Chapter 21 Traffic Management Plan

The current condition of traffic management and related issues in the study area are already discussed in Chapter 6. As described there, various kinds of traffic management measures are already in place and new plans are being considered. This chapter proposes traffic management measures that will further improve the traffic condition and safety. The proposed measures consist of the following aspects:

- Congestion mitigation measures
- Parking management
- Traffic safety
- Traffic demand management

21.1 Congestion Mitigation Measures

21.1.1 Bottleneck Point Improvement

1) Congested locations

Traffic congestion in Istanbul has been worsening gradually with the ever increasing number of vehicles and has already become a chronic disease. The economic loss as well as environmental impact of congestion is huge and more attention must be paid to the problem and effort must be taken to mitigate the traffic congestion.

Traffic control center of the municipality should keep the congestion data, which is normally expressed as the queue length, congestion time, or average travel speed.

Traffic Coordination Directorate is developing traffic management improvement plans for congested locations along the selected arterials streets. They conduct traffic volume count survey at congested intersections and prepare improvement plans using computer simulation program. Such activities must be strengthened as routine work.

Heavily congested locations have been identified by the Study Team through discussions with transportation related agency people. They are shown in Figure 21.1.1. A total of 30 locations are identified, of which 13 locations are point while remaining 17 locations are section of expressway or arterial street as summarized below.

Source: Study Team

Figure 21.1.1 Congested Locations

Table 21 1.1 Type of Congested Location

	Expressway	Arterial street	Total
Point	10	3	13
Section	10	7	17
Total	20	10	30

Source: *ibid.*

Cause of congestion at these locations has been studied and the results are summarized in the table below. Three main reasons are identified for congestion, namely merging of flows, poor geometry and high side friction.

At interchange on the expressway, entering flow from arterial street or joining flow from connecting expressway merges with the mainline flow. If the mainline flow is already high at near capacity, there is small room for additional traffic. At many expressway interchanges in Istanbul, total traffic demand at merging point exceeds the capacity at the section resulting in the congestion.

Capacity of a road section is a function of road geometry such as lane width, gradient and alignment. Narrow lane has smaller capacity than lane with standard width and capacity of bending road is smaller than that of straight section. Congested section Nos. 22, 23 and 27 in the table have narrow lane width and clearance between carriageway and sidewalk is also narrow. These roads are not straight. As a result of such geometric characteristics, capacity is lower than the road section of standard width.

Capacity is also affected by the condition of roadside and activity there, which can be called side friction. It includes such factors as parked vehicle, crossing pedestrian, bus stop, loading and unloading activity and poor sight distance due to objects placed on the sidewalk.

It is noted that the cause of congestion at No. 9 Bakirkoy – Sahil Yolu (marina) is identified as poor geometry in the table. The actual cause of congestion is, however, reversible lane system applied along Kennedy Main Road. The number of lanes for eastbound traffic is reduced from 3 lanes to 2 lanes, while it is reduced from 4 lanes to 3 lanes for west bound traffic in the afternoon.

Table 21.1.2 Cause of Congestion

No.	Name	Merging of flows	Poor geometry	Side friction
1	Kadikoy - Hasanpasa			O
2	Uskudar - Altunizade	O		
3	Uskudar – Bulgurlu	O		
4	Umraniye – Ymraniye intersection	O		
5	Kadikoy – Atasehir Bridge	O		
6	Beykoz – Kavacik Bridge	O		
7	Besiktas – Levent Brdige	O		
8	Beyoglu – Taksim Square			O
9	Bakirkoy – Sahil Yolu (Marina)		O	
10	Basin Ekspres – Bagcilar Bridge	O		
11	Basin Ekspres – Ikitelli Bridge	O		
12	Tem Gazi Osman Pasa Bridge	O		
13	Esesnier Hal Brdige	O		
14	Maltepe Minibus Road			O
15	D100 Basibuyuk Bridge Maltepe Bridge Section		O	
16	D100 Bostanci Bridge Yenisahra Section			O
17	D100 Goztepe Brdige Location	O		
18	D100 Bogaz Bridge Ayrimi Acibadem Bridge Section	O		
19	D100 Uskudar Sapagi Kadikoy Sapagi Secgtion		O	
20	Buyukdere Road Levent 4 Levent Section			O
21	D100 Levent Sapagi Mecidiyekoy Sapagi Section	O		
22	Besiktas Barbaros Bulvari Akaretler Section		O	O
23	Sishane Kabatas Section		O	O
24	D100 Halic Bridge Okmeydani Bridge Section	O		
25	Maslak Harp Akademileri Ayazaga Sapagi Section			O
26	Hsim Iscan Gecidi Yusufpasa Section			O
27	Balat Yolu Eyup Sapagi Eminonu Sectdion		O	O
28	Vatan Caddesi D100 Sapagi Edirnekapu Sapagi Section	O		
29	D100 Cevizlibag Sapagi Zeythinburnu Sapagi Section			O
30	D100 Bakirkoy Bridge Merter Bridge Section			O

Source: *ibid.*

2) Mitigation Measures

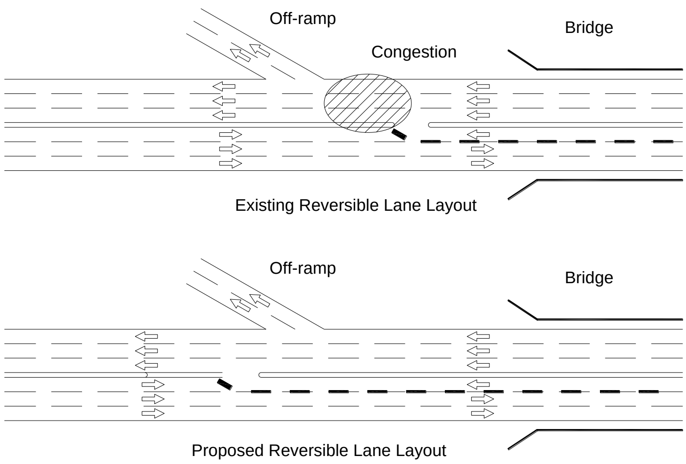
After careful study of the cause of congestion at these locations, improvement measures are prepared for some of them. In fact, it is very difficult to lessen the congestion at merging point on expressway caused by the concentration of excessive traffic except geometric widening of the expressway. The proposed measures presented below do not include such work. They can be implemented in a short time.

Table 21.1.3 Possible Solutions for Bottleneck

No.	Name	Possible Solution
1	Kadikoy - Hasanpasa	• Limit on-street parking along Sogutlu Cesme Cad. to delivery service with time limit of 15 – 30 minutes. • Strict enforcement of the above. • Widening and improvement of sidewalk. • Provision of shuttle bus service connecting parking site and the harbor.
2	Uskudar - Altunizade	• Extension of reversible lane to the nearest interchanges from the bridge on both sides (see the figure below).
3	Uskudar – Bulgurlu	• Additional traffic sign to implement priority rule at roundabout.
6	Beykoz – Kavacik Bridge	• Extension of reversible lane to the nearest interchanges from the bridge on both sides
7	Besiktas – Levent Bridge	• Extension of reversible lane to the nearest interchanges from the bridge on both sides.
8	Beyoglu – Taksim Square	• Enforcement of illegal parking • Provision of taxi stand. • Strict enforcement of no parking / standing. • Construction of pedestrian barrier to prevent jaywalking.
14	Maltepe Minibus Road	• Construction of median barrier. • Prohibition and/or management of on-street parking.
15	D100 Basibuyuk Bridge Maltepe Bridge Section	• Partial widening of D100 at uphill section.
16	D100 Bostanci Bridge Yenisahra Section	• Extension of merging lane. • Prohibition of bus stop use except buses.
17	D100 Goztepe Bridge Location	• Extension of merging lane.
26	Hsim Iscan Gecidi Yusufpasa Section	• Prohibition of on-street parking. • Management of pedestrian movements. • Improvement of signal control
27	Balat Yolu Eyup Sapagi Eminonu Section	• Demand responsive signal at intersection connecting to O-1.

Source: *ibid.*

Reversible lane is introduced on two bridges over Bosporus Straight. The reversible lane ends before the off-ramp and vehicles on the reversible lane must merge into the normal lanes resulting in the congestion under the current layout. It is proposed to extend the reversible lane section further to cover branching point with off-ramp to provide more lanes throughout the reversible lane section. A traffic sign indicating that vehicles taking reversible lane cannot proceed to off-ramp must be set up at the entrance of the reversible lane.



Source: *ibid.*

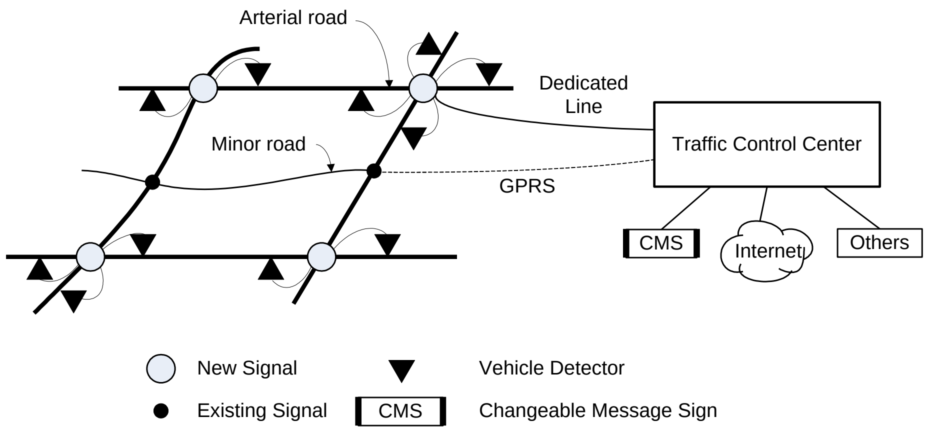
Figure 21. 1.2 Proposed Extension of Reversible Lane

21.1.2 Signal Control System Upgrading

Currently about 800 sets of traffic signal are connected to Traffic Control Center. But their signal operation is basically isolated control type with the built-in signal timing parameters. Isolated control method is not as efficient as the advanced signal system currently installed in many large cities, in which all signals are directly controlled by the computer installed in the control center and signal timing is adjusted automatically with the changing traffic demand.

It is proposed to upgrade the existing signal system by converting signals to the centrally control type and apply more advanced signal control method. It is noted that not all signals will be replaced with new type of signal to reduce the cost of upgrading. Only signals along the arterial roads where traffic operation is critical will be targeted.

As advanced signal control system needs traffic flow data at many locations in the road network in real-time, more vehicle detectors must be installed. These detectors will also be used to provide traffic condition data to the traffic information system that is also to be upgraded. The concept of new signal system is shown in Figure 21.1.3.



Source: *ibid.*

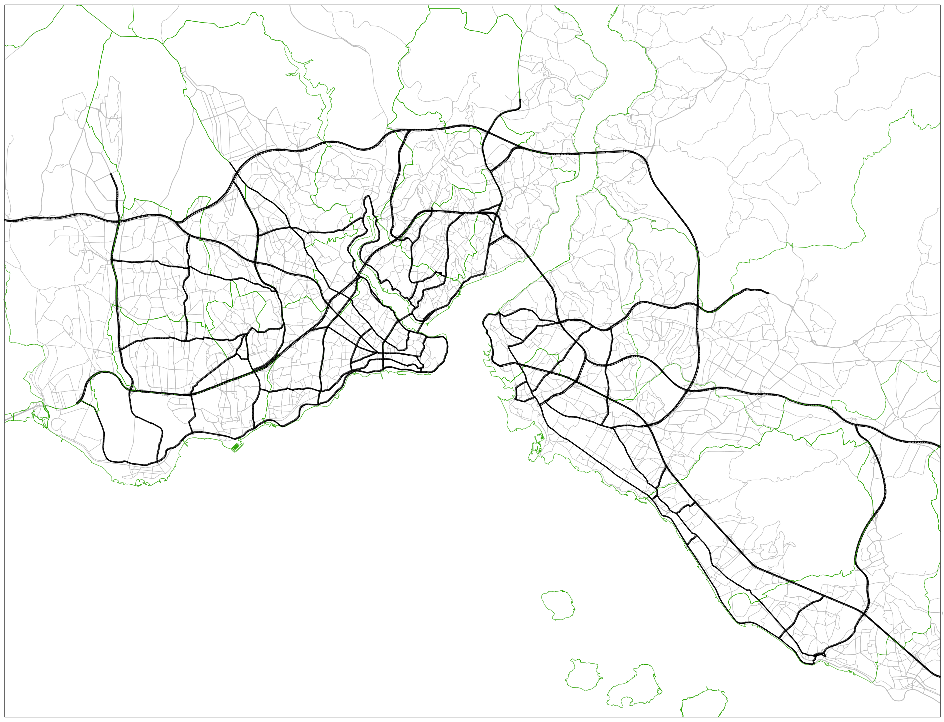
Figure21.1.3 Conceptual System Configuration

In order to implement the upgrading, the following study and the design works must be undertaken:

- Selection of arterial roads along which advance signal system will be introduced.
- Type of signal control method to be adopted
- Data communication system that allow real-time data exchange between the Control Center and each local controller.
- Signal timing parameter preparation and maintenance procedure.

1) Arterial street network

Figure 21.1.4 shows the proposed arterial road network. Signals on these roads will be converted to the new type of signal and connected to the new traffic signal control system. These roads also comprise link network for traffic information system and traffic condition on all of these links will be gathered.



Source: Elaborated by Study Team based on IMM / KGM Information

Figure21.1.4 Arterial Road Network

2) Control method

There are two types of advanced signal control method, traffic responsive control and traffic adaptive control. In general traffic responsive control selects one of the preset signal timing parameter sets that best controls the traffic based on the traffic condition data gathered by vehicle detector. On the other hand, traffic adaptive control generates signal timing parameters based on the vehicle detector data. In terms of signal operation efficiency, adaptive control is said to be better than responsive control. But difference is not decisive and may vary ;among signal systems. It can be pointed out, however, that adaptive control requires more traffic data and adjustment of the system is more complicated. If the many parameters used in adaptive control are not properly tuned, signal operation efficiency will be much degraded. As traffic responsive control selects one of the pre-calculated signal timing parameter sets, there is no risk of abnormal signal operation caused by error in the system parameter adjustment. In conclusion, it is proposed that further study be made regarding the control method to be adopted in the new signal control system.

