GIS based Traffic Accident Analysis System

Ranya Fadlalla Abdalla Elsheikh[1,2]

[1] Department of Geographic and GIS, Faculty of Arts & Humanities, Women Branches, King Abdul Aziz University, Saudi Arabia

[2] Department of GIS, School of Survey, Faculty of Engineering, Sudan University of Science and Technology

Abstract— *In Malaysia, every year over thousands human beings die and tens of thousands are injured in road accidents. This paper focused on the goal of developing tools and methodologies to reduce accidents, and to make roadway safer, through the ability to better interpret accident records and to provide more information for individuals to evaluate accidents. It founds that the customization of GIS application for Traffic accidents analysis could be performed using Map Object and visual basic 6.0. This integration produced expert system provides wide range functions in low cost programming.*

Keywords— Accidents, Analysis, GIS, Map, Object.

I. INTRODUCTION

In Malaysia many efforts has done in order to reduce the number of accident occurrence through several modes of campaign. Unfortunately, from years to years the number keeps increasing [1]. The details of accidents Malaysian were recorded by the Royal Malaysia Police. Accident reports are prepared in textual format renamed by Pol27. Pol27 form contains about 99 items information covered different aspects of accidents such as location, vehicle information, weather describes, crash causes, road condition, crash type, peoples affected, and the fatality of the accidents. This situation makes it difficult to analyze accident results and identify the relation between factors. Many studies have been made to analyze accident data through various statistical means and models [2, 3, 4]. Others studies introduced GIS only as a visualization tool for accident locations (5,6,7).Few of studies used GIS as a management system for accident analysis and determination of hot spots [8]. Traffic accident analysis system is necessary to make road safer. It can be used by accidents researches agencies to evaluate the current situation and provide solutions for better future. In this paper computer based system for traffic accidents analysis was developed based on GIS and Map Objects. The Map Object were designed by ESRI can compile to produce mapping tools, queries, searching, recording and retrieval tools for spatial data management. The system provided spatially referenced representation for accidents locations, and performed graphically representation for the hazardous places on the roadway network. The system

analyzed accidents statistically and provided charts and thematic maps for eleven accidents categories. Hazardous locations determined in two different methods. Severity index that was performed using widely accepted statistical procedures [9, 10]. The total number of specific accidents types that's occurred and the average cost of accidents were calculated in particular location. The severity index calculation provided the ability to identify specific roadway segments or specific nodes that would be candidates for infrastructure improvements. The system provided selection operation through query builder or spatial selection. Exploring individual's accident or nodes have been done through accidents attribute table and through node information module that were provided summary information.

II. METHODOLOGY

2.1 System Design

The main form contained two map objects components. One is map display control to display the map, and the other is map legend control for layers management. There are three different information windows: accidents attribute table, picture boxes for crash image and type, and list component for listing results from various operations (Fig. 1). In addition there are three frames three frames:

i) First frame for adding, removing layers and, accessing to Pol27 manager form, query builder form, and statistics charts form

ii) The second frame for displaying an accidents on a map in different categories by easy selection the desired type

iii) The third is severity indices frame, the user can select Road or Intersection for Severity calculation, and plotting general severity, or specific severity over fifteen different choices.
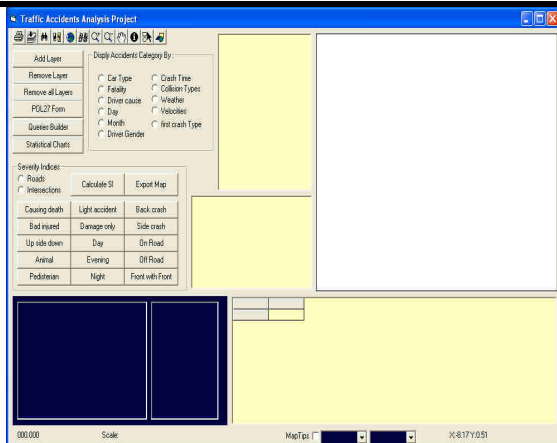
Fig. 1: Traffic accidents analysis project main form.

