- Periodic inspection - A

  This inspection is generally conducted for road structures and related facilities to include as many different points of view as possible. Therefore, this type of inspection is typically done by maintenance crew on site.

- Periodic inspection - B

  Periodic inspection B is conducted to inspect and evaluate in detail the road structures and related facilities such as pavement, drainage, bridges, slopes and traffic safety facilities, and is normally done on foot. Therefore, this requires an inspection plan, and repair plan.

  An annual inspection program for each road structure should be made prior to the site inspection activity, considering the shape, dimensions and repair history of each road structure, based on existing data.

(iii) Special Inspection

Special inspection is a supplementary inspection conducted in addition to the routine and periodic inspections described above, as required due to possible damage due to storms, heavy rain or other unusual conditions.

The content, frequency and coverage differ among these different inspections. Table 6.2.8 shows the contents and frequency of routine and periodic inspection.

Each maintenance office conducts the activities of routine, periodic and special inspections by maintenance patrol unit to cover the motorway of 50 to 70 km long.

Inspections shall be done normally by the maintenance patrol unit, such as inspections for vegetation on slopes, pavement, drainage, slopes, bridges, etc. But the repairs (periodic works) of pavement and bridges are done normally by contract basis.

Table 6.2.8 Routine and Periodic Inspections and Frequency

Functional Category	Classification of Category	Routine Inspection	Periodic Inspection	Special Inspection
Road Surface	Pavement	F	A	
	Curb	F	A	
	Expansion Joint	P	F	
Slope	Vegetation Slope	P	F	If necessary
	Slope Protection Works	P	F	
	Masonry	P	F	
	Retaining Wall	P	F	
Drainage Facilities	Road Surface Drainage	P	F	
	Slope Drainage	P	F	
	Bridge Drainage	P	F	
Bridge	Concrete Super-structure		F	
	Concrete Sub-structure		F	
	Steel Structure		F	
	Painting		F	
	Bearing		F	
	Railing and Curb	P	F	
Tunnel	Lining	P	F	
	Portal	P	F	
	Interior Wall	P	F	
	Ceiling Slab	P	F	
	Drainage	P	F	
Culvert	Reinforced Concrete Box		F	
	Reinforced Concrete Pipe		F	If necessary
	Other		F	
Traffic Safety Facilities	Guard Fence	P	F	
	Anti-dazzle facility	P	F	
Traffic Management Facilities	Traffic Signs	P	F	
	Traffic Markings	F		
	Delineator	F		
	Kilometer Post	F		
Other Facility	Snow Protection Facilities	P	F	
	Meteorological Divices	F		
Vegetation		P	F	
Traffic Conditions		F		
Frequency		see note-1	see note-2	If necessary

F : Inspect the facility fully
P : Inspect the facility Partially
A : Additional Inspection to "F" if necessary
Blank : No Inspection required

Note 1

Routine inspections will be done two (2) to four (4) times a week based on the traffic volume.

Note 2

Items	Frequency
Pavement	1 to 2 years intervals
Bridges	2 to 7 years intervals
Others	every years

Note 3

Frequency in the above is recommended by JICA Study Team.

(c) Standard Work Flow for Inspections

Definition of inspection and investigation is as follows:

(i) Inspection

Inspection involves apprehending of the road structural and traffic conditions to maintain the road in the satisfactory condition and to ensure traffic safety. This also includes judgment on the degree of damage which will be made by chief of maintenance office (MO).

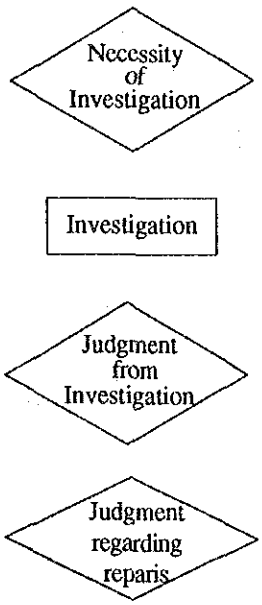
(ii) Investigation

Investigation involves measurement, analysis and evaluation in order to define the content of specific problems concerning items necessary to keep the road in the satisfactory condition in case that the inspection for judgment and evaluation of degree of damages proves insufficient.

Standard flow of inspection is shown in Figure 6.2.28.
The flow specifies the following:

- The extent of inspection is clarified based on the relationship with investigation, maintenance and repairs.
- The inspection includes the records of maintenance and repairs.

Further clarification of essential points in Figure 6.2.28 is shown as follows:



- Necessity of investigation will be studied on whether the damage detected during inspection requires the soundness of whole structures or not.
- Investigation will be conducted when inspection results can not afford a judgment and evaluation on the degree of damages.
- The damaged structures or facilities are evaluated and judged comprehensively from technological viewpoint on the basis of the result of investigation
- In addition to judgment of the degree of damages detected by inspections from technical viewpoint, the budget, operating system and repair method are also to be considered to reach comprehensive judgment.

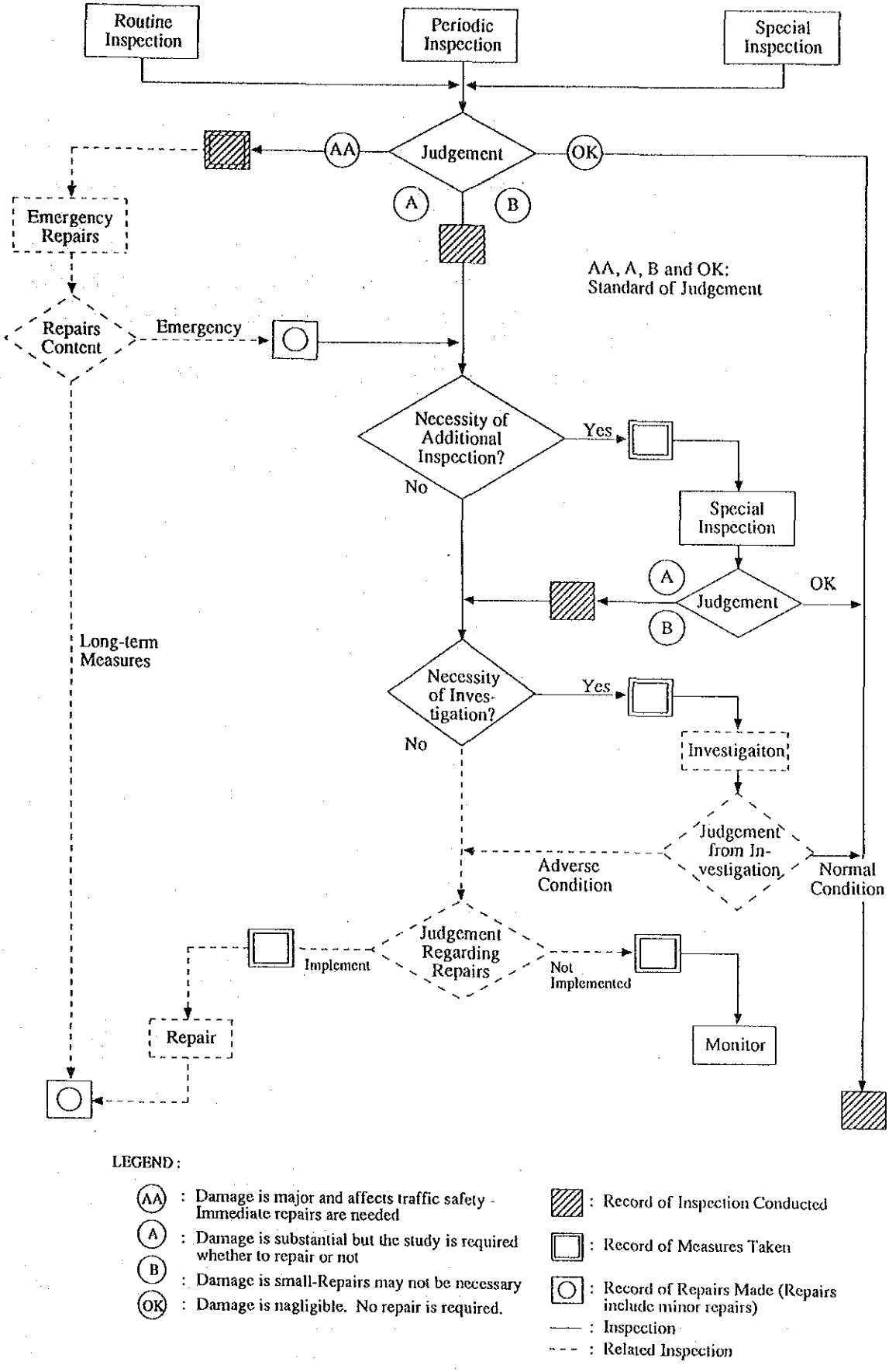


Figure 6.2.28 Work Flow for Inspection

(d) Inspection and its Associated Items

It is essential to conduct inspections efficiently by combining with inspection of other structures when simultaneous inspection is possible, instead of individual inspection for each road structure.

(i) Road structures and facilities to be inspected are shown in Table 6.2.9. Before execution of the inspection, the structures that can be inspected simultaneously should better be grouped to enhance the efficiency.

(ii) The periodic inspection B may be incorporated into the routine inspection process.

Table 6.2.9 Inspection Items for Road Structures and Facilities

Functional Category		Classification Category		Road Structures and Facilities		Items
1.	Road Surface	(1)	Pavement	(1)	Asphalt pavement	① Obstacles on the road (fallen materials, fallen stone, collapsed earth), oil stain, foul road surface ② Pot hole, peeling, subsidence ③ Faulting ④ Rutting ⑤ Crack ⑥ Cross-sectional roughness and corrugation ⑦ Stripping of thin surfacing ⑧ Water storage
				(2)	Concrete pavement	① Obstacle on the road (fallen materials, fallen stones, collapsed earth), oil stain, foul road surface) ② Pot hole subsidence ③ Faulting ④ Friction (rutting) ⑤ Crack, edge breakage ⑥ Deformation (cross-sectional roughness) ⑦ Joint breakage ⑧ Buckled or lift of slabs ⑨ Water storage
		(2)	Expansion Joint	(1)	Groove	① Damage to joint proper ② Damage around joint ③ Water leakage ④ Abnormal sound
				(2)	Rubber joint	① Damage to joint proper ② Damage to secondary material ③ Faulting ④ Abnormality in spacing ⑤ Water leakage ⑥ Abnormal sound
				(3)	Metal joint	
		(3)	Curb	(1)	Asphalt Curb	① Damage to the curb proper
				(2)	Concrete Curb	
2.	Slope	(1)	Vegetation	-		① Collapse ② Crack, bulging, falling ③ Spalling, galley ④ Piled soil on term ⑤ Seepage water ⑥ Fallen tracks abnormally thick weeds, ⑦ Dead planting ⑧ Accumulation of dust ⑨ Spall and rolling stones
		(2)	Slope Protection Work	(1)	Concrete Block Crib	① Crack, stripping ② Looseness, bulging, subsidence ③ Scour ④ Drainage, seepage
				(2)	Cast-in-place Crib	
				(3)	Concrete/Mortar spraying	① Crack, stripping ② Push-out, bulging, misligned joint ③ Honey comb ④ Scour ⑤ Drainage and seepage
				(4)	Concrete Block Pitching	① Crack, stripping ② Push-out, bulging, misligned joint ③ Scour ④ Drainage and seepage
				(5)	Netting & Fence	① Damage to net/fence proper, ② Damage to the accessories ③ Corrosion ④ Damage to the foundation ⑤ Earth accumulated in the back of net
		(3)	Masonry	(1)	Concrete Block Masonry	① Crack, looseness, bulging ② Settlement, displacement, inclination ③ Abnormality in joint ④ Scour ⑤ Drainage, seepage
				(2)	Concrete Block Pitching	
				(3)	Stone Masonry	
				(4)	Gabion	① Breakage, damage, corrosion of steel wires ② Deformation

Functional Category		Classification Category		Road Structures Facilities		Items
		(4)	Concrete Retaining Wall	(1)	Reinforced Concrete	① Crack, edge breakage ② Stripping ③ Exposure and corrosion of reinforcement ④ Settlement, displacement, inclination ⑤ Abnormality in joint ⑥ Scour ⑦ Drainage, seepage
				(2)	Non Reinforced Concrete	① Crack, stripping ② Bad connections, Settlement displacement, Inclination ③ Abnormality in joint ④ Scour ⑤ Drainage, seepage
3.	Drainage	(1)	Road Surface Drainage	(1)	Shoulder Drainage	① Damage to the facility proper ② Bad connections ③ Accumulation of soil and dust
				(2)	Median Drainage	
				(3)	Inlet	
				(4)	Cascade Drainage	
				(5)	Manhole	
		(2)	Slope Drainage	(1)	Top of Slope Drain	① Damage to the facility proper ② Bad connections ③ Accumulation of dust and earth ④ Sectional area reduced by weeds
				(2)	Berm Drains	
				(3)	Toe Drains	
				(4)	Inlet	
		(3)	Bridge Drainage	(1)	Inlet	① Damage to the facility proper ② Bad connections ③ Accumulation of dust and earth
				(2)	Drainage pipe	
		(4)	Frontage Road and Adjacent area Drainage	(1)	Drain	① Damage to the facility proper ② Bad connections ③ Accumulation of dust and earth ④ Sectional area reduced by weeds
				(2)	Inlet	
				(3)	Manhole	
4.	Bridge	(1)	Concrete Super-structure	(1)	RC Girder	① Water leakage ② Crack, edge breakage ③ Stripping edge breakage ④ Exposure and corrosion of reinforcement ⑤ Honey comb ⑥ Deflection ⑦ Clearance of bridge
				(2)	PC Girder	
				(3)	RC Slab/PC Slab	
		(2)	Concrete Sub-Structure	(1)	Abutment	① Crack, edge breakage ② Stripping ③ Exposure and corrosion of reinforcement ④ Honey comb ⑤ Water leakage ⑥ Settlement, displacement, inclination ⑦ Scour
				(2)	Pier	
				(3)	Footing	① Settlement, displacement, inclination
				(4)	Protection	
				(5)	Revetment	
		(3)	Steel Structure	(1)	Girder	① Crack of steel structure ② Deformation and edge breakdage ③ Loose and dislodged bolt ④ Loose and dislodged rivet ⑤ Abnormal sound ⑥ Clearance of bridge
				(2)	Steel Plate Floor	
				(3)	Piers	

Functional Category		Classification Category		Road Structures Facilities		Items
				(4)	Cross Beam	
		(4)	Steel Plate Deck	-		① Water leakage ② Crack, edge breakage, abrasion ③ Stripping ④ Exposure and corrosion of reinforcement ⑤ Honey comb ⑥ Segregation of additional girder
		(5)	Painting	-		① Crack, stripping, rust ② Water leakage
		(6)	Bearing	(1)	Metal Bearing	① Damage of metal bearing ② Damage of the accessories ③ Corrosion ④ Damage of the bearing concrete, bearing mortor and guide mortor ⑤ Abnormal sound ⑥ Abnormality in spacing ⑦ Accumulation of soil and dust
				(2)	Elastomeric Bearing	① Crack, push-out; displacement ② Damage of the bearing concrete and bearing concrete ③ Accumulation of dust
		(7)	Railing & Curb	(1)	Steel Railing	① Damage ② Corrosion and bearing mortor
				(2)	Concrete Railing	① Crack, edge breakage ② Stripping, damage ③ Exposure and corrosion of reinforcement
				(3)	Curb	① Crack, edge breakage ② Stripping ③ Exposure and corrosion of reinforcement ④ Water leakage
5.	Tunnel	(1)	Lining			① Crack, edge breakage ② Peeling, dislodgment ③ Water leakage, free line ④ Abnormality in joint
		(2)	Portal			① Crack, edge breakage ② Peeling ③ Exposure and corrosion of reinforcement ④ Abnormality in joint ⑤ Scour ⑥ Settlement, displacement and inclination ⑦ Drainage and seepage
		(3)	Interior wall			① Damage to the slab proper ② Damage to the accessories
		(4)	Ceiling slab			① Damage to the slab proper ② Damage to the accessories
		(5)	Drainage			① Damage to the slab proper ② Accumulation of soil and dust
6.	Culvert	(1)	Reinforced Concrete Box			① Crack, edge breakage ② Stripping ③ Exposure and corrosion of reinforcement ④ Honey comb ⑤ Water leakage ⑥ Settlement scour ⑦ Abnormality in joint
		(2)	Reinforced Concrete Pipe			① Crack ② Stripping ③ Exposure and corrosion of reinforcement ④ Settlement ⑤ Damage of joint ⑥ Accumulation of soil and dust
		(3)	Other Type Culvert			① Damage of culvert ② Corrosion rust ③ Settlement ④ Damage of joint ⑤ Accumulation of soil and dust
7.	Traffic Safety Facilities	(1)	Guard Fence	(1) (2)	Guard Rail Guard Pipe	① Damage of fence ② Damage of accessories ③ Corrosion ④ Damage of foundation

Functional Category		Classification Category		Road Structures Facilities		Items
		(2)	Anti-dazzle Facility	(1) (2)	Anti-dazzle Net Anti-dazzle Plate	① Damage anti-dazzle facility ② Damage of accessories ③ Corrosion
8.	Traffic Manage-	(1)	Traffic Signs			① Damage to the sign proper ② Damage to the accessories ③ Corrosion, ④ Damage to the foundation
	ment Facility	(2)	Traffic Markings			① Damage of traffic paint
		(3)	Delineator			① Damage to delineator proper
		(4)	Kilometer Post			① Damage to the marker proper
9.	Other Facility	(1)	Snow Protection Facilities	(1)	Snow Fence	① Damage to the fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
				(2)	Avalanche Protecting	① Damage to the fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
		(2)	Meteorological Device	-		
10.	Vegetation		-			① Tree and lawn growth state ② Damage by blight and noxious insects
11.	Traffic Conditions		-			

(iii) The way to associate inspections before actual execution varies depending on the inspection system, road traffic conditions, and local and structural conditions. In this context, the specific combination may be determined in each main maintenance center. Table 6.2.10 is presented for examination of the appropriate combination, showing the "Type of road structures and facilities to be inspected" and "Road structures and facilities" that can be inspected together with the others.

(e) Preparation of Inspection Plan

The inspection plan must be prepared before implementation of the inspections. The plan must contain the following matters:

- Type, scope, and location of inspection
- Inspection process
- Qualified inspectors and a communication system
- Inspection method
- Report preparation method
- Other particular pertinent matters

Inspection shall be done under the control of the chief of MO with assistance of the maintenance engineer. The head of MMC will decide the selection of priority works (maintenance and repairs) with construction method, considering budget constraint.

(i) Precautions

The inspection plan must be prepared to ensure rational and effective execution of the inspections. Before preparation, a method appropriate to the planned inspection is selected according to the accuracy required of the road structures and the implementation state (method and result) of this selected method confirmed beforehand. This precautionary approach is to avoid confusion and bewilderment during the inspection on site. To know the past inspection result of the road structures and facilities, and to understand thoroughly the characteristics of the structures, the as-built drawings design standard and drawings should be referred to as much as possible.

Table 6.2.10 Inspection and its Associated Items

LEGENT
- ○ ; Inspect the facility fully.
- ◎ ; Inspect the facility Partially.
- △ ; Inspect the facility (not major item for in spection) together with the mark ○.
- ↳ ; Inspect the facility together with the mark ○
- Blank ; No Inspection required

Types of Inspections			Classification of Structure: Road Surface			Slope				Drainage Facilities					Bridge						Tunnel						Culvert			Traffic Safety Facilities				Traffic Management Facilities				Other Facilities					
			Pavement	Expansion Joint	Curb	Vegetation Slope	Slope Protection Work	Masonry	Retaining Wall	Road Surface: Shoulder	Road Surface: Median	Slope	Bridge	Adjacent areas to Road	Concrete Superstructure	Concrete Substructure	Steel Structure	Painting	Bearing	Railing & Curb	Lining	Portal	Interior Wall	Ceiling Slab	Drainage	Reinforced Concrete Box	Reinforced Concrete Pipe	Other Type Culvert	General Fence (Guard Rail Guard Pipe): Shoulder	General Fence (Guard Rail Guard Pipe): Median	Anti-dazzle net: Shoulder	Anti-dazzle net: Median	Traffic Signs	Traffic Markings	Delineator	Kilometer Post	Snow Fence	Meteorological	Vegetation	Over Bridge	Traffic Conditions
Routine Inspection (2~4 times/ week)			○	◎	○	◎	◎	◎	◎	◎	◎	◎	◎							◎	◎	◎	◎	◎	◎				◎	◎	◎	◎	◎	○	○	◎	○	◎	◎	◎	○
Periodic Inspection A (once/year)			△	△	△	○	○	○	○	○		○	◎	○	△	◎	△	△	△	◎	◎	◎	◎	◎	◎	◎	◎	◎	○		○		△				△	△	△	△	
Periodic Inspection B	Road Surface	Expansion Joint		○									↳		↳				↳																							
	Slope	Vegetation Slope				○	↳	↳	↳			↳																														
		Slope Protection Work				↳	○	↳	↳			↳																														
		Masonry				↳	↳	○	↳			↳																														
		Retaining Wall				↳	↳	↳	○			↳																														
	Drainage Facilities	Road Surface: Median									○																			↳		↳										
		Slope				↳	↳	↳	↳			○																														
		Bridge		↳									○	↳					↳																						
		Adjacent Area to Road											↳	○		↳																									
	Bridge	Concrete Superstructure		↳										↳	○					↳																					
		Concrete Substructure												↳		○																									
		Steel Structure															○	↳	↳																						
		Steel Plate Slab		↳												↳	↳																								
		Painting														↳	○																								
		Bearing		↳									↳						○																					
		Railing•Curb													↳					○																					
	Tunnel	Lining																			○																			
		Portal																				○																		
		Interior Wall																					○																	
		Ceiling Slab																						○																
		Drainage																							○															
	Culvert	Reinforced Concrete Box																								○														
		Reinforced Concrete Pipe																									○													
		Other Type of Culvert																										○												
	Traffic Safety Facilities	Guard Fence: Median									↳																		○		↳										
		Anti-Dazzale net: Median									↳																			↳		○									
	Traffic Management Facilities	Traffic Sign																															○								
	Other Facilities	Noise Barrier																															↳								
		Snow Fence																																		○					
Special Inspection (If necessary)			If necessary																																						

(ii) Inspection process

The scheduling of inspections is important, not only to prevent the inspection from concentrating excessively in a certain period or any unnecessary inspection process from being executed, but also to ensure efficient tie-up with other maintenance and repairs. The scheduling of inspections to be prepared includes the following two types.

