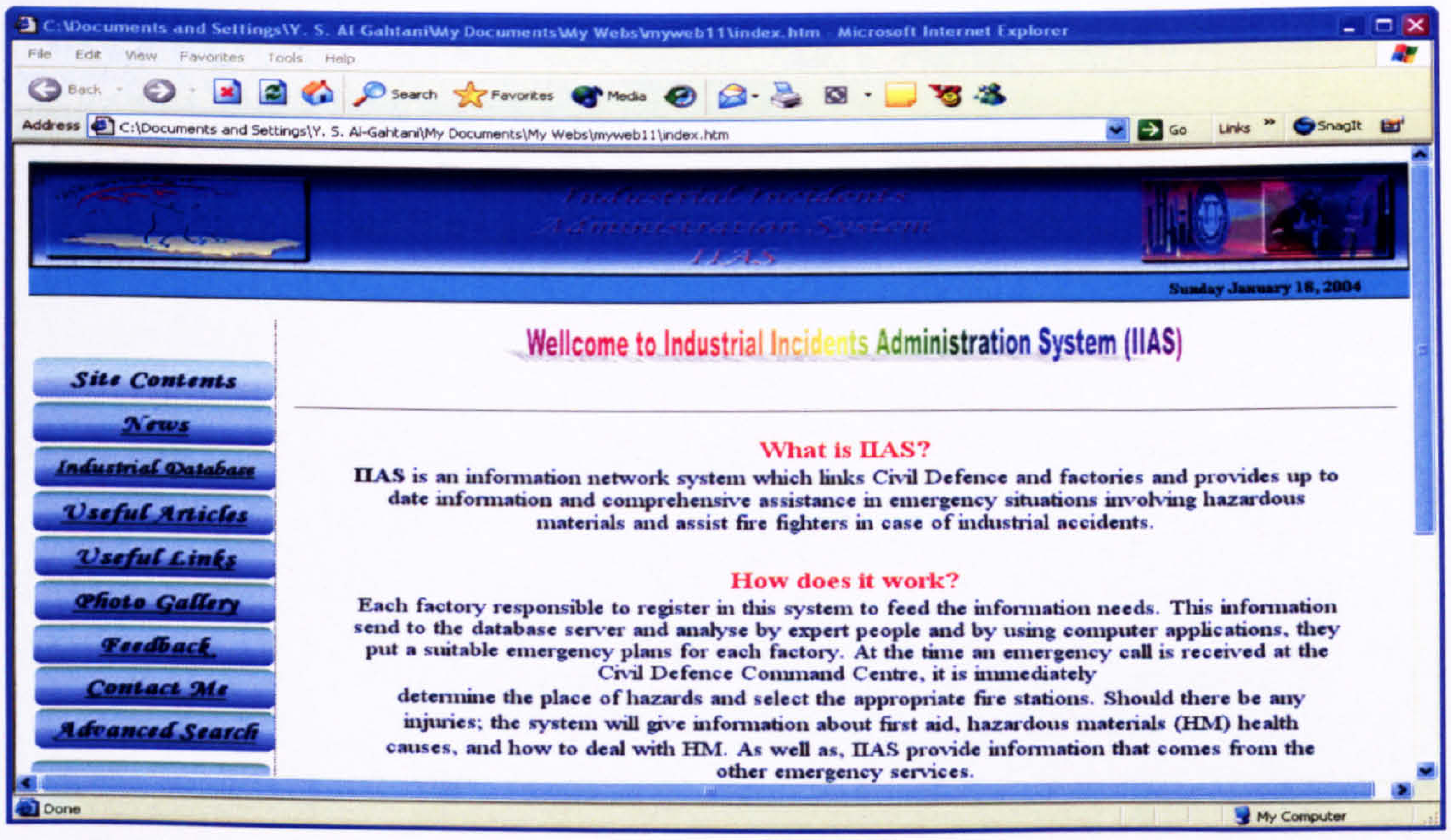


Figure 9.2 Home page of the prototype

This system is designed to provide specific functionalities for different kinds of user. In addition, it will serve as an effective system to tackle the issues discussed in Chapter 7. The corresponding overall functional requirements of the proposed system can be summarised as follows:

- To be a highly integrated system. This implies that the system will integrate the main functionalities, systems and processes to enable more powerful and consistent functions and services.
- To create a centralised platform that can provide, not only information services to specific users, but also a more flexible and effective channel that enables both sectors to communicate with each other.
- To be able to conduct deep analysis regarding collected data about hazardous materials and to implement initial intelligent functionality to support the decision-making processes of fire-fighters during industrial accidents.

Figure 9.3 illustrates the typical layout of the factories' database page. With regard to each component, the web structure can be divided into three levels. The first level presents the whole functionality within the particular component. The second level present specific functional choices for each functionality, while the third level contains web pages that are concerned with query input and result output.

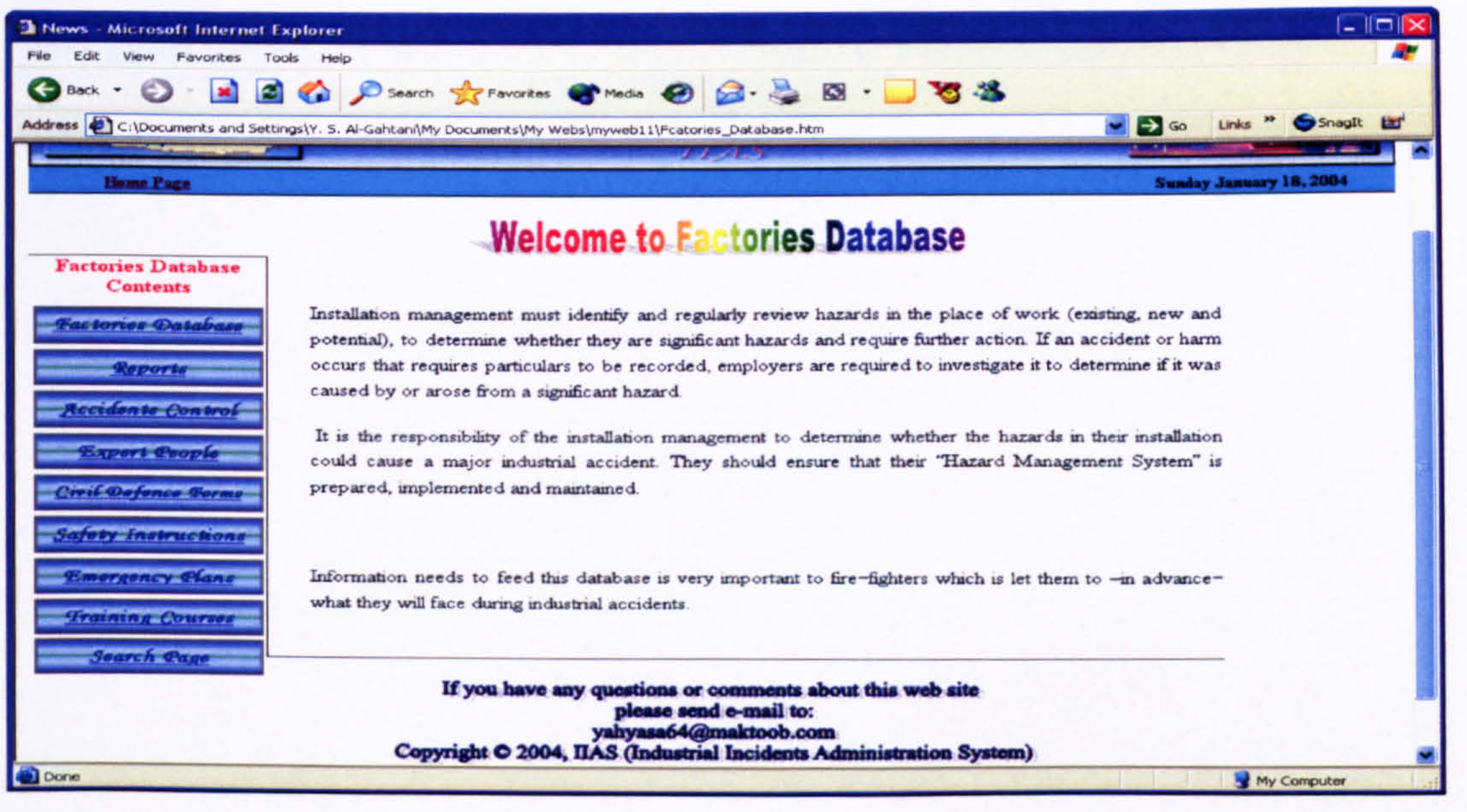


Figure 9.3 Factories' database page

9.3 IIAS Prototype Evaluation (IIAS – Web Site)

"To discover which designs work best, watch users as they attempt to perform tasks with the user interface. This method is so simple that many people overlook it, assuming that there must be something more to usability testing. Of course, there are many ways to watch and many tricks to running an optimal user test or field study. But ultimately, the way to get user data boils down to the basic rules of usability:

- *Watch what people actually do.*
- *Do not believe what people* say *they do.*
- *Definitely don't believe what people predict they may do in the future"*

(Nielsen, 2001).

The International Standards Organisation (ISO 1998, p.8) defined usability as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Preece (1994) defined usability as a measure of the ease with which a system can be learned and used, its safety, effectiveness and efficiency and the attitude of its users towards it. Usability can be defined as the effectiveness, efficiency and personal satisfaction with which people are able to access and make productive use of the available resources. The importance of the interface and the functionality it enables cannot be overemphasised. Thus, the usability of the Web interface and functionality should be evaluated and enhanced to the greatest degree possible. Usability is about much more than the "look and feel" of the system interface. In other words, effective systems generate positive feelings of success, competence, mastery and clarity in the user community. When an interactive system is well designed and communicates its functions and navigational structure to novice users with a minimum of cognitive overload, the interface almost disappears, enabling users to concentrate on their work, exploration or pleasure (Reeves *et al.*, 2003, p.27).

Shneiderman (1998, p.15) mentioned that the usability of any type of user-interface is determined by a combination of five measurable human characteristics: (1) ease of learning, (2) high speed of user task performance, (3) low user error rate, (4) user retention over time, and (5) subjective user satisfaction. With reference to IIAS, this means that (1) learning how to access the resources and using the database should be easy to accomplish within a short time, (2) finding a desirable resource should take minimal time, (3) errors of handling resources and materials should be rare, (4) returning to the system within a reasonable time should not require learning the user interface all over again, and (5) exploring and going through the site should be a pleasant and rewarding experience.
Based on these principles, usability is an important aspect of good system design because it focuses on users and whether they can successfully use the system or Web site. It also allows the users to define what "quality" is for them in the context of a particular subject gateway and is therefore an essential component of the continuous improvement process (Clark & Frost, 2002).

There are many methods for measuring a system's usability (Campbell, 2001, p.2). The evaluation process was directed with two main objectives in mind: to determine the effectiveness of an interface in use and to provide a means for suggesting improvements (Ross, 2000, p.332).

There are two types of test in this study and they differ in terms of design and the operation to be carried out. The first test is for the IIAS Web site interface. The purpose of the test is to identify areas of possible improvement for the information exchange to be evaluated. The test is directed mainly at those working in the industrial area.

The second test is for the IIAS database and GIS application. The purpose of the test is to identify areas of possible improvement for the integration of the information about the factories and their linkage with the applications. The test is directed mainly to those that are working in the Civil Defence Command Centre to evaluate the availability of the information and the competency of the database during the industrial accidents.

Due to the exploratory nature of the study in dealing with the design of an information network, the study does have several limitations. First, the following limitations with the instrument:

- The instrument only asks respondents to view a demo site, so most respondents may not be able to sense the impact of the standard user interface.
- The instrument attempts to measure a number of user attitudes and perceptions but it cannot probe deeply into respondents' opinions and feelings.
- The study uses a sample Web site that is relatively small and simplistic in its design.
- One of the main factors for consideration in designing the prototype is the fact that it is compatible with the proof of concept standard. Compatible, in this

sense, means that the standard user interface is able to process information exchange.

To find usability problems specific to the evaluated prototype, the researcher combined two evaluation techniques: ten heuristics by Nielsen and eight golden rules by Shneiderman. The purpose of this was to identify a great proportion of major usability problems in all faces of the prototype. Figure 9.4 shows the evaluation procedures.

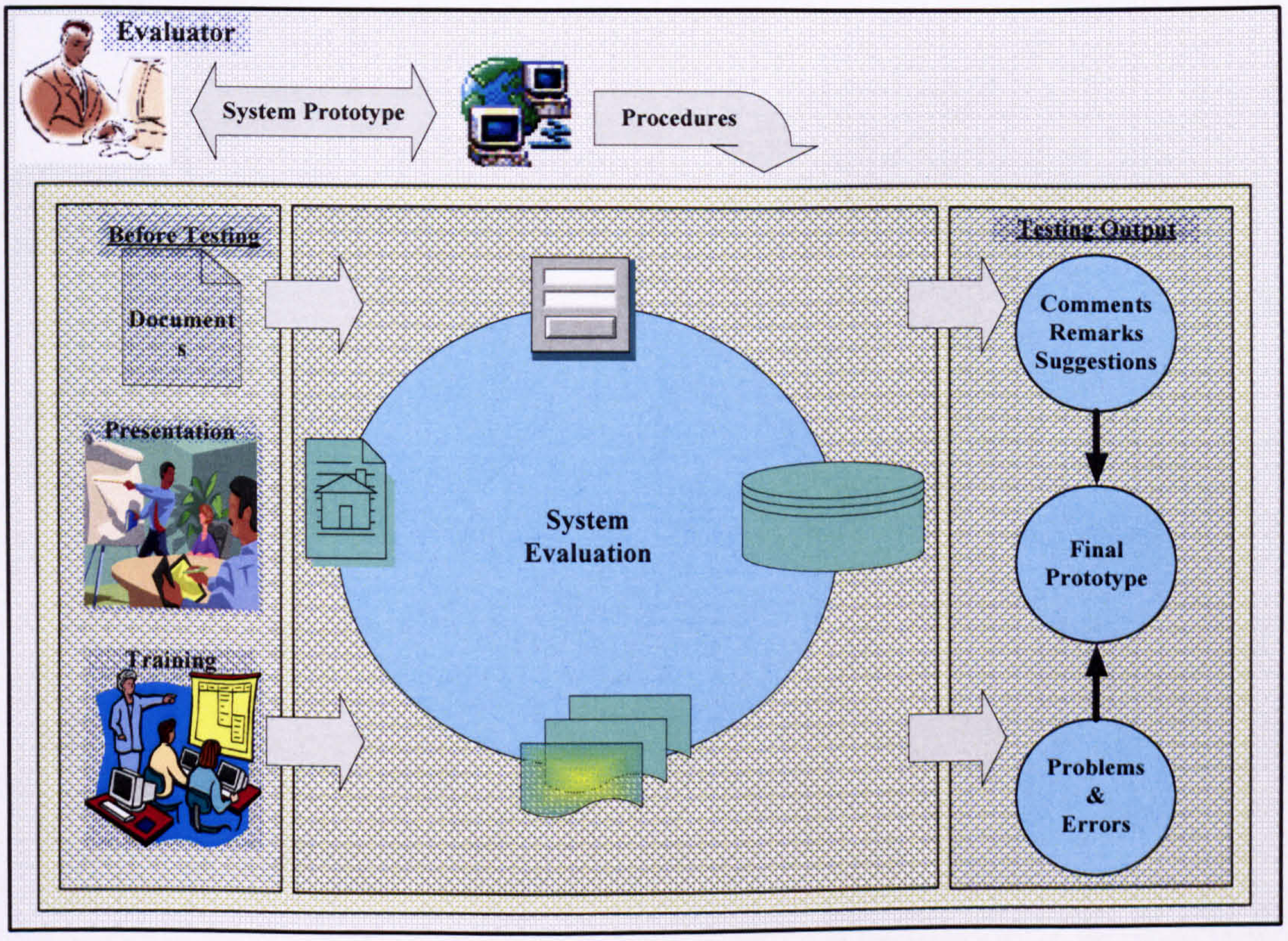


Figure 9.4 System prototype evaluation procedures

9.3.1 Heuristic Evaluation

A. Heuristic Evaluation Technique

Nielsen (1994, p25) defined heuristic evaluation as "a usability engineering method for finding the usability problems in a user interface design so that they can be attended to as part of an iterative design process. Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognised usability principles". Nielsen's "10 Usability Heuristics" focus on the ease with which users can navigate through a Web site and their ability to perform and complete tasks using the site. Nielsen recommended that 3-5 evaluators will give acceptable results.

Shneiderman (1998, p.74) also described eight golden rules of interface design. These rules focus on increasing the productivity of users by providing simplified data-entry procedures, comprehensible displays, and rapid informative feedback that increase feelings of competence, mastery and control over the system.

Zhang *et al*, (2003) combined Nielsen's ten heuristics and Shneiderman's eight golden rules and stated 14 heuristics with semantic tags (words in the brackets), names, general descriptions, and specific information about the heuristics. These are called the Nielsen–Shneiderman heuristics because these heuristics are mostly based on their work. These 14 heuristics are as follows:

1. **[Consistency]** Consistency and standards. Users should not have to wonder whether different words, situations, or actions mean the same thing. Standards and conventions in product design should be followed.

2. **[Visibility]** Visibility of the system state. Users should be informed about what is going on with the system through appropriate feedback and display of information.

3. **[Match]** Match between system and world. The image of the system perceived by users should match the model the users have of the system.

4. **[Minimalist]** Minimalist. Any extraneous information is a distraction and a slow-down.

5. **[Memory]** Minimize memory load. Users should not be required to memorise a lot of information to carry out tasks. Memory load reduces users' capacity to carry out the main tasks.

6. **[Feedback]** Informative feedback. Users should be given prompt and informative feedback about their actions.

7. **[Flexibility]** Flexibility and efficiency. Users always learn and users are always different. Users should be given the flexibility to create customisation and shortcuts to accelerate their performance.

8. **[Message]** Good error messages. The messages should be informative enough such that users can understand the nature of errors, learn from errors, and recover from errors.

9. **[Error]** Prevent errors. It is always better to design interfaces that prevent errors from happening in the first place.

10. **[Closure]** Clear closure. Every task has a beginning and an end. Users should be clearly notified about the completion of a task.

11. **[Undo]** Reversible actions. Users should be allowed to recover from errors. Reversible actions also encourage exploratory learning.

12. **[Language]** Use users' language. The language should be always presented in a form understandable by the intended users.
13. **[Control]** Users in control. Do not give users that impression that they are controlled by the system.

14. **[Document]** Help and documentation. Always provide help when needed.

B. Evaluation Procedures

15 evaluators were chosen from a representative group of research students: two were taken from Loughborough University, two from Leicester University, one from De

Montfort University, five from the Civil Defence organisation, and five from the Industrial Sector. They were all briefed prior to the tests so that they fully understand the heuristics that they would be using to evaluate the site. The evaluation was conducted between the second half of February and the middle of March, 2004.

Each individual evaluator was given between 30 - 45 minutes. The researcher, who was thoroughly familiar with both the IIAS Web site and the heuristics being used, recorded notes during the sessions, noting where problems with navigation occurred or where the evaluators were confused. Positive comments were also recorded. Evaluators were forced to use the navigation features inherent in the site.

Prior to the evaluation, the evaluators were given time to familiarise themselves thoroughly with the site. They were then asked to perform a set of simple tasks. The evaluators were taken through the site systematically and asked to comment on the headings and labels, as well as the site contents. They were permitted to ask questions if they needed help navigating or using the site. They were also encouraged to make any general comments about the IIAS Web site and IIAS services.

In order to prepare for the evaluation, a single sheet containing the 14 heuristic principles, with full details for each principle, was given to the evaluators. The aim was to give a clear picture of the evaluation process. This information can be found in Appendix-6. For those who carried out the evaluation in Saudi Arabia, the heuristic principles were translated into Arabic.

C. Evaluation Analysis

After the usability test had been completed, the information, suggestions and comments from each evaluator were compiled and grouped. This information, in conjunction with the suggestions, was used in developing the prototype further. The suggestions are summarised below:

1. Consistency and Standards

The evaluators suggested changing the "Find" button to "Search". They agreed that the prototype design had attempted to follow the standards through the prototype layout. They mentioned as well that the links are the standard blue until clicked on, and are purple after those pages have been seen.

The style, typography, headings and buttons are consistent in all pages. The titles on the pages matched the title in the table of contents on the home page. This made it clear to the users that they had ended up in the correct place. The IIAS logo and links to the home page are always in the same location from page to page; this helps to tie each separate page to the IIAS site as a whole.

2. Visibility of System Status

The evaluators suggested adding "Home link" on all pages and a site map. Two of the evaluators suggested making the prototype viewable on different browsers. In fact, the prototype was tested on different browsers for it to be available as different browsers versions. There is also visible change so, for example, when the mouse hovers on hyperlinks the colour changes, and when users visit any web page its hyperlink colour changes. The structure helps, supports navigation, and provides users with a path to higher levels of navigation and content.