3) Data communication system

GPRS currently used in the signal control system is not suitable for real-time data communication required for the centrally controller signal system and large scale traffic information system covering road network in a wide area. Dedicated circuit with guaranteed transmission bandwidth must be leased from the telephone company. The municipality is already aware of the need for new data communication system and consulted with the telephone company. The issue is that the lease fee of dedicated line is expensive at US$120 per month per circuit. The amount is too high compared with the cost in other countries. Even so it is not recommended to construct self-owned data communication network as the maintenance of the system will become a big burden for the traffic control center. More reasonable amount could be negotiated.

4) Signal timing parameter preparation

Advanced signal system requires more data to be prepared for better operation. There are several kinds of commercially available signal timing parameter calculation software. In order to fully utilize the benefits of these software, adjustment of the parameters used in the software to the local road and traffic conditions is inevitable. The adjustment work is tedious and requires knowledge of both traffic engineering and local traffic flow conditions.

The municipality once introduced one of such signal timing preparation software called SYNCHRO. But the software is now used not for developing signal timing but only to check the abnormality of the data prepared manually. The reason for less usage is that the software was not adjusted to local conditions so that results are often not satisfactory to apply.

In order to fully take advantage of the software, signal timing preparation and review procedure must be established and signal experts must be trained.

21.1.3 Strengthening of Traffic Information System

The real-time traffic flow data collection is the basic function of traffic management. The existing traffic information collection system is designed to monitor the traffic condition mainly on expressways and the roads covered are not sufficient to provide truly useful traffic information to road users. The system will be strengthened in terms of coverage area, type of data, collection frequency, data processing and information dissemination media.

The same arterial road network for signal system upgrading will be adopted as the coverage area of the traffic information system. Arterial roads in the network will be divided into links of the same traffic condition. Vehicle detector will be installed at each link to collect traffic data. The number of vehicle detectors will be much more than the number of the existing system. The data collected will be sent to the Control Center in real-time though the data communication system for signal system. Traffic condition of each link will be determined every 5 minutes and link travel time is calculated.

Once the traffic condition of each link is obtained, the data can be used in many ways including determination of service level, queue length and link travel time. The data will be processed in the format suitable for the media to be used for information dissemination.

It is proposed that traffic information system be designed in such a way that real-time car navigation system like VICS[1] used in Japan can be introduced to Istanbul in the near future.

21.1.4 Enforcement of Illegal Roadside Parking

One of the causes of congestion in Istanbul is illegal roadside parking along arterial roads. If illegally parked vehicles are removed from the road, traffic condition will be improved

[1] Vehicle Information and Communication System adopted and operating in Japan. The system provides real-time traffic condition data to in-vehicle navigation unit through roadside beacons and guides vehicle to destination along shortest time route.

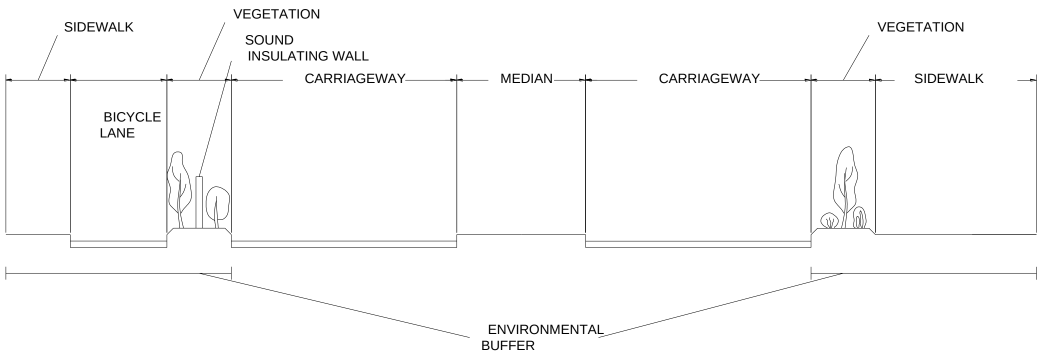
greatly. In fact, enforcement of illegal parking was made strict in June 2006 in Japan. As a result of tougher enforcement, congestion duration and travel time was reduced by 29.4% and 12.2%, respectively, along 32.1 km of roads in the central business district in Tokyo after one month of implementation [2].

Enforcement of illegal parking is carried out at the moment and in fact the number of apprehensions of illegal parking is the biggest in number among the traffic regulation violations. Nonetheless, illegal roadside parking is still rampant causing congestion. Ineffectiveness of enforcement may be attributed to the large number of illegally parked vehicles and lack of the study of the adverse effect of illegal roadside parking.

It is proposed that the enforcement be strengthened with the objective to secure smooth traffic flow along arterial streets. For this purpose, arterial roads will be designated as priority route and enforcement operation will concentrate on these routes. Evaluation of the task must be made by comparing the traffic condition before and after the operation.

21.1.5 Improvement of Pedestrian Environment

It is a basic rule of traffic engineering to segregate vehicles and pedestrians for efficiency and safety. It is proposed to improve the pedestrian environment to enhance traffic safety and promote walking as alternate mode of transportation. Although walking is not a substitute of private vehicle, private vehicle use will be reduced if walking is more pleasant than now. Specific works to be done include sidewalk improvement, vegetation, construction of pedestrian barrier, installation of pedestrian lantern, installation of mid-block pedestrian crossing signal. An example of vegetation is shown in Figure 21.1.5. Creation of pedestrian mall like the one implemented along Istiklal and properly selected streets in Kadikoy and Zeytinburnu area should be promoted also in other places.



Source: Study Team

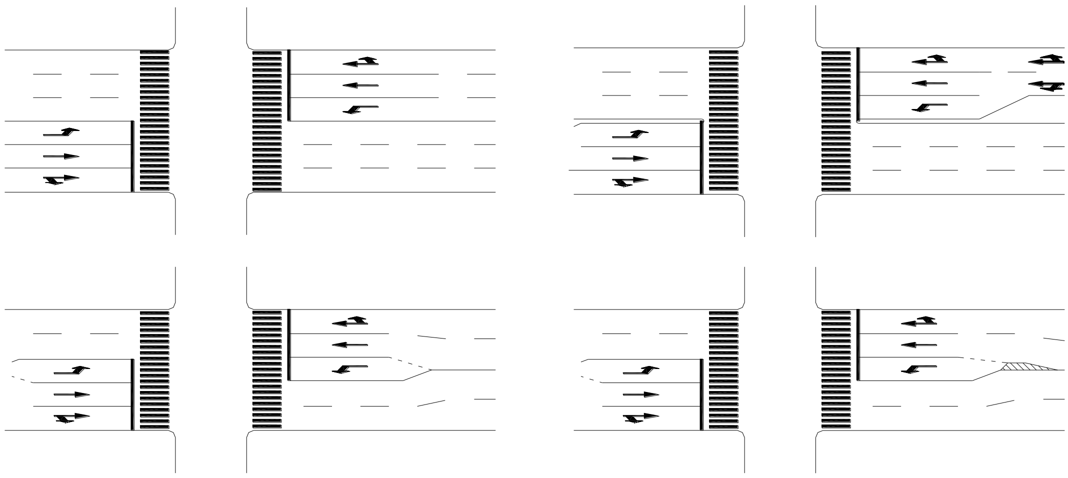
Figure 21 1.5 Example of Vegetation

21.1.6 Left Turn Lane

One of the effective measures to decongest an intersection is provision of left turn lane where left turn traffic volume is high. As left turn movement conflicts with the opposing through traffic, left turning vehicles have to wait until suitable gap occurs in the traffic flow of opposite direction resulting in obstruction of through traffic of the same direction if left turn and through traffic share same lane. Left turn lane segregates left turning traffic from through traffic so that flow can be smoother. Some examples of left turn lane layout are shown in Figure 21.1.6. Depending on the geometry of intersection, different design must

[2] Strict enforcement was made possible due to the delegation of the enforcement operation to private organization.

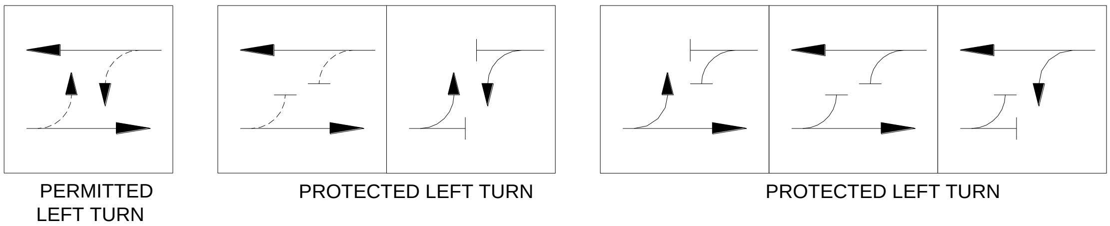
be prepared. As shown in the figure, direction of movement allowed for each lane must be clearly indicated by directional arrow.



Source: *ibid.*

Figure 21.1.6 Examples of Left Turn Lane

At a signalized intersection, left turn can be made in different ways. If left turn volume is low, left turn can be made through permissive left turn phase at the same phase with through traffic, which is sometimes called filtering. If left turn volume is higher than threshold, exclusive left turn phase must be provided to provide sufficient green time to left turn volume. There are several ways to provide left turn phase. Some example is shown in Figure 21.1.7.



Source: *ibid.*

Figure 21.1.7 Examples of Left Turn Phase

21.2 Parking Management

21.2.1 Parking Facility Development Policy

It is proposed for the municipality to review and revise the current parking facility development policy in order to control the traffic demand by parking facility supply. For this, under the new policy, it should be clearly determined in which area parking facility development is promoted or restricted. The policy shall cover the following:

- Definition and classification of parking
- Coordination and linkage with land use plan
- Parking facility required for large building and facility
- Parking development target
- Role of roadside and off-road parking facility
- Role sharing between public and private

- Control and support of parking facility development by private sector
- Review of existing parking development plan

Once the policy is formulated, parking facility development plan must be prepared for each central business district in the city where there is a large parking demand and shortage of parking facility is an issue. The plan shall cover the following topics:

- Current parking condition and issues
- Basic strategy to the parking issue
- Parking supply inventory
- Parking demand forecast and facility development target
- Specific development plan
- Measures to improve operational efficiency
- Environmental considerations

21.2.2 Roadside Parking Management

Proper management of roadside parking is important not only for the parking supply but also for smooth traffic flow. Criteria must be established as to the provision of roadside parking for each class of road. Generally speaking, roadside parking must be prohibited along arterial roads regardless of the parking demand in the area. The criteria may consider such factors as road classification, road geometry, road width, number of lanes, side clearance, traffic volume, congestion level, land use and availability of off-road parking to judge whether roadside parking is allowed or not at a specific road section. Guideline for the operating details such as allowed parking duration, parking fee level and structure, and type of vehicles allowed must also be prepared.

Traffic Coordination Directorate of the municipality will be tasked to engage in the roadside parking planning and review work. Traffic Police must be consulted when new parking regulation is decided and when there is a change in the roadside parking facility, however. The Directorate undertakes the roadside parking management task and decides whether roadside parking is prohibited or allowed at a road section periodically. It is suggested that ISPARK is defined as an organization to operate parking facility and collect parking fee. They will not be involved in the planning of roadside parking.

21.2.3 Enforcement of Illegal Parking

As proposed earlier, more strict enforcement of illegal parking must be implemented to secure smooth traffic along arterial roads. For the more effective enforcement operation the following actions are recommended:

- Clear and visible indication of no parking section: This can be achieved by more traffic signs along the prohibited section together with the color paint along curve stone or on the pavement. At the same time, roadside parking space will be clearly marked with paint as rectangular box.

- Use of clamp, tag or other devices to be attached to illegally parked vehicle: These devices prevent vehicle to move or indicate illegally parked vehicle and work as disincentive for illegal parking.

- Monitoring through video camera: Video camera installed along arterial road can be used to monitor the illegal parking. If illegally parked vehicle is found, warning message can be announced through public addressing system or traffic police nearby is called to the site for warning or apprehension.

Although it would require the enactment of new law, enforcement can be deputized to a private organization of suitable qualification as practiced in some countries including Japan. Enforcement procedure must be clearly defined and staff must be trained if the scheme is to be implemented.

21.2.4 Development of Parking Facilities for Building

The existing regulation is not effectively followed. Building permit system must be reviewed and monitoring system must be strengthened to enforce the requirement more strictly. Technical standards must be developed as to the design of parking facility to provide better and safe parking service.

The regulation will stipulate the

- Types of building to which regulation is applied
- Calculation formula to determine the required number of parking spaces
- Standards for parking facility including parking space size, parking space for disabled or handicapped, carriageway, layout, entry and exit points, and associated facilities such as fire detector.

21.2.5 Parking operation

In order to encourage more efficient use of the existing parking facilities, the following measures are suggested:

- Parking information system with static and dynamic sign indicating location of parking facilities and their availability
- Parking facility search web site
- Promotion of shared parking among the different type of parking demand
- Parking facility for specific type of vehicle such as delivery van
- Introduction of automatic payment system for both roadside and off-road parking

21.3 Traffic Safety

21.3.1 Review of National Traffic Safety Program

National Traffic Safety Program was undertaken by Turkish Government with the financial assistance from the World Bank from 1996 to 2001. The program formulated action plans to be implemented from 2002 through 2012. Intermediate review of the program was schedule in 2006. The review was, however, not conducted except updating of some data. Wide ranging recommendations are proposed for the enhancement of traffic safety in the county. Although the program was a nation wide project, there are good institutional and technical recommendations that Istanbul can refer to. It is suggested that Istanbul will review the program and develop its own traffic safety program.

More specifically, the traffic safety program for Istanbul covers such undertakings as:

- Setting of traffic safety vision, goal and targets
- Strengthening cooperation among the government and non-government

organizations involved in traffic safety.

- Development and application of traffic accident database
- Safety audit, accident black spot analysis and improvement works
- Traffic safety education for students and general public.

21.3.2 Strengthening of Organizational Set-up

Several government organizations including the municipality, traffic police, General Directorate of Highways (KGM), and Jandarma are concerned with traffic accident and traffic safety. In addition, there are several private organizations like insurance company and NGO’s who engage in the traffic safety related activities. Good cooperation and coordination among these organizations are indispensable to promote traffic safety. It is necessary to clearly demarcate the roles and tasks of these organizations and establish the cooperation among them to prevent traffic accident and promote traffic safety. At the same time, traffic safety experts who are knowledgeable with all aspects of traffic safety and traffic engineering will have to be trained. More budgets must be allocated to traffic safety to support these activities.

