Practice report

Framework for assessing traffic impacts generated by mega complexes: a case study of San Stefano grand plaza, Egypt

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This paper develops a generic framework of the process involved in conducting traffic impact assessment (TIA) for mega-complexes, applies it to a real world unique project and derives lessons of use in similar situations. The process involves surveys and analysis of present traffic and pedestrian circulation systems, and parking and transit conditions, to establish current levels of services, traffic problems and issues. Projections are made of the normal growth in traffic and generated demand, as a result of proposed developments and land-use changes. Future expected levels of services are determined and compared for the with-project and without-project scenarios, taking into account other expected traffic issues, such as pedestrian, parking, safety, and environmental problems. Finally, ways of mitigating adverse effects are explored and assessed. The suggested TIA process is applied to San Stefano grand plaza, Alexandria, Egypt.

Keywords: traffic impact assessment; Egypt; mega-complexes

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IN MANY CITIES of the world, and particularly in developing countries, development projects are springing up, generating travel demand and causing significant impacts on the urban transport network. This growing demand accompanied by inadequacies of the transport infrastructure and inefficient traffic management and control lead to severe traffic-related problems, in particular, traffic congestion and delays, parking problems, increase in vehicle operating costs and energy consumption, traffic conflicts, accidents and environmental pollution.

Typically, traffic impact assessment (TIA) studies are conducted to assess the impacts of proposed land-use changes on components of the traffic system. This paper develops a structured and comprehensive framework for conducting TIA for mega complexes. It involves surveys and analysis of the present traffic and pedestrian circulation systems, and parking and transit conditions. These are used to establish current levels of service and traffic problems.

This is followed by projecting future normal growth in traffic demand. The core of the process lies in assessing the traffic expected to be generated as a result of proposed developments and land-use changes. The generated traffic is assigned to the surrounding network and added to the normally expected traffic.

Future expected levels of services are then determined and compared for the with-project and the without-project scenarios. The potential and scale is identified of other expected traffic issues, such as pedestrian, parking, safety, and environmental problems that may result from the development project.

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Finally, ways for mitigating adverse effects resulting from changes in expected traffic demand are explored and assessed.

The applicability of the TIA process is investigated with respect to San Stefano grand plaza in Alexandria, Egypt. This is one of the biggest development projects in Egypt and the Middle East. It involves various changes to the surrounding land-use pattern. The new complex is designed as a multi-use luxury development overlooking Mediterranean coastline with a total built-up area in excess of 400,000 m^2. It is meant to provide a variety of functions, including commercial outlets, offices, cinemas, restaurants, lounges, apartments, a hotel, and a beach resort. The paper concludes with eliciting a number of practical lessons resulting from the application of the TIA process to San Stefano grand plaza.

Proposed framework for conducting TIA

The main goal of the TIA process is to identify, examine and assess traffic-induced impacts resulting from planned new developments and land-use changes, and to propose recommendations on how to relieve and accommodate such impacts in an efficient and effective manner. This is meant to assist decision-makers in protecting the future rights of existing and potential road users, pedestrians, parkers and owners and visitors of existing developments. The other purpose of TIA is to ensure that the planned new developments themselves are not hindered by the traffic problems that they are expected to cause. An initial screening assessment by traffic experts has to precede any full-fledged TIA investigation.

Based on the experience of the author and a review of the literature (ITE, 1988; 1992a; 1994; SZO, 1998; ODOT, 2001; MCDOT, 2001), a framework of the process of conducting a TIA for a planned new mega development is developed, see Figure 1. This process is characterised by being comprehensive and structured. It is composed of eight main stages, which are detailed in Figure 2 and presented briefly below.

The main goal of traffic impact assessment is to identify, examine and assess traffic-induced impacts from planned new developments and land-use changes, and make recommendations on how to relieve and accommodate such impacts in an efficient and effective manner

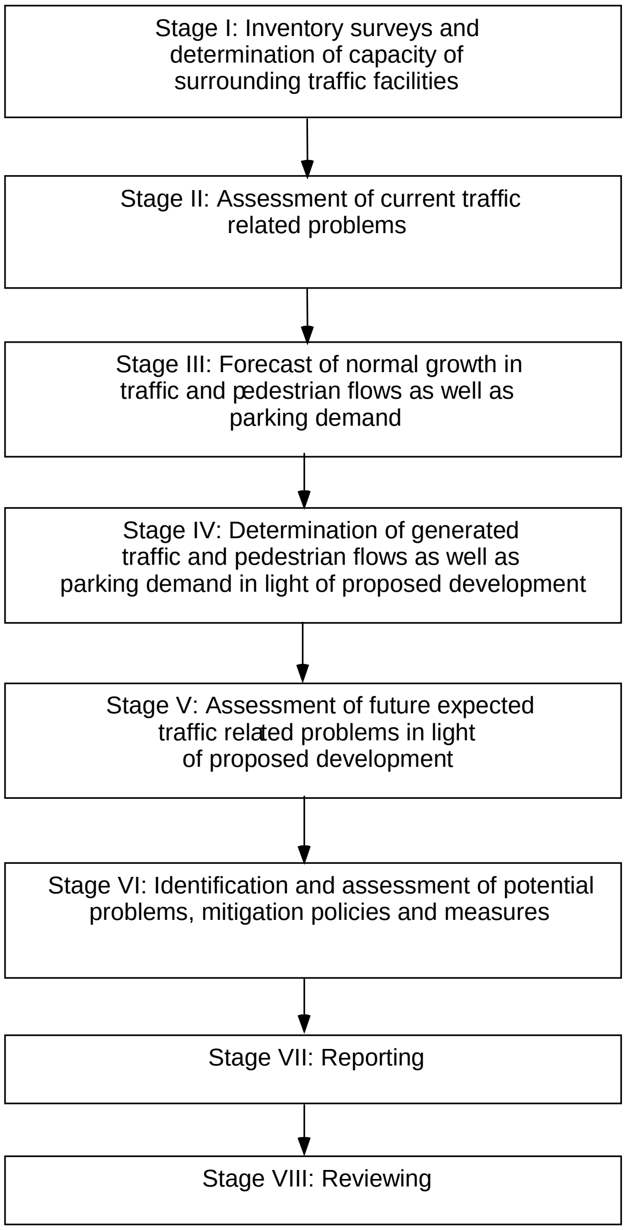

Figure 1. Main stages constituting framework for conducting traffic impact assessment for mega projects

Stage I: Inventory surveys/capacity determination

Step I-1: Creating a base map The TIA process starts by identifying the location(s) of the planned new developments. Examining these site locations acts as the basis for defining the study area and establishing the boundaries within which induced traffic impacts are assessed. This culminates in creating a representative base map of the study area.

Step I-2: Coding land parcels and transport facilities In this step, existing developed land parcels are coded along with all transport facilities within study area. This includes road and pedestrian networks, and areas designated for parking and transit stops.

Step I-3: Inventory surveys This step is concerned with conducting several types of inventory survey.

