REPUBLIC OF LEBANON

COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

Republic of Lebanon
Office of the Minister of State for Administrative Reform
Center for Public Sector Projects and Studies
(C.P.S.P.S.)

GREATER BEIRUT TRANSPORTATION PLAN

الجمهورية اللبنانية
مكتب وزير الدولة لشؤون التنمية الإدارية
مركز مشاريع ودراسات القطاع العام

LONG TERM PLAN

REPORT NO. 12

JUNE 1995

IAURIF - SOFRETU - TEAM INTERNATIONAL

REPUBLIC OF LEBANON

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I INTRODUCTION

The study of the Greater Beirut Transportation Plan has been conducted in several steps:

- Collecting 1994 data about population, urbanization, traffic and trips in the Metropolitan Region and calibrating a trip forecast model liable to reproduce existing situation.

- Evaluating 2015 trip demand by means of the previous model, according to urban development and mobility assumptions.

- Elaborating two contrasted Transport Supply Scenarios liable to meet future demand (the fist one including a "heavy" mass transit network, the second one privileging private car use and road network development).

- Simulating the operation of the two Scenarios by means of a trip assignment model.

- Analyzing the basic Scenarios according to the operation and the productivity of proposed networks, the coherence with urban planning targets, the perspective investments costs and the consequences upon natural and urban environment.

- Preparing an optimal Scenario providing the best compromise between level of service and economic return and supplying the frame of the Long Term Transportation Plan.

- Describing proposed infrastructure networks and identifying right-of-way corridors to be protected.

Several reports have already been released in the framework of the study:

- Report No. 3 "Data Collection" (October 1994), presenting all traffic data collected in Greater Beirut Area on the occasion of 1994 traffic surveys.

- Report No. 8 "Existing Land Use in Greater Beirut Area", (June 1994) presenting the results of the land use survey executed in Greater Beirut Area in 1994 and the methodology of the Household Survey.

- Report No. 9 "Household Survey Results" (November 1994), presenting the basic data collected about population, employment and trips in the Metropolitan Region in 1994.

- Report No. 10 "Urban Development Forecasts" (December 1994), presenting long term Greater Beirut Area development forecasts.

- Report No. 11 "Long Term Transportation Scenarios" (April 1995), presenting and estimation of 2015 trip demand in GBA and describing the two contrasted Transportation Scenarios liable to meet it.

The present Report (No. 12) is devoted to the compared analysis of the two basic Scenarios and to the description of the Long Term Transport Plan that results from it. A technical file is annexed to this report, presenting detailed technical data about the proposed network (list of projects, alignments, ...).

A later Report (No. 13) will be concentrated on highlighting a medium term action plan (2005) comprising the priority investments to be launched during the next 10 years.

II ANALYSIS OF SCENARIOS

II.1 THE TWO TESTED SCENARIOS

II.1.1 The Stakes of the Future

Two main points feature the future stakes of Transport systems in GBA:

- The large extent of needs that will arise to nearly 5 million daily motorized person trips in 2015 (compared to 1.5 million today). The scale of issues will change.

- The requirement of a complete policy review to meet this demand in acceptable condition regarding economic rentability and protection of urban and natural environment. Mass Transit (in the wide sense) ensures today 29% of trips, but in the absence of any mass transit system, the main part of this market is actually taken in charge by taxi-service (17%). This situation cannot last in the future.

These considerations have guided the choice of the methodology used to prepare the Long Term Transportation Plan. Two contrasted Transport supply and Modal split Scenarios have been elaborated:

- Scenario A foresees the creation of a "heavy" mass transit network in Beirut Urban Agglomeration (BUA)[1] . It is associated to modal split assumptions privileging public transport use for trips inside BUA.

- Scenario B proposes, on the contrary, a priority development of road network, as well inside BUA as outside. It is associated to modal split assumptions privileging private car use.

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[1] Beirut Urban Agglomeration (BUA) gathers Beirut City and the continuous urban fabric that spreads from Antelias to the North, to Lebanese University to the South. It sheltered about 1 million inhabitants in 1994 (84% of GBA population). It will still shelter 3/4 of it in 2015.

The analysis of operating simulations in these two Scenarios allows to highlight their potentialities, their limits and their "return-rate". It enables comparing their capabilities to meet future trip demand in the different parts of GBA and to build the optimal network of the Long Term Transportation Plan.

The two Scenarios and the evaluation criteria have been presented in detail in Report No. 11. They are quickly recalled hereafter.

II.1.2 Scenario A

The main characteristic of Scenario A is to provide all BUA population with a "heavy" mass transit system located less than 1 km from their dwelling unit. The network proposed to reach this target includes:

- The Saida - Tripoli railway line, operated as a Regional Metropolitan line inside GBA (38 Km from Jounieh to Damour).

- Six (6) urban metro-type lines inside BUA (66 km in total).

- A complementary bus network ensuring a feeder structure towards the "heavy" mass transit network and servicing outlying areas.

Regarding road network, Scenario A has two main characteristics:

- It includes the whole projects presently studied or launched by Lebanese authorities (CDR, CEGP, SOLIDERE ...), but with sometimes capacity reductions compared to their original design.

- It foresees the construction of new roads between the Boulevard Périphérique and the South, North and East Entrances of the Metropolitan Region (where future demand will be large and impossible to be met by only public transport). Daily modal split table associated to these network assumptions is as follows:

Market Share of Mass Transit
by Origin-Destination Pairs
Railway, Metro, Bus

DESTINATION / ORIGIN	MB	NS	CS	MS	EA	To all Destinations
MB	75	60	40	15	15	56
NS	60	35	15	5	12	30
CS	40	15	15	5	7	17
MS	15	5	5	5	2	7
EA	15	12	7	2	3	11
From all Origins	56	30	17	7	11	33

MB[2] Municipal Beirut
NS[2] Near Suburbs
CS Coastal Suburbs
MS Mountain Suburbs
EA External Area

According to these modal split assumptions, the overall market share of Mass Transit (Taxi-Services excluded) will be 33% of daily motorized person trips executed in GBA in 2015.

II.1.3 Scenario B

Scenario B has been built in the extension of existing trends. Relying on an intense use of private car, it privileges the development of road network, mainly by the upgrading of the infrastructure network already included in Scenario A[3]. It will notably consist of :

- The completion, without any capacity reduction, of the works presently launched in Beirut and suburbs.

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[2] BUA is the addition of MB and NB

3 The opening of new road breakthroughs inside the existing urban fabric appears very difficult and all Scenario B infrastructure use the right-of-way of the roads proposed in Scenario A.

- The enlargement or the upgrading of some of the roads presently designed as Urban Boulevard into express roads (Beirut Corniches, Sin El Fil, Chiah, Airport Boulevard...).

With regards to Mass Transit, Scenario B proposes, as Scenario A, the re-use of Saida-Tripoli Railway operated as a Regional Metro inside Greater Beirut but it does not include any other "heavy" mass transit line. Basic mass transit system will consist of a bus network serving the whole built-up area and well connected to the Railway line. Taxi-service will still play a significant role in this Scenario inside and outside Urban Agglomeration. Daily modal split Table associated to Scenario A is as follows:

Market Share of Mass Transit
by Origin-Destination Pairs
Railway, Bus

DESTINATION / ORIGIN	MB	NS	CS	MS	EA	To all Destinations
MB	37	25	12	4	6	25
NS	25	17	8	4	7	15
CS	12	8	8	4	3	8
MS	4	4	4	4	2	4
EA	6	7	3	2	3	5
From all Origins	25	15	8	4	5	16

In Scenario B, the overall market share of Public Transport (railway and bus included but Taxi-Services excluded) will border 16% of total trips executed in GBA in 2015.

II.1.4 Evaluation Criteria

The two basic Scenarios have been tested and evaluated by means of indicators measuring network productivity, investment cost, coherence with GBA regional planning strategy. These indicators (average trip duration, average speed, saturation rate...) have been calculated from the trip assignment simulations. More than their absolute value, much depending on simulation technical method, their hierarchy should first be taken into account to orient the choices of the Long Term Transport Plan.

Selected indicators are the following:

- Private Vehicular Trips: consistency of cost of construction of the network, saturation rate of road network along the main geographical screen lines that structure GBA motorized trips, average trip duration and speed according to the type of road and the location, average access time to the main GBA poles and trip duration between these poles .....

- Mass Transit Trips: consistency and cost of Mass Transit Network, average trip duration, traffic and load of Mass Transit lines, average access-time to the main GBA poles and trip duration between these poles...

II.2 VEHICULAR TRIP DIAGNOSIS

II.2.1 Overall Outputs

The table hereafter presents the overall results of the comparison between the 2 Scenarios, with regards to vehicular trips.

NETWORK DESCRIPTION		SCENARIO A	SCENARIO B
HIGHWAYS	length (km)	68	84
EXPRESS WAYS	length (km)	68	85
URBAN BOULEVARDS	length (km)	115	82
WHOLE BASIC NETWORK	length (km)	**251**	**251**
TOTAL INVESTMENT COST	(millions US$)	4,850	5,650
AVERAGE SPEED AT AM peak (km/h)	in whole GBA	22	18
	in Municipal Beirut	27	17
	out Municipal Beirut	19	18
	east of Nahr Beirut	20	19
	west of Nahr Beirut	17	17
SATURATION RATE OF NETWORK	in whole GBA	1.26	1.28
	inside BUA	0.9	1.2
	east of Nahr Beirut	1.3	1.3
	west of Nahr Beirut	1.5	1.6
AVERAGE ACCESS TIME AT AM peak hour (minutes)	BCD	53	50
	Airport	35	33
	Nahr El Mott	33	33
	Hazmieh	45	46
	Laylaké	52	62
	Khaldé	39	39
VEHICULAR TRIP DURATION AT AM peak	BCD/Airport	13/23	18/41
(according direction, in minutes)	Nahr EL Mott/Khaldé	50/91	48/84
	Ras Beirut/Antélias	23/30	31/40
	Port/Nahr El Kalb	26/34	24/34
	Port/ Alley	33/34	43/59
	Port/Nahr Damour	68/135	65/146

A first finding can be learned from the table. In Scenario B, that privilegiates private car use and does not include large investments regarding public transport, road network has been widely sized to meet vehicular trip demand. In spite of this large supply, saturation rate remains very high. At the scale of the whole GBA, average saturation rate reaches 1.16 but it exceeds 1.5 along the main geographical cuts of the Metropolitan Region. Saturation rate decreases with Scenario A that privilegiates public transport use inside Beirut Urban Agglomeration and does not include a large road network in this area.

With regard to investment cost, roughly estimated, Scenario A road network is the lowest (4.8 billion US$) and Scenario B the highest (5.6 billion US$).

The relative superiority of Scenario A over Scenario B (regarding road network saturation level) is confirmed nearly with all other indicators. Average speed is 22 km/h in Scenario A, it is only 18 km/h in Scenario B with a specially meaningful difference inside Municipal Beirut (27 km/h instead of 17 km/h). If road access-times to the main GBA poles are quite similar according to the Scenario (53 minutes for instance instead of 50 minutes to reach BCD), travel duration at morning peak hour (mph) is often in favor of Scenario A for some important connections (23 minutes between BCD and Airport in Scenario A instead of 41 minutes in Scenario B, 34 minutes between the Port and the eastern GBA entrance with Scenario A instead of 59 minutes with Scenario B).

This paradoxal result (traffic conditions are better with a less largely sized road network) is of course closely linked to the modal split assumptions adopted for each Scenario. It illustrates the necessity to develop a modern mass transit network in GBA. Only such a system is able to meet the considerable trip demand that will take place inside BUA. It will permit to alleviate road infrastructure needs in this area and to preserve environment. It is the key of success for a city that targets to get back its former role of Near East metropolis.

The quasi structural inability of Scenario B for meeting future GBA trip demand has led to focus the geographical analysis of road network outputs (presented in the following chapter) on Scenario A.

II.2.2 Analysis According to Geographical Screen Lines

The map on the following page, represents the main "cuts" or screen lines that structure trip geographically inside GBA. The analysis of traffic flows crossing these cuts allows to test the adequacy of road supply in meeting future needs. The simplified results of this test are given in the table hereafter.

Saturation Rate of Road Network across the Main GBA Cuts in 2015 (Morning Peak Hour, to Beirut)

Cut	Scenario A			Scenario B		
	Capacity v/h	Traffic v/h	Saturation Rate	Capacity (v/h)	Traffic (v/h)	Saturation Rate
A	24000	28035	1.17	24600	40567	1.65
B	25600	36532	1.43	26800	43831	1.64
C	16500	31006	1.88	23200	33188	1.43
D	9400	19552	2.08	10600	21359	2.03
E	21800	35183	1.61	26700	45201	1.69
F	19300	302 02	1.56	23200	34916	1.51
G	13200	21770	1.65	16100	23616	1.47
H	10200	11104	1.09	11100	12417	1.12
I	27400	33077	1.21	29200	46697	1.60

Cut A (South Corniche of Municipal Beirut)

This cut corresponds to the ring of Corniches that surround Municipal Beirut between the Sea and the River. The road network of Scenario A appears a little undersized, compared to future demand (saturation rate of 1.17).

Cut B (Hazmieh - Chiah Boulevard)

Saturation rate remains important in Scenario A. Ouzai Penetrator will have to be provided with highway characteristics.

Cut C (Airport - Damascus Highway)

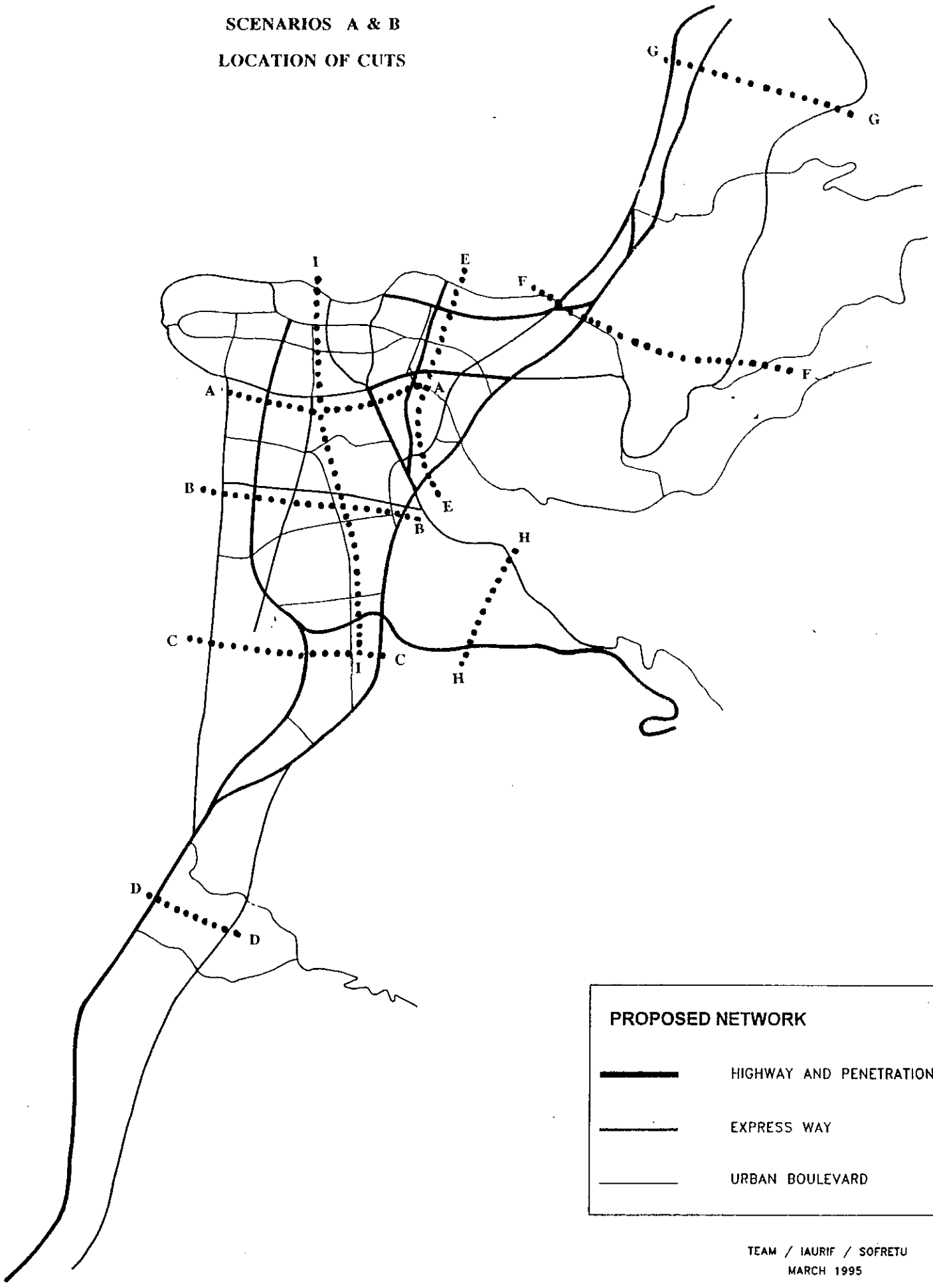
Saturation rate across this cut is very high (1.88 with Scenario A). It should lead to carry out the highway network planned in this area with the initially foreseen size, and not with the dimensioning proposed by Scenario A. That notably means that:

- Ouzai Penetrator should be 2 x 2 lanes
- South Penetrator should be 2 x 3 lanes
- Boulevard Périphérique should be 2 x 4 lanes.

LONG TERM TRANSPORT PLAN

SCENARIOS A & B

LOCATION OF CUTS



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Cut D (Khaldeh - Aramoun)

Very high saturation rates are observed at the level of this cut, in both Scenarios (2.08 and 2.03). The addition of the South Highway, the old Saida road and a new mountain road proposed in both Scenarios, east of existing built up area, will not allow to cope with the future traffic generated by South Lebanon and South Coastal Corridor. The proposed mountain road should have real highway characteristics between the Boulevard Périphérique and Damour.

Cut E (Nahr Beirut)

Road network appears very saturated when crossing the River (average saturation rate of 1.61 and 1.69 according to the Scenario). All existing or future possibilities to cross Nahr Beirut should be used to the maximum. That means:

- The strengthening of Dora-Quarantina connection.
- North Penetrator (existing coastal road) with 2 x 3 lanes.
- Borj Hammoud Boulevard with 2 x 2 lanes.
- Sin El Fil Penetrator with 2 x 2 lanes.
- The upgrading of Futuroscope - Chevrolet connection into an express way.
- The upgrading of the road using the old Jisr El Pacha bridge (between Mkalles and Hazmieh).

Cuts F and G (North Cuts at Jdaideh and Dbayeh Levels)

Saturation rates are high along these two cuts in both Scenarios (more than 1.5). The traffic linked with North Lebanon, Metn and Kesrouan will be intense and it cannot be taken in charge in good conditions by the only railway line. In addition to A1 along the sea, A2 will have to be constructed and the complementary mountain road proposed in both Scenarios to connect Metn and Kesrouan with an outlet towards Boulevard Périphérique (Baouchriyeh) appears very necessary.

Cut H (Damascus Road and Highway)

Road network is similar in both Scenarios along the corridor, including Damascus Road and Damascus Highway. They appear a little undersized and Damascus Road should be strengthened between Hazmieh and Jamhour.

II.2.3 Urban and Environmental Issues

The alignment and the dimensioning of proposed road networks answer technical specifications in order to meet future needs. However, these specifications are not the only one to be taken into account. The protection of urban and natural environment can also be taken as a constraint that should be well appreciated before any planning decision. Two types of road can be distinguished:

- The roads that are part of the Infrastructure Recovery Program engaged by the Lebanese authorities and about which a more or less consensus has already been achieved.
- The roads that correspond to new projects and that have not been the subject of any debate till now.

Planned Roads

The road program presently launched by the Lebanese authorities raises two types of issues:

- A number of planned roads cross some neighborhoods that shelter a very valuable urban and building inheritage and that represent the "memory" of old Beirut. The opening of new roads in these neighborhoods will provoke the destruction of many interesting buildings of Ottoman and Mandate epoch. It will speed up the destructuration of a still preserved urban inheritance.