21.3.3 Accident Database

Currently it is very difficult to obtain the correct traffic accident data. This is due to the separated and distributed structure of traffic accident data gathering and processing system over different organizations. It would be best to develop single hierarchy accident reporting system in the traffic police. Accident data prepared by police station will be reported to the national headquarters’ through district, city, and provincial traffic police departments. Traffic accident data collected by The Istanbul Traffic Police Department must be integrated into the database and maintained by the Department. Coordination with other organizations must be established at each level and accident data must be easily available to other organizations.

The establishment of unified accident database is urgent as the accident reporting system will be modified soon and investigation by The traffic police Department will be no longer required for property damage accident. Instead, insurance company is expected to collect the property damage accident data.

In connection with the accident data base, definition of the fatality must be changed and international standards in which death within 30 days of accident is considered as fatality due to accident. The modification is important to allow international comparison of traffic accident condition.

21.3.4 Accident Black Spot

Once accident black spot analysis was undertaken and improvement works were implemented by the municipality under the national traffic safety program. The program was very successful and achieved large reduction in the number of accidents as well as the number of fatalities and injuries[3]. The operation was, however, discontinued for unknown reasons. It is proposed to revive the activity for the prevention of traffic accident.

[3] Project performance assessment report by the World Bank is available at http://lnweb18.worldbank.org/oed/oeddoclib.nsf/DocUNIDViewForJavaSearch/C9CA0DEFCAF8F20385257070007ECD8E/$file/ppar_31520.pdf

On the other hand, The Traffic Police Department undertook their own accident black spots analysis in 2007 and identified 32 black spots as shown in Figure 21.3.1. They also made brief descriptive analysis of the black spots together with the proposals for improvement. Their reviews and proposals are valuable as the report bases on their knowledge and experience of the site and the nature of the accidents.

Source: The Istanbul Traffic Police Department

Figure 21.3.1 Accident Black Spots identified by Traffic Police

21.3.5 Road Safety Audit

Road safety audit is a formal safety performance examination of an existing or future road or intersection by an independent audit team. Road safety audit is different from traditional safety review. The features of road safety audit are:

- A safety audit uses a larger (3-5 persons) interdisciplinary team.
- Safety audit team members are usually independent of the project.
- The field review is a necessary component of the safety audit.
- Safety audits use checklists and field reviews to examine all design features.
- Safety audits are comprehensive and attempt to consider all factors that may contribute to an accident.
- Safety audits consider the needs of pedestrians, cyclists, large trucks as well as automobile drivers.
- Safety audits are proactive. They look at locations prior to the development of accident patterns to correct hazards before they happen.

Sample road safety audit sheets are attached as reference.

21.3.6 Traffic Safety Education

The municipality engages in the two applausive traffic safety education activities of traffic education park and traffic education bus. Two facilities provided traffic safety education to 145,000 students during 2006 – 2007 school year. The activities should be continued. In addition to this, other traffic safety education must be initiated or strengthened.

Although the traffic safety education program is given to the frequent violators of traffic regulation, there is almost no opportunity for ordinary drivers and general public to learn about traffic safety. Thus there must be traffic education program though various channels including TV, radio, new paper and on street activities.

There are many topics to be taken up in traffic safety education. Some examples are given below.

- preparing and controlling the vehicle
- maneuvering in limited space
- signs, signals, and pavement markings
- vehicle characteristics
- human functions used in driving
- roadway variations
- intersections
- lane changes
- passing and overtaking
- non-motorized traffic
- internal factors affecting driving performance
- physical factors affecting driving performance including seatbelt usage and its benefits
- alcohol and drugs
- vehicle maintenance

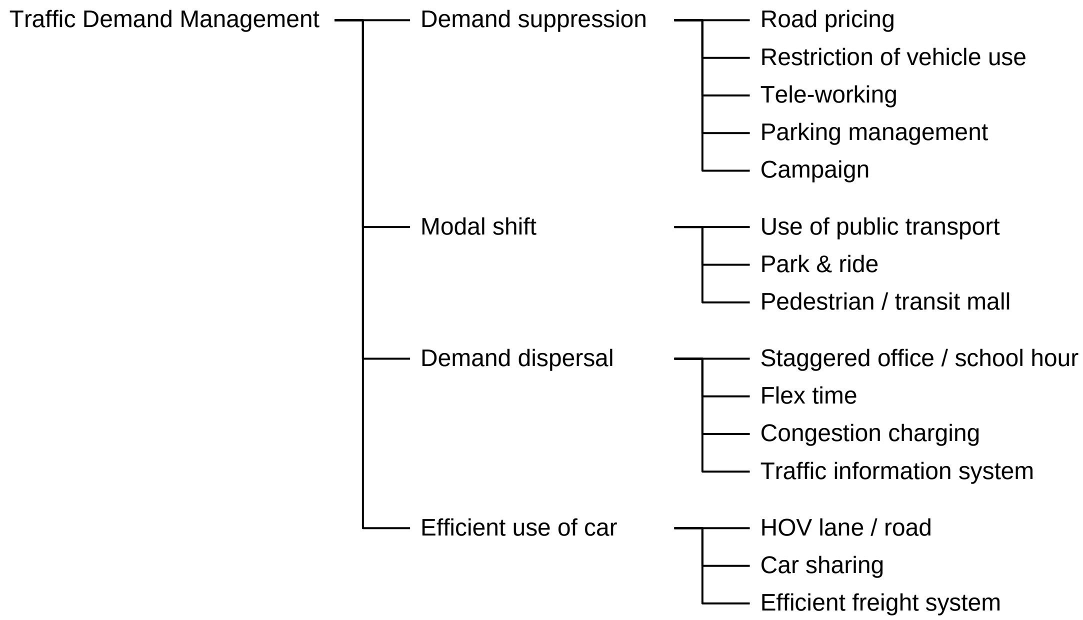
In this connection, it is suggested that although driver’s license system is a nation wide system, the current system that does not have validity period and license is valid throughout one’s life be modified and renewal system at intervals of 3 – 5 years be introduced from the viewpoint of driver’s education on traffic safety.

21.4 Traffic Demand Management

Traffic demand management (TDM) refers to the measures that control use of private vehicles with the objectives of easing traffic congestion and lessening the environmental impacts. The number of vehicles in Istanbul is rapidly growing while the road space is limited and substantial expansion of road network capacity is physically and financial impossible. If no measures are taken, Istanbul will face heavy congestion much worse than present on its road network in near future. Therefore, it is worth while to study the possibility of introducing any types of TDM measures. Because implementing TDM requires a long lead time and careful preparation.

21.4.1 TDM Measures

Typical TDM measures are shown in Figure 21.4.1. They can be classified into four groups. All of these measures intend to reduce the number of private vehicle trips or their peak directly by restricting vehicle use or indirectly promoting attractiveness of other modes of transport.



Source: Study Team

Figure 21.4.1 Typical TDM Measures

It is proposed to conduct a study on congestion charging as one of the short term projects of traffic management. The reason is that congestion charging has the direct and large impact on the vehicle trips as evidenced by the two operating systems in London and Singapore. In addition, review of the plan to construct transfer centers being pursued by the municipality is proposed.

21.4.2 Park and Ride

Park and ride scheme is intended to reduce the number of private vehicle trips from suburbs to city center by transferring them to public transport on the way. The reverse transfer occurs in the evening when commuters go home. As vehicles are parked at transferring point, parking facility is required there.

In general transfer center will be constructed at the following locations:

- Easy and short access to public transport by walking
- Easy access to arterial roads
- Medium to low level of service on the access roads
- Small environmental impacts like noise, air pollution, vibration, etc.
- Land or space of suitable size available

Traffic impact study will examine the changes that transfer center will cause and cover the following scope:

- Description of the proposed site
- Site plan including all access

- Circulation plan around the site
- Land use in the vicinity
- Assumptions made in demand forecast
- Existing and projected traffic volume (daily and peak hour)
- Forecast of transfer center demand (daily and peak hour)
- Traffic control plan
- Environmental impacts

21.4.3 Congestion Charging Principles

Congestion charging refers to the system that imposes fees to reduce peak hour traffic demand to optimal levels at the congested area. In order to construct an effective and fair congestion charging system, the following principles must be established:

1) User Perspective

- Easy for users to understand.
- Convenient – does not require vehicles to stop at toll booths.
- Transport options – consumers have viable travel options available (i.e., alternative modes, travel times, routes, destinations).
- Payment options – easy to use with multiple payment options (cash, prepaid card, credit card, etc.)
- Transparent – charges evident before trip is undertaken.
- Anonymous – privacy of users is assured.

2) Traffic authority Perspective

- Traffic impacts – does not require each vehicle to stop at toll booths or in other ways delay traffic.
- Efficient and equitable – charges reflect true user costs.
- Effective – reduces traffic congestion and other transportation problems by changing travel behavior.
- Flexible – easily accommodates occasional users and different vehicle types.
- Reliable – minimal incorrect charges.
- Secure and enforceable – minimal fraud or non-compliance.
- Cost effective – positive return on investments.
- Implementation – minimum disruption during development phase. Can be expanded as needed.

3) Society's Perspective

- Benefit/cost – positive net benefits (when all impacts are considered).
- Political acceptability – public perception of fairness and value.
- Environment – positive environmental impacts.
- Integrated – same charging system can be used to pay other public service fees (parking, public transit, etc.)

21.4.4 Study on Congestion Charging

The proposed study will investigate the possibility of introducing congestion charging system to the central area of Istanbul. The study item will include:

- Target area
- Target type of vehicles and exemptions
- Pricing strategy (time based, congestion based, amount and structure)
- Pricing method (pass, toll booth, electronic tolling, optical vehicle recognition, GPS)
- Effect of congestion charging on congestion alleviation
- Social, economic and environmental impacts
- Enforcement and violator apprehension
- Organizational set up and legislation of necessary laws and regulations

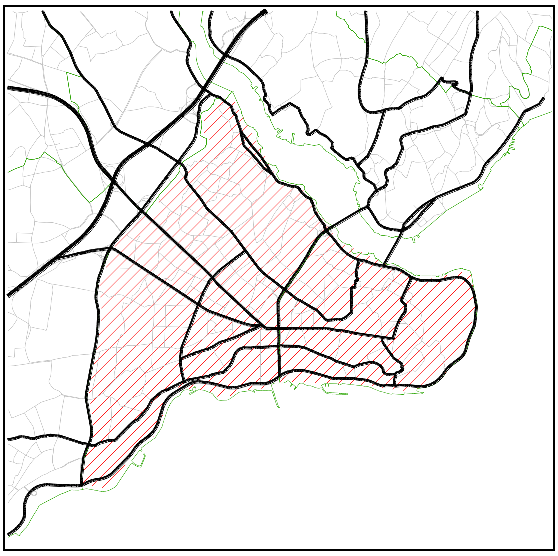
Discussions are presented below regarding some study topics listed above.

1) Target Area

Suitable area must be selected as target area to effectively reduce vehicle trips without too much negative impacts. Criteria for selecting target area

- Roads in the area are congested.
- Other modes of transport are reasonably available.
- Many vehicle trips end at the area (not many vehicle trips passing through the area).
- Geographically boundary is clear.
- The number of access roads to the area is limited if toll gates are used as pricing method.

Based on the criteria above, the Old City area surrounded by wall as shown in the figure below is proposed for the candidate area for congestion charging.



Source: *ibid.*

Figure21.4.2 Proposed TDM Area

2) Pricing method

There are several methods to collect fees. Singapore used to use pass system but they replaced it with electronic tolling system. London congestion charging uses video camera to automatically recognize number plate. Typical pricing methods are summarized in Table 21.4.1.

Table21.4.1 Typical Pricing Methods

Type	Description
Pass	Vehicle users must purchase a pass and post it on the front shield to enter a restricted area. Enforcement is made manual at checkpoints.
Manual Toll Booths	Vehicles stop and pay at a booth. Toll booths must be placed at all entering points to a restricted area. Inner trips are not charged.
Electronic Toll Gate	An electronic system charges users as they pass a point in the road system. Toll booths must be placed at all entering points to a restricted area. Inner trips are not charged.
Optical Vehicle Recognition	An optical system charges users as they pass a point in the road system. Checkpoints are not necessarily at entering points to a restricted area. Inner trips can be charged. Data exchange with vehicle registration system is required for charging.
GPS	GPS is used to track vehicle location. Data are automatically transmitted to a central computer that charges users. Additional system is required for enforcement.

Source: *Ibid.*

Comparison of pricing methods is made as summarized in the table 21.4.2.

Table 21 4.2 Comparison of Pricing Methods

Type	Equipment Costs	Operating Costs	User Inconvenience	Price Adjustability	Enforcement
Pass	Low	Low	High	Poor to medium.	Easy (manual)
Manual Toll Booths	Medium	Medium	High	Medium to high.	Easy (manual)
Electronic Toll Gate	High	Medium	Low	High	Easy (electronic)
Optical Vehicle Recognition	High	High	Low	High	Medium (database)
GPS	High	High	Low	High	Difficult (additional system)

Source: *Ibid.*

Among these pricing methods, electronic type electronic toll gate, optical vehicle recognition, and GPS, are applicable to Istanbul as manual methods are not convenient to users and they cause congestion at pass selling stand or manual toll booths. Each electronic method has its advantage and disadvantage, so that close study is required and applicability to Istanbul must be examined before selecting pricing method.

3) Impact on traffic demand

The impacts of congestion charging on traffic demand by targeted type of vehicle depend on the amount and structure of fees, target area, availability of alternative routes and modes. In general, two things can be said.