① Annual inspection process plan
② Monthly inspection process plan

The scheduling of inspections is prepared at the beginning of the year concerned for ①) and before start of the month concerned for ②. It is necessary for ② to take the implementation state of the previous month into account.

(2) Maintenance and Repairs

(a) Road Cleaning

The road cleaning tasks are summarized as shown below:

- Road cleaning including interchanges and parking lots will be done by KGM on force account.
- Cleaning of bridge rail, guardrail, and tunnel wall will be done by KGM on force account.
- Cleaning interchanges green area, toilets, parking areas will be done on a contract basis.
- Rest areas, service areas; The cleaning of the parking lots and facilities, grass cutting, etc., will be done on a contract basis under Build, Operate and Transfer (BOT).
- Drainage cleaning. Cleaning of drainage culverts and channels will be done on a contract basis.

(b) Vegetation Control

As well as the initial soil preparation and planting, vegetation control activities include lawn mowing, tree and shrub trimming, watering, weed control, lawn fertilization, herbicide spraying, chemical spraying of lawns, soil addition, grass and weed cutting in vegetation ground cover areas, and slope fertilization.

Lawn mowing involves cutting of grass to a uniform length acceptable to KGM, at somewhat regular intervals. This should be done primarily with grass cutting machines, but should be done manually around sensitive areas, such as around tree trunks, poles, in pavement or curb cracks. The work should be done in a manner not to damage neighboring vegetation.

Tree and shrub trimming is cutting and removing of excessive branches or vegetation growth. It should be done at least once a year so as not to do harm to the vegetation, and to promote strong and healthy development. This activity may include machine or manual work.

Watering, weed control, chemical spraying, and lawn fertilization should all be done in a manner to enhance desirable vegetation growth, and according to the manufacturer's specifications.

The equipment for vegetation control activity includes all necessary equipment for lawn cutting, vegetation trimming, chemical application, watering, fertilizer application, waste removal, and the transportation equipment required for necessary manpower, vegetation control equipment, and waste products.

Grass cutting and watering will be done on a contract basis. The grass cutting will be done by hand sickle or by small machine, and watering is done to trees only in the season from June to October.

(c) Snow and Ice Control

The purpose of snow and ice control is to maintain safe and stable traffic flow during the winter. Snow & ice control operations shall integrate the following four elements:

- Collection and distribution of climate and road condition information
- Snow removal and de-icing
- Traffic management
- Traffic safety protection

(i) Inspection

Snow and ice inspections by maintenance patrol cars should be conducted when snowfall and icing are predicted from the weather forecast. The following are criteria used to dispatch maintenance patrol cars:

- When a snowstorm or heavy snow warning are given by main maintenance center

- When the temperature falls to 2 °C
- When the minimum temperature is predicted to be less than 0 °C.

The location of installed devices shall be carefully selected to gather appropriate data.

(ii) Snow and Ice Control

① Snow and ice control operations

Snow & ice control work varies depending on weather, road and traffic conditions. The administrative structure shall reflect conditions to conduct effective snow & ice control. Snow & ice control shall be divided into three (3) categories: warning, dispatch for operations, and emergency.

The warning stage of snow & ice control is set when snowfall or motorway icing is anticipated by weather forecast. While monitoring road surface conditions, necessary personnel shall be called to prepare for dispatch.

The dispatch stage of snow & ice control occurs when snowfall or motorway icing is forecasted or has occurred. The work consists of the following:

- Snow removal work
- Spreading de-icing agent
- Leading snow removing vehicles fleet

The emergency stage of snow and ice control occurs when traffic congestion due to heavy snowfall lasts many hours despite snow removal efforts. Not only is snow removal being conducted to the maximum capacity, but assistance from other offices and/or agencies is requested to remove stuck vehicles or help persons in stuck vehicles.

There are several snow removal methods: manual removal, machine removal, and melting methods. Among those methods, machine removal is the most popular method for good cost performance, reliability and flexibility.

Only machine snow removal on the motorway is discussed herein.

For KGM, it is the policy to remove snow to the surface of the motorway, or to a "black" condition since most vehicles do not use snow chains or studded tires.

Therefore, the following concept (Figure 6.2.29) will be applied for snow & ice control, considering dispatch, traffic regulations and road closures.

② Number of snow removal fleets required

The following is an example of a typical calculation to determine the number of snow removal fleets required for snow removal. The calculation method is based on the method used at the Japan Public Highway Corporation.

Conditions

Maximum snowfall rate per hour = 6 cm/hr

Equipment operational velocity = 30 km/hr

Efficiency of operation = 0.8 x normal

Safety factor for distance of operation = 1.1 x normal

Calculation for N, number of snow removal fleets required:

N = (Distance of operation x 2x 1.1)/(30 x 0.8)

= (50 km x 2x 1.1)/(30 x 0.8)

= 4.5 fleets or approximately = 4 fleets

The minimum number of snow removal vehicles for any fleet is two vehicles to be able to maintain four lanes open to traffic to operate in a thorough and efficient manner. Typically a range of two to four vehicles can keep a segment of roadway open with a cycle of at least once per hour over the same segment.

The following Figure 6.2.30 is a standard example of how a maintenance office (base station) and two maintenance sub-stations can work effectively to maintain a motorway during snowfall.

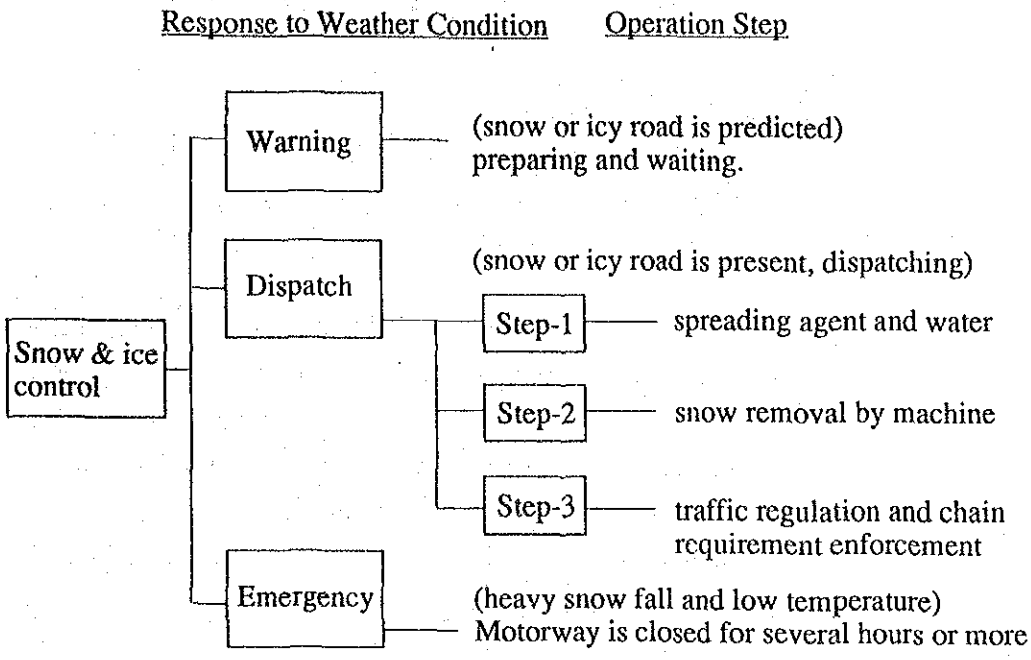


Figure 6.2.29 *Snow & Ice Control and Traffic Regulation*

Example

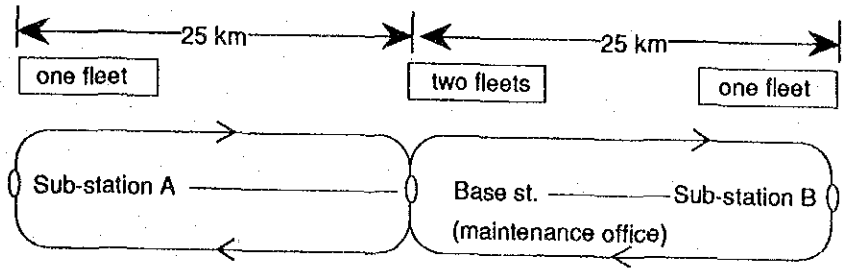


Figure 6.2.30 Standard Location Base Station and Sub-station

In the above example, newly fallen snow is removed approximately once per hour in each section of roadway if two fleets are positioned at the base station (maintenance office) and one each at the maintenance sub-stations.

Required Equipment Numbers

The equipment requirements for snow and ice control are dependent upon the following four items:

- The anticipated snowfall along specific sections of motorway
- The depth to which snow is removed from the road surface
- The number of lanes to be opened to traffic during a snowfall
- The frequency of snowplowing or ice removal for each traffic lane per hour

Typical snow and ice removal equipment for 4 lane sections of road are shown in the following Table 6.2.11. In addition to looking at the basic requirements shown in the following table, it is essential that the snow and ice removal fleet and facilities for each specific section of motorway be designed to take into account the length and design of the particular section of road to be maintained, as well as the location of the salt stores or suppliers.

Table 6.2.11 Typical Number of Snow Removal Vehicles

	Type of Equipment	(Ave. snowfall 1.0 - 0.3 m)	(Ave. snowfall 0.3 - 0.05 m)	(Ave. snowfall less than 0.05 m)
Fresh Snow Removing	10 ton truck	2	1	-
	Unimog truck with attachment	4	2	1
	7 ton truck	2	1	1
Prevent freezing	chemical sprayer	2	2	1
	sprinkler truck	2	1	1

Notes (1) The equipment numbers are determined based on an assumption that most vehicles do not use snow chains on tires nor studded tires.
(2) Freezing prevention will be conducted after removing fresh snow.

(d) Repairs of Traffic Safety and Management Facilities

Types of work include the repair and replacement of the following facilities that will be damaged due to traffic accidents or from other causes;

- Guardrail & cable
- Anti-dazzle plate
- Guide & regulatory signs
- Traffic Markings
- Delineator
- Km post (at intervals of 100 m)

Normally the need for this type of work is detected by maintenance patrol unit or traffic patrol unit who have arrived at the scene of an accident and are checking the area for damaged facilities. Other than at known accident sites, patrol may observe damages to facilities while making drive by or walking inspections. These damaged facilities should be reported to the maintenance office concerned, maintenance engineer, and appropriate action taken. The chief of maintenance office must decide if immediate action must be taken (constitutes an immediate hazard to motorway users) or if the work can be done on a scheduled basis. The patrol unit must determine if appropriate traffic control devices (such as warning signs, barricades, traffic cones, etc.) must be used until the damages are repaired.

The repairs and replacement of traffic markings and guard rail & cable and lighting post with lamp are conducted on the contract basis.

(e) Maintenance and Repairs of Pavement

The purposes of pavement maintenance and repairs are the following:

- To sustain pavement durability and the integrity of the pavement structure
- To sustain driver's comfort and maintain traffic safety
- To avoid environmental deterioration

Asphalt concrete pavement has been adopted for all sections of the motorway except the tollgates in Turkey. There are two (2) types of asphalt pavement maintenance, those being identified by routine inspection and periodic inspection (or investigation).

Minor repairs of pavement identified by routine inspection consist of pothole repair, crack sealing and patching of small damaged area and adjustments of roadway surface differences.

Repairs of pavement by overlay or replacement are required as identified by periodic inspection or investigation due to cracking and rutting caused by heavy traffic and asphalt deterioration. An evaluation method shall be established to determine the thickness and scheduling of overlay or replacement required, based on a measurement and analysis of the existing pavement roughness, cracking ratio, skid resistance and depth of rutting.

(i) Procedure for establishing repair plan

The following procedure shall be taken to establish the long term repair plan, based on repair evaluation method by measurement of rutting, skid resistance and cracks.

- preparation of surface condition management chart
- evaluation of the surface condition
- programming of prioritized motorway sections
- programming of annual repair activities.

(ii) Maintenance and Repairs

Pavement works such as pothole and crack repair will be done by force account by road maintenance unit under maintenance engineer of maintenance office. Significantly large overlay works will be done on a contract basis with the contractor furnishing all the heavy equipment, including the paving machines, bituminous distributors, and compaction equipment (steel wheel roller, pneumatic rollers), etc.

(f) Maintenance and Repairs of Bridges

The necessity of maintenance and repairs to bridges is due to the following reasons from experience:

- Deterioration will start due to weather, natural environment immediately after the completion of most structures of civil works;
- Effects of live loads by vehicles and loading frequency will increase as an elapse of the time;
- Structures of civil works will be constructed in general with some unexpected defects which cause to loose the efficiency and safety of the structures.

In addition to the above, reliability of technical products is known to decrease as an elapse of the time from experience. It is necessary to emphasize that a bridge is one of those technical products.

In order to maintain bridges in good condition, the deck surface, superstructure and substructure of bridges shall be monitored by routine, periodic and special inspections. When deficiencies are found, maintenance or repair shall be

conducted. The purposes of maintenance and repairs are classified in two categories as follows:

- To retain the load bearing capacity and to sustain bridge durability;
- To prevent failure of the bridge structure and to maintain traffic safety.

It is necessary to keep design data, in particular, detailed engineering specifications and as-built drawings of bridges and viaducts, since planning and engineering of the maintenance and repairs of structures strongly require them.

(g) Maintenance and Repairs of Tunnels

Damages or failures in the tunnel ceiling or sidewalls can have grave consequences on traffics, and must be guarded against them by diligent and regular inspection procedures. Once a failure has been detected, an immediate evaluation on the damages and assessment of potential repair methods is required, so as to know how to best proceed with the case in a safe and reasonable manner.

Other than structural problems, the inside of the tunnel must be kept in good condition, so that it is always a safe facility for drivers to use. The tunnel walls must be regularly cleaned, the lighting must be adequate and be kept operable, the drainage facilities and the roadway and shoulder surfaces must be kept in good operating condition, clean and free of dust and debris. Proper ventilation must be provided and maintained, and as mentioned in the traffic management sections, emergency telephones should be quickly arranged in case of their breakdowns.

(h) Maintenance and Repair of Cut & Fill Slopes

Slope protection is performed to shield the slopes against erosion and weathering by covering them with vegetation or structures. Slopes are stabilized by means of drainage facilities or retaining structures.

Repairs of cut and fill slopes are performed to prevent erosion from rain water by growing plants on the slopes and by firmly binding the slope surface with plant roots. The vegetation eases temperature changes on the ground surface and provides attractive landscaping. Vegetation is used wherever possible, since the costs for vegetation are relatively low.

Using structures for slope protection is adopted on slopes not suited to vegetation, and where the stability can not be assured by vegetation alone. In such cases, slopes require retaining walls, piles and slope anchors to resist earth pressures.

Where there is spring water on the face of a slope, the slope drainage should be used in addition to slope protection in order to prevent scour and to stabilize the slope.

Damages and failures can be identified by routine inspection, periodic inspection and special inspection. Repairs will then be determined based on criteria.

6) Vehicles and Equipment

(1) Required vehicles and equipment

The maintenance and repairs will require the following major vehicles and equipment;

Motorway maintenance	Major vehicles and equipment required
1. Inspections	• Sedan car
2. Road cleaning	• Road cleaner • Sprinkler truck • Unimog truck • Truck • Traffic sign truck
3. Traffic safety facilities	• Road lift vehicles • Truck • Portable welding machine
4. Vegetation control	• Pick up • Truck
5. Snow and ice control	• Truck with snow plow • Unimog with attachment • Chemical sprayer • Loader • Sprinkler truck
6. Asphalt	• Dump Truck • Asphalt plant • As cutting machine • Roller • Generator • Compressor • Grader • Unimog truck
7. Bridge	• Welding machine • Compressor • Truck • Maintenance gantry
8. Tunnel	• Compressor • Road lift vehicle • Welding machine
9. Restoration for traffic accident	• Towtruck • Traffic sign truck

(2) Number of vehicles and equipment

Considering weather conditions of snowfall and temperatures, one maintenance office with a coverage of 50 km motorway long will have the number of vehicles and equipment as shown in Table 6.2.12.

Table 6.2.13 shows the required number of vehicles and equipment for each region based on the jurisdictional length of the motorway.

The required number of vehicles and equipment is estimated for the force account works of the motorway maintenance and operations including the traffic management and operations;

Table 6.2.12 Number of Equipment for Standard Maintenance Office (50 km)

Vehicles and Equipment	Numbers of Equipment Required for Standard Maintenance Office (50 km)		
	Heavy snowfall area	Light snowfall area	Slight snowfall area
1. Sedan Cars	3	3	3
2. Sedan Cars (Maintenance Patrol)	3	3	3
3. Sedan Cars (Traffic Patrol)	4	4	4
4. Pickups	2	2	2
5. Dump or Maintenance Trucks	5	3	2
6. Unimog Trucks	4	2	1
(attachment)	(14)	(11)	(9)
7. Beam Lift Vehicles	1	1	1
8. Road Cleaners with Vacuum	1	1	1
9. Sprinkler Trucks	2	1	1
10. Compressors	1	1	1
11. Cutting Machines	1	1	1
12. Rollers	1	1	1
13. Portable Welding Machines	1	1	1
14. Towtrucks	2	2	2
15. Grader	1	1	1
16. Traffic Sign Trucks	3	3	3
17. Mini Buses	5	5	5
18. Generators	1	1	1
19. Small Tractors	-	-	-
20*. Asphalt Plants	1	1	1
21. Loaders	2	2	2
22*. Maintenance Gantry for Bridge	1	1	1
Totals	45 + (14)	40 + (11)	38 + (9)

* A set of equipment will be provided for one main maintenance center with coverage of 200 km to 250 km.

Table 6.2.13 Required Vehicles and Equipment for the Motorway of 1,500 km

Vehicles and Equipment	Number Required (Unit)					
	Regional Division					
	1	2	4	5	17	Total
1. Sedan Car	12	12	15	24	18	81
2. Sedan Car (Road Maintenance)	12	12	15	24	21	84
3. Sedan Car (Traffic Management)	16	16	20	32	24	108
4. Pick up (Machine/Electric)	8	8	10	16	13	55
5. Dump or Maintenance Truck	20	8	25	23	32	108
6. Unimog Truck	16	4	20	15	24	79
Attachment: Snow plow-4 Covered salt storage-2 Guardrail washer-1 Drill-1 Grass cutter-1 Tunnel wafer-1 Excavating arm-1 Front sweeper-1 Mud pump-1	(56)	(36)	(70)	(75)	(84)	(321)
7. Road Lift Vehicle	2	2	3	3	3	13
8. Road Cleaner with Vacuum	4	4	5	8	8	29
9. Sprinkler Truck	8	4	10	10	12	44
10. Compressor	4	4	5	8	9	30
11. Cutting Machine (Asphalt)	4	4	5	8	6	27
12. Roller	4	4	5	8	6	27
13. Portable Welding Machine	4	4	5	8	7	28
14. Towtruck with Winch	8	8	10	16	14	56
15. Grader	2	2	5	3	3	15
16. Traffic Sign Truck	8	8	10	16	12	54
17. Mini Bus	20	20	28	42	32	142
18. Generator	4	4	5	8	6	27
19. Asphalt Plant	1	1	2	3	2	9
20. Loader	8	8	10	16	12	54
21. Maintenance Gantry	1	0	1	1	1	4
Total	166 + (56)	137 + (36)	214 + (70)	291 + (75)	265 + (84)	1,074 + (321)

6.2.3 Architectural Facilities

The actual size of each architectural facility referred to section 5.10 is not uniform and depends on the extent of the service and size of the subject area. The actual facilities to be introduced at a main maintenance centre or maintenance office also vary depending on the local requirements. In the case of high snowfall mountainous areas in the north and east for example, measures to combat snow and ice are the most important while such measures are not required in the south and west. The prospective sizes and configuration of the architectural facilities are examined next in view of estimating the project cost on a reliable basis.

1) Main Maintenance Centers

The construction of 8 main maintenance centers across Turkey is currently planned. Using the main maintenance center planned at the Adana East Interchange within the jurisdiction of the Regional Division Office 5 as an example, the possible size and configuration of the main maintenance center is estimated here based on its drawings.

2) Maintenance Office

Using the Kavacik Maintenance Office near Istanbul under the jurisdiction of the Regional Division Office 17, the construction of which is near completion as of August, 1992, as an example, the possible size and configuration of the maintenance office is estimated. The construction of some 30 maintenance offices across Turkey is currently planned.

3) Maintenance Sub-station

The maintenance sub-station will be seasonal facilities, operating only in winter. Consequently, the facilities should be kept to a minimum to limit the initial construction cost as well as maintenance cost. The construction of some 35 maintenance sub-station across Turkey is planned.

4) Toll Collection Offices

The number of toll booths and the size of the monitoring station and office at each toll collection station will depend on the passing traffic volume forecast. The toll collection station near Adana under the jurisdiction of the Regional Division Office 5 will be used to determine the general size of the stations. The construction of some 70 toll collection offices across Turkey is planned.

5) Barriers

The size of the barriers on motorways will also depend on the passing traffic volume forecast. The barrier on Izmir-Cesme motorway will be used to determine the general size of the barriers. Some 20 barriers across Turkey are planned.

6) Parking Areas

A public toilet will be constructed at each parking area. The ratio of Turkish style bowls and Western style bowls will be 6:4. Some 100 parking areas across Turkey are planned.

7) Service Areas

As the service areas will generate profits, the use of the BOT method is planned for their construction and management. Accordingly, determination of the standard size is rather difficult unless the accurate traffic volume and composition of travelling vehicles for each service area are known. It will be the responsibility of the private enterprises which will construct and manage the service areas to decide the size and configuration of each service area. Some 15 services areas across Turkey are planned.

8) Rest Areas

The difference between a rest area and a service area is whether or not overnight accommodation facilities, such as a hotel or motel, are provided. Apart from accommodation facilities, a rest area is exactly the same as a service area. The introduction of some 5 rest areas across Turkey is desirable.

9) Training Center

The establishment of 2 training centers, i.e. one at the halfway point between Ankara and Istanbul and one near Izmir or Adana, is desirable to enable the continuous education/training of KGM employees.

6.3 Organization

6.3.1 Organization Setup

The existing organization of the KGM Headquarters will be improved based on the recommendation discussed in Chapter 5, Section 5.3, for the OMM system of 1500 km motorway. The following new divisions are created in the headquarters organization;

- Division of Motorway Maintenance, Traffic Management and Control; and
- Division of Toll Management and Motorway Revenues.

The recommendation also includes the improvement of the regional division offices for the OMM system of 1500 km motorway. The organization charts (Figures 6.3.1, 6.3.2 & 6.3.3) are a recommendation for regional division offices, main maintenance center and maintenance offices.

