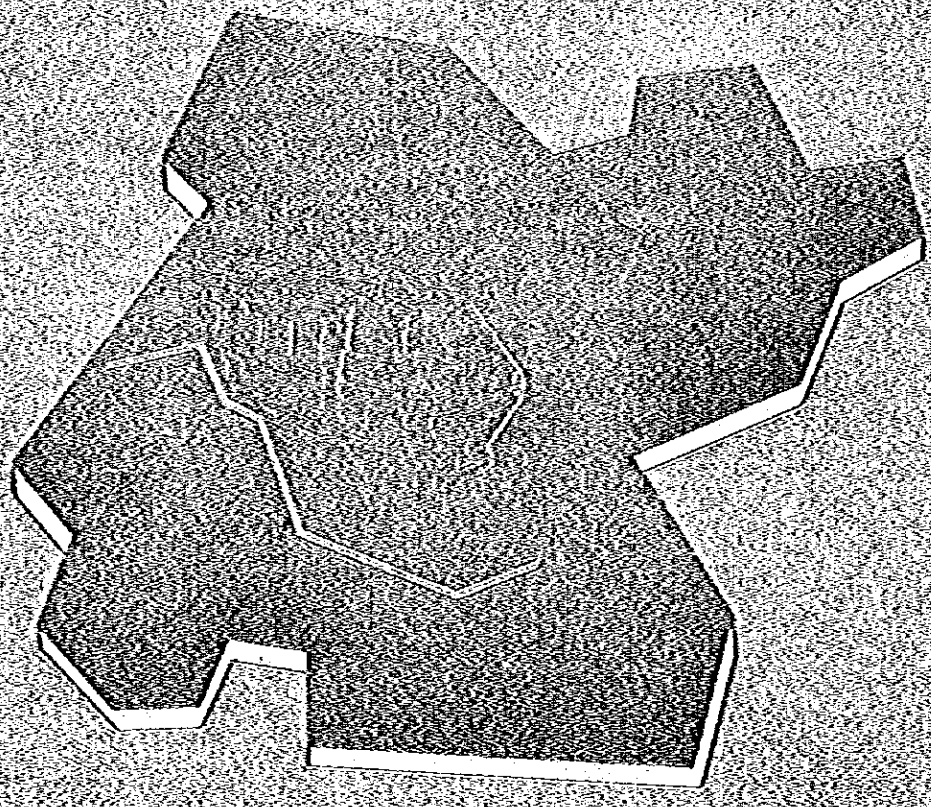
社会開発協力部報告書

No. 08

GUANAJUATO NEW RAILWAY DEVELOPMENT PROJECT IN THE UNITED MEXICAN STATES

FINAL REPORT



DECEMBER 1983

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

No.

GUANAJUATO
NEW RAILWAY DEVELOPMENT PROJECT IN THE UNITED MEXICAN STATES

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(JICA)

PREFACE

In response to the request of the Government of the United Mexican States, the Government of Japan decided to conduct a feasibility study on the New Railway Development Project in the State of Guanajuato and entrusted the study to the Japan International Cooperation Agency (JICA).

The JICA sent to Mexico a study team headed by Mr. Yoshiaki Sato, Director of the Japan Railway Technical Service, in April 1983, under the guidance of the Supervisory Committee chaired by Dr. Takasuke Watanabe, Associate Professor of Tokyo Institute of Technology.

The team held discussions with the officials concerned of the State Government of Guanajuato on the Project and conducted a field survey in Mexico. After the team returned to Japan, further studies were made and the present report has been prepared.

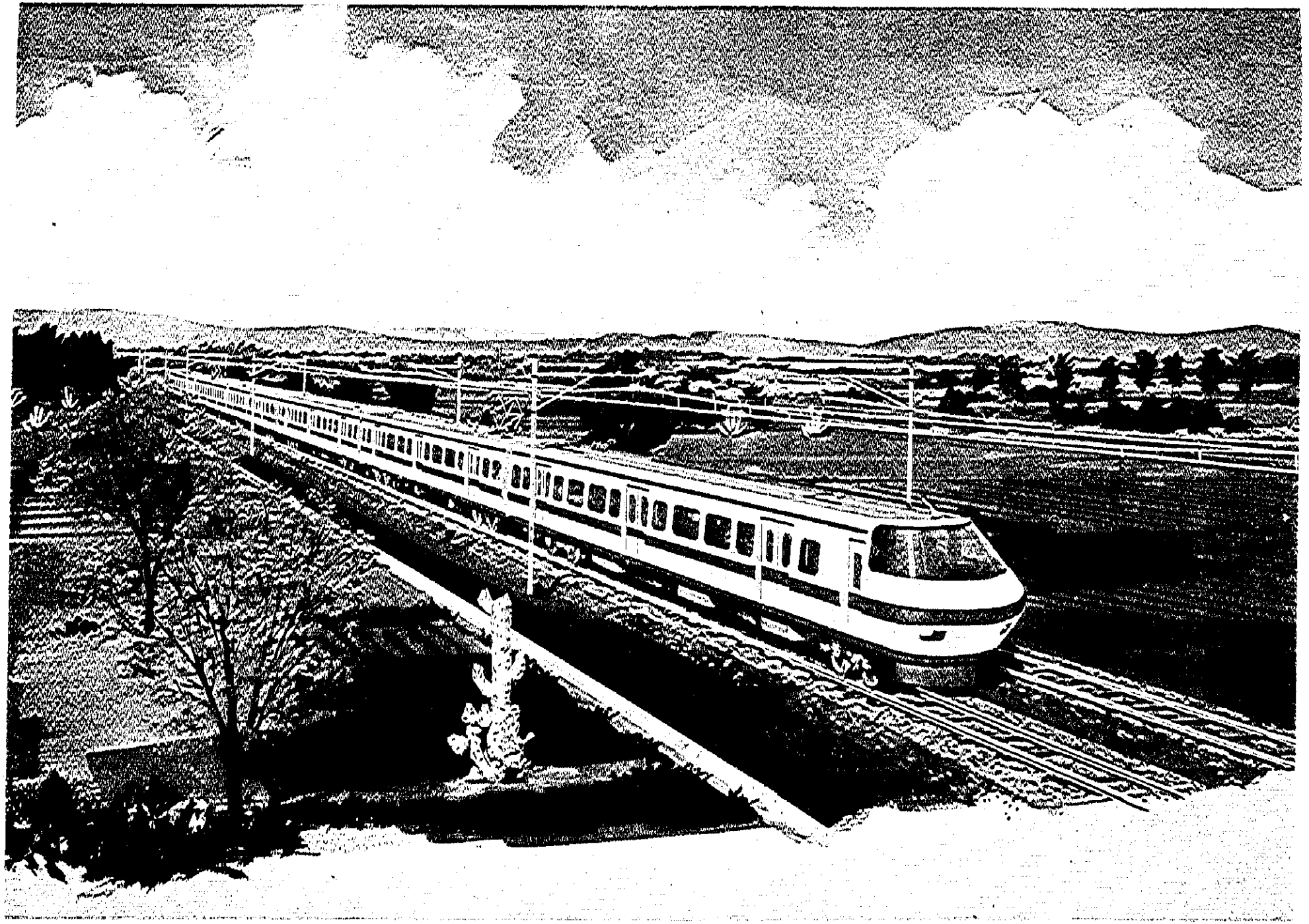
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

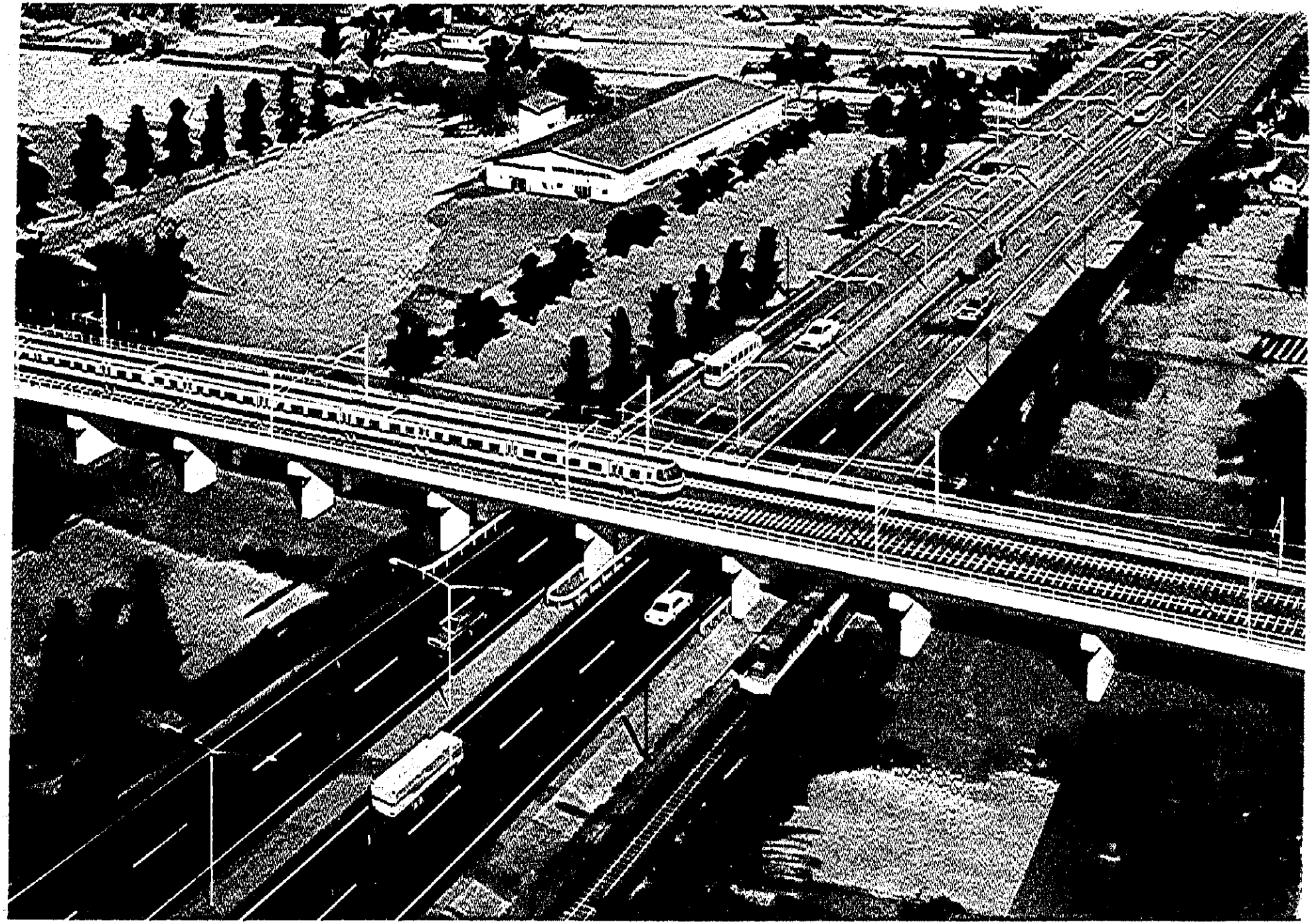
I wish to express my deep appreciation to the officials concerned of the Government of the United Mexican States for their close cooperation extended to the team.

