



GIS Applications for Road Network of Port Said, Egypt.

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ABSTRACT

There is no doubt that one minute can save a human life. Emergency services such as ambulance, police, and Fire Bridge are among the most important applications of Geographic Information System, GIS. ArcGIS is considered a powerful tool that allows decision makers to view, understand, question, interpret, and visualize data at any road problem. Such a model for Port Said road network could be created to solve complex constraints, e.g., traffic congestion, population, and road capacity. Such problems have become crucial for traveling on roadways. Integration of GIS/GPS/GSM enabled Port Said emergency system to get the fastest path for drivers.

KEYWORDS: GIS, network analyst, GSM, emergency services, fastest path

1. INTRODUCTION

Human life may be saved by one minute by providing him with faster medical assistance. Developing emergency system could achieve an improving transport services to reach destination in least possible time [4, 6]. Using a built-in system in ambulance could save patients life and solve roads' problems [5].

GIS plays the major role to store data and make a full database which has an ability to display results and solve routing problems [1, 8].

Fire accidents require flash decisions to make fire trucks reach to scene faster to extinguish the blaze and prevent spread of fire [12]. Police presence is important to investigate incident. Finding out causes of accident and recording all information about incident, e.g., accident time, position of incident on road network, and number of infected people or deaths. Recording accidents data are useful to make statistics about frequency rate and most accidents locations on Port Said road network. In this paper, the factors affecting on fastest rout as a result of road and traffic conditions will be presented, analyzed, and discussed. Obtaining a full database of road network will help the integration system of GIS/GPS/GSM to solve most of road problems [7-9-10].

1.1 Port Said Data Collection

ArcGIS Network Analyst is a major tool used for getting the fast solution of the optimum route for the drivers of emergency vehicles [2, 3]. It requires specified and detailed information of Port Said

network to build a GIS database to be used to solve roads problems.

Creating and building a correct database of Port Said needs collecting data from many sources and monitor its changes regularly. Changing and updating these data depend on many factors such as using a modern technology for monitoring roads, traffic volumes, and accident rates.

Creating a network database of Port Said requires:

- A digital map of Port Said road network.
- Descriptive information of the daily traffic flow and monitoring peak hours.
- Official statistics that explain the number of accidents, crimes, fires, and the frequency rate of occurrence.
- Detailed information about roads (name, one or two way, speed limit, length, width, and type).
- Locations of hospitals, ambulance Stops, police stations, Fire Bridge stations, and their surrounding streets.
- Using GPS technology.

2. METHODOLOGY OF AMBULANCE SYSTEM

2.1 The Fastest System

The fastest ambulance system depends on enabling nearest ambulance driver to reach to accident location using the fastest route [4]. Transporting patients to the nearest hospital using fastest route, taking into account road conditions, is illustrated on Figure (10).

When an accident occurs on road network, the central emergency station receives a call from an accident witness. The information delivered to the central emergency operator depends on the witness ability to gather and describe accurately the accident. These information may include (type of the accident -

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how happened - accident location - how many people were injured and their statue and mortality - is there a fire scene). Then the operator records all data and immediately makes an address query using Arc Map to find the exact position of the accident on the map.

For fast ambulance service, a GPS receiver must be installed in each ambulance vehicle to determine its real-time position (E, N coordinates) by the signal transmitted by satellites. Then, the operator immediately begins to locate all the closest ambulance stations and select the nearest one to the accident position using the ArcGIS Network Analyst tools. Zooming all the surrounding routes on maps which lead to accident location, the base station will directly guide the selected ambulance with accident location to move to it directly. Driver will be guided by the fastest route and its direction with dispatching information about road case and traffic conditions. This reduces the dependence on experience of driver of roads conditions e.g., traffic jams and the common problems which happened in many roads to reach the scenes in time [3, 7].

Locating the nearest hospitals using the fastest path achieved at the same time of locating the nearest ambulance stations. So the base emergency station is considered the source of basic geographic and spatial information of road network and its public facilities (Figure 3, 4).

The support of the traffic control room, exchanging data and reports of road conditions, traffic flow, and traffic congestion at peak hours, to the emergency base room is very useful for choosing the best way to access the incident and alternative routes if any problem occurred on the network.

2.2 Data Exchange

Since each ambulance vehicle has a GPS receiver to determine its exact position (longitude, latitude, time, speed) at real time using satellites signals, the vehicles must be equipped with a computer with software of GIS and Network Analyst and mobile device.

The data is transmitted from the ambulance vehicle position to the base emergency station by a wireless network like Wi-Fi. Such a protected network is similar to Wi-Fi protected access (WPA) that should connect all sectors in Port Said city. Exchange data between emergency sectors requires integration of different communication systems. GSM (Global System for Mobile Communications) is a special communication network which provides a powerful messaging service that enhances and facilitates roaming through automatic network location detection and registration [9]. GSM used as a communication platform in GPS based vehicle monitoring system because of its high frequency, capability, wide coverage, and open interface, Figure (1) [10].

The nearest ambulance driver will receive a road map by wireless network. Map should contain the fastest route data to guide driver to get to his destination. These stored data include exact accident position, nearest hospital, and the chosen fastest route from ambulance station to the accident as well as from accident to the nearest hospital, (Figures 5, 6). At the

end of the journey the patients reaches to hospital at the shortest possible time to receive the medical care necessary to save his life.