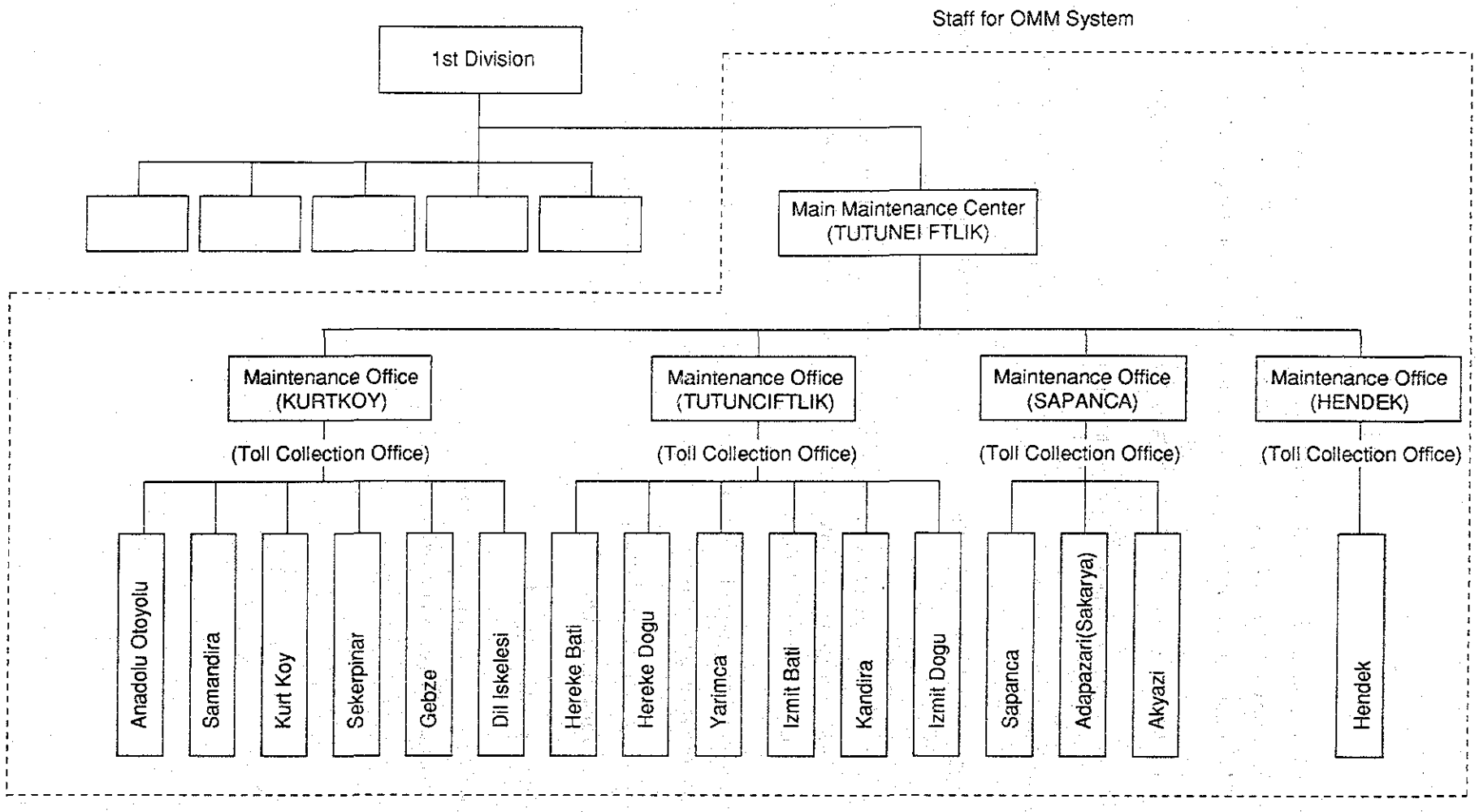
Figure 6.3.1 and Figure 6.3.2 show a case of the regional division 1 of main maintenance center, maintenance offices and toll collection offices of which organizations are common to regional divisions 2, 4 and 5.

A summary of the organization, or three tier organization setup corresponding to the 1,500 km motorway networks is shown in Figure 6.3.4.

Main tasks and responsibilities of each office for the motorway OMM system are summarized in Table 5.3.1 and Table 5.3.2, as shown in Section 5.3.

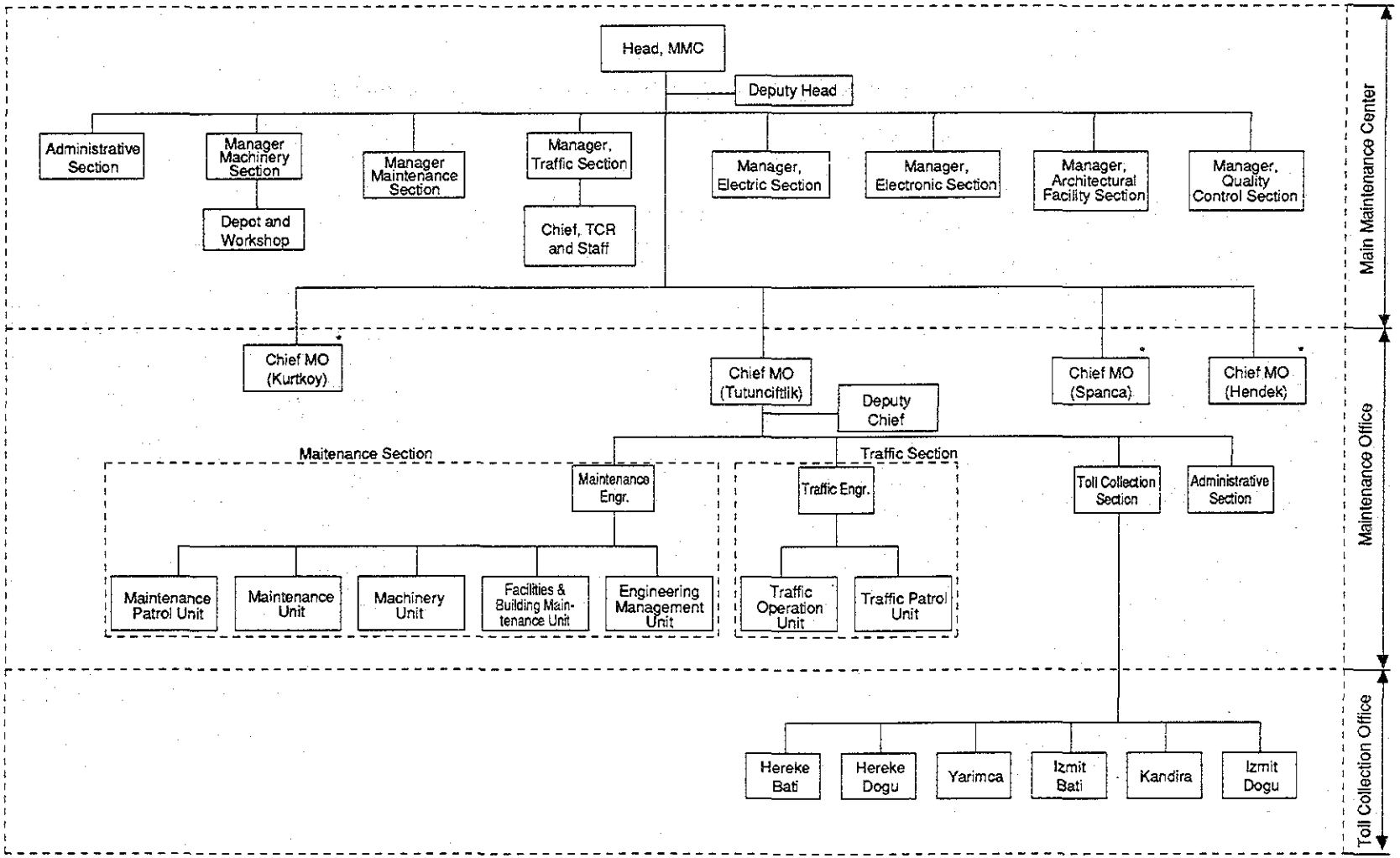
6.3.2 Total Personnel Required

Based on above mentioned organization for the motorway OMM system of 1,500 km, the total personnel required is approximately estimated in Table 6.3.1.



This figure shows a case of the regional division 1.

Figure 6.3.1 Organization Chart for Regional Division Office



Notes (1) * Detailed organization is not shown, as it is similar to Chief MO (Tutunciftlik).
(2) This organization indicates a case of Regional Division 1.

Figure 6.3.2 Main Maintenance Center, Maintenance Office and Toll Collection Office

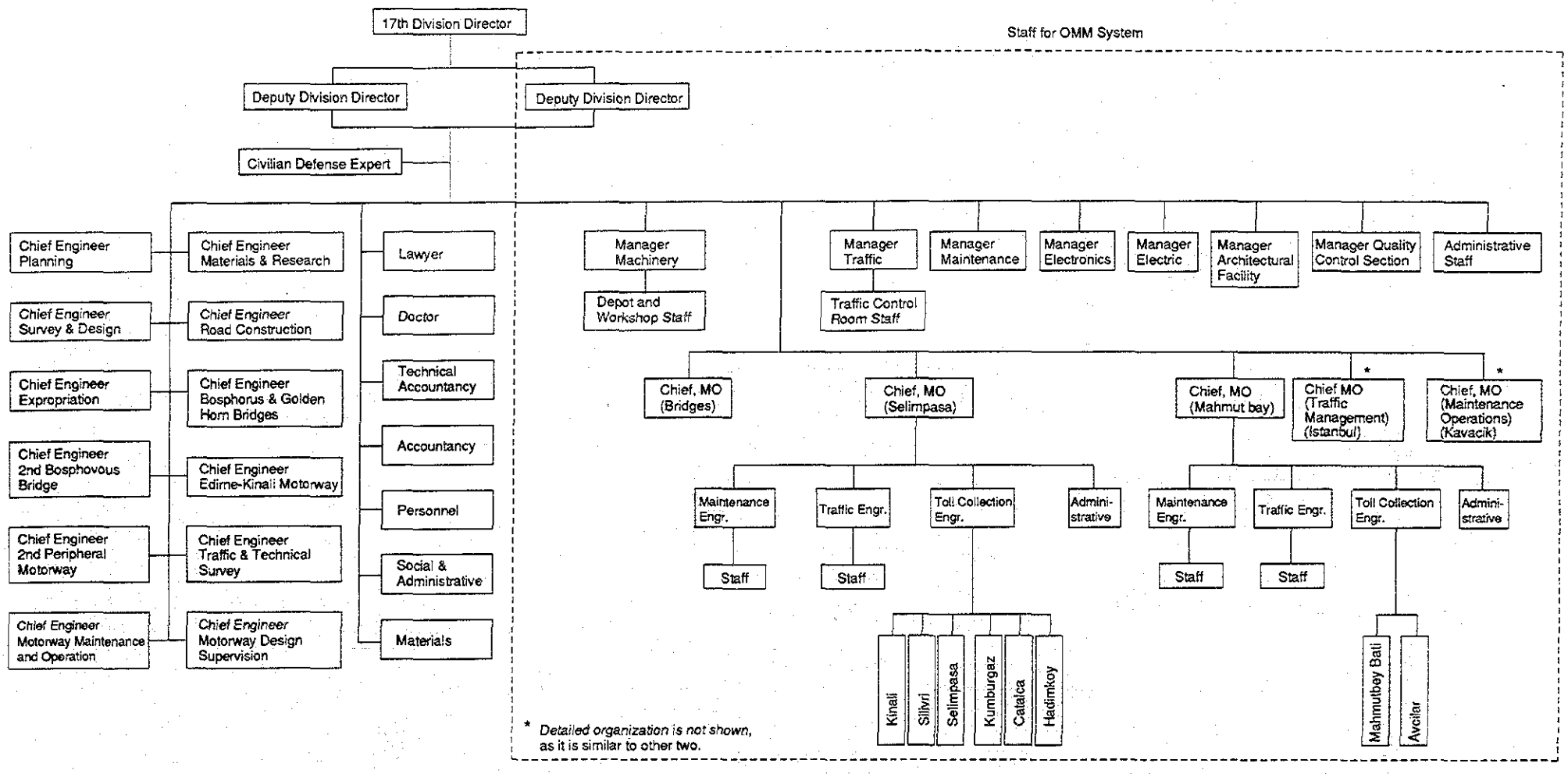


Figure 6.3.3 Organization Chart for Regional Division - 17

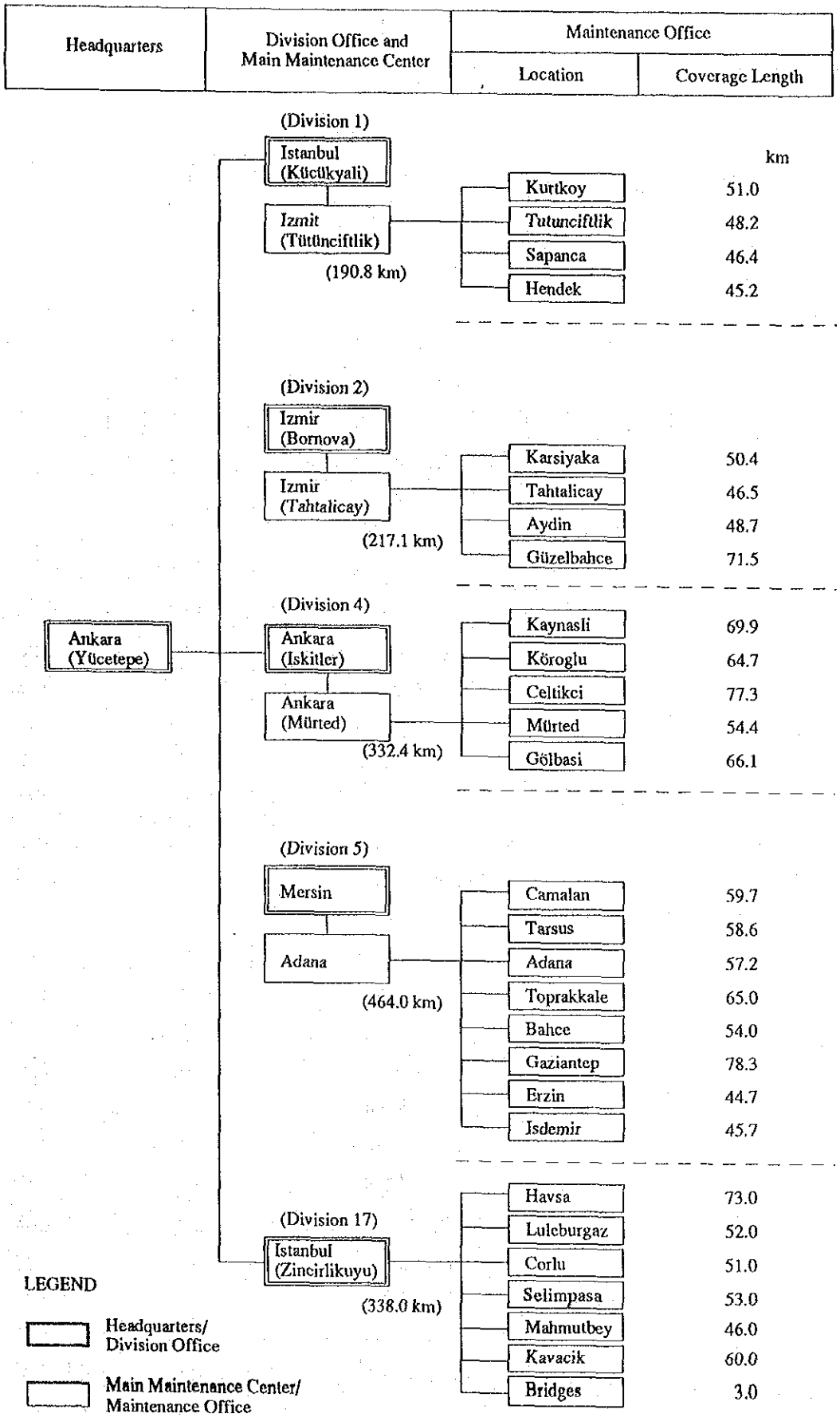


Figure 6.3.4 Three Tier Organization Setup for Motorway OMM System

Table 6.3.1 Total Personnel Required for Motorway OMM System of 1,500 km

Division	Motorway Length (km) / No. of M.O.	Group	MMC	MO
1.	190.8/4	• Traffic Management	19	96
		• Maintenance	55	152
		• Toll Collection	0	257
		• Administration	21	88
		Total	(95)	(593)
2.	217.1/4	• Traffic Management	19	93
		• Maintenance	55	185
		• Toll Collection	0	230
		• Administration	21	88
		Total	(95)	(599)
4.	322.4/5	• Traffic Management	19	120
		• Maintenance	55	201
		• Toll Collection	0	162
		• Administration	21	110
		Total	(95)	(593)
5.	464.0/8	• Traffic Management	36	192
		• Maintenance	103	315
		• Toll Collection	0	436
		• Administration	41	176
		Total	(180)	(1,119)
17	338.0/7	• Traffic Management	36	144
		• Maintenance	103	239
		• Toll Collection	0	323
		• Administration	41	142
		Total	(180)	(848)
Total	1,542.3/28	• Traffic Management	129	648
		• Maintenance	371	1,092
		• Toll Collection	0	1,408
		• Administration	145	604
		Total	(645)	(3,752)

6.4 Cost Estimation

1) General

The purpose of the cost estimate is to determine the cost of implementing a complete motorway maintenance & operations and traffic management system for the "short term implementation program" for approximately 1,500 km sections of the motorway in the Republic of Turkey. Some sections of the motorway already have some of the facilities necessary for the maintenance & operations and traffic management system recommended by other study. These facilities, including buildings, equipment, and personnel are also counted in these estimates.

The service areas and rest areas will be developed by KGM using the BOT (build, operate and transfer) system, in which the private sector will provide the facilities initially, and then turn them over to KGM at a later agreed upon time. Construction cost for these facilities shouldered by the private sectors, and the cost is not included in these estimates.

The cost to develop the system of maintenance & operations and traffic management & operations is comprised of three elements, as follows:

- The installation cost for traffic management and operations, and existing and new equipment cost for maintenance and operations to develop the initial system;
- The cost for traffic management and maintenance operations; and
- The cost to operate and maintain the facilities and equipment.

2) Traffic management and operations

(1) Construction Cost

The construction cost which includes the facilities and equipment cost and installation cost is estimated for the recommended system configuration, which includes the following items:

a) Information gathering system

- Emergency telephones
- Traffic detectors
- Meteorological information facilities
- Closed circuit television (CCTV)

b) Information processing system

- Central processor
- Peripherals
- Graphic display panel
- Software

c) Motorist information system

- Variable message signs

d) Measurement system

- Vehicle height checkers
- Axle weight scales

e) Communications system

- Trenching, conduits and cables
- Trunk line systems
- Local line systems
- Exchanges

It should be noted that this construction cost does not include costs of office building, air-conditioning system and generator.

The unit costs of the equipment are estimated based on the information from available sources in foreign countries, as this kind of equipment is not available in Turkish market and has to be imported. The imported equipment cost includes the customs and tax.

System construction cost is shown in Table 6.4.1 for each regional division office.

Table 6.4.1 Summary of Construction Cost Estimates for Traffic Management/Operation System

(Unit : 1,000 US$)

Items	Regional Division				
	1	2	4	5	17
1. Information Gathering System & Measurement System	7,797	7,627	7,721	12,739	14,484
2. Information Processing System	10,523	10,523	12,462	18,277	14,400
3. Motorist Information System	6,833	6,542	1,745	6,106	9,886
4. Communication System	23,363	24,992	32,084	44,999	35,080
TOTAL	48,516	49,684	54,012	82,121	73,850

(2) Operation and Maintenance Cost

The operations and maintenance cost of the system includes the following items:

(a) Electricity

Electricity is consumed by both the traffic control/operations rooms and the roadside equipment. Power consumption calculated for each type of equipment is first determined and then the total power consumption is determined for the entire system.

(b) Maintenance of the system

The system maintenance cost consists of labor, vehicles, spare parts and miscellaneous expenses. It is assumed that maintenance work is undertaken by maintenance companies on a contract basis.

Estimated operations and maintenance cost is shown in Table 6.4.2.

Table 6.4.2 Summary of Annual Operations/Maintenance Cost

(Unit: 1,000 US$)

	Regional Division					
	1	2	4	5	17	Total
Estimated Amount	2,426	2,484	2,700	4,106	3,692	15,408

3) Motorway Maintenance and Operations

The cost estimates for the motorway OMM system are made up of the following items:

(1) Personnel Cost

All staff of main maintenance centers and maintenance offices for the OMM system of the motorway in Regional Divisions 1, 2, 4, 5 and 17 is counted for the cost estimates.

Regional Division 1 ---------- 688 persons
Regional Division 2 ---------- 694 persons
Regional Division 4 ---------- 688 persons
Regional Division 5 ----------1,299 persons
Regional Division 17----------1,028 persons

(2) Vehicle and Equipment

All vehicles and equipment required for the OMM system are counted herein. The following number includes the existing and newly purchased vehicles and equipment.

Regional Division 1---------- 166 units
Regional Division 2---------- 137 units
Regional Division 4---------- 214 units
Regional Division 5---------- 292 units
Regional Division 17 ---------- 265 units

(3) Fuel and Lubricant Cost

Fuel and lubricant cost for motorway for motorway OMM system is estimated based on the required number of vehicles and equipment for the 5 divisions.

(4) Spare parts and Repair Cost

Spare parts purchase cost and other material cost for motorway OMM system are estimated for repairing for all vehicles and equipment based on the past records and experiences in Regional Division 17 and others.

(5) Pavement Cost

As maintenance cost, repair costs for potholes, crack, rutting, etc. are estimated.

As repairs cost, asphalt overlay and replacement cost is estimated based on the service levels. The overlay and replacement works will be done on a contract basis.

(6) Long Span Bridges

Repairs cost of 1st and 2nd Bosphorus and Golden Horn bridges is estimated. The periodic inspection and repairs such as slab, corrosion control and joint replacement will be done on a contract basis.

(7) Electricity Cost

Electricity cost is estimated for lighting for the motorway, main maintenance centers and maintenance offices.

(8) Traffic Markings

Traffic markings cost is estimated to be done on a contract basis, considering the service levels due to traffic volume.

(9) Water Cost

Water cost is estimated for all offices of the OMM system and for spraying on the motorway for snow and ice control.

The water for vegetation control will be included in vegetation control cost on a contract basis.

(10) Salt Cost

Salt cost is estimated for the snow and ice control based on the service levels and the classification of heavy, light and slight snowfall and temperature.

