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Establishment of a Database System for the Environmental Rehabilitation of Kuwait

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ABSTRACT

Since the liberation of Kuwait in 1991 research and environment institutions have investigated the impact of war on the environment of Kuwait. The information acquired on the environment and soil has been large in magnitude and comprises of many components relating to soil characteristics; terrestrial, marine and coastal environments; public health; and ground water. Most of the research studies, however, were conducted independently causing data fragmentation and resulted in lack of integration and proper interpretation. Several database systems were developed such as the “Soil Survey Information System” (SIS) and the "Environmental Database Management Reporting & Assessment System" (EDMRAS) utilized for the United Nations claims in Kuwait. The database’s system design and architecture; environmental media data themes, data entry; validation, integrity and security control; as well as the interface with the GIS mapping resource systems are all presented and discussed in this manuscript.

Key words: Environmental damages, data management, GIS, Gulf War, Kuwait, modeling and assessment.

INTRODUCTION

The impact of the Iraqi invasion and the Gulf War on the environment of Kuwait are still evident (Literathy, et al. 2003). Several studies by independent engineering and environmental firms have been conducted to assess the environmental damages on the terrestrial, groundwater, public health and marine environments. These firms used different approaches, interfaces and produced data types in various formats. Consequently, the data and information collected was scattered, incompatible and difficult to integrate and interpret to support the technical, legal, and management functions in evaluating the impacts of the Iraqi Aggression (Roy & Asem 2002). The Government of Kuwait showed a high interest in establishing a soil survey for agriculture and land use planning after the invasion and this project (Omar & Al-Ghawas , 1996)  was awarded to an Australian company AACM International Pty. Limited proving to be highly successful. The Soil Survey project generated a vast amount of data and a Soil Information System (SIS) was developed (Grealish et al. 2004). A large portion of the SIS database was GIS related; furthermore triggering the next project relating to the environmental war damages funded by the United Nations, which was initiated in 2001. This was an enormous five-year project that dealt with leading consultants from all around the world to basically put an economic value on the damages attained by the invasion. The Kuwait Institute for Scientific Research (KISR) was responsible for managing a program of investigations to quantify the environmental damage resulting from the Iraqi aggression in 1990. These investigations involved preparing a Natural Resource Damage Assessment (NRDA) through monitoring and assessing damages associated with the Iraqi invasion of Kuwait, and by conducting research and studies to produce scientifically sound and legally defensible conclusions with respect to:
• Assessment of Iraqi Aggression-related damages to Kuwait’s natural resources.
• Assessment of human health and ecological impacts resulting from the environmental damages caused by the Iraqi Aggression.
• Analysis of decision alternatives and least cost options for restoration.

These projects required a database that would be leading edge with an intensive GIS system and high quality assurance/quality control QA/QC standard to stand scrutiny and support the legal aspects in court. The purpose of this paper is to report an approach that was defined to integrate an Environmental Management Information System (EMIS) that would incorporate existing data and new data generated from an environmental monitoring and assessment program.

The Environmental Data Management, Reporting, and Assessment System (EDMRAS) is a state of the art Database management system used for the United Nations claims project that was designed to combine and strengthen our capabilities to evaluate the economic value of environmental damage (Roy, et al. 2002), assist in selection of the best remediation/rehabilitation alternatives, expedite operations and improve quality of environmental information.

**Approach**

To meet the EDMRAS objectives, initially all data should be collected and stored in a centralized data management system. The system should be capable of supporting different data types and formats, compatible with multiple interfaces, fixable to support different types of users and contains Natural Resource Damage Assessment NRDA models and analytical tools such as chemical, biological, physical, toxicological and economic databases. EDMRAS should also be an internationally approved data management system that can maintain data credibility levels suitable to result interpretation, analysis and presentation.

Several meetings with the independent firms were held to define the system requirements, which are listed below:

The system should provide:

- Secure data access and disaster or sabotage protection.
- Reliability and availability of the system through the use of proven technologies and redundant systems.
- Unalterable record of work done so each bit is able to withstand detailed scrutiny.
- Best-of-breed information technology to ensure that data generated is demonstrably above reproach.
- Documentation of the processes and procedures used in collecting and generating data so that independent experts may verify the integrity of the data and derived works.
- Software and systems automation to enable rapid collection and examination of the data, elimination of disparate information sources to save cost and time and prevention of potential losses associated with duplication of data and elimination of redundant data collection and entry operations to create efficiencies.
- Scalable system architecture to meet the current and future data storage requirements.

Data and data themes were also distinguished during these meetings. Measurement of tabular data, spatial data and metadata were identified as three types of data to be stored in the system. Measurement data is environmental data measured in the field or through laboratory analysis. Spatial data refers to GIS data such as points, lines or polygons that represent a physical location. Metadata describe the content, quality, condition, and other characteristics of data.

**Design**

**Hardware Components**

To enforce the system security requirement, the following components have been used through out the design: Firewalls to protect the network from unauthorized access, virus protection on the server and workstations, intrusion detection and prevention to detect internal and/or external hacker attacks comparing suspicious traffic to a database of well-known attacks, strong authentication to control user authentication by requiring username, password and random access codes generated by an assigned key fob, and logging services to maintains a historical archive of different activities.

