A GIS based traffic accident data collection, referencing and analysis framework for Abu Dhabi

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ABSTRACT: Abu Dhabi Municipality has identified the need for the development of an accident data collection, referencing, management and analysis system, for Abu Dhabi. This is part of a strategy to implement a GIS based Transportation Information and Management System comprising several components of which an accident management system would be one. This paper presents the main findings of the initial study, together with the proposed framework of the new system. In particular, the Paper discusses some of the results of a regional and international review of similar initiatives. The Paper also explains the method of using GPS to reference an accident location by using a GIS map, since the accurate identification of accident location was a critical element. The study is still underway and the final output is expected to be a workable GIS based accident data collection, referencing, management and analysis system.

RÉSUMÉ : La Municipalité d'Abu Dhabi a identifié le besoin de développer un système de collecte, de référencement, de gestion et d'analyse des données d'accidents pour Abu Dhabi. Cela fait partie d'une stratégie visant à mettre en oeuvre un Système de Gestion et d'Information de Transport basé sur le SIG comprenant plusieurs composants dont ferait partie un système de gestion d'accidents. La communication présente les découvertes principales de l'étude initiale, ainsi que la structure proposée du nouveau système. La communication traite en particulier de certains des résultats d'une revue régionale et internationale d'initiatives semblables. La communication explique aussi la méthode pour utiliser le GPS pour référencer l'emplacement d'un accident en employant une carte du SIG, puisque l'identification précise de l'emplacement d'un accident était un élément critique. L'étude est toujours en cours de réalisation et on s'attend à ce que la production finale soit un système, basé sur le SIG, de collecte, référencement, gestion et analyse des données d'accidents, qui fonctionne.

1 INTRODUCTION

The city of Abu Dhabi and its urban environs continues to experience rapid growth, which is characterized by increasing population, trade, vehicle ownership and traffic movements. Institutional, human resource and system capacities in dealing with road traffic and related operational issues however have unfortunately not kept in pace with the overall rapid urbanization. This situation has created a challenge in dealing with the road safety problem in the city.

Consequently, Abu Dhabi Municipality Roads Directorate identified the need for the development of a well structured accident data collection, referencing, analysis and management system. This has been envisioned as part of a structured strategy to implement a Transportation Information and Management System (TIMS) comprising several components of which the accident management system would be one. Other components would include continuous traffic counting, operational analysis, highway asset management and travelers guidance and information systems, amongst others. All these sub systems would be implemented on an integrated wide GIS system.

The first stage of TIMS is the simultaneous development of three system components; the accident referencing and analysis system, AREST, (the subject of this paper), the continuous traffic counting programme (COPAS) and the operational analysis programme (OAP). This paper presents the development of the AREST architectural framework and system.

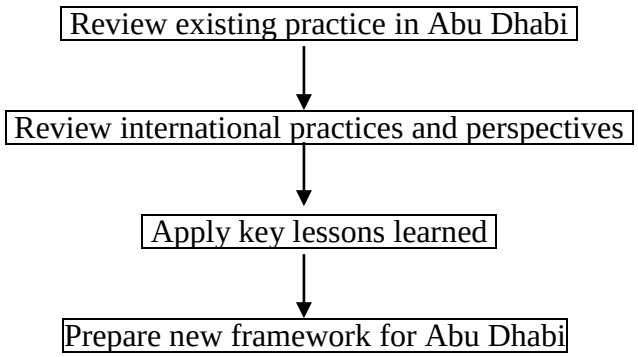
In order to reach a practical framework, a number of preparatory tasks were carried out. These include a review of international practices in the area of interest, a thorough review of the existing practices of accident data collection, management and analysis by the Abu Dhabi Traffic Police Department and the Municipality's Road Directorate as the

highway authority. The Paper in particular highlights some of the results of a regional and international review, including a detailed comparison of accident data collection forms from around the world.

The single biggest problem with the quality of accident data in Abu Dhabi has been the disregard to identify and record the precise location of the accident. Therefore one of the most important aspects of the study was to develop a practical method to achieve this as a fundamental data parameter. It was also decided to take advantage of latest technology in using electronic data capture and storage devices. The Paper explains the method of using GPS and GIS together to accurately reference an accident location on a GIS map using a portable device. The issues of accident data storage, database design, data retrieval and subsequent analysis are also discussed. Finally a framework is developed to tie all aspects of the AREST together, within the overall context of the TIMS. This framework is presented, as the basis for further development of the system in the future.