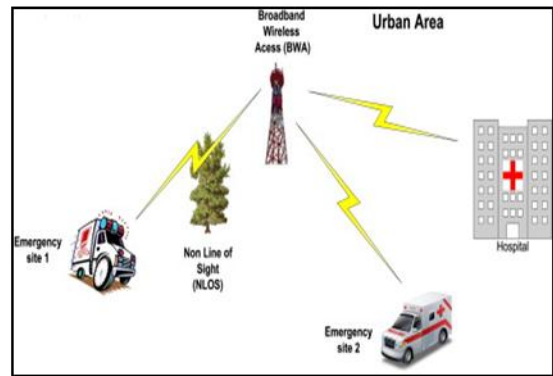


Figure 1: Ambulance system

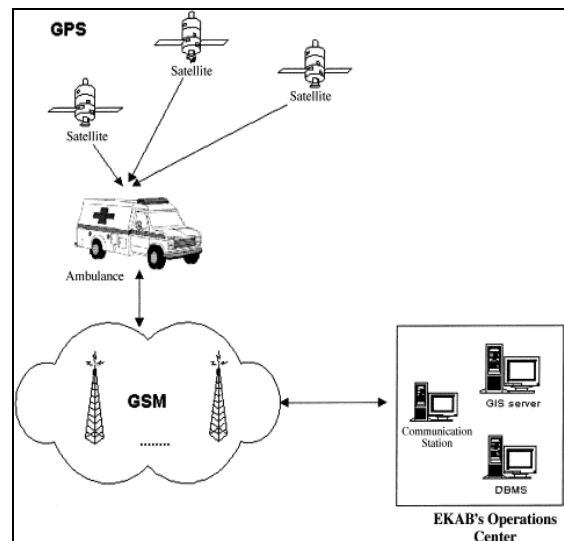


Figure 2: GPS/GSM system

3. GIS DATABASE

The process of analyzing and displaying results needs accurate spatial database [1]. Information from traffic control room helps users to get the optimum path using ArcGIS Network Analyst, e.g. (speed limit, traffic volume at peak hours, traffic flow, and traffic jam in roads which impedes the movement of an emergency vehicle, traffic signals, accident on roads, turns, and intersections). Police reports are also considered important to gather data which include recorded accidents happened on roads, accident locations of major or minor roads, accident occurred time, and causes of accident .

Data will be stored and classified within attribute tables for each feature as follows:

1. Road network (name, speed limit, one way, length, drive time, major road, minor road).
2. Ambulance station (ID number, name, and label).
3. Hospitals (ID, name, label, and type).
4. Accident, (ID, cause, time, date, and nearest landmark).

4. TIME PERIODS FOR APPLICATIONS

Time periods on Port Said road network change as a result of changing reasons. Variation of traffic conditions and rush hours throughout the day affect on time periods [4]. Some other factors affect the time periods, such as coming and departure times of employers and pupils. The people culture is also considered influential factor, that some people don't respect roads rules and traffic laws, e.g. (lack of respect traffic signals, speed limit, and emergency vehicle's alarms). Roads maintenance and digging works will increase vehicles accumulation on roads. These reasons increase rate of traffic accidents and make citizens live at risk.

In rush hours, traffic congestion may grow leading to traffic jam and gridlock especially on main roads. Speed decreases to 5 km/hour and may reach to 0 km/h in some streets. Drivers couldn't path from these streets in critical time and alternative paths must be identified. Emergency drivers prefer to use only the main road to reach directly to hospital in normal time.

5. APPLICATIONS FOR POLICE AND FIRE STATIONS

Road accidents are often accompanied by explosion and fire that need fast reach as soon as possible to prevent fire spread to surrounding areas. Police must be present at the scene to make all necessary legal procedures to ensure that citizens' rights must be kept. Similarly when a crime occurs at any area of the city police must arrive quickly to crime site to rescue citizens and prosecute offenders. So there is no doubt that saving time by using fastest path is the main factor in the emergency system for police and Fire Bridge to reach their destinations, Figure (11, 12), [12,13].

Both police and fire drivers follow the same model of fast ambulance for getting nearest police or Fire Bridge station to accident or crime location.

6. APPLIED GIS MODEL IN PORT SAID

Port Said GIS model which has been applied on its network assumed that an accident occurred in El Nasser Street in El Arab district. This street is considered main and vital road as it contains the markets area leading to traffic jams especially at peak hours. Such street makes emergency drivers stuck in traffic and face difficulties when an accident occurs. Thus, quick decisions must be taken to overcome problems and make drivers reach quickly to the scene using GIS. First operator begins to find the nearest ambulance stations and hospitals from accident site using network analyst setting analysis (Figure 3, 4). In this model, the closest facilities were determined to reach within 2 minutes at most; the result was El-Kuwait ambulance station which was reached at 1.4 minutes. The two nearest hospitals were El-Tadamon hospital and El-Mobaraa hospital with drive times of 1.85 minutes and 1.98 minutes, respectively (Fig2.1).

The chosen ambulance driver will be informed with accident location and the fastest path which allow saving time as possible to reach location. Fastest paths have been gotten by operator of emergency base station using GIS (Figure 5, 6). Similarly, this model will be applied to the rest of emergency services as police and fire bridge stations. Drivers will be guided with information of nearest police and fire stations and the calculated fastest routes from an accident position. The case of more than one accident occurring at the same time in different locations was assumed at El-Zohor, El-Manakh, and El-Dawahi districts. The nearest police stations have been calculated as follows , Figure (9):

- For the first accident, El-Zohor police station was the nearest.
- For the second accident, El-Manakh and El-Arab stations were the nearest.
- For the third, El-Dawahi station was the nearest police station.

All the nearest police stations depended on maximum drive time of two minutes. The fastest paths are shown in Figure (10).

Similarly, the example of GIS model of Fire Bridge is shown in Figures (11 and 12).