  The road that will link Justice Palace to BCD (via Sodeco) across Yessouieh is a typical example. It will have to be designed and carried out with a very careful attention in order to minimize destruction and damages and to improve its integration with the local street network. It will have to be designed as an Urban Boulevard and not as an expressway.

- Other planned roads cross very populated neighborhoods whose occupancy has been made in an illegal and anarchic way during the war. The right of way of these roads it has been used to develop new housing quarters. The construction of the planned roads will be difficult and it will necessitate hazardous prerequisite land freeing. The roads that will cross South Suburbs (Borj El Brajneh, Ouzai) and East Suburbs (Borj Hammoud) belong to this category. Delays stand to be long before their carrying out, and they will impose complementary rehousing programs.

New Unplanned Roads

Two types of difficulties can be met with the new roads proposed in both Scenarios and unplanned so far:

- Some of them use the existing right of way of existing roads, and they will not necessitate extra expropriation. They will have to be redesigned so as to fulfill their new function and to achieve a larger capacity. Several Urban Boulevards are thus proposed to be transformed into expressways with systematically grade separated crossing. Traffic increase along these roads will meaningfully modify their integration in the city and it will raise acute environmental issues (noise, pollution, safety). Such a road strengthening is not possible everywhere, specially when the available right of way is limited and cannot be enlarged without expensive expropriation: it is notably the case of the road linking Saloumeh Roundabout to Qualaa Roundabout. A complete tunnel solution appears the only one acceptable in such a site.

- Some other roads, proposed and tested in both Scenarios are completely new and do not correspond to any existing or decreed alignment. In some cases, their impact is considerable. The road proposed to link Boulevard Périphérique (Baouchriyeh) to Kesrouan via Fanar, Bsalim and Mtaileb at an average 300 m altitude raises for instance very acute insertion difficulties. This road plays an essential role to alleviate the traffic of Nahr El Kalb corridor and a part of it has already been the subject of right of way reservation (between Baouchriyeh and Fanar). It crosses very dense neighborhoods in Fanar, and some of the most outstanding sites of Metn. It will necessitate a high number of structures (bridges, tunnels). In case it was retained in the Transportation Plan, this new road would necessitate thorough alignment and impact studies.

  Similar issues are met for a number of roads proposed in the built up area and where alignment has not been decreed and protected till now. The section of the Rocade Urbaine Nord (RUN) between Chatila and Sport City is one of them. It

crosses a very populated neighborhood where the density of urban fabric makes it very difficult to create a new breakthrough. The final alignment of such a road cannot be proposed in the Transportation Plan without an overall upgrading study for the whole district.

That means, in some cases, that the proposals of the Transportation Plan will only define the principle of a connection and that they will have to leave a sufficient margin for local adaptations imposed by the studies prerequisite to their execution.

II.3 MASS TRANSIT DIAGNOSIS

II.3.1 Overall Outputs

The table hereafter provides the overall results of the comparison between the two tested Scenarios regarding mass transit transport.

NETWORK OUTPUTS		SCENARIO A	SCENARIO B
RAILWAY-METRO	number of lines	4	1
	length of network (km)	75	38
	investment cost (millions US $)	2500	540
	seat x km supply (millions/year)	3600	720
	yearly traffic (millions)	290	28
	highest AM peak interstation traffic	16000	6700
OTHER "HEAVY" LINES	number of lines	3	
	length of network (km)	29	
	investment cost (millions US $)	660	
	seat x km supply (millions/year)	350	
	yearly traffic (millions)	74	
	highest AM peak interstation traffic	7700	
WHOLE TRUNK NETWORK	number of lines	7	1
	length of network (km)	104	38
	yearly traffic (millions)	364	28
	seat x km supply (millions/year)	3950	720
	investment cost (millions US $)	3160	540
BUS NETWORK	yearly traffic (millions)	156	203
	investment cost (millions US $)	70	320
MASS TRANSIT MARKET SHARE	in whole GBA	33	16
	inside BUA	55	26
	between BUA and the rest of GBA	14	7
AVERAGE TRIP DURATION	(minutes)	34	40
AVERAGE ACCESS TIME AT AM peak	BCD	27	32
(minutes)	Airport	46	61
	Nahr El Mott	34	40
	Hazmieh	36	41
	Laylaké	40	40
	Khaldé	47	48
TRAVEL DURATION AT AM peak	BCD/Airport	36	62
(minutes)	Nahr EL Mott/Khaldé	44	44
	Ras Beirut/Antélias	50	66

II.3.2 Scenario B

By construction, Mass Transit plays a modest role in Scenario B. Except for the railway line, no other "heavy" mass transit line is included in it. Simulation results are coherent with what could be expected from such a choice.

- With an overall market share of 16% of total motorized trips (200 million of passengers each year instead of 520 millions in Scenario A), it corresponds to a sort of "minimum service" whose only target is to meet the needs of non-motorized travelers and captive riders.

- In spite of a largely sized road network, the road and Transportation system proposed by Scenario B does not contribute to improve traffic conditions in the more congested area of GBA (BCD and BUA, North and South GBA Entrances), as shown in the previous chapter.

With regards to Mass Transit trips, Scenario B outputs are nearly always lower than those of Scenario A ones. Average Mass Transit trip duration is longer (34 minutes instead of 40 minutes) and Airport BCD travel duration is for instance much longer (62 minutes instead of 36 minutes). In Scenario B, investment cost is nevertheless much lower (1 billion US$ instead of about 3 billion US$ in Scenario A). Regarding operating conditions, some of the bus lines proposed by Scenario B will have very high ridership that will often exceed the capacity admitted for this technology (2000 passengers at peak hour), without special arrangements (signal priority, dedicated lane). The line linking Borj El Brajneh to Coca Cola will thus have a peak hour traffic of 6000 passengers (1 direction). The railway line brings a substantial contribution to meeting mass transit needs in Scenario B. It will be the most used line with 7000 passengers at PH on the heaviest section and it will ensure 12% of total mass transit traffic.

In spite of the advantages linked with the use of the railway line as a Regional Metro inside GBA, Scenario B does not seem to provide a relevant answer to the transport issues that will take place in GBA by year 2015, regarding mass transit as well as vehicular trips.

II.3.3 Scenario A

Scenario A has been designed with the target to provide all BUA inhabitants with a "heavy" mass transit line located less than 1 km from their dwelling unit. It proposes a diversified network whose alignment and technology have been defined from the analysis of desire lines of potential customers. It includes the railway line, 6 other "heavy" mass transit lines (metro, street car) and a dozen of bus lines. The total investment cost of this system has been evaluated at 3,2 billion US$. The sketch presented in the following page indicates the AM peak load of the 7 "heavy" mass transit lines (railway included) of Scenario A.

Among the 7 axes, only 4 appear to justify the choice of a "heavy" technology (like metro) with traffic of about 10.000 passengers per direction at morning peak hour:

- the railway line,
- the North South line (Borj El Brajneh, Coca Cola, Verdun, BCD, St. Michel),
- the East West line (Ras Beirut - Hamra - BCD - St. Michel, Jdaidèh, Antélias),
- the Airport line in its northern section (Coca Cola - Patriarcat - BCD).

The analysis of load-diagrams for North-South line and airport line shows a very intense transit movement at Coca Cola.

- The North-South line has a "heavy" traffic between Borj El Brajneh and Coca Cola, but beyond Coca Cola traffic drops down in a severe way.

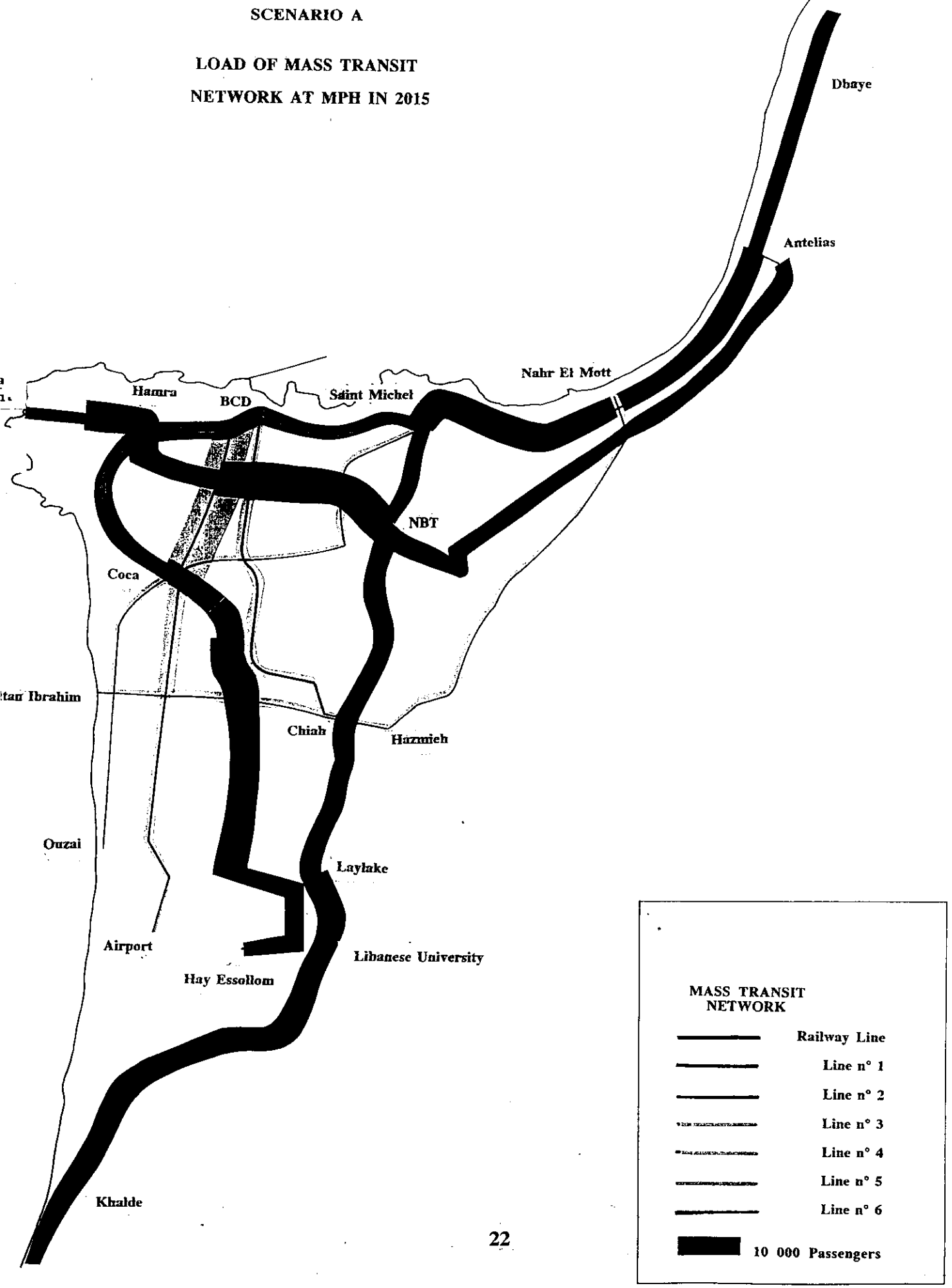
- The Airport line has a very light traffic south of Coca Cola, but traffic increases very much north of Coca Cola.

SKETCH 1

LONG TERM TRANSPORT PLAN

SCENARIO A

LOAD OF MASS TRANSIT NETWORK AT MPH IN 2015



Everything appears as if the travelers coming from South Suburbs preferred to leave the North-South line at Coca Cola and use the Airport line between this station and BCD (with a much faster access towards BCD). The North-West section of North-South line (Coca Cola - Verdun - Hamra) has only a traffic of 5 to 6000 passengers at AM peak, values that do not justify the construction of a heavy mass transit line along this corridor. The merging of North-South and Airport lines north of Corniche Mazraa along a medium alignment using Mar Elias Street appears desirable.

The Eastern section of Ras Beirut - Antélias line (between Jdaideh and Antélias) transports only 5000 passengers at morning peak hour. This value is low for a heavy mass transit system like a metro. Otherwise, an important intermodal Treminal is planned in Nahr El Mott (railway, metro, road station, and bus terminal). The location of the terminal of East-West line in Antélias makes the connection of this line with Nahr El Mott complex difficult (except if creating a turning back section between Jdaideh and Nahr El Mott, technical choice that is not really satisfying). The choice of Nahr El Mott as the terminal of East-West line appears better.

With 10000 passengers at AM peak on its loadest section (nearly 300000 daily boarding passengers), the Railway line ensures an important role in the future Mass Transit System.

The three other "heavy" mass transit lines reach a level of traffic (3000 passengers at AM peak) that does not allow the creation of "heavy" lines (metro type).

The traffic of the bus feeder lines is compatible with the proposed technology even if some of them appear sometimes quite loaded (2500 passengers at AM peak on the section Hazmieh - Chevrolet for instance).

II.3.4 Other Stakes

The diagnosis made on the compared outputs of the mass transit networks proposed in Scenarios A and B, allows to define quite precisely the future architecture of the long term Mass Transit System in GBA. The urban organization of GBA in 2015 will be featured with three main components:

- BCD recovery that will get back its former role of major employment and service center.

- The appearance of new development poles in the suburban areas located along Boulevard Périphérique.

- The confirmation of Beirut Urban Agglomeration (as defined in page 4) as the main service, employment and population basin of GBA (it will shelter 75% of GBA population in 2015).

Compared to these heavy trends, the stakes involved by a new transportation system can be described as follows:

- **Space**: It cannot be extended in BCD and more generally in the dense areas of BUA and along the coastal corridors. It should be used and managed in an efficient way, taking into account the "productivity" and the "space-return" of the different transport modes. A railway line (12 m of right of way) can carry as many passengers as 5 highways with 2 x 3 lanes, each one (135 m of right of way).

- **Accessibility**: It should be the best possible and warranted to everybody. The outputs of private car (whose use is reserved to the upper and middle classes) are presently very modest in many GBA areas (dense urban area, coastal corridors). They will be really improved if a large place is left to mass transit (that is open to everybody). Only the setting up of a modern Public Transport System in BUA and along coastal corridors will be able to ensure good trip conditions for the whole GBA population (private car users and mass transit users). It will be profitable for everybody.

- **Environment**: Car traffic is a source of pollution and nuisance (noise, exhaust gas, hazards, ...). It can much degrade the quality of urban life. Only an intense use of public transport in dense areas can allow to get a real improvement in that field.

- **Urban Development**: GBA has undergone intense centrifuges development dynamics during the war; and a major part of existing traffic congestion is due to this anarchical development. A "recentrality" policy should be implemented today. BCD reconstruction project is a first significant example of this policy. However, this one can fail if it is not accompanied and supported by the complementary construction of a modern Mass Transit System serving the development poles proposed by the GBA Master Scheme.

- **Human Solidarity and Economic Development**: Creating a public transport network in the whole GBA can be a powerful tool to reinforce citizenship solidarity and unify the territory. It will allow the largest number of people to get an easy access to the different districts of the Metropolitan Region. It will breakdown the former partitioning of the city; and it will enlarge the employment and service market at the scale of the whole GBA. It can be a powerful tool for a better human integration and a new economic take off.

- **Financial Resources**: The large extent of financing needs to rebuild the infrastructure network of the country will impose drastic and difficult choices. In dense urban areas, the return of the public money invested in Mass Transit Systems is always largely superior to that of the road-oriented invested money. Such an investment goes mainly to providing transport infrastructure and rolling stock rather than pay for expropriated land and dislocate people.

III LONG TERM PLAN

III.1 GENERAL FRAMEWORK

III.1.1 Targets

The Long Term Transportation Plan prepared from the comparative diagnosis of Scenarios A and B has four main targets:

- It aims at meeting trip needs in GBA by year 2015. Future demand has been estimated to a bit less than 5 million motorized trips per day, which is 3 times the existing demand. It corresponds to a high estimate and offers good security conditions for dimensioning future infrastructure networks.

- It aims at giving back Beirut its former role of Near East Metropolis by means of a modern road and transportation system. A good accessibility, internal as well as external, contributes much to the attractiveness of a city.

- It endeavours to protect urban and natural environment by limiting new road breakthroughs that could destroy existing neighborhoods or valuable landscape; and by developing a land saving Mass Transit System liable to meet the huge number of trips generated in the dense built-up area.

- It seeks to be realistic and economically feasible and matches financing capabilities of Lebanon.

The network proposed by the Long Term Transportation Plan associates in a close and complementary way, a Mass Transit System devoted to serve the dense areas of BUA (notably BCD) and the coastal corridors and a road network devoted to reunify Beirut suburbs and ensure good connections between GBA and the rest of the country.

The Transportation Plan targets to provide Lebanese authorities with an Action Plan enabling them to:

- Put into perspective the whole set of road and transport investments to implement during the next 20 years.

- Draw the track allowing to achieve this target, both physically (priority programs to contract during the next 10 years) and economically (amount and phasing of necessary investments) as well as regulatory (regarding the institutional capabilities required for the management of the future transportation system).

III.1.2 Modal Choice

Modal choice table adopted in the Long Term Plan is not really a simulation output. It relies on a number of assumptions regarding the future behaviour of travelers, given a certain transport supply. It has been built from the knowledge of similar ratios observed in cities of same size, morphology and economic level. The Mass Transit Network proposed in the Long Term Plan expresses a compromise between the basic target of Scenario A (providing all BUA inhabitants with a metro-like line less than 1 km from their dwelling unit) and the concern of optimizing and limiting the investment cost of this network after realizing that the expected ridership on some tested lines was below the thresholds that warrant mass transit. The final modal split table, close to that of Scenario A, is nevertheless at a lower level (regarding mass transit use).

Mass Transit Daily Market Share
by Origin-Destination Pairs
Railway, Metro, Bus, ...

Origin \ Destination	MB	NS	CS	MS	EA	To all s
MB	60	50	35	10	15	42
NS	50	30	15	5	10	27
CS	35	15	15	5	5	15
MS	10	5	5	2	2	5
EA	15	10	5	2	3	10
From all Origins	42	27	15	5	10	26

According to these assumptions, the overall mass transit market share (taxi services excluded) will be 26% of daily motorized person trips in GBA in 2015.

III.2 ROAD NETWORK GENERAL ORGANIZATION

III.2.1 Network Description

Only primary and main secondary roads are included in the long term road network that does not deal with local servicing (tertiary level network). Three categories of roads have been distinguished:

- Highways, separated lanes roadways: They include Long Distance Motorways, Boulevard Périphérique and Penetrators and constitute the primary network of GBA.

- Expressways, separated lanes roadways : They ensure the main secondary servicing to the urban areas.

- Urban Boulevards, divided or individual roads: They constitute the secondary level of servicing.

The map on the following page shows the road network proposed for the Long Term Plan.