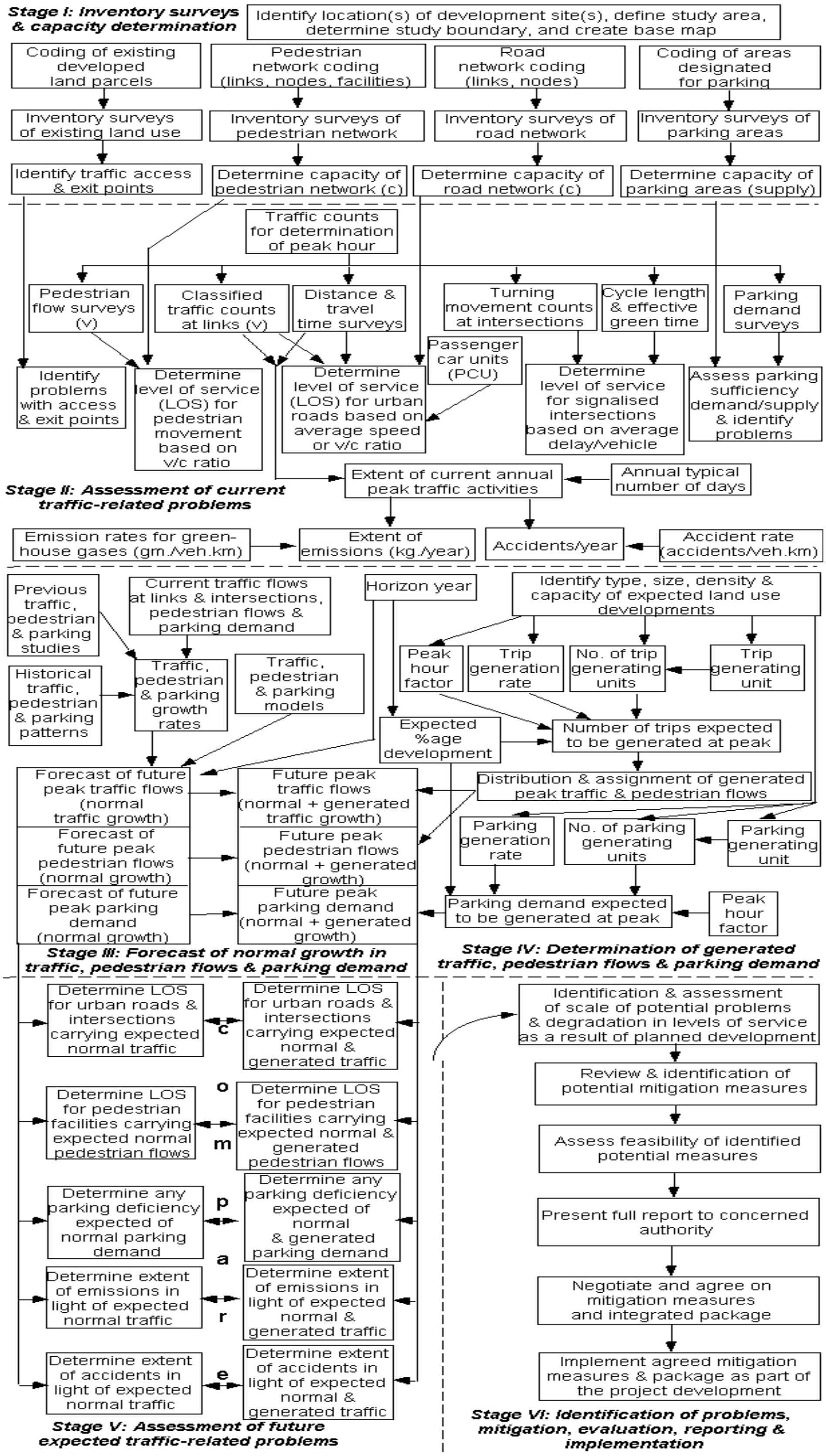

Figure 2. Detailed framework for conducting traffic impact assessment for mega projects

The first is concerned with establishing the types of surrounding land use — residential, commercial, office, mixed and so on. This is followed by a number of other inventory surveys to establish the capacity of existing transport facilities including road links, intersections, pedestrian links and nodes, and parking areas.

Step I-4: Identifying access and exit points and determining transport capacities After the inventory surveys, access and exit points for each developed land parcel can be identified. Also, capacities of the different transport facilities are established. In this context, either local standards are used, or international manuals, such as the *American Highway Capacity Manual* (USDOT, 2000).

Stage II: Assessing current traffic-related problems

Step II-1: Traffic counts to determine peak hour To conduct the required traffic, pedestrian and parking demand surveys, a representative peak hour has to be established. Hourly traffic counts during peak periods are undertaken. These are diagrammatically represented and the highest hourly peak is selected.

Step II-2: Conducting traffic and demand surveys Several surveys and traffic counts are conducted during the established peak hour to measure the current peak demand. These include classified traffic counts at road links, distance and journey-time surveys for urban arterials, turning movement counts at intersections, cycle length and effective green time of traffic signal operation, pedestrian flow surveys, and parking demand surveys.

Step II-3: Assess current levels of service and traffic-related problems The main objective of this step is to identify and assess the scale of key traffic-related problems. The core of such assessment is to conduct level of service (LOS) analysis for pedestrian and vehicle facilities. For pedestrian walkways, LOS can be determined based on volume/capacity ratio (TRB, 1980). For urban arterials, LOS is determined by average travel speed, see USDOT (2000). As for urban intersections with traffic signals, LOS is determined by the average stopped delay per vehicle (USDOT, 2000).

Parking sufficiency can be assessed by computing the demand/supply ratio (ITE, 1994). Access and exit points for development sites should be carefully examined to identify any potential problems. Two other traffic-related problems are also assessed: the extent of environmental emissions induced by traffic; and the expected number of traffic accidents. Air pollution and noise can be measured using specialised equipment. However, in many instances, such equipment is not available. Good estimates of emitted gaseous pollutants can be produced by multiplying annual traffic activities by appropriate emission rates. The literature is rich with such emission rates, see, for example, IPCC (1996) and USEPA (1999). Acceptable accident rates can be produced by relating historical accident data to traffic activities; these can then be multiplied by current traffic activities to give expected number of accidents.

Stage III: Normal traffic, pedestrian, parking growth

Step III-1: Establishing traffic, pedestrian and parking growth rates This stage starts by reviewing previous traffic, pedestrian and parking studies that have been conducted within or near the study area. The main purpose is to elicit growth rates used by these studies to forecast future traffic, pedestrian and parking demands. Another alternative would be to derive the growth rates from historical counts of traffic and pedestrian flows and surveys of parking demand.

Step III-2: Forecast of future traffic, pedestrian flows and parking demand Once growth rates are established, forecast models are used to predict expected future levels of traffic and pedestrian flows, and parking demand. These forecasts span over a period from the present year to a future horizon year, which, ideally, is the year when the project is expected to be fully developed and in operation. However, in many situations, big projects may be staged over a number of phases.

Such forecasts are meant to represent the normal growth pattern in the study area regardless of the planned new development(s). In this context, sophisticated traffic forecast models can be used; alternatively the simple compound growth model can be applied:

$$\text{TFP}^{\text{future}} = \text{TFP}^{\text{present}} (1 + i)^n$$

where

TFP = traffic flows at peak
i = normal traffic growth rate
n = forecast period

Stage IV: Generated traffic, pedestrians, parking

Step IV-1: Determining number of trips expected to be generated at peak This step starts by identifying types, sizes and densities of expected land-use developments. Then local or internationally published manuals are examined (ITE, 2000a), to establish:

- appropriate trip-generating units in accordance with types of land use;
- number of trip-generating units in accordance with the size, density and capacity of the land use;
- trip-generation rates in accordance with land-use types and the trip-generating units used;
- peak-hour factors used for eliciting expected peak trips out of daily-generated trips.