7. DISCUSSION and CONCLUSIONS

Emergency management system plays an important role to solve many roads problems. Port Said city suffers from population growth and traffic congestions which have bad influence on emergency system. Using GIS Network Analyst helps in analyzing data and getting roads solutions. Closest facilities, fastest routes, and alternative paths have been obtained to reach to emergency destinations (Figures 9, 10, 12 and 13). An integration system of GIS/GPS/GSM to find location of drivers in the real time and send routing information between emergency unites, Figure (7) was applied. Also, when more than one accident occurred at the same time in different locations, the same scenario of fast emergency system can be applied.

The applied models have led to the following results:

- The primary goal of this model is the development of emergency service in Port Said; makes it an integrated fast system which will be more useful for citizens.
- Importance to remember that the fastest path is not always the shortest path, depending on road conditions and traffic flow, it is possible that fast journey takes more time than shortest one, but it will reach first to its destination because no traffic congestion prevent traveling when users take the fastest path.

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Attribute	Value
ObjectID	14
FacilityID	5
FacilityRank	1
Name	accident - التضامن
IncidentCurbApproach	1
FacilityCurbApproach	1
IncidentID	1
Total_Drive time	1.854628

Attribute	Value
ObjectID	15
FacilityID	6
FacilityRank	2
Name	accident - المبرة
IncidentCurbApproach	1
FacilityCurbApproach	2
IncidentID	1
Total_Drive time	1.980925

Figure 2.1: Closest hospitals drive time.

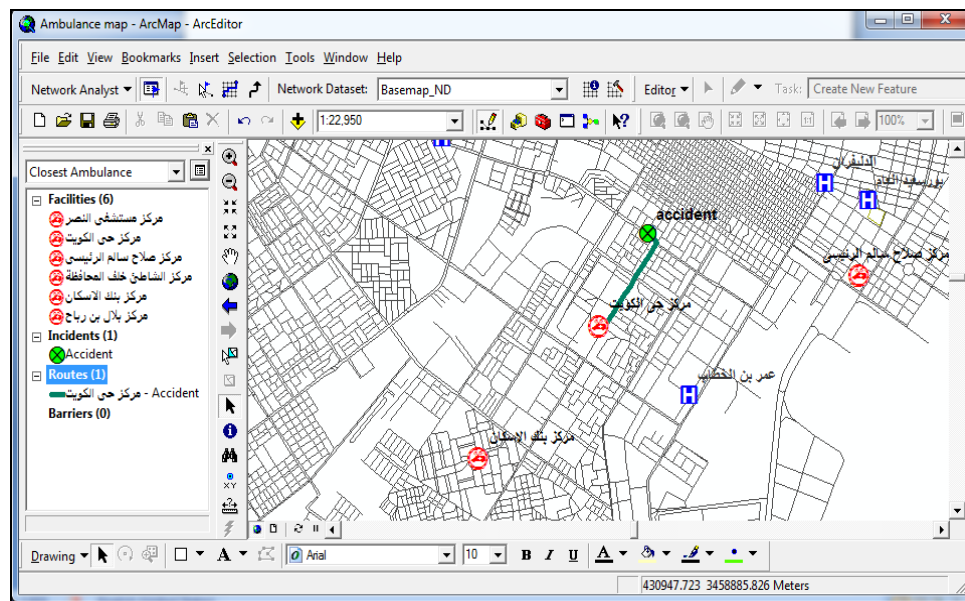


Figure 3: The nearest ambulance station, (El Kuwait station).

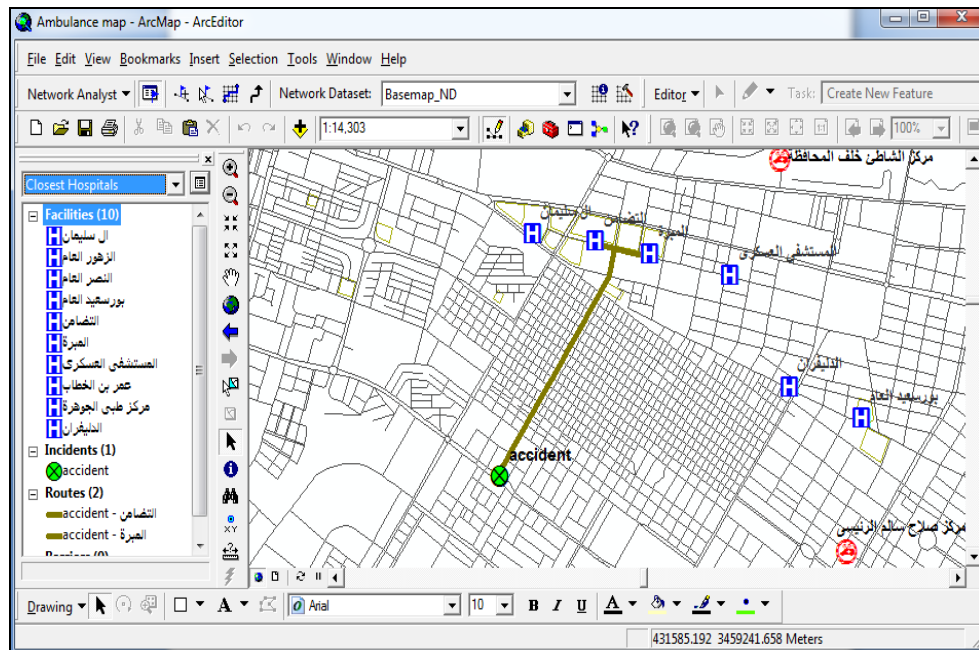


Figure 4: The nearest hospitals from the accident (El tadamon and El mobaraa hospitals).