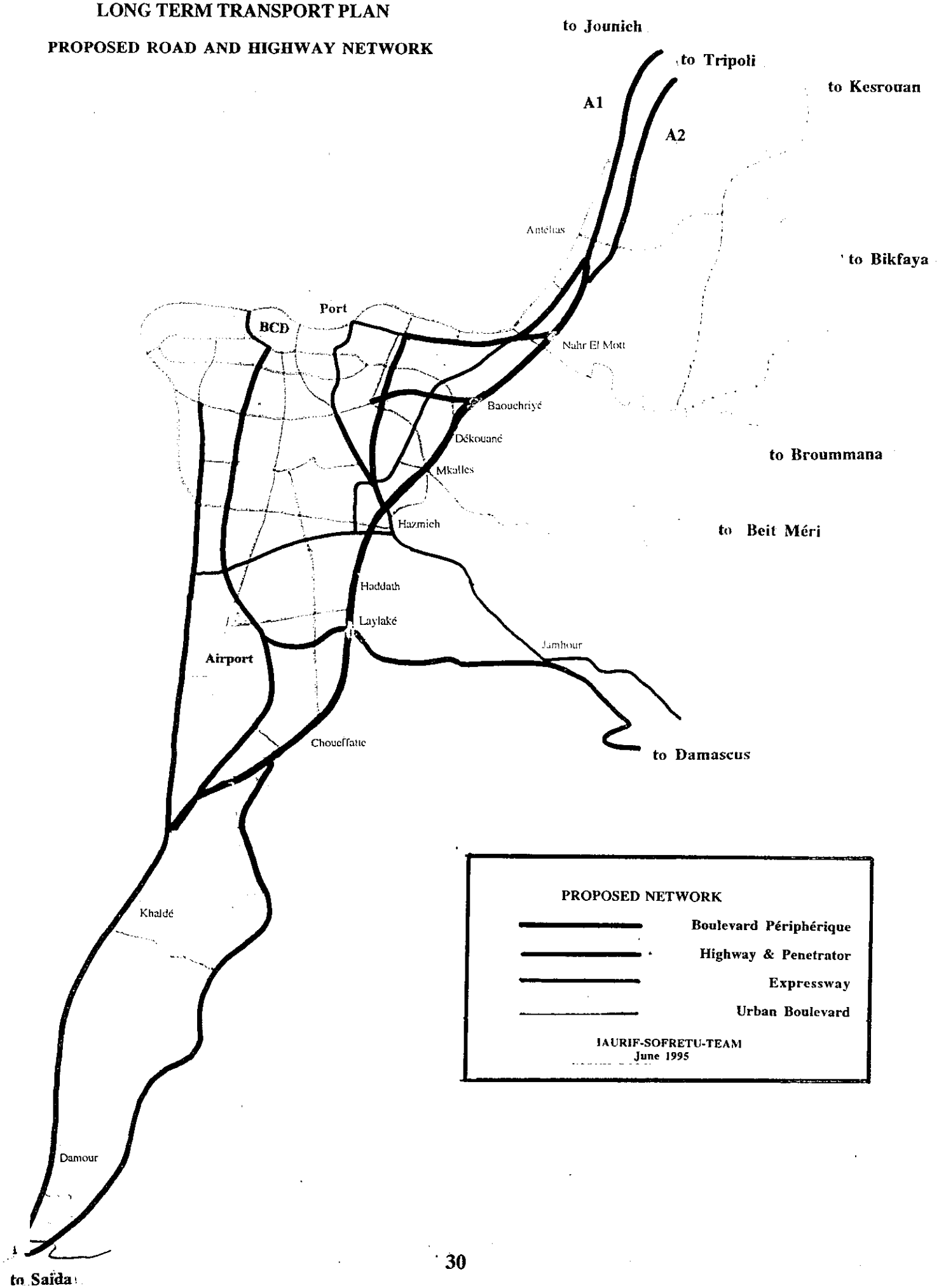
A) Beirut Périphérique Boulevard (BPB)

Boulevard Périphérique constitutes the backbone of the future road network. It is a large bypass highway that diverts transit traffic away from Beirut Urban Agglomeration. It ensures the unity of the Metropolitan Region by reuniting Beirut suburbs. It owns an essential integration and reunification function.

BPB, 18 km long, links Antélias to the North, with Khaldeh to the South. It serves the future Regional Secondary Centers proposed by GBA Master Scheme to establish a new equilibrium with BCD and to reorganize Beirut suburbs (Nahr El Mott, Hazmieh, Laylakeh). Average geometric characteristics of BPB are those of a 2 x 4 lane highway. It exchanges by means of specially designed interchanges, with 5 Long Distance highways (ensuring the connection with the rest of the country) and with 7 Urban Penetrators (that provide primary access to Beirut City and inner suburbs. A number of interchanges are also provided by the Urban Boulevard network.

LONG TERM TRANSPORT PLAN

PROPOSED ROAD AND HIGHWAY NETWORK



B) Northern Entrances

Two highways connect the Boulevard Périphérique to North Lebanon:

- A1 (2 x 4 lanes) using the right of way of existing coastal road between Antélias and Nahr El Kalb (works in progress);

- A2 (2 x 3 lanes) also connecting Antélias to Jounieh, East of the previous highway (at an average altitude of 100 m), according to an alignment that has been recently surveyed by Dar El Handasah.

Meeting future transport needs at the Northern Entrance would require, as indicated before (see II.2.2) the construction of a third highway (15 km long) that has been tested in the two basic simulations (Scenarios A and B). Diverting from BPB at Baouchriyeh, this highway crossed Fanar and progressively reached the 300 m altitude, winding in the large natural panorama laying down Ain Saadé and then successively crossing the roads of Nahr El Mott - Roumieh, Jal El Dib - Nabay, and Antélias - Bikfaya before spanning Nahr El Kalb towards Antoura and Jounieh.

This new highway raises various and difficult issues:

- Urban issues in Fanar where it crosses urbanized areas and requires the destruction of a number of recently erected buildings.

- Landscape issues all along its track that cross some of the nicest sites of Metn (Ain Saadé - Mont Lasalle Panorama, Nahr El Mott, Nahr Antélias, Nahr El Kalb).

- Functional issues in so far as this road, to be really useful and efficient, should exchange with all the roads coming down from the mountain (Bickfaya, Beit Meri, Broummana); and provide them with a direct outlet towards Beirut and Jounieh. These interchanges will be difficult to organize and design.

- Economic issues because it will necessitate numerous structures and will cost a prohibitive sum of money (around 600 million US$).

Given all these constraints, this road has only been partially retained in the Transport Plan.

The section Baouchriyeh - Fanar - Roumieh Road (5 km) has been completely given up, and only the principle of the North Section (Roumiyeh Road - Nahr El Kalb) has been retained under the reserve of a detailed alignment survey and environmental impact study be prerequisitely executed.

The reduction (from 3 to 2) of the number of highways linking GBA and Jounieh obviously raises a severe issue because it lessens available road supply and does not allow to meet future needs. The solution for this problem should be searched at 4 levels:

- The development of job opportunities in Jounieh and surrounding areas in order to decrease the commuting needs between this district and GBA. Transport networks cannot solve all the problems and only a strong town planning and economic policy can allow to promote a more autonomous way of development for Kesrouan and Metn hills areas; and therefore to alleviate trip-demand between these areas and the Metropolitan Region.

- A more important role for Beirut - Tripoli railway line whose stations should be provided with well connected feeder parking areas.

- A better connection of the Northern section of the mountain highway (Roumieh road - Nahr El Kalb) with the Périphérique network. The existing Nahr El Mott - Roumieh- Broummana road will have to be enlarged and strengthened in order to provide a convenient outlet towards BPB (Nahr El Mott).

- A strengthening of A1 highway whose long term capacity could be increased by a road viaduct constructed over the

existing right of way and which could not exceed 2 x 2 lanes in order to create necessary exchanges.

In addition to the 2 Long Distance highways previously described, the main network of the northern GBA districts located outside BPB will consist in 3 Urban Boulevards coming down from the mountain:

- the existing road of Bikfaya leading to BPB in Antélias whose capacity and safety will have to be improved;
- the previously mentioned Broummana - Roumieh Road, linked with BPB at Nahr El Mott (to be enlarged and upgraded);
- the Beit Mery - Mansourieh Road connecting with BPB at Mkalles (to be upgraded).

The principle of a link between Nahr El Mott - Roumieh Road and Bikfaya (via Baabdat) has also been retained; but this road will require a thorough environmental study because of numerous topographical and landscape constraints.

C) Eastern Entrances

The only Long Distance highway proposed east of GBA, is Damascus highway (2 x 3 lanes) that was recently offered for tendering (CEGPL). It appears sufficient to meet future needs along this corridor should the existing Damascus Road be transformed into expressway between Hazmieh and Jamhour. Damascus Highway will exchange with BPB at Laylakeh and Damascus Road at Hazmieh.

D) Southern Entrances

Two long distance highways are proposed towards the South:

- the existing coastal road, designed as a highway between Khaldeh and Damour (2 x 4 lanes), about to be offered for tendering with 2 x 3 lanes.
- a new highway leaving BPB south of Choueifat and joining the coastal highway after Damour. The alignment of this new road (2 x 3 lanes) will not raise too severe difficulties except along the existing road of Bchamoun and at the

crossing of Nahr El Yabes (a 900 m long tunnel will notably be necessary after the viaduct crossing the river). This highway (14 km long) will be constructed at an average altitude of 300 m. It will serve upstream the new urban areas foreseen along the southern coastal corridor and notably the future Regional Secondary Center of Saydet Khaldeh (to which it will be linked by a new 4 km long Urban Boulevard).

E) The Inner BPB Network

Inside BPB, Beirut Urban Agglomeration will be served by a hierarchical and meshed network of Urban Penetrators, expressways and Urban Boulevards.

Urban Penetrators

- North Penetrator (2 x 3 lanes) will use the right of way of the existing coastal road from Antélias and Nahr El Mott (BPB) to Quarantina (works in progress between Antélias and Nahr El Mott);
- Sin El Fill Penetrator (2 x 3 lanes till Sin El Fil Expressway; and then 2 x 2 lanes) will link Baouchriyeh (BPB) to Corniche Gemayel (Justice Palace) in an already decreed alignment;studies in progress
- Port Penetrator (2 x 2 lanes) will connect Hazmieh to Quarantina along Nahr Beirut without any intermediate exchange, north of Chevrolet. It will ensure a direct link between BPB and the Port (a section exists already between Sin El Fil bridge and Quarantina);
- Justice Palace Penetrator (2 x 2 lanes) will connect Hazmieh (BPB) to Corniche Gemayel (Justice Palace) (a section of this Penetrator will be common with Port Penetrator between Hazmieh and Chevrolet); studies in progress.
- East Penetrator (2 x 2 lanes) will connect Laylakeh (BPB and Damascus Highway) to the Airport and South Penetrator; studies in progress.
- South Penetrator (2 x 4 lanes between East Penetrator and Chiah Boulevard; 2 x 2 lanes north of Rocade Urbaine Nord) will link Khaldeh (BPB) to the Airport (East Penetrator), Sport City and BCD. It will be the only Penetrator to reach BCD (by means of Selim Salam

Tunnel). Works are in progress between Sport City and the Airport; studies in progress south of the airport

- Ouzai Penetrator (2 x 2 lanes) will link Khaldeh (BPB) to Verdun - Unesco (Corniche Mazraa), by using the existing Ouzai coastal road. A section of this Penetrator is under works between Ouzai and Verdun - Unesco. Southern section (Ouzai - Khaldeh) will have to be designed (and partly put underground) in accordance with the extension program of the Airport (works in progress).

Expressways

A number of urban expressways will complete the Penetrator network previously described.

- one of which is part of BCD Reconstruction Project. It concerns the section of BCD Ring between South Penetrator and Seaside Corniche (Hotels district);
- two others will ensure the direct connection of North Penetrator and Justice Palace Penetrator via Achrafieh (Sassine) and the coastal road (Charles Helou). They are already partly executed;
- a last one will be an inner BPB expressway linking Nahr El Mott to Ouzai, via Salomeh, Alba, Futuroscope, Chevrolet, Camille Chamoun and the Rocade Urbaine Sud (from Hazmieh to Ouzai). The creation of this ring expressway (internal to BPB) will require the construction of an about 1 km long tunnel between Salomeh and Futuroscope.

Urban Boulevards

Urban Boulevards will ensure a regular meshing of Beirut Urban Agglomeration. Proposed network often corresponds to existing or planned roads. It will be organized in the following way:

Inside Municipal Beirut

- the Ring of Municipal Beirut Corniches (Mazraa, Gemayel, Seaside, Raouche);
- Independence Corniche (Sassine - Sodeco - Verdun - Koreitem) and Fouad Chehab Corniche (Achrafieh - Tabaris, BCD) extended to the West by Hamra-Edde couple till Koreitem. These two Corniches will be gained to

the west (towards seaside corniche (Raouche) and to the east (towards Borj Hammoud Boulevard across Nahr Beirut, works in progress).
- The couple Verdun - Rachidine Road is the extension of Ouzai Penetrator towards Hamra;
- Bechara El Khoury Avenue is the extension of Airport Boulevard;
- the new South-East Boulevard linking Justice Palace (Corniche Gemayel) to BCD via Sodeco (studies in progress);
- the new Quarantina Boulevard is the extension of the new Maritime Boulevard Antélias - Dora (studies in progress);
- Ramlet El Baida Boulevard existing from Raouche Corniche to Ouzai Penetrator (along the sea).

In Southern Suburbs
- Airport Boulevard (previously mentioned);
- Rocade Urbaine Nord whose right of way has been nearly utterly freed between Ain Roummaneh and Tayouneh; an alignment should be searched between Chatila and Sport City;
- New Chatila - Choueifat Road (works in progress) between Rocade Urbaine Nord and BPB;
- Chiah Boulevard from Hazmieh to Bir Hassan (Sultan Ibrahim), upgrading works in progress;
- New Hadath - Cocody Boulevard, existing between Hadath (BPB) and Borj El Brajneh and under study between Borj El Brajneh and the Airport (Cocody);
- New Tiro Boulevard between South Penetrator and BPB, south-east of the Airport. Studies in progress

In Eastern Suburbs
- New Maritime Boulevard between Antélias, Nahr El Mott and Dora, that will follow the alignment of the rehabilitated railway line Beirut - Tripoli; studies in progress
- New Borj Hammoud Boulevard that will link Dekwaneh (BPB) to the fork of Independence - Fouad Chehab Rings in Achrafieh (studies in progress);
- Mkalles - Alba - Sin El Fil Boulevard that should be upgraded;

- Mkalles - Qualaa Boulevard towards Inner Ring Expressway;
- Mkalles - Hazmieh Boulevard via the old bridge of Jisr El Pacha, that should be upgraded.

The whole proposed basic network totals 248 km. Some of proposed roads correspond to existing thoroughfares (that will have to be upgraded in some cases). Others are new roads included in the Recovery Program (studies and works in progress). Others however correspond to completely new alignments. The table below presents an analysis of the proposed network according to these criteria and according to the type of road (Long Distance Highway, Boulevard Périphérique, Penetrator, Expressway, Urban Boulevard).

Type of road	Long Term Plan			
	Total length (km)	Existing & not requiring extensive upgrading works (km)	Existing & requiring extensive upgrading works (km)	New roads (km)
Long Distance Highway	47	-	18	29
BPB	18	-	-	18
Penetrator	38	4	10	24
Expressway	23	8	8	7
Urban Boulevard	122	60	18	44
Whole basic network	248	72	54	122

To summarize, the proposed roads of Long Term Plan includes 126 km of existing roads to be rehabilitated or extensively upgraded, almost one half of the roads included in the Long Term Plan. New roads constitute the other half with 122 km.

III.2.2 Reservation of Right of Way Corridors

The localization of the corridors necessary to implement the proposed network constitute one of the main outputs of the Long Term Plan. It allows to protect the right of way of future roads and to preserve it for the future. From this point of view, several situations can be met.

1. Some roads correspond to existing ones with a sufficient right of way. No new protection measure is necessary in this case. It is notably the case of the major part of Municipal Beirut internal network.

2. Some other roads correspond to existing ones with too narrow a right of way to accommodate the upgrading works proposed by the Long Term Plan. Two solutions are possible in this case:

   - either an extension of right of way where the urban fabric is loose enough to permit such a widening. It is notably the case of the Nahr El Mott - Roumieh road or of a number of Urban Boulevards or Expressways using the alignment of existing roads;
   - a modification of geometrical characteristics of the proposed road, when the crossing urban fabric is too dense and too tight (underground or aerial execution in the available right of way for instance). It is notably the case of the section Salomeh - Futuroscope section of the internal ring expressway that will have to be built in tunnel.

3. Some other roads are related to new projects constituting part of the Emergency Program, subject currently alignment and design studies. In this case, the consultant group mission consisted in checking the coherence between these projects and the proposals of the Transportation Plan, underlining the possible contradictions between them and proposing corridor extension when necessary.

4. Some roads are completely new. Neither an alignment survey nor corridor reservation has been executed so far. A number of which is part of urban upgrading or development programs. Their alignment, indicated for information in the

Long Term Plan, will have to be precised in the framework of the overall development project for the concerned neighborhood. It is notably the case of Rocade Urbaine Nord that will cross Sabra-Chatila, between Chatila Roundabout and Sport City. Other new roads will cross areas in which no urban development is foreseen. The alignment survey carried out by the Consultant Group led to two types of proposals:

- the localization of a right of way corridor if insertion constraints are reasonable. It is the case of the New South Highway between Choueifat and Damour;
- the definition of the principle of the road without any precise alignment description if topographic environment constraints are very severe. The alignment of the new road cannot be defined without a detailed insertion study. It is the case of Metn - Kesrouan connection linking Nahr El Mott - Roumieh - Broummana Road with Ajaltoun Road (Kesrouan) at an average altitude of 300 m and of the new Bikfaya road branching off the previously mentioned road, down of Roumieh.

5. A road has been given up between Baouchriyeh and Fanar although it had been decreed in the past. Insertion conditions and urban fabric appears too difficult and too dense to maintain the projected road. A new decree abolishing the former one will have to be promulgated, abrogating the former ones.

   A technical file is annexed to this report. It gathers all observations and proposals regarding the Long Term Plan road network and the right of way corridors to reserve.

III.2.3 Exchanges

The "return" of a network depends very much on the quality of exchanges. As indicated before, the road network proposed in the Long Term Plan is a hierarchical and meshed network where 3 types of roads are distinguished (without taking account of local access roads).

- Highways (Boulevard Périphérique, Penetrators, Long Distance motorways);
- Expressways;
- Urban Boulevards.

The exchange system between these various roads should be strictly organized in order not to mix traffic whose nature and function are not similar.

Highways always exchange with Expressways or Urban Boulevards by means of specially designed interchanges. Local servicing has no direct access on highway network. When necessary, highways are completed by lateral service lanes that bring the local traffic to specially designed interchanges. Geometrical characteristics of future exchanges will of course depend on future traffic intensity and local insertion constraints.

Expressways exchange with lower level roads (Urban Boulevards) by means of grade separated intersection but they can directly exchange with the local servicing network in a unidirectional way (merge-diverge but crossing not allowed).

Urban Boulevards exchange generally at grade with the local network under traffic signal control.

A technical file, annexed to this report, illustrates the previous principles. Complementary detailed design studies will be necessary to precise their feasibility. A part of which are in progress in the framework of the Emergency Program.

III.2.4 Network Operation

A) Overall Outputs

The table hereafter collect the overall results of operation conditions provided by the long term plan, according to the same indicators as those used in evaluating the two Scenarios.

Vehicular Trips

NETWORK DESCRIPTION	Total length (km)	248
HIGHWAY	length (km)	103
EXPRESSWAY	length (km)	23
URBAN BOULEVARDS	length (km)	122
TOTAL INVESTMENT COST (Millions US$)		4 billion US$
AVERAGE SPEED AT AM peak hour (km/h)	whole GBA	24
	inside Municipal Beirut	28
	outside Municipal Beirut	22
	East of Nahr Beirut	26
	West of Nahr Beirut	20
SATURATION RATE OF NETWORK	whole GBA	1..o6
	inside BUA	1.10
	East of Nahr Beirut	1.2
	West of Nahr Beirut	1.0
AVERAGE ACCESS TIME AT AM peak hour (in minutes)	BCD	31
	Airport	27
	Nahr El Mott	23
	Hazmieh	28
	Laylaké	41
	Khaldé	25
AVERAGE TRIP DURATION AT AM peak hour (According direction in minutes)	BCD/Airport	15/25
	Nahr EL Mott/Khaldé	20/34
	Ras Beirut/Antélias	20/28
	Port/Nahr El Kalb	19/21
	Port/ Alley	17/32
	Port/Nahr Damour	32/79

In general, the network finally adopted in the Transportation Plan has a number of attributes largely superior to those of Scenario B (regarding vehicular trips) and it costs much less.

The analysis of road network operation should however be refined at two levels:

- the large geographical cuts of GBA (screen-lines)
- the load on the different sections of GBA network.