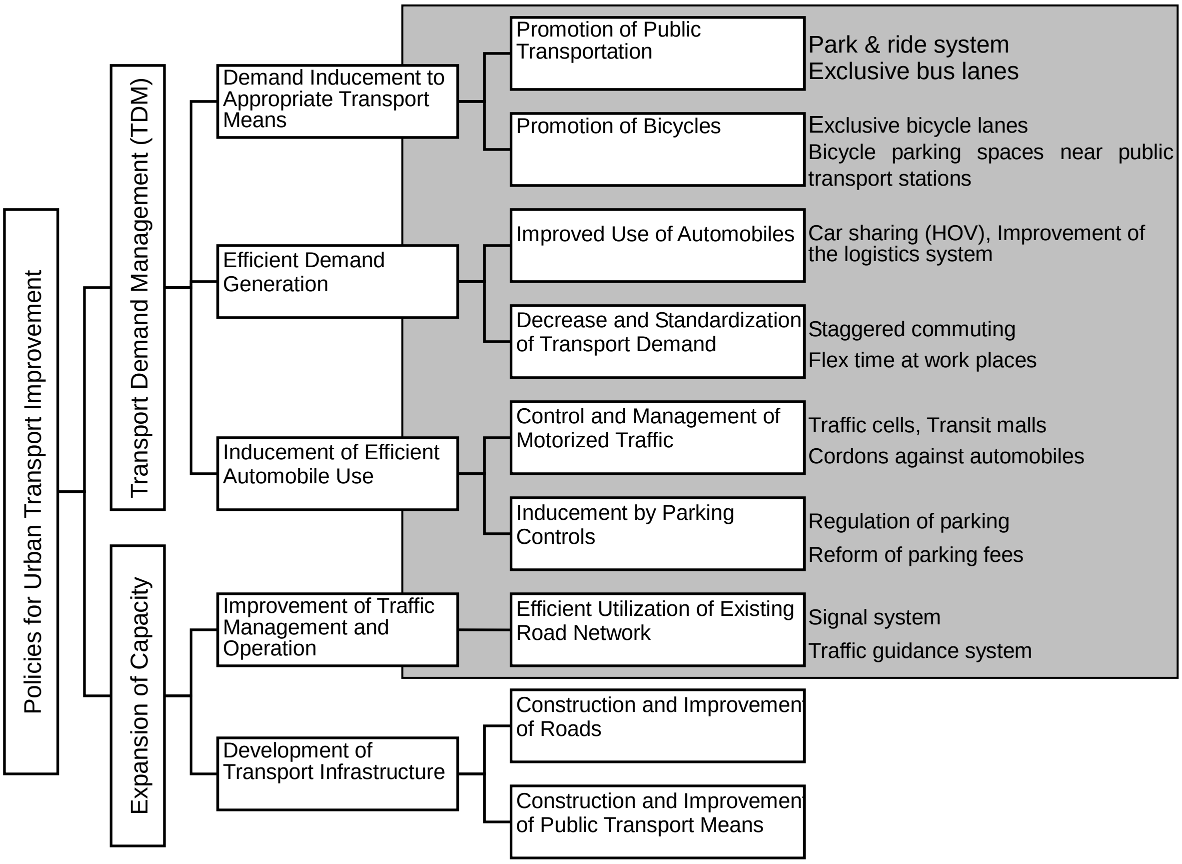
- Vehicle trips shift from peak to off-peak when there is no or small charge.
- The better the alternative mode (public transit, walking, bicycle, etc.), the more

congestion charging cause mode shift.

21.5 Transport Demand Management (TDM)

To ease the problem of growing traffic congestion and alleviate the worsening air pollution, the municipal government of Istanbul has been constructing new roads, widening the existing roads and taking other supply-side measures. The limited availability of the right of way and the mounting cost of land acquisition in the metropolitan area, among others, have begun to constrain the supply-side approach to the situation. It is now increasingly felt necessary to employ the demand-side approach as well to cope with the problem of congestion.

The transport demand management, or TDM for short, normally comprises three policy dimensions: namely, demand inducement to more appropriate transport means, efficient demand generation and inducement of efficient automobile use. The present study thinks it necessary to add another dimension, i.e., improvement of traffic management and operation, which involves the improvement of signal systems, prompt information on the traffic situation and other measures that raise the efficiency of utilizing the available transport capacity.



Source: *Ibid.*

Figure 21.5.1 Four Policy Dimensions of Transport Demand Management

Among the various policy possibilities suggestible for the four TDM dimensions, those most suited to the present conditions in Istanbul appear to be four: namely, (1) collection of tolls from highway users, (2) park & ride, (3) parking controls, and (4) introduction of traffic cells in the historic conservation area. The four suggestions are explained in detail below.

21.5.1 Collection of Tolls from Highway Users

Japan and Italy, for example, have long made it a rule to collect tolls from the users of metropolitan highways, to have them share part of the highway construction costs (beneficiaries-pay principle).4 In recent years, USA and France have started to charge the users of certain sections of the metropolitan ring roads. This TDM practice gives the cost resistance to the private car owners who travel on arterial roads to access the CBD.

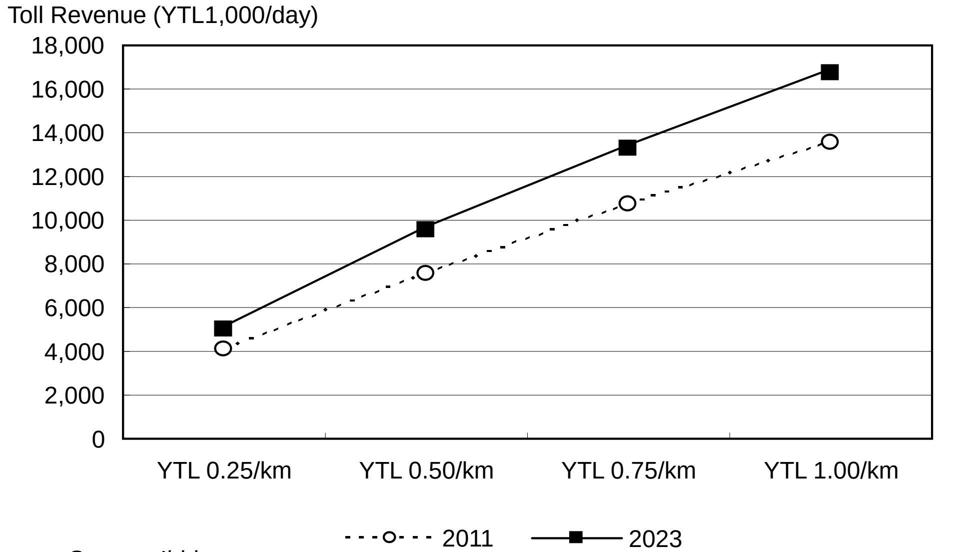
Highways D100 that cross metropolitan Istanbul in the east – west direction are at present free of charge except crossing the Bosporus. It is possible to control the transport demand by introducing the toll system to these and other arterial roads.

Table 21.5.1 shows the demand forecasts for 2011 and 2023 at different toll rates per km and the estimated toll revenues.

Table 21.5.1 Daily Demand Forecasts and Expected Revenues on Tolled Highways

Highway Toll Rate (YTL/km)	Average V/C Ratio	Length of Congestion (km)			Congested Trip Length (%)			Total Trip Length (km)	Total Revenue (YTL1,000/day)
		1.0<	1.2<	1.5<	1.0<	1.2<	1.5<		
2011									
0.25	0.62	70.9	31.7	26.5	10.0	6.2	5.0	1,305.1	4,049
0.50	0.56	52.4	23.3	25.5	7.9	5.2	5.5	1,305.1	7,577
0.75	0.53	55.8	20.8	25.0	9.2	4.1	5.7	1,305.1	10,745
1.00	0.50	45.0	15.1	25.7	7.7	2.7	6.1	1,305.1	13,554
2023									
0.25	0.79	77.8	61.7	76.5	8.0	7.1	12.9	1,305.1	5,023
0.50	0.74	86.2	55.7	73.3	10.5	8.1	11.4	1,305.1	9,547
0.75	0.68	66.2	50.1	63.0	7.8	6.8	10.5	1,305.1	13,318
1.00	0.64	64.4	37.8	60.2	7.5	5.4	10.7	1,305.1	16,731

Source: *Ibid.*



Source: *Ibid.*

Figure 21.5.2 Daily Toll Revenues Estimated for 2011 and 2023

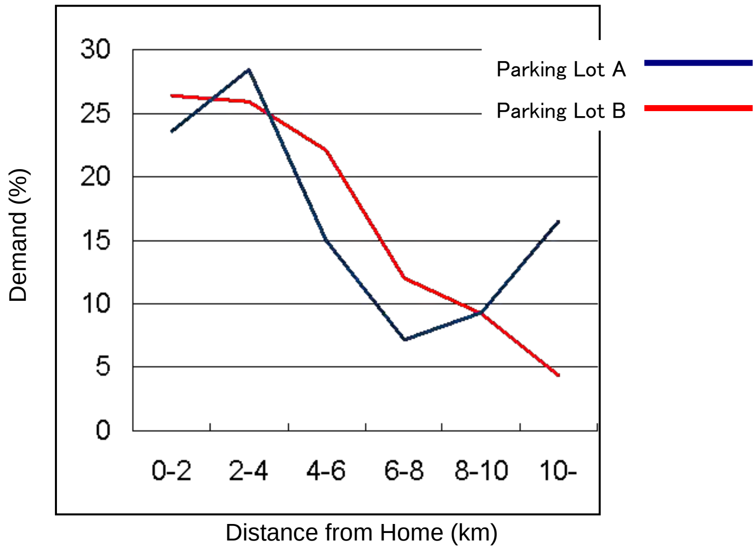
4 The toll is about USD 0.25 - 0.29/km in Japan and worth USD 0.06 -0.08/km in Italy.

21.5.2 Park & Ride

As indicated by the findings of the experiment, the full-scale introduction of the park & ride system will require a number of measures as explained below.

1) Distance from home to the parking lot

The distance must be within 4km. The demand for park & ride drops sharply if the distance exceeds this limit. The provision of parking spaces must be carefully done by estimating the potential demand within a 4km radius from a given bus stop.

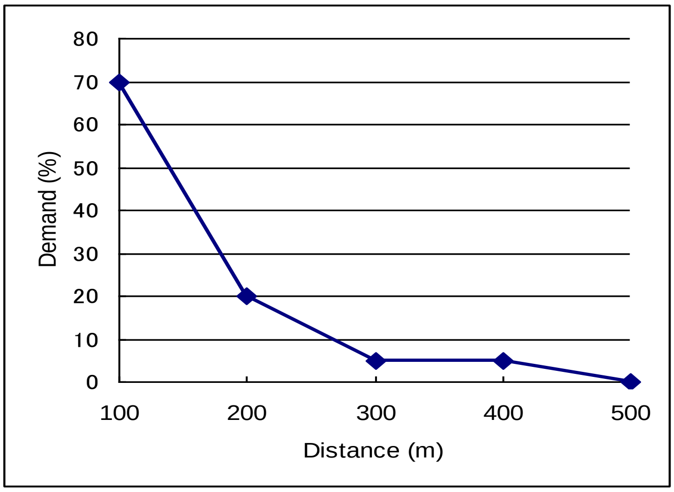


Source: *Ibid.*

Figure 21.5.3 Demand Forecasts for Parking Spaces by Distance from Home

2) Distance from the parking lot to the bus stop

The distance must be within 150m, as indicated by the findings of the experiment.

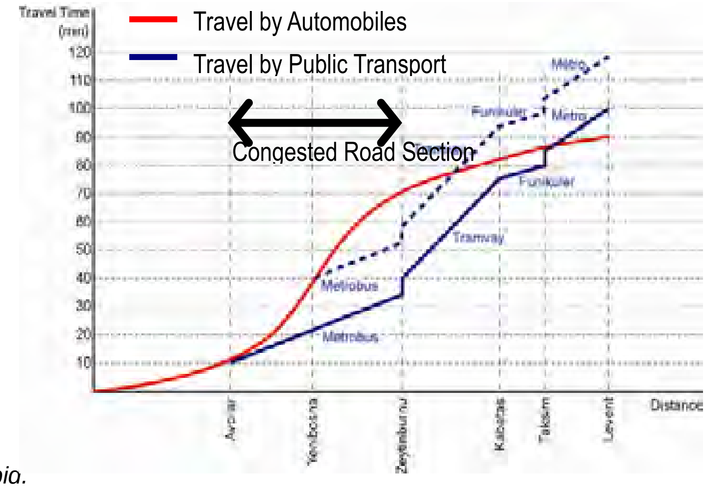


Source: *Ibid.*

Figure 21.5.4 Demand Forecasts for Distance from the Parking Lot to the Bus Stop

3) Location of parking spaces

The park & ride system is meant to reduce automobile traffic entering the CBD. Therefore, parking lots must be provided further away from the built-up areas before the congestion starts to clog the arterial roads to the CBD. When the parking lots are located in the congested area, the advantage of park & ride in travel time is lost over the automobile use. The parking spaces must be provided outside the chronically congested area, in the distance of 15km or more from the central area of Istanbul.

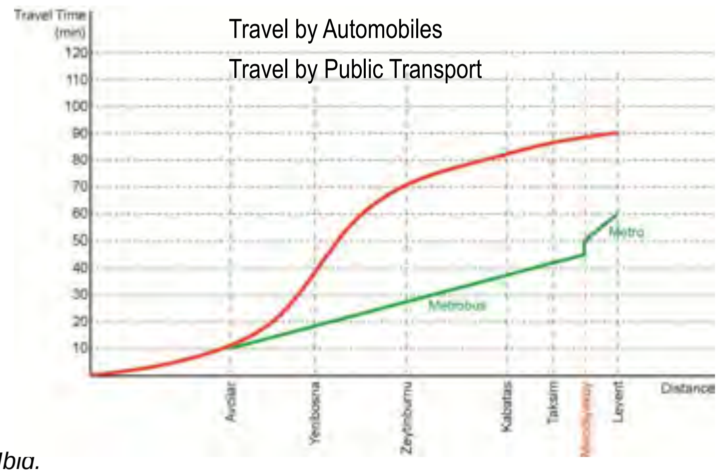


Source: *Ibid.*

Figure 21.5.5 Travel Time by Park & Ride as Affected by Location of Parking Spaces

4) Extension of public transport services into the CBD

As already mentioned, the metrobus route used for the experiment does not reach the CBD of Istanbul. Quite a few participants in the experiment had to transfer to other bus services to reach their destinations. The park & ride system will not bring the expected benefits unless this shortfall is remedied. As mentioned earlier, most of the participants who favorably viewed the experiment were those who could reach their destinations by the experimented metrobus route. The on-going extension of the route to Mecidiekoy, when completed, will undoubtedly change the situation in favor of the park & ride system, as shown by the forecast in Figure 21.5.6.