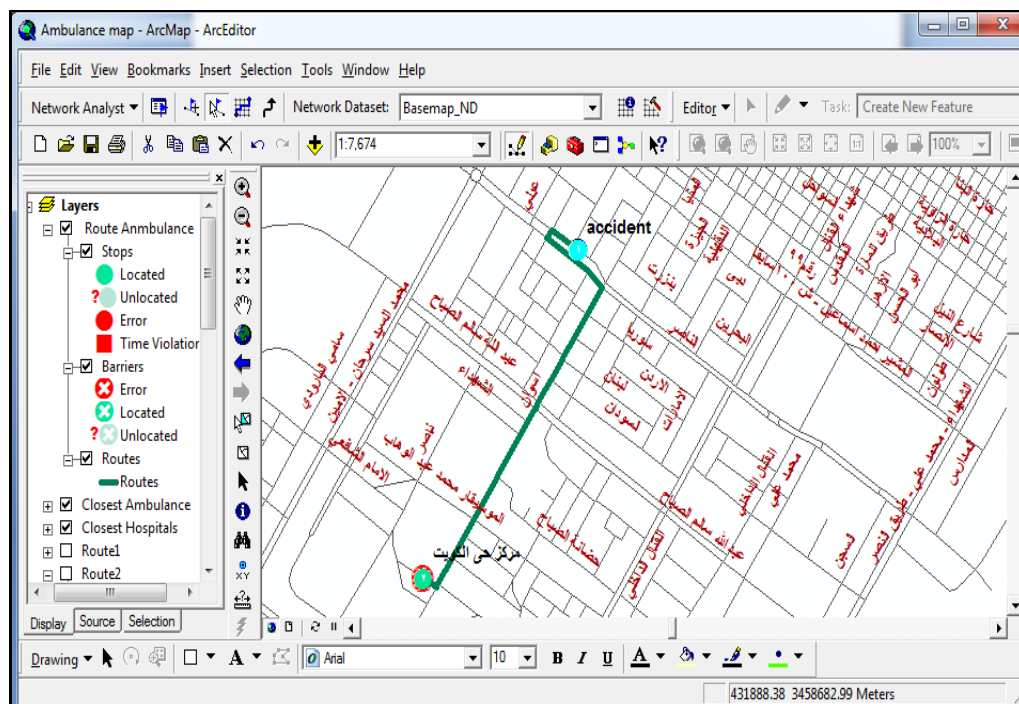


Figure 5: The fastest path from EL Kuwait ambulance station to accident location.