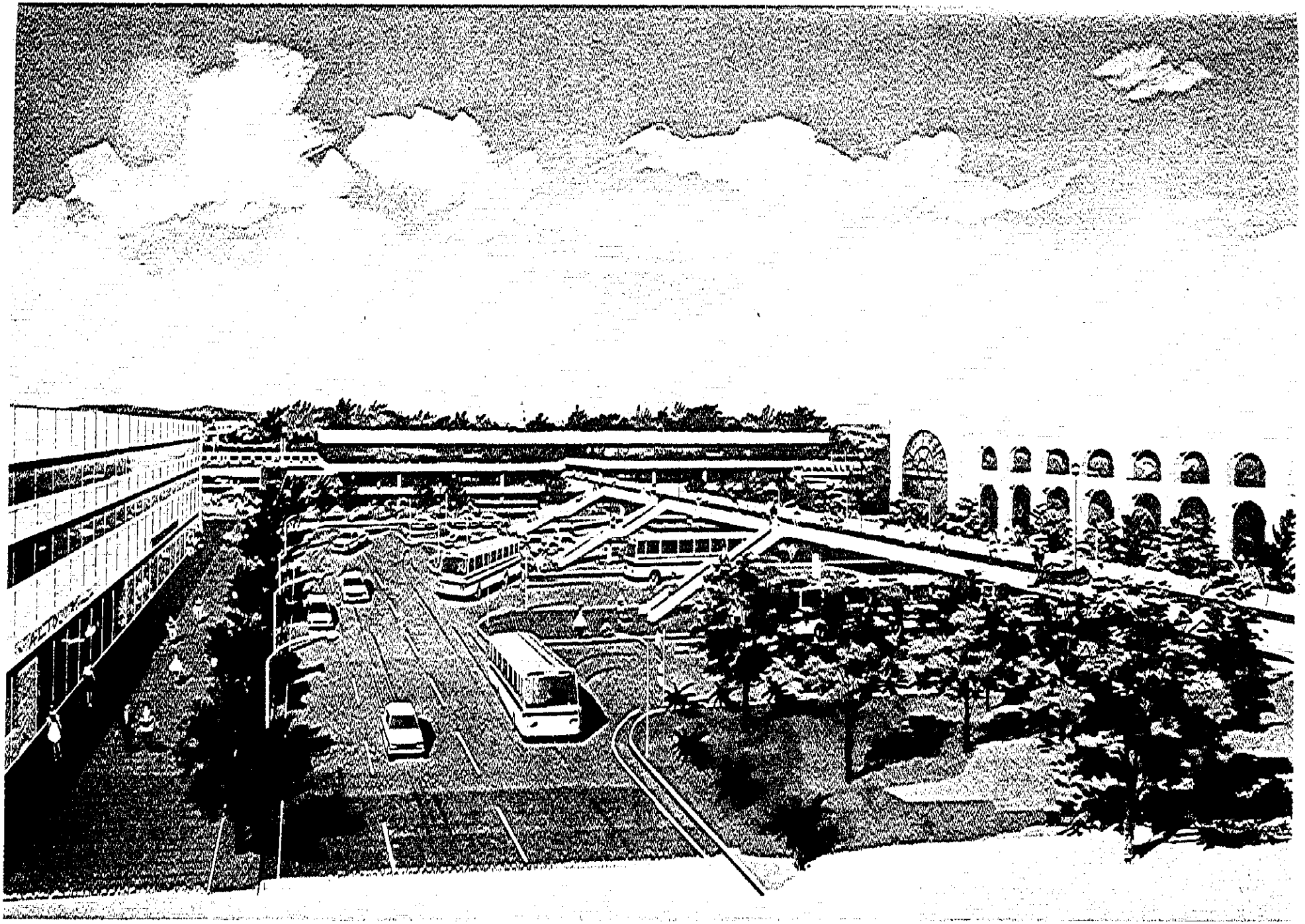
December 1983

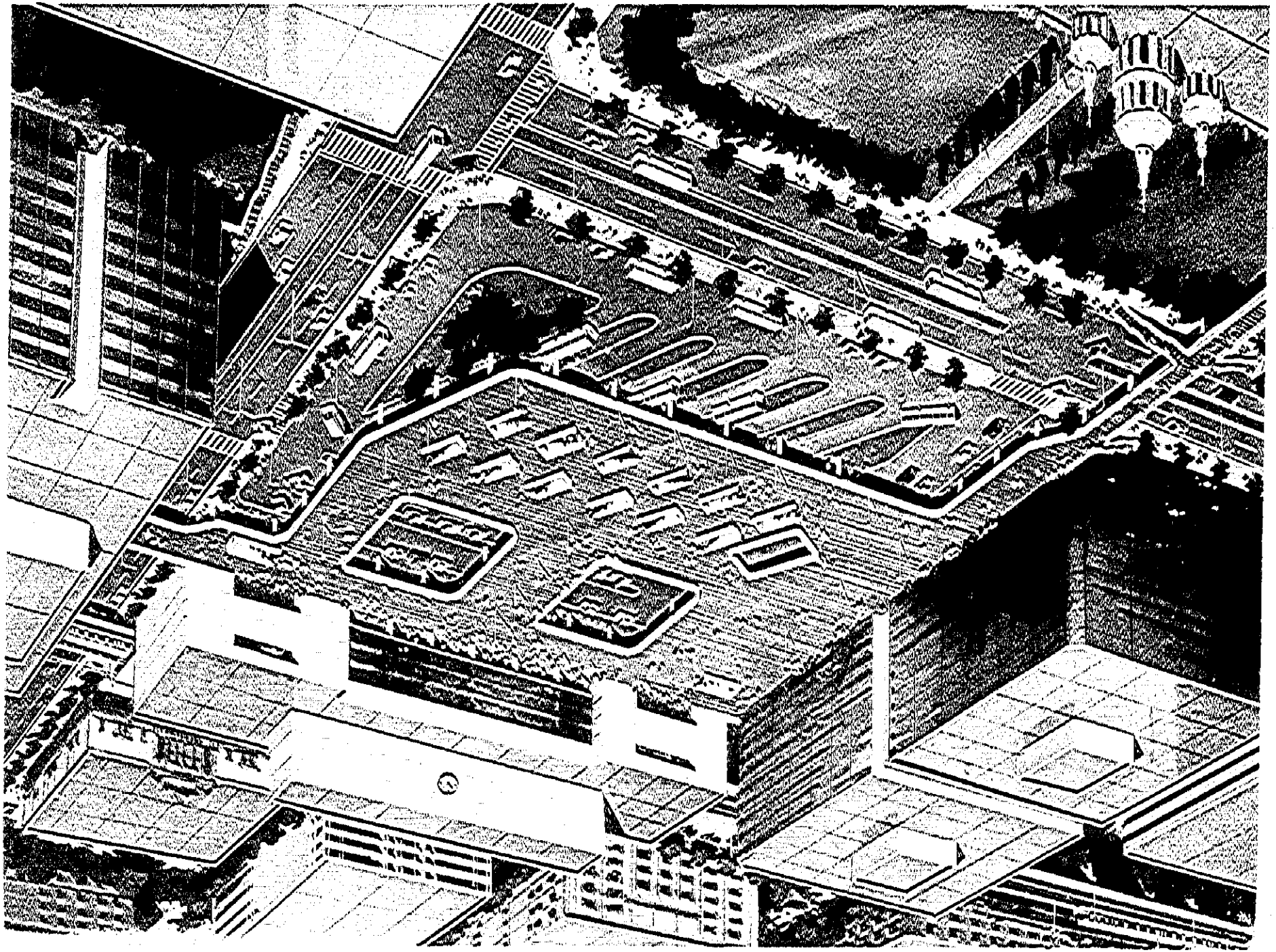
Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

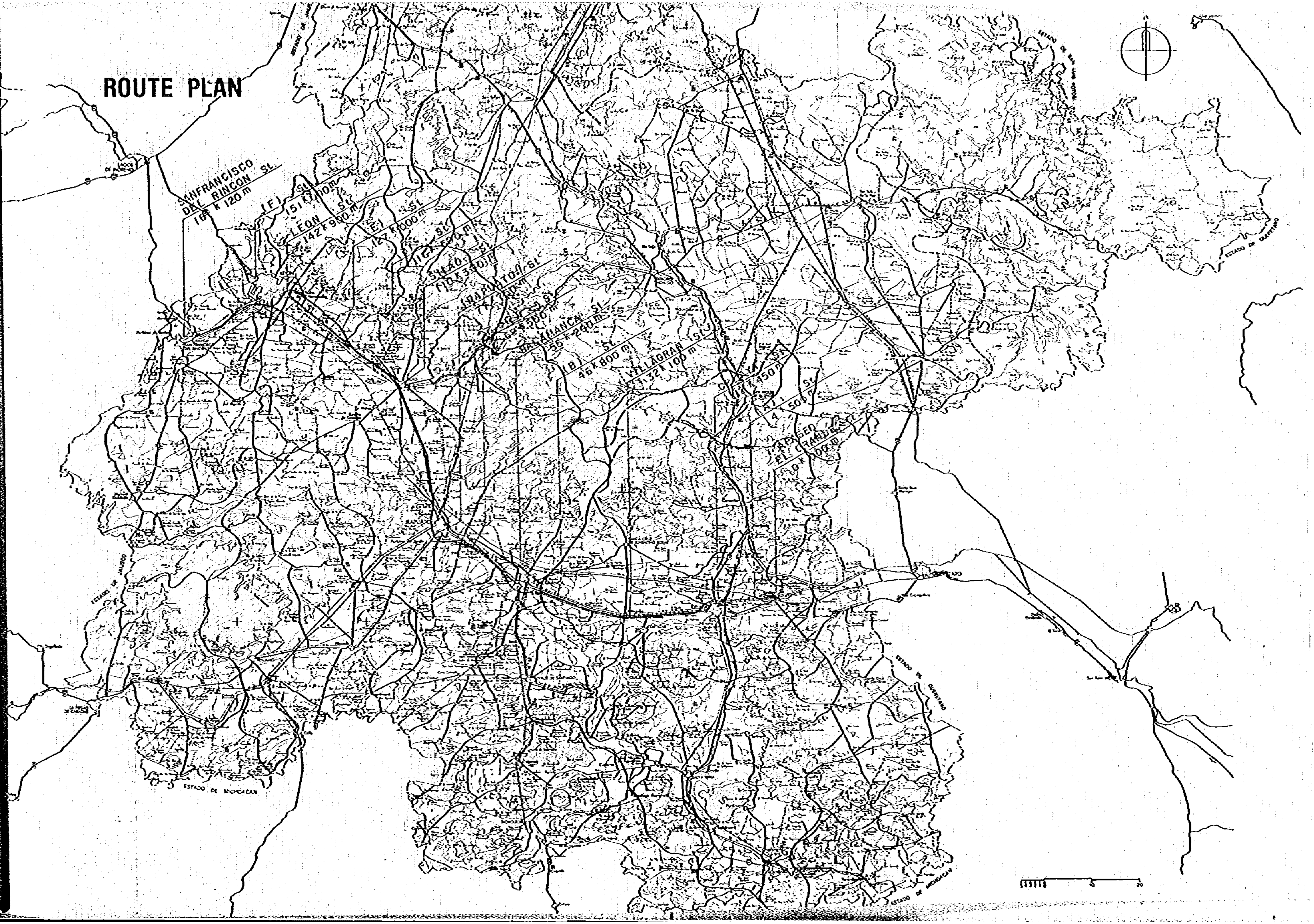






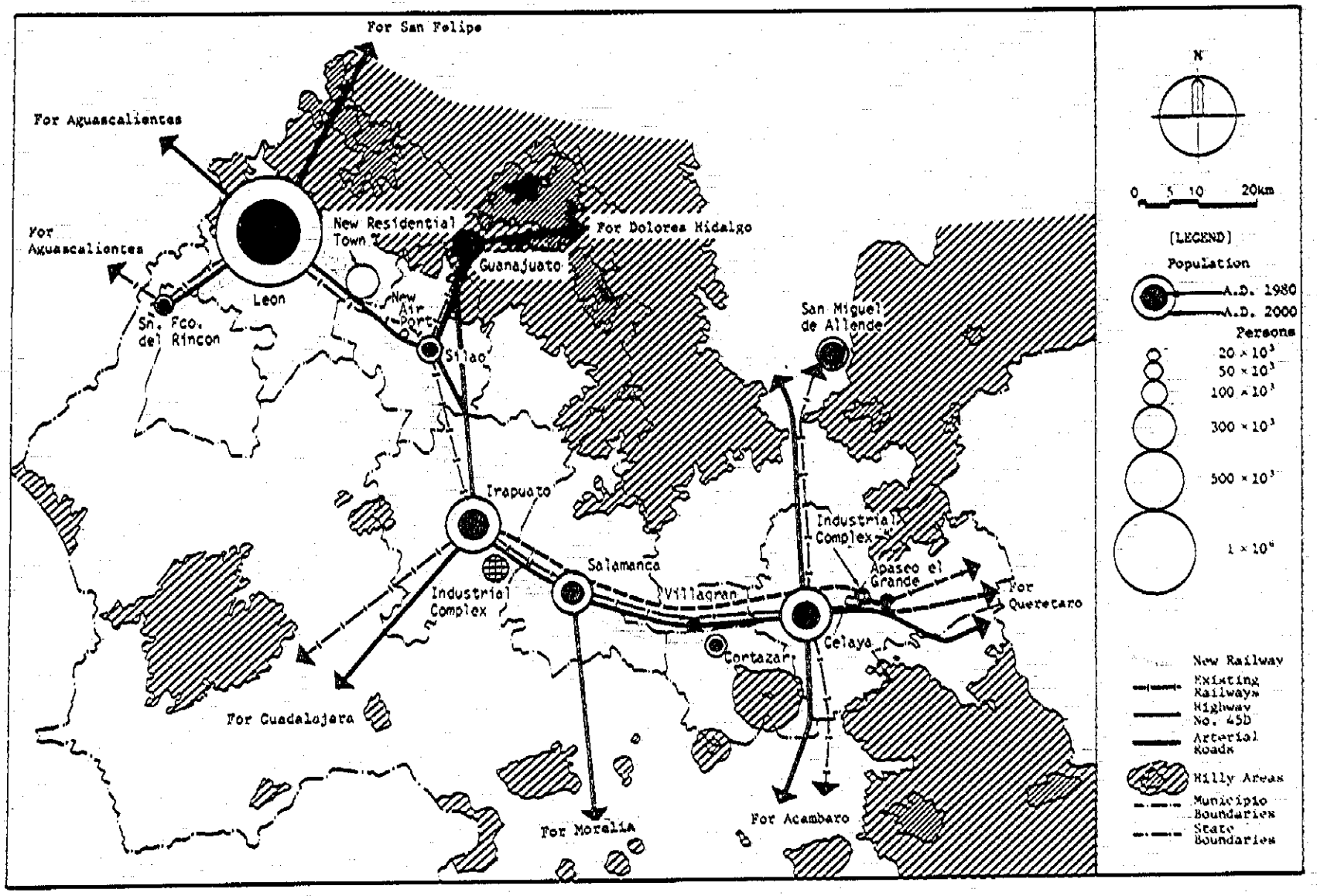


ROUTE PLAN



SANFRANCISCO DEL RINCON SL
120 m
(F) SL
LEON SL
142 K 900 m
(E) SL
127 K 000 m
SILAO SL
110 K 300 m
IRAPUATO SL
SALAMANCA SL
55 K 200 m
(B) SL
46 K 800 m
VILLAGRAN SL
32 K 100 m
(A) SL
4 K 500 m
APASEO EL GRANDE SL
ESTADO DE JALISCO
ESTADO DE MICHOACAN
ESTADO DE QUERETARO

SUMMARY AND CONCLUSION


For San Felipe
For Aguascalientes
For Aguascalientes
New Residential Town
For Dolores Hidalgo
Guanajuato
New Air Port
Leon
Sn. Fco. del Rincon
Silao
San Miguel de Allende
Irapuato
Industrial Complex
Salamanca
Villagran
Apaseo el Grande
For Queretaro
Celaya
Cortazar
Industrial Complex
For Guadalajara
For Morelia
For Acambaro
N
0 5 10 20km
[LEGEND]
Population
A.D. 1980
A.D. 2000
Persons
20 × 10³
50 × 10³
100 × 10³
300 × 10³
500 × 10³
1 × 10⁶
New Railway
Existing Railways
Highway No. 45D
Arterial Roads
Hilly Areas
Municipio Boundaries
State Boundaries

Purpose of Study

The Bajio Industrial Corridor in the State of Guanajuato is one of the most important areas from view point of the Federal Government's urgent policy of dispersing both population and industry in the nation.