(11) Works on Contract Basis

Costs for the following work are estimated on contract basis by concession companies or private firms;

- road facility cleaning (periodic works only) for signs, drainage, and lighting
- repairs to the guardrail & guardwire and lighting
- traffic markings
- grass cutting
- repairs of pavement such as overlays & replacement
- bridge repairs

(12) Others

All other motorway maintenance costs for traffic safety facilities, bridges, other structures, architectural facilities, etc. are estimated as 20 % of the costs of items 3, 4, 5, 6, 7, 8, 9 (2) and 9 (3) as itemized in Table 6.4.3.

Motorway maintenance and operations costs are summarized in Table 6.4.3.

Table 6.4.3 Summary of Road Maintenance and Operations Costs (1992 prices)

(Unit: 1,000US$)

Items	Division and Motorway Length (km)				
	1 (190.8)	2 (217.1)	4 (332.4)	5 (464.0)	17 (338.0)
1. Personnel and oil & Luburicant Cost	9,447	9,259	9,909	17,072	13,859
2. Vehicles and Equipment Cost	10,523	6,850	13,553	15,718	16,434
3. Parts , Repair Cost	737	480	949	1,100	1,150
4. Pavement (maintained)	13	13	19	28	35
5. Bridge / Painting Cost	-	-	-	-	16
6. Electricity Cost	105	273	327	216	382
7. Water Cost	5	5	8	11	8
8. Salt Cost	177	5	399	19	202
9. Works on Contract Basis					
(1) Pavement Repair Cost	5,293 (Every 9 y)	15,501 (Every13y)	23,747 (Every13y)	34,267 (Every13y)	8,401 (Every 6 y)
	5,464 (Every13y)	-	-	-	13,554 (Every13y)
(2) Traffic Marking Cost	596	439	587	1,096	810
(3) Other Cost	1,069	1,249	1,908	2,663	2,112
10. Others, 20% of (3+4+5+6+7+8+9(2)+9(3))	540	493	839	1,027	943

Note : Y indicates years

4) Estimation of Architectural Facilities Construction Cost

The estimation of the construction cost of various architectural facilities shall be based on the estimated total floor area of the building to be multiplied by the construction cost per m^2 (TL/m^2) determined separately for each type of building.

With regard to service areas and rest areas where operational earnings are expected, use of the BOT method utilizing private capital is planned for their construction and management, making it extremely difficult to predetermine the size and configuration of these facilities. The construction cost of these facilities shall be estimated for reference purposes only and this cost shall not be included in the total building construction cost. The estimated building construction cost shall not include the cost for building sites and taxes.

With regard to the power building where the substation and emergency power generator unit will be housed, the building cost shall be estimated separately from the electrical equipment cost. The building construction cost shall not include the cost of the fail-safe power supply unit for the traffic control equipment (CVCF, battery and rectifier).

The construction cost given in the previous section includes the cost of such building services as the electrical service and plumbing work in addition to the cost of the building proper.

It must be noted, however, that the estimated building construction cost does not include the cost of equipment and devices directly related to the traffic control system.

An amount equivalent to 3 % of the initial investment amount shall be listed to cover the annual maintenance cost of the buildings in question.

Table 6.4.4 Cost Estimation for Architectural Facilities

	Name of Architectural Facilities	Regional Division					Total (US$)
		1 (US$)	2 (US$)	4 (US$)	5 (US$)	17 (US$)	
1	Main Maintenance Center	1,385,551	1,385,551	1,385,551	1,385,551	1,385,551	6,927,755
2	Maintenance Office	1,885,790	3,507,475	2,827,869	4,400,178	3771,581	16,392,893
3	Maintenance Substation	536,051	536,051	670,064	1,072,103	804,077	3,618,346
4	Toll Collection Office	1,374,661	1,008,085	824,797	2,566,034	1,191,373	6,964,950
5	Barrier	75,228	225,683	75,228	15,455	225,683	752,277
6	Parking Area	302,511	518,590	129,647	734,669	518,590	2,204,007
7	Training Center	0	0	369,735	0	369,735	739,470
	TOTAL	**5,559,792**	**7,181,435**	**6,282,891**	**10,308,990**	**8,266,590**	**37,599,698**

Note: Exchange Rate 1 US$ = TL 6,900 (June, 1992)

5) Summary of Cost Estimation

The summary of cost estimations is prepared as shown in Table 6.4.5, based on the previously discussed conditions.

Table 6.4.5 Summary of Cost Estimates

(Unit: 1,000US$)

Items	Regional Division 1		Regional Division 2		Regional Division 4		Regional Division 5		Regional Division 17	
	Installation Cost	Annual Operation Cost	Installation Cost	Annual Operation Cost	Installation Cost	Annual Operation Cost	Installation Cost	Annual Operation Cost	Installation Cost	Annual Operation Cost
1. Traffic Management & Operations	48,516	2,426	49,684	2,484	54,012	2,700	82,121	4,106	73,850	3,692
(1) Information Gathering System and Measurement System	7,797		7,627		7,721		12,739		14,484	
(2) Information Processing System	10,523	2,426	10,523	2,484	12,462	2,700	18,277	4,106	14,400	3,692
(3) Motorist Information System	6,833		6,542		1,745		6,106		9,886	
(4) Communication System	23,363		24,992		32,084		44,999		35,080	
2. Motorway Maintenance & Operations	10,523	23,446	6,850	27,717	13,553	38,692	15,718	57,499	16,434	41,542
(1) Personnel, Oil & Lubricant Cost	-	9,447	-	9,259	-	9,909	-	17,072	-	13,859
(2) Vehicles & Equipment	10,523	-	6,850	-	13,553	-	15,718	-	16,434	-
(3) Parts & Repair	-	737	-	480	-	949	-	1,100	-	1,150
(4) Maintenance & Repair (Force Account)	-	300	-	296	-	753	-	274	-	643
(5) Maintenance & Repair (Contract Basis)										
• Asphalt/Periodic (1st)	(Evy	9 y) 5,293	-		-		-	-	- (Evy	6 y) 8,401
(2nd)	(Evy	13 y) 5,464	- (Evy	13 y) 15,501	(Evy	13 y) 23,747	(Evy	13 y) 34,267	(Evy	13 y) 13,554
• Others		1,665		1,688	-	2,495	-	3,759	-	2,992
(6) Others	-	540	-	493	-	839	-	1,027	-	943
3.** Architectural Facilities	-	-	-	-	-	-	-	-	-	-
Total-A (excluding asphalt/periodic)	59,039	15,115	56,534	12,216	67,565	17,645	97,839	23,338	90,284	23,279
Total-B (only including asphalt/periodic)	-	10,757	-	15,501	-	23,747	-	34,267	-	21,955

Note ** : Architectural facilities cost is not accumulated to the total since the cost was counted for road construction works as the motorway facilities cost, or for BOT.

6.5 Evaluation

6.5.1 General

The Government of Turkey has a plan to adopt a repayment system to cover all costs involved in motorway construction and operation by toll revenue and to establish a balanced budgetary system for motorway development in Turkey. However, the present financial resources for motorway construction are obtained through KOI mainly from contractors' credit. In the motorway projects, KOI act as agency which handle the investment fund for motorways including payoffs to contractors and management of toll revenues. Ninety (90) percent of toll revenues from motorways is designated to KOI and 10 percent is allocated to KGM for motorway maintenance and operations. However, detailed allocation of expenditures and responsibilities for establishing and operating OMM system on a long term basis seems not to have been clearly defined. Under these circumstances, it would be helpful to visualize here approximate cash flow on the KGM account for establishing and operating the proposed OMM system for a relatively long term. A financial study is conducted to examine the viability regarding establishment and operations of the proposed OMM system based on several assumptions and cases as described below.

6.5.2 Basic Assumptions

The following assumptions are made for the basic case of this study:

(1) KGM will receive 10 percent of total toll revenue, and use all the facilities for OMM system built or installed under the motorway construction contracts by KOI fund without any extra financial burden to KGM.

(2) KGM will procure and install additional equipment for traffic management and maintenance operations necessary to complete the proposed OMM system on KGM account.

(3) The proposed OMM system will start to be developed in 1993 and completed within 1995. The complete system is assumed to start operations in 1996.

(4) The toll revenue allocation corresponding to the above OMM system is assumed to enter KGM account from the beginning of 1996.

(5) The toll rate is assumed fixed at the present rate converted in US currency for the duration of the project life. This assumption means that toll rates in Turkish currency is adjusted timely according to the changes in conversion rate between the two currencies.

(6) The traffic volume in 2000 and 2010 used for calculation of toll revenue is due to JICA study team's forecast. The revenues thus forecasted for the years 2000 and 2010 are 90% and 82% respectively of those forecasted by KGM and received by the JICA study team in April, 1993. The revenue values for other years are inter- or extra-polated using the equal ratio compatible to both values.

(7) The project life after the start of operations of OMM system is assumed 15 years from 1996 to 2010 for the calculation of internal rate of returns.

(8) Corresponding to the revenue forecast which is based on the assumption of net growth rate of about 6 % per year in GDP, annual increase of personnel cost for OMM operations is taken into account in the calculation accordingly.

6.5.3 Revenue Forecast

The result of toll revenue forecast as mentioned above is shown on Table 6.5.1.

Table 6.5.1 Toll Revenue Forecast and Allocation to KGM (unit:US.$1,000)

	2000	2010
Division-1	208,229	335,803
Division-2	66,283	178,702
Division-4	82,634	110,161
Division-5	225,831	402,139
Division-17	228,945	368,947
Total	811,922	1,395,752
KGM's share		
10% of total	81,192	139,575
20% of total	162,384	279,150

6.5.4 Cash Flow on KGM Project Account (Base Case)

Cash flow based on the above basic assumptions is shown in Table 6.5.2. As seen from this cash flow, OMM account of KGM will continue to show red balance for the project period of 15 years and this trend will not improve thereafter, too.

Table 6.5.2 Cash Flow in Base Case

(Unit : million U.S.$)

	Initial Cost	Annual Cost	Total Cost	Revenue	Net Revenue
1993	18.56		18.56		-18.56
1994	185.63		185.63		-185.63
1995	167.07		167.07		-167.07
1996		101.96	101.96	65.37	-36.32
1997		105.48	105.48	69.01	-36.47
1998		117.72	117.72	72.85	-44.87
1999		113.22	113.22	76.91	-36.31
2000		117.18	117.18	81.19	-35.99
2001		126.50	126.50	85.71	-40.79
2002		125.29	125.29	90.48	-34.81
2003		129.45	129.45	95.52	-33.93
2004		142.07	142.07	100.84	-41.23
2005		230.49	230.49	106.45	-124.04
2006		142.33	142.33	112.38	-29.95
2007		146.77	146.77	118.64	-28.13
2008		151.28	151.28	125.24	-26.04
2009		155.87	155.87	132.22	-23.65
2010		174.24	174.24	139.58	-34.66

6.5.5 Cash Flow on KGM Project Account (Case-2: toll revenue share 20 %)

In order to examine financial status of the OMM project by means of toll revenue share, Case-2 is set up for the case where 20 % of total toll revenue is allocated to KGM for OMM operation. Other conditions are not changed from those given in the basic assumptions. The corresponding cash flow calculated for this case is as shown in Tables 6.5.3. The cash flow shows that the OMM operation is considered manageable if 20% of the total toll revenue is allocated to KGM. The internal rate of return is calculated at 9.26 % corresponding to this cash flow. Generally speaking, the internal rate of return of about 10 % is a moderate value especially when the governmental project is financially evaluated. However, a project with such I.R.R value is judged to require a soft loan with an interest rate lower than 10 %.

In order to further examine the sensitivity of the toll share to the internal rate of return, the relationship between the two variables is calculated and shown on the graph given in Figure 6.5.1. As seen in the graph, IRR falls negative when the toll share drops to 16 % and IRR approaches 30 % when the share exceeds 30 %.

Table 6.5.3 Cash Flow in Case-2

(Unit : million U.S.$)

	Initial Cost	Annual Cost	Total Cost	Revenue	Net Revenue
1993	18.56		18.56		-18.56
1994	185.63		185.63		-185.63
1995	167.07		167.07		-167.07
1996		101.96	101.96	130.74	29.05
1997		105.48	105.48	138.02	32.54
1998		117.72	117.72	145.70	27.98
1999		113.22	113.22	153.82	40.60
2000		117.18	117.18	162.38	45.20
2001		126.50	126.50	171.42	44.92
2002		125.29	125.29	180.96	55.67
2003		129.45	129.45	191.04	61.59
2004		142.07	142.07	201.68	59.71
2005		230.49	230.49	212.90	-17.59
2006		142.33	142.33	224.76	82.43
2007		146.77	146.77	237.28	90.51
2008		151.28	151.28	250.48	99.20
2009		155.87	155.87	264.44	108.57
2010		174.24	174.24	279.16	104.92

Internal Rate of Return = 9.26 %

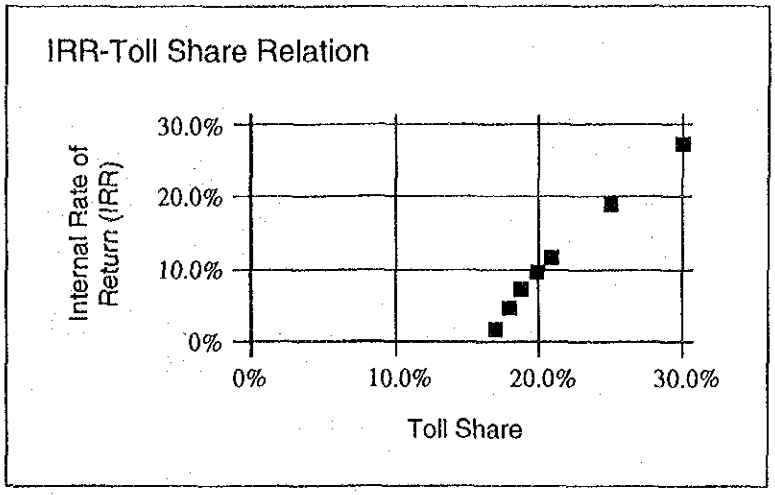


Figure 6.5.1 IRR-Toll Share Relationship

6.5.6 Toll Revenue Forecast and Sensitivity to its Error

As logically understood from the discussion in the preceding section, a similar relationship must exist between IRR and the error in toll forecast. To examine this relationship, the toll share to KGM is fixed at 20 % and the error in the toll forecast is measured by the percentage of deviation from the JICA Forecast shown in Table 6.5.1. Thus,if the actual toll revenue is found 10 % larger than the forecasted value, the error is measured at plus 10 %.

The result of calculation is shown in Figure 6.5.2. From the graph, it is understood that the actual IRR will be improved to 14 % if the actual toll revenue is found 10 % larger than the forecasted values. It can approximately be said that the IRR is approximately 15 % if KGM's forecast mentioned in (6) of 6.5.2 herein is adopted and the toll share of KGM is assumed at 20 %, as KGM's forecast gave about 10 % larger amount than that of JICA forecast.

It is also understood from the graph that even if KGM's 20 % share of toll revenue is approved by the authorities, the IRR will be minus if the actual toll revenue is 20 % less than that of the JICA forecast.

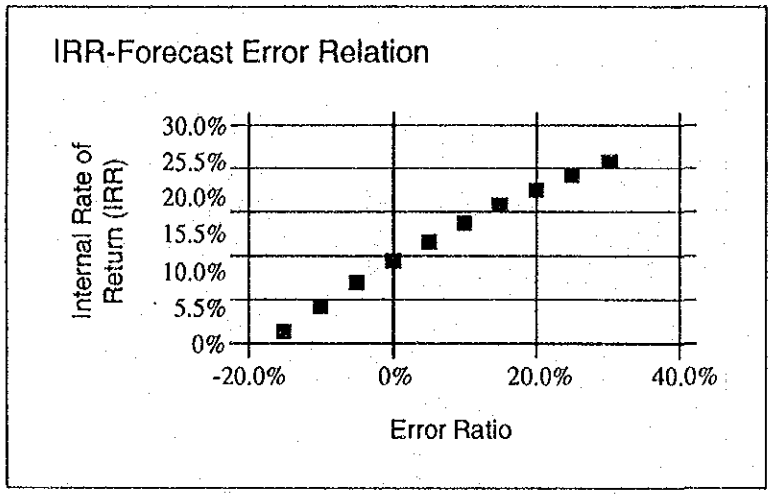


Figure 6.5.2 IRR-Forecast Error Relationship

6.5.7 Cash Flow on KGM Project Account (Case-3: initial investment cost to KOI account)

In the previous Case-2, if the initial investment necessary for completing the OMM system is done by KOI on their financial responsibility, KGM's share of the total toll revenue must be reduced considerably. From this point of view, Case-3 is set up as follows:

(1) The initial investment cost to complete the OMM system is to be borne by KOI as an extra construction cost of the motorway.

(2) The 15 % of the total toll revenue is allocated to KGM for the OMM operation. Other conditions remain unchanged from those assumed for the base case.

The cash flow for this case is as shown in Table 6.5.4.From the cash flow and the result of I.R.R calculation, it seems that this case is sufficiently manageable for KGM's OMM operation. However, if KGM's share of the total toll revenue is reduced to 14.5 % without changing other conditions, the cash flow is as shown in Table 6.5.5 and the IRR is calculated at 9.43 %. As seen in these two cases, only 0.5 % change in share of the toll revenue resulted in 20 % change in I.R.R value.

It should also be noted herein that the I.R.R. turns into negative when the share ratio is reduced to 14 %. As the internal rate of return is an index to indicate efficiency of an investment, it would not be a right way to discuss financial status by means of IRR in these cases where the initial investment is nil or negligibly small.

Table 6.5.4 Cash Flow in Case-3 (Initial Investment KOI Account)

(Unit : million U.S.$)

	Initial Cost	Annual Cost	Total Cost	Revenue	Net Revenue
1993					
1994					
1995					
1996		101.69	101.96	98.06	-3.63
1997		105.48	105.48	103.52	-1.96
1998		117.72	117.72	109.28	-8.45
1999		113.22	113.22	115.37	2.15
2000		117.18	117.18	122.87	5.68
2001		126.50	126.50	128.57	2.07
2002		125.29	125.29	135.72	10.43
2003		129.45	129.45	143.28	13.83
2004		142.07	142.07	151.26	9.19
2005		230.49	230.49	159.68	-70.82
2006		142.33	142.33	168.57	26.24
2007		146.77	146.77	177.96	31.19
2008		151.28	151.28	187.86	36.58
2009		155.87	155.87	198.33	42.46
2010		174.24	174.24	209.37	35.13

I.R.R. = 29.44 %

Table 6.5.5 Cash Flow in Case-4 (Toll Revenue Share 14.5 %)

	Initial Cost	Annual Cost	Total Cost	Revenue	Net Revenue
1993					
1994					
1995					
1996		101.69	101.69	94.79	-6.90
1997		105.48	105.48	100.06	-5.42
1998		117.72	117.72	105.63	-12.09
1999		113.22	113.22	111.52	-1.70
2000		117.18	117.18	118.77	1.59
2001		126.50	126.50	124.28	-2.22
2002		125.29	125.29	131.20	5.91
2003		129.45	129.45	138.50	9.05
2004		142.07	142.07	146.22	4.15
2005		230.49	230.49	154.35	-76.14
2006		142.33	142.33	162.95	20.62
2007		146.77	146.77	172.03	25.26
2008		151.28	151.28	181.60	30.32
2009		155.87	155.87	191.72	35.85
2010		174.24	174.24	202.39	28.15

I.R.R = 9.43 %

6.5.8 Cash Flow on KGM Project Account (Case-5: employee's conversion)

There might be an opinion in some sectors that a large government organization like KGM must have developed to a size which can absorb some extra duties without increasing the budget. The present number of KGM personnel is about 33,600 according to 3.1.2 of this report. The number additionally required for the OMM system is about 4,400 according to Table 6.3.1 in this report. Is it possible to manage to create these 4,400 personnel by converting some of the present 33,600 personnel to new jobs? It means that the remaining 29,200 (87 %) personnel must maintain and operate 31,000 km of state roads and 27,000 km of provincial roads and other tasks originally assigned to KGM. Actually, among 33,600 employees, only 11,203 personnel are directly engaged in the maintenance and operation of state highways and provincial roads according to 3.2.1. Therefore, it may practically be difficult to arrange all of additionally required personnel by conversion of existing personnel.

However, to examine this effect, Case-5 is herein set up for the case where a half of additionally required personnel are converted from the existing personnel. Therefore, no extra budget is required for 2,200 personnel for OMM operation in this case if wages for these personnel are paid from KGM's general budget. Other conditions remain unchanged from the base case.

The cash flow for this case is shown in Table 6.5.6. As understood from the table, the project account continues to be in red balance throughout the project period. Then, next case is examined by Case-6 where KGM's share of the toll revenue is 18%. In this case, the cash flow will become as shown in Table 6.5.7. Now, the internal rate of return is 9.45 %. It is understood that this conversion of existing KGM personnel into OMM will reduce KGM's toll share by 2 %, when it is reminded that the Case-2, where the toll share is 20 % and other conditions are the same as the Base Case, gave the IRR of 9.26 % almost equal to that of this Case-6.

Table 6.5.6 Cash Flow in Case-5

	Initial Cost/ P-cost	Annual Cost	Total Cost	Revenue	Net Revenue
1993	18.56		18.56		-18.56
1994	185.63		185.63		-185.63
1995	167.07		167.07		-167.07
1996	-15.84	101.69	85.85	65.37	-36.32
1997	-16.32	105.48	89.16	69.01	-36.47
1998	-16.80	117.72	100.92	72.85	-44.87
1999	-17.31	113.22	95.91	76.91	-36.31
2000	-17.83	117.18	99.35	81.19	-35.99
2001	-18.36	126.50	108.14	85.71	-40.79
2002	-18.91	125.29	106.38	90.48	-34.81
2003	-19.48	129.45	109.97	95.52	-33.93
2004	-20.07	142.07	122.00	100.84	-41.23
2005	-20.67	230.49	209.82	106.45	-124.04
2006	-21.29	142.33	121.04	112.38	-29.95
2007	-21.93	146.77	124.84	118.64	-28.13
2008	-22.58	151.28	128.70	125.24	-26.04
2009	-23.26	155.87	132.61	132.22	-23.65
2010	-23.96	174.24	150.28	139.58	-34.66

Table 6.5.7 Cash Flow in Case-6

	Initial Cost/ P-cost	Annual Cost	Total Cost	Revenue	Net Revenue
1993	18.56		18.56		-18.56
1994	185.63		185.63		-185.63
1995	167.07		167.07		-167.07
1996	-15.84	101.69	85.85	117.66	31.81
1997	-16.32	105.48	89.16	124.22	35.05
1998	-16.80	117.72	100.92	131.13	30.22
1999	-17.31	113.22	95.91	138.43	42.52
2000	-17.83	117.18	99.35	146.14	46.79
2001	-18.36	126.50	108.14	154.28	46.14
2002	-18.91	125.29	106.38	162.87	56.49
2003	-19.48	129.45	109.97	171.94	61.97
2004	-20.07	142.07	122.00	181.51	59.51
2005	-20.67	230.49	209.82	191.62	-18.20
2006	-21.29	142.33	121.04	202.29	81.24
2007	-21.93	146.77	124.84	213.55	88.71
2008	-22.58	151.28	128.70	225.44	96.74
2009	-23.26	155.87	132.61	237.99	105.38
2010	-23.96	174.24	150.28	251.24	100.96

IRR = 9.45 %

6.5.9 Review and Conclusion

Through the above analyses of cash flows in several cases concerning the financial arrangement for KGM's OMM account, the following should be remarked.