In some instances, the horizon year considered by the TIA does not represent the year when full development of the project is expected to materialise. In this case, a percentage representing the expected development should be adopted. The following represents the mathematical formulation used for the derivation of the number of vehicle trips expected to be generated at peak time:

$$\text{VTG}^{\text{peak}} = \text{TGU} * \text{TGR} * \text{PHF} * \text{EPD}$$

Where

VTG^{peak} = vehicle trips generated at peak time
TGU = number of trip-generating units

TGR = trip-generation rate
PHF = peak-hour factor
EPD = expected percentage development.

These generated trips are then distributed and assigned to the surrounding road network. A similar exercise can be undertaken to determine generated pedestrian flows and to assign these to appropriate pedestrian facilities.

Step IV-2: Determining parking demand expected to be generated at peak This is similar to the previous step in terms of starting by identifying types, sizes and densities of expected land-use developments. Then local or internationally published manuals are examined (ITE, 2000b) to establish:

- appropriate parking-generating units in accordance with types of land use;
- number of parking-generating units in accordance with size, density and capacity of the land use;
- parking-generation rates in accordance with land-use types and used parking-generating units
- peak-hour factors used for calculating expected parking demand at peak from daily-generated parking.

The following represents the mathematical formulation used for the derivation of number of parking spaces required to accommodate parking demand expected to be generated at peak hour:

$$RPS^{peak} = PGU * PGR * PHF * EPD$$

Where

RPS^{peak} = required parking spaces at peak hour
PGU = number of parking-generating units
PGR = parking-generation rate
PHF = peak-hour factor
EPD = expected percentage development.

Step IV-3: Normal and generated traffic, pedestrian flows and parking demand This step involves a simple addition of normal and generated forecasts for traffic flows, pedestrian flows and parking demand.

Stage V: Assessing expected traffic-related problems

Step V-1: Assess future levels of service and traffic-related problems in light of normal growth The main objective of this step is to identify and assess the scale of key traffic-related problems in light of normal traffic growth. This would be similar to step II-3 using the new demand values obtained in light of normal traffic growth.

Step V-2: Assess future levels of service and traffic-related problems in light of normal and generated growth The main objective of this step is to identify and assess the scale of key traffic-related problems in light of normal and generated traffic growth. This would be similar to step II-3 using the new demand values obtained in light of normal and generated traffic growth.

Step V-3: Compare future levels of service and traffic related problems In this step, a comparison would be made of levels of service and of other traffic problems for two scenarios: the normal traffic growth scenario; and a combination of normal and generated traffic growth.

Stage VI: Potential problems and their mitigation

Step VI-1: Identification and assessment of potential traffic-related problems As a result of comparing the two scenarios in step V-3, traffic problems can be identified in terms of expected degradation in levels of services *for* the road and pedestrian network and/or in terms of insufficiency of parking supply to meet expected demand. Also, environmental emissions and number of accidents are expected to increase as a result of the increase in traffic flows. Severe problems might arise with respect to access and exit points to the existing and planned development sites.

Step VI-2: Review and identification of potential mitigation measures The purpose of this step is to identify and propose measures to prevent, reduce or relieve traffic impacts expected to be induced by the planned new development(s). The traditional strategy for tackling traffic problems has been to add more capacity to the network supply system, thus allowing for better traffic conditions. However, resources are becoming limited, and the tendency has been to adopt policies and measures that enable optimum utilisation of the road network.

In recent years, demand-based measures, sometimes referred to as congestion-management measures, have been top on the agenda, whereby the primary purpose is to reduce the impact of travel on the road and transport system by improving the efficiency of demand for travel. This can be done by applying incentives and disincentives that are meant to modify car users' behaviour towards increasing car usage efficiency, shifting to other high occupancy and non-motorised transport modes, spreading the demand over time and space and reducing the amount and need for car travel. The literature includes several classifications of congestion management policies and measures (see IHT (1996) for a representation of the European classification; AUSTROADS (1995) for that of the Australian classification and USDOT (1994) and Meyer (1999) for the American classification.

Step VI-3: Assessing proposed measures Most traffic-relief programs can be described as piecemeal approaches, that is, looking at separate solutions for single problems at single sites. These, when implemented alone, will only provide marginal relief to traffic problems. It is widely recognised that a combination of several complementary measures to form an integrated traffic-relief package is the key to attaining better results.

This research, along with others (UoW, 1995); May and Roberts, 1995) advocates the development of integrated programs to relieve traffic problems. Such programs cannot, however, include a random combination of policies and measures. Which components are selected for the package will depend on the type and intensity of the traffic problem and on the environment and constraints under which these will be implemented. Prioritisation and choice of relief packages can be based on criteria such as:

- public acceptability;
- applicability and effectiveness;
- potentiality of package ingredients to work together towards achieving favourable traffic conditions within available resources;
- level of support and political acceptance;
- financial and economic appraisal.

The applicability of the proposed TIA process is demonstrated by one of the largest urban development projects in Egypt — San Stefano grand plaza, Alexandria — to derive and disseminate some practical lessons from such an application

Stages VII & VIII: Reporting and reviewing

Reporting is mainly concerned with presenting the results of the TIA in a useful report format. Assessing the adequacy of the TIA report is an important step that could be conducted by a concerned authority or commissioned to independent specialised TIA reviewers. The review should take into account the points of view of stakeholders and assess the acceptability of the proposed solutions.

Reviewing is an extremely important stage as it ensures the integrity and comprehensiveness of the conducted TIA. This is equivalent to the regulatory role that most transport sectors are introducing in their efforts to protect the public interest and ensure standards. The conclusions of the review are negotiated with the concerned authority. Finally, agreed mitigation measures are recommended for implementation.

In the next section, the applicability of the proposed TIA process is demonstrated with respect to one of the largest urban development projects in Egypt and probably in the Middle East — San Stefano grand plaza in the old coastal city of Alexandria. This is meant to derive and disseminate a number of practical lessons resulting from such an application.

TIA for San Stefano grand plaza, Alexandria

Strategically placed in the heart of the Corniche of Alexandria, Egypt, San Stefano grand plaza is surrounded by some of the best districts in Alexandria. This is a huge project designed as a multi-use luxurious development overlooking the Mediterranean shoreline with a total built-up area in excess of 400,000 m^2. Panoramic views of the plaza are shown in Figure 3. The building is a mixed use 30-floor complex of three underground parking floors, six floors for commercial activities (shopping mall,

Figure 3. Panoramic views of San Stefano grand plaza
Source: <http://www.san-stefano.com>

retail, comprehensive entertainment, executive offices and conference suites) with the remaining floors comprising luxury residential units.

In addition, a four-seasons hotel comprising guest rooms and serviced flats is included. The development of the grand plaza involves various changes to the existing land-use pattern of the site. For such major developments, TIA is deemed necessary for the concerned authority to protect the rights and interests of the public affected by the development. TIA is also essential for the developer to ensure the project's viability. There now follows an outline description of the application of the TIA process for this development.

Site analysis

Site visits were conducted to establish current traffic problems. San Stefano is on an area of approximately 30,000 m^2 of prime real estate land overlooking the Mediterranean Sea. It is 3 km away from the Sidi Gaber main train station, 5 km from the airport, 9 km from downtown Alexandria, and 10 km from the city's entrance.