In order to arrive at a practical new framework for a new and effective accident management framework for Abu Dhabi, a number of major preparatory tasks were undertaken as shown in Figure 1.

Figure 1 Outline Methodology for Preparation of AREST Framework



2 REVIEW OF EXISTING PRACTICE IN ABU DHABI

The collection of road accident data in Abu Dhabi is the responsibility of the Traffic Police. All accidents, whether non-injury or injury, are required to be reported and investigated by the Traffic Police at the time and scene of the accident. We can succinctly summarise the situation by looking at five main areas; accident recording, accident location referencing, data storage, data/information exchange; and; analysis and reporting. The following sections provide a summary of the main review findings for each category.

2.1 *Accident data recording*

Road accidents are currently recorded on paper, on two different paper forms; a four page form for injury accidents and a one page form for non-injury. At the scene of a non-injury accident, the officer attends the accident, collects data which is largely written long hand, and makes a decision on fault at the scene. The various involved parties are then issued carbon copies of the data form to take to their respective insurance agencies for further processing. For injury accidents the police attend the scene which usually involves additional police personnel. There is much more time available for data collection, but again most of the information is written long hand. The injury accident forms are then finally completed by the Police officer in the Police station. Despite the availability of many fields on the non-injury and injury accident forms, not all data and information is recorded, resulting in incomplete and also inaccurate data, on the form itself and later when the information is transferred to the database.

2.2 *Accident location referencing*

Until January 1st 2003, there was no formal system for location referencing and it had been acknowledged for a long time as a fundamental deficiency in the accident records. Abu Dhabi only recently has established a street and building addressing system, but this is not used by the general public and the various agencies. Accident location therefore was still being described in words in general terms with often a road name and a land mark being used, but if the road was very long, there was no effective way of determining where along the road the accident actually took place. Since January 1 2003, Global Positioning System (GPS) devices have been used to record the coordinates of accidents on revised forms. All injury accident data should now include GPS coordinates. This however has not been entirely helpful for a number of reasons; first, because it has demonstrated that in the urban high rise environment of Abu Dhabi, these GPS coordinates can have errors of up to 100m, second, GPS coordinates are in longitude and latitude and not a geo-referenced easting and northing, and third, it was found that there was inaccuracy and inconsistency in the transcription of GPS coordinates from the device onto the paper forms. Therefore, even with the introduction of GPS alone, the current system of locating accidents is still not entirely useful nor reliable. The determination of location therefore was studied very carefully in the framework and an improved method was proposed as discussed later.

2.3 *Data storage*

Once all paper forms are completed by the investigating Police officer, these are then given to data entry operators back at the office to enter onto an Arabic Oracle database, using Oracle Forms as the front-end application. The accident database structure contains mainly three tables as follows;

- The accident master table containing accident details
- The accident detail table containing vehicle and driver information for each accident
- The injured persons table which contains information for the casualties

The main linkage between the tables is the accident reference number and the year of the accident.

Whilst there is a good structure to the database, a major problem is that data and information is not updated in a structured manner when it needs to be. The prime example of this is the updating of the casualty severity if it changes. Whilst the definition of a fatality as one which occurs within one month of the accident is understood, there is no proper mechanism for this data item to be updated in the database. Although there is a police desk in each of the four main accident hospitals in Abu Dhabi, and if a casualty died within one month after receiving serious injuries, this information does not necessarily get updated in the main accident database. Therefore there is a likelihood that numbers of fatalities in Abu Dhabi are being under-reported.

2.4 *Exchange of information/data between police and other agencies*

There is no formal exchange of accident data between Police and other agencies except for some high level reporting to the Ministry of Interior who have a standing requirement to produce some general periodic statistics. Data between internal Police departments is exchanged using a Local Area Network (LAN). Information is exchanged between the Traffic Police and the Municipality as the highway authority through official meetings and written reports.