3. Match between the System and the Real World

The evaluators mentioned that this prototype is concerned with hazards and emergencies. The prototype speaks the language of fire-fighters and industrial workers so the prototype's language and contents were familiar to them. Suggestions were made that the prototype should also contain more general information, such as "safety at home", "safety procedures at different places", and "dealing with fires", to give all site visitors general information in simple language. Although this suggestion was made, the main focus of the prototype is industrial fire-fighting and hence the prototype is centred on this area.

4. Aesthetic and Minimalist Design

One of the evaluators suggested that some pictures for the Civil Defence and Industrial Sector should be added to give a clear indication relating to the prototype that, in fact, authorisation is needed from these sectors. This will be done in the final implementation. Others suggested the removal of irrelevant pictures and moving the "Feedback link" from the top to the bottom of the home page or to put this in the table of contents. They also mentioned that the system is aesthetically pleasing but might be improved with the use of colour.

The IIAS site excels in having a minimalist design. There is no extraneous wording on any page. All the key links are on the very first screen and the user is directed to follow those links for more information.

5. Minimise Memory Load

The evaluators did not provide any suggestion here. They agreed that each page should contain simple headlines and page titles that clearly explain what the page is about and that will make sense when read out-of-context in a search engine results listing.

6. Informative Feedback

The evaluators did not make any comment or suggestion on this heuristic principle. The prototype gives the users information in detail to help those who have insufficient knowledge and understanding of the concepts.

7. Flexibility and Efficiency of Use

The evaluators mentioned that the prototype gives clear titles and detailed contents. These help users, both the experienced and the inexperienced, to obtain all their needs. The ease of use of buttons such as "home page", "next" or "previous" support the flexibility of the prototype.

There were valuable links to other sites, such as the "Useful Links" page and the "Useful Articles" page, which add to the efficiency of the resource. Information that might be important to the user is easily accessible.

8. Help Users Recognise and Recover from Errors

Evaluators suggested that should keep the "Comments Page" activated. This will help users to write their comments and suggestions and send them to the system. They will mention what they want or what problems they faced, so this will give feedback to the Webmaster to update the system prototype and solve any problems.

9. Error Prevention

The evaluators noted that there were some errors that occurred during navigation. These include:

- Add an "Advanced Search" page
- Provide "Help" from within the search box
- The "Submit" button was not activated. This is so because it is still in the prototype stage. It will be activated in the final system.

Other errors came from non-working buttons, such as "training courses", "emergency plans", and "news". These will be active in the final implementation in the real world.

10. Clear Closure

Evaluators did not provide comments or suggestions regarding this step. One of them said that "*The prototype gave me clear starting and ending indications for each point*".

11. Reversible Actions

All evaluators mentioned that they did not face any problems during their navigation through the prototype and that they could go to different levels of navigation easily.

12. Use Users' Language

Evaluators mentioned that the real users' language is Arabic and therefore they may find it difficult to use this site in another language. In fact, in the final implementation the prototype will have an Arabic language section.

13. User Control and Freedom

The evaluators made some valuable suggestions after encountering some problems. These suggestions included:

- Users often choose system functions by mistake so they need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. They suggested undo and redo buttons.
- Make the page title clear and make each focus on a specific topic. This will help users to avoid wasting time on subtopics that do not concern them.
- Users know that they can try anything on the Web and then click on the "back" button to return to familiar territory. The back button is one of the most often used navigation features so it is necessary to keep this active.

- People rarely read Web pages word by word; instead, they scan the page, picking out individual words and sentences. For this, the table of contents should have a detailed list to help users find the information that suits their needs.
- Credibility is important for Web users. They need to know whether a page's content can be trusted. High-quality graphics, good writing and use of outbound hypertext links can increase credibility.

14. Help and Documentation

Three of the evaluators noted that the Web site does not have a separate section for on-line help. One of the evaluators suggested that full explanations should be provided on how to use the "Factory Database". However, users will find text descriptions are available on each page. Also, the "Research Button" helps users to find what they are looking for. According to the database document, at the final implementation and after the registration step, the factory can download documents which have detailed information on how to use this system, as well as the authentication mechanism and information security.

Generally, the heuristic evaluation was an important step during the re-engineering process of the first prototype. Consequently, it was possible to present the test users of the experimental evaluation with a working and consistent version of the first prototype. The success and richness of the observations indicate that another detailed expert evaluation during the final design of the system would be useful.

D. Evaluation Questionnaire

At the end of the evaluation process, the participants were asked to fill in a short questionnaire, providing some demographic information and some other data about the prototype.

The questionnaire consisted of 14 questions on the system interface structured by four criteria that are relevant to human-computer interaction. These factors were appearance, information, functionality and application. The evaluators were asked to record their evaluation on a scale of 1-7, where 1 = Poor and 7 = Excellent. See Appendices (8-9).

E. Evaluation Questionnaire Analysis

The main aim of this section is to analyse the level of success of the prototype interface evaluation. Firstly, a reliability analysis was carried out in order to investigate the internal consistency of the scales. Cronbach's alpha coefficients were calculated to examine the reliability of the scales. All reliability tests on the four categories indicated that Cronbach's alpha coefficient value was well above 0.6, and the overall value of Cronbach's alpha was greater than 0.70. This means that the coefficient alphas for the categories were reasonably good and therefore were considered adequate for research purposes. The reliability alpha test results of the four categories are summarised in Table 9.1 below.

Categories	Cronbach Alpha
Appearance	0.72
Information	0.69
Functionality	0.61
Database	0.81
Overall Alpha Value	**0.73**

Table 9.1 Internal consistency of the four categories

The interface evaluation analysis can be considered to be successful in terms of mean values since each of the measured categories is high. On a 1-to-7 scale, all of the categories were estimated to be more than 5, as shown in Table 9.2. From the table it can be noticed that the means of all statements are consistent; this is supported by the alpha result.

Statements of Appearance	Mean Value
Background colours	6.07
Text colours	5.67
Contrast of text to background colours	5.27
Font type and size is easy to read	6.27
Pleasing to the eye	5.20
Appearance Grand Mean	**5.70**
Statements of Information	**Mean Value**
Amount of text	4.33
Information value	5.60
Information is easy to find	6.00
Information is organised	6.40
Information Grand Mean	**5.58**
Statements of Functionality	**Mean Value**
Links are clickable	4.80
Pages download quickly on your computer	5.60
Information is easily located	5.53
Functionality Grand Mean	**5.31**
Statements of Database	**Mean Value**
Database is easy to find on the website	6.13
Database instructions are easy to understand	5.00
Database Grand Mean	**5.57**

Table 9.2 Mean value of all statements - HE

Figure 9.5 shows a histogram of the mean value of all four categories which indicated the consistency of the results.

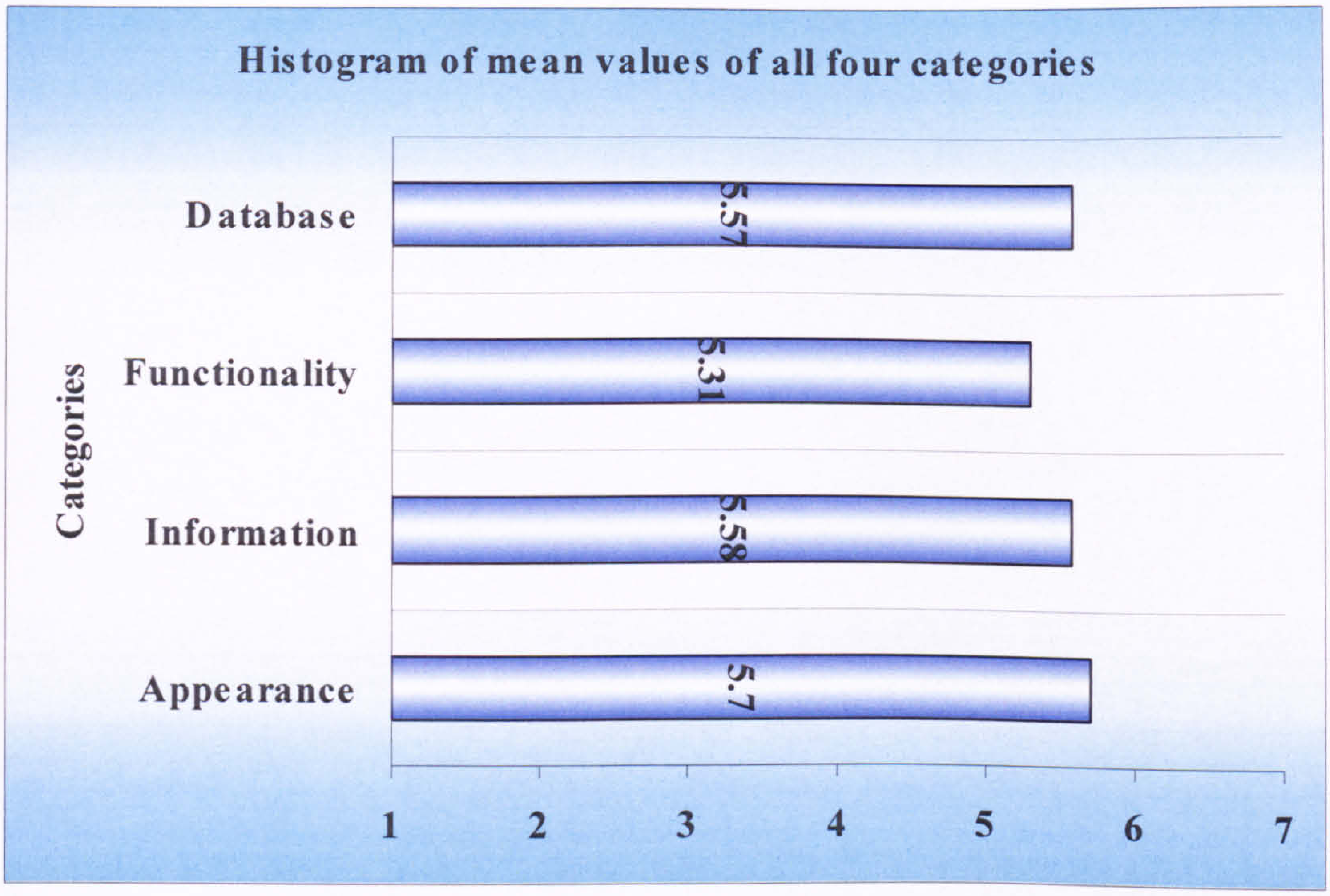


Figure 9.5 Histogram of categories' mean values

9.3.2 Cognitive Walk-Through Evaluation

A. Cognitive Walk-Through Evaluation Technique

Cognitive Walkthrough (CW) is a usability inspection method based on psychological theory, a theory about what affects the ease with which a new interface can be learned (Polson & Lewis, 1990). McMullen (2001, p.12) defined CW as a "review technique in which evaluators role-play the part of the user and walk through the interface in an attempt to complete certain information seeking tasks, such as using an online database to find a journal article". Moreover, this method is very useful in the early stages of design development for identifying problems that the user may encounter along the information-seeking path.

In CW, the sequence of actions refers to the steps that an interface or application will require a user to perform in order to accomplish a certain task. The designer tries to predict users' actions by doing the actual tasks themselves. The users go through these actions to find if there are any usability problems. The main focus of the CW is to identify how easy a system is to learn. CW evaluates each step that is necessary in completing an actual task, attempting to uncover any problems or errors in design. More specifically, the focus is on learning through exploration. So, the kinds of check that are made during the walk-through ask questions that address this exploratory kind of learning. To do this, the evaluators go through each step in the task and provide a story about why that step is or is not good for a new user (Polson *et al.* 1992a).

To carry out a CW, four things are needed (Abowd, 1995):

1. A description of the prototype of the system. This does not have to be complete but it should be fairly detailed.
2. A description of the task the user is to perform on the system. This should be a representative task that most users will want to do.
3. A complete, written list of the actions needed to complete the task with the given prototype.
4. An indication of who the users are and what kind of experience and knowledge the evaluators can assume about them.

CW consists of two phases: preparation and execution. In the preparation phase the analyst selects a prototype to be tested, action sequences for each task, and evaluators. For each task the analyst specifies a correct action and the expected system feedback after each action. In the execution phase (Jacobsen & John 2000, p.1), the analyst closely examines each action in an action sequence and asks the following four questions:

1. Will the user try to achieve the right effect?
2. Will the user notice that the correct action is available?
3. Will the user associate the correct action with the effect trying to be achieved?

4. If the correct action is performed, will the user see that progress is being made towards the solution of the task? (Wharton *et al.*, 1994, p.112).

B. Evaluation Procedures

Ten evaluators were chosen from the Civil Defence Command Centre. They have solid experience in terms of accident administration. They were given a two-hour lecture on the IIAS prototype over three days, with the assistance of a data show presentation. This lecture contained an introduction to the IIAS, the information that would be available, and how to use this information in the case of industrial accidents.

The evaluators were given two paper documents. These documents were divided into three parts: an introduction, a section on how end-users should use the prototype, and an evaluation sheet. The documents for the evaluation procedures were translated into Arabic. The purpose of the Arabic version was to permit respondents with little or no knowledge of English to complete the evaluation. The complete CW evaluation is shown in Appendices (10-11).

C. Evaluation Analysis

During the system design stage, the simple design was effected, taking into account the people who will work with it, even though useful information was gathered through the evaluation process.

Using the evaluators' comments and remarks as a guide, the following list of potential changes that needed to be made to the system was devised:

1. The five main buttons need to have their names added. Evaluators could not distinguish between these buttons so each one needs to have its own picture.

2. One of the evaluators mentioned that: "*I prefer to maximise the size of boxes to give a clear view of the information*". Redesigning the size of all the dialog boxes might help to give a wider view and this might help when looking for information.

3. The GIS application has many functions other than the main buttons. Evaluators need to know these functions. In fact, there is no need for them to understand these functions; they only need to know how they can use the five main buttons during accidents. Moreover, the designer, in the final stage, will suspend these functions for protection.

4. The industrial map is real. When the name or number of the factory is entered, it will appear automatically on the map and connect with the Industrial Fire Brigade. So, the evaluators were asked to keep the map on the screen without closing it.

5. Evaluators asked if the application would work at all times and what would happen in the case of failure. To answer this question, another system will be kept as a standby.

6. Evaluators asked about the updating of the data. Updating will be executed every time automatically when the tables in the database are refreshed from the production sources.

D. Evaluation Questionnaire

In order to obtain end users' opinions about the system, the researcher used an evaluation questionnaire adopted from 'The Software Usability Measurement Inventory (SUMI)' (Kirakowski & Corbett, 1996). SUMI is a standard questionnaire specifically developed and validated to give an accurate indication of which areas of usability should be improved. It has been tested in industry and mentioned in ISO-9241 as a method of measuring user satisfaction (Kirakowski, 2000). The questionnaire was composed of 11 statements measuring five criteria that are relevant to human-computer interaction. These criteria were: design & layout, efficiency, ease of use, helpfulness, and system reliability. The evaluators were asked to record their opinions on a four-point Likert-type scale ranging from 1=Strongly Disagree to 4=Strongly Agree.

E. Evaluation Questionnaire Analysis

The main aim of this section is to analyse the level of success of the system prototype evaluation. Firstly, a reliability analysis was carried out in order to investigate the internal consistency of the scales. Cronbach's alpha coefficients were calculated to examine the reliability of the scales. The overall value of Cronbach's alpha was found to be greater than 0.79 which means that the coefficient alphas for the categories were good and were therefore considered adequate for research purposes.

The evaluation analysis can be evaluated as successful in terms of mean values since each of the measured categories is high. On a 1-to-4 scale, all of the categories were estimated to be more than 3, as shown in Table 9.3. From the table it can be seen that the mean of all statements are consistent; this was supported by the alpha result.

Statements of Design & Layout	**Mean Value**
System was acceptable	3.4
Information presented was clear	3.2
HCI was pleasant to use	3.2
Design & Layout Grand Mean	**3.3**
Statements of Efficiency	**Mean Value**
The system assist me	3.5
Information was effective in helping me	3.5
Efficiency Grand Mean	**3.5**

Statements of Ease of Use	Mean Value
The system was simple to use	3.3
Information was easy to find	3.3
Information provided was clear	3.8
Ease of Use Grand Mean	**3.47**
Statements of Helpfulness	**Mean Value**
Completing the task	3.4
Information provided was understandable	3.5
Helpfulness Grand Mean	**3.45**
Statements of System Reliability	**Mean Value**
Mistakes recovery	3.3
System Reliability Grand Mean	**3.3**

Table 9.3 Mean value of all statements - CW

Figure 9.6 shows a histogram of the mean value of all criteria which indicate the consistency of the result.

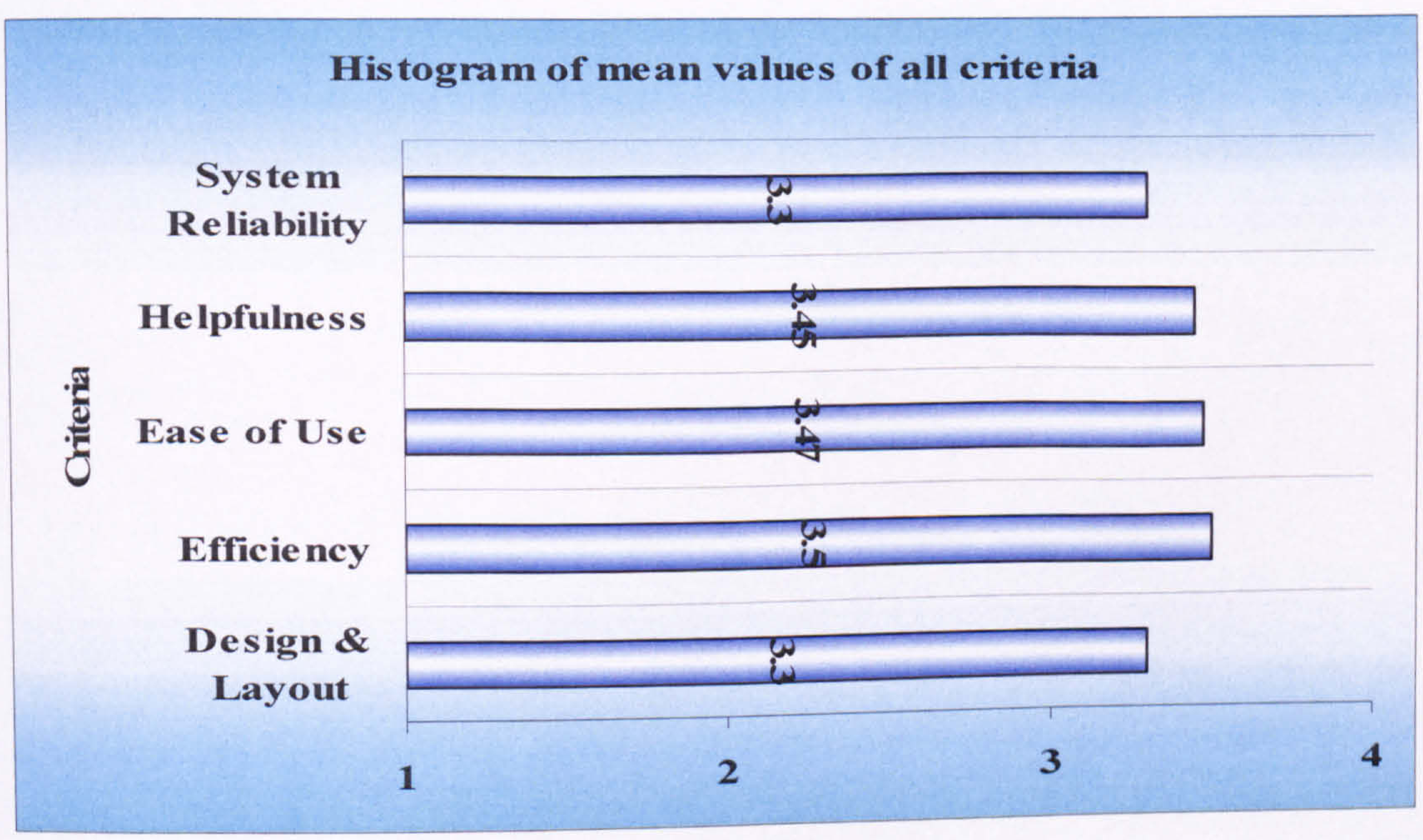


Figure 9.6 Histogram of criterias' mean values

9.4 IIAS Prototype Architecture

The IIAS system model is a composite of the three sub-models, as shown in Figure 9.7. These sub-models are Web interface, databases, and GIS spatial data. They are integrated to ensure the provision of effective and efficient information that will ultimately contribute to the effective control of industrial accidents and the enhancement of fire-fighters.

