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# A Framework for Abu Dhabi Police Traffic Monitoring and Response Center

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***Abstract*—The city of Abu Dhabi has witnessed a major growth in its population over the past two decades. This growth has resulted in a significant increase in the number of vehicles in the city. Abu Dhabi Police Department (ADPD) is currently working on the development of a traffic monitoring and response center. The main objective of this paper is to present the main framework for ADPD's traffic monitoring and response center, which will allow for a more robust operation of the police department activities. The core element of the response system is a microsimulation model for the city. This paper presents the main framework for ADPD traffic center and the initial results of the microsimulation model development. The well-known microsimulation model VISSIM is utilized to create the core of the traffic monitoring and response center, which will allow ADPD to test and investigate different scenarios.**

***Index Terms*—Traffic simulation, traffic monitoring, incident detection, incident management.**

## I. Introduction

The United Arab Emirates, abbreviated as the UAE, or shortened to "the Emirates", is a country that is situated in the Arabian Gulf. The country is a federation of seven emirates. Abu Dhabi is the capital city of the country. UAE experienced a rapid growth in the past few decades due to the oil discovery, leading the country to be one of the most developed countries in the Middle-East region. Abu Dhabi is the largest among the other emirates and it is famous for oil industry.

The city of Abu Dhabi has witnessed a major growth in its population over the past two decades. This growth has resulted in a significant increase in the number of vehicles in the city. Abu Dhabi Police Department (ADPD) has been striving to provide the best quality of service to the residents of the city. The ADPD is currently working on the development of a traffic monitoring and response center. As part of the cooperation between academic institutions and governmental agencies, the ADPD agreed with two academic institutions in UAE to work on the development of a traffic control center that will help the police department in managing their work in the city. It should be noted that the signal control in the city is not the responsibility of ADPD. Therefore, the system does not include any modules dealing with the optimization or changes in the traffic signals. Also, the paper considers the development of a microsimulation model for the city, which is the core module in the developed framework for the control center. The microsimulation model will be utilized to preplan for responses to different incidents on the road network in Abu Dhabi.

## II. Literature Review

This section provides a brief review of some research related to the paper subject.

The use of microcomputer applications in the development of traffic operations control centers has been investigated by a team of researchers from California Polytechnic State University, USA. The research considered the increasing demand for modern approaches to optimize the traffic operations and the large number of tools available to the operators. The authors investigated the use of microcomputers in traffic control centers and discussed the justifications for operational improvements and the significance of developing simulators to help in operating traffic control centers. [1]

Kazumasa et al [2] considered the need of police departments for new developments in order to response to the significant changes required for traffic control centers as a result of different trends in the community. Accordingly, they have proposed a new system that provides more advanced signal control operations through different subsystems. These subsystems facilitate the operation of transit vehicles, the management of traffic operations, and the reduction of traffic congestion. The proposed system utilized the innovations in operational functionality and the networking of the whole system to develop an integrated traffic management. The system implementation started in 1997.

The use of traffic simulation to examine traffic incident management approaches has been investigated by Wirtz et al [3]. They considered the preplanning for freeway incident management through the use of a dynamic traffic assignment. The simulation experiments included the modeling of different incident durations and

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intensities along the Chicago's highway system. Furthermore, the effects of incidents and the proposed actions to relieve these effects were evaluated in terms of lane mile hours for highway links, operating at Level of Service "F". It was concluded that some intuitive responses may result in an increase in the traffic congestion level at the location of the incident and at the roads in the immediate vicinity of the incident. For example, the simulation results illustrated that the congestion will spread along the parallel paths if the impacted freeway segment, where the incident happened, is fully closed. In addition to these results, it was also concluded that late responses will result in an increase in the congestion level.