The system architecture design (Fig. 2) shows that most of the forms can be accessed directly from the main interface, and all modules interact with the map directly except statistical charts module, the interaction could be by highlighting the accident or node positions on the map automatically while some operations in other module related to that position was performed, the project designed to easy interact with user, so by selection on map the accessing to accidents or nodes identification can be done.
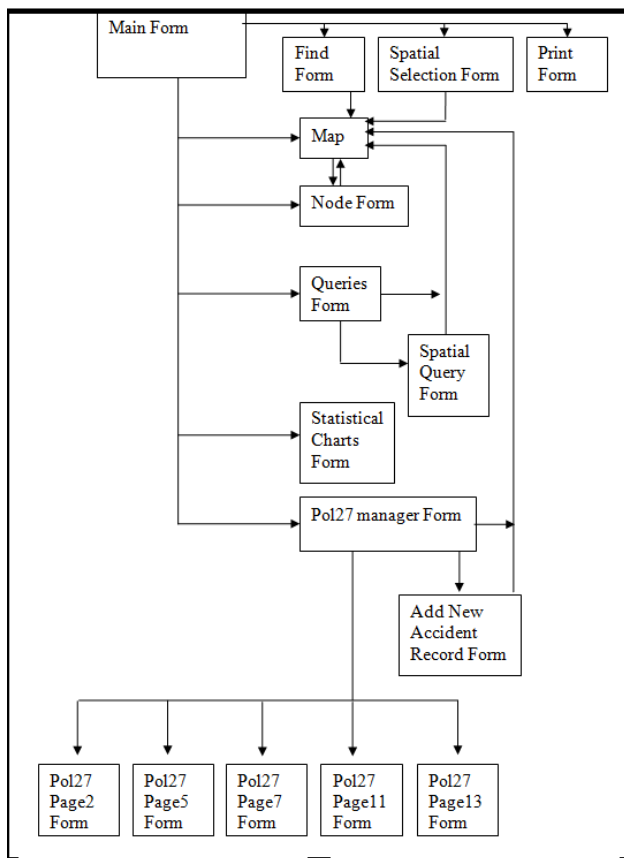

Fig. 2: System architecture design, forms and relations.

The system used Legend control to manage and display layers with its categories, layers can be in On/Off mode,

and can arranged as well as users preference, Map Object can represents layer categories in different colors as in (Fig. 3)
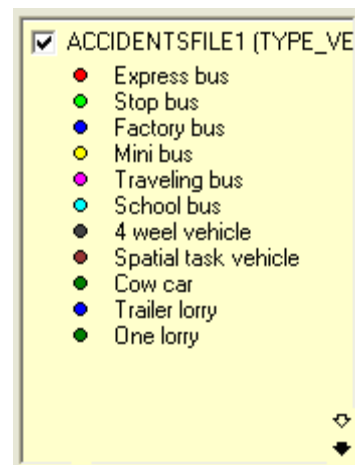

Fig.3: Legend control.

2.2 Accidents Categories Displaying
Accidents can be graphically displayed and classified on the map based on eleven different accidents fields (Fig. 4).
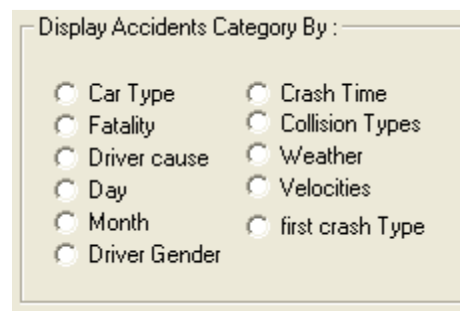

Fig.4: Display accidents by category

2.3 Severity Indices Calculation Function
It's possible to determine the number and severity of the accidents on specific roadway segment and Intersections, each roadway segment or node will have a severity index. The methodology for computing the severity index based on causing death, bad injured, light accident and damage. To develop a roadway severity value for the individual roadway segment or node, it is necessary to combine the accidents into an aggregated total using the potential monetary value of the accident as a unifying factor.