(1) The present financial framework with KGM's toll share of 10 % is considered not adequate for the OMM operation on an internationally acceptable level.

(2) If the Government wish to adopt a financial framework for development and operation of Turkish motorway similar to the present one in the future too, the toll share ratio for OMM operation should be revised as follows:

i. 20 % in case KGM shall bear the initial investment cost for completing OMM system.

ii. 15 % in case KOI shall bear the initial investment cost for completing OMM system.

(3) In the above cases, the Government should arrange a soft loan to KGM if KGM experience deficits in its account in initial stages of operation.

(4) Considerable errors in toll revenue forecast is unavoidable, as the forecast value is influenced by many factors such as future economic condition of the country, toll rates policy, further development of total road system, future increase in number of vehicles etc., which are beyond the control of highway officials. There is also a technical difficulty in the fact that there is no up-to-date O-D survey data in the areas concerned which are indispensable for the forecast of traffic and revenue with high accuracy and the fact that the motorway system concerned is just in an initial development stage now and there is no traffic data in a complete network. Therefore, it should be understood that the forecast value adopted herein involves considerable errors with a range of 20% or more. It is advisable to periodically review the financial framework among the authorities concerned and adjust it to a suitable one for the actual conditions.

(5) Any large organization tends to grow with ages to an organization comfortable for the people belonging to the organization deviating from the original purpose on its foundation. As KGM is also a large and old organization, there might be an opinion to point out that the organization must have some potential to absorb some extra duties with existing facilities and human resources. As seen in Case-6 in the preceding section, the toll share for KGM can be decreased by 2 % if a half number of personnel required for OMM operation is converted from the existing employees without supplement of new employees. KGM should sincerely examine the present organization and function thereof toward a more efficient organization and try to minimize new employment for OMM operation. The same can be said about the facilities and equipment for OMM operation. At least, KGM should be prepared for such discussion, when the toll share issue is negotiated with other authorities concerned.

In the above analysis and discussion, toll rates have been fixed at the present one on the basis of US currency. In this moment of the study, it is considered a moderate and inevitable assumption, as the motorway development fund has mostly been arranged from international bank loan and the current exchange rate between the local and US currency is very unstable. However, it should be noted that the toll rate assumed herein would be felt unreasonably expensive in the near future, if the present weakness of Turkish Lira against US dollars remained unchanged for the time being and the per-capita income growth could not compensate

this effect. The actual toll rates should be determined taking into account that the motorway is an important national infrastructure and its sound development will indirectly help promote the growth of national economy.

How much percent of toll revenue should be allocated to motorway operation and maintenance ? In the case of Japanese motorway system, about 30 % of toll revenue is allocated to the OMM operations. In the case of Indonesian motorway system, the percentage is heard more than that. However, it should be noted that the toll rates are kept relatively low in these countries as a government policy and the motorway development fund is arranged by a help of the Government from various sources. Taking these facts into consideration, it is considered moderate to allocate some 20 % of motorway toll revenue to OMM operations.

It should be highly evaluated that the Turkish Government have developed a high quality motorway network almost reaching the length of 1,500 km in a remarkably short period on a self reliant basis. However, it is important to operate and maintain the completed motorway on a level of high quality and to further develop the motorway system to the long term target of 3,000 km. Therefore, it is hereby recommended to the Government of Turkey to review more carefully the present financial framework for the motorway development and operations and to agree on a more practical and balanced framework among all the authorities concerned.

Under these circumstances, it will be very difficult for the KGM to determine now if the OMM system proposed herein should be implemented at once as it is before the financial condition for the OMM operation is confirmed. The progress of motorway construction for the 1,500 km network is now delaying a little according to the latest information from KGM. Therefore, the actual implementation schedule for OMM system should be flexibly rearranged by the KGM in consideration of the progress of coordination on financial problems with other authorities concerned. Depending on the result, rearrangement in scope of work for traffic management system or degrading of the service level of the same would become necessary in the actual implementation program.

Recommendation

7. Recommendation

As described in the preceding chapter, the motorway system in Turkey will be developed to 3,000 km network in the long term plan. Therefore, the OMM system recommended herein is only an initial step for the complete system in the future. In the course of further development, KGM are recommended to continuously study the following subjects and develop the motorway maintenance, operations and traffic management (OMM) system in a good balance with further development of motorway system in Turkey.

(1) A sound development of the motorway system must be backed up by a sound financial system for motorway development and operation system. As recommended at the end of preceding chapter, we hereby recommend the Government of Turkey to review more carefully the present financial framework for the motorway development and operations and reach a more practical and balanced framework coordinating all the authorities concerned.

(2) In the OMM system hereby recommended, maintenance offices under the main maintenance centers have limited authority for any decision requiring judgment. In the initial stage of operations of a new organization, it would be unavoidable to depend too much on limited number of reliable and qualified persons for any decision. However, we strongly recommend the KGM to try their best to transfer the authorities given now to the main maintenance centers to maintenance offices as promptly and widely as possible through the accumulation of actual operation and systematically programmed training of employees, as excessive concentration of responsibilities to main maintenance centers is expected as the work load increases.

(3) In connection with the above subject, we recommend the KGM to further develop the existing employee training facilities for the above purpose. The development will also help smooth conversion of the existing employees into the OMM operations mentioned in 6.5.8 in the preceding chapter. The Operation Manual submitted herewith as a part of this study will be a good software material for this purpose. We hereby recommend the KGM to improve this material themselves in the course of accumulation of their own experience and innovation of related technology in the world.

(4) Next to the effective utilization of existing personnel, privatization of the system operations should be positively studied by KGM. Toll collection services, the privatization of which is now considered extremely difficult by the KGM, may also be carried out by private companies if a workable inspection system by KGM is properly introduced and a proper insurance or guarantee system is arranged.

(5) Maintenance and management cost for urban motorway sections will gradually increase along with the increase in the traffic volume and aging of road structures. The KGM are recommended to start a study if the present system not to charge toll from intraurban motorway users should be maintained even when the urban motorway system has been further developed.

(6) Education of motorway users will be more effective than the introduction of any sophisticated equipment for traffic and safety management although it is a time consuming project. Licensing system for drivers should be reviewed in this line and introduction of related curriculum in the compulsory school education should be considered.

(7) In this study, planning for traffic management and operations on the second peripheral road in Istanbul was of a primary focus. However, for relieving the actual traffic congestion, a further intensive study is required to establish an areawide traffic control system which covers all related roads and is capable of collecting and analyzing detail traffic data in a wider area . KGM is recommended to continue this study for better solution.

(8) As to the axle scale problem discussed on the latest technical committee meeting between KGM and JICA, the Study Team's position is now as follows: It is actually impossible to completely shut out any overloaded vehicle from the motorways without causing interruption on motorway entrance and its connecting roads. Therefore, a practical solution would be to provide at least one axle scale on one motorway entrance and timely control overloaded vehicles in order to minimize the intrusion of such vehicles into motorways without causing traffic congestion. The KGM are requested to study rearraangement of the scheme before actual implementation after discussing the matter intenally in consideration of this guideline and the overloaded vehicle control program now under planning for the total road system in the country.

Appendix

Appendix : Immediate Implementation Plan

Note:

This Immediate Implementation Plan was prepared in October, 1992 to establish the requirements for implementing a complete motorway maintenance, operation and traffic system for the open motorway segments in Regional Divisions 1 and 17 from Kinali to Sakarya (320 km long).

6. Immediate Implementation Plan

6.1 Introduction

The immediate Implementation Plan will establish the requirements for implementing a complete motorway maintenance, operations and traffic management system for the open (or soon to be open) motorway segments in Divisions 17 and 1. This involves the section of motorway from Kinali to Sakarya, Kazanei (including the second Peripheral Road and Second Bosphorous Bridge), and also includes 24 km of the First Peripheral Road (and the First Bosphorous Bridge). The total length of motorway in the Immediate Implementation Plan is approximately 320 km.

As mentioned above, this entire section is nearly all open to traffic, and will be complete and open to traffic in 1993. The following points are considered important relative to the 320 km Immediate Implementation Plan:

1) Following the submittal and approval of the Immediate Implementation Plan, the Short-term Implementation Program for the OMM System for 1,500 km of motorway will be submitted to KGM in the form of a rough draft by May, 1993.

2) The existing features of the maintenance, operations and traffic management system will be basically unchanged, such as the existing road maintenance facilities and equipment, and traffic management equipment such as emergency telephones, fixed guide signs, variable message and variable speed limit signs, CCTV systems, etc., will not be changed. The recommended Immediate Implementation Plan will recommend a system which adds to the existing system, not changes the existing system.

3) The service and rest areas will be operating under the BOT (build, operate, transfer) system, in which private contractors will be providing all the services necessary for those areas to function in a manner satisfactory to KGM. The requirements for those areas was previously discussed in Chapter 5, as an integral part of the 3,000 km motorway OMM system.

4) As a new system of motorway OMM is being established in the Republic of Turkey, significant knowledge and experience would be furnished from this "Immediate Implementation Plan" segment in the Istanbul urban area, and use it as a "test section". Important lessons learned from this 320 km section can be applied elsewhere in Turkey on other segments of the motorway.

6.2 Planning and Engineering

6.2.1 Traffic Management and Operations

1) System Configuration

The traffic management and operations system for the motorway has four major functions. They are information collection, information processing and decision making, information dissemination, and execution and enforcement of the decision.

The structure of the system configuration is shown in Figure 6.2.1.

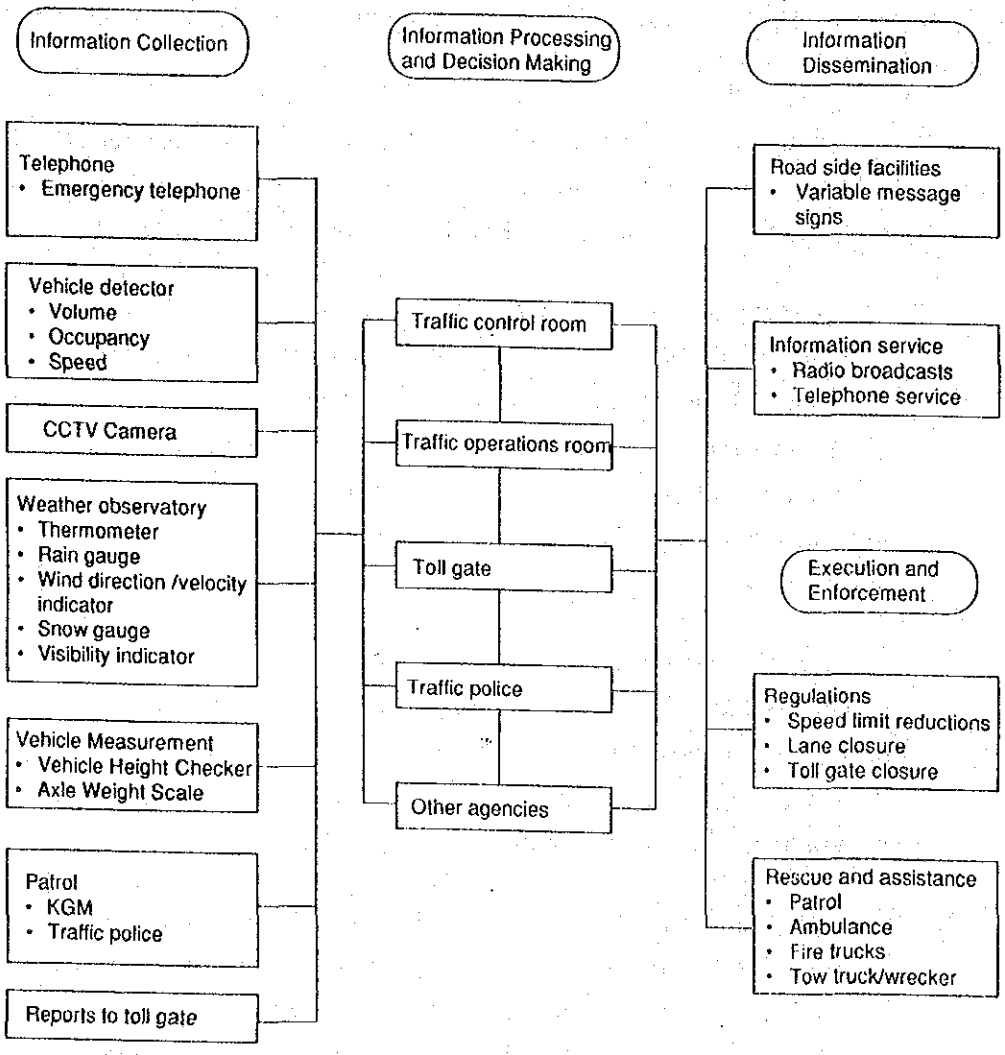


Figure 6.2.1 Traffic Management and Operations System Structure

(1) Information Collection

The information collection system will consist of three different systems, those being on automatic system, a manual system and a visual system. Traffic data and traffic incident information are either automatically gathered through traffic detectors, weather observatory equipment and other devices, or manually reported by emergency telephone or by the radio communications system provided by patrol cars. The CCTV system is also a tool for traffic surveillance as it furnishes the system operator with a visual image of the traffic situation.

(2) Information processing and decision making

Information processing and decision making is accomplished in the traffic control room. The traffic control room is the core of the traffic main segment and operation system. All information is gathered at the center where traffic management activities such as incident detection, assistance to drivers, detour implementation, special enforcement, etc. are activated in response to monitoring of the traffic situation.

(3) Information dissemination

Roadside information dissemination devices such as variable message signs and variable speed limit signs are controlled from the traffic control room so that road and traffic conditions can be conveyed to road users. Information is provided through a telephone service, in which an inquiry is answered either by operator or by a prerecorded message.

(4) Execution and enforcement

If an incident occurs on the motorway, countermeasure must be taken swiftly. There are a variety of traffic control measures that can be taken such as a speed limit reduction during an adverse weather condition, closure of a shoulder, closure of a lane, and total closure of a section of motorway. Traffic control measures must be executed in a coordinated manner by both the motorway management body (KGM) and the traffic police. The traffic control room has a major responsibility for overseeing such activities.

2) Traffic Control Room and Traffic Operations Room

(1) Outline of the functions for the traffic control room and the traffic operations room

The traffic control room is located at the main maintenance center and is the core of the traffic management and operations system.
It accommodates a computer system and associated equipment as well as staff to operate the system and to plan for countermeasures to be taken when incidents occur.
The traffic operations room is located in each maintenance office. Its purpose is to gather and distribute data from/to roadside equipment and to monitor information so as to respond promptly to incidents. Another important function of the traffic operations room is to back up the functions of the traffic control room (to some extent) in case of a communications interruption between the traffic operation room and the traffic control room.

(2) Outline of construction

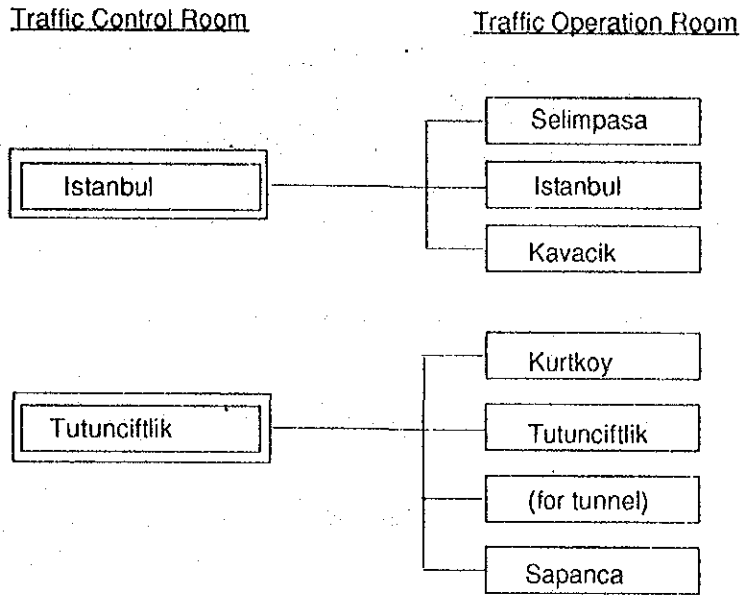
The traffic control room is a location where staff are stationed and control desks, terminals and a display panel are located. It is also a room where the computer, peripherals and other equipment are installed a power room where an uninterruptible power supply system is placed, and provides other spaces such as offices, a workshop, a storage room, etc.

The traffic operations room is a control room where a monitoring or control desk is installed and a carrier terminal station where peripherals and a data transmission system are located.

(3) Location

The traffic control room should be located at the main maintenance center. The traffic operations room should be located at the maintenance offices in order to monitor certain information required for management activities, such as patrolling, motorway maintenance activities and the provision of first-aid.
As shown in Figure 6.2.2, two traffic control rooms and seven traffic operation rooms are proposed for the traffic management and operation system.

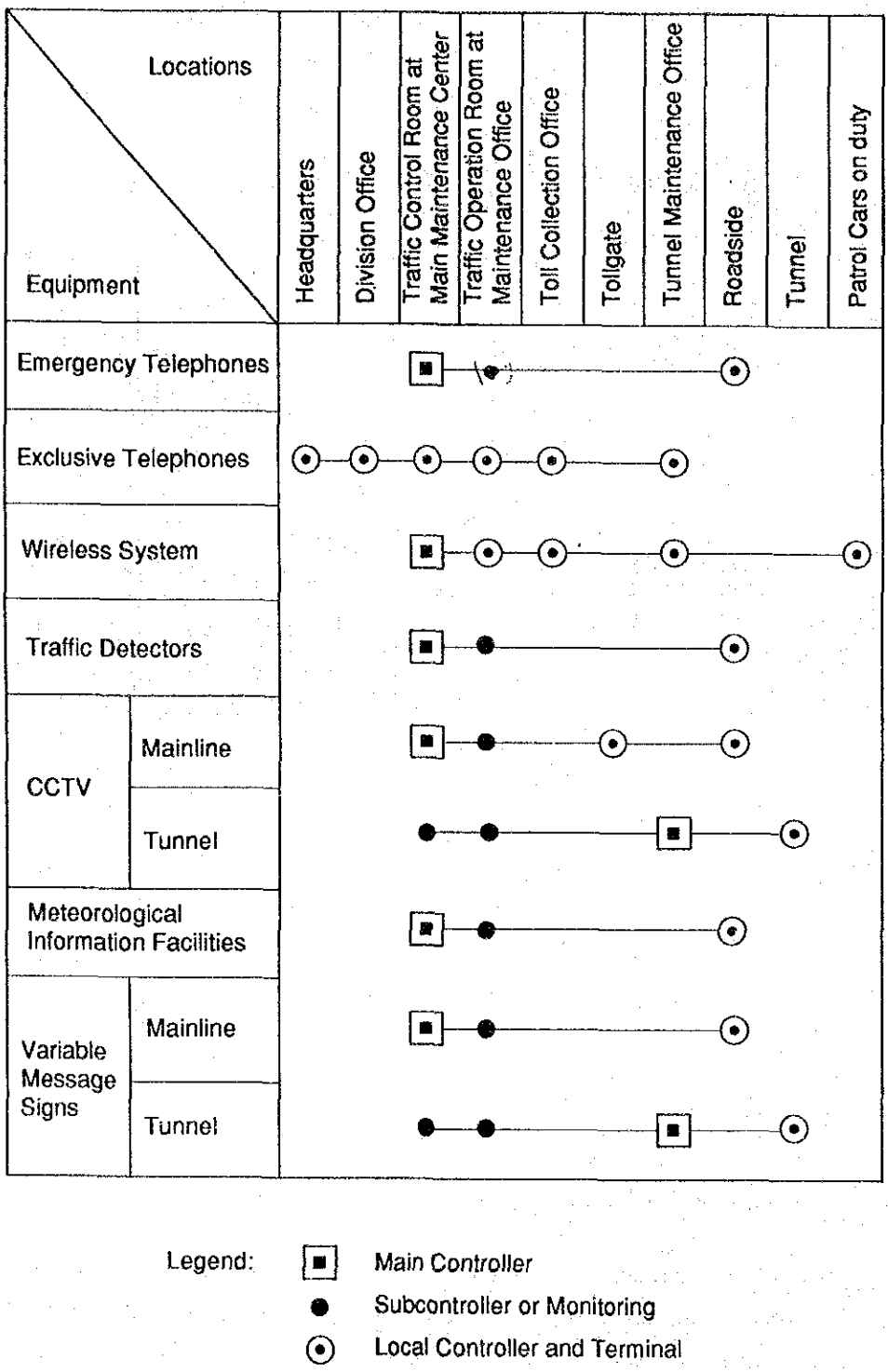
Figure 6.2.2 Locations of the Traffic Control Room and the Traffic Operation Room



(4) Connection of roadside equipment

Roadside equipment is installed at various locations along the motorway as described in the following section, and this equipment is controlled either by the maintenance office or by the main maintenance center. The communications network is established between the offices and from the offices to the roadside equipment. Figure 6.2.3 illustrates the location of the roadside equipment and now this equipment is connected and operated.

Figure 6.2.3 Connection of Roadside Equipment



3) Installation Standards

As mentioned above, a traffic management and operations system consists of various facilities and equipment on the roadside and at various locations within the motorway management organization as well as a communication network.

These facilities and equipment are installed differently in different segments of the motorway to reflect the appropriately designated traffic management and operation service level. Table 6.2.1 shows the general guidelines for installation standards for various facilities and equipment on the motorway, according to service level.

For Service Level 3, the basic facilities such as installation of emergency telephones and establishment of the communication cable network are implemented. In addition to these, other basic facilities which provide for safety on the motorway are installed. These other facilities include traffic detectors at representative locations of the jurisdiction of maintenance offices with traffic operation rooms, meteorological information facilities at representative locations that might experience severe weather, variable massage signs at each entrance of tollgate booths and long tunnel entrances. Measurement facilities such as vehicle height checkers and axle weight scales are installed at tollgates for preservation of the motorway itself.