The system is different from the types of system that have been described in Chapter 3 in this study because this system is suitable for the situation of Saudi Arabia and is applicable for implementation in any case. The system model has certain attributes which are:

- The system has many users and the primary mission of the system is to provide content and services for these users.
- The system has a full spectrum of entities that make up the information exchange among all concerns.
- The system is linked to an array of factories and emergency services which are working directly and indirectly for the system.
- The system has an array of databases which provide and serve as repositories for all forms of data that the system needs to function and accomplish its goals in an optimal manner.
- The content of information provides an enormous amount of collective knowledge that the system continually draws on to ensure that it is using the best practices from each set of data.
- The responsible agent continually performs functions for the benefit of the system and the users.

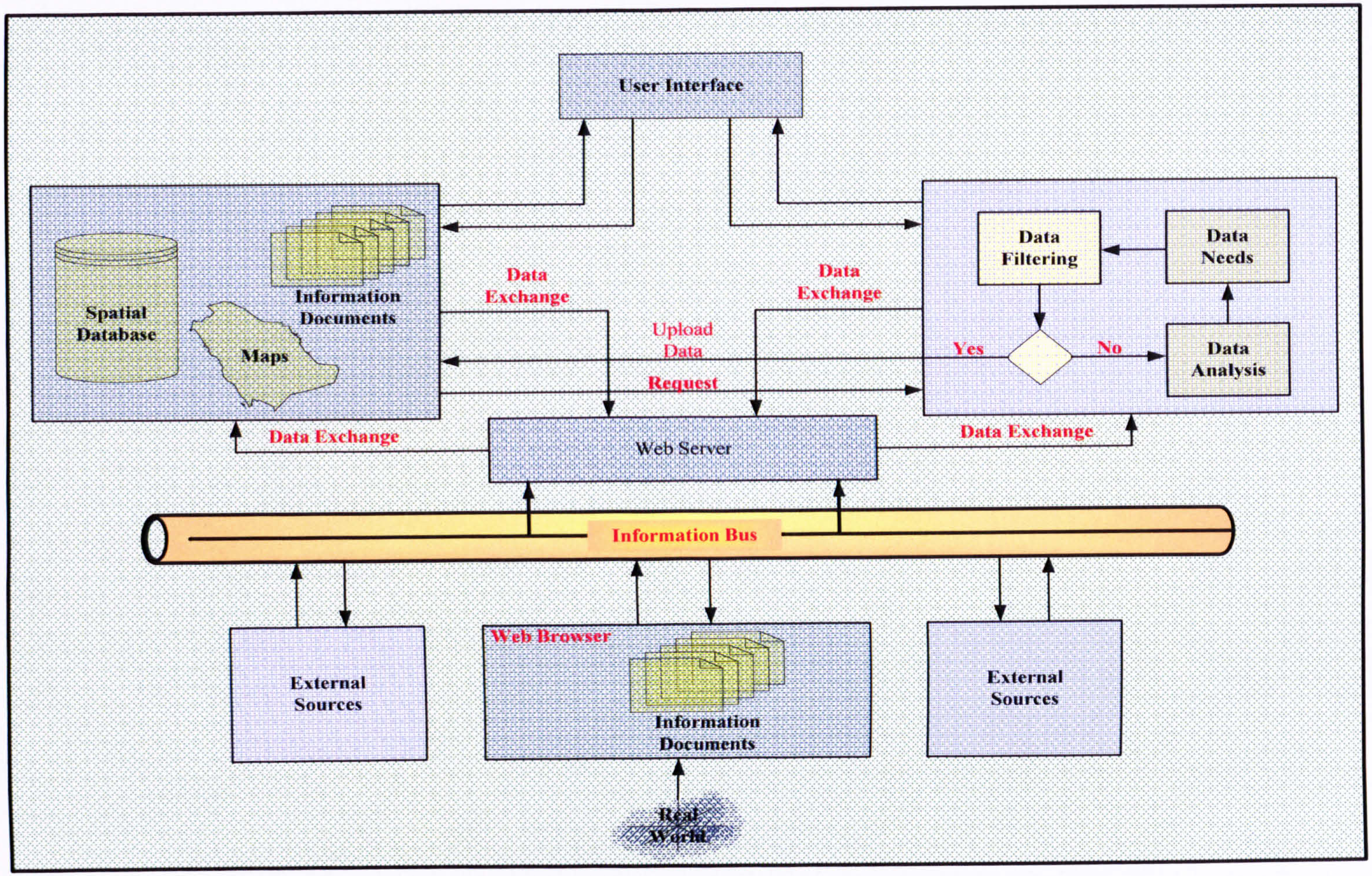


Figure 9.7 IIAS Prototype Architecture

The fact that all of these attributes are incorporated into one system is one of the most important characteristics that allow this system to enhance information exchange.

The IIAS Web interface provides the data on which the databases and GIS depend. Both of the latter are required in order to provide information for emergency services to deal efficiently and effectively with industrial accidents. The database gives useful information about hazardous materials and GIS provides spatial data about the factories and hazardous materials stores.

Taking a systemic view of the IIAS system model and identifying the provision of information exchange as the system of interest, it has many implications for the control of industrial accidents. It is anticipated that attitudes towards ICT and the morale of staff and users will have a positive benefit on the system as a whole. This will enable both the Civil Defence and Industrial Sector to prosper and take their rightful place at the heart of the system for information provision.

9.5 Summary

The main purpose of this chapter was to describe the successful implementation of IIAS in assisting the collaboration of the Industrial and Civil Defence sectors in Saudi Arabia.

Carrying out a usability evaluation is an essential step in human-computer interface design and should take place at all stages in a system life cycle. A variety of usability evaluation methods are needed in a development process because usability is a complex multidimensional concept that should be looked at in many ways. Different methods serve different evaluation purposes and reveal different problems. Therefore, they should be used as a complement to each other and not as isolated efforts. Heuristic evaluation is an inexpensive and quick inspection method. It is intended for the evaluation of software systems but can be applied to embedded systems as well.

Still, cognitive walk-through is usually more effective in evaluating smart products, especially if learnability is evaluated. The questionnaire analysis results indicated the acceptability of the IIAS and the applicability of the system to implementation.

The main lessons learnt in the adopted methodology include:

1. The prototype was found to give significant benefits at the evaluation stage.
2. The feedback from the evaluators and their comments were found helpful.
3. The benefit from evaluation is that the end-users have direct involvement in the design phase to ensure that the system fulfils their requirements. It also helps to overcome many of the initial fears and suspicions of the users.
4. Finally, the experiences gained during the system design and evaluation phases of the prototype were more useful than any problems or difficulties faced.

Despite its limitations, primarily due to its exploratory nature, the findings of the study provide a valuable insight into the users' acceptance of IIAS. The next chapter offers in detail a discussion of this research.

10.1 Introduction

The main focus of this study has been on the development of a conceptual framework for improving the current status of industrial accidents' control. The framework is aimed at accomplishing two main goals: the use of ICT to improve the information exchange between the Civil Defence and Industrial Sector, and to provide an information network model for the Industrial Incidents Administration System (IIAS), designed to highlight the method by which data should be transferred between the Civil Defence and Industrial Sector, as well as other emergency services involved in assessing and controlling industrial accidents.

The vision and design for the system that was presented in Chapter 8 is substantially different from the current system used for exchanging information during industrial accidents in three ways. First, the design is grounded in Civil Defence tasks, especially for Industrial Fire Brigades. The aim is to provide them with up to date information about the hazardous materials that are present in the Industrial Sector. Second, the conceptual framework of the system is designed to facilitate full collaboration and integration among all of the sectors concerned with the control of industrial accidents. Third, the system design is based on a Web-base interface, a set of databases and a GIS application, tailored to the requirements of the users that hopefully will facilitate effective data-exchange.

The objectives of this research, as stated in Section 1.3 of Chapter 1, were:

1. To investigate the current use of ICT in the Civil Defence department and the Industrial Sector in Saudi Arabia in the management of industrial accidents.

2. To investigate the benefits that arise from the use of current ICT systems available in Saudi Arabia:

    a. To study users' needs, expectations and attitudes towards information technology in the Civil Defence department and the Industrial Sector.

b. To study the information flows and use of information among the employees of the Civil Defence organisation and the Industrial Sector in Saudi Arabia.

3. To study the benefits of designing an information network for dealing with potential disasters.
4. By using an appropriate systems-based methodology, to develop a model for a proposed high-speed information network for sharing and exchanging information between the two sectors concerned.

This chapter aims at discussing the results of the study presented in earlier chapters. It also aims to discuss the proposed model and the prototype system, as well as evaluating the results. Figure 10.1 shows a roadmap of the discussions leading to a fulfilment of the research objectives.

To facilitate effective discussion, use is made of the initial research objectives to give a clear direction while, at the same time, assisting in determining the success or otherwise of the research in relation to these objectives.

10.2 Current Status of ICT

10.2.1 ICT Services

This study revealed that ICT services in the Industrial Sector were more advanced than those in the Civil Defence sector. This is because IFB staff do have insufficient computer skills as well as poor qualifications. The lack of ICT services and the lack of qualified ICT staff in IFBs were seen as major obstacles limiting the benefits that might be gained form the ICT services. The results of the survey indicate that most

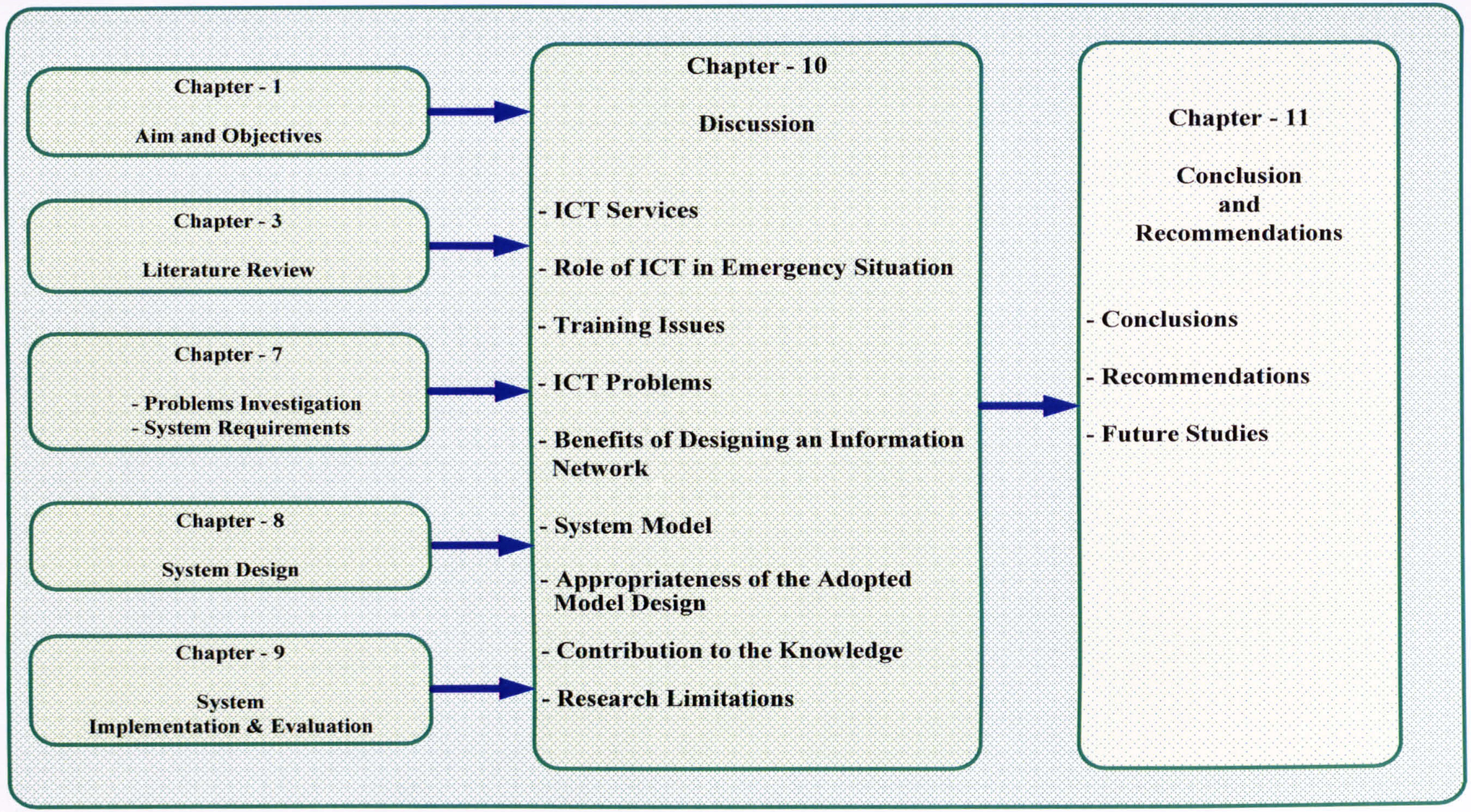


Figure 10.1 Roadmap of Discussion

departments in both sectors have computers. On the availability and use of computers at work for daily tasks, the results show that the majority of the IFB staff never use computers at work (N=190) while the majority of the Industrial Sector staff indicated that they always use computers at work (N=158). The significant differences between these two groups stem from the nature of the duties and responsibilities of the employees of both sectors. While the roles and responsibilities of fire-fighters rarely lend themselves to the use of computers (they are in the field or waiting for an incident to be reported almost all the time), the roles of Industrial Sector employees require constant use of computers.

The CDCC employees were more advanced than personnel from IFBs in computer utilisation. Despite this, the study revealed that the CDCC still uses manual maps to determine the location of incidents. As was evident in the results of the interview survey, the main reasons for the shortage of ICT services in the CDCC are due to:

- Lack of qualified manpower to use ICT effectively,
- Lack of a sophisticated GIS,
- Lack of an infrastructure for digital maps of Saudi Arabia.

The results also show that there is no connectivity between the Civil Defence departments and the Industrial Sector, despite the availability of computers and Local Area Networks within each sector. Although computers are in use in both sectors, they are not used in the technical aspects of incident control but for normal business activities such as the use of word-processors. The current system for dealing with industrial accidents is manual-based and depends on the experience of staff.

Overall, respondents were dissatisfied with the current situation regarding ICT because the computer applications did not match their information needs; also they asserted that the computers were poorly maintained. Their hope is have more advanced computer systems, advanced applications, and networking, all of which could help them to improve their job performance. Here, the management executive should be aware of ICT issues, then, if these are known, the issues can be overcome.

10.2.2 The Role of ICT in Emergency Situations

ICT can increase the speed, volume, quality and transparency of information exchange through faster access to, and distribution of, information. ICT also makes possible entirely new procedures, interaction among sectors, information and communications, which were previously impossible because of high cost or unmanageability (Stephenson, 2002). ICT can minimise the negative effects of distance and time in terms of emergency management; it can also enhance processes and communications between sectors. Emergency management procedures can be shortened and controlled more precisely, and access to information can be shared and data made available in real time, 24 hours a day. Furthermore, ICT will help to improve the co-operation between the sectors since it reduces the negative effects of distance and time, allowing parties to communicate with each other even if they are thousands of miles apart. ICT also allows improved communications between emergency services and assistance agencies.

Because ICT is used only minimally by the two sectors, the call system that is presently in use for emergency situations is the telephone. Concerning the use of ICT for controlling industrial accidents, 88% of the respondents said that they have a warning system to detect and control fire incidents and that this warning system is connected to the control panel to help workers to locate the accident. Regarding using ICT to deal with industrial accidents, that is using an automated directional system to call the fire brigade automatically, the respondents said that they had no automatic directional systems in place but they want to have as this system in future. The study shows that the respondents were keen to have a more advanced emergency management system.

In the management of an emergency, different organisations become involved in the response. Agencies such as fire-fighters, medical emergency departments and police departments undertake such emergency responses within their everyday activities. These agencies, organisations and departments must be prepared to provide training and the required resources, such as spatial data, when the need arises. ICT is particularly important for emergency management. The Civil Defence organisation especially would profit from the use of ICT in facilitating emergency management since ICT offers many facilities such as providing and processing data and information in the planning process, as well as giving the time of the accident. The CDCC, for instance, would profit from being able to retrieve data for preparing decisions and for providing the IFBs with accurate information.

The overall opinion of staff within the two sectors is that ICT will facilitate future work in emergency management and accident control. Creating models, simulations and scenarios will contribute to improved emergency management and simplify the forecast of the effect of different planning alternatives on incidents control. Databases from different sectors (Civil Defence departments, the Industrial Sector, other emergency services) can more easily be integrated. Simulation, multimedia, interaction and visualising might even replace traditional plans containing maps and texts. Additionally, ICT might lead to more efficient infrastructure planning and better emergency management. However, to achieve these advantages further ICT education will be necessary.

Geographic Information Systems (GISs) may represent a useful tool for managing, planning and responding to emergencies (Comfort, 2003). A GIS can present different types of information and such information could be used to provide more accurate estimates of the resources required in dealing with disasters. Stage Three of the SDLC presented the proposed system which was designed to overcome issues that exist in the current system. The system model for this study (see Figure 9.7 on p. 239) provides a solution to these issues. It will improve and enhance the current emergency management situation and will provide up-to-date information for decision-makers helping them to take the right decisions in emergency control.

The study has shown that the co-operation between the two sectors is very limited. Stage One of the SDLC identified problems associated with cooperation between Civil Defence departments and the Industrial Sector; this information originates from the primary evidence collected in the questionnaires and interviews. This stage revealed the need to improve information exchange in terms of emergency management.

Stage Two identified five fundamental requirements (ICT planning, management support, ICT training, user participation, proposed system efficiency) that would help in improving and enhancing the current system (see Chapter 7, Section II 7.2). These requirements will help in designing the proposed system (Stage 3), as well as increasing co-operation and improving information exchange between the two sectors.

10.2.3 Training Issues

Training is essential in introducing ICT successfully. It is a tool to improve and increase staff skills and performance that will reflect in an overall improvement in both sectors. The study revealed that both sectors provide training courses but these are not always adequate to meet the needs of staff members in terms of using ICT. Furthermore, the survey results show that there is a shortage of training courses on how to use ICT in emergency management.

The main aim of any organisation is to provide sufficient staff training to enable them to use ICT services effectively and efficiently. Despite that, this study shows that the two sectors still fall short of achieving this target. From the questionnaire survey, about 82% of the respondents were not taking any courses in the use of ICT in emergency management. This seems to be a very high percentage and this problem needs to be overcome. Furthermore, both the questionnaire and interview surveys revealed a number of training issues. These issues include:

- The quality of courses was still insufficient to improve staff skills in using ICT,
- ICT courses for use in emergency situations were not available,
- There was a lack of management support for providing suitable training courses in how to use ICT in emergency management.

To overcome these issues, provision should be made for advanced training programmes on useful ICT services for dealing with industrial accidents and staff should be encouraged to attend these courses. This would improve the professional efficiency of staff as they will gain knowledge of and be able to organise ICT services; this would, in turn, enable them to use ICT to its full potential. It is also important that both sectors should co-operate with each other to run seminars and workshops in using ICT in emergency management.

It is clear from the findings that training in the two sectors in terms of disaster management still needs to be explored and the benefits of ICT should be harnessed to make training more effective and to prepare workers to meet the changing needs of the future. Both sectors need to evaluate their ICT services in terms of disaster management training by testing out the benefits of these services. To do this, they should consider the views of the users of these facilities. The weaknesses surrounding the use of ICT services needs to be discussed as, the less these facilities are used, the more likely it is they will be scrapped or will never be installed at all. When users evaluate their services to obtain feedback about the shortcomings of what they offer, they often discover that there is a shortage of equipment such as terminals, PCs, etc. or there is a need to upgrade the system. This problem will not be solved if there is insufficient support.

The study shows the respondents' attitudes toward ICT: the results were generally positive towards the use of ICT in work. Interestingly, 41% of the respondents who indicated that they have no computers for use in their work highlighted the importance of the use of computers and ICT facilities at work. However, some also raised concerns about the effectiveness of ICT training and the level of management support. The results indicate that change to, and use of, ICT are increasingly becoming important for both sectors. This will help in building and increasing the ICT skills of workers, will improve information seeking, expand the use of the Internet, and aid in controlling incidents effectively.

10.2.4 ICT Problems

The study revealed a number of problems associated with implementing ICT systems within both sectors. These problems were attributed mainly to changes in the organisational structure of both sectors. Respondents expressed their concerns about the lack of funding and difficulties in obtaining financial support from those in management positions. Technical problems, associated with both the quality of services, hardware and software compatibility, a shortage of ICT personnel, and low-level training were also identified. Furthermore, some ICT directors expressed concern that senior management might be not adequately informed about the difficulties that might be encountered in establishing any viable system. However, top management support, end-user involvement, and the degree of success in getting the system up and running are very difficult to predict.

Jegillos (2000) mentioned in his research that certain problems have to be solved in order to improve information flow during emergency situations. These problems are:

- The lack of a monitoring system and information dissemination coordinating councils;

- The non-synchronisation of disaster assessment reports;
- A lack of communication and transportation facilities.

This study revealed that the current mode of information flow is the 'conventional' mode through the exchange of paper forms. Information flow was obviously abundant but the quality of information being disseminated requires improvement. Furthermore, the lack of staff skills concerning the use of certain types of ICT, the lack of ICT training in emergency management, and the lack of management support must be considered as the main ICT problems. As a result, there is a need to put more effort into redesigning the information flow between these two sectors, as well as overcoming or improving the above problems.