2.5 *Analysis and reporting*

Due to the limited quality of information contained in the accident databases, rigorous analysis and reporting is not able to be done. Limited querying and compilation of generalised statistics is carried out by the Traffic Police. Thirteen such general reports are generated on a periodic basis for the Ministry of Interior and other reports for internal purposes. On an individual accident basis however, detailed investigation is carried out into serious accidents, but this is done for legal purposes.

Within the limited constraints of the information available, the Municipality do attempt to study roads and areas of high accident incidents. In many cases, these studies lead to recommendations for modifications to the road layouts, which are often discussed with the Traffic Police.

3 INTERNATIONAL PERSEPCTIVES IN ACCIDENT INVESTIGATION

Road traffic accidents occurring on roads are generally the result of many different factors affecting the vehicle or vehicles. For example, an accident could be the result of a driver going too fast (in excess of the speed limit), on an inadequately maintained section of the road, in a vehicle that is poorly maintained. Therefore, the accident described could be said to be the result of at least three contributory factors albeit in varying amounts. It is because virtually all road traffic accidents are the result of different factors that there is now a trend to move away from calling them ‘accidents’ and using the term ‘crash’ or ‘collision’ instead. (For the purposes of this Paper, we will maintain the use of the term ‘accident’).

The above description of a road traffic accident also illustrates that an accident can be of interest to different agencies; the police, if the vehicle is going too fast, the highway authority, if the road is poorly maintained, and the educational department for lack of awareness of safety measures.

Accident information can therefore prove to be useful to different stakeholders and can be used for the following commonly, referred to as the three “E’s”:

- Enforcement;
- Engineering:
- Education:

The Police as the enforcement authority universally have the responsibility for the collection of accident details at the scene of an accident. Their role in enforcing the laws relating to the movement of vehicles will mean that a substantial amount of data needs to be collected at an accident in case of future legal action. Much of this data will be of a confidential nature and would not be required for accident analysis. However, non-specific information including the accident location is useful for the general reporting and analysis of traffic accidents.

Traffic engineers, are major users of this data to help monitor the overall performance of the highway network and to enable them to respond to any inherent problems. It is necessary, therefore, for all concerned to have access to a relevant sub-set of the accident data, or for them to maintain their own independent database consisting of a sub-set of the

original data with a common link for interconnectivity.

It is well recognised that a programme of traffic accident reduction schemes, based on an accurate and comprehensive database of accident information, will enable authorities to achieve a substantial reduction in the number of traffic accidents. It should therefore be a requirement of a successful system that it meets the needs and aspirations of all stakeholders.

Road safety is recognised internationally as an area in which governments can influence the tragic toll in terms of human life and injuries that road accidents create. Authorities can set realistic programmes, both in terms of human and financial resources, for reducing accident risk for all types of road user.

For example, the Australian government has shown a strong commitment to road safety, (Government of South Australia, 2003). This is evident in the tough regulatory environment that sees high penalties for the biggest behavioral risk factors, such as speeding and drink driving. Road and enforcement authorities have placed great emphasis on their efforts to redress and contain road accidents. The Australian government has recently announced ambitious national targets that aim to halve the number of road fatalities by the year 2010.

Sweden has discarded the concept used internationally of 'trade-offs'. Road safety is now officially regarded as an absolute priority for the government and road authorities. It is now seen as an ethical question not an economic or a political question. This principle has radical implications in the sense that all road planning and management decisions must now place the safety human of beings at the starting point of considerations for road and traffic system construction. Whilst setting ambitious targets for the year 2010, Sweden is seriously committed to Vision Zero – quite literally aiming at no road deaths nor serious injuries. (US Department of Transportation Federal Highway Administration, 1999)

In the Netherlands the government is committed to the principle of sustainable safety. The Road Safety Research Institute, and the Ministry for Transport have worked closely together in formulating the Sustainable Safety Strategy. Borrowed from the concept of ecologically sustainable development, the government has applied the essence of this ecological principle to road safety. The concept is that providing road mobility needs of the present generation should not produce a road environment that contributes to an inherent risk of death or injury to future generations.