For Service Level 2, the function of the facilities and equipment installed for Service Level 3 are to be enhanced by either increasing the numbers of units installed or adding now devices. The installation of traffic detectors, for example, is increased to provide for locations with large traffic volume variations such as junction and interchanges located in major cities. With these increased numbers of detectors, more traffic data including merging and diverging traffic volumes at junctions and access and egress traffic volumes at major interchanges can be accurately counted. Visual information gathering is made possible by introducing CCTV systems at Service Level 2. CCTV cameras are installed at representative locations having high traffic accidents and severe weather conditions for traffic flow observation. The numbers of variable message signs are also increased in Service Level 2 and installed upstream of off-ramp at major interchanges.

Table 6.2.1 Installation Standards

Facilities/Equipment			Service Level		
			Level 1	Level 2	Level 3
Communication Facilities	Emergency Telephones		• 2.0 km intervals on both sides (1.5 km in metropolitan area). • 200 m interval in tunnel (≥1,000 m), or vicinity of the exits (<1,000 m).		
	Exclusive Telephone & Wireless System		• Exclusive telecommunication circuit between Main Maintenance Center, Maintenance Office and Toll Collections Office. • Wireless communication system between Main Maintenance Center, Maintenance Office and patrol cars.		
Measurement Facilities	Vehicle Height Checkers		• In front of each tollgate entrance.		
	Axle Weight Scales		• In front of each tollgate entrance.		
Traffic Information Gathering Facilities	Traffic Detectors		• On both sides of motorway at points of frequent traffic congestion, large variations in traffic volumes and at locations necessary for the collection of traffic volume statistical data for traffic control. • Particularly, they should be installed at intervals of 1.0 km on the 1st peripheral road of Istanbul to detect the extent of traffic congestion.	• Points of large variations in traffic volumes and at locations necessary for the collection of traffic volume statistical data.	• Representative locations of the jurisdiction of maintenance offices with traffic operation rooms for collection of traffic volume statistical data.
	CCTV		• At toll barriers and junctions, locations with merging/diverging of traffic flows and in sections having traffic congestion and high traffic accidents. • Locations of severe weather conditions.	• Representative locations for traffic flow observation having high traffic accidents and severe weather conditions.	-
	Meteorological Information Facilities		• Representative locations with severe weather conditions.		
Motorist Information Facilities	Variable Message Signs	I.C. Off-ramp	• Prior to major I.C. off-ramps		-
		Ordinary Road	• Prior to intersections on principal trunk roads connecting to the motorway.		-
		Tollgate	• At each entrance booth at the tollgates.		
		Tunnel Entrance	• Prior to each long tunnel (≥500 m) entrance.		
	Radio Broadcasts		• To all areas from broadcasting stations with information for respective areas.		

Service Level 1 is established to achieve a higher level of sophistication than Service Level 2 where all the necessary data collection devices are installed to gather detailed and accurate traffic data, in particular traffic congestion data. The information dissemination function is further expanded by installing variable message signs prior to each interchange off-ramp.

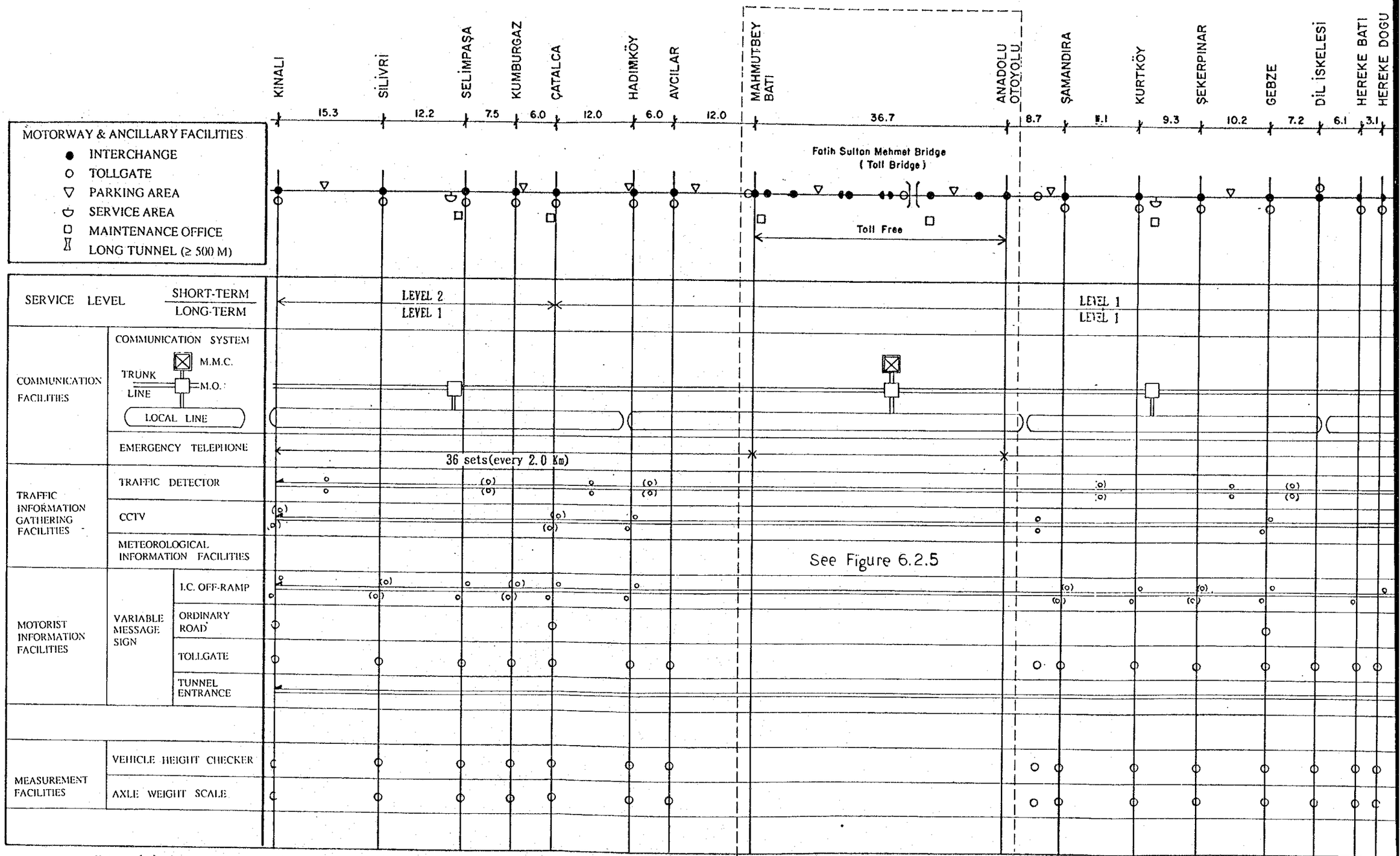
4) Proposed Traffic Management and Operations System

Based on the installation standards of the traffic management and operations system, the final proposed traffic management and operations system installation plans on the Kinali - Sakarya motorway are shown in Figures 6.2.4 and 6.2.5. All of the proposed roadside equipment is shown schematically on the figures at their appropriate locations. A framework for the system plan is established as described below.

- The system plans for the year 2000 (short term) have been prepared for the study routes.
- The system planning network for the motorway between Kinali and Sakarya is illustrated.
- Two traffic control rooms will be established one at Istanbul and the other of Tutunciftlik.
- A total of seven traffic operation rooms will be established as the next level of traffic control below the traffic control rooms mentioned above.
- The communications network using fiber-optic cable/metallic cable and carrier transmission cable will be established between the offices and the roadside facilities.

In particular, traffic volume distribution of the first and second peripheral road in Istanbul is very unbalanced in the Istanbul central area, and traffic congestion on the first peripheral road is severe. In this study, planning for traffic management and operations on the second peripheral road is the primary focus, but planning on both peripheral roads is necessary for relieving the service traffic congestion situation mentioned above. However, because detailed traffic data collection and analysis in the Istanbul urban area is not being conducted presently, adequate facilities have not been installed on the first peripheral road. In the future, an intensive study to establish an areawide traffic control system to be able to collect and analyze detailed traffic data in this area will be necessary. Accordingly, proposed facilities installation on the first peripheral road minimize necessarily.

Figure 6.2.4 Proposed Facilities Installation Plan for Traffic Management and Operations System on KINALI - SAKARYA Motorway



Note : ( ) shows necessary equipment in long-term.

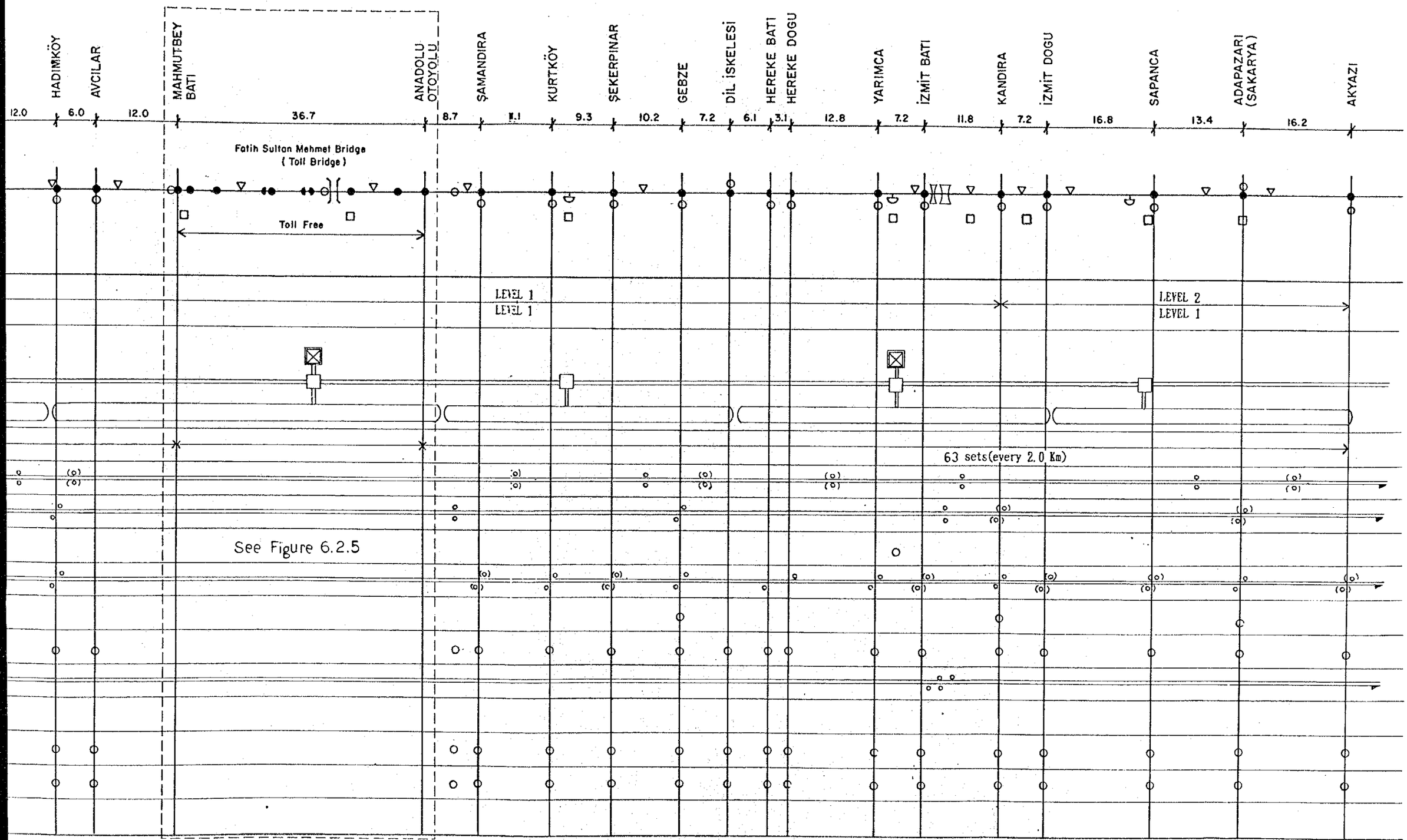
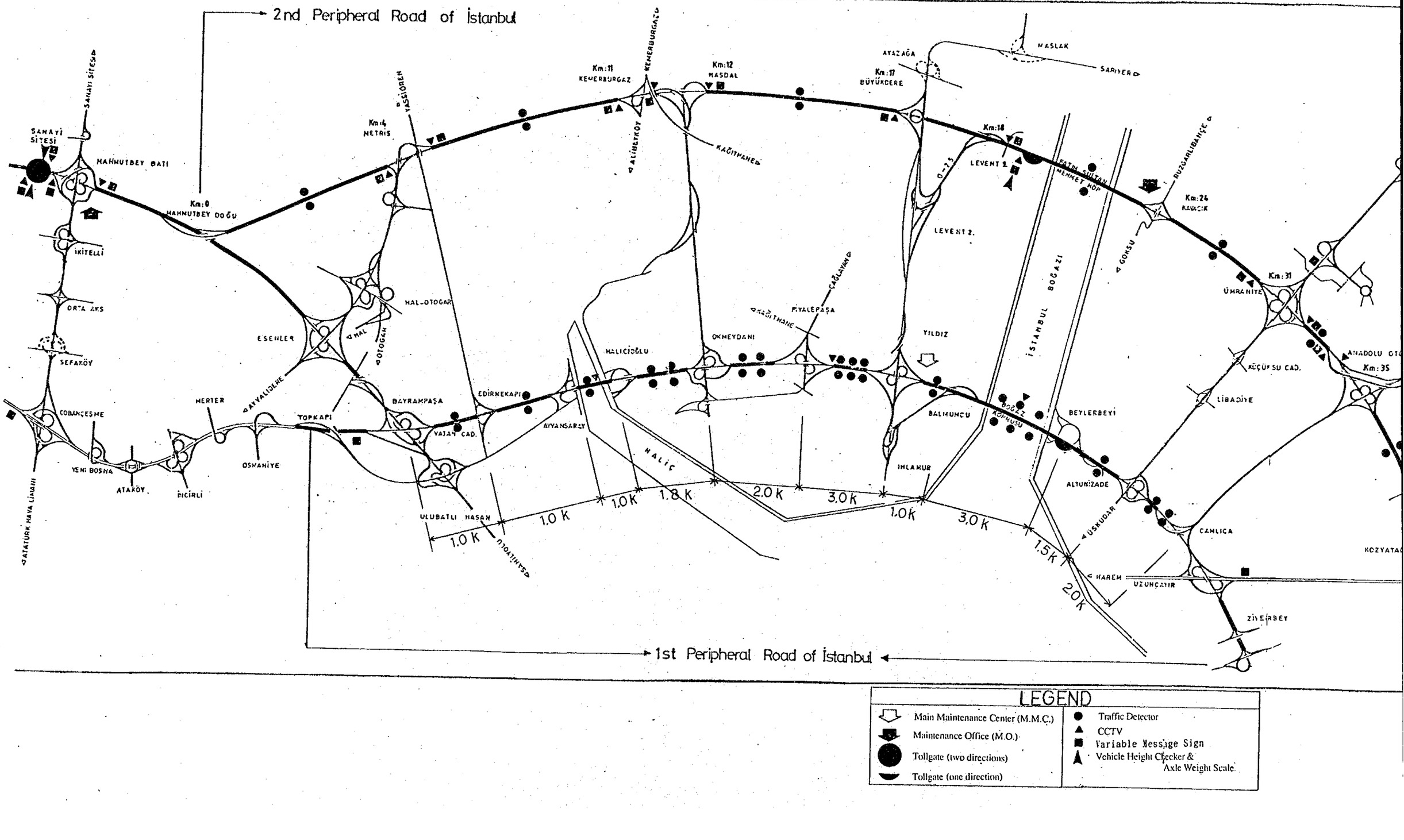
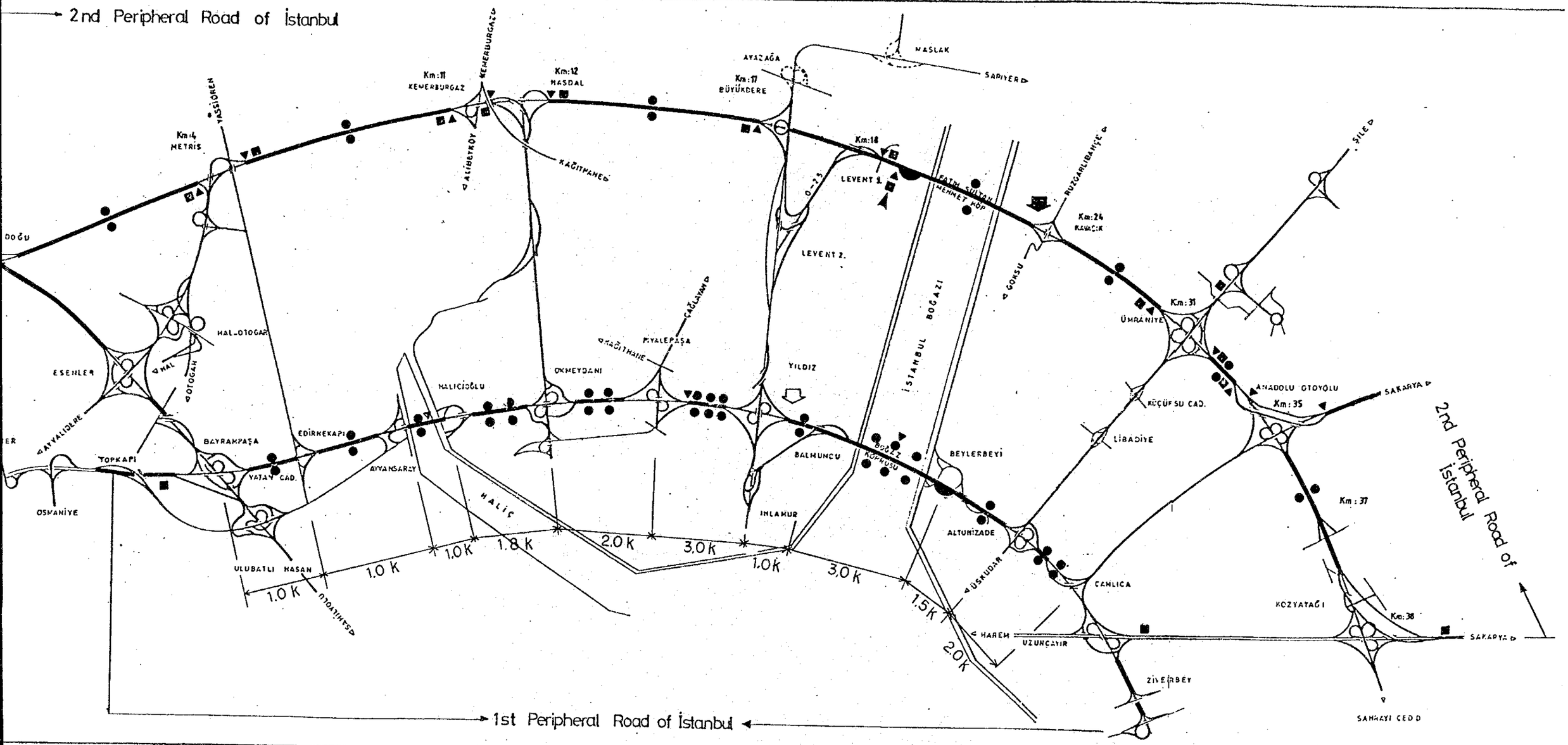

HADIMKÖY
AVCILAR
MAHMUTBEY BATI
ANADOLU OTOYOLU
ŞAMANDIRA
KURTKÖY
ŞEKERPINAR
GEBZE
DİL İSKELESİ
HEREKE BATI
HEREKE DOGU
YARIMCA
İZMİT BATI
KANDIRA
İZMİT DOGU
SAPANCA
ADAPAZARI (SAKARYA)
AKYAZI
12.0
6.0
12.0
36.7
8.7
11.1
9.3
10.2
7.2
6.1
3.1
12.8
7.2
11.8
7.2
16.8
13.4
16.2
Fatih Sultan Mehmet Bridge
(Toll Bridge)
Toll Free
LEVEL 1
LEVEL 1
LEVEL 2
LEVEL 1
63 sets(every 2.0 Km)
See Figure 6.2.5

Figure 6.2.5 Proposed Facilities Installation Plan for Traffic Management and Operations System in ISTANBUL Central Area





LEGEND

Main Maintenance Center (M.M.C.)	Traffic Detector
Maintenance Office (M.O.)	CCTV
Tollgate (two directions)	Variable Message Sign
Tollgate (one direction)	Vehicle Height Checker & Axle Weight Scale

5) Preliminary Engineering Design

(1) Emergency Telephone

a Function

Emergency telephones are communication tools for road users who need to contact the road management body for assistance in case of an accident, car trouble or running out of fuel on the motorway where no other means of communication is available. The emergency telephone system must be designed with the following requirements in mind:

* Handling and operation of emergency telephones by the user must be simple and straightforward

* The system must be capable of automatically identifying the calling telephone without asking the caller.

* Communication between the calling telephone and the receiver must be clear even when the calling telephone is adjacent to intense traffic noise.

* The system must be capable of automatically recording communication between the caller and the operator on a tape with a time stamp.

The present emergency telephone system is designed as a wireless system and is installed on a partial section of the Kinali - Sakarya motorway. The recommended new system is designed to include in a cable system which will also allow data transmission for traffic management and operation. It is anticipated that existing roadside telephone will be retained in the new system.

b System configuration

Emergency telephone system consists of roadside telephone along the motorway, emergency telephone central controller, and emergency telephone receiving desk in the traffic control room.

c Type of telephone set

Basically, there are two types of emergency telephone sets, one has a built-in speaker, microphone and one or more push buttons to initiate a call. The second type has a handset similar to the one provided with an ordinary

telephone set. In the latter, case the call is initiated automatically by lifting up the handset from the cradle. Functionally, these two types of emergency telephones operate the same. The former type is already in use in Turkey.

d Installation standards

(1) Installation intervals

Emergency telephones are installed at a specific intervals along the motorway. In other countries, the installation intervals range from as short as 200 meters in tunnel, to a distance of 800 meters to 2.0 km along open air sections of motorway.

The existing emergency telephone system in Turkey has adopted an installation interval of 2.0 km away from Istanbul, and 1.5 km in the Istanbul metropolitan area. The proposed system will adopt these same installation intervals.

Guide signs showing the direction to the nearest telephone must be installed at intermediate locations. An illuminated sign at each telephone location is desirable for easy identification at night. However, illuminated signs require power which may not be easily available at the locations along the routes under study, so reflective sheeting on the telephone housing is recommended as an alternative.