10.3 Benefits of Designing an Information Network

Developments in ICT mean that both sectors are looking for new ways of upgrading their services. Advances in technology offer more options for delivering and managing services differently and better than before. From the findings, all participants want instant access to information and they require good quality services, especially since electronic products are becoming cheaper and, at the same time, are offering better quality. Moreover, an information network connecting these two sectors in terms of disaster management should be designed.

There is ample evidence in the literature and from practitioners within the industrial accidents field about the needs and forces that are driving decision-makers and the emergency services to look for better ways to address many of the most intractable problems of incidents concerning hazardous materials. Clearly, improvements need to be made in many areas. Technology-based system designs, such as the proposed model, are superior in many ways to conventional designs.

10.4 System Model

The aim of this thesis was to design an information management system model to deal with processes in emergency management. The research employed quantitative and qualitative methods, such as questionnaire surveys and interviews, together with an SDLC technique. Feedback from among the participants helped to establish a balanced interpretation while interpretation and modelling formed the pattern for designing an information management system model.

The main findings of the study are that both sectors need to support emergency management; they need to increase co-operation and develop information exchange that will allow them to overcome the issues that have been mentioned in this study. As a result, it is important to identify the multiple roles that information plays in emergency management. Figure 10.2 shows the sequences of model building.

The areas in which information systems are expected to enhance emergency situations range from quick response, the quality of services and efficiency in controlling accidents. Nevertheless, little attention has been paid to how integrated administrative and financial support and training should be configured in order to achieve the most efficient and useful model. Co-ordination is informed by and dependent on the documentation of the activities of factories, particularly by monitoring hazardous materials in the Industrial Sector, to help the Civil Defence to be ready for any emergency.

Furthermore, such co-ordination relies on information about the quantity and types of hazardous materials. Thus, the co-ordination should provide the Civil Defence with updated information in order to help in emergency management.

Clearly, there is a need for a system that optimises information flow, as well as supporting and developing ICT (hardware and applications). However, the proposed system will provide optimal organisational value for emergency management only if

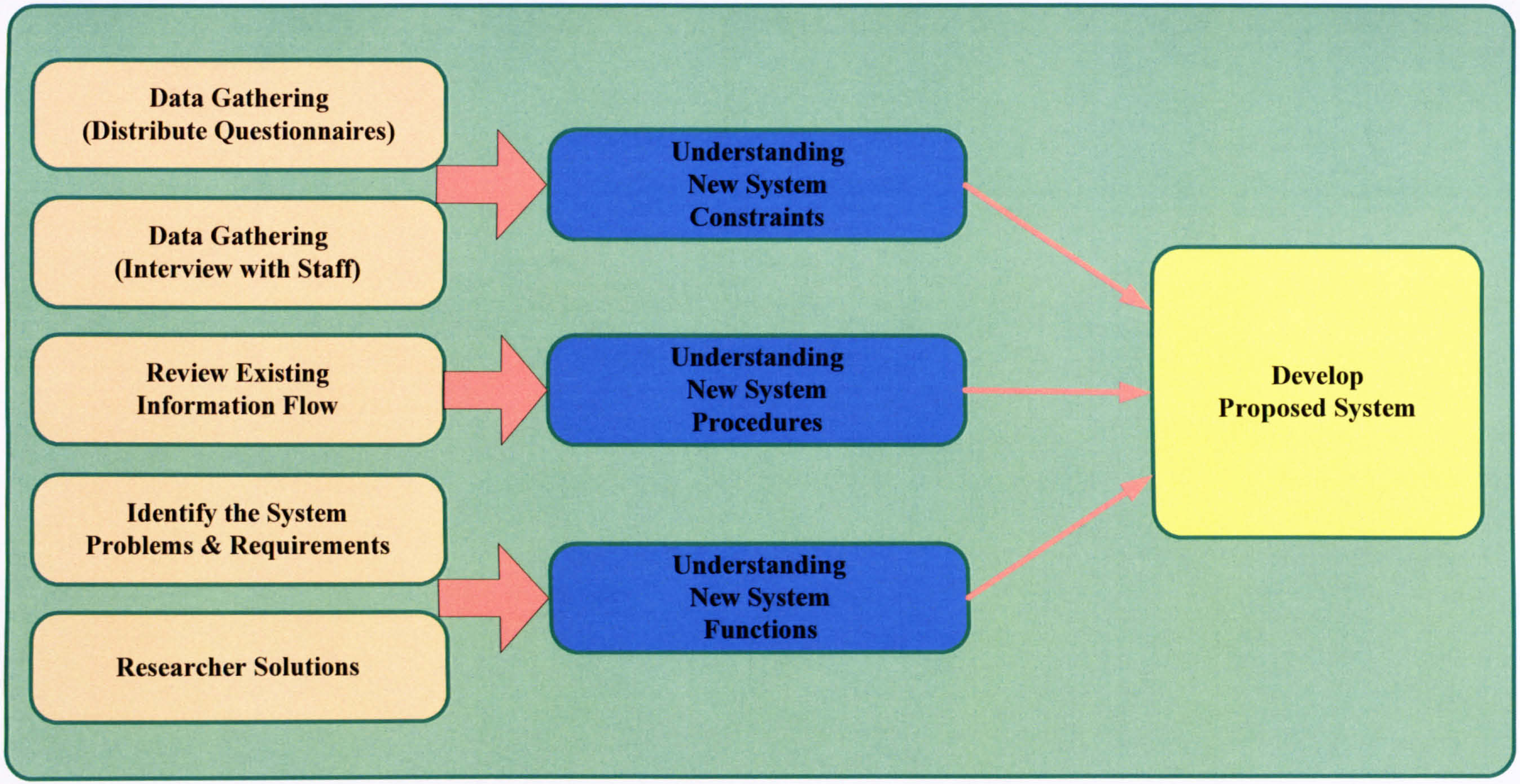


Figure 10.2 Sequences of Model Building

the two sectors support a system model and encourage its implementation in the real world.

The main achievement of SDLC (Stage Three) was the design of the Industrial Incidents Administration System (IIAS), and its successful implementation as a prototype in SDLC (Stage Four). IIAS is a paperless, user-centred, secure method for information exchange able to keep information between the Civil Defence and Industrial Sector in Saudi Arabia up-to-date using electronic sources. The system model consists of online data exchange through the use of the Information Bus; a local database which contains five sub-systems; and the GIS application. Interoperability was an important feature of the proposed system.

The method of prototyping involves developing small sections of the whole system and then demonstrating it to its potential users for evaluation and comment. The main benefit of this method of design is that the users have direct involvement in the design process, thus ensuring that the system fulfils their requirements. It also helps to overcome many of the issues that were mentioned by the respondents.

10.5 Appropriateness of the Adopted Model Design

The conceptual model used in this research for linking the Civil Defence and the Industrial Sector to exchange information electronically, provided a useful framework through which a number of related elements were analysed and discussed. The model design was adopted in order to fulfil the aims and objectives of the research. A number of techniques and approaches were used in achieving these objectives. These included quantitative and qualitative techniques of data analysis, a hard systems approach, and model system design. These were found to be adequate in designing the proposed system. The conceptual model of this study is presented in Figure 10.3.

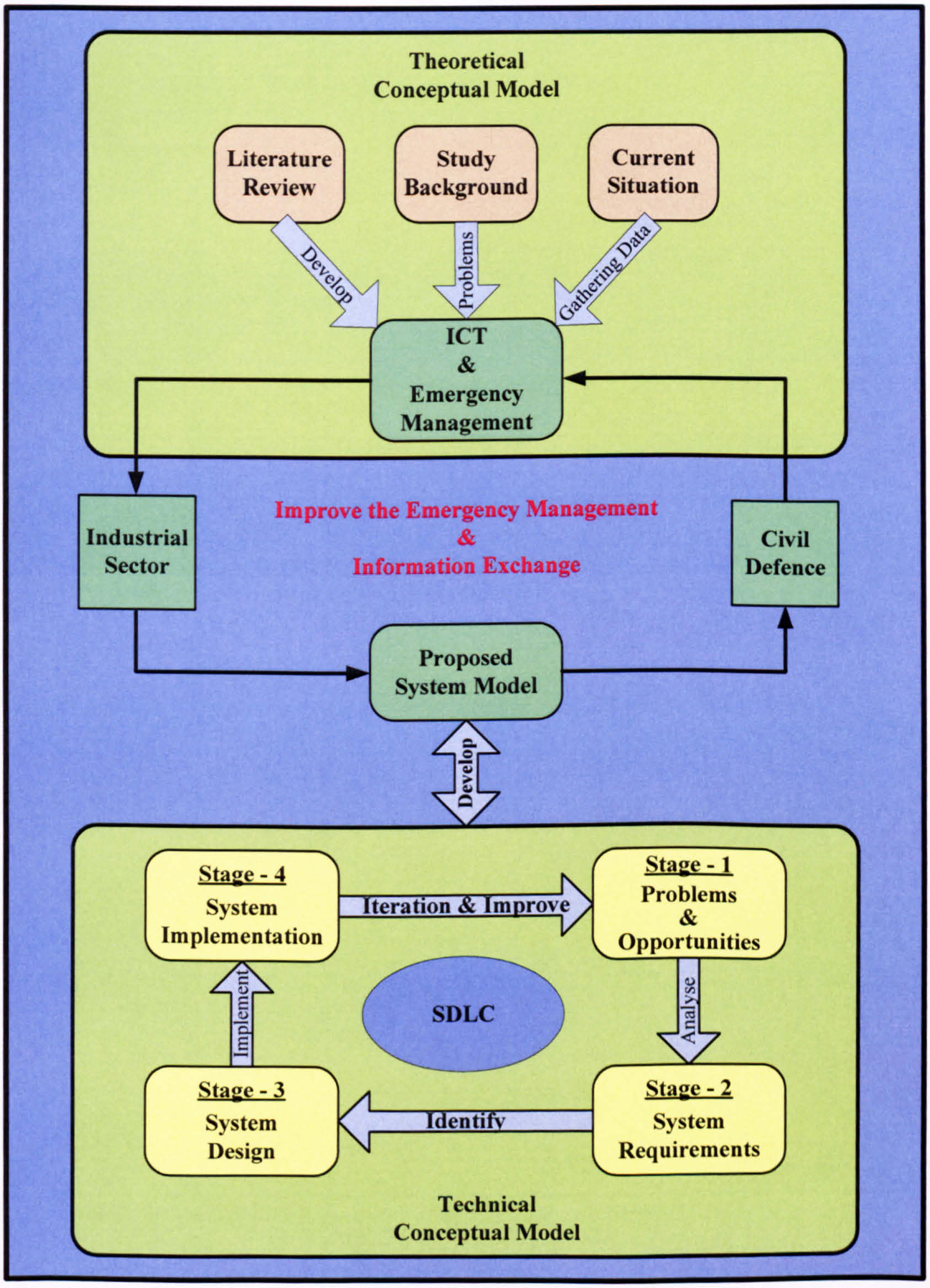


Figure 10.3 Conceptual model of this study

There are various categories or types of problem noted in the literature. This research is aimed at exploring a well-structured problem situation with well-defined problems and clear requirements. As found in the literature, the appropriate methodologies for these situations include methodologies based on the traditional Systems Development Life Cycle (SDLC), frequently referred to as the waterfall model.

Accurate and timely information is necessary for fire brigades' response, preparedness, recovery and mitigation. Industrial fire brigades need data from factories, such as the types of hazardous material, their quantities and places of storage. It is hoped that the proposed model will help emergency management by coordinating information from a variety of databases and making this information available to the CDCC. It can then provide detailed information to other emergency services or decision-makers when needed.

The model's vision is to produce the right information in the right format, for the right person, in time to make the right decision, while the model's mission is to harness information technology to deal effectively with industrial disasters, to save lives and reduce damage to property and the environment resulting from industrial accidents.

The model can be expected to contribute to improving and developing the information exchange system between the Civil Defence and Industrial Sector, thus enhancing the provision of information for the benefit of fire-fighters when dealing with emergencies.

10.6 Contribution to the Knowledge

This study provides the first information system for control of industrial accidents in Saudi Arabia and throughout the GCC region. It draws upon similar studies applied to disaster management in parts of the developed world. The choice of the SDLC model allowed not only an understanding of the issues, but also led to the provision of a proposed system to improve the current situation. The information gathered during the fieldwork was represented in stage one of the SDLC, which identified the problems and opportunities of a proposed information system. Some issues that emerged from this part of the study included a perceived lack of ICT use by the emergency services, a lack of current data about hazardous materials together with no procedures for updating the 'hazards' database, and the lack of co-operation and co-ordination between the Industrial and Civil Defence sectors was identified. SDLC stage two defined the principal requirements for the proposed system (see Chapter 7 for further details). The conceptual model produced for this study (see Figure 8.1, p. 186) helped to identify the activities of the proposed system model and in which sequence they should occur. Outputs from SDLC stage three provided the design for the proposed system model - the IIAS. This system comprises three sub-models (see Figure 9.7, p. 237): web interface, databases, and GIS spatial data. The IIAS provides information that has the potential to yield an impact on the management and control of industrial accidents. The information provided is evidence-based to improve the utility of the developed system and delivers a solution required to satisfy the fourth objective of this study.

The implementation stage (SDLC stage four) provided the procedures to procure a system prototype and its evaluation. Two evaluation techniques were used for this study to achieve sufficient scope to evaluate the whole system. The heuristic evaluation technique captured Web interface issues and identified the problem themes. The Cognitive Walkthrough technique was used to identify problems that the user may encounter along the information-seeking path.

10.7 Research Limitations

There are several important limitations of this research that are related to the conceptual framework, the system design and the design process. First, even though a great deal of effort was made to avoid constraints and conflicting concepts, there is no ideal model for all situations and this framework and design should not be considered as perfect. It is very important for the reader to understand that this model and design were conceptualised and designed from a single idealised vision. This research project should not be the end of the process. It should be used as a starting point or framework for the design of a more advanced system.

Second, this framework and the design of this model cannot be fully evaluated until it is implemented in the real world. Moreover, a significant amount of work would be needed to improve on the design and continual effort would be needed to keep it current with the latest advances in the sciences and technology.

The next chapter gives, in detail, the conclusions and recommendations of this research.

11.1 Introduction

This chapter links the study's aim and objectives with the major findings as a conclusion for this study. As a final point a number of recommendations are presented based on empirical findings. Some suggestions are given for possible future research in this area.

11.2 Conclusions

This study is a descriptive and empirical study of design and implements an information management system that links the Civil Defence and Industrial Sector in Saudi Arabia in order to control industrial accidents through the aims and objectives of this study.

In order to test these objectives, the study employed two complementary assessment tools: the first is a staff survey to test the degree of satisfaction with the services and availability of ICT. The second is an interview questionnaire designed for senior management of each sector. With regard to the survey, 900 questionnaires were distributed to the two sectors. The questionnaire concentrated on the availability of ICT services in each sector and attitude of staff towards using ICT.

Face-to-face interviews were conducted with senior management personnel of the two sectors as well those at KACST and STC. These interviews covered major issues such as ICT services in each sector, the role of ICT in emergencies, and the availability of an information network. The two investigative tools represent a comprehensive package that examines the main issues of this study.

The findings support the existing literature. The significance of this study in contrast with other systems in the literature is the context and implementation of IIAS. It is designed to be applicable within the current context of ICT in Saudi Arabia. However, the system will help decision makers in both sectors to recognise the importance of careful preparation of ICT in disaster management and the work environment in order to promote a successful accident control.

From the study undertaken, the following major conclusions have been reached:

- The use of computers by Industrial Fire Brigades in the Civil Defence organisation in Saudi Arabia is relatively weak when compared with their use by factory staff, in spite of the fact that some Civil Defence departments have already achieved a considerable level of adoption and utilisation of computers and related technology.

- The current use of computers and the positive attitudes of staff in both sectors towards ICT positively correlate with future plans to adopt computer technology. So, further expansion of computer usage can be anticipated.

- There is positive interest in the two sectors towards the use of computers and computer networks in their daily work and for retrieving information. Therefore, the use of ICT in the two sectors is widely anticipated in the near future.

- The two sectors, but especially the Civil Defence sector, suffer from a lack of personnel with sufficient ICT knowledge, experience, management support, and skills to manage and use computers efficiently.

- A lack of ICT training programmes and a lack of management support were the major problems facing the use of computers. It is evident that ICT problems are technical, behavioural and structural.

- The study found that designing an information network to link the Civil Defence and Industrial Sector in Saudi Arabia to facilitate the exchange of information to control industrial accidents is considered to be important in improving the current situation.

- There was lack of co-operation and co-ordination between these two sectors in exchanging information. This is because the current system is still manual-based. This lack has caused shortcomings in the provision, for industrial fire-fighters, of correct and updated information regarding hazardous materials. Furthermore, this has also led to negative effects on the role played by the Civil Defence in dealing with industrial disasters.

To sum up, it can be argued that the Civil Defence organisation has shown that some thought has been given to the benefits of designing an information network to link together all the factories, as well as other emergency services. The interviews showed that the control of industrial accidents is one of the most important targets for the two sectors, so they will support the invention of any technology that will help in the mitigation of all types of hazard. The future is expected to be more promising as experience will enhance the capability of these two sectors to improve their performance.

11.3 Recommendations

There are a number of considerations which could be made to the IIAS to increase its usefulness and applicability. These considerations are suggested to enable the IIAS to improve its goals:

- There should be management support to expand the ICT infrastructure in order to develop and increase the use of computers and to change the current system to a computer-based one.

- To implement the IIAS effectively, the Ministry of the Interior and policy makers within the Civil Defence organisation should demand a rigorous examination of the efficacy, worth and impact of the system and then create policies which demand that the Industrial Sector interacts with IIAS.

- The two sectors should be more careful and precise in their choice of ICT training courses in order to develop the skills of their staff.

- Spatial data for Saudi Arabia are not complete so the responsible authority should complete the digital data for Saudi Arabia so that the Kingdom has the ability to benefit from advanced technologies.

- Since so much of the acceptance and success of systems in organisations is determined by the organisation's culture and managerial support, studies that look at factors that influence the acceptance and use of systems would be an important contribution to this field. Case studies and qualitative research that investigate the implications for leadership and organisational policy would be particularly useful in this area.

- The effectiveness and impact of the system should be subject to empirical testing on multiple real accident scenarios. Some of the criteria that should be tested are: exchange of information, availability of information, correct information, usefulness of the system for decision-makers, user acceptance, usability issues, the impact of the system on dealing with accidents, and the positive and negative impacts of the system on users as a whole. The evaluation of the impact of the system should be based on the viewpoint of the Civil Defence organisation, as well as the Industrial Sector and other emergency services.

This study concentrated on the Saudi Civil Defence and Industrial Sectors, the recommendations mentioned above may not be generalised to public sector organisation. Therefore, this is an area that is worth future investigation and is added to the present study as an integral disaster management system.

11.4 Future Studies

This study has concentrated on one aspect of information exchange in terms of the control of industrial accidents. Based on the findings of this study, a number of areas need further research. These are as follows:

- There is a need to carry out a study to test the efficacy of IIAS in the control of industrial accidents and to compare this with manual-based systems.
- Another possible direct link to future work with this system model is the application of a more user-friendly environment to build an actual decision-support system for disaster situations in action. In the initial stage of development, this work would need the close co-operation of the Civil Defence and Industrial Sector in using an IIAS.
- New requirements are necessary for the development of the IIAS to use more automated and sophisticated tools for warning systems of industrial disasters.
- Further work is needed to investigate the different ways of classifying and modelling emergency situations.
- The IIAS model offers new approaches to providing consistent, role-based accident control. These roles will help users to achieve their goal of controlling accidents in the most efficient way. Obligatory policies are necessary in this context in order to ensure the integrity of the system.
- There is a need to implement a digital environment, as envisaged by this research. The implementation of a digital model in a regional, decentralised manner through co-operation between the Civil Defence and an organisation already duplicating the maintenance of the cadastral map allows for a number of integration and map assembly issues to be tested. Critically, this must be an implementation that uses the model of this research to take full advantage of the digital environment and to reengineer the business processes of industrial accidents control.

- This research has modelled only a component of industrial accidents control. There is also a need to use the IIAS framework to develop a coherent approach to modelling public zones.
- In a system such as IIAS, it is vital that information be maintained and be continually up-to-date. It is therefore important that all the stakeholders, including the Industrial Sector, accept the system and interact with it as required. So much of the acceptance and success of the IIAS in organisations is determined by the organisational culture and managerial support, studies that look at factors that influence the acceptance and use of the system would be an important contribution to the field. Case studies and qualitative research that investigate the human issues and organisational policies are needed and would be particularly useful in this area. One way to investigate the human issues is to investigate the IIAS by a soft systems intervention – principally by the use of Checkland's Soft Systems Methodology (Checklan, 1999). Here, change is attributable to minimising the differences between the systems as it exists in the 'real world' (via a Rich Picture) and the system as it appears in the 'model world' (via a Conceptual Model). Such changes incorporate human issues such as motivation and communication across organisational boundaries.