In order to easily undertake accident analysis and comparison within member states, the European Union is developing a Europe-wide accident database. This programme has resulted in the International Road Traffic and Accident Database, (IRTAD) and the Community Accident Database on Roads in Europe, (CARE). The development of a Community-wide road accident database was strongly supported by road safety professionals as an essential tool for informed decision-making to combat effectively the huge road safety problem throughout the European Union. (EU, 2003). IRTAD has already become a valuable source for comparative analysis of road safety developments in different countries. It is the only international database that explicitly looks at historical consistency and international comparability of data on roads, traffic and accidents. IRTAD is a traffic accident analysis tool that because it needs a common standard for data is encouraging member countries to set consistent international standards.

4 REVIEW OF INTERNATIONAL PRACTICE AND TECHNOLOGY IN ACCIDENT DATA MANAGEMENT

A major task in the methodology to help reach a practical framework for Abu Dhabi was to review relevant international practice in similar areas. Several countries were chosen after a selection to represent Middle East regional practice and other international, developed country practice. These were;

- Kingdom of Bahrain
- Emirate of Dubai, UAE
- United Kingdom
- Sweden
- Australia
- New Zealand
- United States of America (several States)

A number of criteria were considered for the choice of the countries. For examples of regional practice, Dubai and Bahrain were chosen as the similar cities in the region because of their similarity in development, size, socio-economic conditions, familiarity, proximity and the ease at which information could be obtained.

USA, UK, Sweden, New Zealand and Australia were chosen as examples from developed countries. The USA because it offered several developed examples from several states, the UK because of the ease of information availability, Sweden because of its eminence in road safety, New Zealand and Australia because of some relevant practices which were known. The method for the review largely depended on written published papers, information published on the Internet, questionnaires to police and highway authorities and particular experience of the road safety specialists in the study team. The review revealed some interesting facts which provided useful in the consideration of the proposed system for Abu Dhabi. The most important of these findings are

listed in the following sub-sections in the same categories as described for Abu Dhabi.

4.1 *Accident recording*

The under-reporting of accidents was found to be a universal characteristic. Except for the Arabian Gulf states, most countries only require Police attendance when an injury or serious property damage has taken place, whereas in the Arabian Gulf, all accidents (non-injury and injury), are required to be reported to the Police. Accident underreporting creates a bias in the reporting and analysis towards fatalities and the more serious injuries or towards certain types of accidents. Differences in the local tradition for reporting accidents to the police and how the recording procedure is organised are important factors in explaining differences among countries.

In most countries, notes are taken in the field by Police officers, which are then transferred onto coded paper forms once back at the Police station. Pen and paper is still the most commonly used medium for recording accident data in the field, but there is a trend in using electronic digital hardware and software if only in some cases on a trial basis. In this regard, Australia and several states in the US have begun to use mobile data terminals (MDT's) for various police duties including accident data recording.

All the accident data collection forms reviewed contained boxes for numerical codes to represent the accident parameters. Most forms were found to be 2 –4 pages long and covered the requirements for injury and property damage only accidents. The basic accident data parameters in all the accident forms can be summarised in the following broad categories.

- **General information**: Year, Month, Day of the week, Hour etc
- **Location:** Street Number, Intersection No, Geographical/GPS co-ordinate, Milepost, Area Name etc
- **Road user**: Age, Sex, Road user type, Alcohol consumption, Seat belt use, Car passenger position, Driving licence category, Date of Issue,etc.
- **Injury details**: Extent, No of persons Injured, Injured Person Details, Evacuation means etc
- **Road environment**: Road type, Road category, Weather conditions, Lighting conditions, Road surface, Road surface conditions, Traffic control etc.
- **Vehicle:** Vehicle type, Vehicle age, etc.
- **Accident:** Accident type, Manœuvre type etc.

4.2 *Accident location referencing*

Several different types of information to help locate the accident are used in most forms. These include, the street name, highway number, intersection number, or milepost information. The allocation of a geographic coordinate of the accident location is practiced everywhere, but it is not determined in the field but back in the Police office with the help of a map. Some States of the USA, Sweden, Australia and some counties in the UK have started using or are in trials to use GPS as a tool to reference an accident. The use of GPS together with GIS maps stored on MDT's is a trend now for accident data recording. (US Department of Transportation Federal Highway Administration, 2001).