Because of this, the Bajio Industrial Corridor is being rapidly industrialized and urbanized. Therefore, the future development plan must envisage well-balanced growth of each city, including the new residential town and the industrial complexes. To achieve this purpose, transportation facilities must be better developed and improved.

The purpose of this study is to examine the feasibility for construction of a new passenger railway between Apaseo el Grande and San Francisco del Rincon along the Bajio Industrial Corridor.

Conclusions

1) With the routes and station sites planned as in the Fig. on page vi, three alternative cases with different scheduled times of operation commencement and construction sections were studied and economic and financial analyses were conducted. In every case, the EIRR reaches or exceeds the internationally acceptable level of 10 percent and the project can be deemed to be feasible in this sense. However, the FIRR of the project is rather low. Prior to execution of the project, therefore, thorough consideration is required in terms of the financing of both construction and operation funds.

2) In total evaluation of EIRR, FIRR and the dispersion plan, the most recommendable plan is Case 2 (which is planned for partial completion by 1990 and full completion by 1995 aiming at completion of double track by 2000 in the operating section between [A] and [F].)

Each chapter is summarized on the following pages.

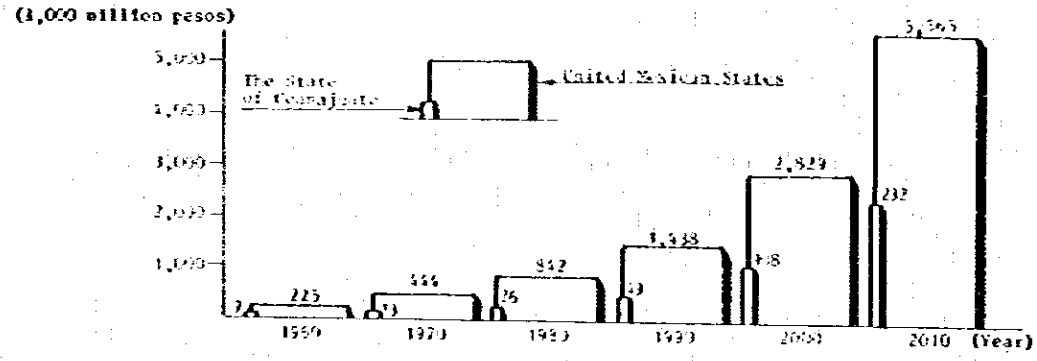
1. Present and Future Socio-economic Conditions

The economy of Mexico had a high annual growth rate averaging 6.6% in real terms throughout the 1970s. Despite the somewhat slower growth in recent years, it is expected that the economy of Mexico will be further industrialized in the near future, mainly in the oil and machinery industries.

Under a national development plan, the State of Guanajuato has been given a priority in terms of industrialization, and is expected to exceed the national average of economic growth due to advantages in terms of geography and other conditions.

Future economic growth rate and scale are as follows:

	United Mexican States	The State of Guanajuato
1980 - 1990	5.5%	6.5%
1990 - 2000	7.0%	8.2%
2000 - 2010	7.0%	8.0%

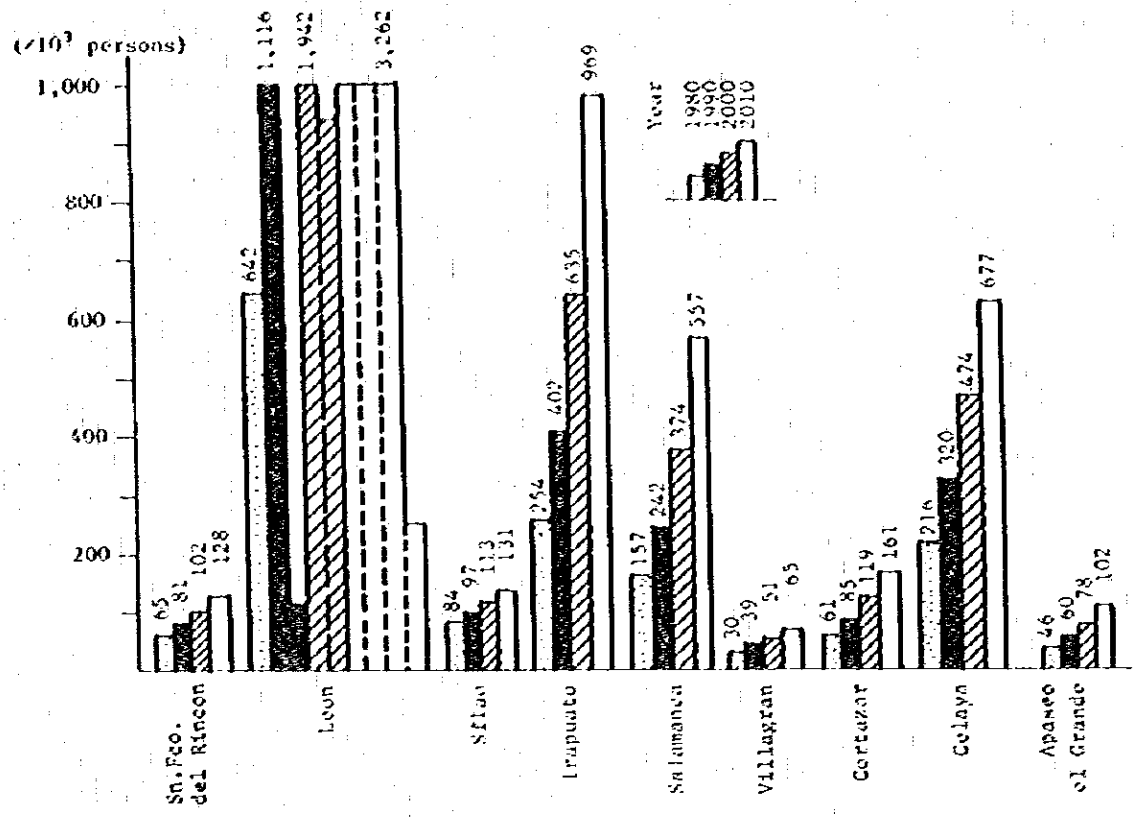


Trend of Gross Domestic Product

The population of Mexico grew 2.9% per year on average in the 1970s and is estimated to grow 2.0% per year until 2000.

Meanwhile, the population of the State of Guanajuato is expected to grow faster than the national average at approximately 3.6% a year from 3.1 million in 1980 to 6.25 million in 2000. In the Bajio Industrial Corridor, among other areas, and specifically, in Leon, Irapuato, Celaya, and Salamanca, a considerable population growth is expected.

The trend of change in population in each Municipio of the Bajio Industrial Corridor is shown in the following figure.



Population of Each Municipio

(Note: From data furnished by the State Government)

Currently, passenger transportation between cities in the State of Guanajuato is reliant on road traffic, mainly by bus. With the population increase and the progress of housing development plans and industrial location plans, the passenger transport volume, especially during the peak commuting hours, is expected to increase considerably. According to the present road development plan, therefore, it is expected that the existing road transportation system will become saturated in the near future, and a new transportation system must be developed to promote balanced urban development.

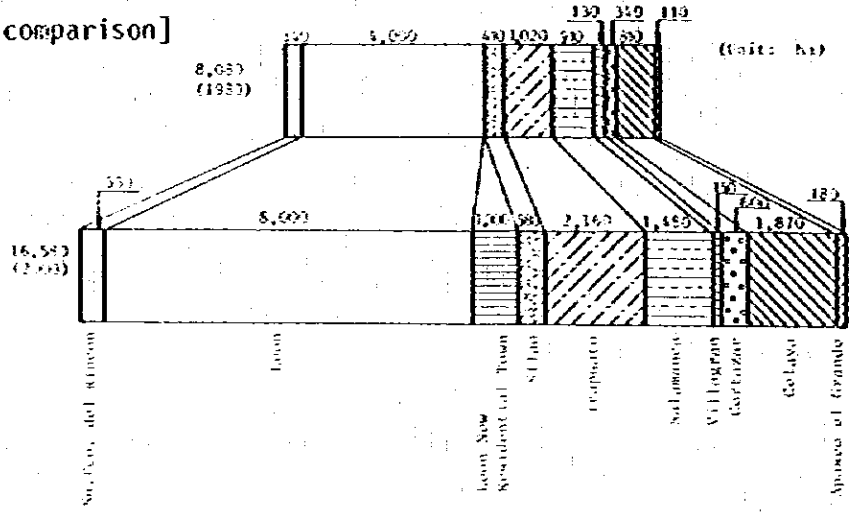
Under these circumstances, the State Government intends to introduce a new railway along the Bajio Industrial Corridor, which would be superior to the existing road transportation in terms of mass transportation, rapidity and punctuality.

2. Urban Development Programs in the Project Related Area

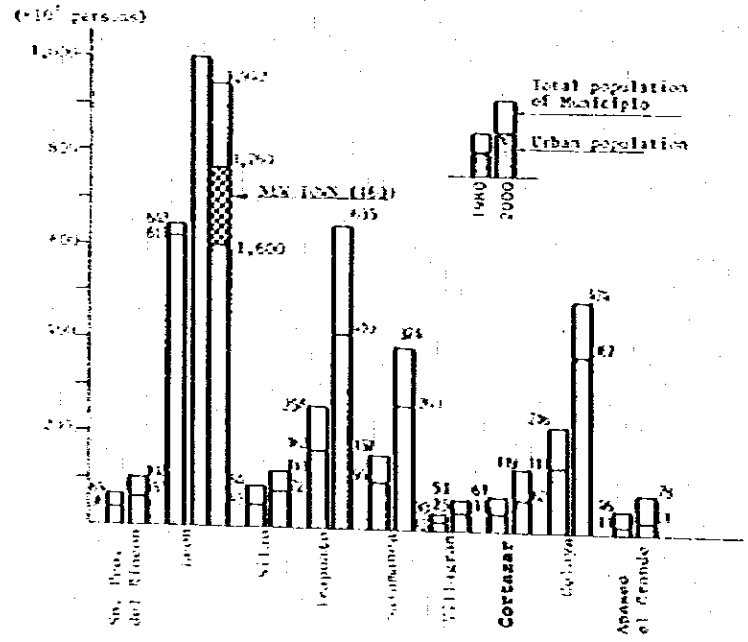
According to the urban development plan for the project related cities, the urban area is expected to expand 1.2 ~ 2.3 times during the period between 1980 ~ 2000. Meanwhile, the urban population is estimated to grow 1.6 ~ 2.8 times during the same period. In the city of Leon, among others, where the population growth will be considerable, the construction of a new residential town is being planned in the suburbs to prevent a further expansion of the urban area.

Also, under an industrial location plan, the construction of industrial complexes is being planned halfway between Apaseo el Grande City and Celaya City and in the south-east of Irapuato.

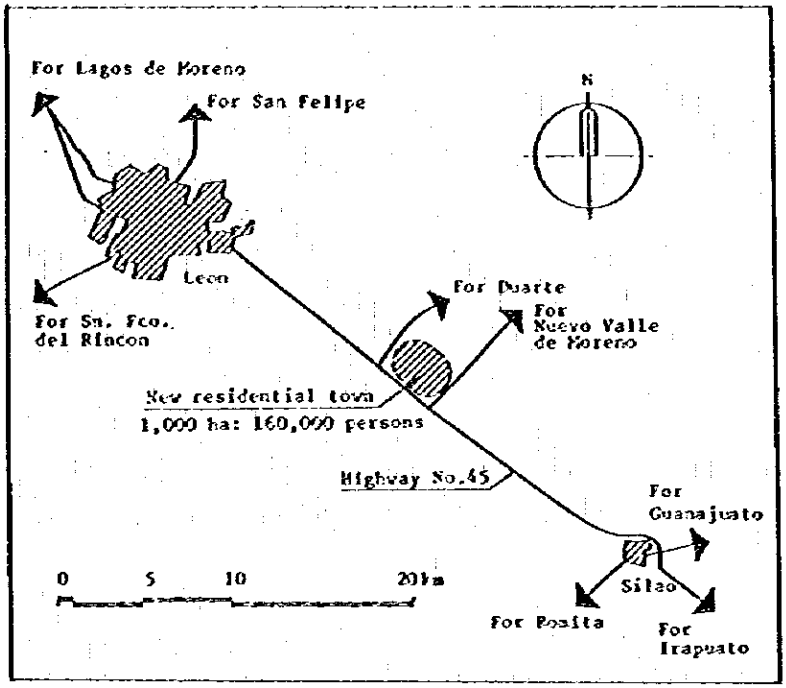
[Urban area comparison]