SI was calculated based on the cost of crashing fatality types, (F)causing death , (A)bad injured, (B)light injured, and (C)property damage, the calculation methodology based on the coefficients in the equivalent property damage (EPD) and Severity Index (SI) equations

$$F\& A \ cost = \frac{(Causing\ death\ crashes)(Cost\ causing\ death) + (Bad\ injured\ crashes)(Cost\ bad\ injured)}{Causing\ death\ crashes + Bad\ injured\ crashes} \quad Equation\ (1).$$

The coefficient of F and A cost is calculated by Equation (2)

F& A coefficient = (F& A crash cost) / PD crash cost Equation (2).

The coefficient of B and C cost is calculated in the same manner. The EPD is calculated by Equation (3).

EPD = F&A coefficient(F+A) +B&C coefficient(B+C)   Equation (3)

The Severity Index (SI) is obtained by dividing the EPD by the total number of crashes (N) as indicated in equation (4)

SI = [F&A coefficient (F+A) +B&C coefficient (B+C)]/N. Equation (4)

The severity indices developed to be calculated for all roadway segments and nodes, and displayed on the map, the higher the severity index the greater the accident impact on the people of the community. Hence, the system designed to ranking and listing severity indices from highest to the lowest. The segments having the top ranks (high indices) were considered as the hot spots. Actually, the ranking will be in three ranges, high, medium, and law severity, the highest will be in red color, the medium in orange, and the law severity in yellow color.

The Fig 5 shows that user has to select calculation on roads segments, or intersections to start SI calculation, the first result will be general severity indices using the previous equation, the system able to calculate severity indices based on one factor only, and the severity calculates in this case by the frequency of occurrence of specific accident type in the same location, the project provides fifteen different types accidents for severity calculation.
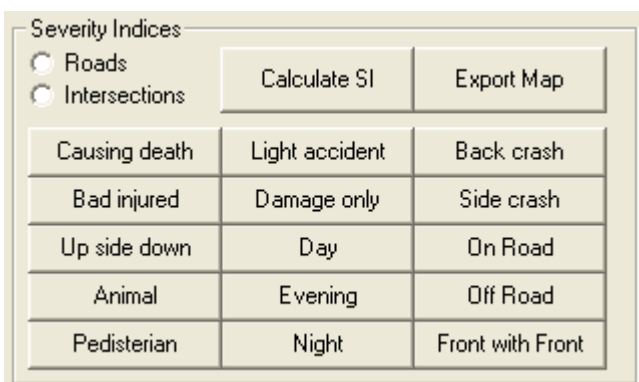

Fig. 5: Severity indices calculation tool.

2.4 Attributes Table
Project used grid table control to display and explore accidents records, by double clicking on the layer name in the legend, the table automatically filling the data, by selecting one accident record's from the table, the exact accident feature flashing on the map, and vice versa.

2.5 Accident Images

An accident image is the tool developed to improves the informatics nature of the system, its provide crash results picture, images used in two places in the project one to display accidents and other to display intersections pictures.

2.6 Collision Types Displayer
Collision types are the simple diagrams to simulate and describes how accidents was occurred, the system considered that the nine comprehensive types are covered the common accidents scenarios as in Fig. 6
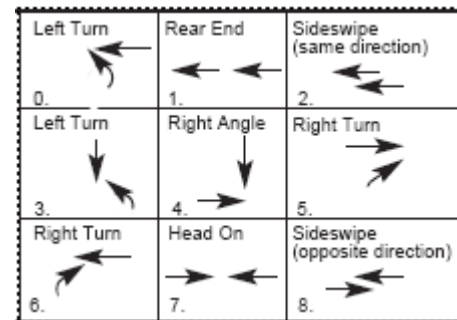

Fig. 6: Collision types used in the project.

The system accept from users the number of appropriate crash scenario, the system associate collision type image to the record under the field (coolis_t) on the attributes table.