4.3 *Data storage*

Accident data entry and storage in the countries reviewed is exclusively done by the Police who then usually make part of the database available to the highway authority upon request or on a pre agreed frequency. The most commonly used database software found in use were MSAccess and Oracle since these are established relational databases which are compatible with most GIS platforms and other related software.

In Sweden and Australia it was found that there is a plan to cross-reference the accident data with other information such as hospital data, thus enabling a further level of quality assurance and data sharing between concerned agencies.

Police accident databases are often a component of larger Police databases and information is linked to driver and vehicle databases. This usually allows some amount of cross validation of information contained in the accident database.

The structure of the road accident data file varies between countries. In most of the countries, at least two sub-files are kept; an accident file and person file. In other countries there are separate sub-files for the vehicle and/or the road. Where files can also relate to other data there can be access to files of infrastructure, traffic volumes, registered vehicles, and the implemented improvements, for example. This was a relevant finding because, the intention in Abu Dhabi was to link accident data to other transportation information also part of the wider TIMS.

4.4 *Exchange of information/data between police and other agencies*

In all countries reviewed, the local highway department obtained accident data from the Police to carry out further analysis. This exchange of data was found to be done by three common methods;

- hard copy transfer (printouts),
- soft copy transfer (floppy disk, CD), and
- wide area network.

Wireless transfer methods were found to be increasingly used largely through dedicated radio channels, but Generalised Packet Radio Service (GPRS) and

Global System for Mobiles (GSM) were also being tested. From the countries reviewed, the only example found of an on line linkage of accident databases between Police, local authorities, hospitals, and other interested organizations such as research and statistics institutes was in Sweden.

4.5 *Analysis and reporting*

As stated earlier, in most countries only injury related or high value property damage accidents are reported and considered in general analysis. In all cases it is the local highway authority that takes the lead in carrying out such accident analysis, with a view to make subsequent improvements to the highway network or make other recommendations. The levels of analysis are largely left up to the individual highway authorities. However, minimum levels of accident reporting statistics are usually required to be presented to local or national level agencies, which may be provided either by the Police or the highway authority. All countries reviewed had a requirement to produce standard sets of accident statistical reports on a periodic basis.

The analysis systems and software being used by highway authorities vary considerably between countries, and also within countries and states. Many authorities are using systems which have been developed in-house over a number of years, but recent developments of accident systems and software, and the ability to link with other systems are leading many organisations to reconsider their approach by moving to proprietary GIS and asset management based systems. Where such special accident software was found in use, it fell into two categories;

- software components as part of wider asset management software systems, and;
- specialized accident analysis software for specific analysis such as collision analysis.

5 THE ACCIDENT MANAGEMENT FRAMEWORK

The studies of the existing situation in Abu Dhabi and the review of international practices were valuable in helping to formulate a new framework for accident data collection, referencing and analysis for Abu Dhabi. Clearly, the single most important item of data which needed to be improved, was the precise determination of accident location. In addition to this, many other opportunities were taken to propose improvements to the overall system, such as revision of the data collection form, use of electronic data capture techniques, revised databases and importantly, the development of an integrated framework on a GIS platform being developed simultaneously by others. We shall look at some of these key improvement proposals in the following sections.

5.1 *Improvement of the existing Abu Dhabi accident data collection form*

The review of international practice involved a detailed evaluation of respective national and local accident data collection forms from the countries studied in an effort to see the changes required in the Abu Dhabi accident form This exercise was very valuable in helping to modify the existing Abu Dhabi form to allow more comprehensive and codified data to be collected.

For each form, various data categories within the accident form were identified within a matrix, with each category being sub-divided into more specific data items. The existing Abu Dhabi accident form was evaluated by comparing the data parameters collected or allowed to be collected, against a matrix of all parameters provided for by all other international forms put together. Table 1 shows a list of all data parameters provided for by all country forms reviewed, and whether the existing Abu Dhabi form provided for the same data parameter in a written or coded format or was not collected at all. A total of 99 different data parameters were noted, which were provided for in all the accident forms put together. The evaluation showed that in Abu Dhabi, information on the roadway conditions, accident description and some key vehicle and driver details were generally lacking in total. However, when compared with individual country or State forms, the amount of information collected in Abu Dhabi was certainly comparable in quantity and type. The main differentiator was that in Abu Dhabi, of all information collected, only about 50% was coded, compared to for example in the UK where it was found to be around 90%.