All analyzed traffic data concern 2015 morning peak hour (AM Peak) traffic.

B) Geographical Screen Lines

The following table presents the results of the geographical cut analysis and gives the saturation rates observed when crossing these cuts (see location of cuts on following page).

Screen Lines (towards Beirut)	Network Capacity (v/h)	Traffic Volume (v/h)	Saturation Rate (V/C)
A	25500	28791	1.13
B	27200	35409	1,30
C	23700	28269	1.19
D	13100	19868	1.52
E	26700	37345	1.40
F	19000	29804	1.57
G	15900	21730	1.37
H	11100	9512	0.86
I	28300	30231	1.07

Even if they nearly always stay at lower levels compared to the two tested basic Scenarios, saturation rates at AM peak towards Beirut across the main cuts of GBA remain high. In some areas, the dimensioning of long term proposed network will not allow to meet vehicular trip demand by year 2015. Five cuts specially raise difficulties:

- Cut B (Chiah Boulevard) where in spite of the addition of Ouzai Penetrator with highway characteristics in the long term network, saturation rate will be high (1.30).

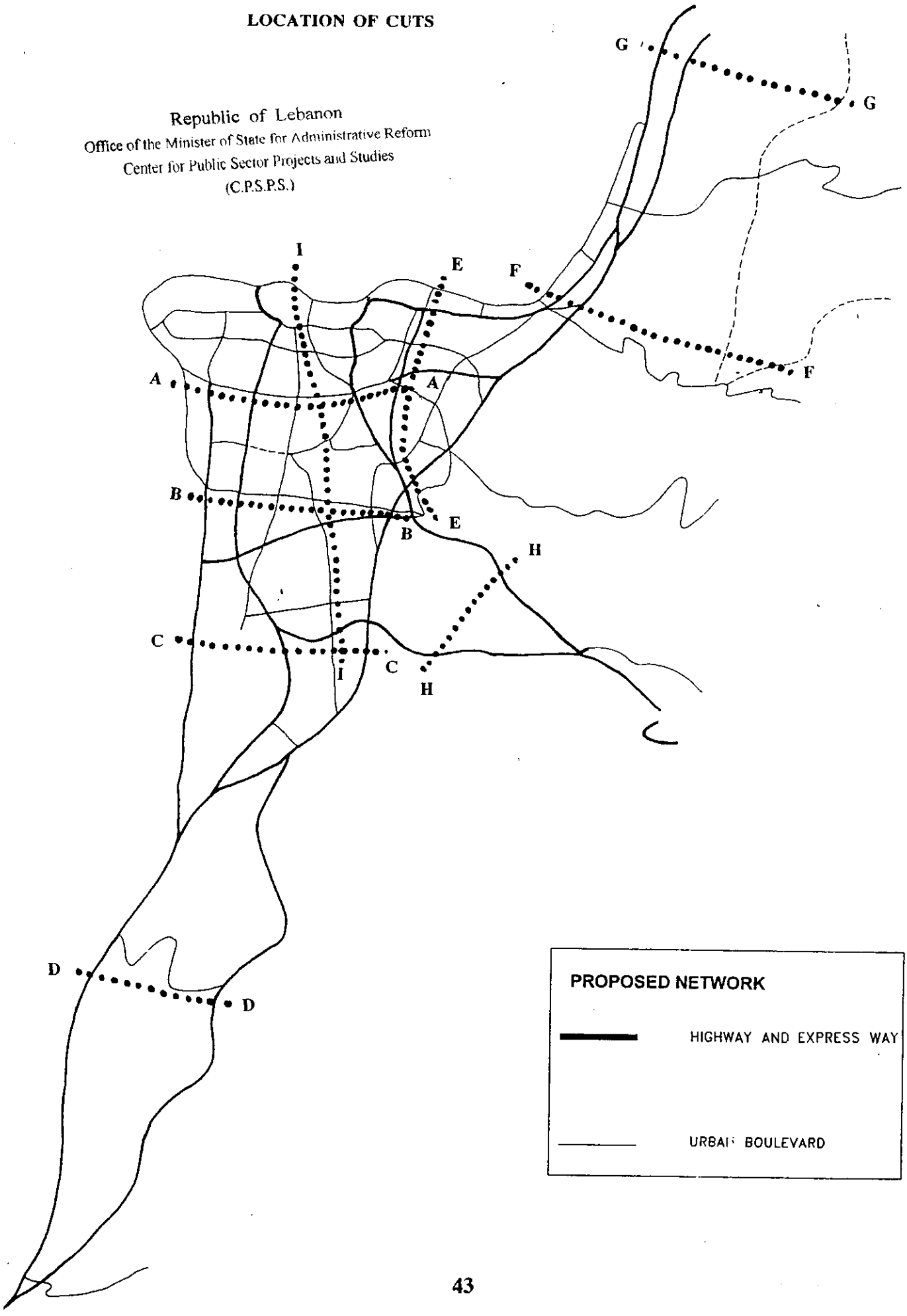
- Cut D (South of Khaldeh) where in spite of retaining highway characteristics for the new mountain road linking Choueifat to Damour, saturation rate will remain very high (1.52).

- Cut E (Nahr Beirut) where the physical possibilities to cross the river cannot be multiplied. They were nearly all included in the two basic Scenarios and they have been left in the long term network. Saturation will be high when crossing the river (1.42).

LONG TERM TRANSPORT PLAN

LOCATION OF CUTS

Republic of Lebanon
Office of the Minister of State for Administrative Reform
Center for Public Sector Projects and Studies
(C.P.S.P.S.)



- Cut F (Nahr El Mott) where saturation rate will be very high (1.57). Suppressing the south section of the initially proposed road to link Baouchriyeh (BPB) to Jounieh via Metn hills has led to a drastic road capacity reduction across Nahr El Mott.

- Cut G (Nahr El Kalb) where in spite of maintaining the mountain road linking Metn and Kesrouan, saturation rate remains quite high (1.37).

Along these cuts, the limits of the future GBA road network are reached and it appears really difficult to get something better, given the numerous urban, landscape and environmental constraints to be respected.

C) Load on Primary Network

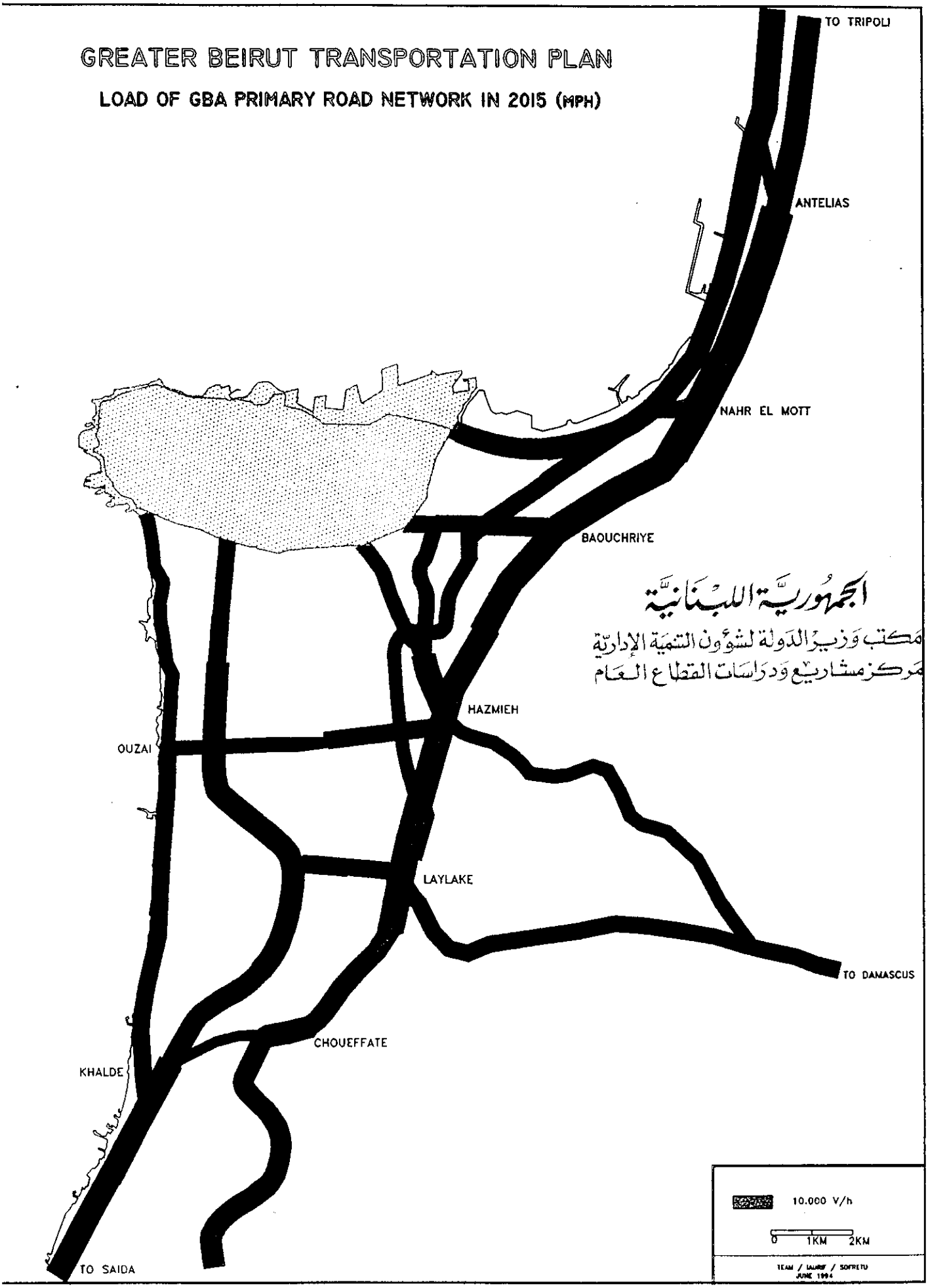
Analyzing the traffic flows along the main geographical cuts of GBA should be completed by the operation conditions of the main primary road network of GBA. The sketch presented on following page illustrates the traffic flows at mph in 2015 along the primary GBA road network (Highways and Expressways).

Two axes deserve to be more specially highlighted: BPB and Inner BPB expressway (Nahr El Mott - Sin El Fil - Chevrolet - Chiah - Rocade Urbaine Sud - Ouzai).

BPB

The following sketch displays the load diagram of the Boulevard Périphérique between Antélias and Khaldeh (rounded up to hundreds of vehicles by direction at AM peak).

800	5600	5500	8900	10100	9100	8900	11200	11500	12700	15200	
1200	10000	7700	11200	12800	10300	3500	11700	8400	9800	11200	
Khaldeh	NSM	Chouef.	Layl.	Hadd.	Chamoun	Hazmieh	Mkalles	Dekw.	Dbayeh	N. Mott	Antélias


GREATER BEIRUT TRANSPORTATION PLAN
LOAD OF GBA PRIMARY ROAD NETWORK IN 2015 (MPH)
TO TRIPOLI
ANTELIAS
NAHR EL MOTT
BAOUCHRIYE
الجمهورية اللبنانية
مكتب وزير الدولة لشؤون التنمية الإدارية
مركز مشاريع ودراسات القطاع العام
HAZMIEH
OUZAI
LAYLAKE
TO DAMASCUS
CHOUEFFATE
KHALDE
TO SAIDA
10.000 V/h
0 1KM 2KM
TEAM / LAURIF / SOFRETU
JUNE 1994

Several findings are learned from these figures:

1. With a theoretical directional capacity of 6800 vehicles/hour (per 4 lanes), BPB is saturated nearly all along its track. The northern section appears specially saturated with traffic forecasts culminating to 15.000 vehicles per hour between Antélias and Nahr El Mott. Even when taking service roads into account, the gap is huge in the BPB northern section. The suppression, in the Long Term Plan, of the Baouchrieh - Fanar - Metn highway has heavy consequences (see above). In the long term, without a serious attempt at controlling demand, there is no real solution except the creation of an expressway viaduct over existing coastal highway, the doubling of the Périphérique by a similar aerial structures or a larger use of the future railway line between Jounieh and GBA.

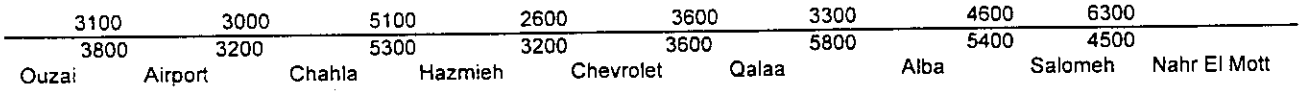
2. Another section appears very loaded: the section between Hazmieh and Hadath with peak hour traffic exceeding 10000 vehicles per direction. The concentration in Hazmieh of one of the main road complex of GBA explains this saturation.

3. The south section Laylakeh - Choueifat appears less saturated with peak hour traffic under 10000 vehicles but overpassing however the theoretical capacity of BPB.

4. The Choueifat - Khaldeh section of BPB is largely under saturated (above 1000 vehicles per direction at peak hour). This can be explained by the new south mountain highway (Choueifat - Damour) that accommodates a large part of the south linked traffic using BPB.

Inner BPB Ring

The following sketch displays the "load-snake" of the proposed expressway connecting Nahr El Mott to Ouzai via Salomeh, Chevrolet and Hazmieh.



The theoretical directional capacity of the Inner BPB Ring is 2400 vehicles per direction at peak hour. The capacity is nearly always largely surpassed with traffic exceeding 3000 vehicle/hour. The heaviest loaded sections are between Sin El Fil and Nahr El Mott. The suppression of Baouchriyeh - Metn - Kesrouan highway explains the high level of traffic obtained in this section.

The general load of Inner Ring Expressway in all its sections largely justifies the transformation of this track into an expressway.

Penetrators

The table hereafter provides the average level of traffic along the 7 Penetrators proposed by the Long Term Plan.

Penetrator	AM peak Traffic towards Beirut (vehicle/hour)	AM peak Traffic from Beirut (vehicle/hour)
North Penetrator	7000 to 7200	6700 to 8000
Sin El Fil Penetrator	4600 to 4900	5600 to 5900
Port Penetrator	5500	4600
Justice Palace Penetrator	3400	4000
East Penetrator	4300 to 4900	4100 to 5300
South Penetrator	4700 to 7900	5400 to 10.000
Ouzai Penetrator	3300 to 5800	1900 to 4500

The network of Penetrators will be quite loaded with traffic often exceeding the capacity of the main roads. However, taking into account the lateral service lanes nearly present all over the Penetrators, the situation appears tolerable.

Access to BCD

BCD site raises a special issue because it will concentrate a high job supply (100000) in the long term and as it is located in the heart of the built up area. The main figures regarding BCD access in 2015 can be summarized as follows:

- 49000 motorized person-trips towards BCD area at AM peak hour, shared in two equal parts (51% with mass transit network, 49% with private cars);

- 14000 vehicles entering BCD area during AM peak hour;
- 23500 vehicles entering or crossing BCD area during AM peak hour (8000 coming from East, 11300 coming from South, 4300 coming from West).

The capacity of the network proposed to reach BCD area appears sufficient to meet future needs (except along the South access corridor) under the condition that a heavy mass transit network can serve BCD area in the long term.

D) General Findings

The traffic figures presented hereabove correspond to the results of an overall simulation, taking account of the whole Greater Beirut area. Rather than precise results, they provide an order of magnitude of the issues that will have to be tackled in the future. The quite general overloading of the network resulting from the simulation should notably be relativized by the willingly high level of demand retained for the long term forecasts (5 million daily motorized person-trips).

Given these considerations, three major points should nevertheless be indicated:

1. The major role of BPB is to organize traffic flows in GBA. It will be the backbone of the long term road network regarding the high level of traffic it will accommodate. As to its functional role, it will distribute this traffic inside GBA.

2. The absence of a really satisfactory solution to meet the vehicular demand along the North and South Coastal Corridors and specially along the North one.

3. The high level of overloading that will characterize the road network in 2015 in spite of drastic choices favouring mass transit network inside the urban agglomeration.

III.2.5 Investment Cost and Financing Way

The table hereafter presents the synthetic results of the investment expenditures linked with the proposed Long Term Plan. A detailed description of network characteristics and costs is provided in the Technical File annexed to the present report.

A) Overall Costs

The network has been divided according to the same typology adopted in II.2.2.

- Highways including Boulevard Périphérique de Beyrouth (BPB), Long Distance motorways (outside BPB) and Penetrators (inside BPB)
- Expressways
- Urban Boulevards.

Two categories of costs have been distinguished: land purchase and works. Costs are expressed in million US $.

Regarding land puchase, basic information about the progress stage of expopriation procedures, has been collected from concerned technical departments (CDR notably) anf from the consultants intrusted with design and engineering studies. Five categories of land price have been distinguished inside GBA (from 50 US $ / m² to 1500 US$/m²...). Regarding works, a basic table of costs have been established taking into account road status (highway, express way, boulevard), geometric caracteristics (2 x 2 lanes , 2 x 3 lanes...) and site constraints (density of urban fabric, flat or steep alignment). The amount of works corresponds to the completion stages of the project. ...

Type of Road	Km	Land Purchase	Works	Total
Highway BPB	18	673	303	976
Long Distance Motorway	47	376	609	985
Urban Penetrator	38	663	316	979
Total	103	1712	1228	2940
Expressway	23	198	96	294
Urban Boulevard	122	444	359	803
Whole Basic Network	248	2.354	1683	4037

The whole amount of investments to be devoted to the Long Term Road Plan borders 4 billion US $. 75% of this program concerns the highway network that is practically non-existing today. The highway network cost is equally shared between BPB, Long Distance Motorways and Urban Penetrators (1 billion US $ each category).

Compared to the length, BPB is the most expensive highway of GBA with an average of 50 million US $/km.

Long Distance Motorways border 20 million US $/km; and Urban Penetrators 25 million US $/km. BPB heavy cost is partly due to the geometrical characteristics of highway (4 x 4 lanes nearly along the whole track). It is however specially due to the huge land freeing cost. This cost represents nearly 70% of total cost for BPB.

Land freeing is very expensive in Greater Beirut, specially inside BPB. It represents 59% of the total investment cost of the Long Term Plan with works amounting only to 1,7 billion US $ (out of a 4 billion total).

B) Geographical Distribution

A breakdown of investment cost has been done to highlight the respective weight of investments devoted to inner BPB area and to outer BPB area. The table hereafter presents the results of this repartition (in million US $).

Geographical Area	Land Purchase	Works	Total	%
BPB	673	303	976	24.2
Inside BPB	1263	478	1741	43.1
Outside BPB	418	902	1320	32.7
Total	2354	1683	4037	100.0

When adding BPB to inner BPB network, the total amount of inner BPB network cost borders 2.7 billion US $, that is the 2/3 of the whole program cost (the 3/4 of which will be devoted to land purchase).

Given the fact that the proposed road investments concerning Municipal Beirut (defined as the area enclosed by the Ring of Corniche Mazraa, Raouche, Seaside and Gemayel, and not strictly corresponding to the administrative limits of Beirut City) amount to about 150 million US $), that means the bulk of investment effort will have to be provided in the Beirut suburbs located inside the BPB track. It corresponds quite well to one of the main targets of Long Term Plan: consolidating and improving the accessibility of Beirut suburbs.

C) **Long Term Plan and Recovery Program**

The budget required by the Long Road Term Plan may appear quite high, but it should be related to the Infrastructure Recovery Program launched by Lebanese authorities and that foresees a number of road upgrading and development works in Greater Beirut.

Regarding the technical content of Recovery Program, it should first be observed that the geometric and design characteristics of the roads proposed in the Long Term Plan does not coincide always with it. The previouly mentioned technical file lists the Long Term Plan projects and indicates their coherence with the Recovery Program presently under works and under study. It can be admitted, as a first approximation, that the Recovery Program is part of the Long Term Plan and corresponds to a first stage of implementation of it.