To conclude, IIAS represents a first attempt to model a system model for disaster management in Saudi Arabia. The results provide support for the more recent publications that argue that disaster management is a complex process, comprising many facets and interactions between these facets. Although the system already performs updated information about hazardous materials, it provides recent information for the decision makers. Particular aspects of the system can therefore be further elaborated in future research.

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Appendix - 1

Formal letter for requesting permission to circulate questionnaires

Dear Sir,

I am a PhD student in Information Science Department at Loughborough University - UK. The work involves a design of an information network between Civil Defence and Industrial Sector in terms of industrial incidents control. It is hoped that the result of the study will help researcher to design and implement better electronic information system that will enable both sectors to exchange information, knowledge, and expertise for better industrial incidents control.

Ministry of industrial and Electricity is responsible about the Industrial Cities in Saudi Arabia, and because of that, I would be most grateful for the opportunity to approach you with a request for requesting permission and help to circulate the attachment questionnaires to the intended factories.

I assure you that any information that may provide would certainly be confidential and used only for this research project.

Finally, I would be appreciating for your co-operation.

Yours Sincerely,

Yahya Al-Gahtani

Appendix - 2

Questionnaire in English

Dear participant,

This attached questionnaire is designed to collect some information relating to you and your current job. This present study is being conducted to design an information network between Civil Defence and Industrial Sector to dealing with industrial disasters. Also this study will investigate the attitude of end-users for using the computer in their daily work.

I believe that your participation is very important, because it will help to explore to what extent the information network are used. The study results will help the researcher to design an information network needed to exchange information and expert people as well as develop the services provision.

I would like to assure you that all your information you provide would be confidential and used only for this research project. Therefore, please answer all the questions in the accompanying questionnaire and return it to the head of your department.

Yours sincerely

Yahya S. Al-Gahtani
E-mail: y.s.al-gahtani@lboro.co.uk
Information Science Dept.,
Loughborough University,
UK.

Part One: Personal details

1- Place of work:	2- Job description:
☐ Civil Defence ☐ Factory	______________________
3- Nationality: ☐ Saudi ☐ Non-Saudi	**4- Educational qualifications:** ☐Under Secondary degree ☐Secondary degree ☐Undergraduate degree ☐ Postgraduate degree Other, please specify: ______________
5- Age: ( ) year	**6- Number of years in your current job: ( ) year**

☐

Part Two: Computer Background & use of information

7- What is your computer background level? Please tick (✓) the appropriate box.

no experience	little experience									High experience
0	1	2	3	4	5	6	7	8	9	10

8. Do you currently use a computer in your job?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

9. Do you have the opportunity to use a computer in order to obtain the information?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

10. Do you think it is necessary to use a computer in order to obtain information to complete your duties?

☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always

11. What type of computer do you use in your job? ☐ No computer ☐ Stand-alone ☐ Networked ☐ Both
12. In your job, does there any information network between Civil Defence and Factories? ☐ Yes ☐ No
13. Exchange of information between Civil Defence and Factories are through: ☐ Manually ☐ Using information network
14. Does the organisation you work for have an Internet Web page or does it plans to connect with the Internet within one year? ☐ Yes ☐ No
15. Does your organisation give you support to take computer courses? ☐ Never ☐ Rarely ☐ Occasionally ☐ Often ☐ Always
16. To what extent do you benefit from computer courses? ☐ Never attended ☐ Little benefit ☐ Medium benefit ☐ high benefit <u>(Go Q.18)</u>
17. What are the main reasons for you not getting benefit from computer courses? ☐ Lack of courses program ☐ Not related to my duties ☐ Not my specialisation ☐ Not seen as relevant ☐ Other reasons
18. Have you taken courses that deal with industrial accidents? ☐ Yes ☐ No
19. Have you taken any on-line courses that deal with industrial accidents? ☐ Yes ☐ No
20. If No, why? ☐ Not available ☐ Lack of management support ☐ Not my specialisation ☐ Not seen as relevant ☐ Other reasons
21 If you face a computer problem in your job, what do you do? ☐ Call a specialist ☐ Use your experience

Part Three: Computer Attitude

22. The box below contains some phrases that are related to attitudes in using ICT. Please tick the appropriate box, Please note that: (5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree).

#	User attitudes	5	4	3	2	1
1	Use of computer					
2	Attitude to ICT					
3	Use of new technology					
4	Attitude to replacement of paper-based systems					
5	Attitude to ICT based systems					
6	Attitude to change					
7	Developing job procedures					
8	Attitude to Arabiasation of computer programs					
9	Attitude to existence of information network between Civil Defence and Industrial Sector for accidents response					

23. With regard to your perception of the level of importance of the use of ICT in your job and your own perception of your competence in using ICT. Please tick the appropriate box, Please note that: (5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree).

		Importance						Competence				
#		5	4	3	2	1		5	4	3	2	1
1	Use of computer in your job											
2	Use of computer in risk analysis											
3	Use of computer in emergency planning											
4	Use of computer in controlling accidents											

5	Use of computer in training exercises											
6	Use of computer in safety data exchange											
7	Use of computer to guide fire fighters											
8	Use of computer in safety precaution											
9	Use of computer in daily work											
10	Use of computer in retrieving information											
11	Use of computer to determine risks in job											
12	Computer courses in accident control											
13	Computer courses in risk analysis											
14	Use of Internet											
15	Using new technology in dealing with accidents											
16	Following the Civil Defence safety instructions in industrial sectors											

24. This question for factory staff only.
If you face an accident in your organisation, what do you do? You can tick more than one.

☐	Call Civil Defence
☐	We already have an emergency plan to control accidents
☐	We have computer technology to deal with accidents
☐	We have a safety department and have the ability to control accidents
☐	We have an emergency team to control the accidents
☐	Other, please specify: -- -- --

If you have any comments you wish to make, please write them in the space below:

Thank you

Appendix - 3

Questionnaire in Arabic

القسم الأول : البيانات الشخصية

1- مكان العمل: ☐ الدفاع المدني ☐ القطاع الصناعي	**2- مسمى الوظيفة الحالية:** ________________
3- الجنسية: ☐ سعودي ☐ غير سعودي	**4- المستوى التعليمي:** ☐ أقل من ثانوي ☐ ثـانـوي ☐ بكالوريس ☐ دراسات عليا ☐ أخرى (حدد): ________________
5- العمر: ( ) سنه	**6- مدة الخدمة في العمل الحالي:** ( ) سنه

القسم الثاني: الخبرة في إستخدام الحاسب الآلي

7- مستوى الخبرة في إستخدام الحاسب الآلي:

الرجاء وضع علامة (✓) أمام الرقم المناسب لتقييم مستوى خبرتك، حيث ان **الصفر** يعني عدم وجود خبرة ثم يرتفع المقياس الى ان يصل الى رقم **عشرة** والذي يعني خبرة كبيرة جداً في إستخدام الحاسب وتطبيقاته دون مساعده من الآخرين.

خبرة معدومة	خبرة قليلة									خبرة كبيرة
0	1	2	3	4	5	6	7	8	9	10

8- عدد سنوات الخبرة في مجال الحاسب الآلي وتقنية المعلومات: ( ) سنه

9- هل تستخدم الكمبيوتر كمتطلب لآداء عملك؟

☐ لا أستخدمه أبداً ☐ نادراً أستخدمه ☐ أحياناً أستخدمه ☐ غالباً أستخدمه ☐ دائماً أستخدمه

10- هل لديك فرصة لإستخدام الحاسب الآلي في العمل؟

☐ لا توجد أي فرصة ☐ نادراً ☐ أحياناً ☐ غالباً ☐ دائماً

11- هل ترى ضرورة إستخدام الحاسب الآلي في آداء عملك؟

☐ ليس ضرورياً ☐ نادراً ضروري ☐ أحياناً ضروري ☐ غالباً ضروري ☐ دائماً ضروري

12- ما نوع الكمبيوتر المستخدم في عملك؟

☐ لا يوجد ☐ حاسب آلي شخصي ☐ حاسبات متصلة بشبكة ☐ حاسبات شخصية ومتصلة بشبكة

13- هل لدى جهة عملك موقع أو إتصال بشبكة الانترنت حالياً أو هناك نية مؤكدة للإتصال بها خلال سنه؟

☐ نعم ☐ لا

14- عدد دورات الحاسب الآلي التي حصلت عليها من خلال عملك: ( ) دورة

15- هل يشجع عملك على الإلتحاق بدورات الحاسب الآلي؟

☐ لا يشجع أبداً ☐ نادراً يشجع ☐ أحياناً يشجع ☐ غالباً يشجع ☐ دائماً يشجع

16- ما مدى الاستفادة من دورات الحاسب الآلي التي التحقت بها؟

☐ لم ألتحق بأي دورة ☐ إستفادة قليلة ☐ إستفادة متوسطة ☐ إستفادة كبيرة (إذهب لسؤال 18)

17- ماهو السبب الرئيسي لعدم إلتحاقك أو لعدم إستفادتك من دورات الحاسب الآلي؟

☐ ضعف برنامج الدورات ☐ ليس لها علاقة بمهام عملي

☐ ليست في مجال إختصاصي ☐ عدم إهتمام مني شخصياً ☐ أسباب أخرى

18- هل اخذت دورات في كيفية التعامل مع الحوادث الصناعية؟

☐ نعم ☐ لا

19- هل اخذت دورات في الحاسب الآلي كوسيلة للإتصال والتنسيق والتحكم عند وقوع الحوادث الصناعية؟

☐ نعم (إذهب لسؤال 21) ☐ لا

20- ما هو السبب في عدم إلتحاقك بمثل هذه الدورات؟

☐ غير متوفرة ☐ عدم دعم الإدارة لمثل هذه الدورات

☐ ليست من إختصاصي ☐ عدم إهتمام مني شخصياً ☐ أسباب أخرى

21- اذا واجهتك مشكلة في الحاسب الآلي ماذا تعمل؟

أستعين بالمختصين ☐ أرجع للدليل الارشادي ☐

أستخدم خبرتي في حل هذه المشكلة ☐ الرجوع للشركات المؤمنة لهذه الأجهزة ☐

القسم الثالث: الرغبة في إستخدام الحاسب الآلي

22- الجدول التالي يحتوي على مجموعة عبارات تتعلق بالرغبة في إستخدام الحاسب الآلي. الرجاء ضع علامة (✓) أمام العبارة التي تناسب وجهة نظرك.

م	الــوصـــــــــــف	أوافق تماماً	أوافق	محايد	لا أوافق	لا أوافق إطلاقاً
1	لأجل الإستفادة من إمكانيات الحاسب الآلي					
2	لأجل الإستفادة من تقنية أنظمة المعلومات					
3	لأجل مواكبة التطور المعلوماتي					
4	لأجل التخلص من الأنظمة التقليدية					
5	لأجل إستخدام الأنظمة الإلكترونية المعتمدة على الحاسب الآلي					
6	لأجل تطوير أعمال المنشأة بإستخدام تكنولوجيا المعلومات					
7	لأجل تطوير إجراءات العمل					
8	لأجل الإستفادة من تطبيقات الحاسب الآلي الموجودة باللغة العربية					
9	لأجل إيجاد شبكة معلومات تربط الدفاع المدني بالمصانع لمواجهة الحوادث الصناعية					

23- مجموعة عبارات تتعلق بأهمية إستخدام الحاسب الآلي في مجال العمل وكذلك مدى توفر هذه التقنية في مجال عملك الحالي. الرجاء ضع علامة (✓) أمام العبارة التي تناسب وجهة نظرك من خلال أهميتها وكذلك مدى توفرها في عملك حالياً.

علماً ان الارقام تعني: (5=أوافق تماماً - 4=أوافق - 3=غير متأكد - 2=لا أوافق - 1=لا أوافق إطلاقاً).

م	الــوصـــــــــــف	الأهمية من وجهة نظرك 5	4	3	2	1		مدى توفرها في عملك الحالي 5	4	3	2	1
1	إستخدام الحاسب الآلي في مجال عملك											
2	إستخدام الحاسب الآلي في تحليل الاخطار الصناعية											
3	إستخدام الحاسب الآلي في التخطيط للطوارئ											
4	إستخدام الحاسب الآلي في السيطرة على الحوادث الصناعية											
5	إستخدام الحاسب الآلي في التعليم والتدريب											
6	إستخدام الحاسب الآلي في تبادل المعلومات											

	المتعلقة بالسلامة الوقائية من الحوادث وطرق مواجهتها											
7	إستخدام الحاسب الآلي في إرشاد وتوجيه رجال الإطفاء											
8	إستخدام الحاسب الآلي في تطوير إجراءات السلامة الوقائية											
9	إستخدام الحاسب الآلي في العمل اليومي											
10	إستخدام الحاسب الآلي في استرجاع المعلومات											
11	إستخدام الحاسب الآلي في تحديد المخاطر في المنشأة											
12	إستخدام الحاسب الآلي في إعداد البرامج التدريبية عن كيفية التعامل مع الحوادث الصناعية											
13	إستخدام الحاسب الآلي في اعداد البرامج التدريبية على كيفية تحليل مخاطر المنشآت الصناعية											
14	إستخدام الحاسب الآلي في الدخول على شبكة الانترنت											
15	إستخدام أحدث التقنيات عند التعامل مع الحوادث الصناعية											
16	إتباع تعليمات الدفاع المدني في المنشآت الصناعية											

24 - **سؤال خاص بالعاملين في المنشآت الصناعية:**

إذا وقع حادث صناعي في المنشأة التي تعمل بها، ماذا تعملون لمواجهة هذا الحادث؟ يمكنك أختيار أكثر من إجابة.

☐	الاستعانه بالدفاع المدني
☐	لدينا خطة طوارئ جاهزة للسيطرة على أي حادث صناعي
☐	نتعامل مع الحوادث الصناعية بإستخدام تقنية الحاسب الآلي
☐	يباشر ذلك قسم السلامة في المصنع
☐	لدينا فريق طوارئ مؤهل يستطيع التعامل مع الحوادث الصناعية
☐	أخرى. من فضلك حدد: __________ __________ __________

إذا لديك أي ملاحظات أو إقتراحات، الرجاء تدوينها في السطور التالية:

شاكراً ومقدراً حسن تعاونكم

Appendix - 4

Interview Questions

Civil Defence & Industrial Sector

a) Current status of ICT services

1. What types of computers are used in command centre?

2. What types of computer applications are used in your work?

3. Does your unit use ICT systems in its functions?

4. In case of an industrial accident, do you use any ICT facilities for reaching and dealing with industrial accidents?

5. Does your unit develop its applications regularly?

b) The role of ICT in emergency situations

6. What is the type of communication with industrial sectors in dealing with accidents?

7. What procedures does your organisation follow when an accident happens?

8. Do you use the ICT in the case of dealing with industrial accidents, (i.e. information network, GIS, automated directorial system?

9. What the difficulties are faced when dealing with industrial accidents, and why?

c) Future plans and expectations for using ICT in dealing with industrial accidents.

10. What are the arrangements between your unit and industrial sectors in the case of an accident?

11. Is there any co-operation and collaboration with Industrial sector in exchange of information and prepare of training programs –especially in case of industrial risks– to increase the workers competence in dealing with industrial accidents.

12. Do you think it is time to develop the communications between your unit and industrial sector to control industrial accident quickly and effectively?

13. How do you evaluate the role that played by fire brigades in dealing with industrial accidents?

14. Does your unit have implementation strategy/guidelines to adopt ICT?

d) Training issues

15. Did your staff have emergency control training involving the use of ICT?

16. Do you have a computer-training plan to develop staff skills and keep them up-to-date with ICT?

e) Current situation of LAN/WAN connections on the computers

17. Do you have any LAN/WAN in your unit, if yes what for?

18. Is it possible to use this network to communicate with industrial sector?

19. What are the main problems that your organisation faces when it implements ICT systems?

The ICT professional in the King Abdulaziz City for Science and Technology (KACST)

1. What kind of services does KACST provide for control of emergency?
2. What kind of assistance does KACST help to establish new system?
3. Do you think KACST will support the new system as a part from the national network?
4. From your point of view, what problems will be encountered in establishing the information network?

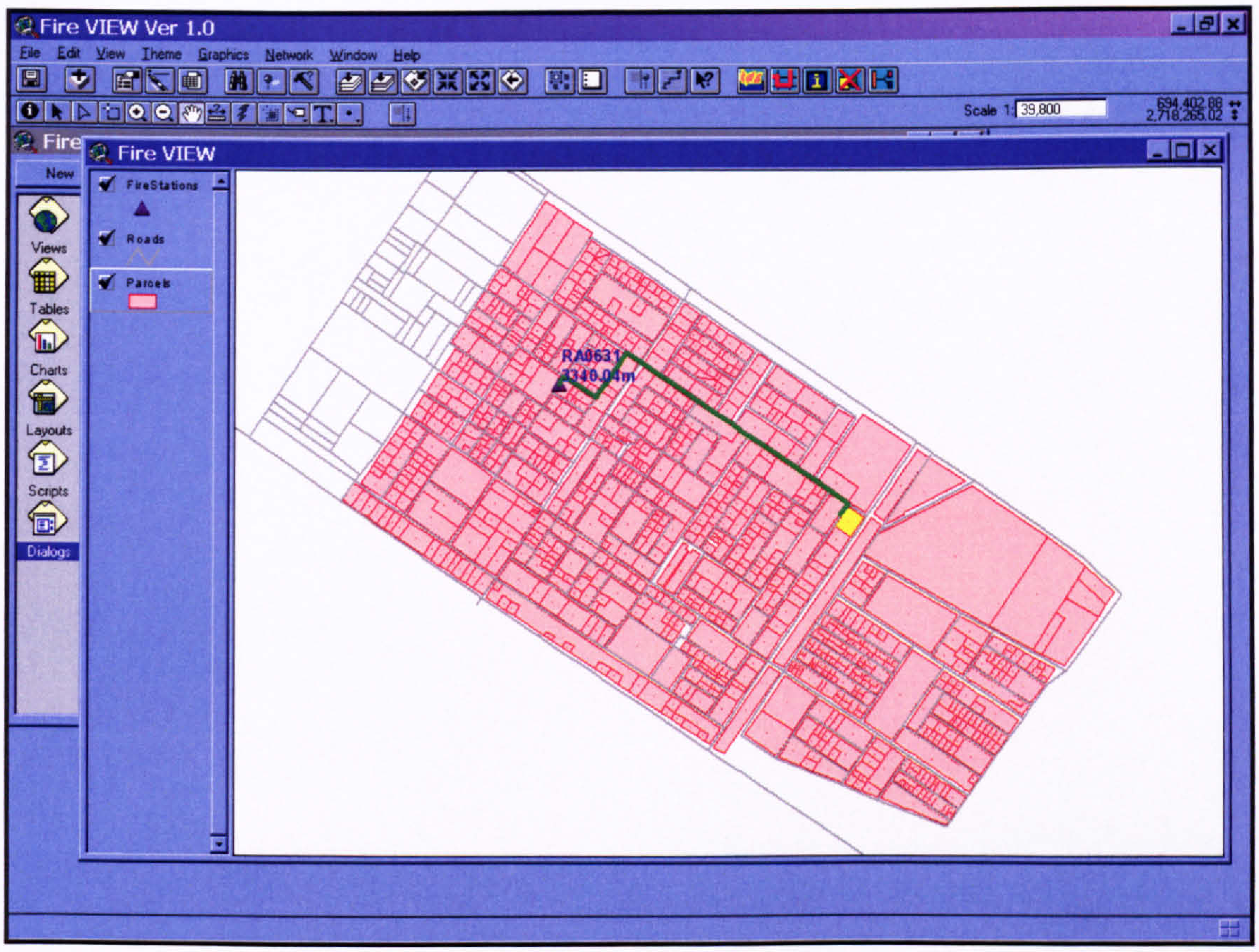
Network service manager at Saudi Telecom Company (STC)

1. What kind of services does STC provide for control of emergency?
2. What kind of assistance does STC help to establish new system?
3. Do you think STC will support the new system as a part from the national network?
4. From your point of view, what problems will be encountered in establish the information network?