II.7 New Accident Module
Add new accident record button leads users to another module (Fig. 7), basic information about the new accident can be entered through this module, the user must enter new accident report number, then pick on the map on exact location by following the coordinates bellow main form, then correct the coordinates manually in the entry form, or by entering the known coordinates directly, the accident point's appears automatically in the map on the selected location, and new record will generates in the same time
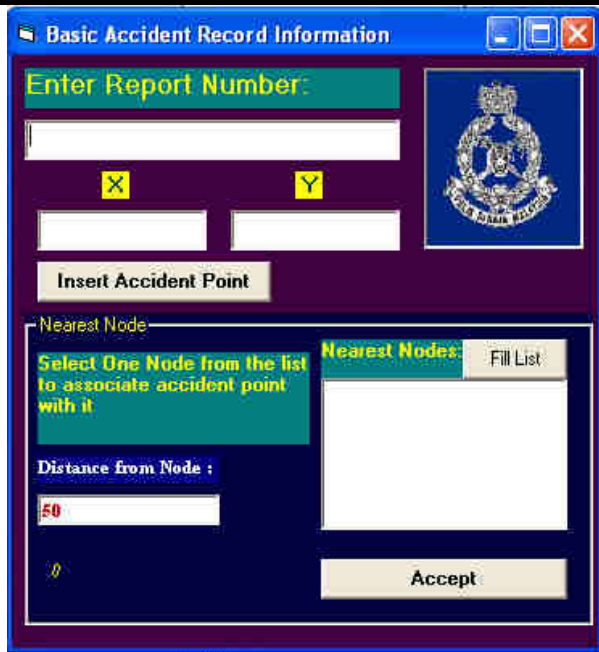
Fig. 7: Basic accident record information module

2.8 Pol27 Pages Modules

Pol27 form contained about 99 different information about the crash accident, details information about drivers, vehicles, road conditions, weather, location, accident causes, injures, pedestrian, and many details related to accident, rich and real information leads to accurate and confidant analysis.

2.9 Queries Builder Module

This module was designed to perform unlimited queries on each layer over all fields through some Boolean operations. It allows users to generate simple or compatible queries, and select the results and exports selections to a new layer. Determination of specific accidents conditions and analyzing the causes behind the accidents can be achieved by this function.

2.10 Spatial Query Module

Spatial selection was designed to select sets of accidents where are within some counties or administration areas this kind of selection can't be done from attributes query, because it's based on the features locations and geometry, using topological situation of the features, the selected accidents set can be exported to a new layer.

2.11 Statistical Charts Module

This module produces statistical charts in two types bar and pie styles. It produces statistics in percentage ratio from the total number of accidents recorded on the data set.

2.12 Nodes Information Module

After calculating (SI) for nodes, the system generates nodes information form that allow users to explore all nodes, whether contained accidents or not. The form displays accident number, and the severity indices on the node. The module produces strict statistics for accidents where occurred on the node, and provides four pictures for each node.

III.   RESULTS AND DISCUSSIONS

3.1   System Implementation

A subset of Chow kit, City center, Golding triangle, Kg baharu, Mahameru area selected as case study. The upper right corner of case study area tied in coordinates 800621.21, 349733.87 m, and the lower left corner in coordinates 799328.32, 348997 .41 m, in UTM WGS48). Case study contained 57 accidents occurred in five months, distributes on 23 nodes over five residents areas. All the requirements information about the case study was added to the system.

Exploring accidents categories distribution, by selecting fatality from category frame, the legend shows that three accidents caused death in the case study (Fig. 8). In addition statistical chart was generated as in Fig. 9 and Fig. 10.
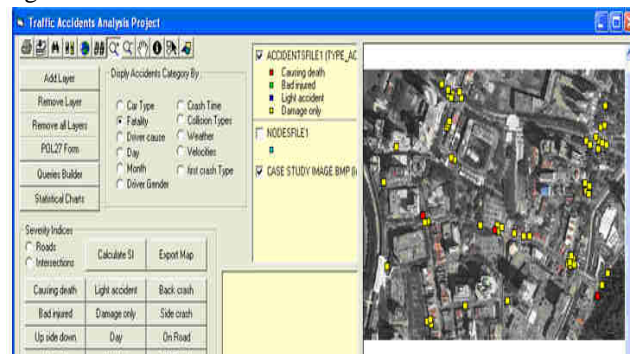