Evaluated upon the same bases as these used to estimate the Long Term Plan, the Recovery Program amounts to about 2,5 billion US $. It should theoretically be executed during the next 10 years, that is about half the duration of the Long Term Plan. Given the huge delay that Greater Beirut road network presently suffers from due to the lack of investments during the war, it does not seem unreasonable to execute during the next 10 years about 62% of the Long Term Plan.

This point will be analyzed in more details when presenting the Middle Term Plan (report no. 13 to be released in July 1995).

D) Financing Means

A part of the Long Term road network will be able to be "self-financed". It is already the case of the SOLIDERE Program (35 million US $ for the works presently implemented that are part of the LTP). It is also the case of Damascus toll motorway, that is about to be entrusted to a group of private investors.

Toll solution could be well adapted to a number of new long distance highways that double the existing network (A2 for A1, South Mountain highway for South Coastal highway). It could much alleviate the burden of public financing for road investment.

When adding Damascus highway, South Mountain highway and A2 highway, the total investment amounts to 700 million US $ (in the limits of the Metropolitan Region). A private way of financing these infrastructures should be carefully considered.

This solution cannot however be generalized everywhere. It cannot notably be applied inside the BPB area for Urban Penetrators, urban expressways and BPB itself. No alternative is offered in this area. The very poor conditions of road network and the lack of a minimum of primary connections between suburban neighborhoods make a toll system impossible to execute without heavy social and urban consequences. If public authorities should concentrate their intervention on some area, the inner BPB one and notably BPB itself should be prioritized. The key of a better urban management for the whole GBA is located in the suburbs.

III.3 MASS TRANSIT NETWORK

III.3.1 Network Organization

From the analysis of Scenarios, it is possible to define the trunk Mass Transit Network to include in the Long Term Plan. This network is coherent with the hypotheses adopted for future GBA urban development. Trunk network is made up of three types of lines:

- **a Regional line (R1)** that will use the coastal railway track and that will be operated like a Regional Metro inside GBA between Jounieh and Damour;
- **two Urban Metro lines** (MA and MB) that will ensure the basic service of Beirut Urban Agglomeration;
  a) an East-West line (MB) linking East Suburbs to Municipal Beirut;
  b) a North-South line (MB) linking South Suburbs to Municipal Beirut.
- **three secondary urban lines** serving BUA and using lighter technology (streetcar or site dedicated bus);
  a) a South-East/North-West line (SC1) between Mkalles and AUB (via Corniche Mazraa);
  b) a Ring line (SC2) between Nahr El Mott, Hazmieh and Ouzai;
  c) a South-West/North-East line (SC3) between Ouzai and BCD.

The trunk network (regional and urban) is completed by a complementary bus network ensuring a feeder function and serving the outlying areas.

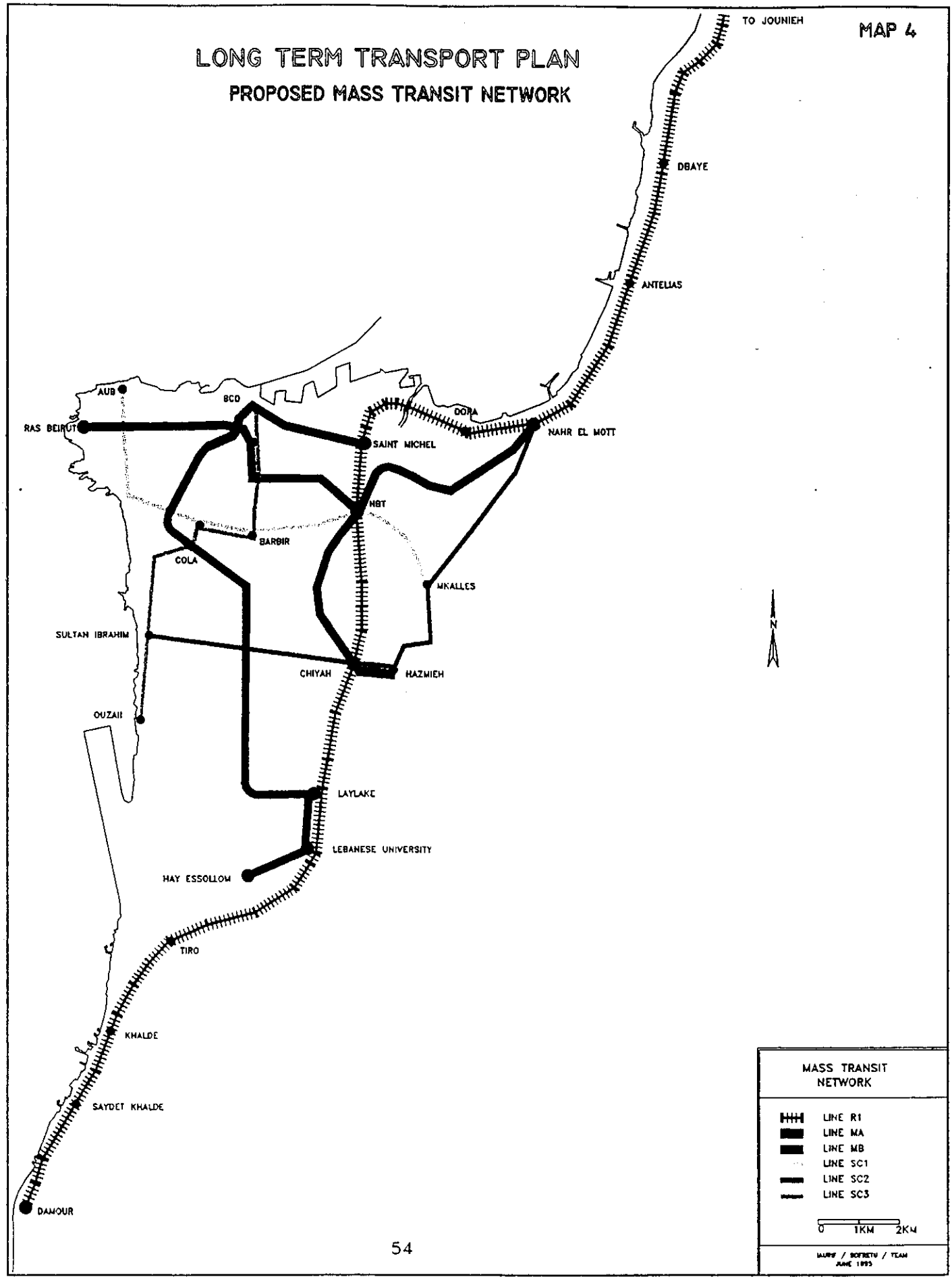
Two large multimodal terminals complete this organization, one at Nahr El Mott at the outlet of North highways, another at Laylakeh at the outlet of East and South highways.

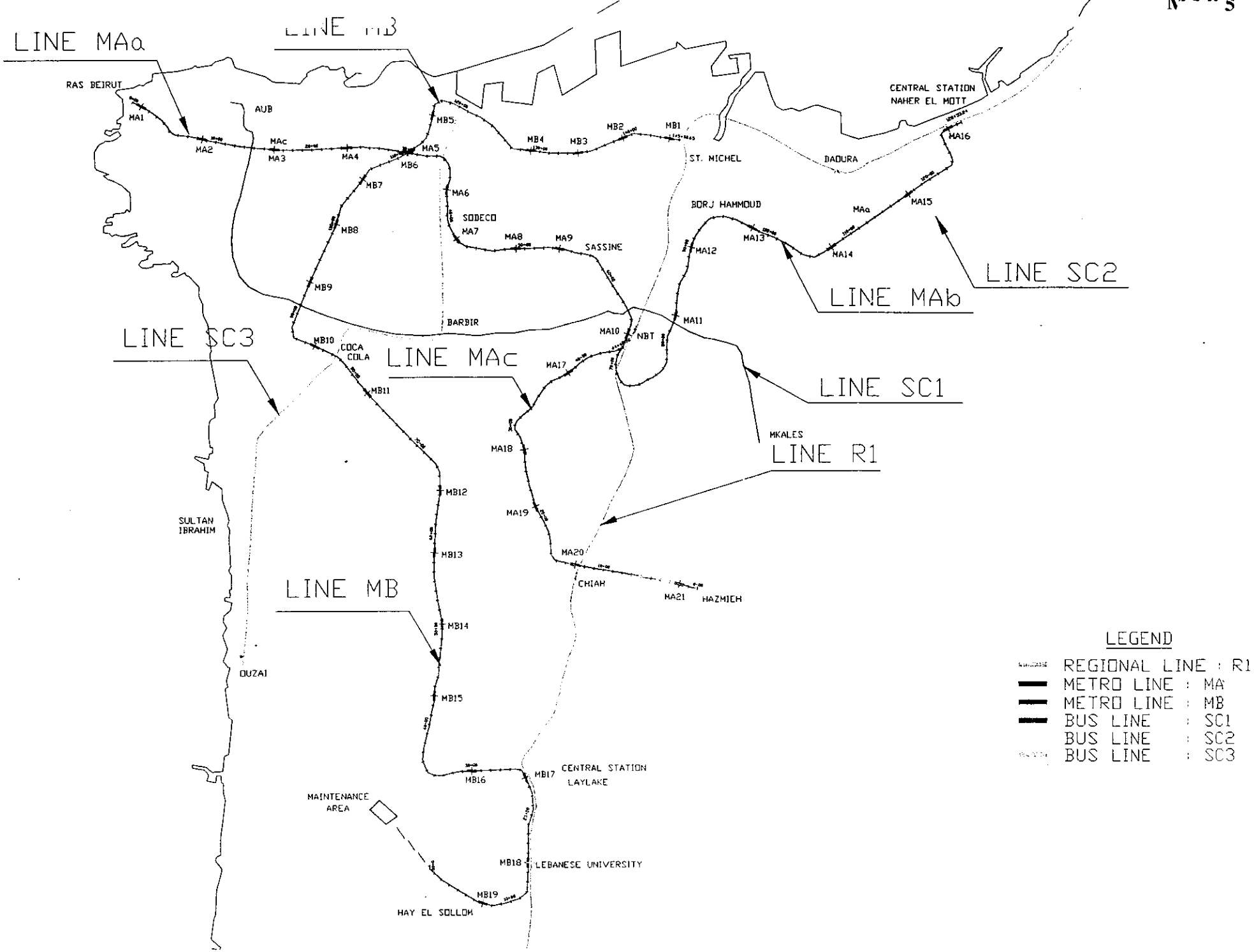
The two maps M4 et M5 on following pages display the Long Term mass transit network. The Sketch 3 illustrates the load diagram of this network. Detailed 1/10000 alignments are provided in the Technical File annexed to this report.

LONG TERM TRANSPORT PLAN

PROPOSED MASS TRANSIT NETWORK

MAP 4



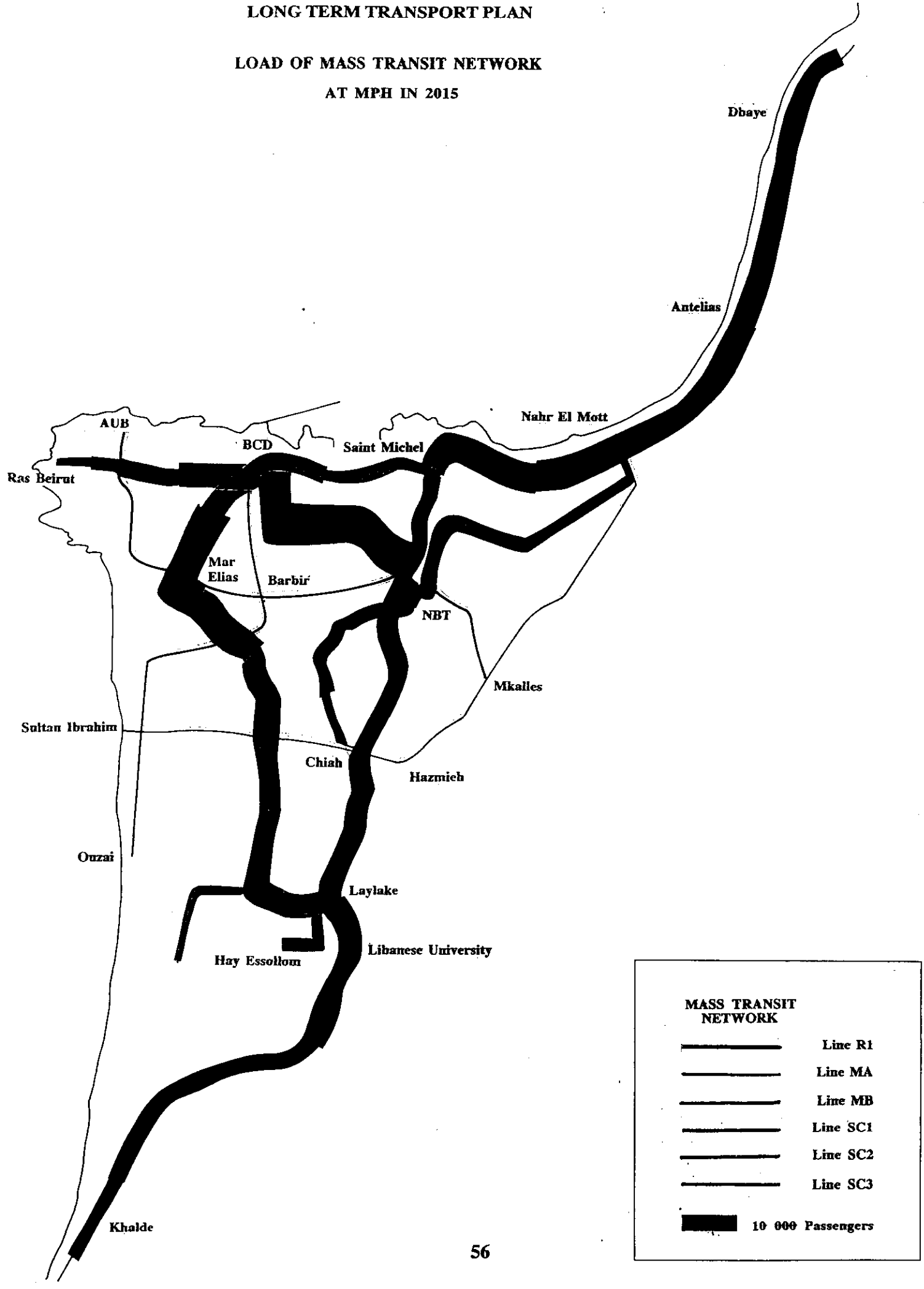

LINE MAa
LINE MB
RAS BEIRUT
MA1
AUB
MA2
MAc
MA3
MA4
MA5
MB5
MB6
MB7
MB8
MB9
MB10
COCA COLA
MB11
MB12
MB13
MB14
MB15
MB16
MB17
MB18
MB19
MB4
MB3
MB2
MB1
CENTRAL STATION
NAHER EL MOTT
MA16
ST. NICHEL
DADURA
MA6
SODECO
MA7
MA8
MA9
SASSINE
BARBIR
MA10
NBT
MA11
MA12
BORJ HAMMOUD
MA13
MAa
MA14
MA15
LINE SC2
LINE MAb
LINE SC3
LINE MAc
LINE SC1
MA17
MA18
MKALES
LINE R1
MA19
MA20
CHIAH
MA21
HAZMIEH
SULTAN IBRAHIM
DOUZAI
CENTRAL STATION
LAYLAKE
MAINTENANCE AREA
LEBANESE UNIVERSITY
HAY EL SOLLOM
LEGEND
REGIONAL LINE : R1
METRO LINE : MA
METRO LINE : MB
BUS LINE : SC1
BUS LINE : SC2
BUS LINE : SC3

SKETCH 3

LONG TERM TRANSPORT PLAN

LOAD OF MASS TRANSIT NETWORK

AT MPH IN 2015



III.3.2 Regional Line (R1)

The mass transit regional service is ensured by the railway line (R1).

III.3.2.1 Route, and Stations

The proposed Regional Servicing will be implemented on the section of the railway line situated between Jounieh (outside GBA) and Damour, that is about 38 km. It will be operated in coherence with other services (national and international traffic, goods transport) that will use the same track.

The so-defined regional line starts from Jounieh Central Station and serves the following stations (see map on following page):

- Zouk (Nahr El Kalb)
- Dbayeh
- Antélias
- Jdaideh (Secondary Center of Nahr El Mott)
- Dora (Borj Hammoud)
- Achrafieh Quarantina (St. Michel)
- Beirut Central Station (NBT)
- Hazmieh Secondary Center (St. Michel of Chiah)
- Laylakeh Secondary Center (Road Station)
- Lebanese University
- Tiro Industrial Areas
- Khaldeh Village
- Khaldeh Secondary Center (Saydet Khaldeh)
- Damour.

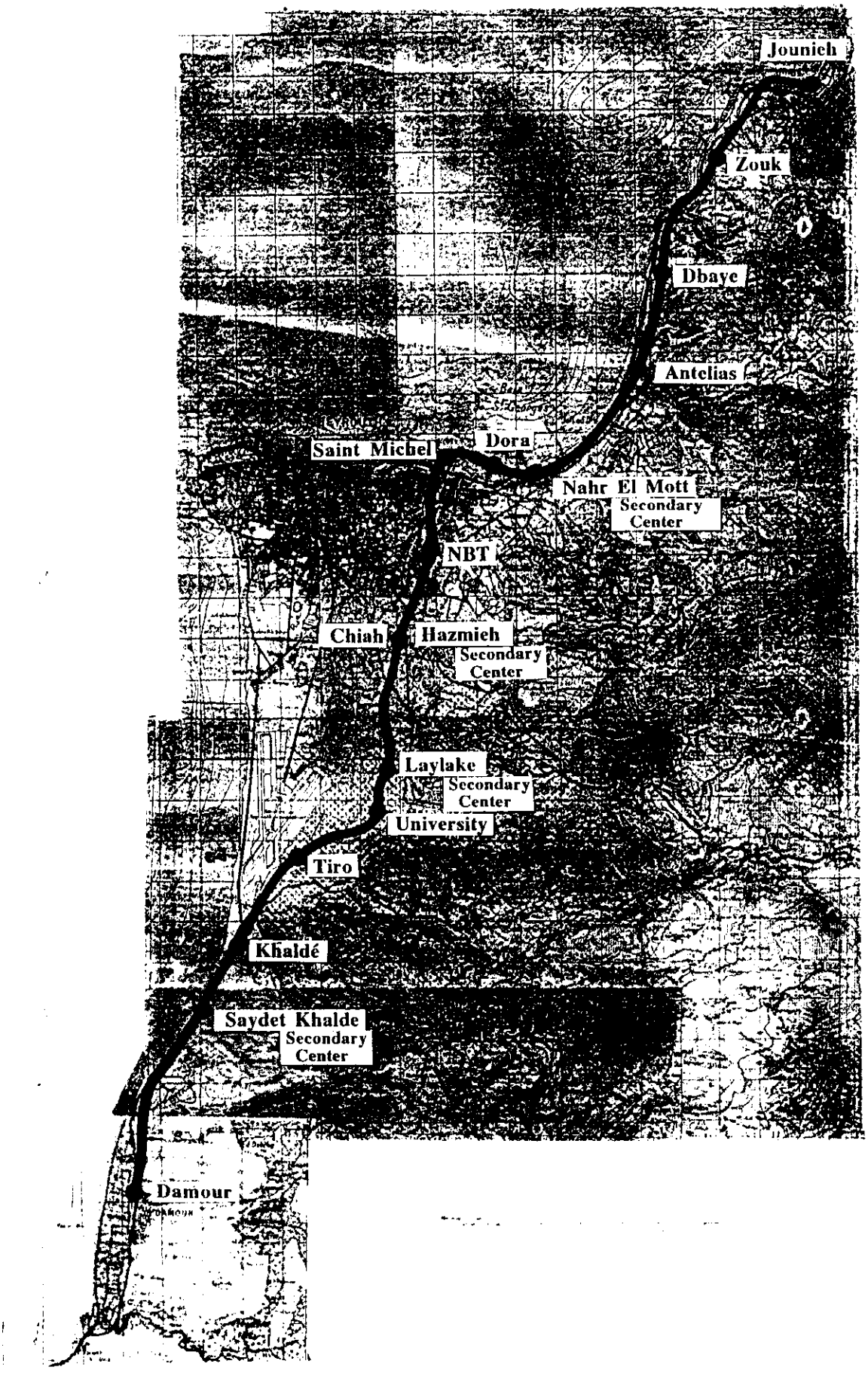
Each station is linked and meshed with the other lines of the Mass Transit Network. Six stations exchange with the two urban metro lines. They are located in:

- Nahr El Mott (MA line)
- St. Michel (MB line)
- NBT Station (MA line)
- St. Michel of Chiah (MA line)
- Laylakeh (MB line)
- Lebanese University (MB line).