The feasibility of using traffic simulation to support real-time traffic management was presented by Fries et al [4]. The research used the micro simulation software PARAMICS to develop a microscopic traffic simulation, of two rural sites in South California, to provide detailed information on traffic performance considering drivers, pedestrians, and highway characteristics. The researchers aimed at examining the effectiveness of such models in providing real-time decision-making information to support the operators of a traffic management center. It was concluded that the requirements of real-time decision making were met for a few combinations of incident durations and simulation accuracy. Accordingly, it was recommended to either increase the computational resources or reduce the size of the simulated network in order to achieve higher accuracies for longer incidents.

In another study, Dia et al [5] assessed the impact of incident management strategies through a simulation study. The microsimulation model used in this study included an area of about 122 square kilometer in the Gold Coast, Australia. The study evaluated the impacts of using ramp metering, Variable Message Signs (VMS), and Variable Speed Limit (VSL) as strategies to manage incidents. The simulation experiments showed that there was a reduction in delays, number of stops, and travel times when the VMS information was provided on the motorway in conjunction with dynamic signal timing adjustments on the alternative routes. The combined impact of these two strategies helped in achieving the pre-incident traffic conditions. The initial results for using VSL exhibited that there is a potential to improve the efficiency of the incident management strategy and the traffic safety. When reducing the speed limit during the incident duration, it was indicated that there is a reduction in the number of stops per vehicle. Finally, the authors concluded that the network structure has a significant impact on the effectiveness of incident management strategies and that the concurrent application of these strategies showed a potential for substantial improvements in travel times and safety conditions.

In Taiwan, an intelligent traffic control system has been considered by Lin et al [6]. In their paper, they have introduced a framework for a traffic control system for Taiwan. The framework provides a description of a Mobile Intelligent Traffic Control System (MITCS), which utilizes different modules including an embedded system that employs micro-mechanical and electrical innovations, wireless transmission, image processing, and solar power. "Finally, an experimental system was built which consisted of Virtual Traffic Police (VTP), Status Monitor Agent (SMA) and Traffic Control Integration Module (TCIM). The system will support a highly efficient, self-organized and self-coordinated traffic control mechanism."

In order to reproduce and predict the impacts of traffic incident responses, a group of Swedish researchers have implemented traffic simulation models that can provide an explicit modeling of driver behavior during incident duration and the driver reaction to the provided information. The simulation model was developed through the use of the state-of-the-art mesoscopic simulation model MEZZO. The researchers also presented a fast calibration procedure. A case study to examine the effect of late response on delays was presented. An improvement of about 30% in the computational efficiency was achieved through the use of linear speed- density functions. In addition, the speed and stability of the calibration process were improved, while maintaining a high level of simulation accuracy. [7]

More recently, the utilization of traffic microsimulation of urban road network was considered by Wang et al [8]. The well-known microsimulation software VISSIM was used for the purpose of this research. The research indicated that such models can be used in real-time detection as it satisfies the needs for practical use and provides an effective approach to solve traffic congestion problems.

## III. Proposed Framework

Based on the reviewed literature, the authors have developed a preliminary framework for ADPD control center. Figure 1 shows a general hierarchy of the center.

As shown in Figure 1, the core module in the system is the microsimulation model, which will facilitate the exchange of traffic information among the different modules of the center. The incident management module will focus on the procedures to be followed to detect an incident on the road network. Whenever there is a detected incident, the incident data will be provided to the microsimulation module. The simulation model will process the data and provide the expected impacts of the incident to the incident management module. The later will propose some strategies to reduce the impacts of the incident. The recommended incident management strategies will be provided to the drivers through different communication channels (e.g. radio stations, SMS, and VMS).

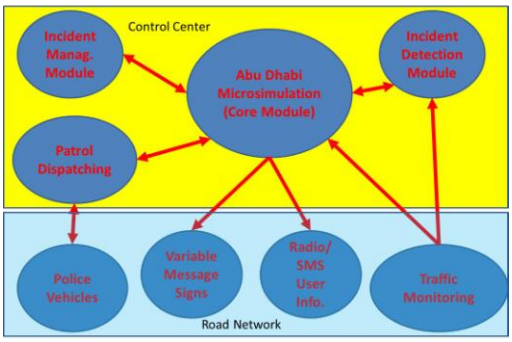


Figure 1. ADPD Control Center Framework.