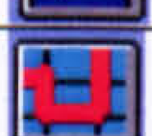
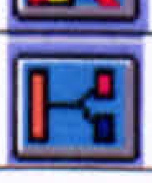
Appendix - 5

GIS Application Documentation

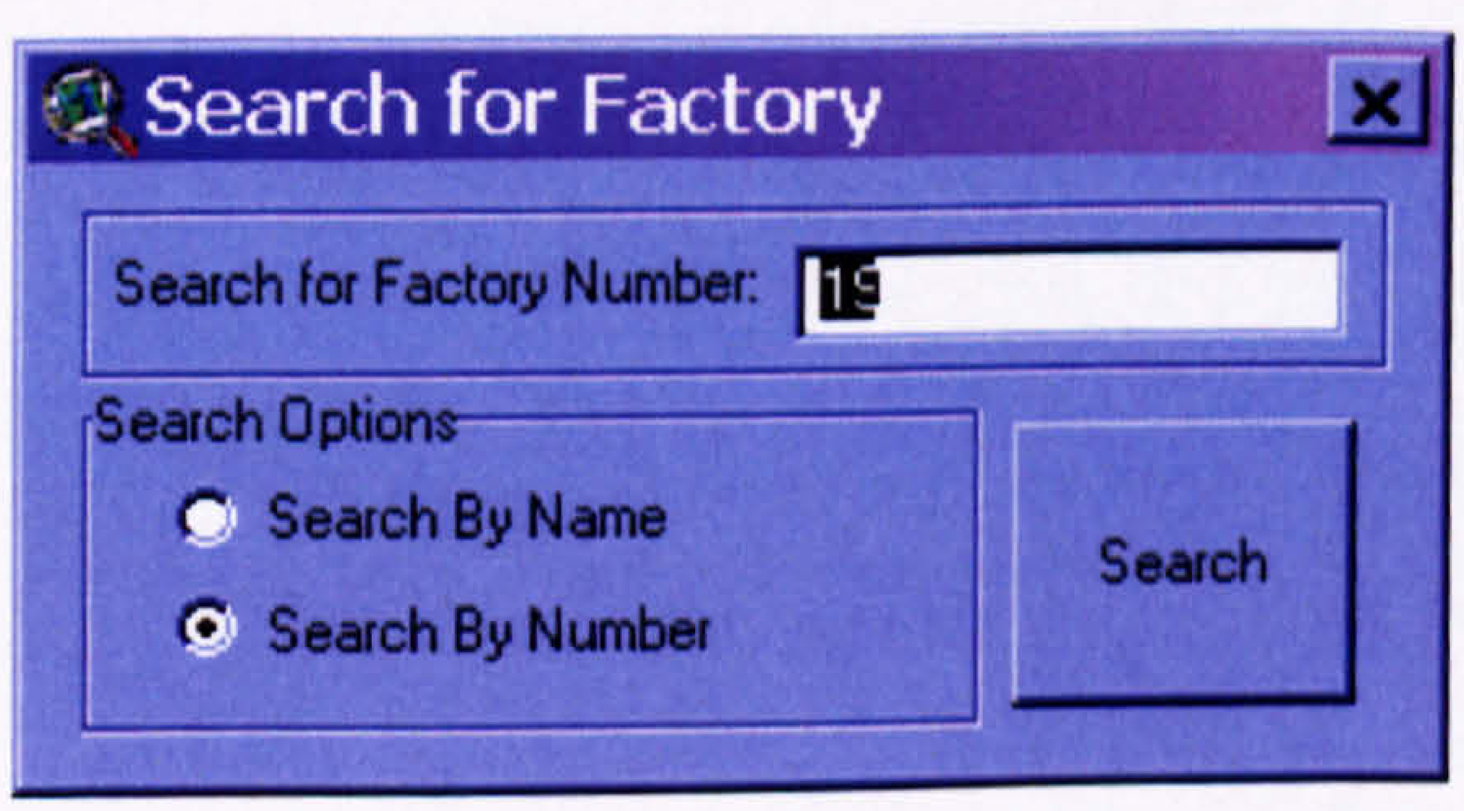
Application Interface



Application Buttons.

Button	Description	Click Script
	Search Factory	FV_SearchFactory_OpenDlg
	Show Directions	FV_ShowDirDlg_Open
	Factory Informations	FV_InformationDlg_Open
	Delete Graphics	FV_DeleteGraphics
	Options	FV_OptionsDlg_Open

Search Factory Button.
Allows the selection of a factory location by entering NAME or ID of the factory. When selection is made, the nearest X number of FIRE STATIONs are showed. Number of nearest fire stations will be based on the number set in "***Number of Stations To Find***" textbox in the "***Options***" dialog box (*see Options Button.*)



The Search Factory dialog box

The sample above shows a search by number (ID) equal to 19.

Search Factory Number. Enter the factory id number to search.

Search Options.

- ***Search By Name.*** Option to search factory by its name.
- ***Search by Number.***Option to search factory by it ID.

Search. **Starts the search process.** Search will automatically show the path of the nearest fire stations. The number of fire stations to find is based on the value set in the Options dialog box.

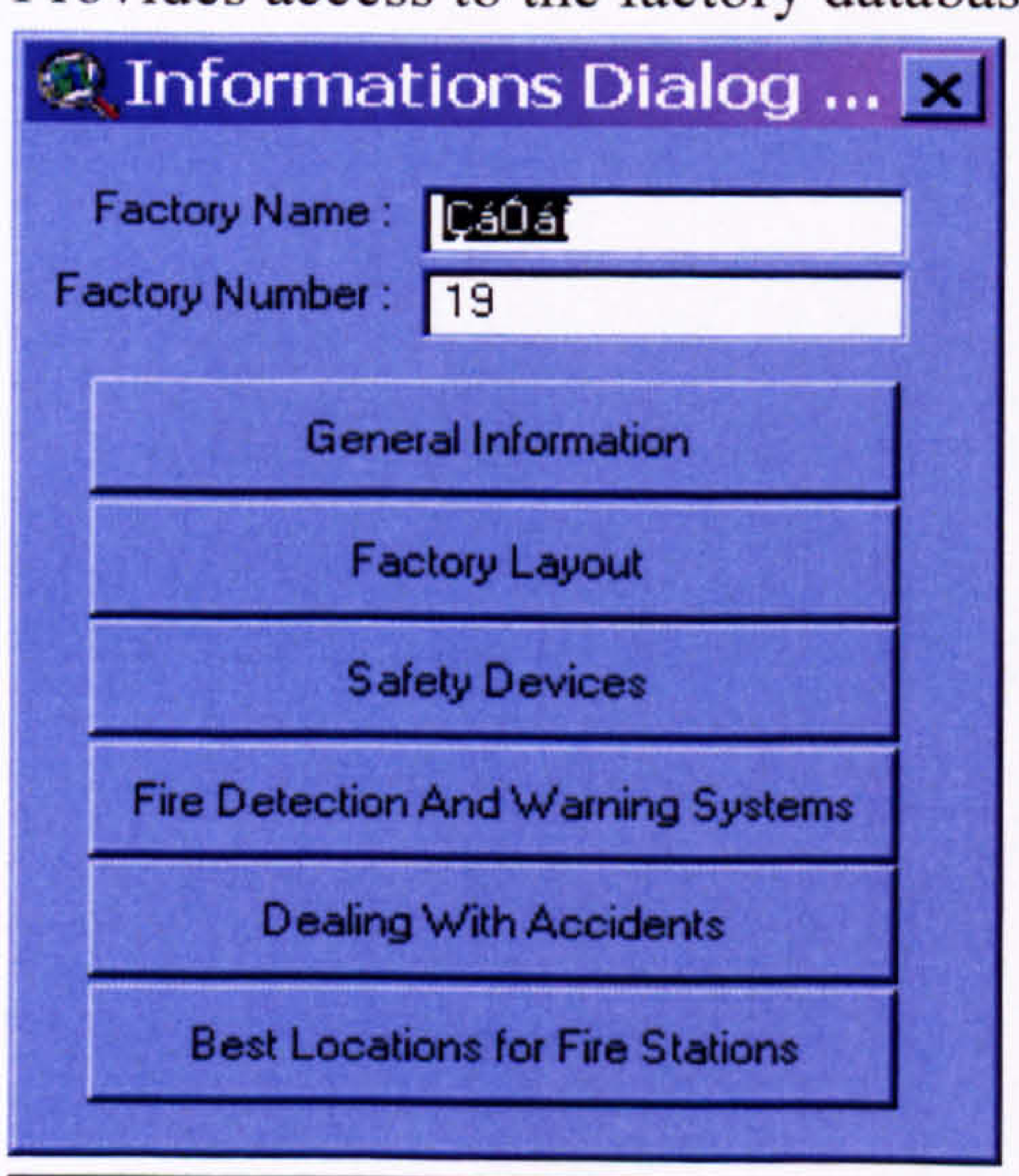
Show Directions Button.
Allows user to view the path and direction of a selected fire station. Also, it provides the user to generate layout of path direction.

The Show Directions dialog box.
Select Station Code. Select Fire Station to get directions.

Directions. Displays the direction from the selected fire station to the selected factory.

Show Layout checkbox. Check or uncheck to display of the map layout.

Factory Informations Button.
Provides access to the factory database. User can view different informations (general, materials, safety devices and fire detection system and warning systems.)



The Information dialog box: Displays different factory-related information.

Factory Name: Displays factory name.

Factory Number: Displays factory ID.

General Information: Displays factory general information such as name, owner's name, etc.

Factory Layout: Displays information on factory layout, and contents such as materials, safety devices, and fire detection and warning system.

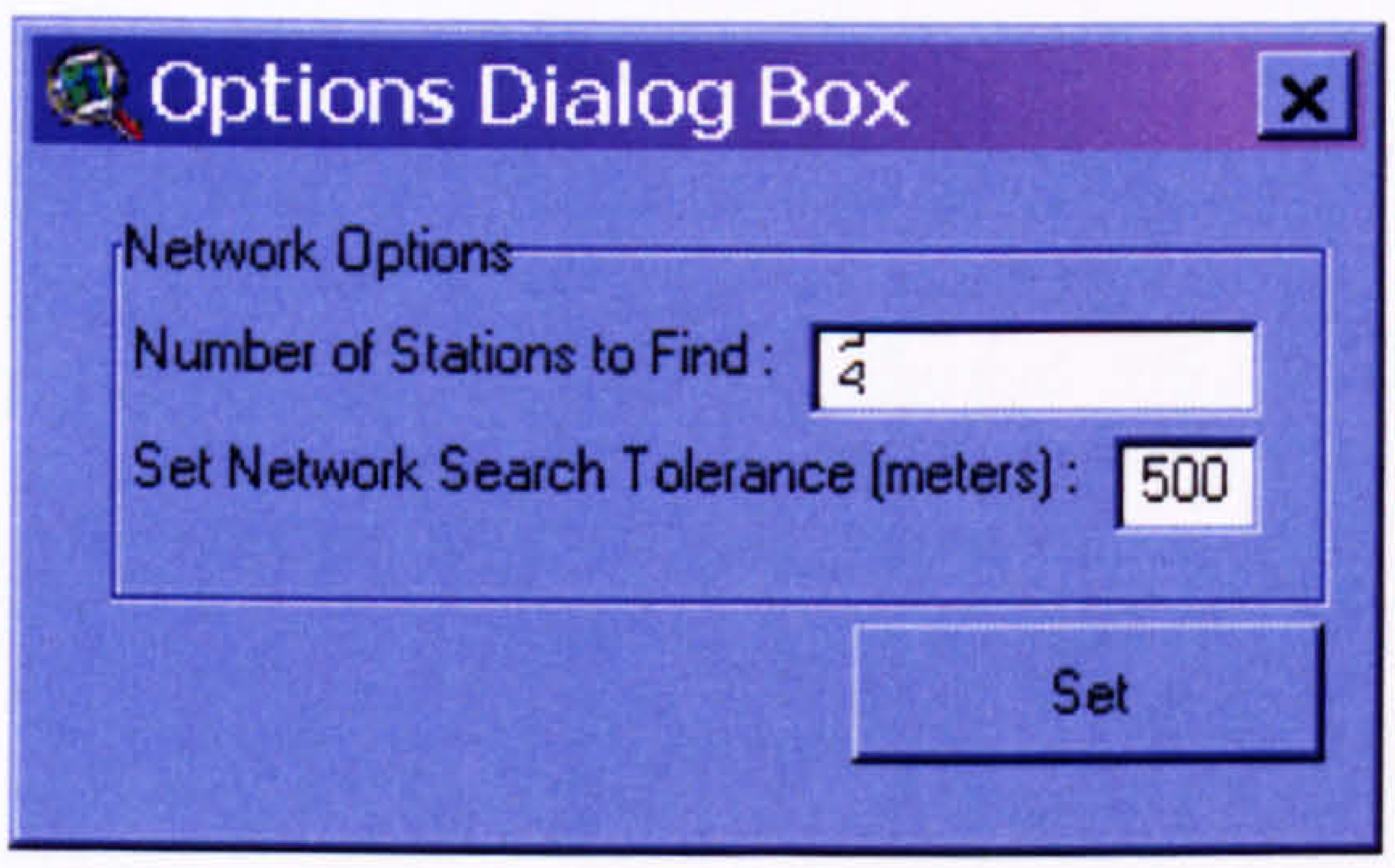
Safety Devices: Displays summary information on availability of safety devices. Fire Detection And Warning System. Displays summary information on availability of fire detection and warning system.

Dealing with Accidents: Displays information on handling accidents

Best Locations for Fire Stations: Notes on possible locations/positions for fire control actions.

Delete Graphics Button: Deletes all graphics generated by the applications from the "Search Factory".

Options Button: Provides the user to set different values as parameters to searching nearest station analysis.



The Options dialog box.

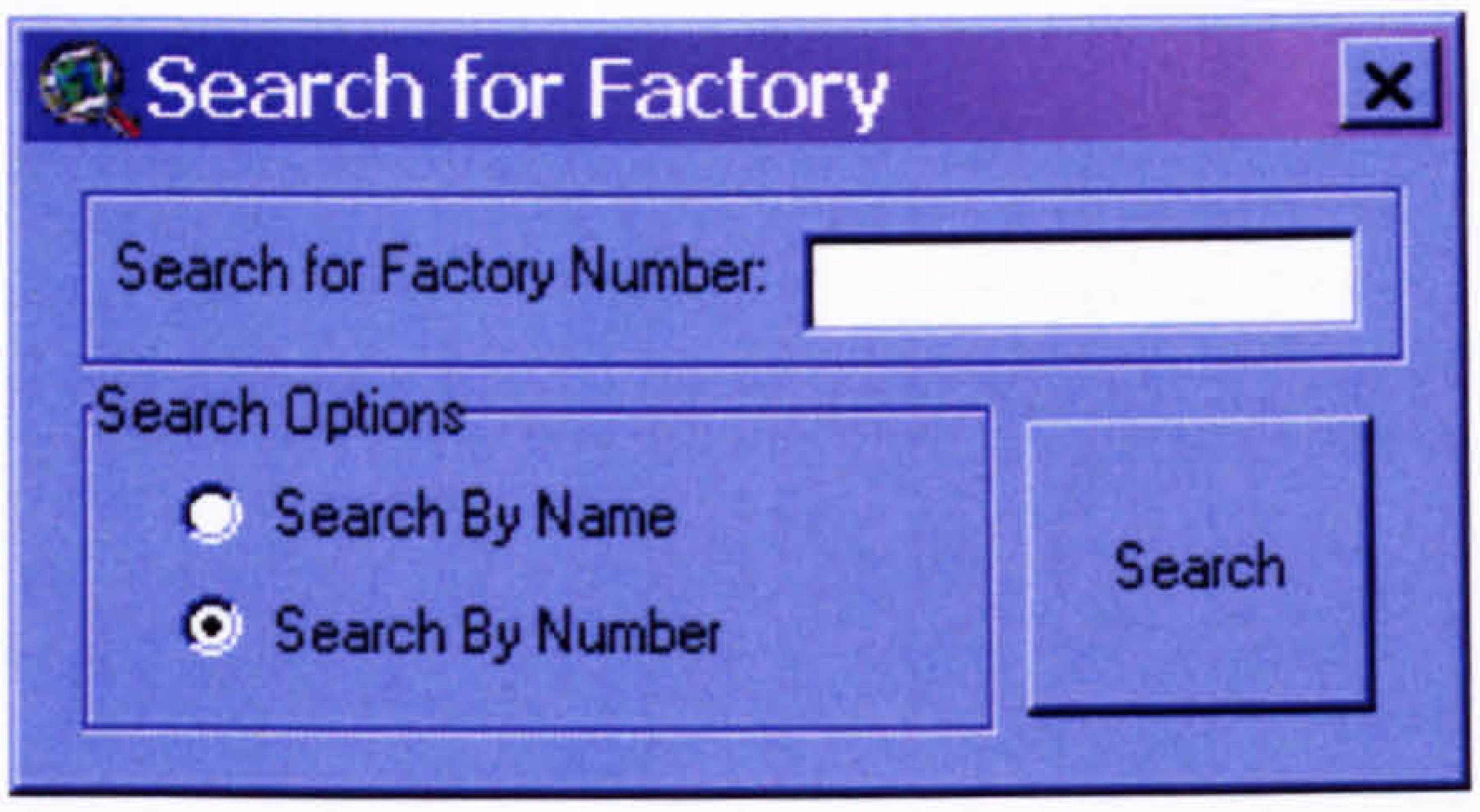
Number of Stations to Find: Allows users to set the number of nearest fire stations to locate.
Set Network Search Tolerance: Allows users to set the tolerance (meters) for network use.

Dialog Box and Scripts Index: <u>Project</u>

Project Property	Script Name	Description
Startup	FV_Startup	Initializes global variables such as home directory, default values for number of fire stations to find and network tolerance.
Shutdown	FV_Shutdown	Deletes temporary blob files created for reading memo fields in relational database.

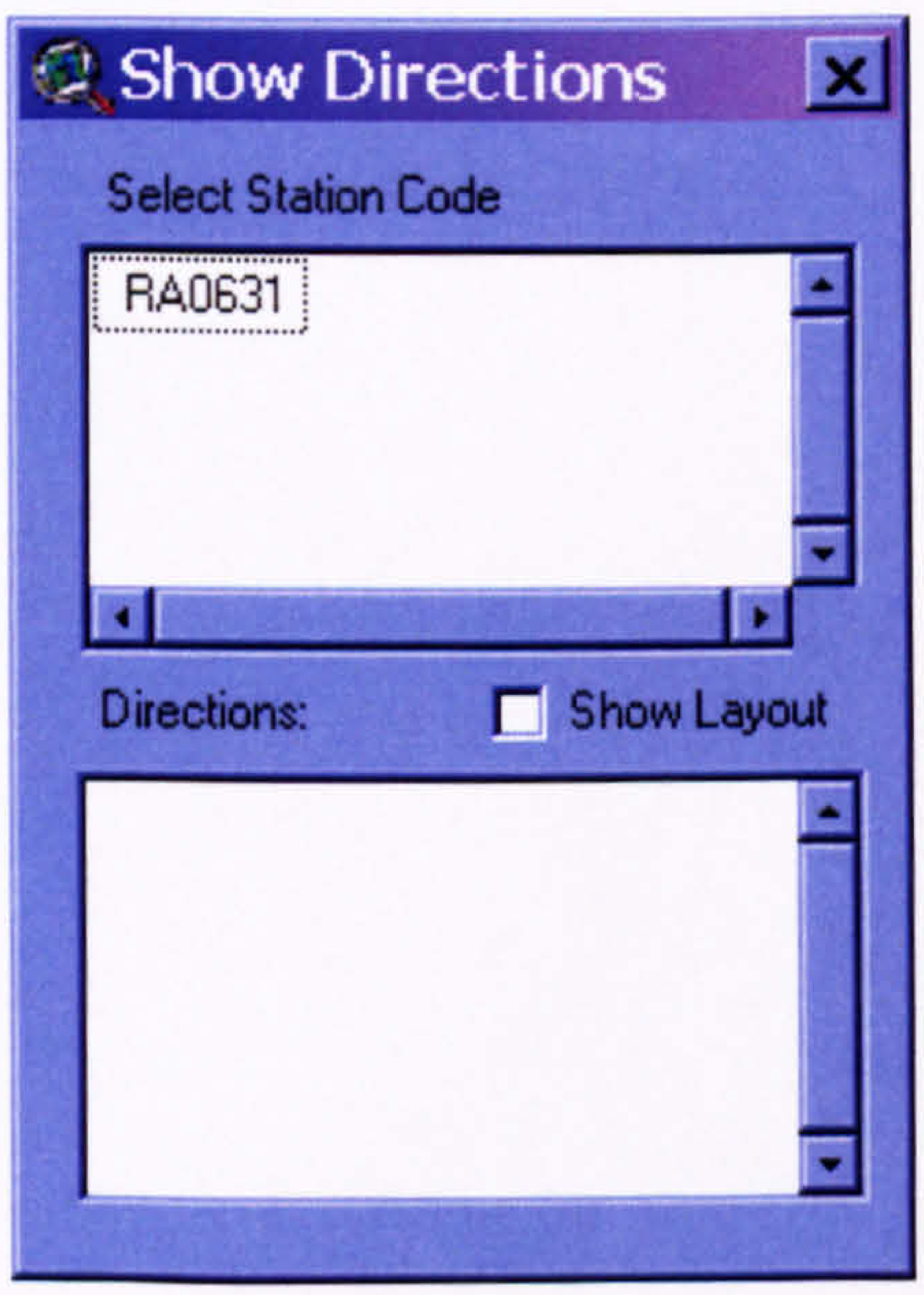
Dialog Boxes.

Search Factory Dialog.