(2) Installation locations

Two telephones must be installed at the same location on opposite sides of the motorway to discourage drivers from crossing the motorway.

The following locations must be avoided when installing emergency telephones:

* Within 100 meters upstream or 50 meters downstream of a sign, with the exception of the overhang type sign,

* Within 100 meters of an overpass section.

e Operations

When a road user initiates a call by pressing the push-button switch on the emergency telephone panel, an indicator on the graphic panel will light up, a chime will sounds and schematic diagram of the calling telephone location is displayed on the CRT terminal in the traffic control room to notify the operator of the call. By pressing the appropriate key, a conversation is possible between the roadside caller and the operator in the traffic control room. Tape recorder is provided with the system for automatic recording.

(2) Vehicle Detectors

a Function

Vehicle detectors are used to automatically detect up-to-date traffic information such as volume, occupancy and speed on the motorway. Detector data is transmitted to the traffic control room, and are then processed collectively in such a manner that traffic management officials can continuously monitor the traffic situation and react promptly when administering the necessary first aid countermeasures.

b System Configuration

The vehicle detector system consists of vehicle detectors installed along the motorway, decor data processors at the traffic operation room and a central computer system at the traffic control room. Figure 6.2.6. illustrate the functional design of the vehicle detector system.

c Types of Vehicle Detectors

There are two types of vehicle detectors in wide use, those being loop and sonic detectors. The loop detector is recommended for use on the motorway because the motorway is wide with three or more lanes in each direction. The type of loop detector recommended is the single loop type. The outline of vehicle detectors by type is shown below:

- Loop Detectors

  Loop detectors generate an electro-magnetic field when current is passed through a loop of wire. The iron component of vehicles interrupts

magnetic field and this interference is detected by the electronics component of the detector.

- Sonic Detectors

  Sonic detectors transmit pulse beams of ultrasonic energy through a transducer towards the roadway. These beams are then reflected back by the presence of a vehicle to the transducer which converts them to electrical energy.

d Installation Locations

Vehicle detectors are mainly installed in all through lanes at representative locations between interchanges to determine traffic volumes and speed. For this purpose, loops are installed about 500 meters upstream of an off-ramp taper. For other purposes such as congestion detection on the first ring road, detectors should be placed at intervals of approximately 1 kilometer in the congestion prone area. Figure 6.2.7 shows the loop detector installation plan. Table 6.2.2 shows the number of detector installations.

e Operations

Detector data from each vehicle passing over the loop detector is transmitted in a realtime mode from the detector unit at the site to the detector data processor in the traffic operations room. The data is processed in five-minute intervals to provide such traffic data as traffic volumes, average speeds and occupancy rates.

The processed data is then sent to the traffic control room for monitoring and recording. In the traffic operations room, traffic data is displayed on the monitor and hard copies are made on the printer, if necessary. In the traffic control room, data is displayed on the graphic panel or on the CRT to help the operators in the traffic control room grasp the traffic conditions, and then stored on the magnetic tape for future analysis.

Figure 6.2.6 Functional Design of a Vehicle Detector System

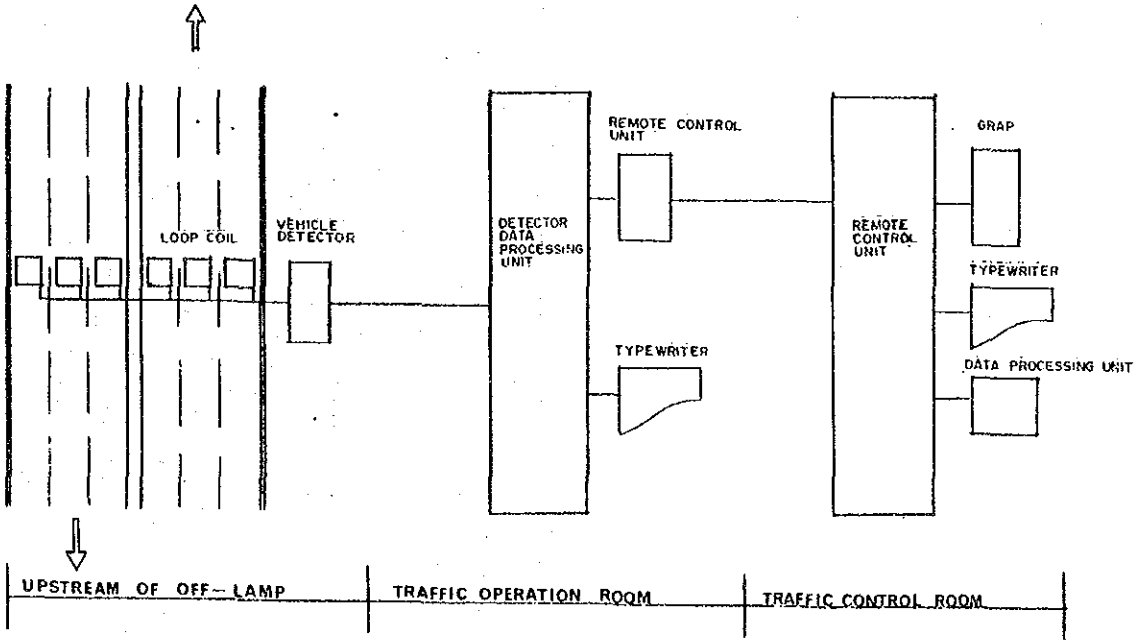


Figure 6.2.7 Loop Detector Installation

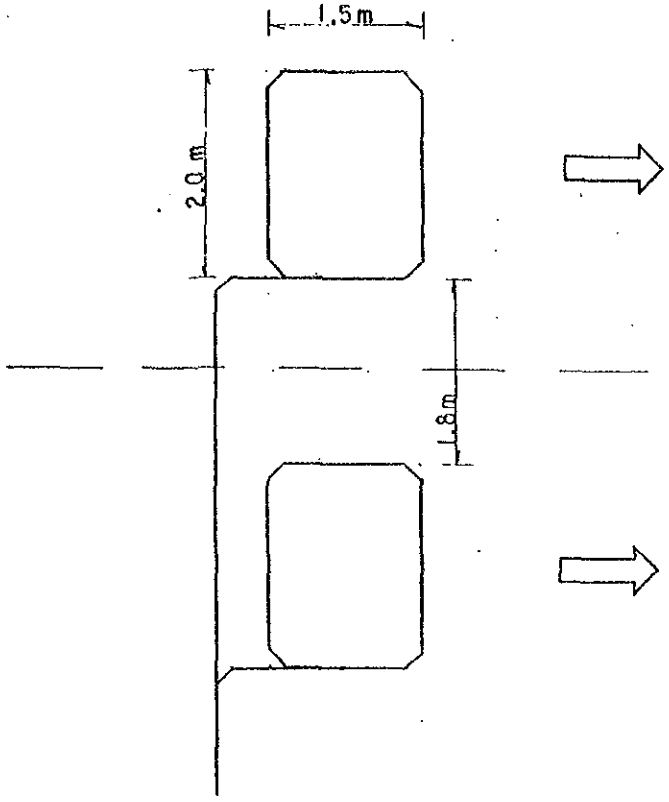


Table 6.2.2 Number of Detector Installations

Number of detector Installations		No. 17 Division	No. 1 Division	Total
	To east	26 set	3 set	29 set
	To west	26	3	29
	Total	52	6	58

Note: 1 set = Loop Coil x No. of Lane x Direction

f Specifications

- Loop Sensor

  - Standard size: 1.5 m (longitudinal) x 2.0 m (lateral)
  - Number of turns: 3 turns or more
  - Installation depth: 60 - 100 mm below road surface

- Detector Unit

  - Number of loops: 4 loops/direction maximum
  - Transmission method: FS-TDM
  - Number of channels: 18 channels/line

- Detector Data Processor

  - Unit time: 5 minutes or 1 hour
  - Processed data:
    - Accumulated total volume per unit of time
    - Average occupancy rate per unit of time
    - Average speed per unit of time

(3) Meteorological information facilities

a Function

The meteorological information facilities are used to gather weather information necessary to prepare for the eventuality of rainfall, winds, fog, snow and ice. They are installed at weather observation stations located along the motorway to monitor weather conditions for the purpose of preventing traffic accidents due to a worsening of climatic conditions. Meteorological observation instruments necessary to measure atmospheric temperature, road surface temperature, amount of rainfall or snowfall, and wind direction and velocity are combined in one unit. Instruments used to measure the visibility of atmosphere are also used, depending on local weather conditions and road administration status.

b System configuration

Weather observatory system consists of an air temperature thermometer, a road surface thermometer, a rain gauge, an anemometer, a visibility meter and a snow gauge all located at the outdoor observation station, with a weather observation panel including a dot recorder at the traffic operation room. Functionally, meteorological data is transmitted from the outdoor observatory station on panel to the traffic control room for further processing, monitoring and recording.

c Installation locations

Meteorological information facilities are installed at representative locations with severe weather conditions such as heavy rain, heavy snow or strong cross winds. In particular, locations with heavy snow and icy road conditions must be considered because of long motorway sections passing through mountainous areas.

(4) Closed Circuit Television System (CCTV System)

a Function

The CCTV system is one of the information collection tools and is used to confirm the occurrence of congestion or other incidents in conjunction with the quantitative data obtained by detectors.

Although visual data provided by the CCTV system do not produce any quantitative data. They contain numerous unquantifiable pieces of information and the system enables operators to investigate traffic conditions in greater details in the traffic control room.

The CCTV system in a traffic management and operation system is used mainly for the following applications:

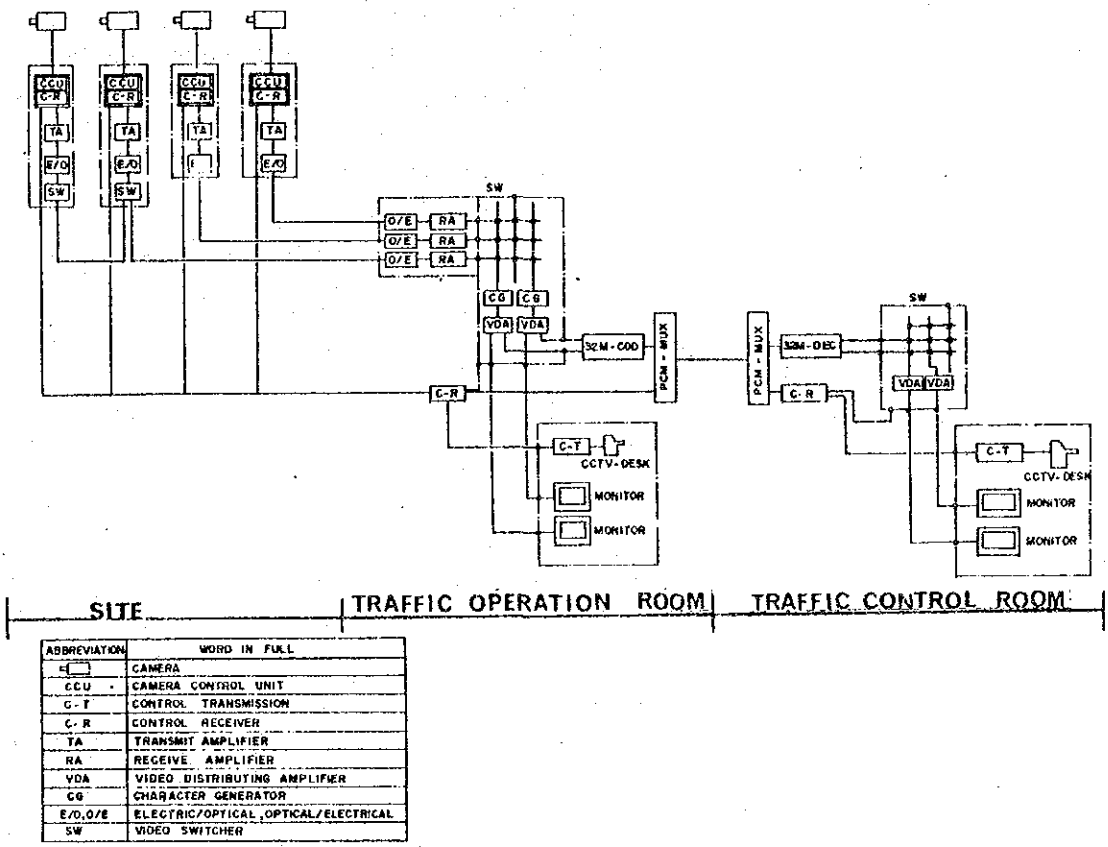
* Traffic flow monitoring
* Disaster prevention in tunnels
* Weather observations
* Others

b System Configuration

The CCTV system consists of a camera and camera controller at the site, a slave remote control unit at the traffic operations room, and a master remote control unit, operator console and monitor TVs at the traffic control room. The video signal taken by the camera is transmitted to the traffic operations room and the traffic control room over the fiber optic cable.

From the traffic control room, command signals such as power on/off, pan, tilt, zoom, telescope, etc. are sent to the camera controller. A video tape recorder with a time signal generator is included with the central equipment for recording and replaying the video image. Cameras in tunnels are controlled from the tunnel maintenance unit, but monitoring is also possible from the traffic operations room and the traffic control room. Figure 6.2.8 illustrate the schematic design of the CCTV system.

Figure 6.2.8 Schematic Design of the CCTV System



ABBREVIATION	WORD IN FULL
	CAMERA
CCU	CAMERA CONTROL UNIT
C-T	CONTROL TRANSMISSION
C-R	CONTROL RECEIVER
TA	TRANSMIT AMPLIFIER
RA	RECEIVE AMPLIFIER
VDA	VIDEO DISTRIBUTING AMPLIFIER
CG	CHARACTER GENERATOR
E/O, O/E	ELECTRIC/OPTICAL, OPTICAL/ELECTRICAL
SW	VIDEO SWITCHER

c Installation Locations

CCTV cameras are installed at the following strategic locations:

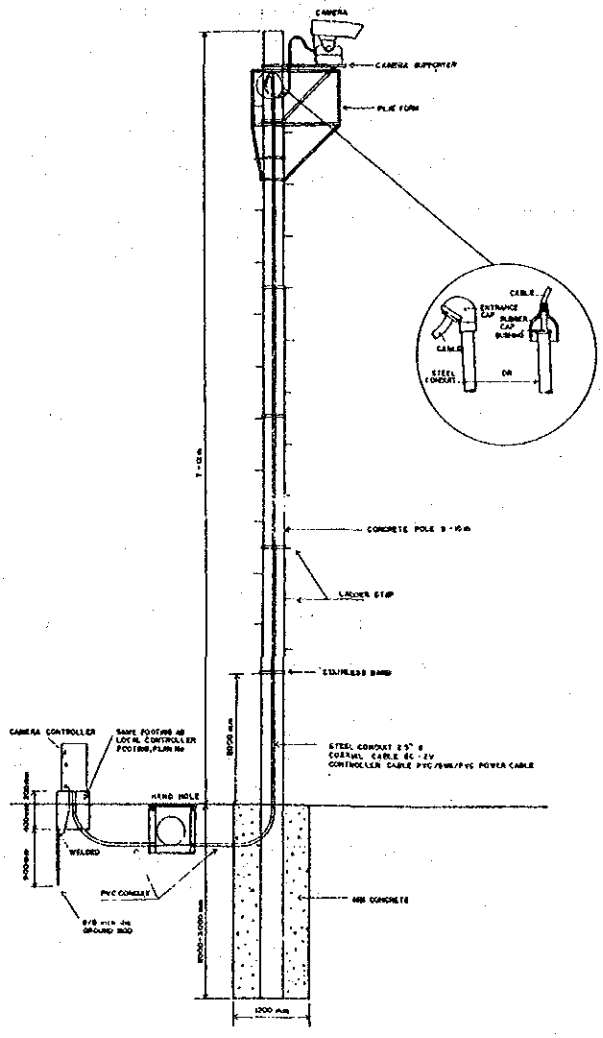
- Sections or locations where recurrent congestion is frequent or expected such as interchanges in large cities.
- In tunnels
- Sections or locations where incidents or accidents are expected to occur due to heavy weaving traffic, poor geometric design, frequent adverse weather condition, etc.
- Other places like toll gates where monitoring of the motorway is required

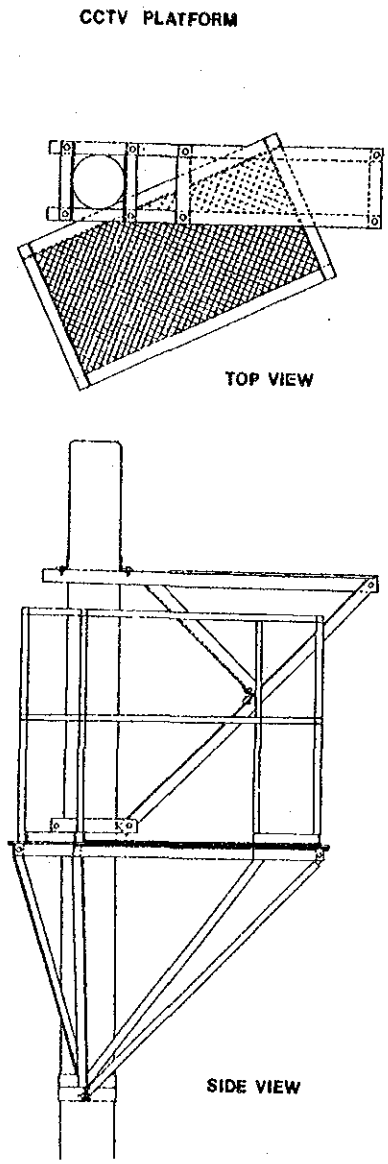
Table 6.2.3 shows the number of CCTV camera installations and Figure 6.2.9 shows the CCTV camera installation plan.

Table 6.2.3 Number of CCTV Camera Installations

No. of CCTV Camera Installation		No. 17 Division	No. 1 Division	Total
	To east	13 set	3 set	29 set
	To west	9	3	29
	Total	22	6	58

Figure 6.2.9 CCTV Camera Installation Plan





d Specification

- Camera

  - Image taking device: 2/3 or 1/2 inch CCD
  - Minimum brightness of object: 5 lux.
  - Horizontal resolution: More than 350 degrees at the center

- Lens

  A zoom lens with an automatic iris function shall be used. The focal distance will be determined according to the conditions at each installation location.

- Universal Head

  - Pan: More than +/- 170 degrees
  - Tilt: +15 degrees or more
    -60 degrees or more

- Camera Controller
  - Video transmitter: PFM-IM (Pulse Frequency Modulation-Intensity modulation)
  - Wave length: 1.3 micro-meter
  - Control signal receiver: Transmission system - Time division cyclic transmission
    Modulation - Frequency shifting
    Transmission rate - 1,200 bits/s

(5) Variable message signs

a Function

Variable message signs are visual communication facilities which are installed at strategic points on the motorway to give the drivers important information such as congestion, accidents, road conditions and detour recommendations. The information (message) displayed at the terminal is determined automatically by computer or by manual operator.

b System configuration

Variable message sign system consists of the variable message signboard and controller installed on the motorway or access road, slave remote controller located at the traffic operation room or tunnel maintenance office, and a master remote controller and operator console located at the traffic control room.

Variable message sign at a tunnel entrance is mainly controlled from the tunnel maintenance office. It is also controlled from the traffic control room when necessary. Monitoring is possible at the traffic operation room.

c Type of signboard

The signboard that is widely used is categorized into two types; the scroll type and the matrix type.

(1) Scroll type

The viewing face of the scroll sign is formed by a continuous belt of flexible cloth or plastic material containing a number of messages. The belt is stretched between two storage drums that are rolled until the desired message is displayed. If desired, a blank space may be positioned on the belt so that no message is visible when the belt is rotated to that space. In many cases the message belt is made of translucent material permitting back illumination.

Scroll type variable message signs may be applicable at entrance to toll booths and will display traffic, road and environmental conditions on the motorway and the location of ramp-closures.

(2) Matrix type

This type of sign is applicable for large size signs on the mainline or access road because its viewing surface is formed by a matrix arrangement.

This type of sign can divided into two types depending on the matrix element. These two types are the Lamp (Light Bulb) Matrix and the LED (Light Emitting Diode) Matrix.

- Lamp (Light Bulb) Matrix

  The viewing surface of the lamp matrix display is formed by an array of incandescent bulbs for each message line. The array can either be a continuous field of bulbs or a fixed number of matrix modules. Typically, the number of message lines varies from one to four.

  By independently controlling the on or off state of each bulb, messages or graphic symbols can be displayed. Messages can be displayed statically or flashed. Messages change instantaneously when a new message is selected.

  Because of the use of incandescent bulbs, this type of display has adequate visibility in bright daylight.

- LED (Light Emitting Diode) Matrix

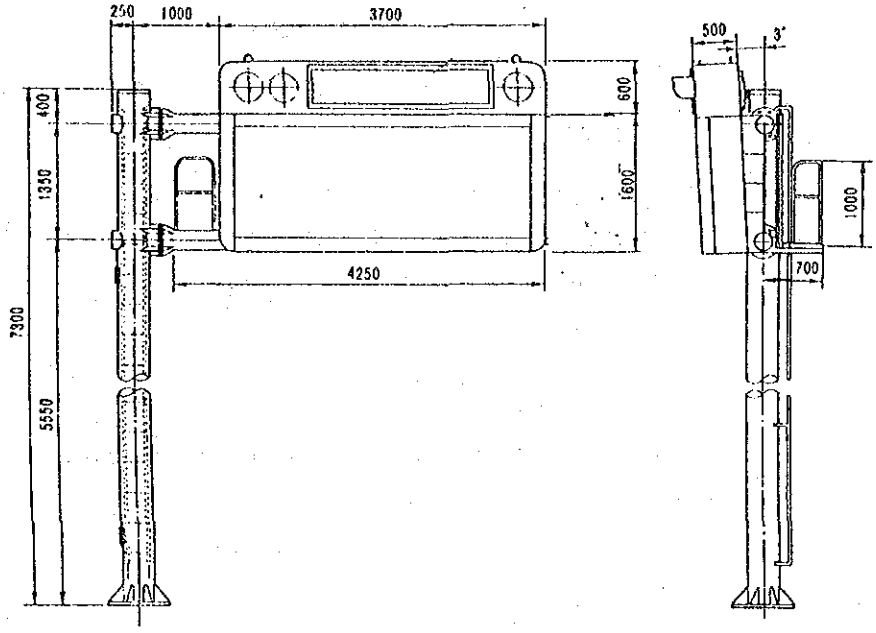
  This type of sign is identical to the lamp matrix type except that a LED matrix is used in place of incandescent bulbs. There are two variations of LED layout. One type of signboard has a matrix of LED arranged in four columns by four rows which would replace one incandescent bulb. LEDs of two different colors, red and yellow, are used so that messages and symbols can be displayed in red, yellow or orange.