In addition to that the information will be provided to the patrol dispatching module to take the needed actions. Another capability of the system is to provide continuous support for the patrol dispatching module in the form of real-time information regarding travel times, average speeds, and congestion levels.

All the modules of the system are currently under development. However this paper will focus on the microsimulation model development.

## IV. MICROSIMULATION MODEL DEVELOPMENT

To develop the core module for ADPD control center, a microsimulation model for the entire Abu Dhabi Island, was constructed. The study area for this project is illustrated in Figure 2.


Figure 2. Study Area

### *A. Data Collection*

In order to develop the microsimulation model, different sets of data were collected. These data sets include the following:

- Traffic count data: some of this data was available at different agencies in Abu Dhabi and some others were collected from the site. The available data includes continuous traffic count data at seven locations in the city. These continuous traffic count values were provided for two years period. The additional traffic counts were conducted for a 24-hr period on a typical working day.
- GIS data: the GIS data for Abu Dhabi Emirate was made available to the authors through ADPD. The received GIS maps were for the 2009. Accordingly, the details of some of the newly opened projects were not included in the data. However, the details of these projects were received as a subarea VISSIM Model combined with the AutoCAD file showing the details of these new projects.
- Radar location data: in order to simulate the actual vehicular speeds in the network, the known speed-cameras' locations were identified in the model. Based on previous studies with Abu Dhabi Police, it was concluded that the percentage of aggressive drivers, who drive above the radar speed limit, was 40%, with almost no limitation to the maximum speed. At the defined Radars' locations, the speeds were limited to the Radar's speed limit and an aggressive drivers' percentage of 5% was considered. Seven locations were identified for the fixed radars in the study area.
- Other subarea models: ADPD had previously conducted two major studies in vital parts within the study area. The first study was aimed at investigating the effect caused by a major incident that blocked one of the major junctions in the city. While the second study was developed to test the opening day scenario of the newly constructed major ring road in the Island.
- The study area includes a total of 113 signalized intersections in Abu Dhabi Main Island. The signal timing and phasing of all signalized intersection have been collected from the governmental agencies in Abu Dhabi.

### *B. Road Network Coding*

The road network was coded using the GIS data received and described in the previous section. Due to the fact that this network is relatively large in the size, the authors investigated the possibility of using the advantages of VISUM Strategic Model interface with VISSIM.

Initially, VISUM was used to create the links of the network and the traffic signals only, which require no matrices or volume generations. Later, the model was exported to ".anm" files that can be read by VISSIM. Following this step, the research team worked on the roads' elevations, and shapes, which resulted in the coded network as shown in Figure 3. It should be noted that this area does not include the other parts that were developed for different parts of the city.

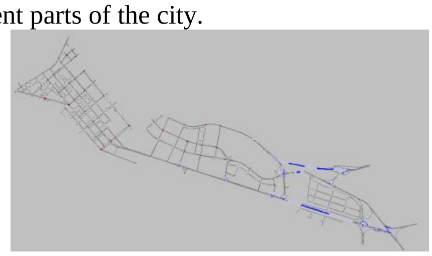

Figure 3. The Coded Road Network

Finally, the two models obtained during the data collection step and the model that was developed in this research were combined together to generate the network for the entire city of Abu Dhabi. The final simulation network is illustrated in Figure 4. It should be noted that the highlighted area in Figure 4 represents the subarea network that was collected from other sources.