The site is rectangular surrounded by a grid of roads (see Figure 4). On the North, the site is bounded by El Corniche street, which is the main urban arterial coastal road traversing Alexandria, following the Mediterranean coastline in an East–West direction. In 1999, El Corniche street was a two-way, single carriageway with two lanes in each direction. It is bounded by the site in one direction and the sea front in the other.

To the South is Abdel Salam Araf street, which runs parallel to the El Corniche road. This is a divided urban arterial road bounded by the site in one direction and the tramline in the other. The site is bounded to the East by Hammam El Saydat street, which is a narrow one-way street allowing traffic to flow from El Corniche street to Abdel Salam Araf street. Hammam El Saydat street is bounded by the site in one direction and several residential blocks in the other.

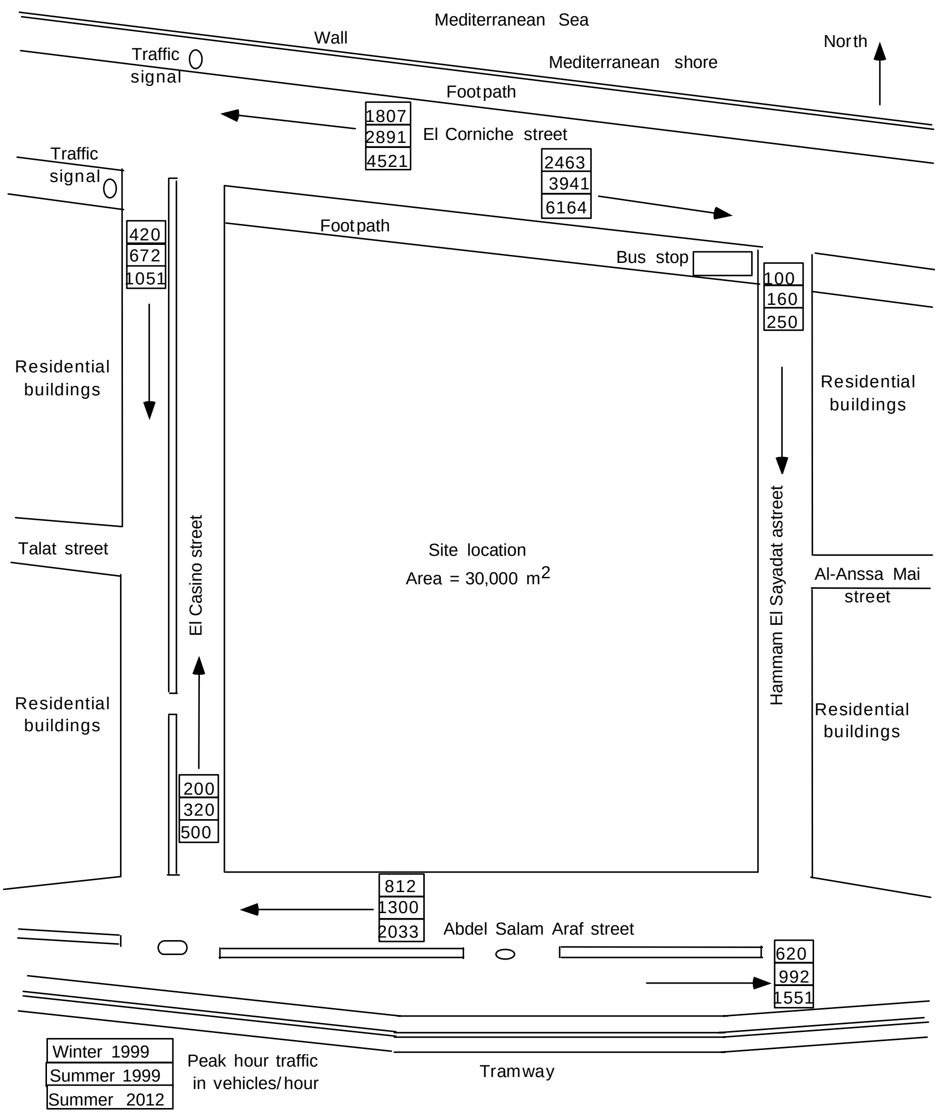

Figure 4. San Stefano grand plaza site plan showing 1999 and forecasted 2012 traffic circulation and flows (without complex scenario)

Note: Sketch is not to scale

Bounding the site on the West is El Casino street, which is a dual carriageway allowing traffic flow in both directions from and into El Corniche and Abdel Salam Araf streets. The two-directional traffic flows are separated by a median island. The road has two lanes in each direction and is bounded by the site in one direction and several residential blocks in the other. The ground floors of these blocks are mainly occupied by commercial and service activities, such as restaurants, shops, pharmacies, car showrooms and furniture stores.

Traffic and pedestrian conditions in 1999

A review of the traffic circulation system, conflicts and flow conditions on the surrounding road network is necessary. In 1999, the intersection of El Corniche street with El Casino street was controlled by a manually operated traffic signal. During most of the day, this was a three-phase signal allowing turning from all three approaches. However, during peak conditions, from 2.00 pm to 4.00 pm, the signal was operated in two phases with prohibition of the left turn from El Casino street to El Corniche street.

A bus stop without a boarding bay caused a certain amount of blockage, creating queues and traffic delays. Another factor that limited traffic flow along El Corniche street was the random stopping of taxis and service buses in front of the site to drop off and pick up passengers. Traffic flow on El Corniche street was also affected by traffic turning right and left into Hammam El Saydat street.

Traffic flow conditions along Abdel Salam Araf street seemed reasonable. This was mainly attributed to the limited demand for parking, since all residential blocks facing this street are located behind the tramway, with access from the other side. Traffic turning left at the Abdel Salam Araf/El Casino intersection created conflicts and hence impeded traffic flows.

Traffic flow along El Casino street seemed acceptable. However, during the summer season, parking demand and traffic conflicts increase causing a reduction in traffic flow. Also, traffic tuning left from El Casino street and into El Corniche street incurred delays at the traffic signals.

Traffic flow along Hammam Al Saydat street is limited. The road is extremely narrow with a relatively high parking demand. Traffic violating the one-way direction is very common causing potential conflicts.

Traffic counts were conducted at the peak hour between 2.00 pm and 3.00 pm on a typical weekday in February 1999. These counts represent the peak traffic along the four roads and at intersections during winter time. Alexandria attracts many visitors during the summer. The San Stefano grand plaza is largely designed to serve them.

Seasonal variation in traffic volumes needs to be taken into account, so traffic flows on the Cairo–Alexandria desert road during the months of June (summer) and February (winter) were compared to because this road carries most of the visitors from Cairo, the capital, to Alexandria. Based on this computation, a traffic seasonal variation factor of 1.6 was estimated. This was used to compute traffic in summer giving the seasonally adjusted figures in Figure 4:

$$\text{peak traffic}^{\text{summer}} = \text{peak traffic}^{\text{winter}} * \text{traffic seasonal variation factor}$$

Pedestrian movements along and crossing El Corniche street are relatively limited. Despite the existence of a pedestrian crossing point, drivers ignore the sign and enforcement is weak. Thus, when pedestrians attempt to cross, vehicle/pedestrian conflicts occur and there is potential for accidents. Pedestrians also move along the kerb to stop taxis and service buses, and to wait for buses at the bus stop in front of the site area.