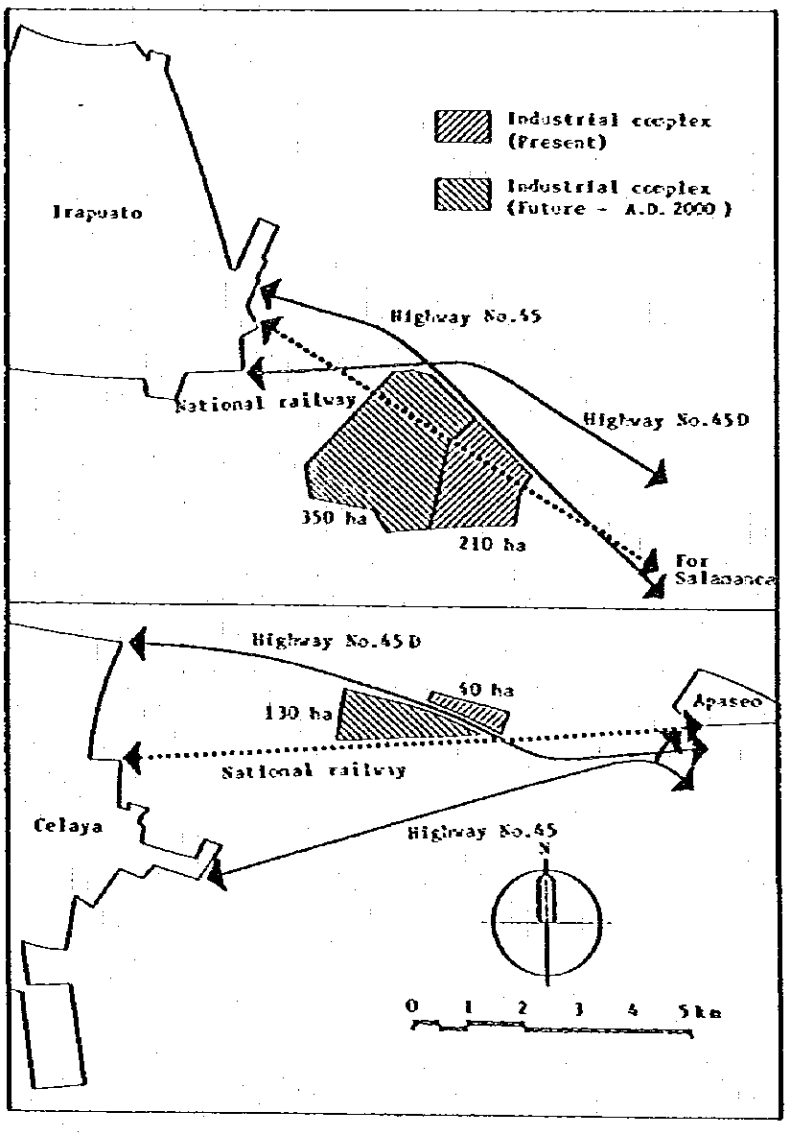


[Urban population comparison]



Location and Scale of New Residential Town under the Housing Development Plan





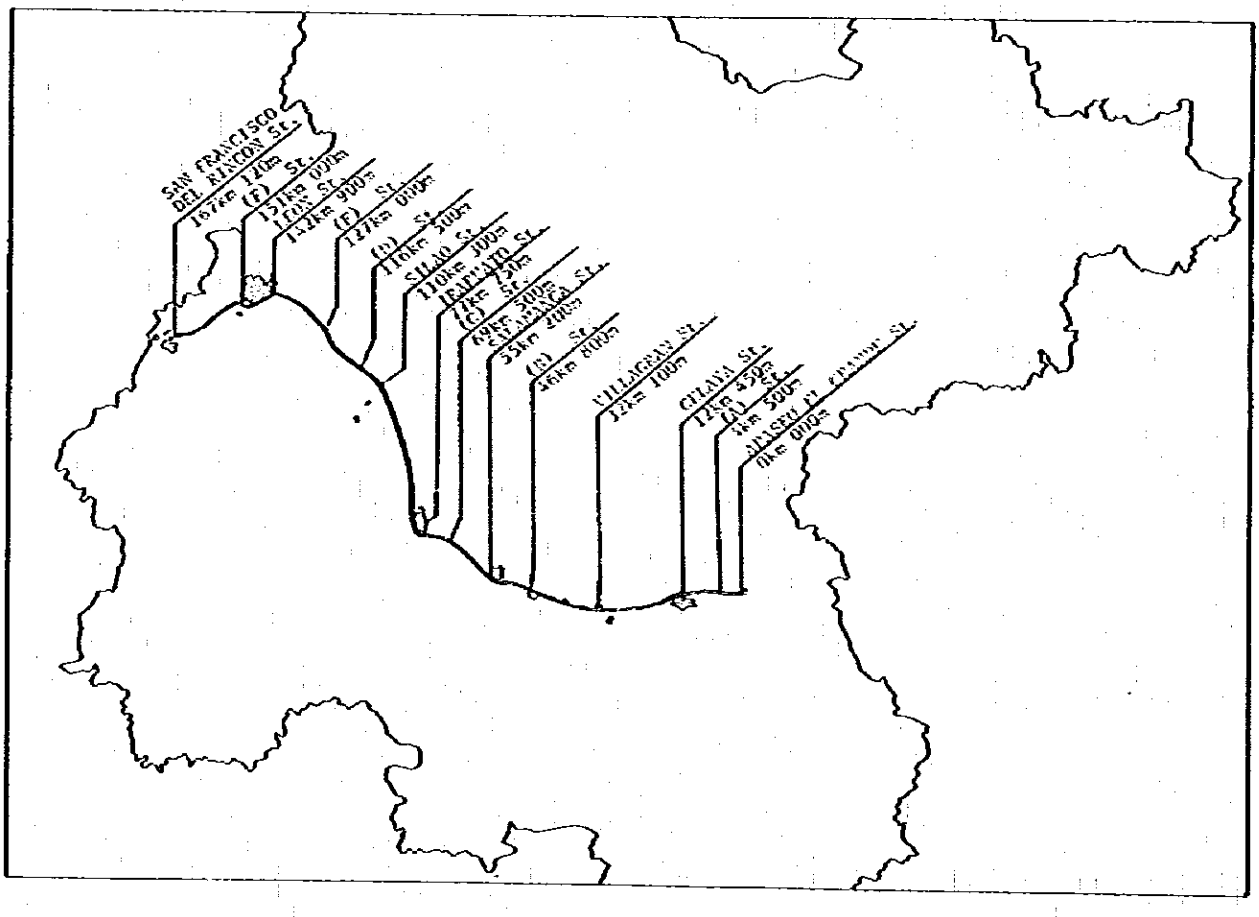
Location and Scale of Industrial Complexes under the Industrial Location Plan

3. Route and Stations

The new railway route is scheduled to connect the major cities between Apaseo el Grande and San Francisco del Rincon, and the construction cost should be kept to a minimum with due consideration to the development plan of each city along the route, topography, and the crossings with existing roads and railways. Through operation over the existing national railways is not planned.

The station locations have been planned with consideration to the purpose of this new railway as an interurban as well as commuter transportation system.

The route is about 167 km in total length with fourteen (14) stations.



Route Plan

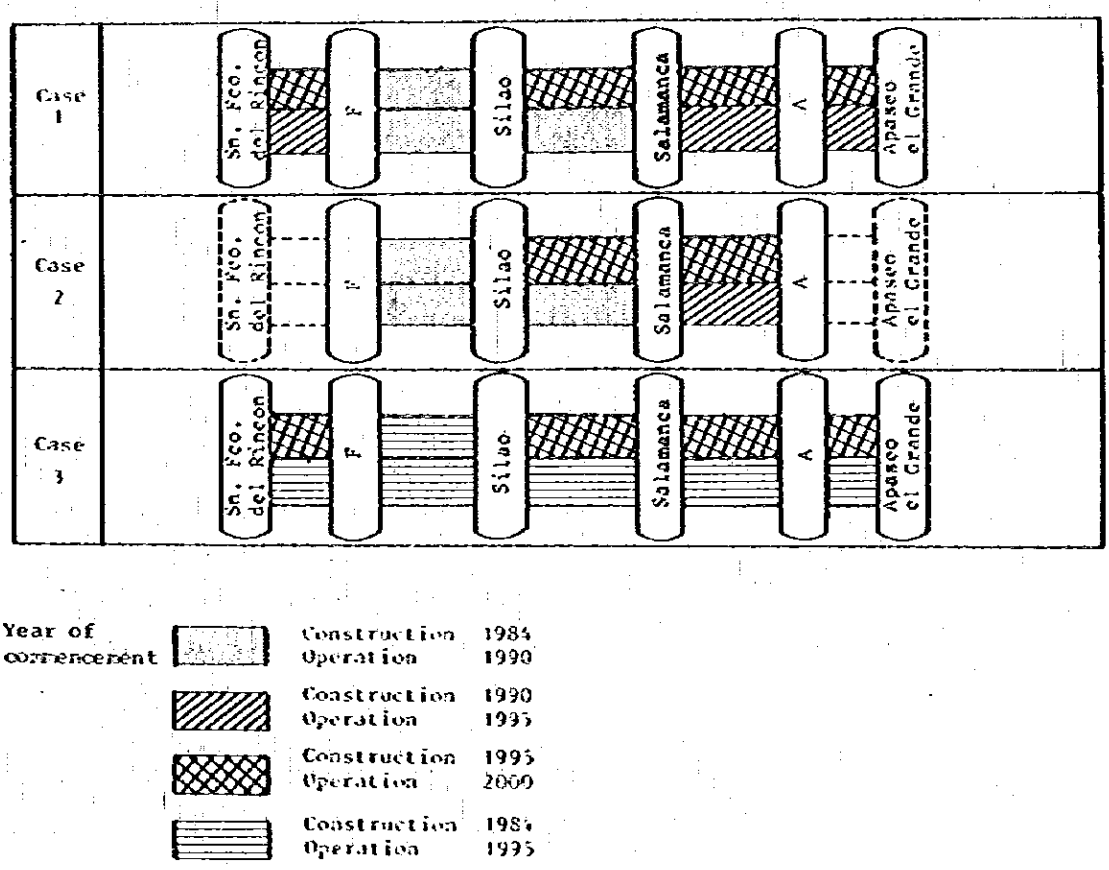
4. Alternatives

As shown in the following figure, three alternative cases are selected for comparison from among all the combinations of the operation commencement year and the construction section.

1) The year of operation commencement is determined to be 1990 or 1995, considering the transport capacity of major roads, progress in urban development and other plans, and the required construction periods.

2) Considering the passenger transportion demand, the construction section is determined as either the whole section or the limited section from [A] to [F] in the figure below.

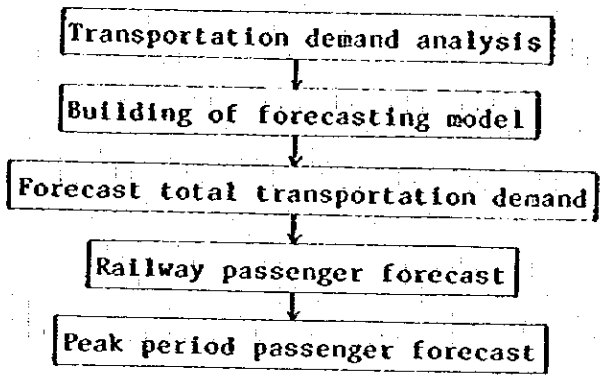
3) Construction works should be executed step-by-step by converting single track into double track, in accordance with the increases of passenger transportation demand.



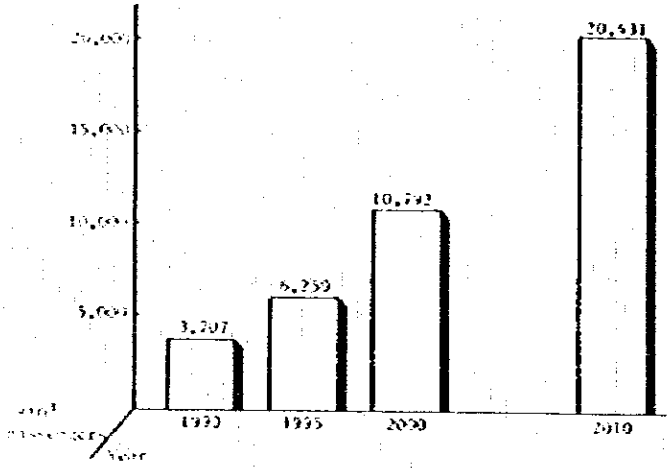
Alternatives

5. Transportation Demand Forecast

The demand forecast process may generally be summarized as follows:



The result of the forecast is as shown in the following figure. The total passenger transportation demand is estimated to almost double between 1990 ~ 1995 and 1995 ~ 2000, respectively. Comparing 1990 and 2000, the increase is approximately triple.