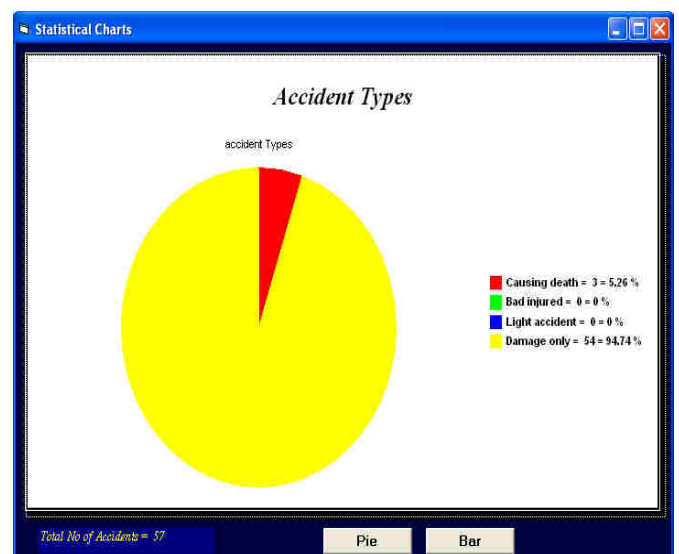*Fig.8: Accidents distribution based on fatality factor in the study area*

Fig. 9: Statistical chart for accidents fatality on the case study
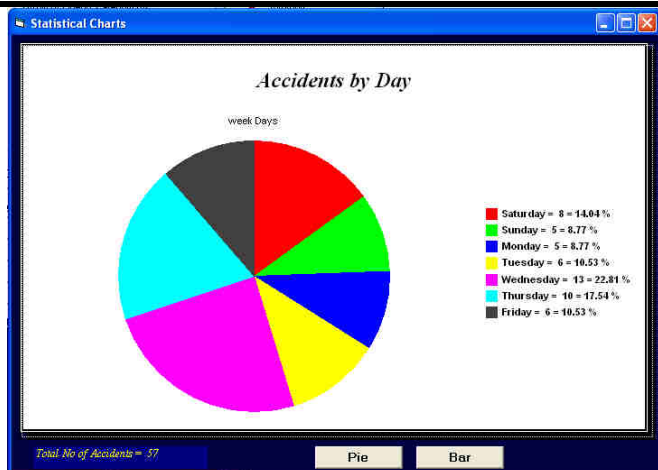
Fig. 10: Case study accidents chart presented based on the day of week

The system can analyze the accidents occurrence based in many other factors such as day, evening, and night. The severity index was calculated to indicate the worst nodes on each character day, evening, and night.

The map in Fig. 11 shows the three hazardous nodes locations. The red color and large size , are the worst places , the orange is the medium severity , the smallest and yellow color are the lowest severities , the severity indices value vary from 1 to 300, based on the average cost of the accidents.
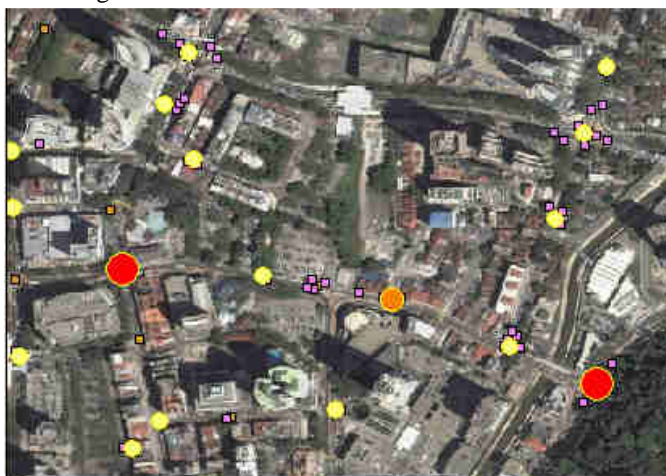

Fig. 11: The three hazardous locations on the case study.