Source: *Ibid.*

Figure 21.5.6 Travel Time by Park & Ride when Public Transportation Reaches the CBD

It is necessary to provide the public transport means in such a way that the riders' transfers would be minimized. The advantage and convenience of the park & ride system will be greatly enhanced by the envisaged extensions and constructions of the metropolitan railway systems to access the central area of Istanbul.

5) Information Service

As found by the experiment, the development of physical facilities like parking spaces and rapid transits will not be enough to have the park & ride system accepted among the metropolitan commuters. It is just as important to post guide maps and notices on the available parking spaces and provide park & ride commuters with the timely and continuous information on congestion, including the possible delay in time to reach their destinations. The information service of this nature is known to be crucial for introducing this new commuting system in the urbanized areas.

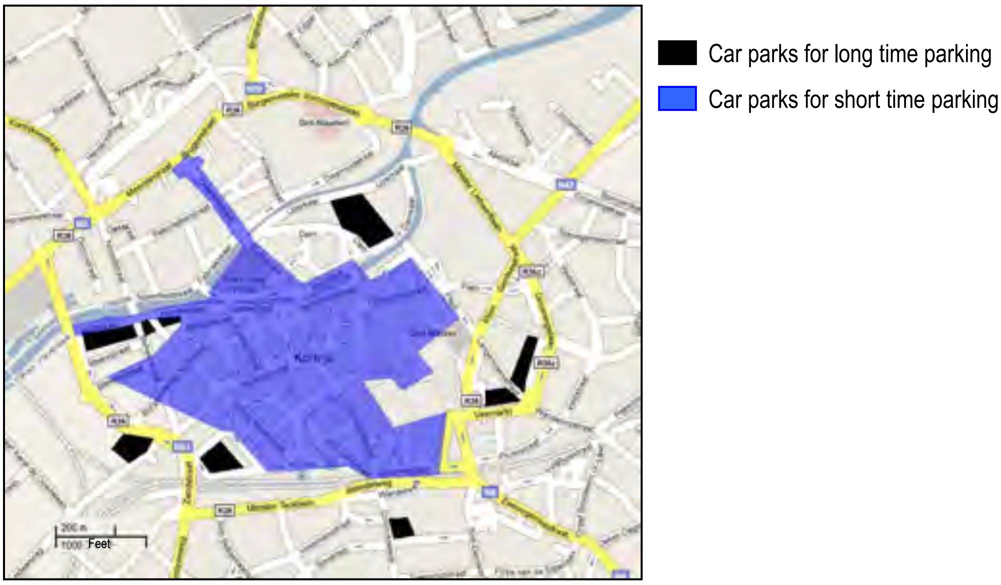
21.5.3 Inducement by Parking Controls

Automobile traffic in the CBD can be reduced and made manageable by a variety of parking controls over the metropolitan area. One example is to provide ample parking spaces along the outer limits of the CBD (promotion of fringe parking). Another is to restrict the expansion of the parking capacity within the CBD. The crackdown on illegal roadside parking in the CBD is also effective. The roadside loading and unloading of cargo often obstruct the traffic but are controllable by making it compulsory for the transporters to secure their own parking space for delivery trucks and vans.

The present study proposes the control over parking fees in the CBD. The increased parking cost will serve to discourage automobile commuters into the CBD, while the increased revenue can be partly diverted to the construction of public car parks. Specifically, a levy can be imposed on fee revenues, while the rate can be varied according to the time of day, the duration of parking and the type of motorized vehicle.

One useful example is found in Kortrijk of Belgium. The rapid motorization aggravated the traffic congestion and intensified the difficulty of finding parking spaces within the CBD. The parking control in Kortrijk consisted of raising the rate for long time parking higher than short time parking within the CBD. Car parks were then increased outside the ring road around the CBD to encourage long time fringe parking at a lower rate, while only short-time parking was tolerably possible within the CBD. The control succeeded in reducing the incoming automobile traffic and eased the congestion in the CBD.

The combination of the fringe parking in association with the park & ride system and the higher parking fees within the CBD is expected to produce similar results in the CBD of metropolitan Istanbul.



Source: Google Map / Study Team

Figure 21.5.7 Parking Control in Kortrijk, Belgium

21.5.4 Introduction of Traffic Cells in the Historic Conservation Area

Many historic edifices and structures are found in the old town of Istanbul and collectively constitute the UNESCO World Heritage Site for conservation. Their on-going deterioration is evident, however, because of the constant exposure to the high congestion and the worsening air pollution of the CBD.

The present study proposes a set of TDM measures which will be able to cope with both the motorized and the pedestrian traffic, while contributing to the conservation of historic sites for continued growth of tourism and local economic activities. The proposed measures set up traffic cells in the historic conservation area and regulate and guide the flows of pedestrians and motorized vehicles into and out of these cells.

The roads inside the historic conservation area are classified into six different categories shown in the figure below, with varying entry restrictions by vehicle type. Full malls are the streets open only to the pedestrians, while transit malls are meant for public transport vehicles as well as pedestrians. These roads are used appropriately to demarcate a number of traffic cells. The entry from the city's arterial roads to these cells is provided by the access roads and main roads with carefully worked-out restrictions by vehicle type. This type of transport demand management does not obstruct the general flows of motorized traffic entering the CBD. The access restrictions by road category are summarized as follows.

Full malls: Accessible only by pedestrians all day.

Transit malls: Accessible only by buses and taxis during day time (7:00 through 20:00) on weekdays. Delivery vehicles are allowed entry during 7:00 – 10:00 and 14:30 – 17:30 on weekdays.

Access roads 1: Accessible all day only by local residents and service vehicles.

Access roads 2: Accessible only by local residents and service vehicles during day time (7:00 – 20:00) on weekdays.

Main roads 1: Accessible only by buses, taxis, delivery vehicles and local residents during peak hours (7:00 – 10:00 and 14:30 – 17:30) on weekdays. Parking is restricted to 30 minutes or less.

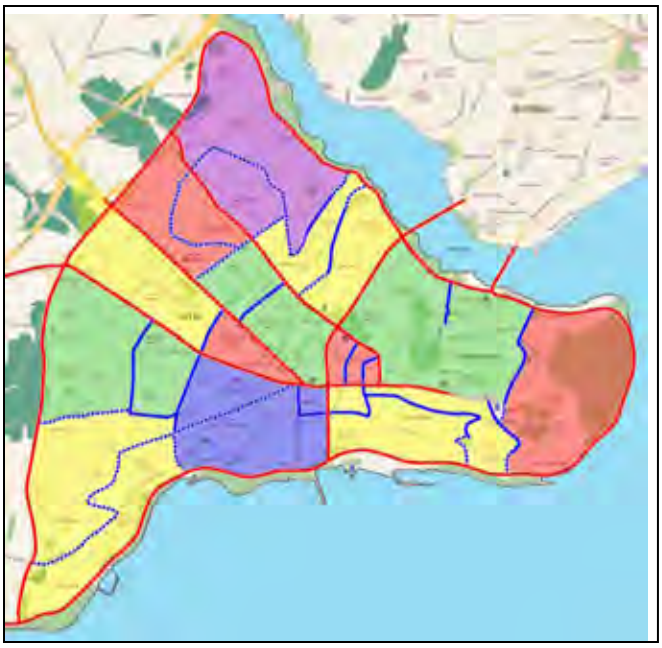
Main roads 2: These roads are arterials in the CBD with no vehicle type access restriction. In fact, the historic conservation area does not contain this road category.

Table 21.5.2 Access Restrictions by Vehicle Type and Road Category

	Private Vehicles	Commercial Vehicles	Vehicles of Local Residents	Public Transport Vehicles	Taxis	Delivery Vehicles	Government Vehicles	Pedestrians
Full Pedestrian Malls								○
Transit Malls				○			○	○
Access Roads 1			○	○			○	○
Access Roads 2	○	○	○	○	○		○	○
Main Roads 1	○	○	○	○	○	○	○	○
Main Roads 2	○	○	○	○	○	○	○	○

Source: Study Team

The traffic cells tentatively proposed for the relevant area of Istanbul are shown in Figure 21.5.8. The road width was used to classify the existing roads into six categories. However, the area is scarcely serviced by two-lane roads and many roads are too fragmentary to form a connected network. Therefore, it will be necessary to invest in the road development with reasonable care not to disturb the residential stability and commercial activities in the area.



Source: *ibid.*

Figure 21.5.8 Tentative Traffic Cells for the Historic Conservation Area

The historic heritage sites in the CBD will require some integrated implementation of other measures in addition to the proposed TDM.

(a) Parking spaces for local residents in the area
(b) Promotion of fringe parking outside the congested area of metropolitan Istanbul
(c) More frequent and area- intensive mini bus services
(d) Provision of spaces for fringe parking serving the automobile traffic on two arterial highways
(e) Prohibition of roadside parking in the area
(f) Early development of transit malls in the neighborhoods with especially important historic monuments (e.g., the area from Sirkeci to Grand Bazaar)

Minibus (Firenze, Italy)

Source of Photo: Left: Internet Site of the city
Above: Study team

Transitmall (Clermont Ferrand, France)

21.5.5 Social Experiment of Park & Ride Using Metrobus Service

1) Background

Reflecting the increasing population in the suburbs of metropolitan Istanbul, chronic traffic congestion has been spreading in recent years to the arterial roads from the suburbs to the CBD. Suburban dwellers are only sparsely serviced by public transport means and require private passenger cars for mobility. They commute by car to their work places in the city and exacerbate the traffic congestion in the built-up areas of Istanbul.

The park & ride system was originally devised to reduce the passenger car traffic in the urban built-up areas by providing parking spaces around suburban stations of public transport means. Driving commuters from the suburbs park their cars at these stations and use the public transport to commute to their work places inside the city. The experiment in Istanbul tried the park & ride system on a metrobus route.

2) Pre-Survey of Car Commuters and Metrobus Passengers

In this study, pre-survey of Metrobus passengers and car commuters had been implemented in a bid to obtain more information about Metrobus services. For example, what kind of transportation mode had been used before there was Metrobus service, points to improve in Metrobus service and reasons why car commuters don’t use Metrobus.

These pre-surveys have been implemented on July 2008, and number of valid response was 797 Metrobus passengers and 420 car commuters.

The pre-survey result on previous transportation mode before Metrobus started operation is shown in Table 21.5.3. About 95 % of Metrobus passengers were public transportation users, and only 5% of Metrobus passengers were car commuters.

Table 21.5.3 Previous Transportation Mode

	Private Car	Bus	Dolmus	Taxi	Railway	Service	Others
%	4.4	65.4	23.1	1.5	4.9	0.5	0.1

Source: Result of Pre-survey of Metrobus Passengers Conducted Study Team

3) Outline of Pre-Study: Park & Ride on Metrobus

(1) Purpose

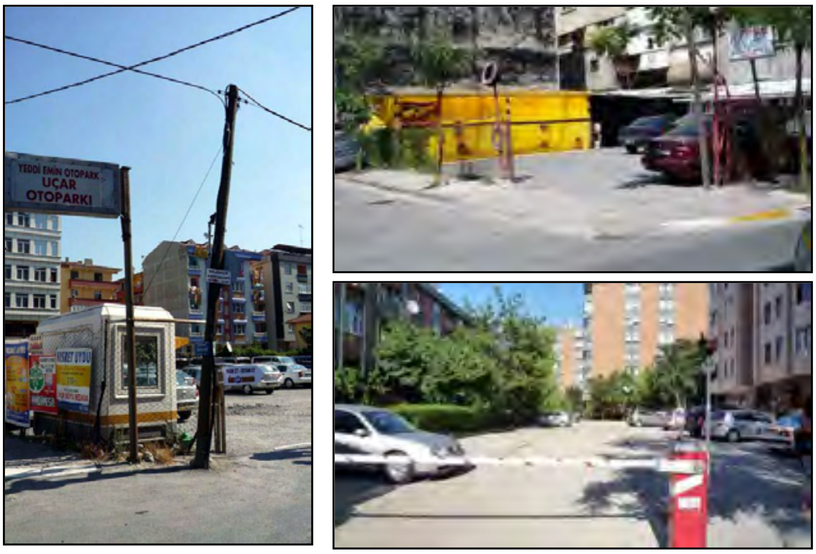
The park & ride system is known as one of the effective measures to alleviate chronic traffic congestion and air pollution by exhaust gas in urban built-up areas. The purpose of the experiment was to test the practicability of park & ride in Istanbul in view of the system's favorable impact on traffic congestion, urban environment and increased reliance on public transportation. The findings of the experiment will serve to clarify policy measures necessary to establish the system in metropolitan Istanbul.

(2) Period of Experiment

The experiment was conducted on weekdays (Monday through Friday) over two weeks in late July 2008.

(3) Outline of Experiment

A sample of 80 driving commuters volunteered for the experiment. They reside in the western suburbs of Istanbul and commute on the Highway D100. They were asked to park their cars at the prearranged metrobus stop and commute by bus to their destinations in the city. Ten public and private parking lots located within 200m distance from the bus stop agreed to provide spaces during the experiment.



Source: Study Team

Photos of the Project Site

4) Outcome of the Experiment and Major Findings

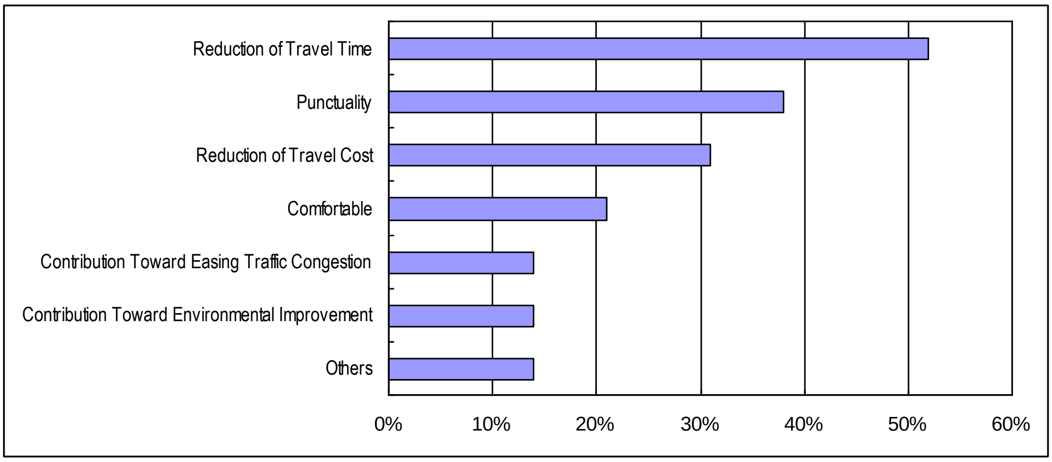
As shown in Figure 21.5.9, the metrobus route chosen for the experiment does not reach the CBD of Istanbul. This shortfall forced a considerable number of the volunteered commuters to reach their destinations by transferring, often more than once, to some other bus service. The experiment was favorably appreciated only by those who could reach their destinations by the metrobus service alone. However, 90% of the sample answered that they would welcome the park & ride system if the metrobus route should be extended to the CBD. The participants in the experiment voiced that the parking spaces need be available within 4km from their residences and within 150m from the metrobus stop.