Total Transportation Demand within The State of Guanajuato (Monthly)

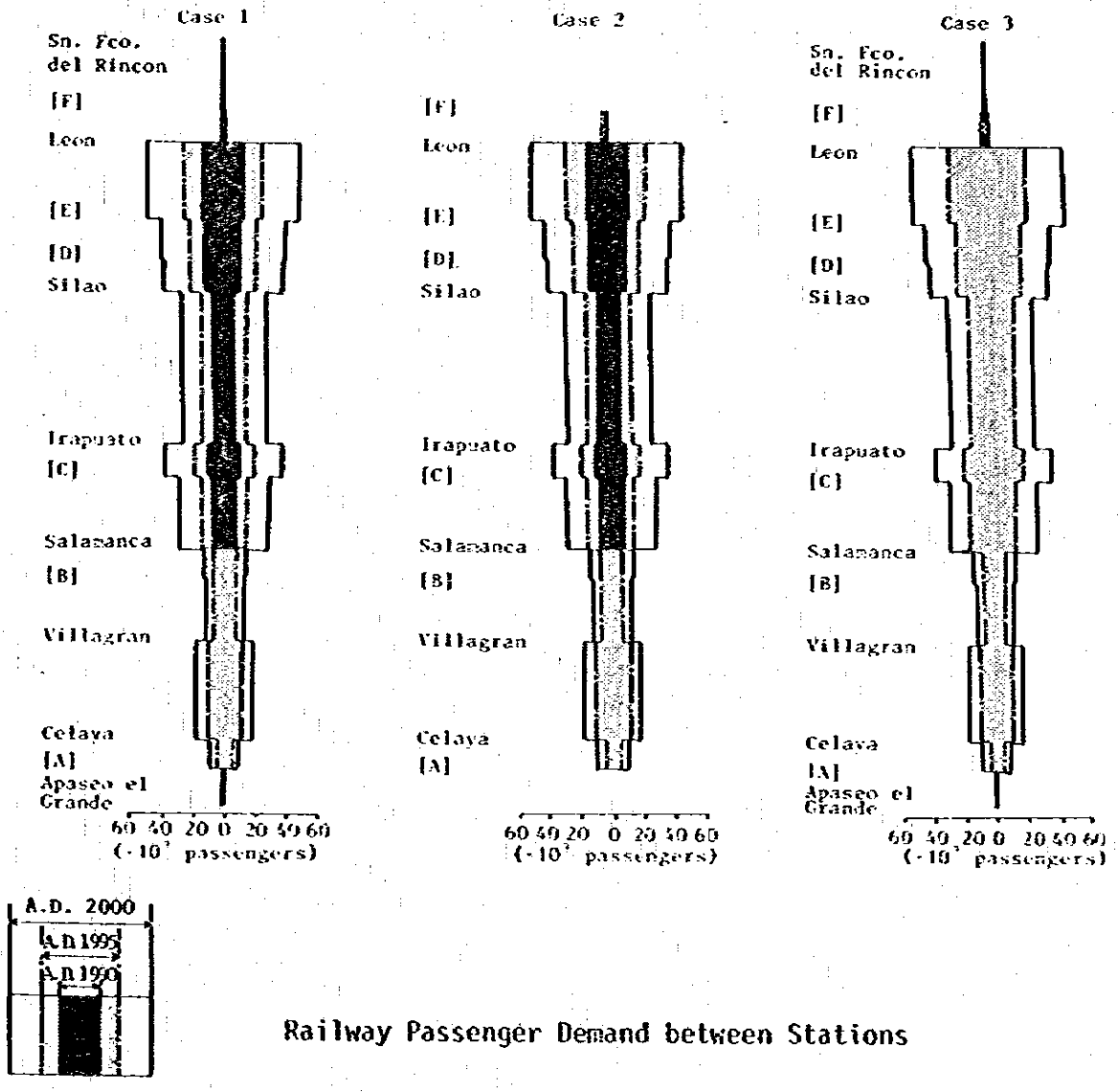
The number of railway passengers is forecasted as in the following table. Both in Case 1 and Case 2, the number of railway passengers is estimated to grow more than four times between 1990 and 2000, and in Case 3, the number of passengers approximately doubles in the five years between 1995 ~ 2000. In every case, the increase rate of railway passengers outnumbers that of total passengers.

(1,000/month)

Year \ Alternative	Case 1	Case 2	Case 3
1990	1,499	1,499	—
1995	3,517	3,510	3,517
2000	6,671	6,660	6,671
2010	12,813	12,798	12,813

Forecasted Railway Passengers

The railway passenger demand between stations is as shown in the following figure. In every case, the number of passengers will be the largest between [E] station and Leon. With both directions combined, approximately 95,000 passengers a day are expected between those stations in 2000, and the passenger demand between Salamanca and Leon station accounts for more than 80% of the total railway passengers. However, between Apaseo el Grande and [A] station and between [F] and San Francisco del Rincon station, the transportation demand is estimated to be very small.



Railway Passenger Demand between Stations

6. Operation and Rolling Stock Plan

Operation plan

A maximum speed of 130 km/h was selected in order to secure an advantage over bus travelling time.

Both electric and diesel systems were studied. An electric system was selected because it consumes less power and it is more flexible (train make-up can easily be changed to meet fluctuating transportation needs).

Travelling time for single track, double track, and scheduled speed are computed and shown in the following Tables.

Travelling Time and Scheduled Speed (Single Track)

		To the North	To the South	Remarks
Travelling time	Running time	114'30"	113'15"	Including spare time
	Stopping time	17'30"	11'30"	Excluding both terminal stations
	Total	132'00"	124'45"	
Scheduled speed		75.9 km/h	80.4 km/h	

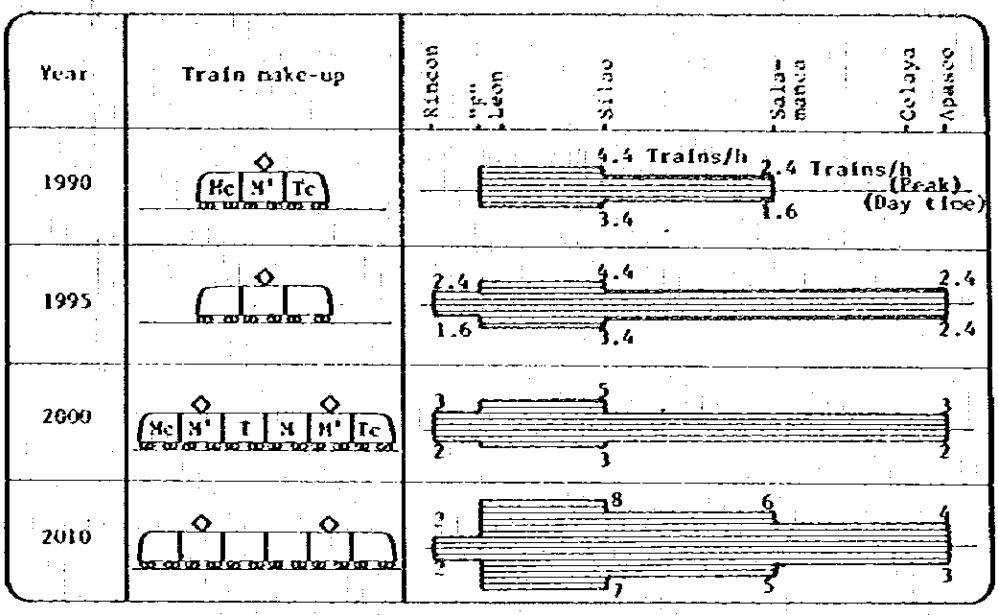
(Double track between Silao and [F])

Travelling Time and Scheduled Speed (Double Track)

		To the North	To the South	Remarks
Travelling time	Running time	102'00"	101'30"	Including spare time
	Stopping time	7'00"	7'00"	Excluding both terminal stations
	Total	109'00"	108'30"	
Scheduled speed		92.0 km/h	92.4 km/h	

Transportation plan

Transportation plan by year based on demand forecast is shown below. (Case 1)



Note: 1. In Case 2, the operating section is between Station [A] and Station [F].
2. In Case 3, the railway is assumed to start its operation in 1995 and the transportation plan is the same as in Case 1.

Rolling stock plan

Number of rolling stock to meet transportation plan requirements for each year is shown below.

(c: cars)

		Case 1			Case 2			Case 3		
		In use	Spare	Total	In use	Spare	Total	In use	Spare	Total
1990	Stage 1	3c × 10 = 30c	3c × 3 = 9c	3c × 13 = 39c	3c × 10 = 30c	3c × 3 = 9c	3c × 13 = 39c	-	-	-
1995	Stage 1	3 × 10 = 30	3 × 3 = 9	3 × 13 = 39	3 × 10 = 30	3 × 3 = 9	3 × 13 = 39	-	-	-
	Stage 2	3 × 16 = 48	3 × 4 = 12	3 × 20 = 60	3 × 15 = 45	3 × 4 = 12	3 × 19 = 57	3 × 16 = 48	3 × 4 = 12	3 × 20 = 60
2000	Stage 2	6 × 16 = 96	6 × 4 = 24	6 × 20=120	6 × 15 = 90	6 × 4 = 24	6 × 19=114	6 × 16 = 96	6 × 4 = 24	6 × 20=120
	Stage 3	6 × 16 = 96	6 × 4 = 24	6 × 20=120	6 × 15 = 90	6 × 4 = 24	6 × 19=114	6 × 16 = 96	6 × 4 = 24	6 × 20=120
2010	Stage 3	6 × 23 = 138	6 × 4 = 24	6 × 27=162	6 × 20=120	6 × 4 = 24	6 × 24=144	6 × 23=138	6 × 4 = 24	6 × 27=162

7. Railway Facilities

Construction Standards

Item	Specification
Track gauge	1,435 mm
Distance between track centers	4,000 mm
Minimum curve radius	1,000 m
Maximum grade	1.5 %
Axle load	14 tons

Structures

Embankment and cutting are the main civil engineering works, and earthwork structure sections account for 94% of the whole route. In central areas of Celaya, Salamanca and Leon, minimum length of continuous viaducts will be constructed so as to keep the urban activities intact.

Classification	Quantity		Remarks
	No.	Length (km)	
Bank		153.5	
Cut		4.1	
Bridge	11	0.4	Reinforced concrete
Viaduct	5	9.0	Reinforced concrete
Box culvert	34		Reinforced concrete
Pipe culvert	512		Reinforced concrete

Station Facilities

A station consists of a platform, platform shed, main building, and a station plaza. The scale of each station will be determined by the station's characteristics and the number of passengers. The scale of the station main building is as follows.

Scale of Station Main Building

Scale of Station	Name of Station
3,400 m^2	Celaya, Salamanca, Irapuato, Silao, Leon
1,000 m^2	Villagran, C
500 m^2	Apaseo el Grande, A, B, D, E, F, San Francisco del Rincon

Celaya, Salamanca and Leon stations will be constructed in the space under viaducts.

Main Electric System

Each system is planned with due consideration to the train's high speed operation and safety.

Main Electric System

Item	Specification
Feeding system	Single-phase AC (60 Hz) AT feeding system Feeding voltage 25 kV
Signalling system	Automatic Train Stop (ATS) Centralized Traffic Control (CTC)

8. Construction Schedule and Investment Scale

Construction schedule and investment scale for each alternative case are as follows:

Construction Schedule

		Stage 1						Stage 2					Stage 3				
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Case 1	Land, compensation																
	Civil engineering work																
	Electrical work																
	Car depot Work shop																

		Stage 1						Stage 2					Stage 3				
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Case 2	Land, compensation																
	Civil engineering work																
	Electrical work																
	Car depot Work shop																

		Stage 2											Stage 3				
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Case 3	Land, compensation																
	Civil engineering work																
	Electrical work																
	Car depot Work shop																

Both in Case 1 and Case 3, the total investment scale is 46,497 million Pesos, of which 18,447 million Pesos (40%) is for civil engineering work and 13,816 million Pesos (30%) is for electric cars. In Case 2, the total investment scale is 43,215 million Pesos, with 16,895 million Pesos (39%) for civil engineering work and 13,125 million Pesos (30%) for electric cars.

Investment Scale

(Unit: Million peso)

Invest-ment / Work classification	Case 1 or 3			Case 2			Remarks
	Foreign Currency	Domestic Currency	Total	Foreign Currency	Domestic Currency	Total	
Civil engineering work	1,909	16,538	18,447	1,689	15,206	16,895	Inclusive of track and station facilities
Electrical work	4,452	5,081	9,533	4,034	4,584	8,618	Electrification, signal, and telecommunication work
Car depot Work shop	1,048	2,310	3,358	1,048	2,310	3,358	
Land compensation	0	1,343	1,343	0	1,219	1,219	
Electric cars	10,447	3,369	13,816	9,925	3,200	13,125	
Total	17,856	28,641	46,497	16,696	26,519	43,215	

Note 1. Construction cost is estimated based on the price level as of April 1983 and price increases are not taken into account.
2. Foreign currencies will be required for 100% of the cars and rails (excluding turnouts), 70% of electrical equipment, and 40% of repair equipment.
3. Exchange rate is based on 1 U.S. dollar = 111.95 Pesos (control rate).

9 & 10. Economic and Financial Analyses

(%)

			Economic Analysis (EIRR)			Financial Analysis (FIRR)		
			Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Base case			10.0	10.5	11.5	3.4	4.1	3.8
Inflation		5%				8.3	9.1	
		10%				13.5	14.3	
Sensitivity analysis	Cost overrun	10%	9.2		10.6			
	Decrease of demand (or fare income)	-10%	8.9		10.3	2.4	3.1	
	Cost overrun and decrease of demand	10% -10%	8.1		9.4			
	Increase of fare income	10%				4.4	5.0	

- In every base case shown above, the EIRR surpasses the internationally acceptable level of 10%, thus indicating the appropriateness of this project. In the sensitivity analyses, there are cases whose EIRRs go below 10%. However, this project still seems to remain economically feasible when benefits such as the effect of urban development, saving of energy resources and conservation of rich farm land, which are difficult to quantify, are considered along with those benefits already counted, the saving of passenger travelling time and cost reduction of transportation means.

- The FIRRs were calculated supposing the railway fare rate be set at the same level as the current bus fare rate (1.4 Pesos/km before IVA). The result shows that the FIRRs of the base cases remain rather low compared with the international level of opportunity costs (international interest level). However, if the railway fare rate could be raised in proportion to and at the same time as the inflation, the FIRRs would considerably rise, going near or above the international level of opportunity costs. In any way, the FIRR must be higher than the weighted average of interest to be paid.