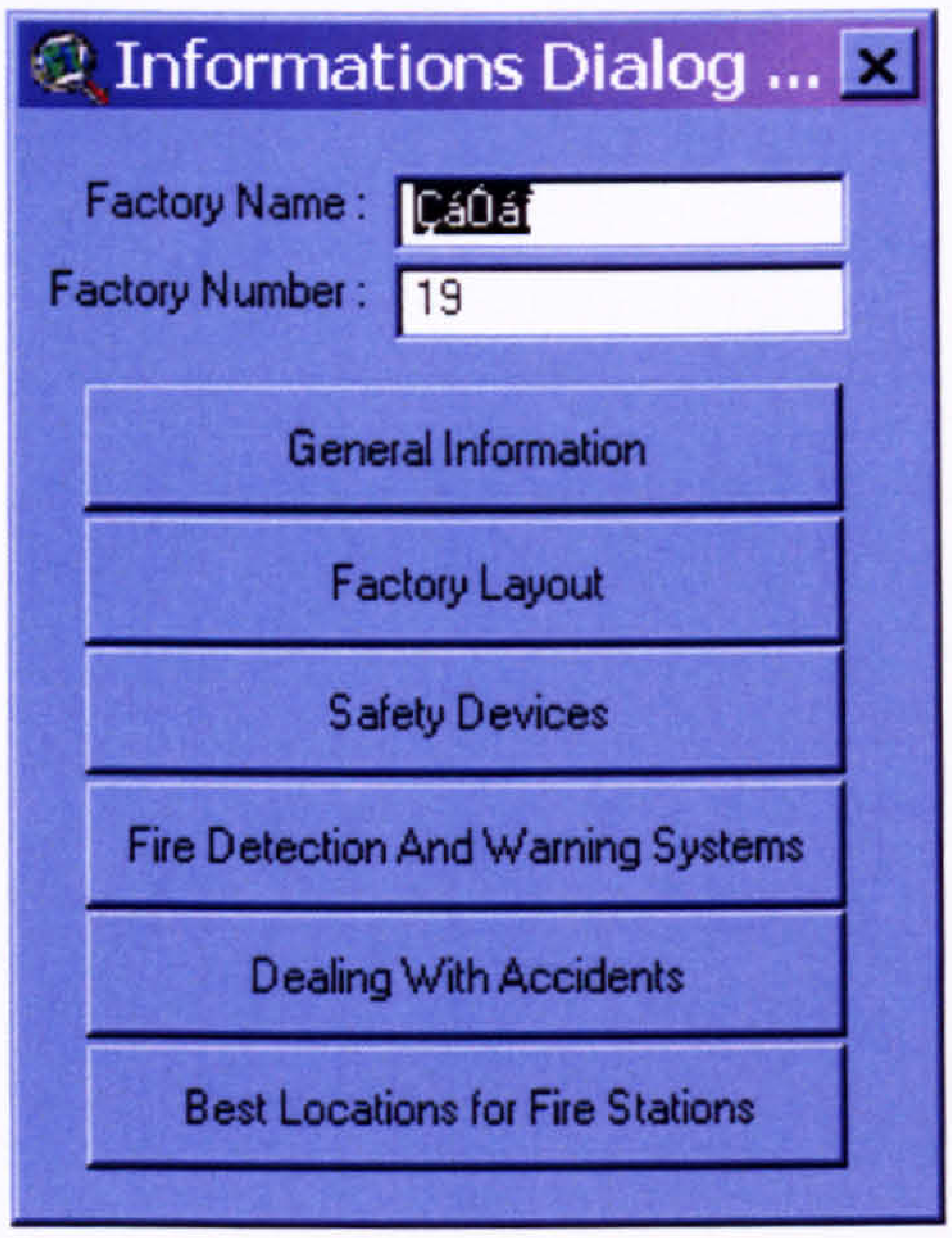
Description	Control Name	Script Name
Search For Factory Number	aTextLine1	None
Search By Name	aRadioButton3	FV_SearchFactory_Option_Click
Search By Number	aRadioButton4	FV_SearchFactory_Option_Click
Search	aLabelButton5	FV_SearchFactory_Search_Click

Show Directions Dialog.



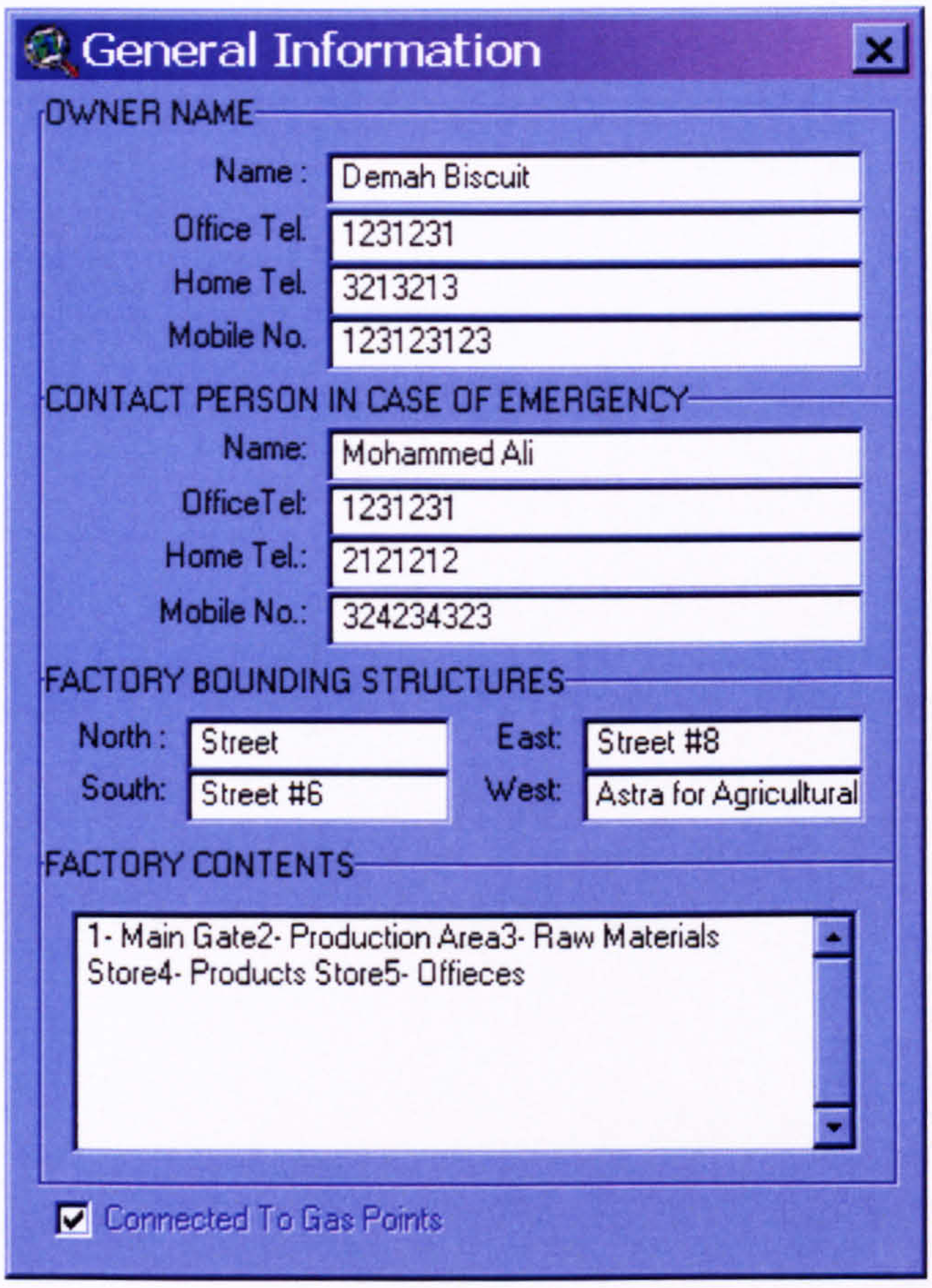
Description	Control Name	Script Name
Select Station Code	aListBox2	FV_ShowDirDlg_Listbox_Apply
Directions	aTextBox4	NONE
Show Layout	aCheckBox19	NONE

General Information Dialog



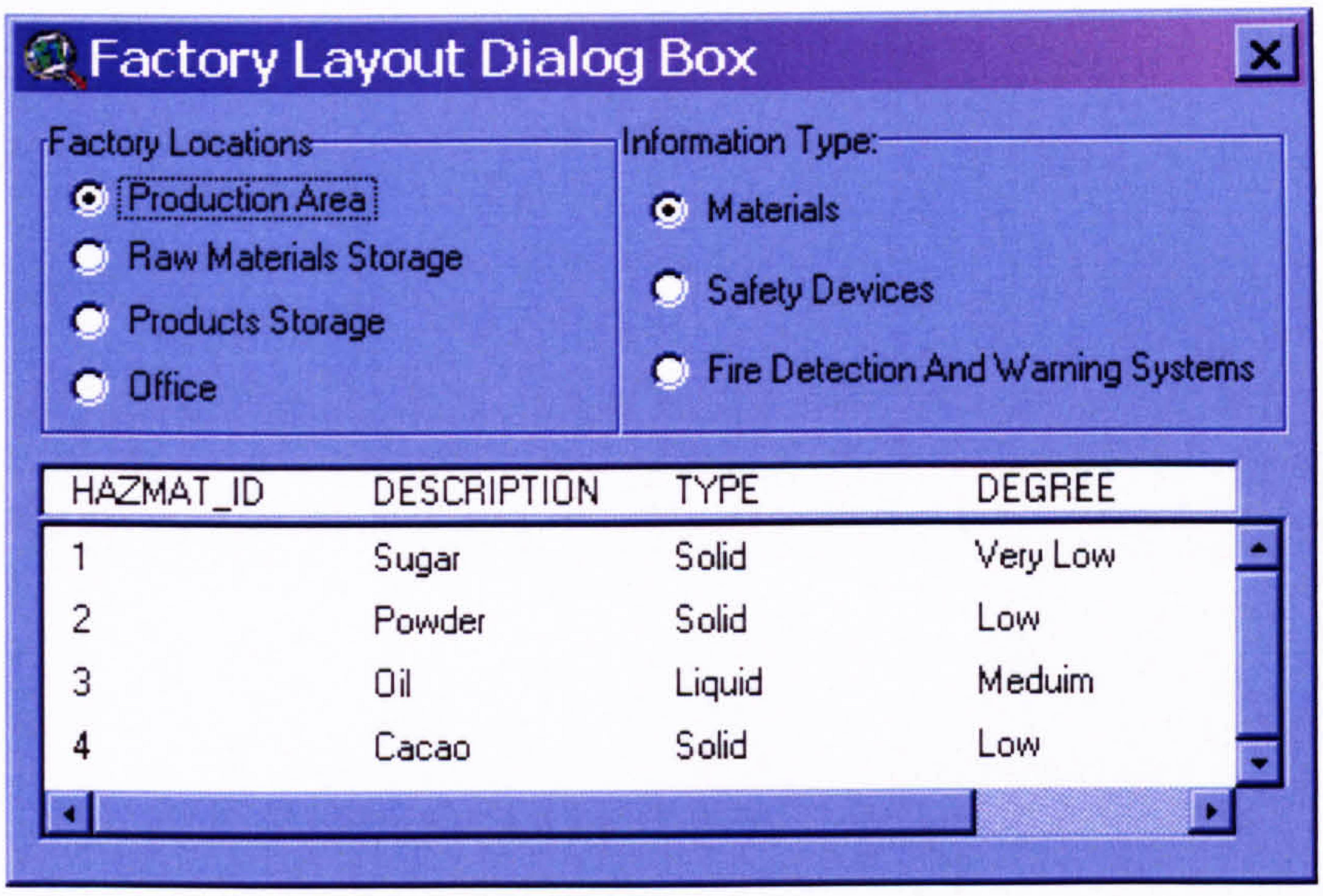
Description	Control Name	Script Name
Factory Name	ATextLine6	NONE
Factory Number	ATextLine7	NONE
General Information	ALabelButton8	FV_GenInfoDlg_Open
Factory Layout	ALabelButton9	FV_FactoryLayout_OpenDlg
Safety Devices	ALabelButton10	FV_SafetyDevicesDlg_Open
Fire Detection And Warning System	ALabelButton11	FV_FireDetection_OpenDlg
Dealing With Actions	ALabelButton12	FV_DealingWithAccidents_OpenDlg
Best Locations for Fire Stations	ALabelButton13	FV_BestLocationFireFighter.Open

General Information Dialog.



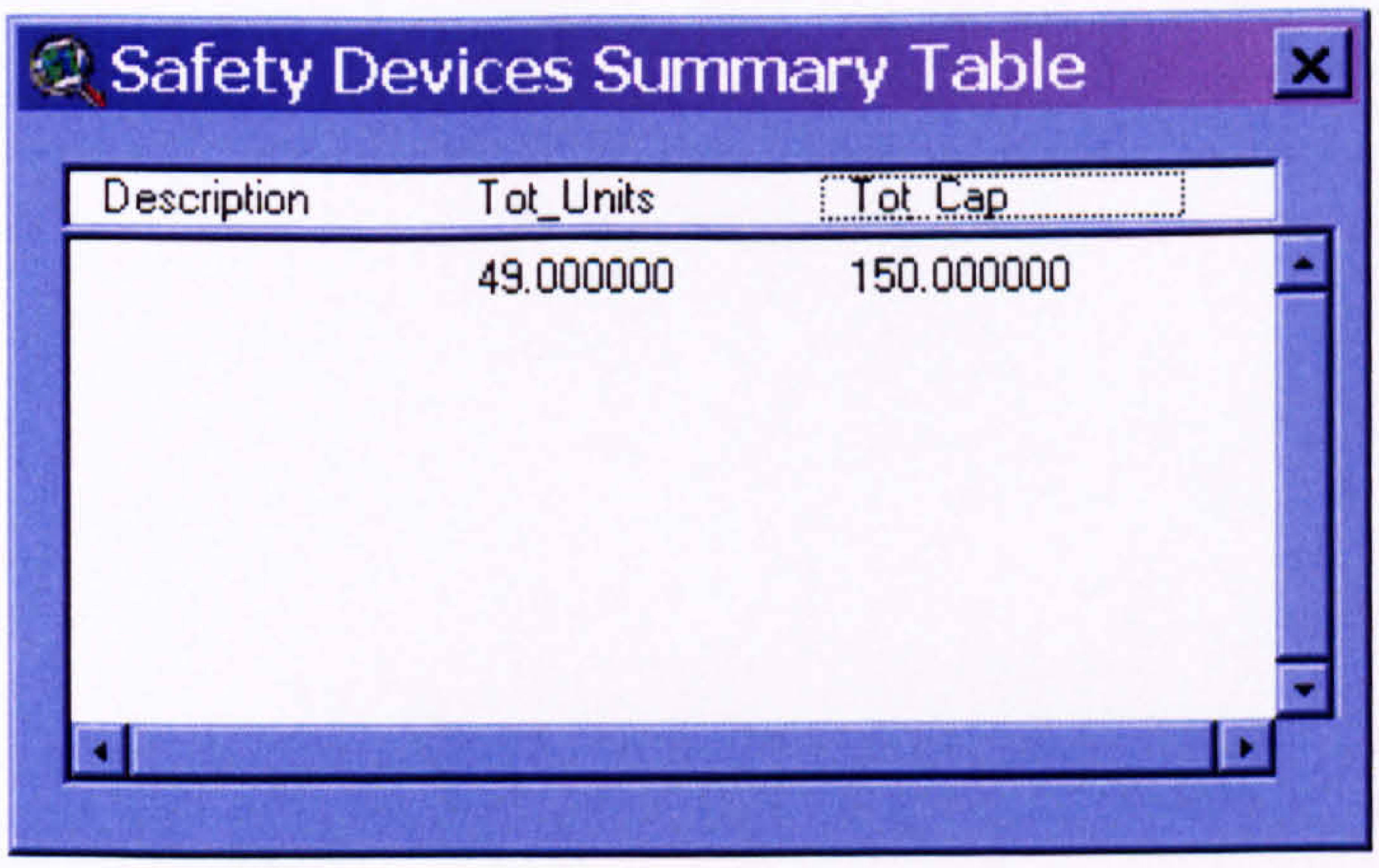
Description	Control Name	Script
Owner Name	aTextLine22	NONE
Owner Tel Number	aTextLine23	NONE
Owner Home Tel Number	aTextLine24	NONE
Owner Mobile Number	aTextLine25	NONE
Contact Name	aTextLine27	NONE
Contact Tel Number	aTextLine28	NONE
Contact Home Tel Number	aTextLine29	NONE
Contact Mobile Number	aTextLine30	NONE
North	aTextLine32	NONE
South	aTextLine33	NONE
East	aTextLine34	NONE
West	aTextLine35	NONE
Factory Contents	aTextBox37	NONE
Connected To Gas Points	aCheckBox38	NONE

Factory Layout Dialog.



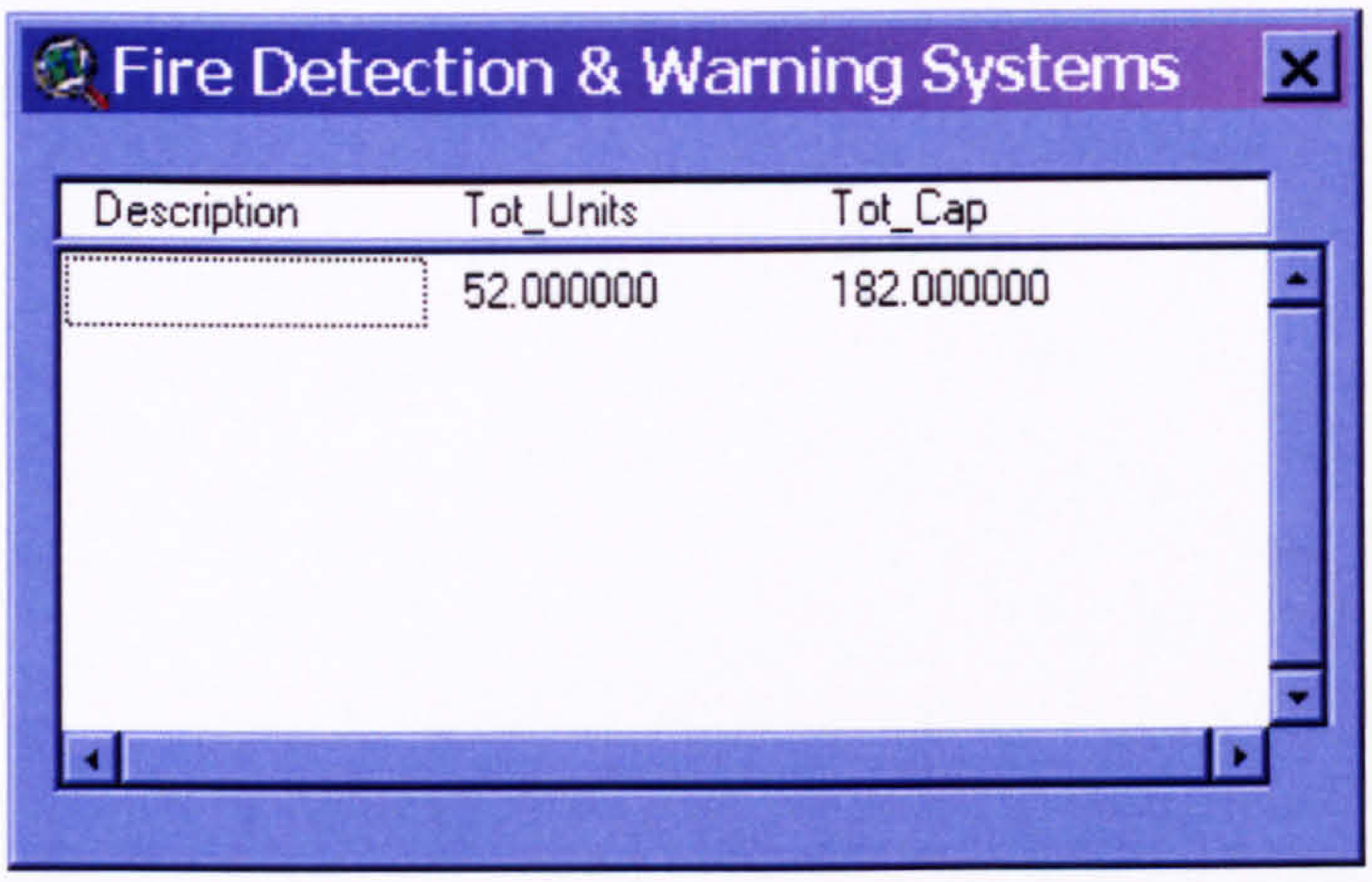
Description	Control Name	Script
Production Area	aRadioButton2	FV_FactoryLayoutDlg_ProdArea_Click
Raw Materials Storage	aRadioButton3	FV_FactoryLayoutDlg_RawMatArea_Click
Product Storage	aRadioButton4	FV_FactoryLayoutDlg_ProdStorArea_Click
Office	aRadioButton5	FV_FactoryLayoutDlg_OfficeArea_Click
Materials	aRadioButton6	FV_FactoryLayoutDlg_Materials_Click
Safety Devices	aRadioButton7	FV_FactoryLayoutDlg_SafetyDevice_Click
Fire Detection And Warning Systems	aRadioButton8	FV_FireDetectionWarningSys_Click
Contents ListBox	aListBox9	NONE