As for Abdel Salam Araf street, pedestrian crossing is limited. However, there is moderate pedestrian movement along the roadside kerb to the side of the tram. This represents mainly passengers accessing the tram station on Abdel Salam Araf street. Pedestrian movement along El Casino and Hammam El Saydat streets is relatively moderate and safe. Vehicles tend to travel on these roads at reduced speed.

Parking and public transport conditions in 1999

Parking is prohibited on both sides of El Corniche street. There is a small hotel in the vicinity of Abdel Salam Araf street, which sometimes uses the road to park tourist buses and some private cars. As for Hammam El Saydat street, mixed parallel and perpendicular on-street parking takes place on both sides of the road. Site visits revealed parking congestion here. The road is serving relatively old residential blocks that are occupied by Alexandria settlers. Most of the apartment blocks are five floors, with the exception of the corner block, which is eight floors. These create continuous parking demand. In addition, a wholesale supermarket is an attraction for shopping and hence short-term parking demand.

On El Casino street, parking on both sides of the road is common by occupants of the residential blocks, and by customers to commercial areas. In winter, parking problems seem to be moderate here. The road is serving some relatively old residential blocks (four blocks with five floors) that are occupied by Alexandria settlers. However, during the summer, the situation is expected to worsen since, on the two corners of the road, there are relatively new blocks (eleven floors with large floor areas). These are mainly occupied in summer by visitors to Alexandria creating a potential for parking congestion during the summer season. Several commercial and service activities on the ground floors of the apartment blocks create short-term parking demand.

Several types of public transport travel along El Corniche street. These include public buses, taxis and service buses. A bus stop is located in front of the site towards Hammam El Saydat Street. Several service taxis and taxis stop at El Corniche street in front of the site to drop off and pick up passengers. In addition, a tramway runs parallel to Abdel Salam Araf street, to the back of the site and there is a tram station halfway along the road.

Normal traffic growth

Traffic has been growing throughout Egypt over the last ten years or so at a rate of about 3.2% per annum (pa). Between 1991 and 1996, vehicle registrations grew at an overall rate of 4% pa, with private vehicles growing at 3.7% pa. Based on the review of growth factors, a normal traffic growth factor of 3.5% was adopted. Applying this to the current existing traffic flows, future expected traffic in year 2012 is presented in Figure 4. The figure shows the peak traffic volumes in the scenario without San Stefano grand plaza.

Generated traffic

The San Stefano grand plaza is composed of areas allocated to several land-use types. The exact distribution of these areas according to these land-use types is presented in Table 1 developed by Webb Zerafa Menkes Housden Partnership (WZMH) project architectures in 1999. The table shows that the designed gross floor area (above grade) is 289,790 m^2. Other important statistics are also displayed in Table 1, where the numbers of apartment units, hotel suites and cabanas are stated. The areas or the number of units present the basis for computation of trip-generation/attraction rates and for parking requirements.

As a result of the development of the San Stefano grand plaza, traffic would be attracted to the complex. A review of existing local studies and international references was conducted to identify appropriate trip-generation/attraction rates. These, when multiplied by the area of generation/attraction units produces the generated/attracted peak-hour traffic resulting from the complex development. This procedure is shown in Table 2.

Assigning and adding this generated traffic to the estimated normal future traffic, produces the expected peak traffic volumes. The estimated future traffic in 2012 (design year) is presented in Figure 5, which shows the expected peak traffic volumes in the scenario with San Stefano grand plaza and with minimum intersection improvements.

Table 1. Distribution of gross floor areas according to land-use types for San Stefano grand plaza (in m^2)

Levels/floor designation	Parking	Retail		Offices	Hotel	Restaurants and lounges	Apartments	Miscellaneous	Totals
		Leasable	Mall						
Parking level P3	26,460	–	–	–	–	–	–	–	26,460
Parking level P2	26,460	–	–	–	–	–	–	–	26,460
Parking level P1	26,460	–	–	–	–	–	–	–	26,460
Lower ground	–	15,345[a]	3,090	–	2,040[b]	–	–	4,880[c]	25,355
Below ground subtotals	79,380	15,345	3,090	–	2,040	–	–	4,880	104,735
Ground	–	9,865	3,080	385	2,325[d]	–	–	4,100[e]	19,755
First	–	6,370	3,710	–	–	2,485[f]	4,085	1,200[g]	17,850
Second	–	–	–	4,980[h]	4,315[i]	–	4,505	3,870[g]	17,670
Third	–	–	–	5,205	575[j]	–	4,505	3,625[g]	13,550
Fourth	–	–	–	4,590	940	–	5,410	–	10,940
Fifth	–	–	–	–	–	–	9,340	–	9,340
Typical (6 to 14) (9 floors)	–	–	–	–	7,290	–	71,450	–	78,740
Typical (15 and 16) (2 floors)	–	–		–	1,620	–	15,760	–	17,380
Typical (17 and 18) (2 floors)	–	–	–	–	1,620	–	15,630	–	17,250
Typical (19 and 20) (2 floors)	–	–	–	–	2,070	–	15,510	–	17,580
Typical (21 and 22) (2 floors)	–	–	–	–	2,070	–	15,140	–	17,210
Typical (23 and 24) (2 floors)	–	–	–	–	–	–	17,010	–	17,010
Typical (25 and 26) (2 floors)	–	–	–	–	–	–	16,770	–	16,770
Typical (27 and 28) (2 floors)	–	–	–	–	–	–	9,520	–	9,520
Typical (29 and 30) (2 floors)	–	–	–	–	–	–	9,225		9,225
Above ground subtotals	–	16,235	6,790	15,160	22,825	2,485	213,860	12,435	289,790

Facts:

Site area: 26,989 m^2

Designed gross floor (above ground) = 289,790 m^2

Designed building height: 30 floors above street level plus mechanical roof

Above areas exclude balcony, terrace and outdoor decks

Apartments = 940

Hotel Suites = 143 rooms

Hotel furnished apartments = 26 cabanas

Parking capacity = 1857 cars

Source: WZMH (1999)

Notes::

[a] Includes 2,360 m^2, cinemas and retail storage

[b] Includes hotel back of house

[c] Includes parking ramps, cores and service areas

[d] Includes 555 m^2, ballroom entrance lobby and 340 m^2 coffee lounge and restaurants

[e] Includes loading bays, parking ramps and residential cores

[f] Includes kitchens

[g] Includes cores and service areas

[h] Includes 600 m^2 stock exchange trading floor

[i] Includes ballroom, pre-function, kitchen, meeting rooms and exhibition halls

[j] Includes ballroom kitchen

Table 2. Review of trip-generation/attraction rates and computation of generated traffic

Area type	Area in m^2 / number of units	Generation/attraction rates (peak hourly trips/area or unit)	Source	Generated/attracted trips
Retail/commercial	23,025 m^2 248,000 $feet^2$	4.8 peak trips per 1,000 $feet^2$ of gross leasable area (GLA) (50% entering/50% exiting)	ITE (2000a)	248*4.8=1,190 trips/hour (595 entering, 595 exiting)
Offices	15,160 m^2 163,000 $feet^2$	1.7 peak trips per 1,000 $feet^2$ of GLA (50% entering/50% exiting)	ITE (2000a)	163*1.7=277 trips/hour (139 entering, 139 exiting)
Restaurants and lounges	2,485 m^2 27,000 $feet^2$	8.7 peak trips per 1,000 $feet^2$ of GLA (50% entering/50% exiting)	ITE (2000a)	27*8.7=235 trips/hour (118 entering, 118 exiting)
Apartments	940 units 213,860 m^2 2,300,000 $feet^2$	0.71 peak trips per multi-family dwelling unit (50% entering/50% exiting)	ITE (2000a)	940*0.71=668 trips/hr (334 entering, 334 exiting)
Hotel rooms and furnished apartments	143+26=169 units 22,825 m^2 Assume an average of 2 beds/room	0.58 peak trips per hotel room (50% entering/50% exiting)	ITE (2000a)	169*0.58=98 trips/hr (49 entering, 49 exiting)
Total				1,235 trips/peak hour/direction

Capacity analysis and level of service determination

In 1999, the San Stefano site was surrounded by four main intersections, one at each corner. One of these intersections, El Corniche/El Casino, was controlled by a traffic signal. The other three were operating as priority-type intersections. Examining expected traffic levels indicated the need to introduce traffic signals at two other intersections: El Casino/Abdel Salam Araf and El Corniche/Hammam El Saydat.