Source: *ibid.*

Figure 21.5.9 Metrobus Route and Social Experiment Sites

The most common complaints were about parking. Some participants had a hard time to locate the prearranged parking lots, and others could not park at all because the parking lot they managed to locate had been already full. The park & ride system for Istanbul would require, in addition to the development of physical facilities like parking spaces and access roads, conveniently posted notice boards and guide maps on available parking lots.

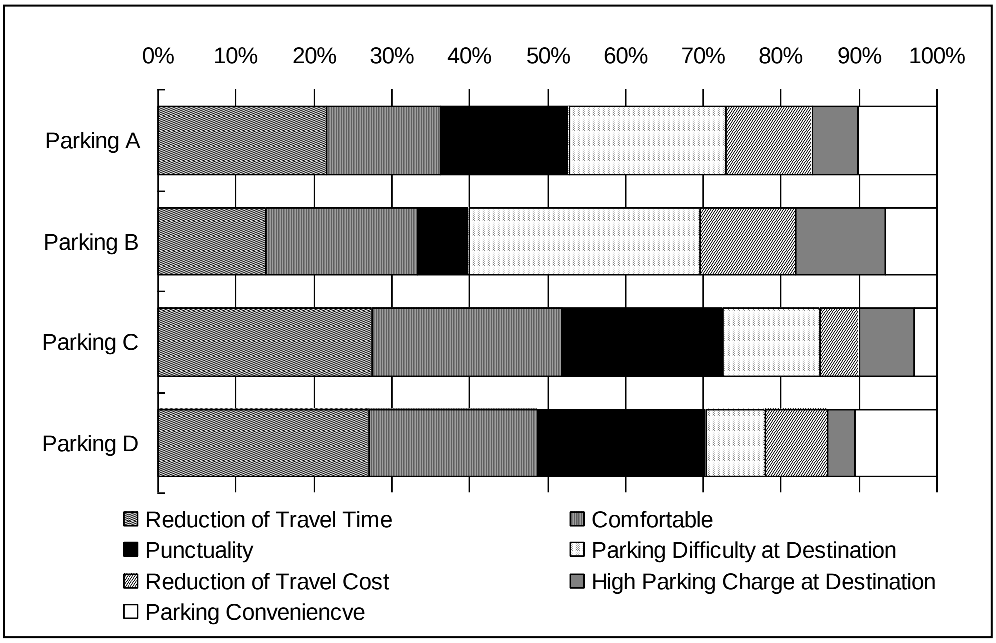
Many people answered that benefits of Park & Ride were reduction travel time and punctuality as shown in Figure 21.5.10.



Source: *ibid.*

Figure 21.5.10 Benefit of Park & Ride

About the questions of important point to use Park & Ride system, each Park & Ride user has a different set of criteria. All the criteria shown in Figure 21.5.11 need to be fully considered to promote Park & Ride



Source: *ibid.*

Figure 21.5.11 Important Point to Use Park & Ride System

5) Conclusion and Recommendation

Major findings of the park & ride experiment are summarized as follows.

(1) Park & Ride

The public transport means should not force users to make many transfers before reaching their destinations in the CBD. At least, the public transport means should go into the CBD.

(2) Parking

Parking spaces must be provided closer to the suburbs and outside the chronically congested areas.

Parking spaces need be located within 4km from the residences of park & ride commuters and within 150m from the station.

Parking spaces need be open for 24 hours with effective security service.

(3) Others

Adequate and timely information must be provided on the location of parking lots and their available capacities, and on the estimated travel time in accordance with changing congestion levels along the routes to the CBD.

Reasonable subsidization need be offered for park & ride commuters concerning parking fees and public transport fares.

Chapter 22 Disaster Protection for Transportation Infrastructure

To develop a stable and safe transportation network strong against natural disasters, it is important to investigate the risk of possible natural disasters and its affect to the transportation network. In Istanbul, a natural disaster which is the most likely to happen and to bring extensive damage to the city is an earthquake.

In this section, the possible natural disasters, especially an earthquake, will be overviewed and necessary earthquake disaster management project for transportation master plan will be mentioned.

22.1 General Background of Earthquake Potentiality in the Study Area

The study area is locating a connection zone between Asia and Europe through narrow strait of Bosporus. Urban area of Istanbul city have been developed both side of Bosporus since Roman Empire and Ottoman Turkey over more than one thousand years.

Marmara Sea region including the study area is an earthquake prone area. Many big earthquakes have been occurred historically. Main cause of earthquake is related to tectonic movement of North Anatolian Fault (NAF) which is developed in the northern part of Anatolian Peninsula from east to west over 1000 km in Turkey. The west end of NAF is locating in the southern sea bottom of Marmara Sea from Istanbul City.

On August 17, 1999, large earthquake magnitude of M 7.4 occurred in Cocaeli, Izmit and Adapazari area which are located about 110km east from Istanbul. Due to this earthquake, 20 thousands of people were killed and many buildings, social infrastructures including urban utilities, public facilities and transportation facilities severely damaged. Another strong earthquake with M.7.2 occurred on November 12, 1999 at Duzce. More than 1000 people were killed or suffered from seriously injured by this earthquake. These two recent earthquakes occurred along the NAF.

Turkish seismologists are warning and estimating a possibility of next strong earthquake at 65% within 30 years at Istanbul area.

Istanbul Metropolitan Area is now having 12 millions of population and this figure will be increased around 16 millions by 2025. Huge urbanization will be continuing in this area.

In order to sustain this urbanization, many urban infrastructures will be developed such as transportation, energy, communication and utilities. Earthquake disaster risk of the study area seems to be increasing day by day due to a rapid progress of urbanization. Therefore, it is very important subject to take a necessary mitigation measures to secure a safety or reduce earthquake disaster damage to urban infrastructures as well as avoiding human loss.

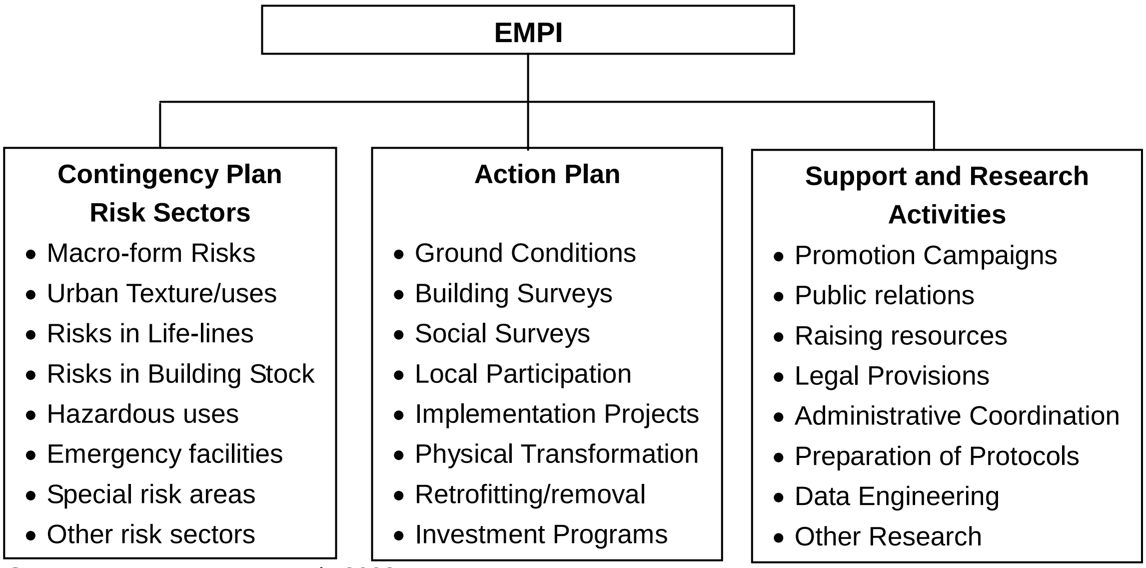
JICA (Japan International Cooperation Agency) conducted a comprehensive earthquake damage estimation study in 2001-2002 as a technical cooperation project to IMM. Based on the recommendations of this report, IMM prepared an integrated Master Plan in 2003 by their own budget for earthquake disaster management in Istanbul area. Content of this section is mainly depending on these two reports. After these studies which covered urbanized area of Istanbul city about 1,800 km^2, Istanbul Metropolitan Area was extended due to change of governmental regulation in 2005, IMM covers total area of previous

Istanbul Province. Therefore, damage estimation is limited only in old Istanbul Metropolitan Municipality area.

22.2 Earthquake Master Plan for Istanbul (EMPI)

The Earthquake Mitigation Plan for Istanbul (EMPI) was formulated by IMM based on the cooperative studies with several universities in July 2003. EMPI is a comprehensive coordination of mitigation measures to be implemented in the face of the impending earthquake in Istanbul, developing a special approach to the problem. It essentially draws the framework for a series of Social Contracts indicating to the operations necessary, and the responsibilities of all administrative units, private bodies, and the ordinary citizens.

The plan is composed from three components: Contingency Plan, Action Plan and Support and Research Activities. The Contingency Plan refers to analyses and risk management activities for the total metropolitan area. Whereas Action Plan refers to local comprehensive rehabilitation projects that cover physical transformation and community regeneration programs. Some of the Support and Research Activities have been accomplished during the EMPI preparation stage and others will have to take place at the implementation stage.



Source: EMPI Team, IMM, July 2003

Figure 22.2.1 Components of EMPI

The risks in infrastructure are pointed out as the followings;

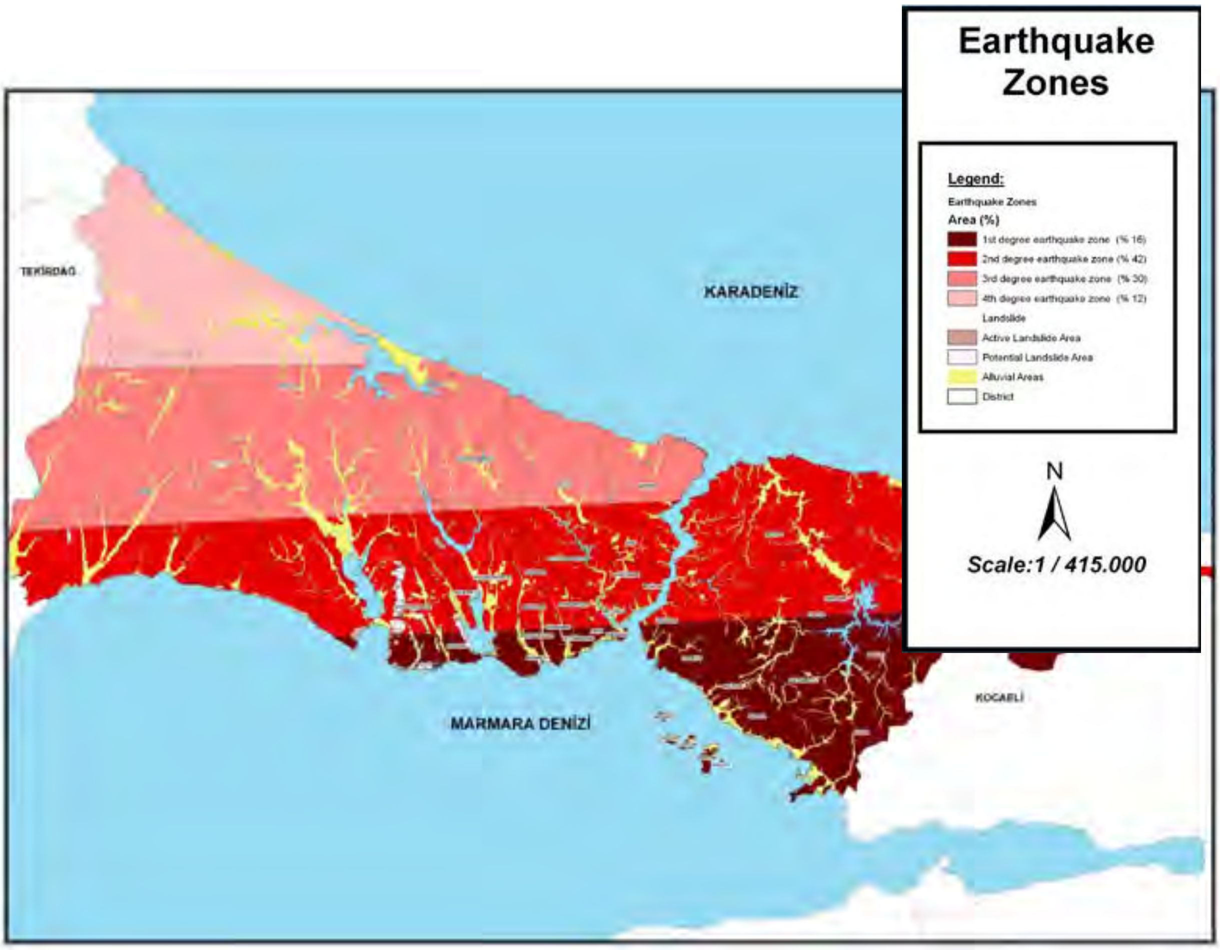
- Risks in existing road system and accessibility
- Emergency use of the road system and infrastructures
- Emergency facilities and the Road System
- Routing, networking and nodes in infrastructures

To make an integration of the Istanbul Contingency Plan in EMPI, 13 project packages are identified in the implementation project list. Regarding the transportation sector, SP3: Risks in Lifelines is including a project package for “Risks in the Macro Level Transportation Network and Mitigation Methods”.