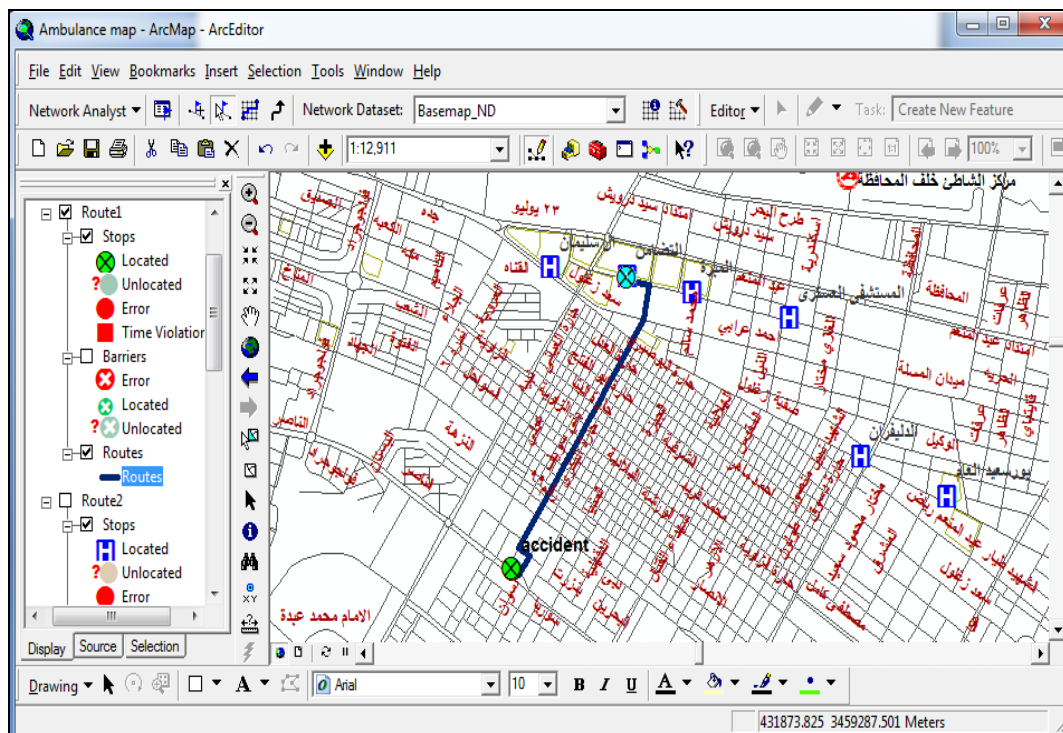


Figure 6: The fastest path from El tadamon hos pital

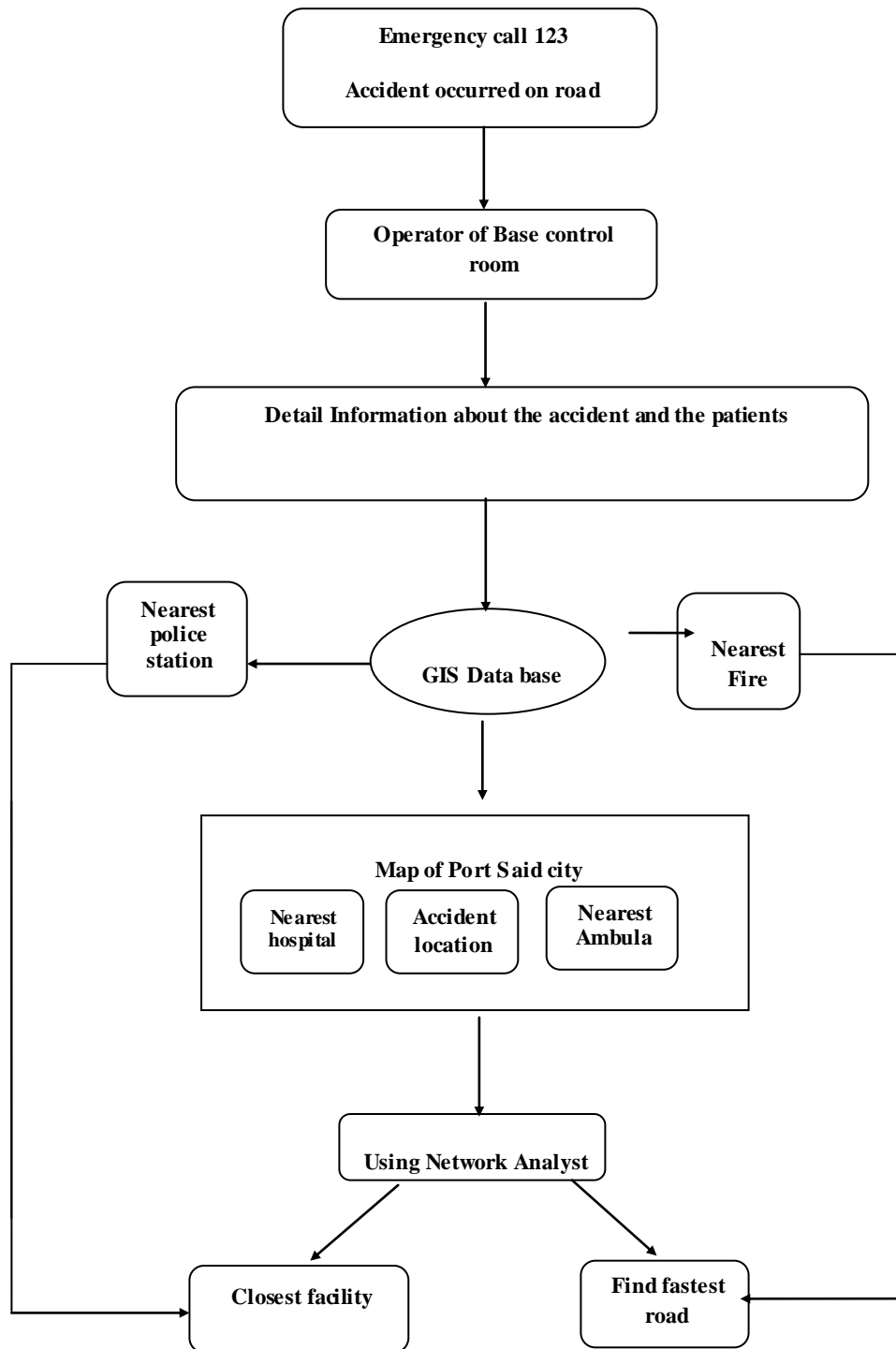


Figure 7: Flow chart of emergency system

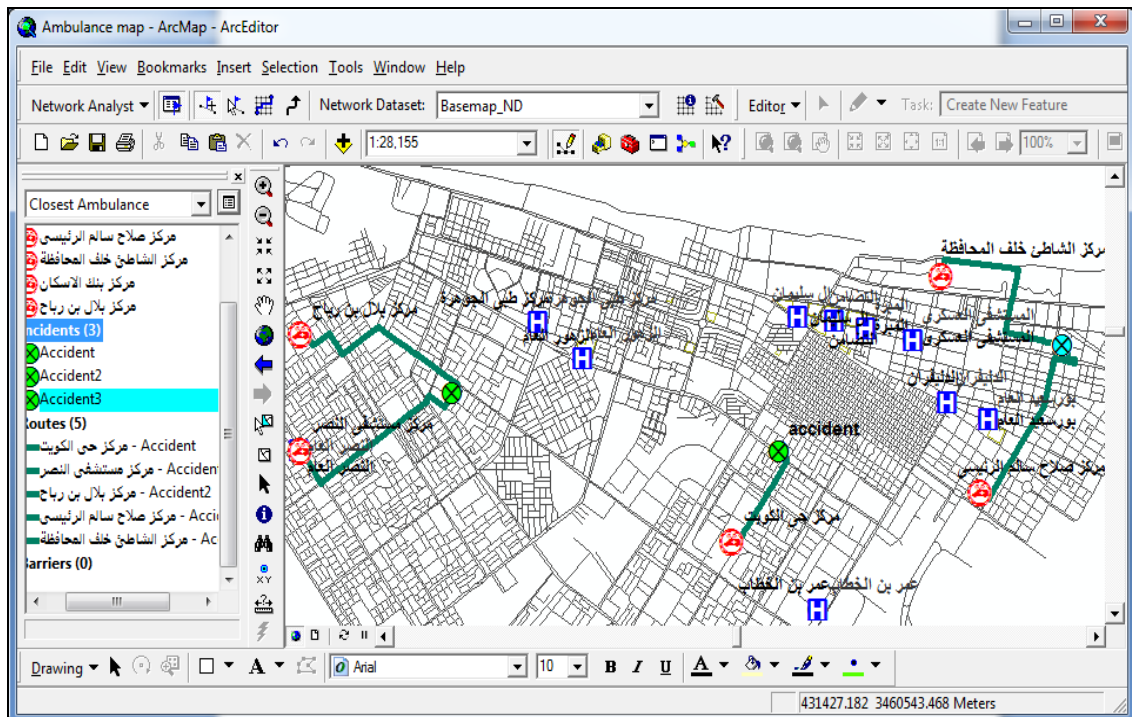


Figure 8: Three accidents occurred in the time in different districts (El manakh, El zohor and El dawahi districts), and find the nearest ambulances stations from each accidents.