To meet the reliability and availability requirements, devices, internal components, services, and data have been made redundant whenever possible. EDMRAS was designed as two separate systems. One is located in the State of Kuwait, labeled as the Kuwait EDMRAS, and the other one is located in Calgary, Canada, labeled as the Calgary EDMRAS. Kuwait EDMRAS delivers highly available user services in Kuwait while Calgary EDMRAS serves as a disaster recovery site for the Kuwait EDMRAS and at the same time serves as a development, testing, and remote troubleshooting facility. EDMRAS was
Roy and Asem

Database System Establishment

designed around the concept of services and network zones. Since Kuwait EDMRAS delivers all EMIS services to authorized users, it was developed to support end-user activity and provide the level of security required by the design objectives. It provides five groups of services to users: Web services, application services, management services, EDMRAS Data Center EDC staff services, and Local EDC user services as shown below in Figure 1.

![Figure 1. Diagram showing Kuwait EDMRAS available services.](image)

The services groups were also categorized into three categories of services:

- EDMRAS user services accessible to users. Includes Web and Application services.
- Administrative services accessible to local EDC users. Includes use of printing and scanning equipment located at the EDC.
- Infrastructure management services accessible to EDC system administrators. Includes the management devices for the Storage Area Network SAN and the security components of the Kuwait EDMRAS.

Due to the nature of Calgary EDMRAS objectives, it was developed with no end-user services. It provides two groups of services for internal use: Storage services and Application Test and Development Services, as shown below in Figure 2.

![Figure 2. Diagram showing Calgary EDMRAS available services.](image)

The Network zones partition areas of the EDMRAS network to isolate them from one another for security reasons. The base of the network was designed as two redundant firewalls that control the traffic flow between different zones of the network. Each one of these zones has been named according to the services it provides.

The design of the Kuwait EDMRAS includes the following zones:

- Application Zone. Contains all infrastructure required to provide EMIS services.
Software Components

EDMRAS services were designed to be provided by a series of software components, both visible and invisible to the end-users. The software components fall into one of three categories:

- **Application Software**: Provides users with a specific interface to EDMRAS data. Application software runs as client software, either directly on users’ computers, or hosted on EDMRAS application servers. EDMRAS users will access the system using one or more of the following client applications:
  - VPN client software. Authenticates users against the EDMRAS security system and connects them to EDMRAS services.
  - Envista Enterprise client software. Provides access to environmental data stored in the Envista Enterprise repository.
  - Citrix Metaframe client software. Provides access to applications running on EDMRAS application servers in the EDC.
  - Web Browser client software. Provides access to Web-based EDMRAS services.
  - GIS client software. Provides access to GIS data stored in the EDMRAS.

Basic access to GIS data is provided through Envista Enterprise and the Web-based software. Dedicated GIS client application software consists of ArcGIS and ERDAS Imagine was also included in the system.
**Auxiliary Software:** Includes auxiliary application software used to access data through secure network access or data exports. Examples of auxiliary software applications that may be employed include:
- Microsoft Office productivity software.
- Other personal productivity software such as Lotus.
- Ad-hoc reporting and analysis software such as Crystal Reports.
- Engineering modeling software.
- Remote licenses of GIS software: ArcGIS, ERDAS or software from alternative vendors (for example, Intergraph Geomedia, and MapInfo).

**Server Software:** Provides services to the users and the software applications.
- Authentication and Access Control server. Provides a single central registry of all user accounts, including usernames, passwords, and system privileges.
- Application server. Allows users to access EDMRAS applications remotely, without requiring the installation of specialized client software on the user’s workstation.
- Worldwide Web server. Provides access to EDMRAS data (e.g. tabular data and EDMRAS maps) over the Web.
- Database server. Provides storage of EDMRAS data, including both tabular and spatial data.

Figure 4 below demonstrates how the database is utilized in various ways for different application purposes.
CONCLUSION

An Environmental Management Information System was developed to incorporate fragmented, incompatible and difficult to integrate data into one centralized data management system.

EDMRAS was designed to help support the technical, legal, and management functions in evaluating impacts of the Iraqi Aggression and has established a foundation of valuable data that can be expanded for future environmental rehabilitation.

The EDMRAS data center is part of a five-year program, initiated by the Public Authority for the Assessment of Compensation for Damages Resulting from Iraqi Aggression (PAAC), to assess environmental damages caused by the 1990 Iraqi aggression against Kuwait. The system was approved, built, tested and went into operation at the Kuwait Institute for Scientific Research (KISR). EDMRAS was designed and built as part of this $100 million dollar plus research project in order to serve as a centralized secure data repository with very high standards in mind. EDMRAS housed all the data relating to the PAAC monitoring and assessment projects and was proven to be highly successful. As a result the data assimilated from these projects was presented to the United Nations and Kuwait was awarded approximately two billion dollars for the rehabilitation purposes of these projects.

The EDMRAS system was designed by a Canadian company (Telus) located in Calgary and was shipped to Kuwait where it went into operation at the Kuwait Institute for Scientific Research (KISR). EDMRAS is currently in the process of being transferred to Kuwait University for further modifications and upgrades to meet the growing requirements of the Middle East region and future rehabilitation projects.

REFERENCES