22.3 Possible Earthquake Intensity

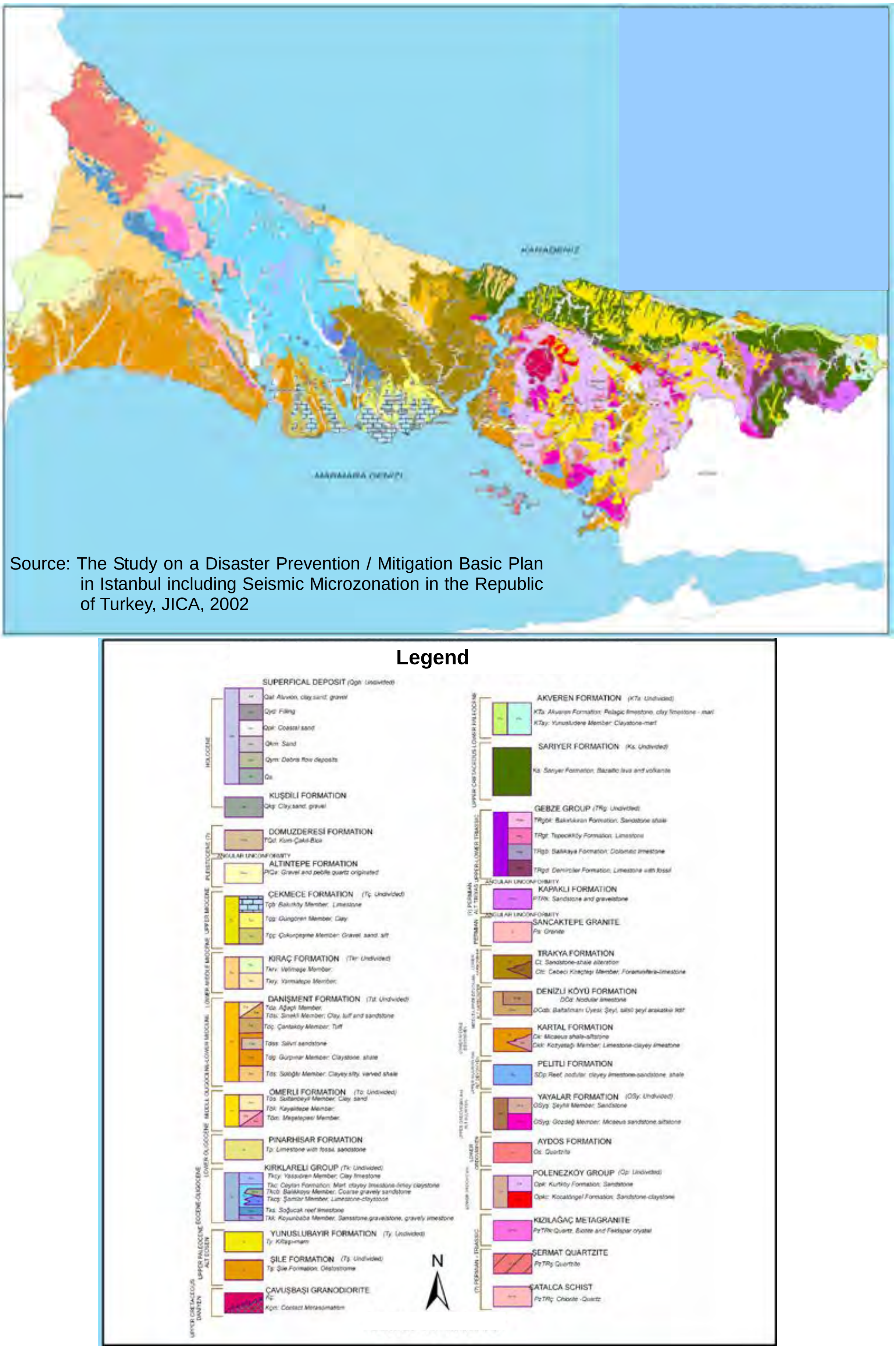
Earthquake intensity in Istanbul area is calculated and mapped as Earthquake Zones (Figure 22.3.1). This map was provided to Study Team by counter part agency. In this map, earthquake zone is divided into four zones. NAF is locating in the southern sea bottom of Marmara Sea from Istanbul. Therefore relative earthquake intensity is larger in southern part of the study area and smaller in northern area due to difference of distance from earthquake source. According to JICA Study on Disaster Management in 2001, PGA (Peak Ground Acceleration) is calculated at 400 to 500 gals, and partly 600 gals at coastal area along Marmara Sea. In northern part of the study area, PGA is calculated at less than 200 gals. Urban area of European side of Istanbul city is mainly covered by PGA value between 300 and 600 gals. PGA value of urban area of Anatolian side is less than that due to difference of geological type.

Geology and geomorphology of the whole Study Area is shown in Figure 22.3.2. which is provided by counter part agency. Detailed distribution of coastal lowland and alluvial lowland which are related to high potential earthquake damage area are shown in this map.



Source: IMPI Team, IMM

Figure 22.3.1 Earthquake Zone



Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.3.2 Geology of the Study Area

22.4 Vulnerabilities of Typical Transportation Facilities and Components

(1) **Road Network:** Roads, bridges, viaducts, signals, traffic signs, closed circuit televisions (CCTVs), parking, street trees, bus stops, taxi bays

Besides the direct damages to road structures leading collapse of surface and/or basement, road blockage due to building collapse can be happened upon the earthquake intensity. The terms “road blockage” or “road blocks” refer to the situation in which a road width of 3m (which would allow for the smallest of vehicles to drive through the road) cannot be secured due to debris from a building collapse. Regarding the bridges and viaducts, bridge breaking and/or significant deformation appearing on the lower structure of the bridge are predicted. Also, collapse of road-side facilities such as signals, traffic signs, street trees may cause injuries of humanities or shutoff of traffic flow and it affects emergency rescue operation and recovery works.

(2) **Railway Network:** Rails, vehicles, signals, rail yards, repair yard, electric facilities, stations/terminals

Direct damages to railway network stop the railway transportation flow, and require security check of the operation. Stoppage of the railway operation causes huge time losses and economy losses of the human activities.

(3) **Ports/Cargo Handling Equipment:** Warehouse buildings, office buildings, waterfront structures, aprons, scales, tanks, cranes, silos, pipelines, and railroad terminals

Pore water pressure build-up and excessive pressure lead to deformation of walls and backfill material, liquefaction and associated damages, submarine sliding and associated deformations on the ports. Damages due to shaking are due to loss of bearing and lateral spreading. All the damage types have been observed at the ports and shore structures in the Izmit bay, during the 1999 Kocaeli earthquake.

(4) **Air Transportation System:** Runways, taxiways, terminal buildings, control towers, hangars

Expected damage includes generic building damage and equipment damage, ranging from broken windows, cracks in walls and frames to partial and total collapse. Unanchored and improperly anchored equipment may slide and topple causing damage to attached piping as well. Gate equipment may become misaligned and inoperable. Fuel tanks and pipes can rupture or be damaged. Tank damage may range from wall buckling, settlement, ruptured piping to loss of contents and even collapse leading to fires and explosions. Airports in low-lying areas, alluvial plains in most cases, may suffer damage due to flooding or tsunamis as well. Runway damage depends on the strength of the underlying soil. They can be damaged due to liquefaction and compaction. Damage includes road displacement, uplift, cracking or buckling of pavement.

22.5 Where to be Protected

Earthquake damage will be highly occurred at vulnerable area of bad soil condition for building or transportation infrastructure construction. In coastal lowland along the Marmara Sea is composed of alluvial soils including clay, sand and gravels (Figure 22.5.1). Groundwater level of coastal lowland is relatively high in general, therefore liquefaction potential by earthquake is highly estimated. In order to protect road damage by liquefaction, detailed geological and geomorphological survey including soil test should be conducted to identify necessary area or point to be reinforced.

Artificially reclaimed areas are distributed in coastal area. Damage by liquefaction at earthquake occurrence is generally observed at reclaimed land, soil test should also be necessary to identify problem area and improve soil condition.

IMM had started new microzoning project covering the whole Istanbul Region since 2006. More than 10 thousands of borehole survey will be conducted to collect detailed geological and soil condition data. Based on this data, IMM will finally compile detailed microzoning map to set new guideline for building construction. This map will be also making great contribution for future development and construction guideline of infrastructure.

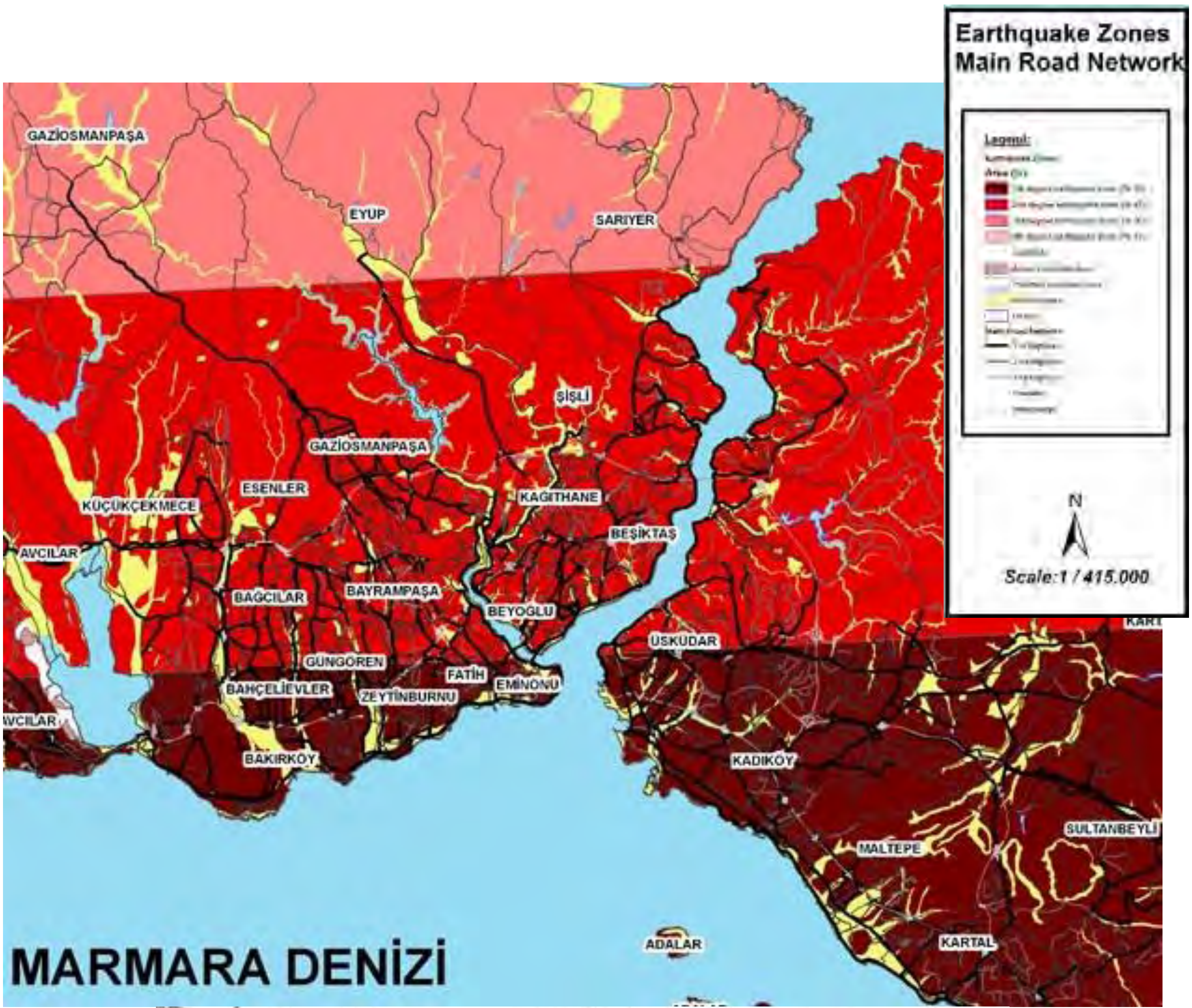
Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.5.1 Distribution of Alluvial

In case of emergency by earthquake disaster occurrence, road network serves for rescue operation and emergency goods transportation. Therefore, such roads should be protected and retrofitted according to its importance. The road importance can be prioritized as the following: 1) loop roads, 2) major radial roads connecting loop roads, and 3) main urban roads connecting main transportation facilities such as sea port, airport disaster management center and evacuation sites.

Figure 22.5.2 shows the total length of the main road by road hierarchy on earthquake zone and it is measured by earthquake zone. It shows that 37% of the main roads (2370km) are located in the 1st degree earthquake zone.