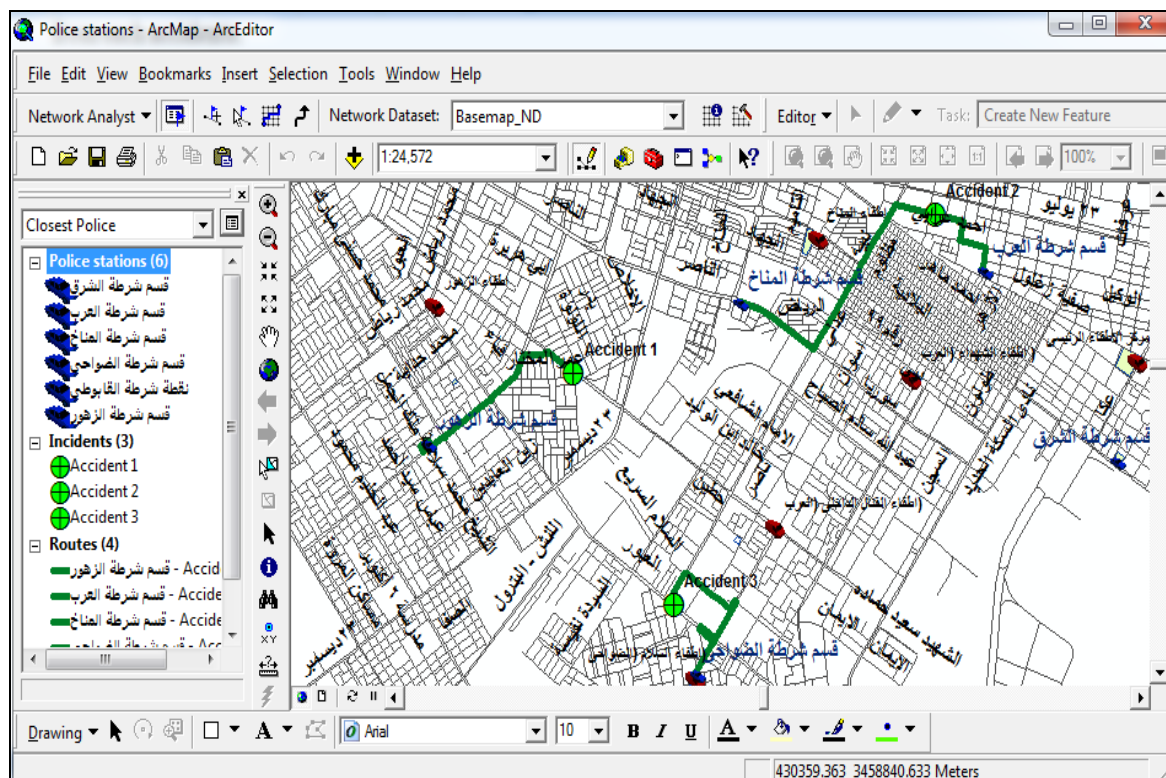


Figure 9: The closest police station from three different accident positions, (El zohor for accident 1, El manakh and El Arab stations for accident 2, El dawahi station for accident 3).