Following this comparison, a study was made of the data which would be required to carry out the desired types of detailed accident analysis such as spot, area, cluster and sliding scale analysis. Parameters were identified which had to remain in the form due to legal and other reasons. By a process of reverse termination, a recommended set of final data parameters were identified which would need to be collected on the form. Therefore this resulted in the need to delete, modify or add parameters from the old form. At the same time, the opportunity was taken to codify as far as possible the parameters, rather than allow a written description. The logical progression of this revised paper form is the implementation of the electronic form. Currently the prototype paper and electronic form are being tested and are intended to be deployed later in the year.

5.2 *Accident location referencing*

In the urban high rise environment of Abu Dhabi, it was established that the most accurate and effective way of utilizing the available electronic data capture

techniques to determine accident location was the simultaneous use of a GPS receiver with a GIS map of Abu Dhabi. The GPS receiver would be fixed in the police patrol car, constantly displaying the location of the vehicle in real time on a GIS map stored in a mobile data terminal (MDT). The MDT would be mounted in the car and also could be detached, allowing the officer to use the terminal at the scene of the accident. Once the officer reaches the accident site, he would use the GIS map displayed on the MDT to reference exactly, the location of the accident with a pointing device. This would then represent a geo-referenced map coordinate in easting and northing which is much more useful then a GPS coordinate. Since the map is GIS based, all necessary road and surroundings features will have been stored in the map, thereby, relating the accident location coordinate to other features such as road name and number, sector name and number, or intersection name, and also surrounding landmark names. This method of accident location referencing achieves accuracy as good as the accuracy of the GIS base map, typically less than 5m in Abu Dhabi island since it is the GIS coordinate and not the GPS coordinate which is used.

5.3 *Data handling and storage*

The MDT has been designed to contain an easy to use electronic form, largely in Arabic, since this is

Parameter	Code
Accident Identification	
Serial No	C
Report No	C
Case No	C
Date	C
Time	C
Day of week	C
Accident Type	C
Investigating officer	W
Accident Location	
Region name	W
Locality name	W
Street name	W
Street number	W
Intersection number	W
Intersection Name	W
Distance from intersection/post	NC
Lighting column number	W
Accident location coordinates	C
Vicinity of accident location	C
Location classification	C
Intersection type	C
Roadway Information	
Median type	C
Road type	NC
Traffic controls	C
Road classification	NC
Roadway alignment	NC
Road surface type	NC
Road surface condition	C
Access control	NC
Speed limit	C
No. of lanes	NC
Environment Conditions	
Weather	C
Lighting	C
Vehicle Details	
Type of vehicle	C
Trailer type	NC
No. of vehicles involved	NC
Plate type	C
Color	W
Vehicle registration number	W
Registration expiry date	NC
State of registration	W
Gross vehicle weight rating	NC
Vehicle make	W
Vehicle model	NC
Tire condition	C
Year of manufacture	W
Insurance company name	W
Policy no. and expiry date	W
Vehicle owner name	W
No. of axles	C
Tinted windows	C
Cargo body type	NC
Hazardous chemical	NC
Point of first impact	NC
Vehicle speed during accident	W
Tire impressions	NC
Damaged parts	C
Extent of damage	C
Safety equipments availability	NC
Safety equipment function	NC
Damage of public property	W
Driver Information	
Driver name	W
Nationality	C
Age and sex	C
Profession	W
License no. and place of issue	W
Date of issue of license	NC
License status	NC
License category and expiry	W
Address	W
Phone number	NC
Educational level	C
Intoxication level	C
Alcohol test	NC
Physical Condition	NC
Use of seat belt	C
Injury Information	
Injured person category	C
No. of injured	W
Injured person name	W
Nationality	W
Age	W
Sex	NC
Address	NC
Hospital name	NC
Injury severity	C
Seating position	NC
Injury area	W
Evacuation means	C
Seat belt usage	C
Injury cause	NC
Accident Description	
Causes / factors	C
Vehicle action before accident	NC
Vehicle direction	NC
Vehicle location during accident	NC
Fire	NC
Pedestrian location	C
Pedestrian action	NC
Witness details	W
Sketch	W
Description	W