Safety Devices Dialog



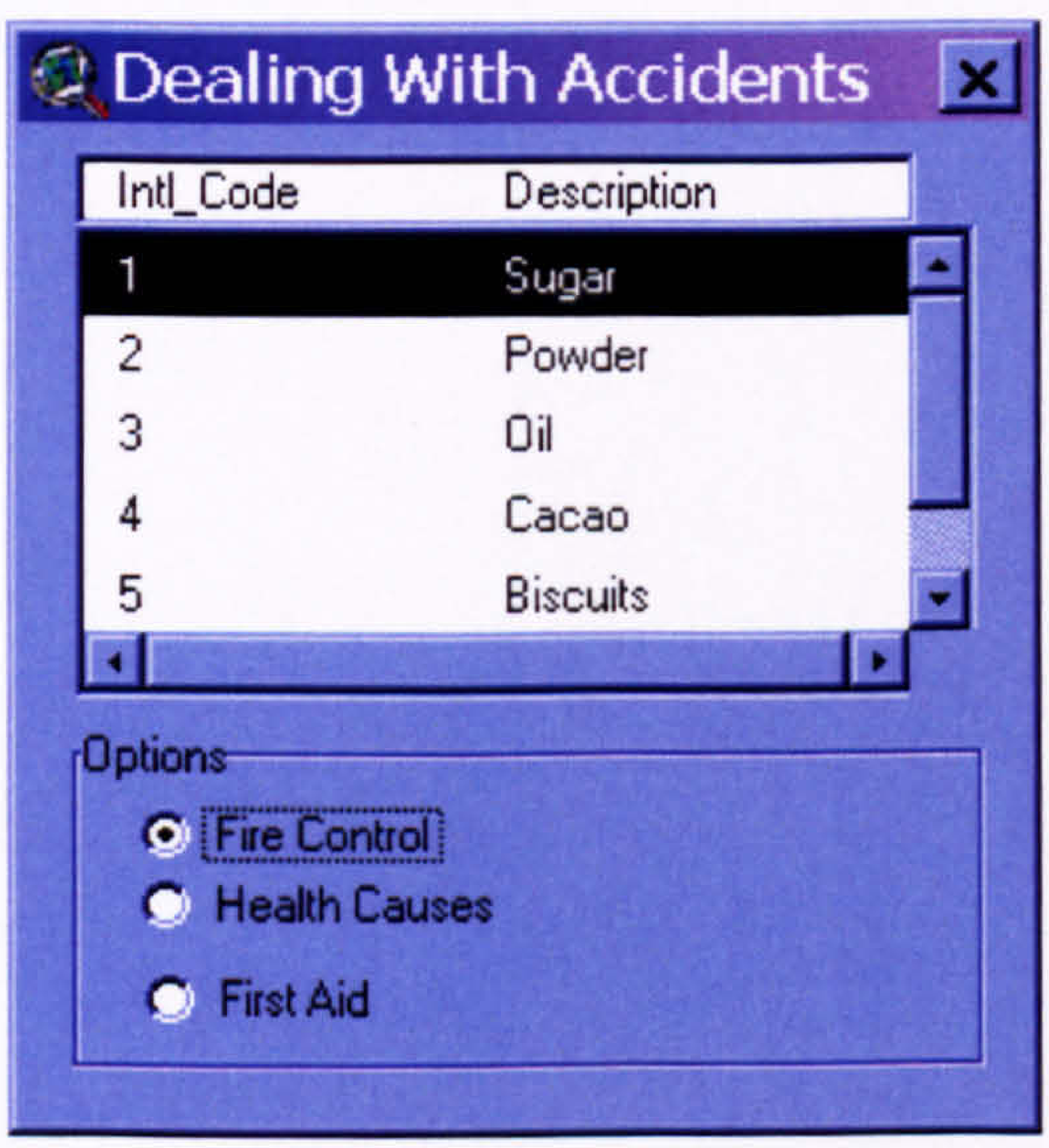
Description	Control Name	Scripts
Safety Devices Listbox	aListBox1	NONE

Fire Detection And Warning System Dialog.



Description	Control Name	Script
Fire Detection & Warning System Listbox	aListBox1	NONE

Dealing With Accidents Dialog.



Description	Control Name	Script
Hazardous Material Listbox	aListBox1	
Fire Control	aRadioButton2	FV_DealingWithAcc_Lbx_Apply
Health Causes	aRadioButton3	FV_DealingWithAcc_Lbx_Apply
First Aid	aRadioButton1	FV_DealingWithAcc_Lbx_Apply

Appendix - 6

Nielsen–Shneiderman Heuristics Principles

Heuristic evaluation is a usability engineering method for finding the usability problems in a user interface design so that they can be attended to as part of an iterative design process. Heuristic evaluation involves 14 heuristic principles which they are as follows (Zhang *et al*, 2003):

1. **[Consistency]** Consistency and standards. Users should not have to wonder whether different words, situations, or actions mean the same thing. Standards and conventions in product design should be followed.
    a. Sequences of actions (skill acquisition).
    b. Colour (categorisation).
    c. Layout and position (spatial consistency).
    d. Font, capitalisation (levels of organisation).
    e. Terminology (delete, del, remove, rm) and language (words, phrases).
    f. Standards (e.g., blue underlined text for unvisited hyperlinks).
2. **[Visibility]** Visibility of system status. Users should be informed about what is going on with the system through appropriate feedback and display of information.
    a. What is the current state of the system?
    b. What can be done at current state?
    c. Where can users go?
    d. What change is made after an action?

3. **[Match]** Match between the system and the real world. The image of the system perceived by users should match the model the users have about the system.
    a. User model matches system image.
    b. Actions provided by the system should match actions performed by users.
    c. Objects on the system should match objects of the task.

4. **[Aesthetic and minimalist]**. Any extraneous information is a distraction and a slow-down.
    a. Less is more.
    b. Simple is not equivalent to abstract and general.
    c. Simple is efficient.

d. Progressive levels of detail.

5. **[Memory]** Minimise memory load. Users should not be required to memorise a lot of information to carry out tasks. Memory load reduces users' capacity to carry out the main tasks.

    a. Recognition vs. recall (e.g., menu vs. commands).

    b. Externalise information through visualisation.

    c. Perceptual procedures.

    d. Hierarchical structure.

    e. Default values.

    f. Concrete examples (DD/MM/YY, e.g., 10/20/99).

    g. Generic rules and actions (e.g., drag objects).

6. **[Feedback]** Informative feedback. Users should be given prompt and informative feedback about their actions.

    a. Information that can be directly perceived, interpreted, and evaluated.

    b. Levels of feedback (novice and expert).

    c. Concrete and specific, not abstract and general.

    d. Response time.

    - 0.1s for instantaneously reacting;
    - 1.0s for uninterrupted flow of thought;
    - 10s for the limit of attention.

7. **[Flexibility]** Flexibility and efficiency of use. Users always learn and users are always different. Give users the flexibility of creating customisation and shortcuts to accelerate their performance.

    a. Shortcuts for experienced users.

    b. Shortcuts or macros for frequently used operations.

    c. Skill acquisition through chunking.

    d. Examples:

    - Abbreviations, function keys, hot keys, command keys, macros, aliases, templates, type-ahead, bookmarks, hot links, history, default values, etc.

8. **[Message]** Help users recognise and recover from error. The messages should be informative enough such that users can understand the nature of errors, learn from errors, and recover from errors.
    a. Phrased in clear language, avoid obscure codes. Example of obscure code: "system crashed, error code 147."
    b. Precise, not vague or general. Example of general comment: "Cannot open document."
    c. Constructive.
    d. Polite. Examples of impolite message: "illegal user action," "job aborted," "system was crashed," "fatal error," etc.

9. **[Error]** Error prevention. It is always better to design interfaces that prevent errors from happening in the first place.
    a. Interfaces that make errors impossible.
    b. Avoid modes (e.g., vi, text wrap). Or use informative feedback, e.g., different sounds.
    c. Execution error vs. evaluation error.
    d. Various types of slips and mistakes.

10. **[Closure]** Clear closure. Every task has a beginning and an end. Users should be clearly notified about the completion of a task.
    a. Clear beginning, middle, and end.
    b. Clear feedback to indicate goals are achieved and current stacks of goals can be released. Examples of good closures include many dialogues.

11. **[Undo]** Reversible actions. Users should be allowed to recover from errors. Reversible actions also encourage exploratory learning.
    a. At different levels: a single action, a subtask, or a complete task.
    b. Multiple steps.
    c. Encourage exploratory learning.
    d. Prevent serious errors.

12. **[Language]** Use users' language. The language should be always presented in a form understandable by the intended users.
    a. Use standard meanings of words.
    b. Specialised language for specialised group.
    c. User defined aliases.
    d. Users perspective. Example: "we have bought four tickets for you" (bad) vs. "you bought four tickets" (good).

13. **[Control]** Users control and freedom. Do not give users that impression that they are controlled by the systems.
    a. Users are initiators of actors, not responders to actions.
    b. Avoid surprising actions, unexpected outcomes, tedious sequences of actions, etc.

14. **[Document]** Help and documentation. Always provide help when needed.
    a. Context-sensitive help.
    b. Four types of help.
        - task-oriented;
        - alphabetically ordered;
        - semantically organised;
        - search.
    c. Help embedded in contents.

Appendix - 7

Covering Letter for Web Site Evaluation

Dear participant,

I am a PhD researcher in the Department of Information Science at Loughborough University, working under the supervision of Prof. Ron Summers and Mr. Ian Murray.

I have designed a Web site prototype for a Industrial Incidents Administration System (IIAS) for the information exchange between Civil Defence and Industrial Sector in Saudi Arabia.

I would like to invite you to evaluate the prototype and inspect the various interface elements and compare them with attached list derived from Nielsen–Shneiderman 14-Heuristics Principles. You should feel free to consider any additional comments or remarks that are relevant to develop this prototype.

The prototype can be accessed at: **http://www-staff.lboro.ac.uk/~lsysa/**

I believe that your participation is very important, because it will help to explore to what extent the information network are used. The study results will help the researcher to design an active information network.

Yours sincerely

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Loughborough University,
UK.

Appendix - 8

Web Site Evaluation

Heuristic Principles	Action
Consistency and standards *Users should not have to wonder whether different words, situate-ions, or actions mean the same thing. Standards and conventions in product design should be followed.*	
Visibility of system status *Users should be informed about what is going on with the system through appropriate feedback and display of information.*	
Match between the system and the real world *The image of the system perceived by users should match the model the users have about the system.*	
Aesthetic and minimalist design *Any extraneous information is a distraction and a slow- down.*	

Minimise memory load *Users should not be required to memorize a lot of information to carry out tasks. Memory load reduces users_ capacity to carry out the main tasks.*	
Informative feedback *Users should be given prompt and informative feedback about their actions.*	
Flexibility and efficiency of use *Users always learn and users are always different. Give users the flexibility of creating customisation and shortcuts to accelerate their performance.*	
Help users recognise and recover from errors *The messages should be informative enough such that users can understand the nature of errors, learn from errors, and recover from errors.*	

Error prevention *It is always better to design interfaces that prevent errors from happening in the first place.*	
Clear closure *Every task has a beginning and an end. Users should be clearly notified about the completion of a task.*	
Reversible actions *Users should be allowed to recover from errors. Reversible actions also encourage explorat-ory learning.*	
Use users' language *The language should be always presented in a form understand-able by the intended users.*	
User control and freedom *Do not give users that impression that they are controlled by the systems.*	
Help and documentation *Always provide help when needed.*	

<u>Please note:</u> you can use extra pages, in case if you have more comments.

Appendix - 9

Web Site Evaluation Questionnaire

Participant #: _____ Date: ____/____/2004

Organisation Name	Educational Level	Gender	Age

Now please proceed to the questionnaire and rate the IIAS Web site according to the following criteria: Note: where 1=Poor and 7=Excellent

Criteria	Questions	1	2	3	4	5	6	7
Appearance	1. Background Colours							
	2. Text Colours							
	3. Contrast of text to background colours							
	4. Font type and size is easy to read							
	5. Pleasing to the eye							
Information	6. Amount of text							
	7. Information value							
	8. Information is easy to find							
	9. Information is organised							
Functionality	10. Links are clickable							
	11. Pages download quickly on your computer							
	12. Information is easily located							
Database	13. Database is easy to find on the website							
	14. Database instructions are easy to understand							

Appendix - 10

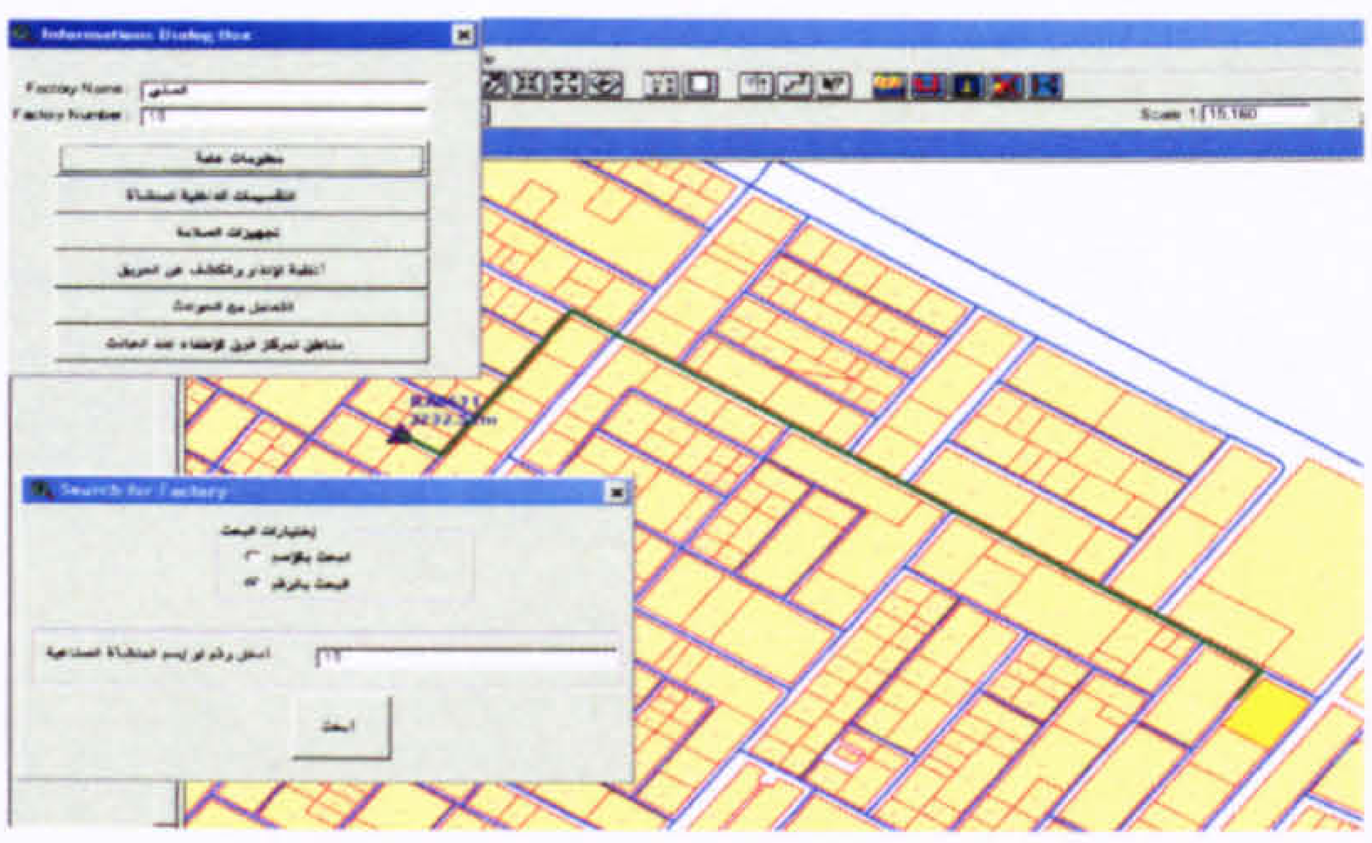
Cognitive Walk-Through Technique for Evaluation of GIS Application

	COGNITIVE WALKTHROUGH **Prototype : Industrial Incidents Administration System (IIAS)** **Part : Database & GIS Application** **Date : --/--/2004** **Evaluator no.: ---**
1	**Description of the system prototype** The prototype is an information network link Civil Defence and Industrial Sector to exchange information. The prototype includes two parts. First part is Web site which is letting the factories to update their information through it. Second part is the hazardous materials database which is linked with GIS application. This evaluation sheet is related to the second part. New features in the second part are downloading data from the Web database and upload it to GIS application which can use during industrial accidents.
2	**Description of the Task the user is to perform on the system** The user -after emergency call- retrieves relevant information from the system.
3	**List of actions needed to complete the task with the given prototype** See Evaluation Sheet
4	**Who the users are and what kind of experience/knowledge the evaluators can assume about them** Civil Defence Command Centre Staff who have a basic knowledge of computers, and more than 5 years work experience.

EVALUATION SHEET

Prototype: IIAS

Part : Database & GIS Application



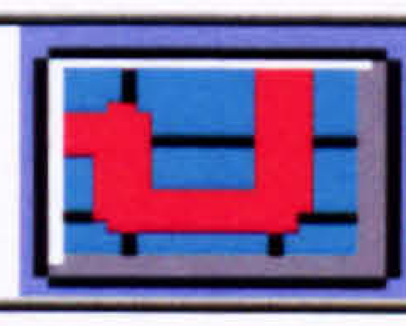
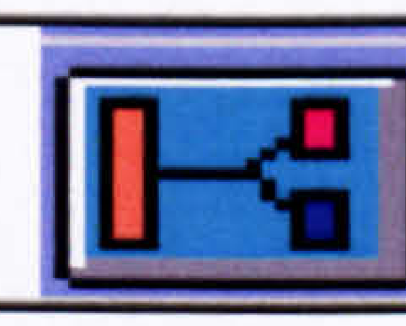
A. Will the user try to achieve the right effect?

B. Will the user notice that the correct action is available?

C. Will the user associate the correct action with the effect trying to be achieved?

D. If the correct action is performed, will the user see that progress is being made toward solution of the task?

Buttons to be Tested

				
Search Factory	**Show Direction**	**Factory Information**	**Delete Graphics**	**Options**

#	**Action Description**	**A**	**B**	**C**	**D**
1	The user logs into GIS application by click on "Fireview_Arabic`" Icon.				
2	The user asks to "Enter Password".				
3	The user will see "Five Buttons" in top right of the screen..				
4	The user wants to search factories by choosing "Search Button".				

#	Action Description	A	B	C	D
5	After adding "Number or Name of the Factory" user close box by clicking "X".				
6	The user wants to search factory information by choosing "Factory Info Button".				
7	The user wants to search general information by choosing "General Information Button".				
8	After finding relevant information close box by click "X".				
9	The user wants to search factory layout by choosing "Factory Layout Button".				
10	Go through this dialog and search in different information at different styles				
11	After finding relevant information close box by click "X".				
12	The user wants to search safety devices that available in factory by choosing "Safety Devices Button".				
13	Read the data that available in this dialog and close the box by clicking "X".				
14	The user wants to search fire detection and warning systems that available in factory by choosing "Safety Devices Button".				
15	Read the data that available in this dialog and close the box by clicking "X".				

#	Action Description	A	B	C	D
16	The user wants to know how to deal with industrial accidents by choosing "Dealing with Accidents Button".				
17	User goes through different options in this dialog. Each option will gives different information than others. Click "X" for close.				
18	The user wants to look for best location for fire stations by choosing "Best Locations for Fire Stations Button".				
19	Read the information that available in this dialog and close the box by clicking "X".				
20	Close the GIS application by press File –then- Exit –then No for not saving any change on project.				

Appendix - 11

GIS Application Evaluation Questionnaire

Participant #: _____ Date: ____/_____/2004

Organisation Name	Educational Level	Gender	Age

Now please proceed to the questionnaire and rate the IIAS system according to the following criteria

Criteria	Questions	Strongly Disagree	Disagree	Agree	Strongly
Design & Layout	1. The interface of the system was acceptable.				
	2. The organisation of information presented was clear.				
	3. The human-computer interface of the system was pleasant to use.				
Efficiency	4. The system has the functions expected to assist me.				
	5. The information retrieved by the system was effective in helping me.				
Ease of Use	6. This system was simple to use.				
	7. It was easy to find the information I needed.				
	8. The information provided by the system was clear.				
Helpfulness	9. I was able to complete the tasks easily.				
	10. The information provided was easy to understand.				
System Reliability	11. When I made a mistake, I could recover easily and quickly.				