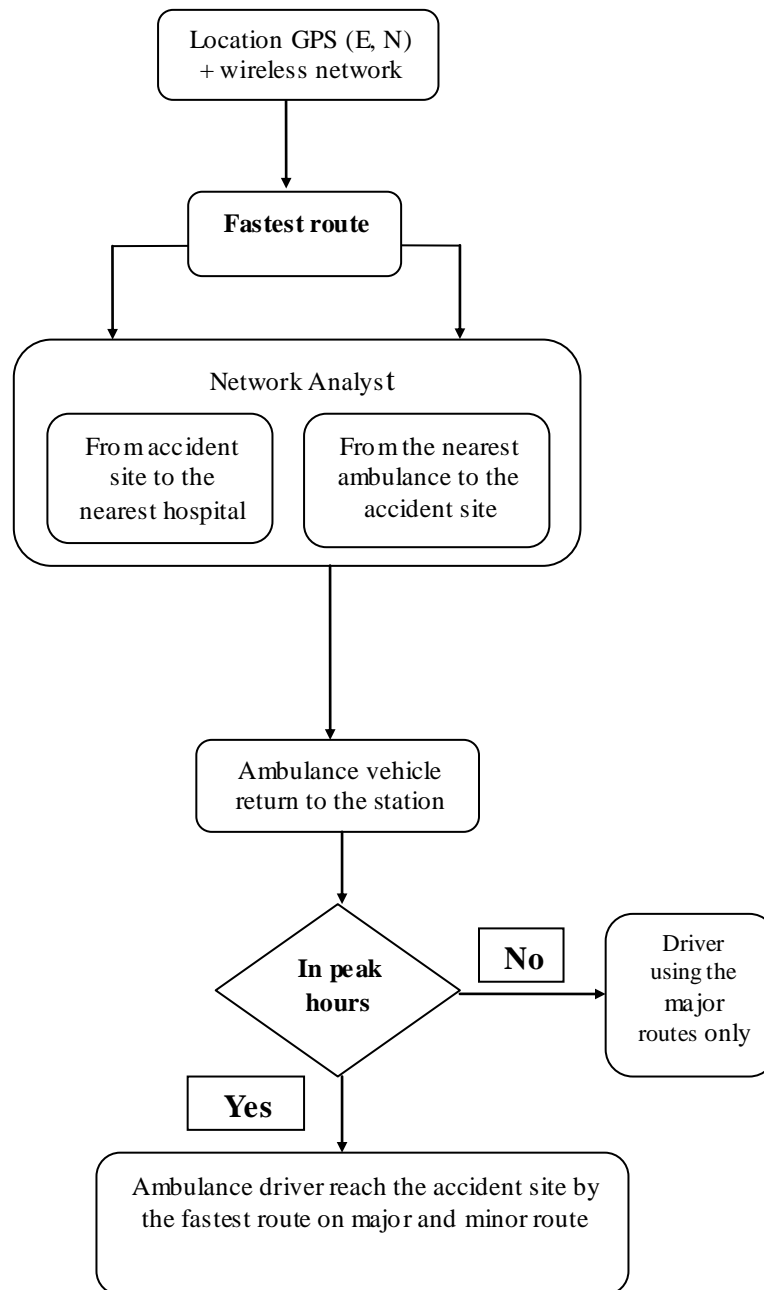


Figure 10: Flow chart of finding the fastest path.

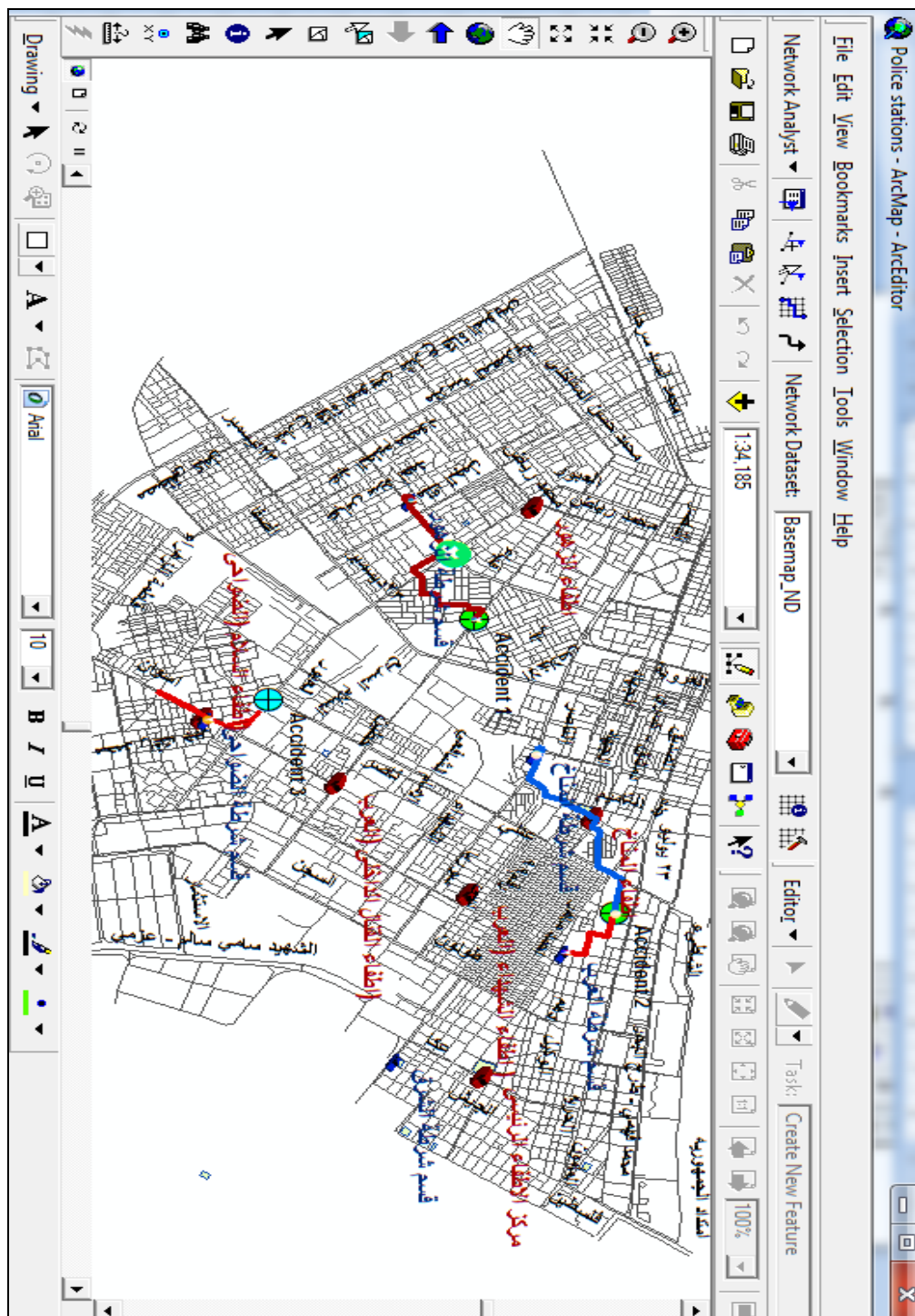


Figure 11: Three fastest paths guide police drivers to reach to three accidents.