  As rather lenient financing conditions were assumed in this analysis as can be seen below, even the base cases remain barely profitable. Consequently, the method of financing would be the most important factor for the successful implementation of this project.

The presuppositions for financing in this analysis are as follows.

Foreign currency portion

Through overseas governmental loans
Interset: 10% P.A.
Period: 20 years (with a grace period of 5 years)
Repayment: Equal semiannual installments for 15 years.

Domestic currency portion

Through the budget of the State or the Federal Government. In this case, no interest payment nor repayment of principal is necessary.

(Note)
Sensitivity and inflation analyses were made on the base cases with the highest and lowest EIRR or FIRR.

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CHAPTER 8 CONSTRUCTION SCHEDULE AND INVESTMENT SCALE

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APPENDICES

INTRODUCTION

INTRODUCTION

1. Project Background

Population in the United Mexican States (hereinafter simply referred to as "Mexico") is increasing at an annual rate of about 3 percent, which brings about large population inflows into major cities. Because of this increasing tendency in those large cities, construction of housing and industrial plants is going on at rapid paces, increasing urban area sprawl. The Federal Government, gravely concerned with this present situation, is now pushing forward the nationwide dispersion program of both population and industry.

The State of Guanajuato is an inland state with a population of approximately 3 million. It is located about 300 km northwest of Mexico City and has a total area of about 30,000 km^2. The greater part of Bajio Industrial Corridor is represented by a zone of about 150 km extending from Apaseo el Grande to San Francisco del Rincon. Cities, each of several hundred-thousand population, exist at intervals of 20 to 30 km along this zone.

At present, the Bajio Industrial Corridor is being industrialized and urbanized rapidly, in accordance with the governmental plan to modernize the nation and disperse industrial plants and population, also because of its geographical advantage. The increments of population tend to concentrate in certain cities in the Corridor, especially in the City of Leon. To avoid such excessive population concentrations, urban functions concentrated in those specific cities must be dispersed into other areas within the Corridor so as to promote well-balanced growth of each city.

At present, public buses and private cars are the sole means of passenger traffic from one city to another in the state. Since the State of Guanajuato is situated nearly in the center of the country, it is a key point of heavy vehicular traffic. Recently, the number of large lorries has been increasing. It is anticipated that such passing traffic volume will continue to increase and will eventually cause congestion problems for future vehicle traffic in the state. The existing national railway line is available mainly for freight transport and, in the field of passenger traffic, is being utilized by long-distance travellers but has no services available for commuters.

Such being the circumstance, the State Government sincerely intends, in its long-range vision, to introduce a new railway with excellent rapid, mass transportation in the existing Bajio Industrial Corridor. The proposed railway construction project is planned to promote urban and housing development programs and industrial location plans in the Bajio Industrial Corridor now being pushed forward by the State Government. These development policies are formulated in line with the biggest target of the national industrial development plan in Mexico, aiming at decentralization of economic activities and urban population. In particular, because the Bajio Industrial Corridor is designated as the priority zone under the national industrial development plan, it can be said that the project has a significant meaning, not only in the State of Guanajuato, but also through out the whole country.

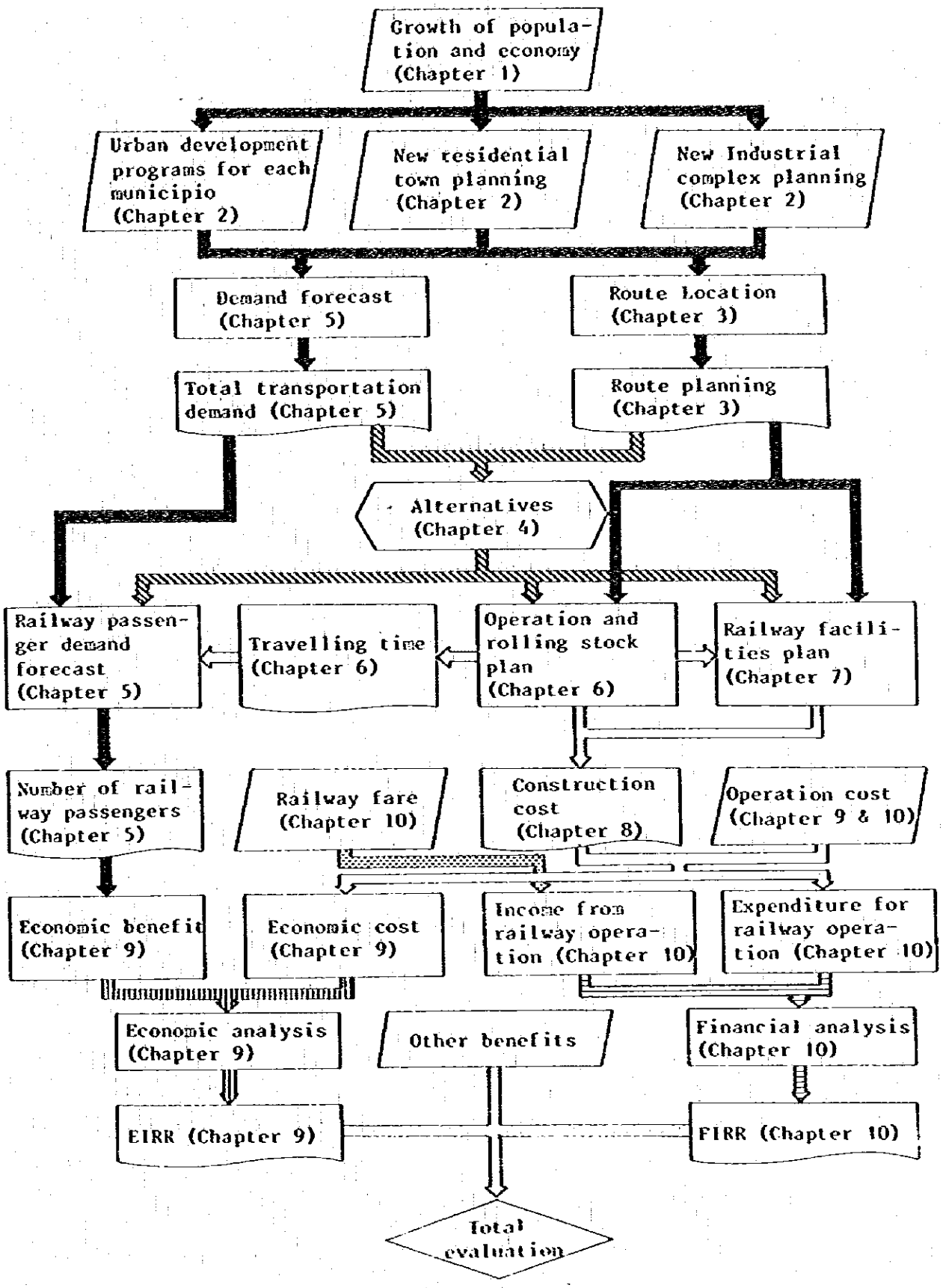
2. Purpose and Scope of the Study

The purpose of this study is to examine the feasibility of construction and operation of a passenger railway between Apaseo el Grande and San Francisco del Rincon. As shown in the following flow chart, the study includes selection of the route and transportation demand forecast based on population trends and economy as well as various related development projects in both the United Mexican States and the State of Guanajuato. It also roughly estimates construction costs based on railway construction and operation plans. These estimates will be used to evaluate the project in view of both national economy and enterprise management. The feasibility of the project must be examined by considering other benefits than those used for economic analysis and also financing arrangements for construction funds.

Since a railway project requires huge investments, its feasibility needs to be carefully examined from the viewpoint of the national economy prior to its implementation. Theoretically, the implementation of a project of this scale usually involves sacrificing other projects. Thus, an inappropriate project could lead to a serious loss in terms of the national economy.

The difficulty, however, arises when we attempt to quantify the effects of the urban development, residential development and the industrial location programs, which are the primary goal of this project. For this reason,

Study Process Flow Chart



these effects cannot yet be considered as benefits in this analysis. Therefore, should the result of this economic analysis be negative, it does not necessarily lead to the conclusion that the project should not be implemented.

However, as the passenger transportation demand forecast, which is one of the bases for calculating the benefits, takes into account the residential development and industrial location programs, the result of this analysis could be useful in determining whether the project should be implemented or not.

The feasibility study is to be conducted in accordance with the following framework:

(1) The study area for the new railway is, as shown in S/W, the area linking Apaseo el Grande and San Francisco del Rincon in the Bajio Industrial Corridor. The following 9 Municipios were chosen as cities to be included in the study.

Apaseo el Grande
Celaya
Cortazar
Villagran
Salamanca
Irapuato
Silao
Leon
San Francisco del Rincon

The Municipios selected above include Leon, the largest city in the State of Guanajuato, and other major cities such as Irapuato, Salamanca, and Celaya within the Corridor in the same state.

(2) The new railway construction plan is based upon the transportation demand forecast for the year A.D. 2000. It duly considers possible future growth of both society and economy as well as the urban and housing development program, and the industrial location plans as presented by the State Government and each Municipio.

(3) The project life shall be 30 years for the economic and financial analysis.

3. Project Features

The new railway is planned to serve passengers between cities or commuters from the suburbs to large cities and is intended to stimulate further growth of the Bajio Industrial Corridor in the State of Guanajuato. From the present situation of the existing traffic system, it can be noted that the roads are developed to a considerable extent with an expansion of the bus network. As in most other regions in Mexico, in the State of Guanajuato the bus service is nearly the sole transportation means available, in actuality and in people's perception for public transport. Therefore, people's impressions about the new railway are somewhat vague.

Nevertheless, it is expected that the new railway transportation service, if completed, will save both time and cost as compared with the conventional bus transportation service. In view of this expected advantage, the State Government is now considering its effective development policy to encourage further growth of the Bajio Industrial Corridor by promoting future use of railway traffic, instead of conventional road traffic. To achieve this purpose, therefore, railway traffic should naturally be superior to bus traffic in rapid mass transportation. Because of the need to comply with such requirements, other alternatives, such as the monorail or new transit systems inferior to an ordinary railway system in those two functional aspects, have not been considered.

Incidentally, please note that the station location and the railway route cited in this feasibility study are assumed only for this study purpose. Therefore, they will require further detailed survey and design prior to project construction.

4. Study Schedule

(1) Preliminary work in Japan

(2) Field study (April 4, 1983 to June 4, 1983)

Prior to field study, the Inception Report was submitted and explained (on April 7 and 8) and was accepted with full consent.

For the period from April 11 through the end of May, the field study was conducted in order to establish the basic concepts of demand forecast, operation plan, and railway construction plan. The study included

collecting and sorting of information and data, discussing with counterpart members, hearing from the concerned authorities, and site observation.

The field study work was divided and shared by the following three groups.

Group No. 1: Development plan, demand forecast, economic analysis, and financial analysis
Group No. 2: Operation plan and electrical facilities
Group No. 3: Railway facilities and route location

Hearing and site observation activities by contact with the concerned authorities during the field study are as follows.

1) Hearing and site observation in nine cities concerned (by Group No. 1): April 12 to 26

2) Hearing and site observation by visit to Ministry of Communication and Transportation, National Railways of Mexico and Metro (by Group No. 2): April 12 to 17

3) Site observation (by Group No. 3): April 13 to 21

4) Hearing from Ministry of Communication and Transportation, National Railways of Mexico, Metro and Ministry of Urban Development and Ecology (by Group No. 1): April 27 to May 3

5) Observation of national highway construction site (by Group No. 3): May 12 to 13

At closing of the field study, the report outlining field study results was prepared for submission and explanation on May 27.

(3) Preparation of Interim Report (June 6 to July 31)

(4) Submission and explanation of Interim Report (August 1 to 13)

(5) Preparation of Draft Final Report (August 15 to October 15)

(6) Submission and explanation of Draft Final Report (October 16 to October 23)

5. Organizations

(1) JICA Supervisory Committee

Dr. Takasuke Watanabe, Chairman	Associate Professor, The Faculty of Engineering, Tokyo Institute of Technology
Hiromasa Ukawa, Member	Senior Officer for Electrical Engineering, Railway Supervision Bureau, Ministry of Transportation
Satoru Onoyama, Member	Deputy Director, Railway Supervision Bureau, Ministry of Transportation
Yoshikazu Shiokawa, Member	Deputy Director, Railway Supervision Bureau, Ministry of Transportation
Yasutaka Kikuchi, Member	Technical Officer, International Affairs Division, Secretariat to the Minister M.O.T.
Mikio Tashiro	Ex-Social Development Cooperation Department, JICA
Kouichi Goto	Deputy Head, General Affairs Department, JICA
Junji Kugimiya	Social Development Cooperation Department, JICA

(2) JICA Study Team

Yoshiaki Sato	General
Tomomitsu Fujimoto	Railway Planning
Yoshikazu Umeki	Demand Forecast
Akira Akiba	Socio-economic Framework
Tatsuyuki Negishi	Regional Development Plan
Yukio Arimori	Planning of Train Operation and Rolling Stock
Shuji Aoki	Route Location
Toshio Ueno	Structure Planning
Yukihiro Takeda	Surveying and Designing
Morio Yasunami	Planning of Construction Execution
Shinichi Kinoshita	Planning of Electrification Signalling and Telecommunication
Kinji Tsunashima	Economic and Financial Analysis

(3) Counterpart members of the State of Guanajuato

Ing. Ramón López Verdugo	Secretario de Programación del Estado
Lic. Leonel Charnichart	Secretario Particular del Ing. Ramón López Verdugo
Ing. José López Cervantes	Asesor General del Proyecto México-Japón
Ing. Mario Duran Vargas	Coordinador General del Grupo México-Japón
Lic. Juan José Chalico	Administrador del Grupo México-Japón
Arq. Eduardo Dominguez	Miembro Especialista en Desarrollo Urbano
Arq. Raymundo Martinez	Director de Planes y Proyectos de Desarrollo Urbano
Ing. Pablo Preciado	Departamento de Evaluacion de Programas Estatales
Lic. Juan Garcia	Jefe del Area de Estadisticas de la Secretaria de Programación y Presupuesto
Ing. Mario Mora	Jefe de Sistemas de la Secretaria de Programación y Presupuesto Estatal
Ing. Martha Ayala García	Jefe de la Unidad de Costos y Precios Unitarios de la Srla de Desarrollo Urbano y obras Públicos
Ing. Miguel Angel Donato	Miembro Especialista en Cartografia
Arq. Carlos Martinez Duran	Miembro Auxiliar del Area de Desarrollo Urbano
Ing. Jose Cruz H. Carrion	Asesor de Ingeniería de Transito
L.A.E. Eduardo Clark Solter	Asesor Análisis Financiero

THE PRESENT AND FUTURE SITUATION OF THE UNITED MEXICAN STATES AND THE STATE OF GUANAJUATO

CHAPTER 1

CHAPTER 1 THE PRESENT AND FUTURE SITUATION OF THE UNITED MEXICAN STATES AND THE STATE OF GUANAJUATO

1-1 The Present and Future Situation of the United Mexican States and the State of Guanajuato

1-1-1 Geographic situation of the State

The State of Guanajuato is an inland state situated in the central part of Mexico as shown in Fig. 1-1-1. It forms part of the central highland and is bounded by the State of San Luis Potosí to the north, the State of Michoacan to the south, the State of Queretaro to the east, and the State of Jalisco to the west.