  A second type of signboard is made up of LEDs of the same color and where one LED replaces one bulb. Thus, the size of the signboard is much smaller than the lamp matrix type and only suitable for toll booths.

  Because of high density of light emitting sources used in LED signs, a LED sign can display a sharper and smaller image than the lamp matrix type. Use of LED also provide longer life and lower power consumption compared with lamp matrix type signs. Equipment cost, however, is slightly higher than a lamp matrix sign of the same size.

From among the type of signs described above, the matrix type is recommended for variable message sign placed prior to interchange off-ramps, intersections on principal trunk roads connecting to the motorway and at the entrance to long tunnels. The matrix type was selected because of the possibility of requiring many different message and need to provide good legibility.

Figure 6.2.10 Example of a Variable Message Signboard (overhang type)



d Message to be displayed

Because length of the message is limited physically by the size of display surface, the message to be displayed must be both concise and comprehensible to road users. In addition, the messages will be displayed in the Turkish language.

In general, a message typically consists of a combination of words and phrases describing the location, cause, and the result of the traffic incident, in addition to the instructions to the drivers as shown below. This must be done within limitation of the total numbers of letters available which is limited by the size of the signboard. As mentioned above, the actual message will be in the Turkish language.

- Location of an incident
  Typical phrases for locations are shown as follows:
  - between XXX I.C. & XXX I.C.
  - XXX I.C. exit
  - ahead
  - XX km ahead

- Cause of an incident

  Typical phrases for the cause of incidents are shown as follows:

  - accident
  - fire
  - snowy
  - cross wind
  - under construction
  - icy road
  - foggy

- Result of an incident

  Typical phrases for the result of an incident are show as follows:

  - traffic congestion
  - section closure
  - lane closure

- Instructions to drivers

  Typical phrases for the instructions or suggestion to drivers are shown as follows:

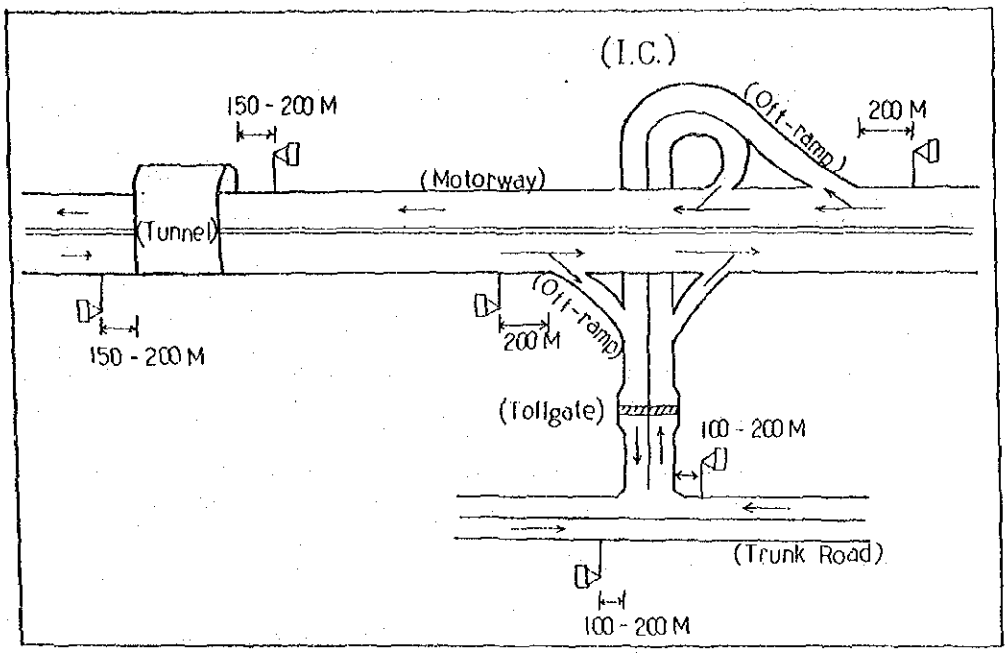
  - exit here
  - drive on the right side
  - drive on the left side
  - entering forbidden area
  - slow down

e Installation location

Variable message signs are typically installed at the following locations:

- prior to interchange off-ramp
- prior to intersection on principal trunk road connecting to the motorway
- at entrance booth at tollgate
- at the entrance to a long tunnel

Figure 6.2.11 Typical installation Location for Variable Message Sings



(6) Radio broadcasting

a Function

Radio broadcasting is one of the most common means of information dissemination. It utilizes broadcasting stations owned and operated by other agencies or companies. Because of this, the system can operate with only a small amount of investment.

Radio broadcasting booth is constructed in the traffic control room and connected to the outside broadcasting station through the telephone line. Announcer at the traffic control room obtains traffic-related information through the wall map, CCTV monitor, CRT terminal, etc. and broadcasts timely and accurate information periodically to ordinary radio programmes. Drivers receive traffic information through the standard car radio which acts as a driver information tool.

b) System configuration

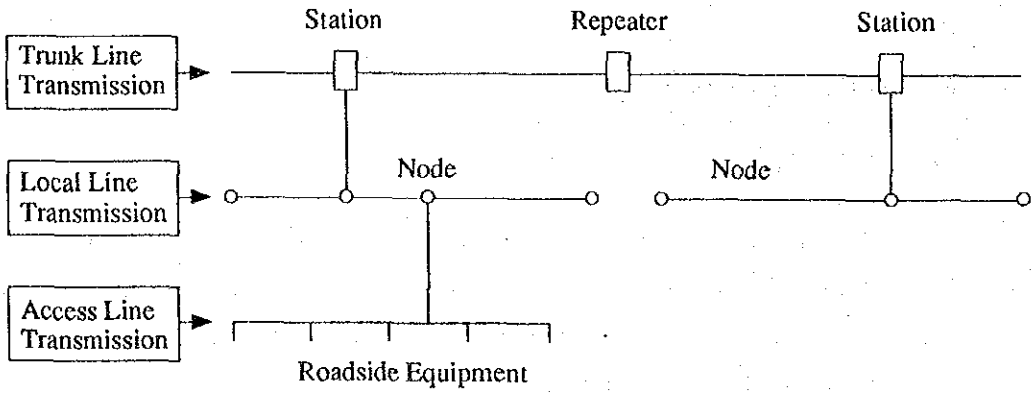
As radio broadcasting system for traffic information makes use of the existing commercial and public broadcasting system, only a microphone and a transmitter to broadcasting stations are necessary and are provided in the traffic control room.

(7) Transmission System

a Function

The basic function of a transmission system is to transfer information from one location to another. A transmission system consists of a three tier hierarchy including a trunk line transmission system, a local line transmission system and an access line transmission system. Figure 6.2.13 shows the three tier hierarchy of a transmission system.

Figure 6.2.13 Three Tier Hierarchy of a Transmission System



Each type of transmission system is described below:

- Trunk Line Transmission System:

A trunk line transmission system links the main maintenance centers and maintenance offices and transmits the bulk of voice and data signals, and in some cases video signals through high speed transmission channels over a long haul (up to several hundred kilometers).

- Local Line Transmission System:

  A local line transmission system provides multiple transmission channels between the nodes established at 2 to 5 km intervals and collects voice and data signals at trunk line transmission stations that are usually established at every maintenance office.

- Access Line Transmission System:

  An access line transmission system connects facilities and equipment in offices and the roadside to a node for local line transmission. The transmission distance is short and normally less than 5 km.

b Trunk Line Transmission System

The trunk line transmission system technologies can be divided into two groups, the analog method and digital method. Because of limitations such as short transmission distances and repeater intervals, inferior quality, lack of technological prospects for the future, the analog method is not recommended.

Two alternatives for the trunk line transmission system are compared to select the most suitable system. The results of the comparison are shown in Table 6.2.4.

Table 6.2.4 Trunk Line Transmission System

System	Cable Type	Signal Type	Capacity	Repeater Interval	Quality	Cable	Remarks
Metallic Cable System	Balanced Pair	Telephone	24 ch	2 km	Fair	PEF	• Not suitable for long haul transmission
		Video	1 ch	2 km	Fair	PEF	• Susceptible to induction due to use of Metallic Cable
Fiber Optic Cable System	Optical Fiber	Telephone	480 ch ~ 5,760 ch	40 km	Good	SM	• Suitable for long haul transmission
		Video	1 ch ~ 12 ch	40 km	Good	SM	• Longer repeater interval • Not susceptible to induction

Notes : PEF : Formed Polyethylene Cable
SM : Single Mode Optical Fiber Cable

As shown in the Table, the fiber optic system has many advantages over a metallic cable system such as better transmission quality, capacity, and longer transmission distance without a repeater. In a fiber optic system, the video

signal is multiplexed with the telephone channels. In a metallic cable system, the video signal transmission is separate form the telephone circuits.

Therefore a fiber optic transmission system is recommended for the motorway in those areas where CCTV will be installed. The remaining segments of motorway can be served with metallic cable until CCTV is installed.

c Local Line Transmission System

A local line transmission system covers a section of motorway of about 50 km, which is the recommended length of route coverage of a maintenance office. Depending on the coverage length of a local line transmission system, a metallic cable system is recommended for the motorway.

d Access Line Transmission System

An access line transmission system connects terminal equipment such as emergency telephones, CCTV cameras, vehicle detectors and variable message signs installed along the motorway to the nearest node. Because of short transmission distance, a metallic cable system is recommended for the motorway.

e Cable

- Trunk Line Cable

  The single mode fiber optic cable is recommended for the trunk line cable. The cable has a small core diameter that allows only single mode (an axial ray) of light to travel through the fiber. This produces no pulse dispersion and offers wide band width.

  Thy types of fiber optic cable recommended are as follows:

  • Trunk Line : F-32M, F-100M

- Local and Access Line Cable

  Color coded polyethylene insulated subscriber's cable (CCP cable) is commonly used for local and access line. In the case of metallic cable, the transmission distance is limited by two factors; alternation by loss and current decrease by resistance.

f Installation

Table 6.2.5 shows the length of cable by type as below.

Table 6.2.5 Length of Cable by Type

	No. 17 Division	No. 1 Division	Total
Length of Cable			
Trunk Line	116.5 km	135.6 km	252.1 km
Local Line	149.4	136.6	286.0
Access Line	71.6	83.7	155.3

(8) Wireless system

a Function

Wireless communication system facilitates the communication between the wireless control desk at the traffic control room and traffic operation rooms and mobile units traveling on the motorway. Patrol cars will be equipped with the mobile radios and communications with the control desk is possible all times. Toll collection offices and other manned stations will also be provided with a stationary radio to backup the wired telephone.

b System configuration

The system consists of the radio control equipment installed in the traffic control room and the traffic operation room, base station equipment including an antenna at the base station, and mobile units to be installed in patrol cars. Portable radio units are also included in the system.

(9) Exclusive telephone system

a Function

Since motorway management involves organizations and offices scattered along the entire motorway network, efficient communications between various locations must be provided. Particularly, in the case of a severe incident, securing a communications channel is essential for executing countermeasures. In this sense the subscriber's telephone system provided by PTT is neither adequate nor economical. For this reason, exclusive telephone system (or in-

house telephone system) covering all of the offices is required. The system makes use of the communication cable system to be established for the entire stretch of the motorway, so that a closed telephone network within the motorway administrative body can be created.

b System configuration

The exclusive telephone system consists of digital exchanges of various capacities placed at headquarters, division offices, main maintenance centers, maintenance offices and toll collection offices, and telephone sets, etc. Data terminals such as those provided for facsimile and videotext can also be connected to this digital exchange.

(10) Central computer system

a Function

There are six fundamental functions located at the central computer facility including information collection, terminal equipment control, the man-machine interface, countermeasures formation, reporting recording, systems operations monitoring and data communication. They are described as follows:

- Information collection
  The purpose of information collection is to collect various information concerning not only traffic but also other related information such as weather, construction work, events, etc. This information is gathered by means of equipment such as vehicle detectors, weather sensors, emergency telephones, and CCTV. Some of the information is automatically collected by equipment, while others are input by the operator.

- Terminal equipment control
  The computer system automatically or in accordance with a command by an operator controls roadside facilities such as variable message signs or variable speed limit signs.

- Man-machine interface
  Various data are displayed on a display terminal in characters or in graphic form. It provides all the information that the computer system has collected, including traffic and incident data. The system is operated upon request to an operator who assists them understand the current motorway

conditions, appropriate and can take countermeasures when necessary. The report will be displayed on a display terminal and will include but not be limited to:

* Current or historical traffic volume on the through lanes
* Occupancy rate or congestion level
* Weather conditions
* Operational status of variable message sign
* Operational status of variable speed limit sign
* Incident information
* System status including equipment malfunctions

A graphic display panel will be installed in the traffic control room to provide an overall visual presentation of the motorway condition by lamp and other display elements, automatically or manually. The following information is likely to be displayed on the graphic display panel:

* Congestion
* Incidents
* Regulations
* Motorway conditions
* Variable message sign operation
* Variable speed limit sign operation
* Emergency telephones

- Countermeasures function

  Part of countermeasures formation is provided by the computer system. For instance, the message to be displayed on variable message signs will be prepared automatically by the system based on the incident information stored in the system. Message are issued to the roadside facilities automatically or after confirmation by the operator.

- Reporting and recording

  Reports are printed as records of traffic data and system operation.

- Systems operation monitoring

  The computer system monitors the operations of the system itself and equipment connected to it including roadside facilities.

- Data communications
  The computer system performs on-line data exchange (such as incident information) with other traffic control room systems through data channels.

b Hardware configuration

The computer system consists of a central processing unit (CPU), peripherals such as a magnetic disk, magnetic tape unit, printer and CRT display, a graphic display panel, a control desk and interface units for connection to a central controller for variable message signs and detector data processors.

Figure 6.2.14 depicts the hardware configuration of the traffic control room and traffic operation room respectively.

The estimated memory sizes of the control processing unit for the traffic control room and traffic operation room, respectively, are about 500 KB and 600 KB. The size of the external memory unit which stores the various programs, parameters and data are about 4000 KB and 500 KB, respectively. Therefore, the total estimated memory size including a safety margin will be above 50 MB, respectively.

c Software configuration

The software is defined as the internal programs or routines professionally prepared to simplify programming and computer operations. These internal programs fall into several categories, the totality of which facilitates the efficient use of the computer. These programs are the operating system, utility programs and application programs. The last two are controlled by the operating system.

d The layout of the Traffic Control Room and Traffic Operations Room shown in Figure 6.2.15 and 6.2.16 illustrates the traffic control room and traffic operations room layout plans.

In laying out the equipment in the traffic control room and the traffic operations room, the functions of the equipment, the operation of the equipment by the operator and the inter-connection between equipment must be carefully considered.

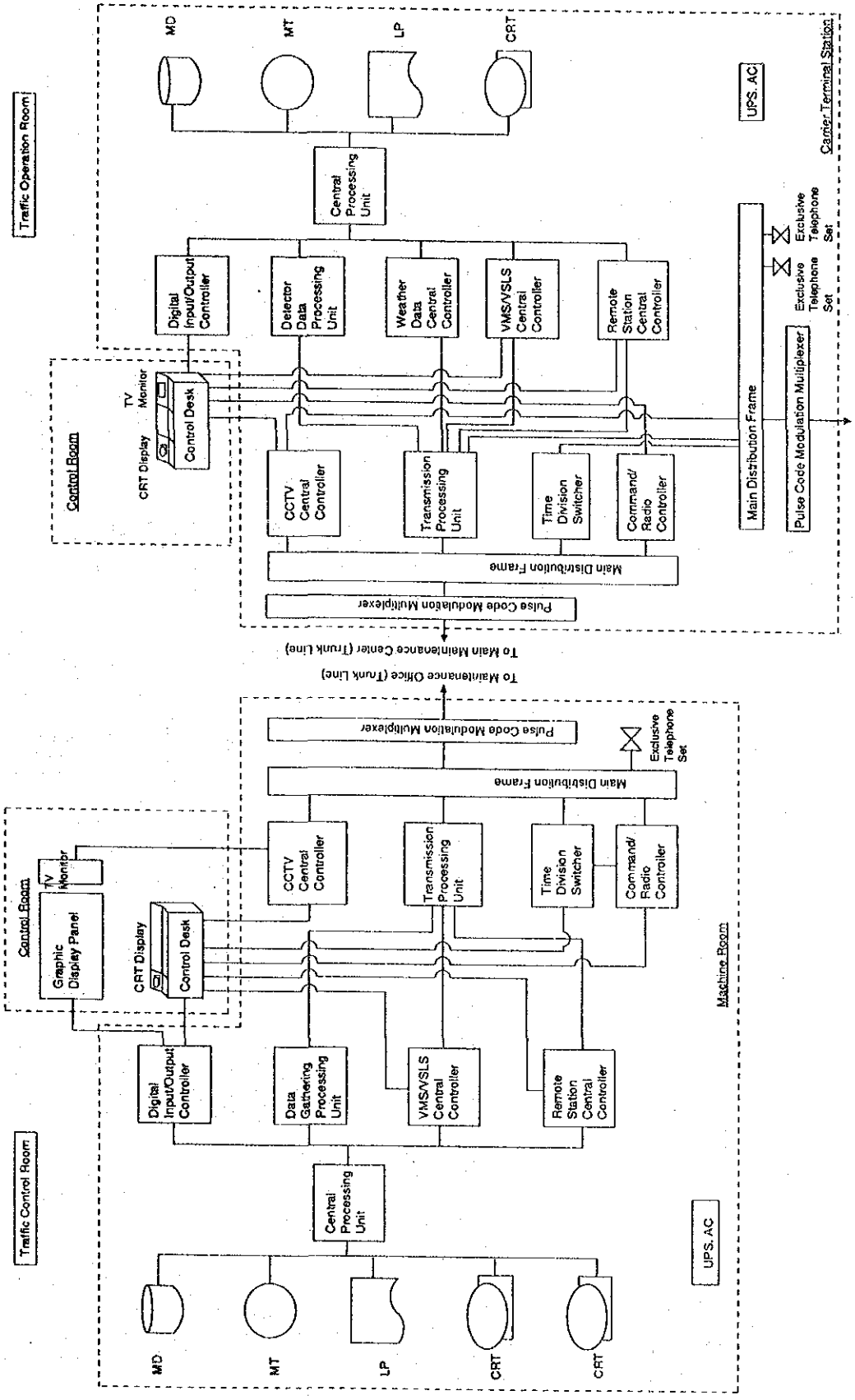


Figure 6.2.14 Hardware Configuration of Traffic Control Room and Traffic Operation Room

Figure 6.2.15 Layout of Traffic Control Room

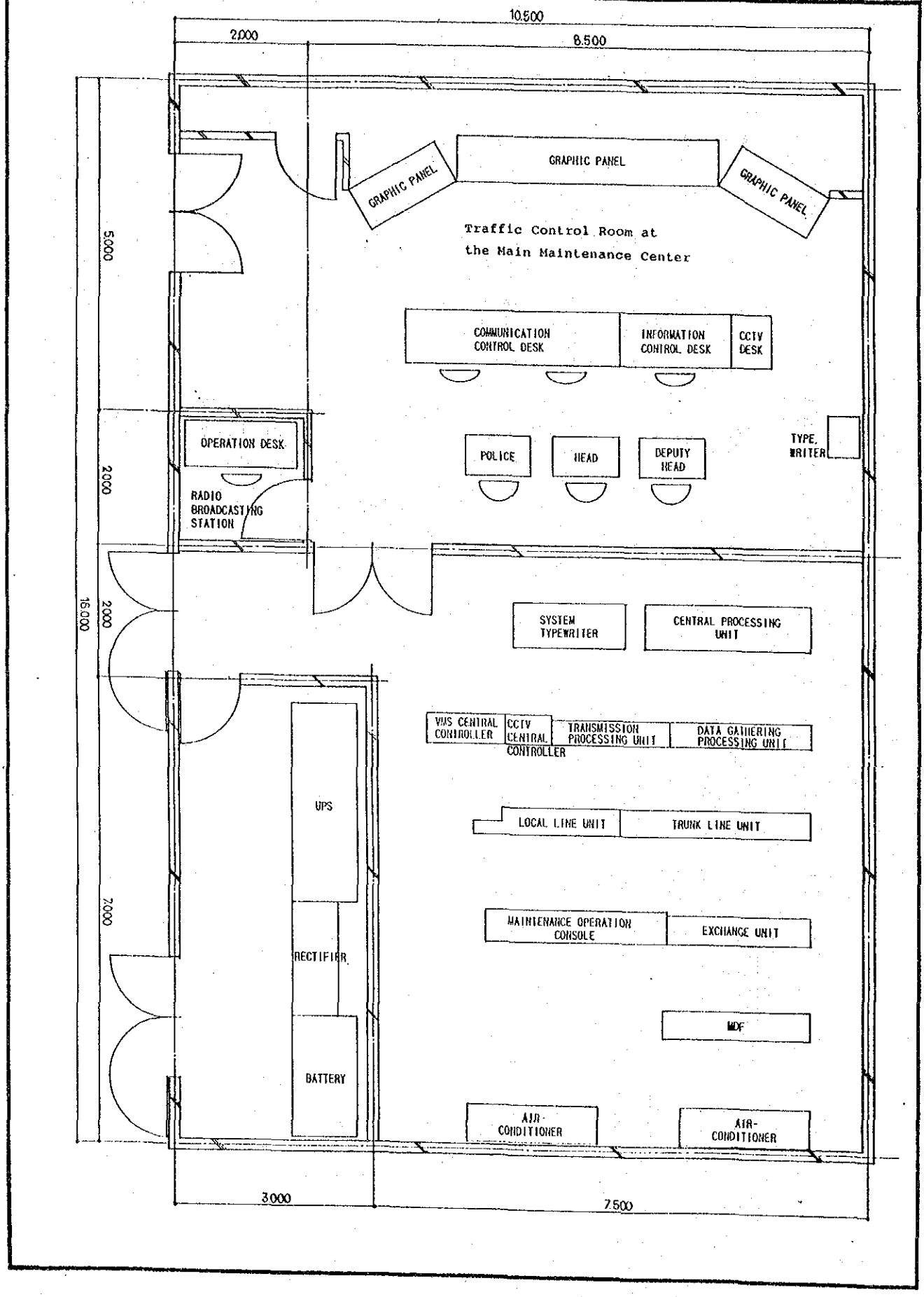


Figure 6.2.16 Layout of Traffic Operation Room