REGIONAL RAILWAY LINE R1

MAP 6

ROUTE, STATIONS AND SERVED POLES



The commercial achievement of the Regional Railway Servicie and therefore its capability to ensure a meaningful part of GBA trips, depends mainly on the accessibility of stations. This accessibility should be warranted for the 3 main feeder ways:

- On foot, by means of special facilities at the crossing of high traffic road axes that isolate the line from urbanized areas, notably along the North Coastal Corridor (Dbayeh, Antélias, Nahr El Mott, Dora).
- Mass Transit lines, by creating well designed stations that allow to organize deck-to-deck exchanges between Regional Metro and other Mass Transit lines.
- Private cars, by locating large feeder parking areas in the vicinity of the station.

The success of such a transportation system requires the reservation of large areas around the stations of Jounieh, Antélias, Nahr El Mott, Dora, St. Michel of Chiah, Laylakeh and Khaldeh.

A special notice should be done regarding three of these stations (Nahr El Mott, NBT and Laylakeh), given their very important role in the whole GBA Mass Transit organization.

The location of Beirut Central Station (NBT) in a large free area belonging to the Office du Chemin de Fer et des Transports en Commun de Beyrouth (OCFTCB) allows to turn this station into a major intermodal exchange center. Important road axes already serve or will improve the accessibility of this station: Municipal Beirut Corniche and Sin El Fil Bridge, Sin El Fil and Justice Palace Penetrators. Their compatibility will have to be ensured and a functional and design study is necessary to precise the organization and the servicing of NBT station.

Nahr El Mott Station will be located close to a large available land located between the coastal road and the sea, and devoted to accommodate a large transportation and road complex. Close to the terminal of MA and SC2 urban lines, it is situated in the vicinity of the complex road interchange where coastal highway (A1), Périphérique bypass (Zalka - Nahr El Mott), Roumieh - Broummana road and Sin El Fil expressway will join and be

connected. The design of all these facilities will have to be made coherent and efficient.

Laylakeh Station will play a role similar to the Nahr El Mott one, to the south of the agglomeration. It will border a large road and transportation complex associating an MB line station and a large road station served by BPB, Damascus Highway and East Penetrator. This site also requires a careful design and a number of prerequisite studies to be used to the maximum of its potentiality.

III.3.2.2 Traffic Forecasts

The table hereafter presents the main technical data concerning the Regional Line that has been relied on to prepare traffic simulation:

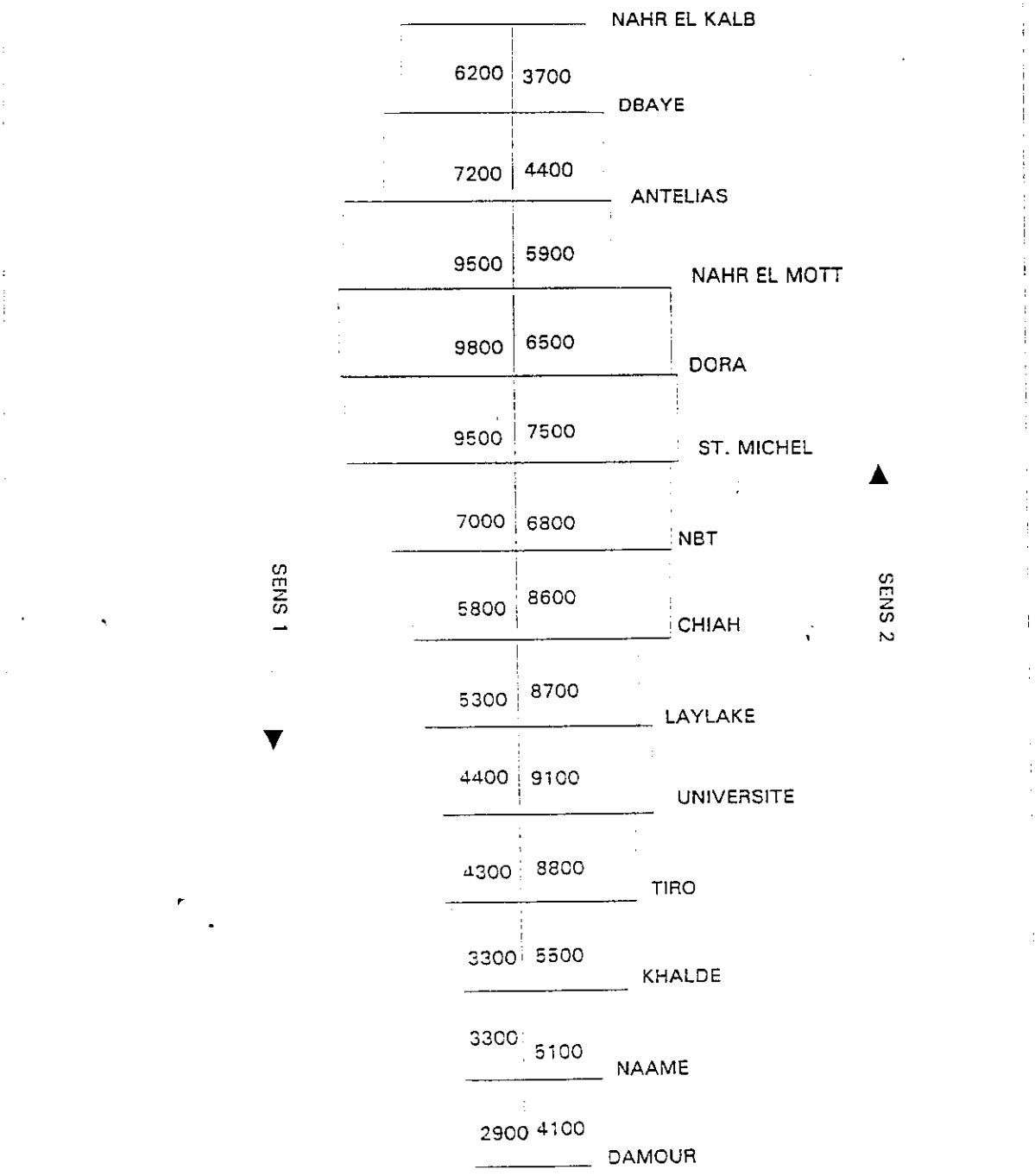
length	38 km
number of stations	15
transit stations	6
average interstation length	2.5 km
commercial speed	50 km/h
minimum headway	20 mn

Traffic test results executed on the previous basis are given in the following table and displayed on sketch 4 on following page (year 2015).

AM peak ridership on the most heavily loaded interstation	9800
daily boarding passengers	264000
average person trip length on the line	11.5 km
average person trip duration on the line	13.8 mn

The operation of the Regional Line, regarding daily boarding passengers as well as AM peak most heavily loaded interstation traffic, corresponds to quite a good use of the proposed infrastructure. The sketch on following page shows an interesting loading, very regular and systematical. This will facilitate the future operation of the line.

LOAD DIAGRAM OF RAILWAY LINE (R1)
MPH,YEAR 2015



III.3.2.3 Technology Choice

Operating conditions of the Regional Railway Line (as resulting from the simulations) confirm the regional function of the line: average interstation distance of 2.5 km, average trip on the line of 11 km. Although peak hour traffic is high (10.000 passengers), it remains largely under the capacity of a Regional Metro Line that can transport more than 60.000 passengers per direction at PH; with a heavy and high capacity rolling stock (till 4000 passengers per train).

It therefore could be devised to ensure the service of the Regional Railway Line with a reduced capacity rolling stock and to increase the headway. However, the operation of regional trains on the same track as the one used by long distance trains and goods trains can only be admitted if the regional traffic does not disturb the operation of the other services.

In order to fix ideas, the table hereafter provides some reference data about the capacity and the PH headway of trains permitting to carry 10.000 passengers at PH.

Type of Rolling Stock	Train Capacity (6 people/m2)	Frequency (per hour)	Headway
Regional Streetcar 1 x 30 m long unit	250	40	1'20"
Regional Streetcar 2 x 30 m long units	500	20	3'
"RER"type Regional Metro 1 x 104 m long unit	1150	9	7'
"RER"type Regional Metro 2 x 104m long units	2300	4	15'

For a regional service as proposed in Beirut and given operation constraints linked to other services, a frequency of 12 trains at PH is the maximum to be admitted. The capacity of the rolling stock is thus defined with 850 passengers per train. With such a frequency, all at-grade intersections with vehicular traffic should be suppressed and replaced by grade - separated crossings.

III.3.2.4 Predimensioning of Regional Service

Taking into consideration all these constraints leads to define the basic specifications of the proposed regional service.

Maximum speed	above 100 km/h
Interstation distance	1.3 km to 3.0 km
Commercial speed	50 km/h
Signalization	Block
Electric traction	Catenary & Pantograph
Voltage feed	1500 vcc/25000 vcc
Rolling stock width	about 3 m
Height & length of stations	imposed by long distance trains
Headway at PH, by direction	5mn
Train capacity	850 passengers (6 p/m^2)
PH Traffic	10.200 passengers
Number of trains	30 (including reserve)
Capacity of 12 trains with 2800 passengers	33.600 pass/hour
Capacity reserve	3.3
Comfort	air conditioning

The Regional Service will have to abide by the constraints of other services with which it coexists. Accordingly, the precise specifications of the future infrastructure will have to be prepared in close coordination with the future railway line. The regional service will be a component of the railway system.

III.3.3 Metro Urban Lines

III.3.3.1 East-West Axis (MA line)

The first urban metro line follows an East-West axis and meet the very high radial demand generated by the close East/South-East suburbs. It is a "fork-type" line whose first branch serves Antélias, Jal El Dib, Jdaideh, Borj Hammoud, Sin El Fil; and whose second branch serves Hazmieh, Chiah, Ain Roummaneh and Furn El Chebbak.

These close suburbs are featured by a high similar trip demand towards Achrafieh, BCD and Hamra. Concentrating this demand along the same mass transit facility in Municipal Beirut appears wishable and realistic.

A) Alignment, served neighborhoods and stations

The alignment of the proposed MA line is drawn along a corridor serving the main following axes or development poles (see map 5 and precise 1/10000 alignment in the technical file annexed to this report)

- Nahr El Mott Terminal Station (transit with R1, SC2 and SC3 lines)
- Sin El Fil Boulevard,
- New Borj Hammoud Boulevard,
- Former railway track in Borj Hammoud,
- Beirut Central Station (NBT) (transit with R1 and MB lines),
- Achrafieh (Sassine Square),
- Independence Avenue,
- Sodeco Square, (transit with SC3 line)
- Damascus Road,
- Martyrs' Square, (transit with SC3 line)
- Riad El Solh Square (transit with MB line),
- Michel Chiha Street,
- Banque du Liban Street,
- Hamra Street, (transit with SC1 line)
- Tannoukhine Street,
- Renaissance Stadium (Ras Beirut).

The South-East branch of MA line follows the large existing thoroughfares of Hazmieh - Chiah Boulevard and Tayouneh - Hadath Road (between Chiah and Ain Roummaneh). These streets have been much damaged during the war and they need upgrading. The construction of a mass transit line featured with a strong positive image will be very fruitful. An extra meshing is ensured with the railway line close to the future Hazmieh Regional Secondary Center.

The alignment of the two branches (Nahr El Mott - NBT and Hazmieh - NBT) converges towards Beirut Central Station (NBT) from where they are joined in a common line towards Sassine Square. Two big structures (a viaduct and a tunnel) will allow to link NBT station and Achrafieh before crossing underground all Municipal Beirut via BCD and Hamra.

The total length of MA line is 17.2 km: 6.5 km for the common track, 6.2 km for East branch and 4.5 km for South-East branch.

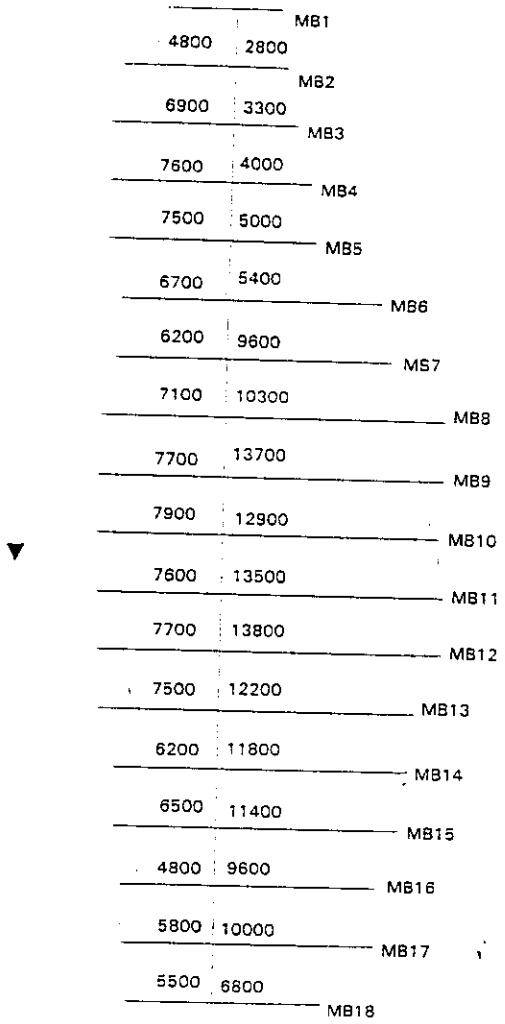
B) Future Traffic

The following table summarizes the network assumptions used to evaluate the traffic of MA line at morning peakhour. For more details about modeling and simulation, a specific technical report is provided in appendix.

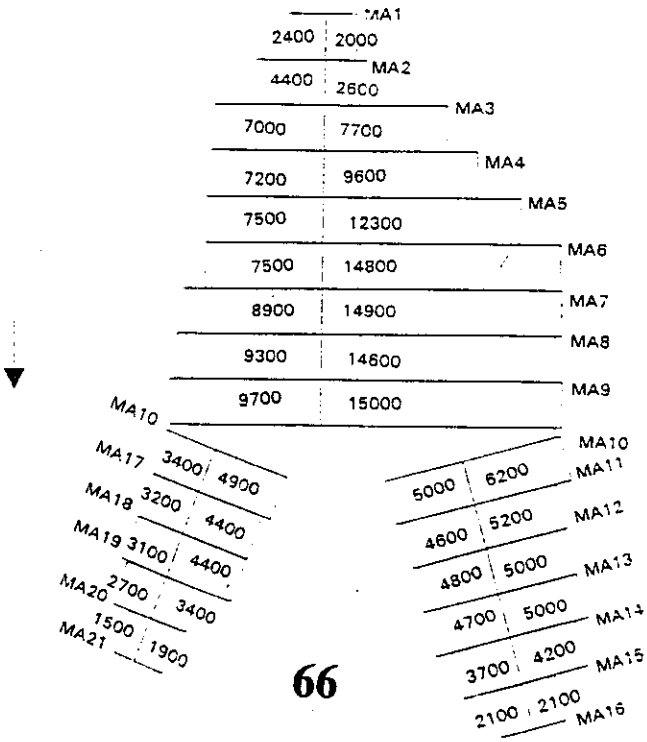
	Length (km)	Number of Stations	Interval Between 2 Trains	Commer-cial Speed	Total Duration	Cumul. Travel Duration
Common track	6.5	10	3'	28 km/h	14	14
Nahr El Mott Branch	6.2	6	6'	32 km/h	20	34
Hazmieh Branch	4.5	5	6'	30 km/h	9	23

Sketch 5 on following page shows the load diagram of the 2 urban metro lines, and notably that of MA line.

URBAN METRO LINE MB
LOAD DIAGRAM AT MPH, YEAR 2015



URBAN METRO LINE MA
LOAD DIAGRAM AT MPH, YEAR 2015



The simulation results show that the section NBT - BCD will be loaded between 12.000 and 15.000 passengers at mph. This load decreases all along Hamra. The most loaded interstation is located between Sassine and NBT, confirming the high interest of a mass transit direct connection between Municipal Beirut and the close suburbs situated at Achrafieh hillfoot. Another positive point is supplied by the balance of traffic between the two suburban branches. Both branches will accommodate nearly the same traffic and this will facilitate the operation of the line.

Load of the loadest intersection at mph	15000
Daily boardings on line	341900
Average distance of trip on line	3.9 km
Average trip duration	8.6 minutes

III.3.3.2 North-South Axis (MB line)

The second metro urban line MB follows a North-South axis corresponding to a high demand at any horizon of the Transport Plan (medium term and long term). In the short run, the demand along this corridor is the heaviest of the future mass transit network. In the long range, existing demand between South Suburbs (Borj El Brajneh, Hay Esseloum) and West Beirut will be enriched by a new demand towards BCD. The traffic towards West Beirut will relatively decrease in favor of a BCD oriented demand: this confirms the necessity of a quite direct alignment between Coca Cola and BCD.

Localizing the Eastern Terminus of MB line in St. Michel Railway Station meets the serving needs of that area and allows to mesh MA line with the Railway line.

A) Alignment, served poles, stations (see map 5)

A detailed 1/10000 alignement is given in the technical file annexed to this report. See also map 5

To the South, MB line leaves Hay Esseloum according to an East-West direction to reach the railway line along the Lebanese University. It follows the railway in a common platform till it crosses the new Boulevard linking Hadath to

the Airport (Cocody), serving the future Laylakeh Secondary Center (R1 line). Then, the line comes back to Borj El Brajneh along Hadath - Cocody Boulevard. A branch of MB line towards the Airport had been first proposed along this Boulevard. It has been given up due to the low traffic on this section. Airport service will be ensured by autobus along existing or future road network (notably Airport Boulevard). After a new 90° turn, the line becomes underground and gets back to a South-North direction. It leaves this road in Chatila Roundabout and crosses Chatila neighborhood to be following Soleiman Boustany and Habib Abi Chahla streets (SC3 line). It serves the Arab University and gets close to Sport City by less than 400 m.

The connection between Coca Cola and BCD is ensured via Mar Elias and Maurice Barrès streets till Riad El Solh Square where a transit is organised with MA line. The crossing of BCD area (between Maurice Barrès street (South-West Gate) and Pasteur street (East Gate) is submitted to numerous insertion constraints due to land and underground use and to the low altitude of natural ground (3-4 m) when approaching the new land fill development site. The proposed alignment follows Etoile Square and Allenby street before getting East towards Charles Helou street. East of BCD, MB line follows Pasteur street and Fleuve street till St. Michel Terminal station (R1 line).

B) Future Traffic

Traffic forecasts have been done with the same network assumptions as used for MA line.

Lengtn (km)	Number of Stations	Peak Hour Headway	Commercial Speed	Total Duration	Average Inter-station
14.4	19	3'	28 km/h	31'	800 m

Ridership of the most heavily loaded interstation at AM peak hour	13700
Daily boardings on MB line	392300
Average trip length on line	3.6 km
Average trip duration on line	7.8 min.

Traffic structure (see sketch no. 5) on this line does not differ very much from the results obtained on East-West line ... even if the average trip distance on line is a little lower and shows a more "proximity" use. Two extremes can be observed on the line, the first one near BCD, the other one around Coca Cola. An intense internal traffic can also be observed inside the Southern suburbs.

III.3.3.3 Technology Choice

A) Possible Technologies

Warranting a good accessibility to everybody implies that mass transit takes a significant share of trip market. It requires that the mass transit system of GBA should use a technology well appreciated by future users. Such an image will be obtained only if the selected technology is accessible, fast, comfortable and reliable.