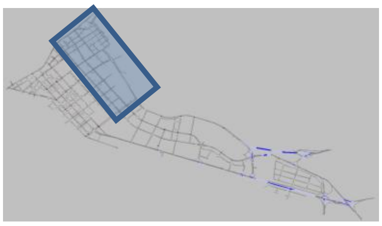

Figure 4. Abu Dhabi Simulation Model

### C. *Driving Behaviour Calibration*

The objective of the calibration process is to ensure that the microsimulation model is a good reflection of the conditions that are or will be present in the field. The model input parameters are adjusted in some cases to replicate the driver behavior, vehicle speeds, and vehicle model composition, which are experienced and will exist in the actual road network. The calibration parameters that are adopted for the creation of the model are discussed in the following subsections. It should be noted that in the absence of specific parameters in Abu Dhabi based on available data, a similar environment data (e.g. Doha, Qatar), was adopted.

The driver behavior parameters used for the model development are shown in Table I.

TABLE I. SIMULATION PARAMETERS

| Parameter | Value |
|---|---|
| Following parameters | |
| Look ahead Distance | |
| Observed Vehicles | 4 |
| Car Following Model | |
| Average Standstill Distance | 2m |
| Additive part of Safety Distance | 2m |
| Lane Change parameters | |
| Necessary Lane Change (route) | |
| Maximum Deceleration (trailing Vehicle) | -3 |
| -1 m/s2 per distance (both own and Trailing Vehicle) | 100m |
| Accepted Deceleration (both own and Trailing Vehicle) | -1m/s2 |
| Other | |
| Waiting time before Diffusion | 60 |
| Safety Distance Reduction Factor | 0.6 |
| Maximum Deceleration for cooperative breaking | -3m/s2 |
| Advanced Merging | Checked |

### D. *Vehicle Speed Distribution*

The vehicle speed distribution curves were adopted from the available data in Doha. A snap shot of the input window for the speed curves is illustrated in Figure 5. Heavy vehicles will assume a speed that is 20 kph less than the light vehicles and passenger cars' posted speed.

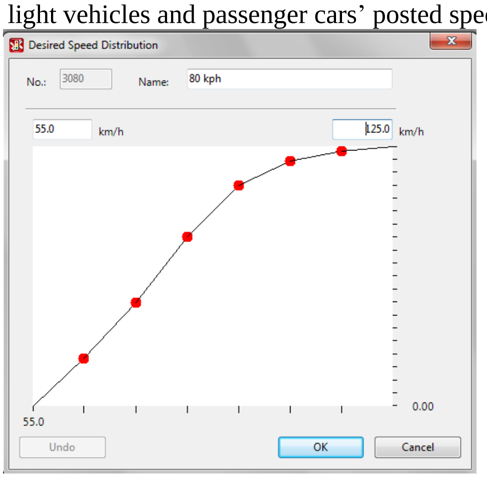


Figure 5. A Sample Speed Distribution Curve

In addition to that, the Heavy Good Vehicle (HGV) curves were slightly changed than the curves shown in Figure 5. The corresponding speeds of the above sample at reduced speed areas are illustrated in Figure 6.

Finally, the curves were changed to linear curves in the scenario of reduced speed areas for both Private Car, and HGV. The corresponding speeds at reduced speed areas are illustrated in Figure 7.