The program ready to receipt the accident coordinates whether by specifying the location on the map directly following the coordinates with the cursor moving, or by entering the coordinates directly in the x, y fields in the form, in this case the project was entered the accident coordinates on the form.   The coordinates was entered are (799694.88, 349324.27), and the new accident report was indexed under the new number: 2200200501400 .

The system provides search operation for the nearest nodes, based on GIS buffering function, the system ask the users to specifying buffering distance to perform

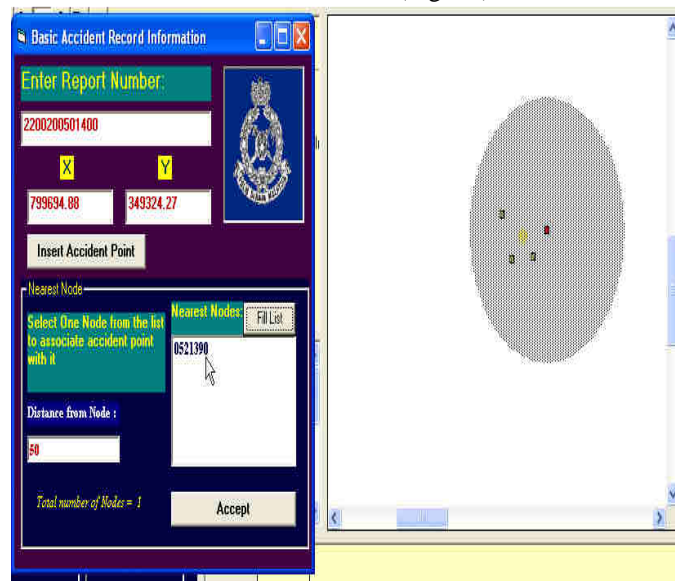search operation for which nodes are within the buffering distances from the accident location (Fig. 12).

Fig. 12: The new accidents point in red color, and the nearest node within distance of 50 m in yellow color.

The system found that within 50 meter buffering, the node number (0521390) was the only intersection point. The system accepts the result and associates an accident to this node. The new data was updated automatically to pol27 record (Fig. 13).
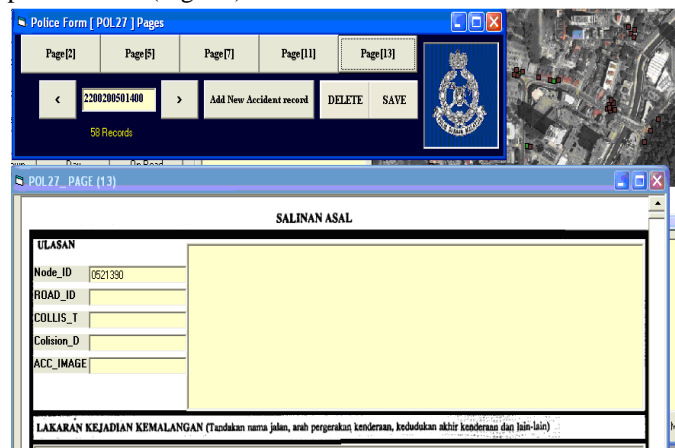

Fig. 13: The new accident record index number and the related node appeared in pol27_ page 13 form.

3.2 Validation

Excel program to examine the correctness of (SI) calculation was developed. The results of the cases which were discussed above, shows that (SI) values in the system have been matched with (SI) calculated in Microsoft Excel

The current software was compared with TRAP_RAVGI for further validation. TRAP_RAVGIS v1.0 is software developed by Road Safety Research Center and University Putra Malaysia in 2004, the program helps to identify accident black spots, and investigate accident

cases. It has three main functions which includes Information update, Black spot identification, and Case investigation. The result of implementing TRAP_RAVGIS package indicated five evaluation levels of fatality risk based on the fatal accident ratio on the node (Fig. 14), and this ratio doesn't plotted on the map. The number of the circles around nodes represents the number of the accidents on the nodes not the fatality risk level, in this system the severity level presented on the map, and the number of accidents on the node shown in the node information module (Fig15 & Fig16).
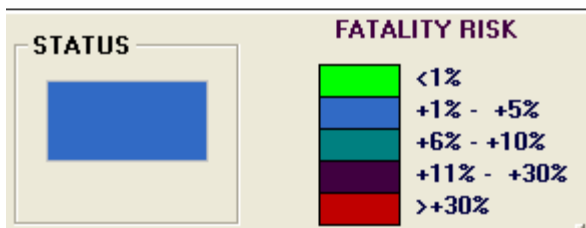

Fig.14: The fatality risk levels in (TRAP_RAVGIS).