Given the volume of traffic to carry at peak hour, three urban mass transit technological choices are liable to answer the question. They consist of:

- Mass Rail Transit (MRT),
- Automated Guideway Transit (AGT),
- Light Rail Transit (LRT).

MRT is devoted to serve the heavy axes of metropoles over 1 millon inhabitants. It circulates on its own platform in a completely protected right of way. Electrical supply is provided by a third rail, contributing to reduce the tunnel clearance. Railway generally rolls steel on steel but pneumatic rolling has been used to improve the operation of classical metros. Tyre rolling increases adherence, allows to climb up steeper slopes (till 8% instead of 4% with a rail MRT) and permits faster speeding up - slowing down (better commercial speed). It also reduces noise and vibrations for neighboring buildings.

MRT trains can offer a unit capacity of 1.500 places and they can accomodate traffic up to 60.000 passengers by hour.

AGT is the closest technology to that of classical metro. It consists of a tyre rolling, small size and automatic metro liable to circulate with a frequency of 1 train per minute. Maximum traffic (with two 30m wagons) can reach 24000 passengers per hour. Its small size allows larger insertion possibilities.

LRT is part of the so called "pre-metro" system that circulated on a dedicated right of way, more or less protected. LRT right of way can be mingled with general road traffic or completely isolated (as it is the case in downtown areas where they are generally put underground) if insertion constraints are very tough.

Maintaining a possible onground insertion and a possible mixing of LRT track and road traffic has a number of consequences:

- electrical feed should be provided by pantographe and catenary,
- rolling way should be rail rolling,
- trains should be shorter and narrower,
- technical outputs regarding reliability, commercial speed and capacity are lower than those obtained with AGT and MRT.

The characteristics of the possible mass transit technologies liable to be used in Beirut are presented in the following table. Quoted figures come from reference data concerning existing mass transit systems in various cities.

	MRT (Rail)	**MRT (Tyre)**	**AGT**	**LRT**
Use range of system (thousands of passengers/ph)	15 to 60	15 to 60	10 to 25	10 to 25
Minimum headway	85s	85s	60s	60s
Steering	assisted	assisted	automatic	manual
Commercial speed (km/h)	28 to 35	28 to 35	30 to 35	18 to 25
Type of dedicated track	integral	integral	integral	partial
Rolling stock clearance (m)	2.5 to 3.2	2.5 to 2.9	2.0 to 2.6	2.0 to 2.6
Train length (meter)	50 to 200	50 to 200	30 to 60	30 to 60
Maximum slope (%)	4%	8%	7%	6%

B) **Comparison Between Technological Choices**

The following table collects 13 criteria allowing to compare the different technological choices. They have been assessed from the special Beirut case. The valuation is growing: the more the "+" symbols are numerous, the more the technology is adapted to Beirut constraints.

	MRT (Rail)	MRT (Tyre)	AGT	LRT
Reserve capacity (compared t ridership forecasts)	+++	+++	+	+
Frequency	++	++	+++	+++
Commercial speed	+++	+++	+++	+
Regularity	+++	+++	++	+
Station accessibility	+	++	++	+++
Insertion	+	++	++	+++
Noise disturbances	+	+++	+++	+
Interference with road traffic	+++	+++	+++	+
Saving on civil engineering works	+	+	++	+++
Savings onInvestment costs	+	+	++	+++
Savings on equipment costs	++	+	+	+++
Savings on rolling stock cost	+++	+++	++	+
Total amount of +	23	26	25	20

Capacity Reserve: Given its nominal capabilities, MRT can be overdimensioned in a first stage of execution, without using all its potentialities.

Frequency: The advantage brought by high frequency little vehicles deserves to be noted. They provide a quasi continuous servicing that is very interesting with a "fork line" operation.

Commercial Speed: With a completely dedicated and protected right of way, the differences regarding commercial speed depend on the interstation distance.

Regularity: Light Metro (LRT) has a double disadvantage compared to MRT. Using an only partially dedicated track, it is very dependent on road traffic and it would operate in Beirut in a poor way (a double train every minute appears quite impossible to ensure without any disturbance). In the

same way, AGT would be also very much depending on traffic disturbance.

Station Accessibility: Two elements condition station accessibility: the interstation distance and their depth when they are underground. LRT system can accept ground level and close stations. In case it would be put underground, stations would be settled at ground level. Due to the quality of tyre rolling insertion conditions, tyre rolling MRT gets a clear advantage over rail rolling MRT and AGT: stations can be located very close to ground level.

Insertion Ease: Insertion constraints are heavy in Beirut due to a very steep topography (see sketch no. 8) and to the narrowness of a number of corridors. Tyre rolling much facilitates the establishment of track profile. The feasibility of a rail rolling metro appears very problematic in Beirut, following the proposed alignments. By means of a reduced clearance, AGT provides an extra advantage for the alignment track. In spite of a rail rolling technology, LTR climbs up steeper slopes and can accept tighter turning radii.

Noise and Vibration: In this field, tyre - rolling is largely the best solution.

Interference with Road Traffic: Integral on site dedicated track is the best solution but it obliges to avoid any interference with road traffic.

Civil Engineering Investment Costs: The clearance required for MRT disadvantages this technology compared to AGT and LRT. Adopting an integral on site dedicated track for AGT would improve civil engineering investment cost, compared to LRT. Otherwise, track operation constraints require a geometrical and mechanical harmonization of the rolling stock used for the different services (regional trains, long distance trains, goods trains) in order to get compatible operations outputs.

Equipment Cost: AGT automatic regulation system weighs the cost of equipment. Tyre rolling is also a cause of higher cost. Accordingly, rail rolling MRT would be the cheapest for this criterion.

Rolling stock cost: The price of a train-unit does not vary very much according to the retained technology. The number of train-units depends on two factors: first the frequency to ensure to meet the demand, secondly the commercial speed of the selected system. LRT system has to take account of the two factors. AGT system should take only account of frequency.

From the previous classification, tyre rolling appears very attractive in the case of Beirut agglomeration. A tyre rolling MRT technology would be very interesting. Its main interest is linked to the high capacity reserve it provides. LRT technology could be an interesting solution from an economical point of view under the express condition that it could benefit from a part of the road network: this would mean a decrease of traffic capacity for private vehicles which seems difficult to obtain in the case of Beirut.

Otherwise, Beirut agglomeration concentrates 1/3 of total Lebanon population and at least an equal part of job supply. For such a metropolis, the construction of two MRT lines (about 32 km) appears quite reasonable. Regarding the servicing, the two MRT lines, would serve (along a 1 km wide corridor axed on the lines) about 900.000 inhabitants and 400.000 jobs in 2015, that is 28.000 inhabitants/jobs per km of line. As a matter of comparison, it can be observed that Lyons and Marseilles, cities which population exceeds 1 Million and regional capitals, are served by respectively 15 km and 18 km of MRT line: servicing rate by km of line (inhabitants/jobs) is 26.000 in Lyon and 23.000 in Marseilles. The AGT system (VAL) operated in Lille, (another large agglomeration), crosses much less dense areas and the servicing rate only arises to 12.000 inhabitants/jobs per km of line.

In conclusion, the proposed technology for future Beirut Metro system will be a tyre-rolling technology.

C) Rolling Stock

The target is here to define a rolling stock choice liable to meet future 2015 demand and to warrant capacity reserve for the very long term. The capacity of the system should be able to be increased without being obliged to develop new infrastructure works but also without having to oversize them too much at the early beginning.

Following demand needs should be first ensured by a convenient operation of the system and, more precisely, by a good management of train frequency. A frequency of 24 trains per hour leads on the East/West fork line to an interval of 5 minutes on each branch. This frequency appears quite fitted to the 2015 traffic forecasts.

Train capacity is directly obtained from the previous constraints. With a flow target of 15.000 passengers on the most heavily loaded section of the line and with a frequency target of 24 trains per hour, each train will have to carry 625 passengers.

Rolling stock geometrical dimension should be relied on when defining infrastructure. The critically rolling stock choice should have been linked with the research of the best compromise between level of servicing and investment cost. Practically, this choice is often dictated by the industrial possibilities and the market. In order to be concrete, only the choices offered by existing rolling stock will be explored. This will not engage later decision.

Marseilles Metro system is well fitted to Beirut constraints, as they arise from the progress stage of studies. It is made up of tyre rolling MRT whose train units are 2,6 m wide and 15 m long. A four-unit train (65 m long) can carry 760 passengers (with 8 people by m^2) or 624 passengers in better comfort conditions (6 people/m^2).

III.3.3.4 Predimensioning of Urban Service

As previously indicated, both future Beirut urban metro lines are featured with very similar characteristics, regarding trip structure and insertion constraints. The same technology will accordingly be proposed for both lines. The following table describes the technical specifications of the future metro system of Greater Beirut.

Maximum speed	80 to 100 km/h
Steering	Automatic and/or manual
Electric traction	Third rail
Electric feed	600 VC - 750VC
Rolling stock width	2.60m
Train length	65m
Peak hour headway, by direction	2.5 mn
Train capacity (6 people/m2)	625 passengers
ph flow (24 trains/hour)	15000 passengers
Maximal flow (45 trains/h and 8 people/m^2)	37500 passengers/hour
Capacity reserve (line MA)	2,5
Capacity reserve (line MB)	2,7
Number of trains (line MA)	35
Number of trains (line MB)	35
Comfort level	Air-conditioning

III.3.3.5 Infrastructure

A) Alignment Constraints

Maximum slopes to be accepted are 8% for current track and 0.4%" in the stations (that is over 70m length).

In a current section, the minimum horizontal rays will be 150 m (general case) or 100 m (in some exceptional cases).

The clearance necessary to accommodate a double direction rolling stock (with all signalization and safety equipment) is 8 m wide and 5 m high. The total right of way of corresponding infrastructure is defined according to the execution methods.

Detailed typical sections of underground infrastructures are given in the technical file annexed to this report.

With an air crossing, the proposed system can be accommodated on a 9 m wide platform.

C) Stations

The present chapter aims at recalling a number of basic concepts about station design and at providing a first dimensioning of projected station. Concept principles are various and they should fit to the selected construction methods. They should integrate geological constraints, town planning constraints (width of street, development or reconstruction programs), political constraints, ...

A station is made of different functional areas:

- decks whose length depend on train length (a 70 m long, 6m width size will be retained),
- access areas for passengers: corridors, mechanical stairs, lifts,
- ticket delivery and control areas,
- technical areas for maintenance and staff.

Sketch 7 on following page shows a typical station organization.

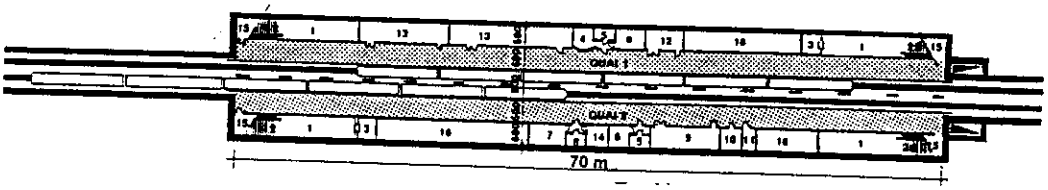
Four large types of stations can be distinguished (see sketch 6 folowing page):

- aerial or ground stations are the cheapest but they can be executed only if allowed by urban fabric (street width),
- underground shallow stations are settled at low depth (-6 m). They are quite accessible for travelers, but they oblige them to get out of the metro station to take another direction (except if a transit corridor is built under the platform),
- deep underground stations (-9 m). They keep a quite good accessibility for travelers, and they allow the creation of a mezzanine between street level and platform level,
- very deep underground stations (-15 m) are linked with heavy alignment constraints (due to underground use) or with an accidented relief.

FUNCTIONAL AND TECHNICAL SYSTEM OF STATIONS

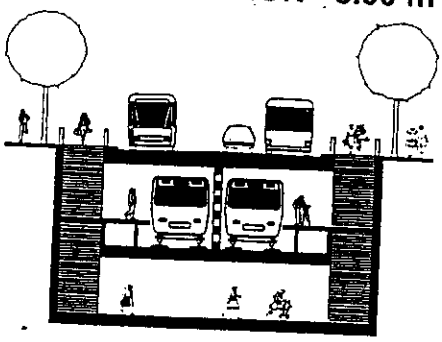
SKETCH 7

1 - Sale and cheking of tickets and passes
2 - Passenger's access
3 - Ticketing agent office
4 - Station suspervisor office
5 - Maintenance Area
6 - Equipment Area
7 - Rest Area
8 - Rest Rooms
9 - Transformer Room
10 - Batteries Room
11 - Low voltage - Electronics Area
12 - Electronics Area
13 - Ventilation and Airconditioning Area
14 - Water pumping station
15 - Escalator equipment
16 - Activity or vending Area

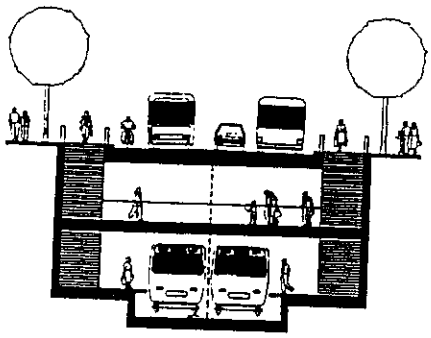


الجمهورية اللبنانية
مكتب وزير الدولة لشؤون التنمية الإدارية
مركز مشاريع ودراسات القطاع العام

UNDERGROUND
SHALLOW STATION - 5.00 m

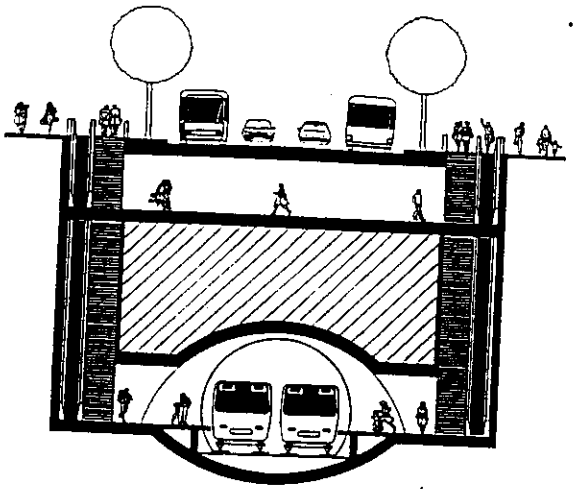


UNDERGROUND
DEEP STATION - 9.00 m

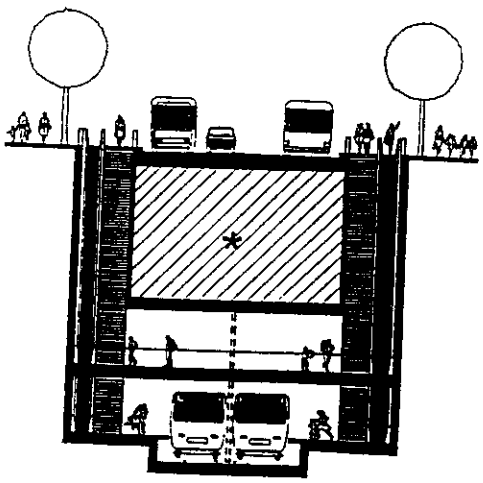


VERY DEEP STATION IN TUNNEL - 15.00 m

KETCH 6



VERY DEEP STATION - 15.00 m



III.3.3.6 Insertion Constraints and Opportunities

Profiles provided on sketch 8 following page illustrate well the constraints caused by the steep topography of Beirut. On both metro lines, slopes reach their maximal admittable value (8%) with a tyre rolling system; if stations are kept near ground level.

Ground or viaduct alignment opportunities are not very frequent on line MB: they can be found only to the south, along the railway line and Lebanese University.

MA line provides more insertion opportunities of that kind :

- on Nahr El Mott branch, first using the former railway track from NBT station to the entrance of Borj Hammoud; and secondly using Sin El Fil boulevard from Borj Hammoud Stadium to Nahr El Mott;
- on Hazmieh branch over Sami Solh avenue and Omar Beyhum street.

The following table breaks down the different types of insertion according to the type of structures and to the line (MA, MB).

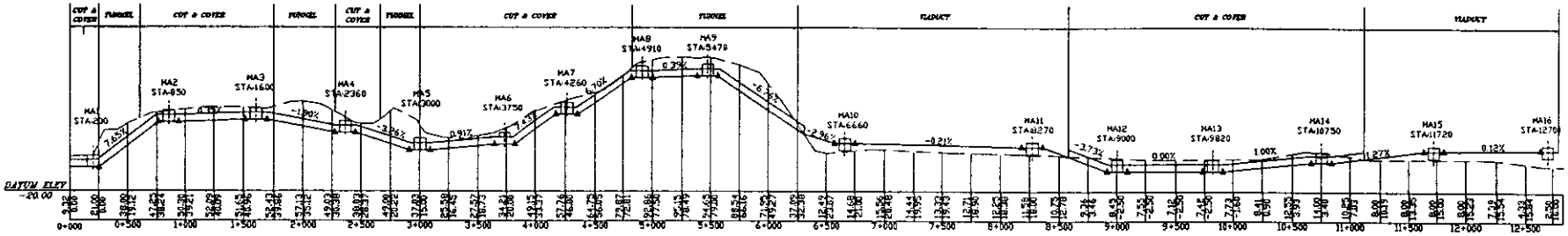
Type of Infrastructure	Line MA	Line MB	Total
Ground level	0	300 m	300 m
Viaduct	7500 m	1150 m	8650 m
Cut and cover tunnel	6. 00 m	12050 m	18550 m
Deep tunnel	3650 m	1000 m	4650 m
Total	**17650 m**	**14500 m**	**32150 m**

It deserves to be noted that 45% of MA line track can be built on ground level or viaduct, compared only 10% for MB line. 85% of the track of MB line can be in cut and cover tunnel.

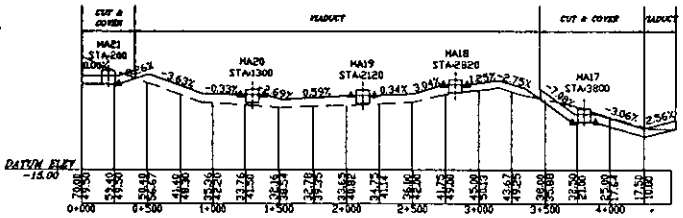
A number of conflict points can be met along the track of both lines. Conservatory protection measures should be taken from now to avoid later insertion problems.

LINE MAa

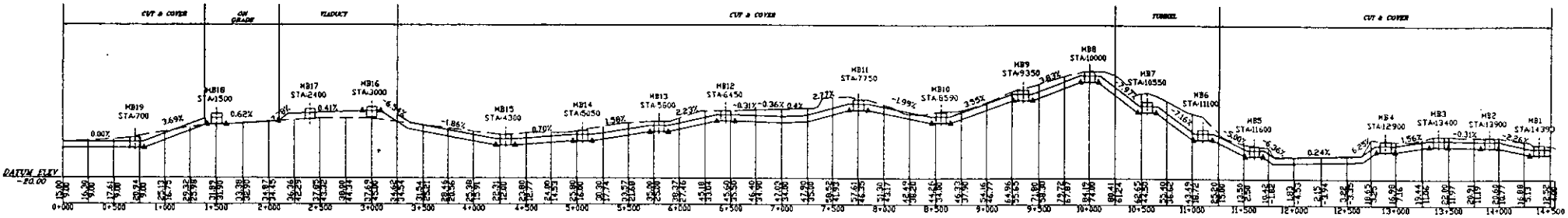
LINE MAb



LINE MAc



LINE MB



LEGEND

NATURAL GROUN

METRO LINE

STATION

These "conflict points" are given hereafter:

A) MA Line (East-West)

- The terminal station of MA line is proposed to be located in Ras Beirut under an estate devoted to be developed as a Conference Center (that it would ideally serve). Ground surface needs regarding a terminal operation (station, train garage and maneuvers area) total 5000 m^2. They should be integrated from now in the design of this facility.