Table 1: Extent of data parameters collected or allowed to be collected on existing Abu Dhabi form
C=Coded, W=Written, NC=Not Collected

the language of familiarity of the police officers. A logical sequence of data entry is followed, with various help and prompt facilities. As learned from international practice, advantage is taken to codify the majority of the form with minimum requirement for long hand descriptions. As many fields as possible are automatically populated, by the entry of a single data item such as driver license or car license number, since the MDT will obtain in real time using a GPRS connection, from the Police main database, all the stored data related to driver license and vehicle registration. Range and logic checks will be in built, thereby maintaining superior data quality. Accident scenes or collision diagrams may be drawn by an in-built electronic diagramming tool. A rugged printer will also be available in the patrol car to allow the multi-ply printing of accident reports for distribution to the involved parties, as currently required under Abu Dhabi regulations. All relevant accident data therefore are entered and stored in the MDT. The sending of this data to the main Police accident database in real time using GPRS may be possible but difficult due to the current limitations on size and speed of data transmission. It is anticipated however that with the introduction of terrestrial trunk radio in the future, real time data transfer from the field to the central server could become efficient. In any event, the accident records entered can be downloaded from the individual MDT's to a Police accident gateway server at the Traffic Police at the end of the shift by means of a wireless local area network connection (WLAN).

The data collected in the field would then need to be further checked for errors and validated by trained quality assurance technicians. Accident data will be accessed through the gateway server situated behind the main Police data server. All editing and manipulation of accident data will be done in the gateway server, and only when all the information has been quality checked, will the final accident record be sent and written to the main Traffic database in the main server of the Police Department. As mentioned earlier, Abu Dhabi Police use the Oracle platform for their database functions and it was evaluated and decided to continue with this software.

5.4 *Data/information exchange*

Both the Traffic Police and the Municipality will require access to accident records to perform their required levels of analysis and reporting. The framework proposes to establish a wide area network (WAN) connection to allow the Traffic Police Department to regularly and efficiently send structured accident to the Municipality Roads Directorate. Due to confidentiality requirements, the Municipality will not receive the full contents of each accident records held in the database, but only a subset containing the essential parameters and information to allow it to carry out its own investigation and analysis functions. In return, the TIMS framework is set up to allow the Municipality to send other information such as traffic counts, which is useful to the Traffic Police for their operational duties.

5.5 *GIS platform and integration*

GIS is a fundamental part of the TIMS and AREST proposed systems, therefore it was necessary to develop the framework and architecture to accommodate this. Historical GIS mapping was available from different sources in Abu Dhabi but in different digital formats. Therefore mapping was converted and integrated to a common ArcView shape file format since this was the platform used by the majority of the sources. The Abu Dhabi Municipality and Town Planning Department are concurrently planning designing an enterprise wide GIS project, together with activities to update GIS mapping for the Emirate to a new base year. This GIS mapping within the overall enterprise wide architecture is proposed to be based on Oracle Spatial, but this would only be implemented sometime in the future. It was therefore decided that the AREST architecture should be designed to allow the current use of mapping available in ArcView and in the future to allow a conversion to Oracle Spatial whenever this was required. This approach was important to allow the AREST system to proceed in the immediate term with currently available GIS mapping in ArcView format but at the same time keeping it open to the Oracle Spatial platform for the future.

5.6 *Analysis and reporting*

Accident analysis and reporting is a very important function of the system, since it will involve the actual use of the designed and integrated tools. The primary method of analysis and reporting will rely on the inherent capabilities of the two fundamental software platforms used in the architecture; the GIS platform and the database platform. ArcView and Oracle have powerful query, spatial and relational analysis and presentation facilities which will allow the majority of the detailed accident analysis and presentation to be done. The framework therefore will utilize these inherent features but at the same time it will also allow the integration of commercial software which can also carry out similar functions and more. Such further detailed analysis can be done using a suitable proprietary software program which is also compatible with the GIS and database platforms. There are a few such software available which can be used for this purpose. Therefore the software and framework architectures have been left open to allow such proprietary analysis software to be integrated into the overall system. It should be

borne in mind that historically very little study of accidents has been possible in Abu Dhabi due to the problems previously detailed. Therefore it is anticipated that even general analysis of accident patterns, on an area, corridor or junction level, will greatly assist in designing and implementing countermeasures, which should yield improvements in road safety for relatively little investment.