Assuming these signals were introduced, capacities and levels of service were estimated and compared both for the with-project and the without-project scenario (see Table 3). The table shows the expected LOS and delays for each of the approaches constituting the proposed three intersections with traffic signals.

According to the *Highway Capacity Manual* (USDOT, 2000), the operational status of an intersection with a volume to capacity (v/c) ratio above 1.00 and an average delay per vehicle of more than 60 seconds, is operating at an over-capacity situation. It is obvious from Table 3 that the whole network around the complex would be in an over-capacity state, causing considerable queues, delays and congestion and probably total blockage.

Parking demand/supply analysis

A parking demand/supply analysis involves the determination of parking requirements in accordance with specific land uses. A review of existing local studies and of international references was conducted to identify appropriate parking-generation

Table 3. Level of service (LOS) assessment for main intersections

Arms and intersections	Operational criteria					
	V/C ratio		Average delay/vehicle (sec)		LOS	
	Without	With	Without	With	Without	With
El Corniche eastbound	1.58	2.2	> 60 sec	> 60 sec	F	F
El Corniche westbound	1.53	2.2	> 60 sec	> 60 sec	F	F
El Casino southbound	0.53	0.53	< 5.0 sec	< 5.0 sec	A	A
El Corniche/El Casino intersection			> 60 sec	> 60 sec	F	F
Abdel Salam Araf eastbound	1.27	1.6	> 60 sec	> 60 sec	F	F
Abdel Salam Araf westbound	1.1	1.3	> 60 sec	> 60 sec	F	F
El Casino northbound	0.54	0.77	> 5 & ≤ 15 sec	> 15 & ≤ 25	B	C
El Casino/Salam Araf intersection			> 60 sec	> 60 sec	F	F
El Corniche eastbound	1.67	2.3	> 60 sec	> 60 sec	F	F
El Corniche westbound	1.8	2.4	> 60 sec	> 60 sec	F	F
El Corniche/Hammam intersection			> 60 sec	> 60 sec	F	F

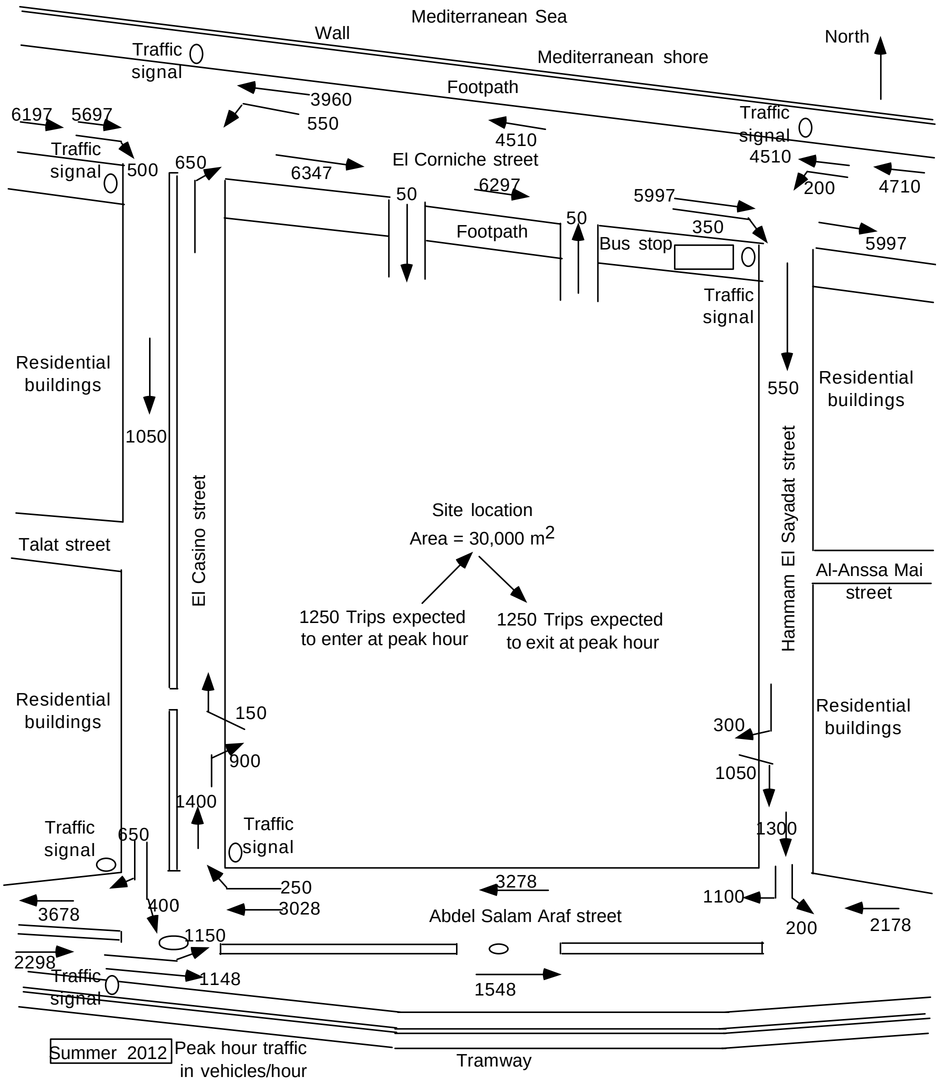

Figure 5. Forecasted 2012 traffic circulation and flows (with complex scenario and minimum intersection improvements)

rates. These, when multiplied by the appropriate parking-generation units, produce parking requirements according to the specific unit/area function. The computation of parking requirements for San Stefano grand plaza is shown in Table 4. The number of spaces currently designated for parking represents the supply of parking as given in the complex concept design prepared by WZMH (see Table 5).

A comparison of parking supply and parking demand was conducted to determine the adequacy of parking areas, and to assess potential problems that might result from any inadequacies (see Table 6).

Assuming a particularly high turnover rate for the commercial parking spaces (>2 vehicles/hour), the total parking demand might be reduced to a minimum of about 2,000 spaces. The parking demand/supply analysis still indicates a discrepancy between the expected parking demand and the supply as proposed by WZMH. The inadequacy of parking supply is estimated at around 400–500 spaces, which represents some 18% of total expected parking demand.