The greater majority of the state territory is 1,500 to 2,000 m above sea level. The local climate is generally mild with an annual average temperature of 18°C and annual rainfall of 700 mm.

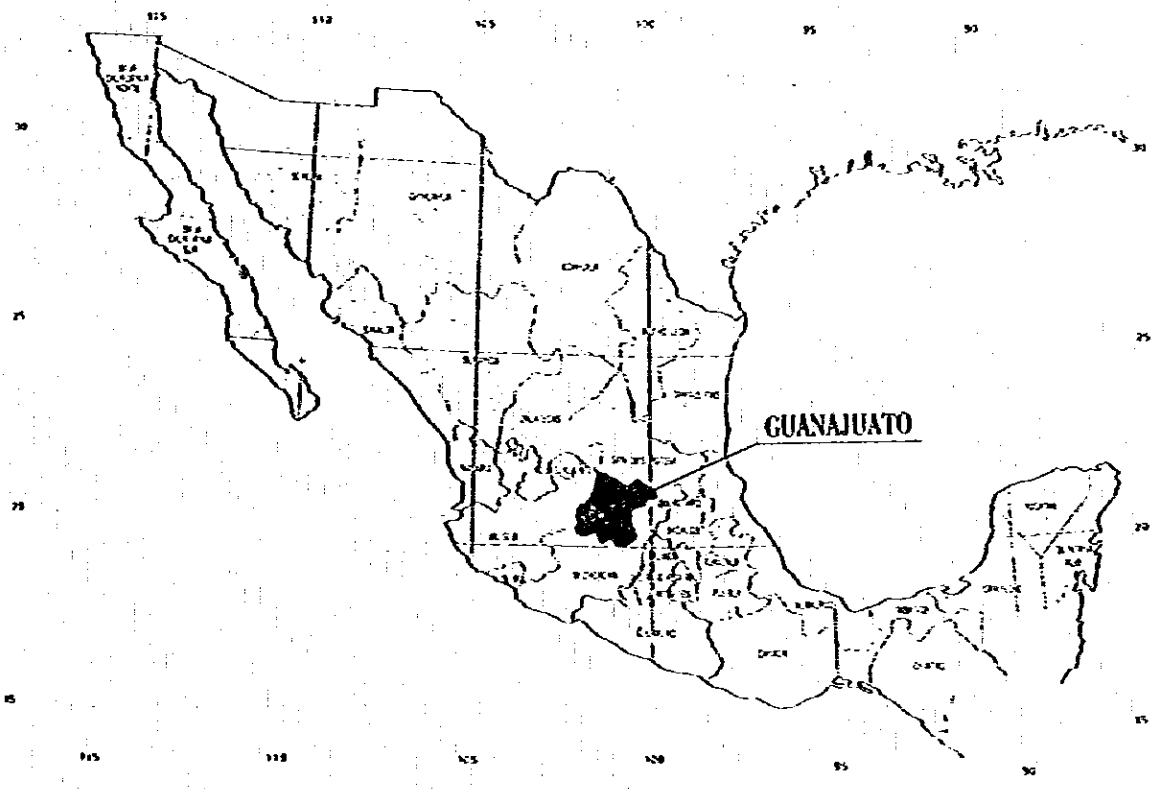


Fig. 1-1-1 Location of the State of Guanajuato

The state has a total area of 30,589 km^2, which consists of 14,508 km^2 flat area (47%), 7,503 km^2 semi-flat area (25%), and 8,578 km^2 sloped area (28%).

Within the State of Guanajuato, the Bajio Industrial Corridor has a total area of 4,326 km^2, about 60 percent of which is flat.

1-1-2 Present population and future forecast in Mexico and the State of Guanajuato

Mexico's total population was 67.38 million as of 1980. Compared to a total of 50.70 million in 1970, there has been a 33 percent increase (2.9 percent annual rate) for the latest decade. However, because of a downturn of the birth rate from the peak rate of 43.4 permill in 1973 to 32.8 permill in 1979, the CONAPO (the National Council on Population) has announced its estimate that the population will grow to about 100 million by A.D. 2000, an annual growth rate of about 2 percent.

All such population increases bring about the inflow from the rural area into the urban areas, most remarkably into Mexico City and other large cities. Because of this increasing tendency in these large cities, housing and industrial plants are being constructed at a rapid pace. As a result, various social problems have surfaced.

Since the Federal Government's object is to improve the national economy for the people by promoting local industries, it is now pushing forward its program to decentralize both population and industrial plants so as to achieve its goal.

The growing population trend in the State of Guanajuato is far above the nationwide level of population growth, as shown in Fig. 1-1-2, with an increase of 37 percent (3.2 percent increase at an annual rate) from 2.27 million in 1970 to 3.10 million in 1980.

The birth rate in the State of Guanajuato shows a downward trend from 56.2 permill at its peak in 1973 to 39.0 permill in 1979. Nevertheless, the rate of natural increase still remains higher than the nationwide average as the death rate has been declining so far. The outflow of population from the State of Guanajuato into Mexico City and others has gradually

slowed its tempo with introduction of new industrial plants into the State of Guanajuato. In recent years, there has been an inflow of skilled workers, though not as yet so many, into the state.

The State Government foresees a high population growth rate in the future. It expects that, in addition to the natural increase of population, there will be an increased inflow from other parts of the country, not to mention a possible decrease in the continued population outflow, if the industrial development plan progresses further. Figure 1-1-2 shows the result of long-range forecast of future population growth up to A.D. 2010 made by the State Government, assuming about a 3.6 percent annual average increase.

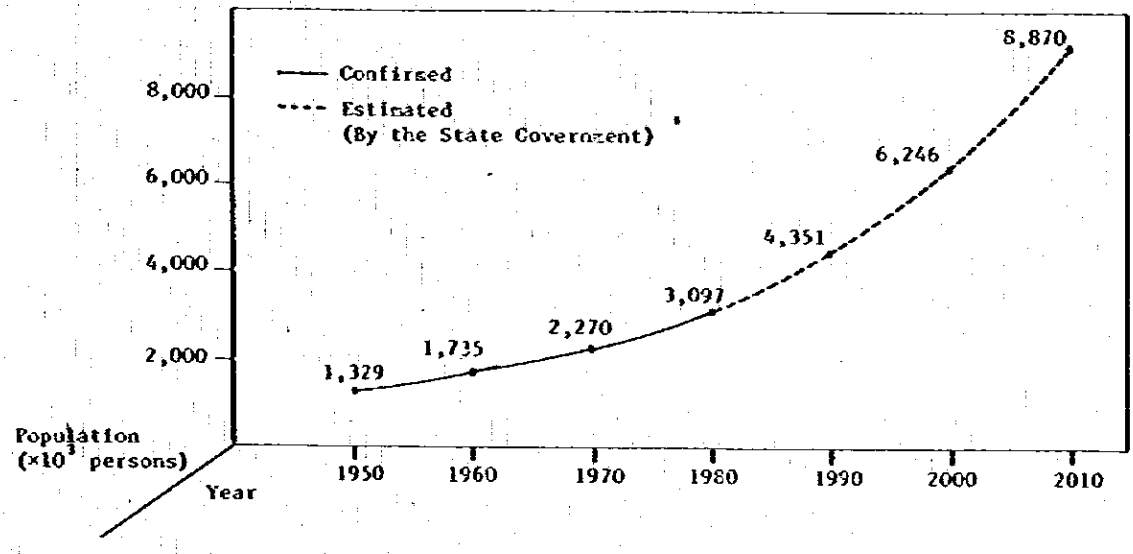


Fig. 1-1-2 Total Population Trend and Future Forecast in Guanajuato

The population flow out of rural areas within the state has concentrated in Leon City and some other major cities. In reference to the future industrial development plan, it is anticipated that the future state population distribution pattern would not be uniform over the whole state territory; the increase rate in the northern and southern regions of the state, where inhabitants are engaged mainly in agriculture and stock farming, would be below the average of the state while population would increase rapidly in the central region including the Bajio Industrial Corridor.

Table 1-1-1 shows the result of a forecast by the State Government of the future population in the state and each municipio involved.

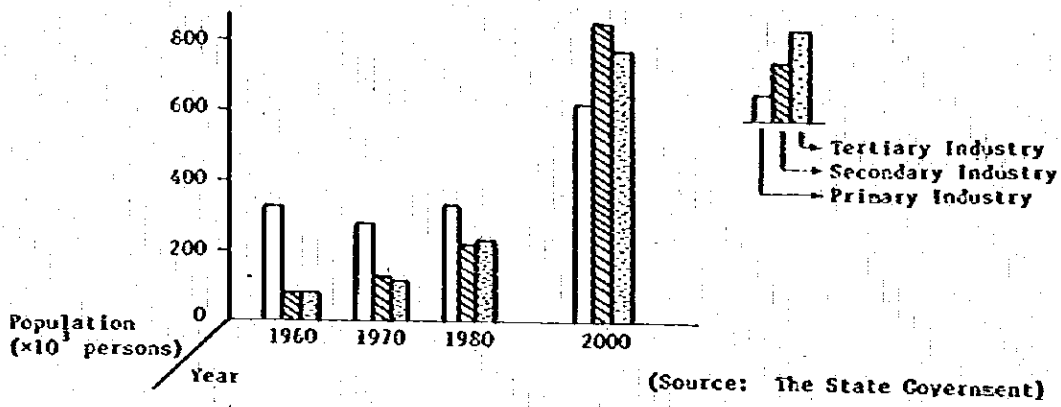
Table 1-1-1 Population of Each Municipio

(Unit: Person)

Name \ Year	1980	1990	2000	2010
Apaseo el Grande	45,769	59,788	78,100	102,021
Celaya	216,103	319,892	473,518	676,858
Cortazar	60,849	85,086	118,977	160,656
Villagran	29,783	39,153	51,471	65,341
Salamanca	156,889	242,135	373,700	556,951
Irapuato	254,173	401,692	634,830	968,835
Silao	84,188	97,433	112,761	130,501
Leon	641,684	1,116,297	1,941,951	3,262,311
Sn. Fco. del Rincon	64,820	81,326	102,036	128,019
Subtotal	1,554,263	2,442,802	3,887,344	6,051,493
Others	1,542,672	1,908,442	2,358,563	2,818,577
Total	3,096,935	4,351,244	6,245,907	8,870,070

(Source: The State Government)

Figure 1-1-3 shows the trend in the number of workers by industries, together with the State Government forecast. Because of large increases in the number of secondary industries, the population is estimated at 818 thousand by A.D. 2000, about 3.7 times that of 1980.



(Source: The State Government)

Fig. 1-1-3 Trend in Number of Workers by Industries

1-1-3 Present and future economic situation prospect in Mexico and the State of Guanajuato

(1) Industries in the State

The State of Guanajuato enjoys favorable conditions for agriculture, with the country's best farm land. It has a long historical background as an agriculture state with a plentiful population. In recent years, however, housing and industrial plants have expanded rapidly into the best farm land areas in the state. It has therefore become important for the State Government to establish administrative measures to preserve the best farm land to conserve agriculture, one of the key state industries.

The major secondary industries in the state are oil refinery and petrochemical industries in Salamanca, leather goods and cement industries in Leon, and food processing industries in Irapuato and Celaya. Those industries are concentrated in large cities along the Bajio Industrial Corridor and are developing at a high annual growth rate.

(2) Industrial development plan in Mexico and the role of the State of Guanajuato

In Mexico, the "National Industrial Development Plan of Mexico (1979 to 1982)" was published and executed as the guideline for industrial promotion activities by the Federal Government. It is outlined below.

First, the basic targets aimed at under the plan can be summarized as follows.

- Decentralize economic activities by avoiding their concentration in a limited number of urban areas.
- Encourage industrial growth by reform of the existing industrial structure.
- Promote national industrialization according to priorities as set up for each industrial sector.
- Aim at national technical innovation and improvement by promoting industrial production for export markets.
- Collaborate closely with private sectors.