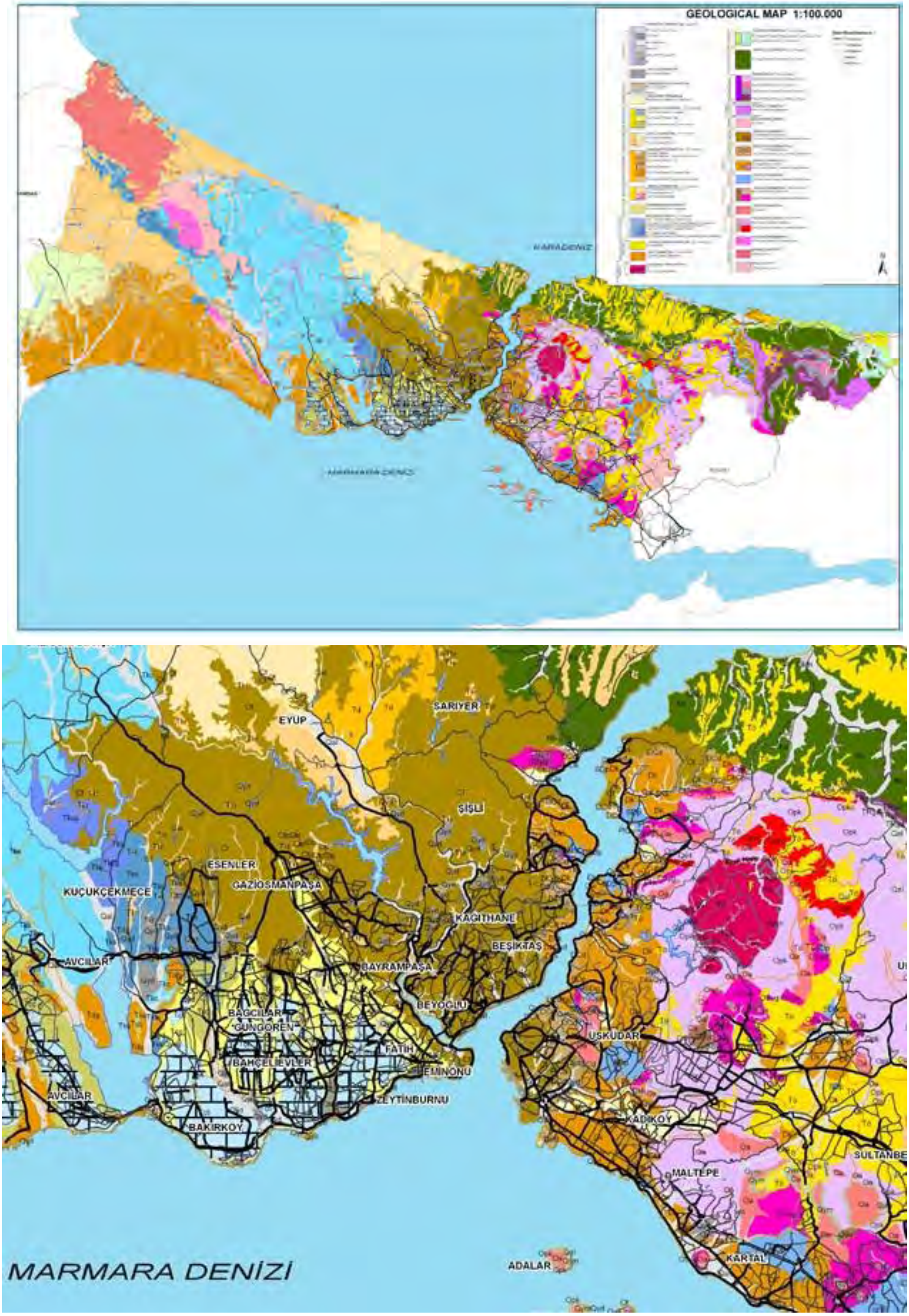
Figure 22.5.3 shows the main road network located on geology map.



Eartquake Zone	Main Road	Total Length (km)	%
1st Degree Earthquake Zone	1st Highway	794	13
	2nd Highway	906	14
	3rd Highway	240	4
	Freeway	264	4
	Interchange	164	3
		2370	**37**
2nd Degree Earthquake Zone	1st Highway	799	13
	2nd Highway	1032	16
	3rd Highway	700	11
	Freeway	440	7
	Interchange	163	3
		3134	**49**
3rd Degree Earthquake Zone	1st Highway	30	0,5
	2nd Highway	131	2
	3rd Highway	529	8
	Freeway	31	0,5
	Interchange	5	0,1
		727	**11**
4th Degree Earthquake Zone	3rd Highway	110	2
	TOTAL	6341	100

Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.5.2 Existing Main Road Network by Earthquake Zone Degree



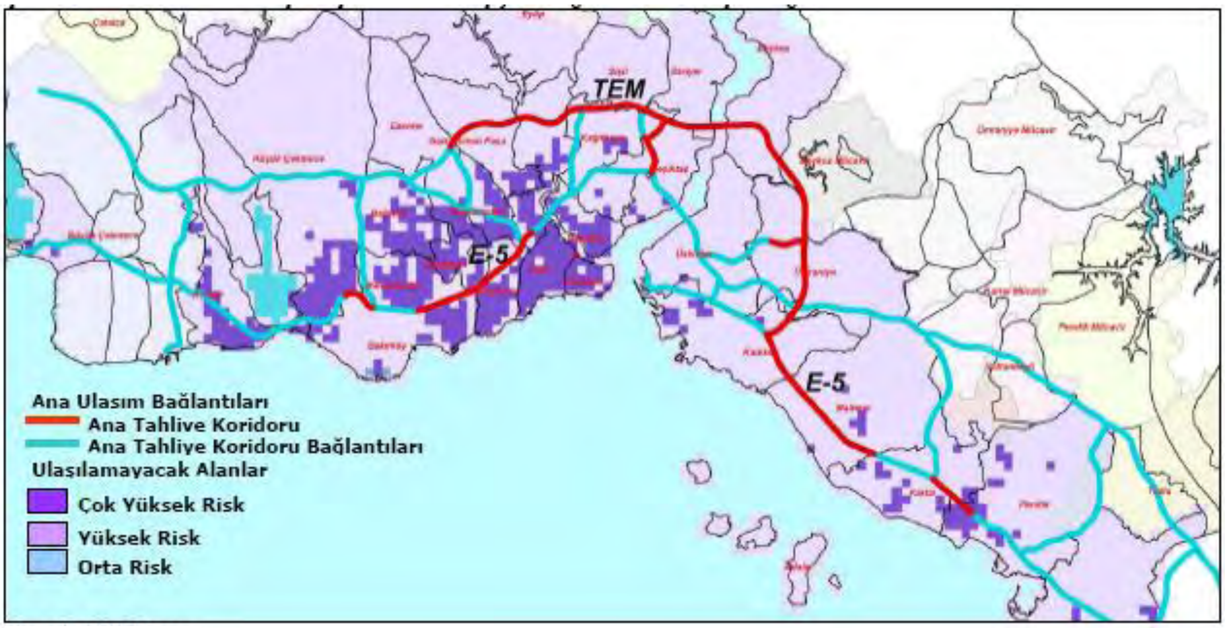
Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.5.3 Geology and Existing Main Road Network

22.6 Earthquake Disaster Management for Road

Road network is working as a key function for transportation of various commodities of human life in urban area. It is very similar to a blood network of human body. If this network function is broken by specific impact such as earthquake, every urban activity will be stopped for long time. In order to avoid such problems, it is important to check the safety of road structures against strong earthquake before hand and implement necessary reinforcement for structures.

Main target of improvement of structures is bridge structure on the emergency road network. Emergency road network system in IMM is still under discussion, however, AKOM and Directorate of Transportation Coordination Board of IMM identified main transportation network for emergency as shown in Figure 22.6.1. However, the network is still tentative, not finalized,yet.

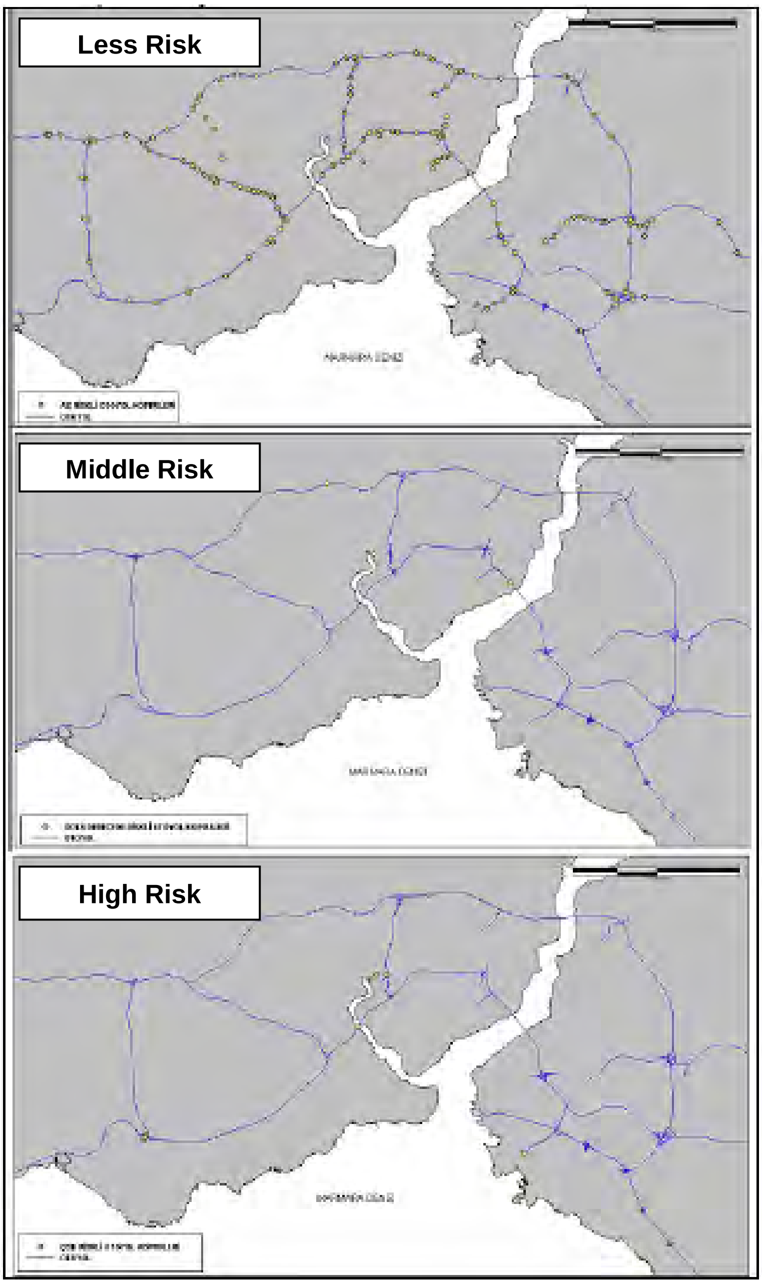


Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.6.1 Emergency Transportation Network Identified by IMM

22.6.1 Analysis of Bridges against Earthquake Impact

In JICA study, totally 480 bridge data were collected from KGM (General Directorate of Highways-17th Division) and IMM. Based on available bridge information, earthquake data and site observation, JICA conducted preliminary earthquake performance analysis by Katayama procedure. As a result of this analysis, out of the 480 bridges assessed, 24 bridges have a high probability of damage due to deck fall and 4 bridges are found to have a medium probability.



Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.6.2 Location of Risky Bridges and Viaducts on the Highways

22.6.2 Present Progress of Bridge Retrofitting Project

Responsible agencies for road maintenance, such as KGM and IMM, recognizes well about the necessity of reinforcement of bridge structures on the road against strong impact of earthquake. KGM's 17^{th} Division Office has already started detailed bridge diagnosis projects and retrofitting works for 13 bridges in their responsible area. The largest retrofitting project is for three big bridges such as the first and the second Bosporus Bridge and the Halic Bridge. This retrofitting project shown in Figure 22.6.3 and Table 22.6.1 is financially supported by Japanese yen credit.

Source: The Study on a Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation in the Republic of Turkey, JICA, 2002

Figure 22.6.3 On-going Retrofitting Project by KGM with Japanese Yen Credit

Table 22.6.1 List of Project to be Implemented by KGM with Japanese Yen Credit

ID	NAME	Responsibility
1	Birinci Bogaz Koprusu: *First Bosporus Bridge*	Works under KGM responsibility and to be implemented by KGM
2	Birinci Bogaz Koprusu Yaklasim Viyadugu (ASYA):*First Bosporus Bridge Approach Viaduct (Asia Side)*	
3	Birinci Bogaz Koprusu Yaklasim Viyadugu (AVRUPA):*First Bosporus Bridge Approach Viaduct (Europe Side)*	
4	Ortakoy Viyadugu (V408): *Ortakoy Viaduct (V408) (First Bosporus Bridge)*	
5	Ortakoy Viyadugu (V409): *Ortakoy Viaduct (V409) (First Bosporus Bridge)*	
6	Fatih Sultan Mehmet Koprusu:*Fatih Sultan Mehmet Bridge (Second Bosporus Bridge)*	
7	Eski Halic Koprusu: *Old Halic Bridge*	Works of which responsibility was transferred to IMM and to be implemented by KGM
8	Yeni Halic Koprusu (BATI): *New Halic Bridge (West)*	
9	Yeni Halic Koprusu (DOGU): *New Halic Bridge (East)*	
10	Yeni Halic Koprusu Yaklasim Viyadugu: *New Halic Bridge Approach Viaduct*	
11	Eski Halic Koprusu Yaklasim Viyadugu : *Old Halic Bridge Approach Viaduct*	
12	Yeni Halic Koprusu Yaklasim Viyadugu (DOGU B): *New Halic Bridge Approach Viaduct (East B)*	
13	Yeni Halic Koprusu Yaklasim Viyadugu (DOGU C): *New Halic Bridge Approach Viaduct (East C)*	

Note: ID is corresponding to the number in Figure 22.6.3
Source: KGM and IMM

22.7 Disaster Management of Transportation Infrastructure

Probability of strong earthquake, magnitude more than 7, was estimated at 65 % within 30 years in Marmara region including Istanbul city. This probability was calculated after Izmit earthquake in 1999. It has already passed 7 years. Fortunately, no strong earthquake occurred during this time in the area. Government agencies and IMM recognize necessity of implementation of damage mitigation measures for public facilities and buildings before big earthquake. In the Earthquake Master Plan of Istanbul, it is pointed out that the more successful the pre-earthquake plans and their implementations are, the lower will be the financial burden after the earthquake. The allocation of funds before an earthquake occurs is certainly needed for human reasons and also technically easier.

22.7.1 Transport Network Strong against Earthquake

It is essential for a Transportation Master Plan to make a transport network strong against earthquake so as to secure human activities. To upgrade the existing transport network, reinforcement of road network for earthquake-resilient must be considered for all new construction work and design standard should be established based on detailed research works.

22.7.2 Secure Emergency Road Network

Emergency road network is a priority road network which serves for transport of emergency medical service, rescue operation, relief goods to designated place. Such road network has already identified by IMM, however, it should be reinvestigated based on detailed study of regional damage volume and identification work of basement for emergency operation such as evacuation sites, disaster management centers, emergency hospitals, etc. These facilities should be connected by emergency road network effectively. Especially for the coastal road which can be prioritized as a part of emergency road should be reinforced based on detailed geology investigation.

22.7.3 Emergency Traffic Management Plan

Establishment of emergency traffic management plan is required to secure the emergency road network for emergency operation and the designated arterial roads to serve for disaster victims getting back to their home. Since it is prospected that the traffic flow falls in confusion by damaged roads, destroyed buildings, and crowded disaster victims on the roads just after earthquake occurrence.

22.7.4 Contingency Plan for Railway, Port and Airport Operation

After an earthquake disaster, railway, port and airport facilities play important roles to accept relief goods from overseas and transport to disaster-affected area, and to be temporary storage of relief goods or debris and garbage. It is necessary to have contingency plans for these facilities in order to keep their operational function available after an earthquake.