Potential problems

The analysis has shown that it is expected that traffic on the surrounding network of roads would reach, and even exceed, the capacity of all intersections and road links. This would lead to a complete road blockage of the site at peak periods. This could be expected to produce queues extending in both directions along El Corniche and Abdel Salam Araf

In cases of emergency, the capacity shortfall of the surrounding roads would be extremely dangerous, with fire and ambulance vehicles not being able to reach the complex, and vehicles being trapped inside the parking areas

Table 4. Parking generation rates and computation of parking requirements for San Stefano

Area type	Area in m^2/number of units	Parking rates (space/area or space/unit)	Source	Parking requirement	Adopted parking requirement (spaces)
Retail/ commercial	20665 m^2 222,000 feet^2	4.0 spaces per 1,000 feet^2 of gross leasable area (GLA) for centres having 25,000 to 400,000 feet^2	ITE (1988)	222*4=888	
		3.0 spaces per 1,000 feet^2 of (GLA)	ITE (2000b)	222*3=666	413
		1 space/50m^2	CG (1998)	413*1=413	
		1 space/50m^2	Dubai City	413*1=413	
		1 space/20m^2	Kuwait City	1033*1=1033	
		1 space/30m^2	Abu Dhabi	689*1=689	
Offices	15,160 m^2 163,000 feet^2	3.0 spaces per 1,000 feet^2 of GLA	ITE (1988)	163*3=489	
		1 space/50m^2	Kuwait City	303*1=303	300
		1 space/50m^2	Abu Dhabi	303*1=303	
Restaurants and lounges	2,485 m^2 27,000 feet^2	20.0 spaces per 1,000 feet^2 of GLA of restaurants	ITE (1988)	27*20=540	
		10 spaces per 1,000 feet^2 of GLA of restaurants/lounges	ULI (1983)	27*10=270	270[a]
Cinemas	4 Cinemas with 750 seats	0.3 spaces/seat	ITE (1988)	750*0.3=225	225[a]
Apartments	940 units 213860 m^2 2,300,000 feet^2	1.5 spaces per multi-family dwelling unit with one or two bedrooms	ITE (1988)	940*1.5=1,410	1,260
		1 space /55m^2	Kuwait City	3,888	
Hotel rooms/ furnished apartments	169 units 22825 m^2	0.3 space/5-star hotel room	ENAS (1996)	169*0.3=51	
	Assume an average of 2 beds/room	1.25 spaces/hotel room	ITE (1988)	169*1.25=211	75
		0.81 spaces/hotel room	ITE (2000b)	169*0.81=137	
		1 spaces/hotel room	ITE (1992b)	169*1=169	
		50% of beds	Dubai City	169*2*0.5=169	
		1 space/55m^2	Kuwait City	415*1=415	
Total					2,543[a]

Note: [a] Some demand will not coincide with peak parking requirements

streets. The other two roads — El Casino and Hammam El Saydat — could also become completely jammed.

The existing road network in the vicinity cannot support the volume of traffic that is likely to be generated by the new complex. The impact of the capacity shortfall is critical, not only on the potential use and commerciality of the complex, but also on the surrounding road network, which will have to bear the burden of absorbing unmet demand. In cases of emergency, this situation would be extremely dangerous, with fire and ambulance vehicles not being able to reach the complex, and vehicles being trapped inside the parking areas. Therefore, finding a solution to the network capacity issue must be addressed adequately.

Table 5. Parking design criteria as proposed by WZMH

Parking	Criteria
Apartments	1260
Hotel	
Retail/office	597
Ballroom	
Total	1,857

Source: WZMH (1999)

Table 6. Parking demand/supply analysis

Area type	Adopted parking demand (spaces)	WZMH parking supply (spaces)	Potential discrepancy (spaces)
Apartments	1,260	1,260	0
Retail/ commercial	413	No specific allocation	
Offices	300	No specific allocation	
Restaurants and lounges	270	No specific allocation	
Cinemas	225	No specific allocation	
Hotel rooms/ furnished apartments	75	No specific allocation	
Sub total	1,283	597	686
Total	2,543[a]	1857	686
	am 2,150[b]		293
	pm 2,245[c]		388

Notes: [a] Some parking demand will not coincide with peak parking requirements: certain trip purposes are am specific, such as work trips, while others are pm specific, such as leisure trips to cinemas and restaurants

[b] Expected morning parking requirement, where parking requirements for cinemas and partly for restaurants are excluded

[c] Expected evening parking requirement, where parking requirements for offices are excluded

The effect would be made worse by cars parking on these roads as a result of the expected inadequacies in the parking supply. The concept design layout seems to provide insufficient parking space for the users of the complex. This could adversely affect the commercial viability of the building and create conflicts, which may spread to the adjacent streets.

If the parking inadequacy is not dealt with, the unmet parking demand would be expected to use the surrounding road network for alternative parking spaces. This would inevitably cause blockage of road lanes and a large number of traffic conflicts, potential accidents, traffic congestion and difficulties in traffic flow on the surrounding network of roads. As a result of inefficient traffic flow, traffic conflicts and congestion, expected exhaust emissions and noise levels would increase presenting an unpleasant situation for the users and customers of the proposed complex.

Proposed improvement measures

Suggested improvements could include traffic management measures to slightly upgrade the El Corniche corridor capacity. These could include introduction of traffic signals at some intersections (already proposed and tested), linked signals, banned turns, parking controls, and so on. Entry and exit to parking areas and internal circulation should be properly designed in accordance with standards. These are meant to facilitate the circulation and movement of traffic at times of events such as celebrations, cinemas and conferences. In this context, it is advisable to have separate entry and exit ramps to the parking areas.

The concept of allocation of parking bays to different grand plaza users can present an important element in optimising the circulation pattern and maximising the efficiency of car park usage. However, this has to be enforced in order to succeed. Such measures should also be accompanied by an increase of parking supply by one extra parking floor.

However, all the above measures are still not sufficient to deal with the expected problems of congestion and total road blockage. El Corniche street carries most of the through traffic from one side of Alexandria to the other, with a peak-hour traffic flow of approximately 4000 vehicles/hour in the summer season of 1999. This traffic volume is already on the high side.

The new development would generate/attract an estimated traffic volume of 2500 in the peak hour. This will add to the problem of traffic flow along El Corniche street. The scheme for widening El Corniche street in each direction would help to alleviate the traffic problem here. To improve the situation further, a covered underpass along El Corniche street was recommended. This would cater for the through traffic and separate it from the local circulation and new development traffic.

The main advantages of an underpass are:

- separating the local traffic and those using the new development from the through traffic on El Corniche street;
- minimising any potential traffic conflicts and substantially improving the network capacity;
- reducing the adverse environmental impacts of the traffic on El Corniche street by having a covered underpass, thus reducing the dispersion of noise and pollution;
- creating an environmentally pleasing area by utilising the covered underpass for landscaping.

On the other hand, the main disadvantages of this underpass are the encroachment on the sea and the need for elaborate and costly marine and construction works.

Selected improvement package

Based on the above analysis and review of potential problems and mitigation measures, a package of improvements including several components was selected (see Figure 6). First, it was decided, as part of the improvement of the whole Corniche in Alexandria, to widen El Corniche street to become an urban arterial with five lanes in each direction separated by a narrow median. This entails the removal of the intersections of El Corniche with El Casino and El Corniche with Hammam El Saydat. This is expected to accommodate the through traffic along El Corniche without it being impeded by local traffic generated by San Stefano grand plaza. In addition, the road width and number of lanes can accommodate entry, exit and parking manoeuvres along the portion of El Corniche facing the complex. It is to be noted that the cost of this widening (in front of the plaza) was covered by the San Stefano developers.