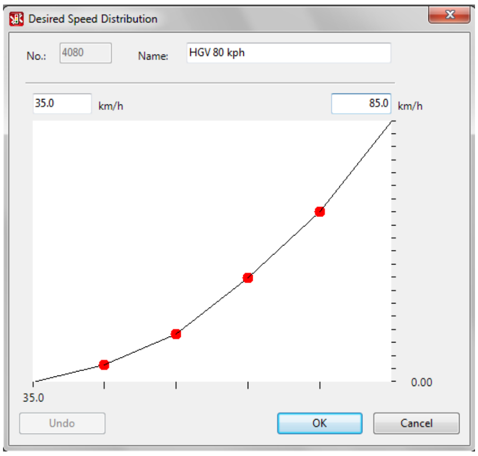


Figure 6. HGV Speed Distribution Curve

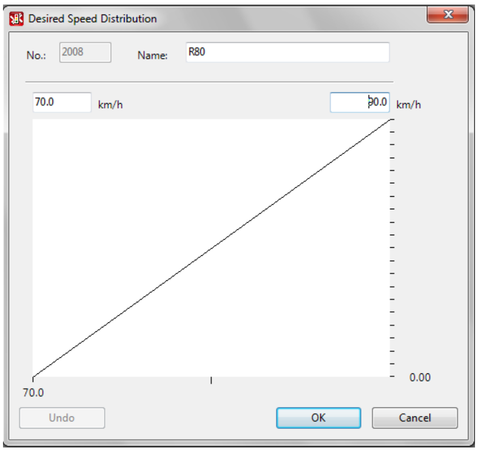


Figure 7. Reduced Speed Areas Speed Distribution Curve

### E. *Vehicle 2D/3D Distribution*

The vehicle type and model distribution for the CAR models was adopted from similar driving environment, (e.g. Doha, Qatar). The distribution was based on a previous survey conducted in Qatar for one of the consulting projects carried out by AECOM, Qatar. Table II lists the CAR type distribution adopted in the VISSIM model.

### F. *Vehicle Routes*

The fact that the other two available models in the study area were built using a static assignment, combined with the fact that the budget and time allocation of the current project did not allow for a full traffic and trip chain surveys in Abu Dhabi, had guided to the scenario that the current model will be using a static assignment routing.

TABLE II. VEHICLE DISTRIBUTION AND DIMENSIONS

| Vehicle Type | Vehicle Model | Total Length (mm) | % of Total Vehicles |
|---|---|---|---|
| 4x4 Cars | | | |
| Toyota | Land cruiser | 4,890 | 26.4 |
| Toyota pickup, Mitsubishi, Nissan | Hilux, L200 - Pick-up | 4,955 | 11.6 |
| Mitsubishi, Lexus | Pajero, Infiniti | 4,645 | 3 |
| Jeep, Hummer | Grand Cherokee, H3 | 4,801 | 0.3 |
| Dodge | Ram | 6,190 | 0.5 |
| GMC, Chevrolet Pick-up | Yukon, Tahoe Silverado, Sierra 3500 Denali | 5,179 | 9 |
| Others e.g. Nissan, Kia, Hyundai, Peugeot, Suzuki | | 4,455 | 6.2 |
| Cargo Pick-up & Van, Nissan Navaro, Bently | Chevy Van | 5,408 | 10.2 |
| Small/Medium Cars | | | |
| Honda, Chevrolet, Toyota, Nissan, Kia, Hyundai, Citroen, Mitsubishi | Civic, Lacetti Hatchback, Corolla, Camry, Tida Sedan, Sunny, Lancer | 4,473 | 31 |
| Mercedes/Porsche | CLS Coupe, 911 - Carrera S | 4,672 | 1.9 |

To best simulate such assignment in a network with such size, it has been insured that the decision-making will be starting as early as possible on each link (less than 5 meters from the start of the link). In addition to that, the routes where coded at each intersection.

Moreover, the traffic volumes were only input at the feeding links of the external links; with a link at each district to balance the trips (attract the extra trips, and generate the missing trips).

## V. FUTURE WORK

As mentioned earlier, this paper provides preliminary information on the project. Future work will include the numerical results for testing the constructed VISSIM microsimulation model to study the performance of network under different traffic conditions, such as accidents. It will be also used for testing the response time under several factors, such as traffic congestion. The expected factors that will be considered in the network are:

- Journey time
- Average Speed
- Maximum speed
- Minimum speed
- Average delay.

In addition to these experimental results, the model will be upgraded to a dynamic model and will be integrated with the other modules of the control center.

## VI. CONCLUSIONS

This paper presented a general framework for a traffic control center to be used by ADPD. The paper also presented a brief description of the core module for the center, which is a microsimulation model for Abu Dhabi.

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