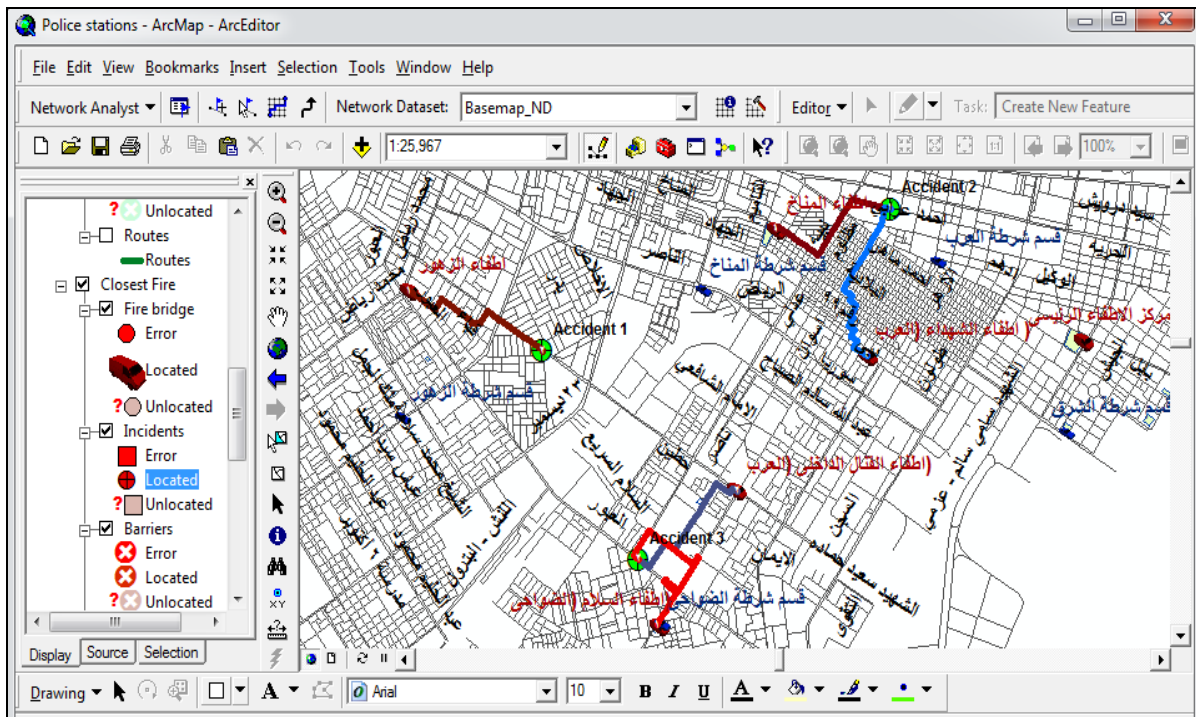


Figure 12: Closest fire stations from the three accidents.

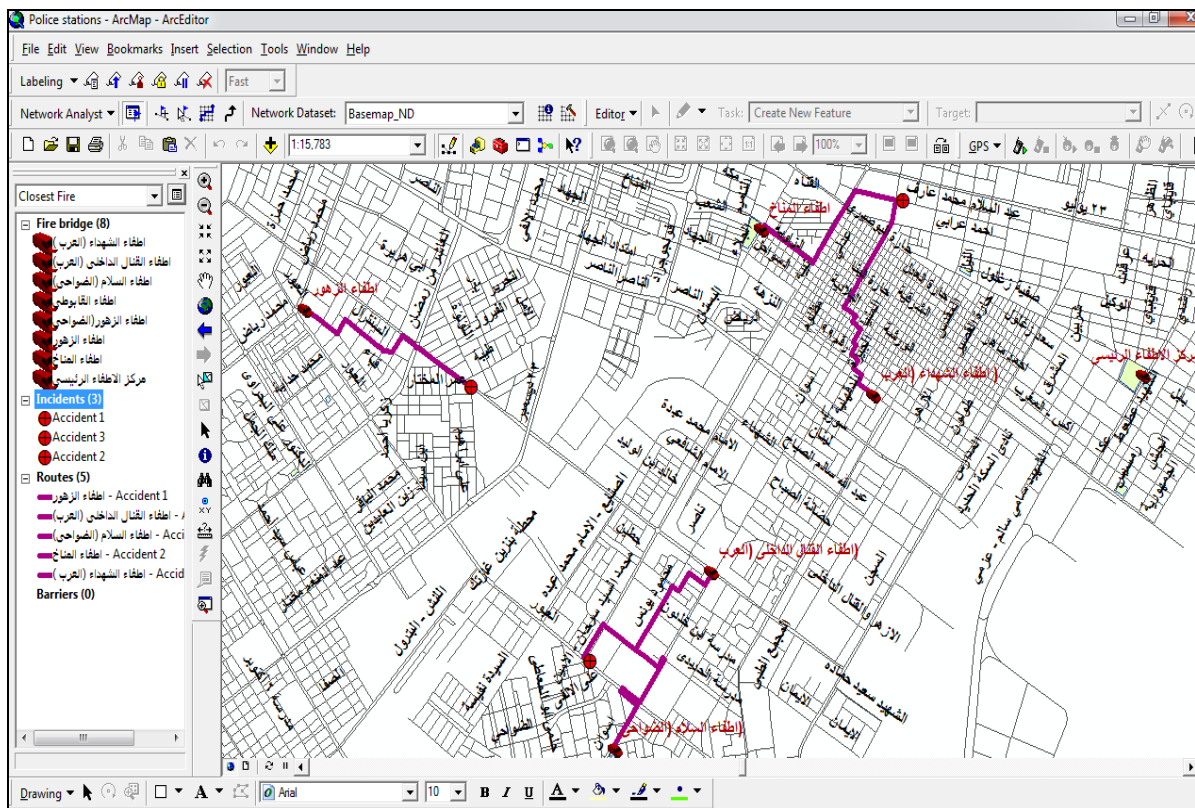


Figure 13: Fastest paths to each different accident locations.