Another important component of the relief package is to provide future residents and workers expected to commute to/from San Stefano grand plaza with magnetic parking cards. These would allow users to enter the underground parking lots with no stoppage or impedance. Gates for the parking entrances would be provided with a system for automatically identifying residents and workers' vehicles. This would avoid long queues accumulating in the two side roads and causing blockage around the plaza.

Furthermore, the bus stop in front of the plaza would be relocated. Developers would also provide a pedestrian tunnel to enable grand plaza residents and visitors to cross El Corniche street to reach the beach and marina area safely and comfortably.

Conclusion

This paper has developed a framework of the process involved in conducting a TIA for mega projects. It is

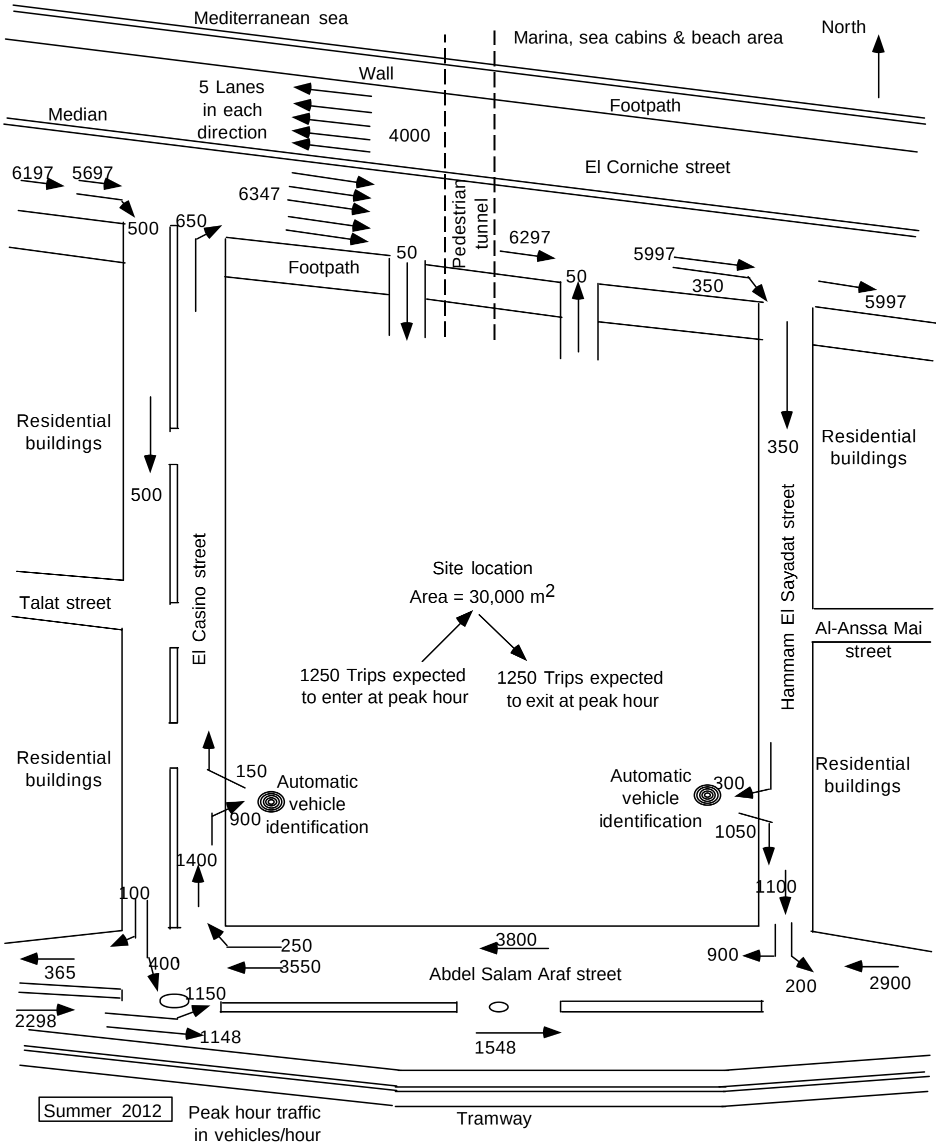

Figure 6. Forecasted 2012 traffic circulation and flows (with complex scenario and selected improvement package)

characterised by being comprehensive and structured. The applicability of the TIA process was investigated with respect to San Stefano grand plaza in Alexandria, Egypt, one of the biggest development projects in Egypt and the Middle East, involving various changes to the surrounding land-use pattern.

For such huge development projects, what is effectively at issue is determining a transport demand and supply balance that protects the rights of existing users as well as not hindering the commerciality of the development

The TIA analysis showed that traffic on the network of roads surrounding the plaza is expected to exceed the capacity of all intersections and road links. This would lead to a complete road blockage of the site at peak periods. The concept design layout seems to provide insufficient parking space for the plaza users. This could adversely affect the commercial viability of the building and create conflicts, which may spread to adjacent streets. Several measures were proposed to mitigate such effects. These were explored and the selected mitigation package was discussed.

Based on the application of the TIA process to San Stefano grand plaza, a number of lessons can be learned:

- TIA should be conducted as early as possible in the development process. When insufficient attention is given to the assessment of traffic impacts, unexpected traffic problems can negatively affect the success of the development and damage its marketability and return on investment (MCDOT, 2001). Developers should be even keener than local authorities to conduct TIA for their developments, as any traffic problems that might occur in the future would definitely impede the vitality and commerciality of their developments.

- For such huge developments as San Stefano grand plaza, architecture concept design should not be finalised before conducting the TIA. TIA is a useful tool for early identification of potential traffic-related problems and can play an important role in the concept design of the development.
- Traffic counts and surveys should be conducted both in winter and summer so as to take into account the seasonal variations that are extremely important in summer resort cities such as Alexandria.
- Studies to determine appropriate local traffic-generation rates expected from different land use are extremely important in deciding the extent of future expected generated traffic.
- Assessing the LOS for surrounding intersections is more important than for surrounding road links, as links in the urban context are short and have to be assessed as part of a longer urban arterial. However, relatively recently research was conducted to show how the capacity in terms of road width affects the computation of LOS for urban links, and how that LOS should be assessed on a ten-point scale, that is, A to J rather than the currently used A to F (Maitra, 1999).
- In the case of San Stefano, it is expected that LOS in the surrounding roads and intersections would reach F, hence causing congestion and total blockage. In such situations, it is wise for developers to consider capital investments to increase the capacity of the surrounding network by widening main roads (already implemented) or constructing an underpass that would take all through-traffic and leave the existing surrounding roads as a local network for San Stefano users.
- Studies to determine appropriate local parking requirement rates expected from different land use are extremely important in deciding the extent of future required parking supply.
- Despite the preciousness of land, developments such as San Stefano should provide all necessary parking within their own premises so as not to cause any road blockage as a result of on-street parking in the surrounding network.
- It is extremely important in TIA to decide on the design year, that is, the year when it is thought that development will be completed and potentially used. This is used for traffic forecasting and deciding the extent of generated traffic.

In conclusion, for such huge development projects as San Stefano grand plaza, what is effectively at issue is determining a transport demand and supply balance that protects the rights of existing users in terms of accessibility, mobility and environment as well as not hindering the commerciality of the development and guaranteeing its efficient use.

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