5.7 *Summary of system framework and architecture*

The previously detailed procedures and systems, can lead us to a general framework and architecture to integrate the various components and functions of the proposed system. There are essentially three major locations for activities in this framework; the accident site, the Police office and the Municipality office. Activities at the accident site will center around data collection using either the new paper or electronic forms. Activities at the Police office are centered around data verification, quality assurance, and storing in the main accident database. Activities at the Municipality are centered around obtaining the filtered periodic accident data for detailed analysis, and providing in return other data useful to the Police such as traffic count data.

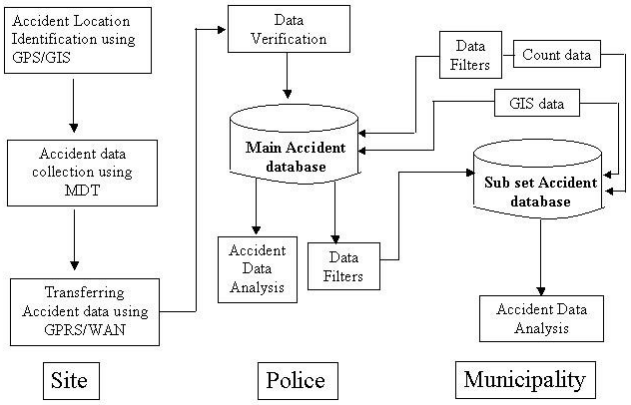
The system architecture will allow for the collection of data either by electronic (mobile client) or paper based means. In the case of the latter, the hard copy data will be transferred to a desktop client back at the police office. From the field GPRS is the preferred technology available for data transfer. In case of loss of availability of GPRS at the site, then data will be saved to storage media within the MDT and downloaded later. Accident location will be determined using a GPS receiver to generally locate the position, and then using the GIS map stored in the MDT to accurately geo-reference the accident location. A diagramming tool is included in the electronic form, which will allow the quick drawing of the collision using pre-prepared road layouts, templates and icons. The resulting diagram will be linked to the accident record and referenced to the accident number.

The key activities at the Police office will be the accurate transcription of the paper forms if used, and if electronic forms have been used, then data will need to be downloaded and further quality checked and assured before final writing and storing to the main accident database. It is only after this process should any analysis on the data be carried out by the Police.

The proposed framework also allows for the integration of the accident hospitals in Abu Dhabi, where it is intended to equip the existing police desks there with a work station connected by GPRS to be able to transmit data to the accident database. This will allow information relating to casualties which may change over time to be entered from the hospital police desk, thereby keeping the database up to date. This procedure should thereby reduce the instances of underreporting of fatalities mentioned earlier.

Accident data will be accessed by the Municipality through a WAN, but only for those fields which are required for detailed analysis, since there will be some confidential information contained in the main accident database. The Municipality is then in a position to carry out detailed analysis using the improved data set and the newly available tools based on the GIS, database and specialized analysis programmes. The generalised architectural framework for AREST is shown in Figure 2.

Figure 2: Generalised AREST Architectural Framework



6 CONCLUSIONS

A review of the existing situation and practices in Abu Dhabi and also across other selected countries has contributed in formulating a new framework for a system of accident data collection, management and analysis in Abu Dhabi. A fundamental parameter in accident data collection is the accident location. A method has been devised to be able to accurately determine and record this information in the Abu Dhabi context. It has been demonstrated that improved automated and electronic procedures do have a place in the overall processes. The benefits of this should ensure greater accuracy, better quality assured data and better efficiencies. Basing the system on a GIS and structured database platform will also offer the appropriate analysis and reporting tools. The level of success of the implementation of this new framework depends on various factors including the speed at which the authorities can adopt and adapt to the new system. One thing is sure in that it is vital to make up for the significant time lost over the years in being able to accurately collect and manage accident data as a primary means to help in the improvement of the road safety situation in Abu Dhabi. The framework and system proposed should go a long way to help achieve this goal.

7 ABOUT THE AUTHORS

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