TRAP_RAVGIS provides an accidents reports and nodes information in two pages in one form, accidents main details page and nodes photos page (Fig.15). This project provides nodes information module that represents severity level and statistical charts. The statistics covers accident fatality, accidents times, types of first crashes, and vehicles types, rather than four pictures for the node site (Figure 4.19).
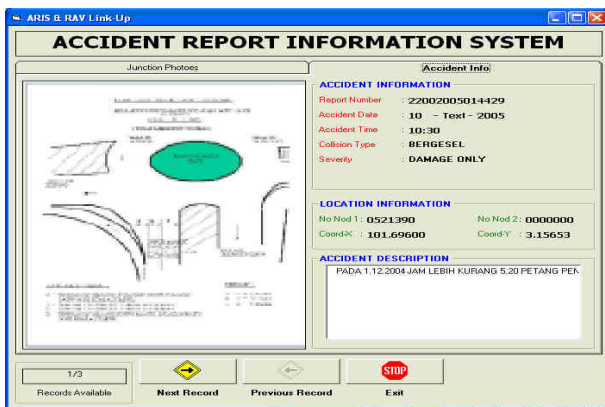

Fig.15: Accidents report information system in (TRAP_RAVGIS).

Fig. 16: (TAAP) nodes information module.

Road Accident View Analysis package (TRAP_RAVGIS) provides district accidents summary charts focused on four accidents characteristics, severity, collision type, time, and vehicle type, the charts in bar type only and represents the number of accidents for each category. In this system eleven accidents statistical charts can be done, the statistics performed for the active accidents data set, the charts could be in bar or pie style as the user preference, and its represents the statistics in percentage. The system has the capability to represents accidents locations independents on the nodes locations or roads interpolated centers (Fig. 17). In addition the accidents could be located anywhere on the map based on its coordinates. Statistics analysis can be performed through attributes tables.
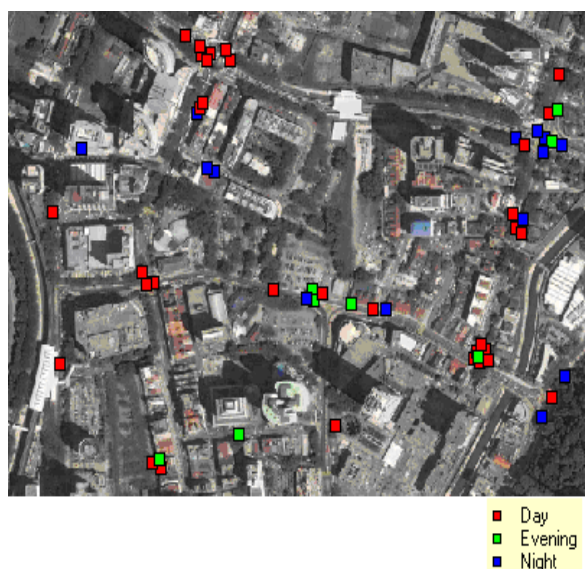

Fig.17: Accidents locations based on its coordinates, represented by crashing time.

IV.   CONCLUSION

This project performed computer based system for traffic accidents analysis dealt with GIS MapObjects. The map object were designed by ESRI can compile to produce mapping tools, queries, searching, recording and retrieval tools for spatial data management. The system provided spatially referenced representation for accidents locations, and performed graphically representation for the hazardous places on the roadway network. This system provided selection operation through query builder or spatial selection. Exploring individual's accident or nodes have been done through accidents attribute table and through node information module that were provided summary information. Pol27 used as background on the attribute input output module to perform familiarity with police officers. The severity index calculation provided the ability to identify specific roadway segments or specific nodes that would be candidates for infrastructure improvements.

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