- BCD is presently the subject of intense reconstruction works and things are going quickly. Decisions regarding the insertion of MA line in the project should be taken as soon as possible. BCD managers endeavour to get the best return rate of the real-estate they should develop, and they cannot freeze large pieces of land without any guarantee for a better future use. They can also be worried to have to dig again the streets they are presently upgrading, when the metro is built. For MA line, conflict points are located at Damascus - Amin Bachir crossway. The metro track will turn by 90° in that place. Given the maximum admissible radius that MA line can accept (100 m), the line will be obliged to pass underground of two clusters presently unbuilt, but devoted to be built in the future.

- NBT MA station will necessarily be built on a viaduct over the railway station. Indeed, MA line should leave Sassine square at a 75 m altitude, and the slope constraints will not allow to put NBT station on ground. Moreover, this station will be the node of the two branches going to Nahr El Mott and Hazmieh. Constraints will be numerous in that place, and a strict coordination of all projects will have to be ensured.

- Borj Hammoud crossing will mainly use the former railway track, but large road infrastructure works are about to start between Achrafieh and Sin El Fil (new Borj Hammoud Boulevard). These works will entail numerous modifications regarding sanitary networks; and they will be accompanied by the construction of side lanes that will

complicate the future insertion of MA line. MA line alignment should be approved quickly and integrated as a constraint for the design studies of the new Boulevard (presently in progress).

- The areas of Ain Roummaneh and Chiah crossed by MA line should be upgraded due to war damage. The metro line alignment should be integrated into the rehabilitation projects in order to alleviate later implementation costs and to make these areas benefit from the positive impact of a metro line.

B) MB Line (North-South)

- BCD is again a conflict point. MB line will meet a number of difficulties when entering the reconstruction area, coming from East: the alignment should be as close as possible to the future Business Center projected on the land fill area; but the level of natural ground is 2 m over sea level along this alignment. Two issues will be met:

  - underground structures will be located below the water table, increasing the cost of construction;
  - many underground constraints make the definition of the future alignment difficult.

  Given these considerations, the proposed track "Riad El Solh square - Etoile square - Allenby street - new East-West Boulevard" appears realistic. It will nevertheless requires a turning radius slightly under 100 m to enable the line to take an eastern direction towards Pasteur street. This track crosses an unbuilt cluster and it imposes underground right of way reservations to preserve the future execution of MB line.

- The connection between Mar Elias street and Abi Chahla street (south of Corniche Mazraa) will raise also some difficulties if the still unbuilt plot located at the north east corner of these two axes is developed without taking into account the turning radius constraints of the metro line.

- The connection between Soleiman Boustany street and Chatila roundabout will be done underground, under the existing cemetery. An aerial track could however be

proposed in the framework of the rehabilitation program concerning this neighborhood, following the Rocade Urbaine Nord alignment.

- To the south, after crossing Borj El Brajneh, the line makes a 90° direction change towards Laylakeh. MB alignment is proposed to follow the Haddath-Cocody Boulevard. A good coordination will have to be searched between these two projects. In the same way, the integration of MB line on a platform common to the railway line will have to be carefully studied between Laylakeh and Lebanese University.

III.3.3.7 Depots, Workshops and Maintenance Areas

Two functions should be integrated in the metro system:
- train depots,
- equipment maintenance.

The level of detail of the Transportation Plan does not require to describe the precise organization of these two functions, but land needs should be assessed in order to dimension and propose the location of these maintenance and parking areas.

A) Train Parking

In each terminal station, a minimum number of trains should be parked in order to avoid dead runs at starting and closure time. The number of trains to be parked is linked with the line frequency, the travel time of a train on this line and working conditions of employed staff. A larger depots zone should also be reserved in maintenance workshops area.

B) Maintenance

Maintenance works require heavy and expensive equipment that should be rentabilized to the maximum. The so-called "Large Revision Workshop" will be preferably common to the two lines: this constraint imposes that MA and MB lines be connected. The railway line between NBT and Laylakeh could be used for that purpose.

C) Total Needs

Several locations should be searched:

- one for the "Large Revision" workshop,
- five others for parking areas close to the five terminal stations of the network.

The number of necessary trains will be 35 for each line, that is 70 in total.

The following table provides an estimation of necessary areas, and proposes the location of the six sites (see maps in the technical file annexed to this report).

Location	Depots (ha)	Maintenance (ha)	Total area (ha)
Ras Beirut (MA line)	0.45		0.45
Nahr El Mott (MA line)	0.65		0.65
Chiah (MA line)	1.35	2.0	3.35
Hazmieh (MA line)	0.27		0.27
St. Michel (MB line)	2.07	2.0	4.07
Hay Esselom (MA & MB lines)	1.08	10.0	11.08

III.3.4.5 Complementary SC Lines

Three secondary SC lines will complete the metro network in areas whose servicing does not require an integral on-site dedicated technology. An efficient trafic control policy will have to be ensured along the selected routes.

III.3.4.1 Beirut Ring Line (SC1)

Starting from Mkalles roundabout, SC1 line ends up at American University. It is foreseen as an on-site dedicated bus line. Further insertion studies will fix the level of protection. The main role of SC1 line is to provide a good quality ring servicing along the strong Corniche Mazraa axis and to ensure the connection between South Beirut neighborhoods. It will serve:

- Mkalles Roundabout, (transit with SC2 line)
- Alba Roundabout,
- NBT Central Station, (transit with R1 and MA lines)

- Justice Palace Square,
- National Museum,
- Barbir, (transit with SC3 line)
- Mazraa, (transit with SC3 an MB lines)
- Verdun,
- Abdel Aziz Street, (transit with MB line)
- Bliss Street,
- American University.

III.3.4.2 Inner BPB Ring Line (SC2)

This on-site dedicated bus line starts at the road station and multimodal Terminal of Nahr El Mott (R1 line and MA lines). It follows the track of BPB till Hazmieh after crossing SC1 line in Mkalles. It exchanges with MA line in Hazmieh from where it follows Chiah Boulevard till Sultan Ibrahim. Along Chiah Boulevard, transit is possible with:

- the railway line and MA line in Chiah,
- MB line in Ghobeiry,
- SC3 line in Bir Hassan.

SC2 line has a clear ring vocation connecting together the suburbs of Beirut. It uses road axes whose right of way is sufficient to be shared between vehicular traffic and mass transit traffic.

III.3.4.3 North-South Radial SC3 Line

This radial line completes the metro service between South-East Beirut suburbs and BCD. When crossing Ouzai and Jnah, the alignment use the side lanes of Ouzai Penetrator, in the heart of future development zones. North of Jnah, it follows boulevard de la République, crosses Coca Cola and takes Borj Abi Haidar street till Corniche Mazraa. On Corniche Mazraa, it uses the same dedicated site as SC1 line up to Barbir. It uses then Bechara El Khoury till BCD and Martyrs' square.

SC3 line is well meshed with the other strong axes of the network:

- MA line in Coca Cola and BCD,
- MB line in Sodeco and BCD,
- SC1 line along Corniche Mazraa.
- SC2 line in Sultan Ibrahim

III.3.4.4 Recapitulation

The following table summarizes the main features of the devoted sites bus lines (SC1, SC2, SC3). The peak hour traffic traffic will require using a vehicle whose capacity will be larger than the one of a standard autobus (100 people). An articulated vehicles solution will be the best.

	SC1 Line	SC2 Line	SC3 Line
Length of line	8.5 km	10.5 km	7.7 km
Commercial speed	20 km/h	20 km/h	20 km/h
Peak hour headway	3'	2.5'	3'
Peak hour ridership	2500	3900	3200
daily boardings	51200	121500	169200
Average trip length on line	1.9 km	2.9	1.8 km
Vehicle needs	25	35	24

III.3.5 Road Stations and Transport Terminals

As indicated when presenting the Long Term Road Network, the return-rate of a Mass Transit network also much depends on the exchange system that links its various components. Transit should be systematical between the different lines that cross together, and it should be provided in a comfortable and easy way. In the same way, intermodal exchange (road - mass transit) should be facilitated in order to encourage people to use the mass transit system. The creation of large and well designed intermodal transportation Terminals requires well planed space.

Without entering the functional details of the proposed Terminals, it is necessary to evaluate their surface needs and their location. Land costs are very high in Beirut, and they will have to be included in the total investment cost of the system. Real estate pressures are very intense in many parts of GBA,

and land conservation measures should be quickly taken to protect the selected sites.

The table hereafter provides, for each exchange pole, the surface to be reserved in the future. In addition to urban mass transit needs, interurban bus terminals needs have been evaluated as well as a number of park and ride facilities that can encourage private car users to use public transport.

Exchange Pole	Area for Urban Mass Transit	Area for Interurban Mass Transit	Car Parks for Private Cars
Antélias	800 m^2		200 cars
Nahr El Mott	2000 m^2	3000 m^2	500 cars
Dora	4000 m^2		100 cars
St. Michel Station	1200 m^2		
NBT Station	3000 m^2	400 m^2	500 cars
Chiah Station	1200 m^2		
Laylakeh	2000 m^2	5000 m^2	500 cars
Khaldeh	800 m^2		200 cars
Total	11.400 m^2	8.400 m^2	2000 cars

These areas meet the strict technical needs of exchange poles. They correspond to a minimum, specially in three sites that should play a major role in the future organization of GBA road and transportation system: Laylakeh, Nahr El Mott and NBT.

Laylakeh will be the large South Gate of the Metropolitan Region when Damascus Highway, East Penetrator and BPB are constructed, combining a railway service, a metro service and an intercity service. Nahr El Mott will play a similar role on the North Gate of GBA. In these two sites, transport functions will be prominent, but they will not be the only ones... Commercial activities, facilities and business centers could be located in the vicinity of the transportation Terminal... They would allow to get a better return of public investment and contribute to a better urban organization of Beirut suburbs. Large scale urban development projects should be prepared in these areas, covering a much larger surface than that of the transportation facilities.

NBT will also play a great role in the future at the connection point of the two branches of MA metro line and of the railway line (Central Station). It will also benefit from a very good road servicing by means of Justice Palace Penetrator and Sin El Fil Penetrator. The linkages of these highways with the local road network will have to be carefully designed so as to provide NBT site with a convenient access. The whole NBT site should be put under study and design and development studies should be launched as soon as possible.

III.3.6 Network Operation Output

The table hereafter collects the overall results of operating conditions provided by the Mass Transit network proposed in the Long Term Plan according to the same indicators as used in the two basic Scenarios.

RAIL-METRO (R1, MA, MB)	number of lines	3
	network length (km)	71
	investment cost (millions US $)	2321
	seat x km supply (millions/year)	3.100
	annual traffic (millions)	260
	AM peak highest interstation traffic	15.000
OTHER LINES (SC1, SC2, SC3)	number of lines	3
	network length (km)	27
	investment cost (millions US $)	125
	seat x km supply (millions/year)	410
	annual traffic (millions)	79
	AM peak highest interstation traffic	4.700
TRUNK MASS TRANSIT NETWORK	number of lines	6
	network length (km)	98
	annual traffic (millions)	335
	seat x km supply (millions/year)	3.510
	investment cost (millions US $)	2446
BUS NETWORK	annual traffic (millions)	143
	investment cost (millions US $)	70
MASS TRANSIT MARKET SHARE	whole GBA %	27
	BUA internal trips	47
	trips between AUB and Rest of GBA	11
AVERAGE TRIP DURATION	(minutes)	36
AVERAGE ACCESS TIME AT AM peak	BCD	30
(minutes)	Airport	51
	Nahr El Mott	36
	Hazmieh	36
	Laylaké	40
	Khaldé	46
TRAVEL DURATION AT AM peak	BCD/Airport	49
(minutes)	Nahr EL Mott/Khaldé	44
	Ras Beirut/Antélias	52

In a general way, the overall attributes of the LTP Mass transit network are slightly under the similar results obtained with Scenario A, but they remain quite satisfactory. Regarding the specific operation of the various components of Mass Transit network (regional line, urban metro lines, SC lines, etc.), main findings are gathered in the previous chapters presenting the network.

III.3.7 Investment Cost

The evaluation of investment cost presented hereafter has been made on homogeneous bases. Civil engineering costs are based on France costs, scaled down by 30% (from the comparison between similar recent works in France and Lebanon). A provision of 10% of total works amount has been done to take account of possible network diversion. Regarding equipment, they have been taken at their France cost. All prices have been converted into US$ (with 5 FF/$).

The following table presents the investment costs (in million US$) according to the type of cost and to the lines.

Line	Civil Engin.	Fixed Equipment	Rolling Stock	Land Purchase	Total
R1	270	89	175		534
MA	559	160	127		893
MB	485	131	127	47	832
SC1	31	4	7	89	42
SC2	35	5	10		50
SC3	24	3	6		33
Park and ride facilities	4			50	54
Road stations	5	2		11	18
Bus network					70
Total	**1413**	**394**	**452**	**197**	**2526**

Investment costs specific to the two urban metro lines (MA, MB) arise to 1.725 million US$, that is an average cost per km of 54 million $, value quite coherent with similar projects implemented in other countries.

The total investment cost of the Mass Transit system proposed in the Long Term Plan arises to 25 billion US $.

III.3.8 Institutional Organization

The success of a Transport Plan, and more generally of a Transport policy depends much on the institutional and administrative organization that will be set up to implement the technical proposals of the Plan. This is specially true regarding Mass Transit organization in Greater Beirut.

No transportation system deserving really this name exists today in the Metropolitan Region. The Public Transportation Company (OCFTCB) ensures less than 1% of motorized trips, the private Transportation companies accommodate about 9% of daily trips and the bulk of mass transit is actually taken in charge by Taxi/Services (17%) that cannot really meet mass transit needs. The chaotic situation prevailing today will prove to be catastrophic tomorrow with a trip-demand multiplied by 3, unless a new organization be set to plan, regulate and control public transport.

The large extent of present difficulties and the very low level of servicing offered by the various components of Greater Beirut Mass Transit system should lead to closely link short term, middle term, and long term institutional proposals. A long range and continuous process should today be engaged. The proposed organization should be able to answer the various deadlines of the plan and to follow the technical evolution of the Mass Transit system proposed at these various dates.

III.3.8.1 A Prerequisite Step: Creating a TRA

In the Immediate Action Plan Report (Report no. 4), it has been proposed to create a Transport Regulating Authority that would be in charge of the whole passenger transportation issues.

Situated outside existing administration or councils (Conseil Supérieur des Transports, Direction Générale des Transports, Office des Chemins de Fer ...), but depending on the Ministry of Transport, the proposed TRA would have three main missions:

- planning passengers transport according to the development of cities and regions, and ensuring the execution of governmental policy in that field;

- implementing the transport policy: selecting the routes to serve, defining servicing technical specifications, establishing fare system, selecting the operators (after tendering), managing the investment and operating budgets in which public authorities are involved;

- controlling the operation of the system and ensuring that selected operators really fulfill their obligations as defined in the technical specifications.

Relationship between TRA and operators should be subject to contracts in order to clearly share the responsibilities between the actors.

The interest of such an organization is to restore and strengthen the authority of the State by the reconstitution of a jurisdictional framework well adapted to the current reality of public transport and to future needs.

The State would finance fixed investments and organize public transport in a first stage of implementation. The operators (that will possibly include a renovated Public Transport Company is so far as it can compete with private operators, being submitted to the same tendering formula) would execute the service and would have to maintain facilities and equipment put at their disposal.

III.3.8.2 The evolution of the system

Such an organization as described above will remain relevant during the later stages of Transport Plan implementation. Heavy investments will have to be launched . One of the main issues will consist in financing the large Mass Transit system proposed by the Transport Plan (railway line rehabilitation, metro lines, and other light urban lines, in addition to bus network development). The amount of necessary investments has been estimated at 2.5 billion US$. This financing will have to be supplied, either by public funds (in which case operators will have only to maintain and operate the system in the framework of management contracts) or by private funds (in which way, a

franchise contract willhave to be signed with a group of private investors). Mixed formulas will also be possible.

In both cases, TRO will remain the higher contracting authority, able to plan passengers public transport, to implement government policies, to make a choice between bidders, to control the realization of services as well during the construction of the system as during the operation of the network. Whatever would be the juridictional form of the contract, fare policy and fare setting will have to remain in the scope of work of TRA, working as the executive power.

A specific paper is annexed to this report presenting the various envisageable formulas and their advantages and drawbacks.

IV. CONCLUSION

At the end of this report, a number of findings can be highlighted. They can be summarized as follows:

1. Beirut recovery as one of the most attractive metropoles of Near East will not be able to be obtained without huge road and transportation investments. The extent of future needs (5 million motorized daily trips in GBA by year 2015) and the very poor present situation of infrastructure network (due to 20 war years) will impose a constant and severe effort to catch the lost time back and to provide GBA with a road and transportation network fit to this ambition.

   The total amount of investment needed to reach such a target borders 6.5 billion US $ during the next 20 years : 4 billion US $ for the roads, 2.5 million US $ for the mass transit system.

2. "All car" solutions will not be able to meet the whole future needs, and a modern mass transit system should be put in place in Greater Beirut. Beirut agglomeration has the chance to be quite dense inside the limits of the Boulevard Périphérique (200 to 400 inhabitants per hectare). This asset should be used to the maximum. Diversified transportation networks should be constructed to serve the inner BPB area. It will be made of a 38 km long regional metro line (the rehabilitated railway), two urban metro lines (one East-West, another North-South totalling together 33 km), three secondary "on site devoted" urban lines (27 km long in total) and a complementary bus network. It will allow to take 27% of the total GBA motorized trip market.

   The total cost of this program amounts to 2.5 million US $. It can appears high but it includes infrastructure, equipment and rolling stock... to be compared with the cost of the road Long Term network that does not include vehicules... and that is nevertheless much higher.

3. In the absence of a new efficient mass transit system, traffic conditions stand to become unbearable after 20 years. Even with it, they will remain difficult at peak hours.

Numerous constraints (urban, topographic, environmental ...) make today difficult searching new road alignments in Greater Beirut and land is very expensive everywhere. The Long Term road network has proposed to take these constraints into account. It is organized around a major 18 km long highway, Beirut Boulevard Périphérique (BPB), linked with the external areas by means of 5 Long Distance Highways, and connected to the inner area by means of 7 Urban Penetrators and of a complementary network of Expressways and Urban Boulevards. Il will allow to meaningfully improve traffic conditions and it will provide a powerful tool for unifying city and suburbs under however the conditions that it be well managed and that an efficient traffic control policy be implemented at the same time.

The proposed basic network will be 250 km long, and it will cost about 4 billion US $. More half of which will be devoted to land purchase.

4. A Transport Plan cannot be devised and implemented without a complementary town and regional planning policy. This is true in Beirut as everywhere. Future trip needs will be considerable in GBA but means liable to meet them will be measured. To intervene on the demand (upstream) is nearly always much less expensive than to intervene on the supply (downstream).
Internal trip needs can be reduced or rationalized by a more harmonious repartition of jobs and population inside GBA. The 1987 Master Scheme proposed to create a number of new powerful development poles along BPB and at the main nodes of future transport system. This policy should be confirmed and implementation accelerated.
The huge trip needs that will take place along the Northern and Southern corridors can also be lessened if a regional planning policy is applied in Lebanon with the target of reaching a better balance between GBA and the rest of the country.

Present trends regarding housing scattering in the mountains around Beirut and regarding the parallel concentration of activities inside the Metropolitan Region, generate many useless and costly trips that could be avoided. They should be stopped in favour of a more self-sufficient way of development for the different parts of Lebanese territory.

5. Financing needs will be huge to implement the Long Term Transportation Plan. New solutions will have to be explored to meet them. Some new roads proposed in the Long Term Plan will double existing ones. They could be entrusted to the private sector and a toll system be instituted.
   In the same way, the private sector could be invited to participate to developing the new mass transit system as it is currently observed in many world metropoles. Whatever the retained solution, a public Transport Authority will be necessary to be settled in order to plan, organize and control the development of a modern mass transit system.

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