To achieve all these objectives, concrete measures have been established. These include priority setting for each industrial sector, setting of preferential areas for decentralization of economic activities, and incentive measures to support small and medium enterprises.

In particular, the priority guidelines for these preferential areas provide five categories as follows:

Area I-A (Preferential incentive area):
Seaside industrial zones in cities neighboring four major ports

Area I-B (Preferential incentive area):
Urban areas with potential to develop as industrialized cities

Area II (Preferential area in the state):
Areas officially designated by concerned Federal Government Committees as the center of industrial activities in the State

Area III-A (Expansion control area):
Mexico City and other areas including its satellite cities

Area III-B (Expansion adjustment area):
Densely populated areas under influence of Area III-A

Within the State of Guanajuato, Municipios such as Apaseo el Grande, Celaya, Villagran, Salamanca, Irapuato, Silao, and Leon are designated Area I-B, while other Municipios such as San Francisco del Rincon, Purisima de Bustos, San Jose Iturubide, and Acambaro are designated Area II.

This designation reveals that the Bajio Industrial Corridor plays an important part in the National Industrial Development Plan. The following points can be cited to justify why the Bajio Industrial Corridor is expected to show further industrialization and growth.

The first point worthy of explanation is that the Corridor is located in the center of the country, near major industrialized zones and large markets such as Mexico City and Guadalajara. The second point is that main national railway and highway routes pass through the Corridor. Besides, large and medium cities exist along those railways and roads

and can serve as the potential core for future industrial development. There is labor force in abundance. Agricultural products in abundance are readily available for the food processing industry. The leather industry has long been flourishing in and around Leon Municipio.

All these factors considered, it can be expected that the industry of the State of Guanajuato will continue its growth.

The new "Basic Conception for National Development," published in 1983, is regarded substantially as a continuation of a conventional industrial promotion policy.

(3) Changing trend and future framework of economic growth in Mexico and Guanajuato

Mexico had long depended solely on agricultural and mining industries. However, with rapid industrialization after the end of World War II, the economic growth in this country in the 1970s reached as much as 6.6 percent (annual average) in real terms. This high growth is obviously attributable to industrial expansion in the sectors of manufacturing, oil-related production, electric power, and transportation. Especially, during the latter half of the 1970s, the growth was supported primarily by large expansion of the petroleum-related industry on the strength of abundant crude oil production. Thus, the growth rate achieved in 1980 and 1981 was as high as 8.3 percent and 7.9 percent respectively.

Very recently, however, the economic growth rate has slowed its pace because of stagnant oil prices. On the other hand, through the series of governmental policies for industrialization, future productivity and economy growth increases can be expected with progress of technical research and development in each industrial sector.

In the State of Guanajuato, the annual economic growth rate (in real terms) jumped from 6.6 percent, below the national average (7.0 percent) in the 1960s to 7.0 percent, above the national average (6.6 percent) in the 1970s due to rapid expansion of secondary and tertiary state industries.

Table 1-1-2 shows the gross domestic product trend for Mexico and the State of Guanajuato, together with the State Government forecast. While the nation's annual growth rate is estimated at 5.5 percent for the 1980s and 7.0 percent for the 1990s and 2000s, the corresponding growth rate in the State is estimated above the forecasted rate for the nation due to the past real trend and the future industrialization potential (6.5 percent in the 1980s, 8.2 percent in the 1990s and 8.0 percent in the 2000s).

Table 1-1-2 Past Trend and Forecast of GDP

Item / Year / Name	GDP (1,000 Million Pesos at 1970 Price Level)						Average Annual Growth Rate (%)				
	1960	1970	1980	1990	2000	2010	1960 - 1970	1970 - 1980	1980 - 1990	1990 - 2000	2000 - 2010
Mexico (A)	225.5	444.3	841.9	*1,438	*2,828.8	*5,564.6	7.0	6.6	*5.5	*7.0	*7.0
GTO State (B)	7.0	13.3	26.1	*48.9	*107.6	*232.4	6.6	7.0	*6.5	*8.2	*8.0
State share of national GDP (B/A) (%)	3.1	3.0	3.1	3.4	3.8	4.2	—	—	—	—	—

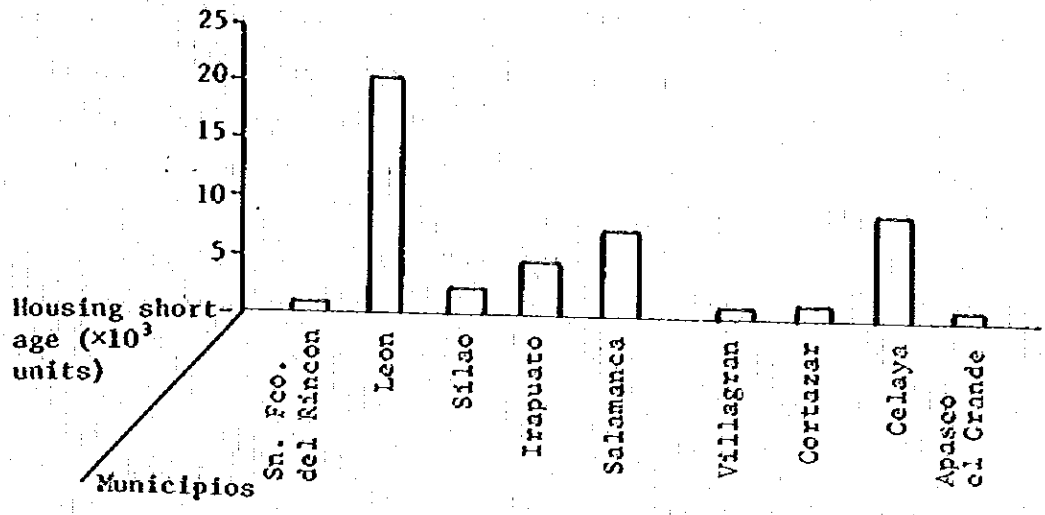
Note: Figures with * are estimates of the State Government.
Source: The State Government

1-1-4 Present situation and future program of urban facilities

(1) Housing construction

From 1970 to 1980 population in the State of Guanajuato grew at a 3.2 percent annual rate while housing increased at a 1.4 percent annual rate resulting in a short housing supply.

As shown in Fig. 1-1-4, shortage of housing is conspicuous especially in Leon and other large cities now undergoing rapid population growth. There is indeed a pressing need for the State Government to take immediate measures to solve the housing problem.



(Source: The State Government)

Fig. 1-1-4 Housing Shortage by Municipios (as of 1982)

At present, the housing area is expanding at the urban outskirt zone and making inroads into the best farming land. To prevent any further sprawling and conserve the good arable land for agricultural use, the State Government has a specific housing construction plan. This plan uses specified land area somewhat apart from the old urban area and unsuitable for agricultural use. The plan envisages construction of a new town of 160,000 population on about a 1,000 ha site on the hill near the boundary between Leon and Silao.

(2) Industrial complex siting

In the State of Guanajuato, rapid industrialization is expected, the conventional plant siting in the State has done, as well as a housing development, by expanding a large city or by forming a belt zone alongside an existing railway or road. The State Government has formulated development projects for construction of two industrial complexes, a 560 ha site in Irapuato and a 170 ha site near Celaya. They are planned to secure road transportation, railway service, and fuel supply for highly efficient operation of the plant and loading of products in order to establish large industries in the future. The project site for development is deliberately selected apart from good arable area wherever possible.

(3) Urban facilities

To cope with escalating needs for urban facilities resulting from future population growth in the State of Guanajuato, urban facilities which satisfy educational, medical, commercial, cultural, recreational, and administrative needs must be developed further. In addition, infrastructure such as water supply, sewerage, and road traffic systems must be expanded. The State Government now considers formation of the integrated urban system as shared by priority development in the following five core cities:

Leon ..... Medical, commercial, and educational functions
Irapuato ..... Recreational, commercial, and educational functions
Salamanca .... Commercial and educational functions
Celaya ..... Commercial, administrative, cultural, and educational functions
Guanajuato ... Commercial, administrative, and educational functions

1-2 Present Transportation Conditions in the State of Guanajuato

1-2-1 Transportation facilities

(1) Roads

The existing road network in the State of Guanajuato extends over 6,330 km in total length. This can be converted into average length of 207 m per square km area, far above the nationwide average of 92 m. However, when compared in terms of kilometers per 1,000 population, the average length is 2.3 km in 1977, below the nationwide level of 2.8 km.

National Highway Route No. 45 serves as the main interurban road through the Bajio Industrial Corridor. It has a single lane in each direction between Apaseo el Grande and Irapuato, but narrows between Villagran and Salamanca, reducing maximum speed to 60 km/h as compared with 90 km/h for the other sections. The two lanes existing between Irapuato and Leon are now being broadened to four lanes, with partial completion for some length. The road conditions vary from section to section as stated above.

Apart from the National Highway, a toll road has been built between Apasco el Grande and Irapuato with a single lane on each side trafficable at maximum speed of 100 km/h. Two additional lanes are planned. Nevertheless, the road is still far from the centers of Celaya, Villagran, and Salamanca.

(2) Railway

The existing railway network within the State of Guanajuato has a total length of 1,011 km. There also exist two railway routes running through the Bajio Industrial Corridor: one connecting Mexico City, Irapuato, and Guadalajara; the other connecting Irapuato and the Mexico - United States border. At present, the existing national railways serve mainly freight transportation. All the existing railway routes within the state are single track with many sidings to industrial plants along the way. Therefore, only eight passenger trains, including mixed trains, are operated a day even between Irapuato and Salamanca. Besides, because those passenger trains are operated mainly for long-distance travel and most of them are scheduled to pass through the State of Guanajuato at night, they are seldom utilized for local commuting services.

At present, an electrification double-track plan is being developed by the Ministry of Communications and Transportation between Mexico City and Guadalajara to increase the traffic capacity for freight transportation. The work for the section between Mexico City and Queretaro is expected to be completed by 1985. The section between Queretaro and Guadalajara, which will most likely pass through the State of Guanajuato, is still under study and the plan about how to carry passengers remains undecided.

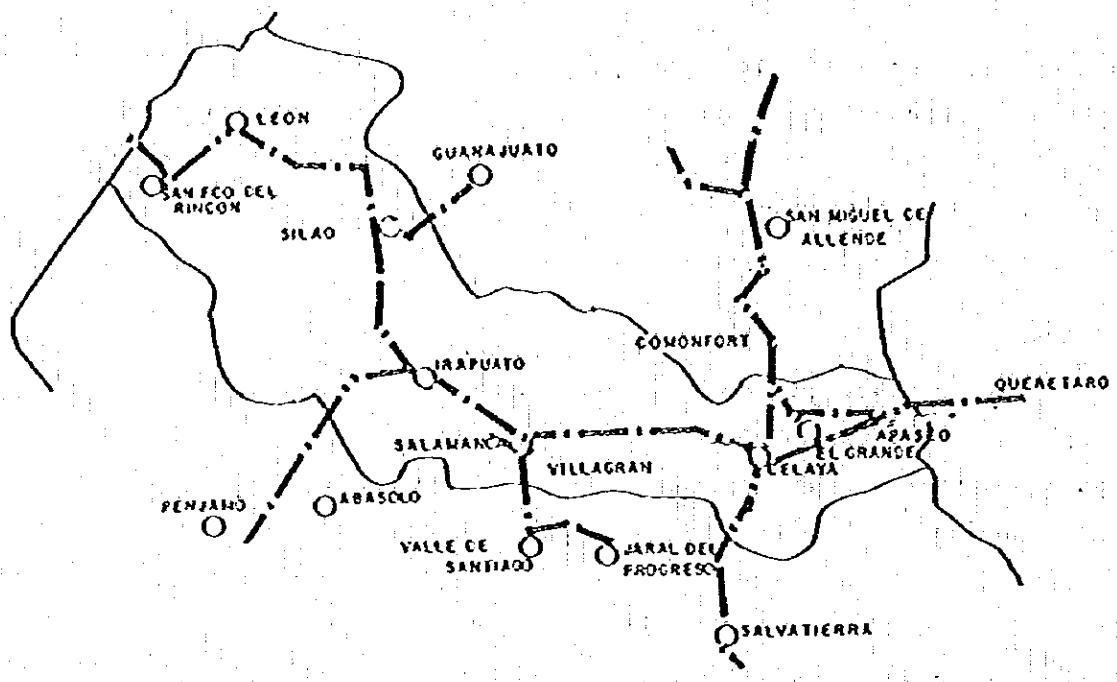


Fig. 1-2-1 Existing Railway Routes within Bajio Industrial Corridor

(3) Airport

The Leon Airport is situated 11 km southeast of Leon City. Regular flights are available direct to Mexico City. Although the number of air passengers is not so great, it doubled between 1977 and 1982. To meet such an increasing demand, the number of daily flights has been increased from two to three.

The existing Leon airport provides no possibility for future expansion because it is sandwiched tightly between the National Highway on its west side and the hilly zone on its east side. A new airport is therefore planned northwest of Silao by A.D. 2000.

(4) Road traffic

As of this date, the bus is generally the only available means for public transportation services within the State of Guanajuato.

Public bus services in Mexico are ordinarily classified into first, second, and third grades: the first grade for long-distance, interurban service; the second grade for medium-distance, interurban service; and the third grade for connection service between major cities and neighboring rural areas.

The main bus services within the State is operated by Flecha Amarilla (second grade), whose service network expands far and wide throughout the State. The company, for example, operates buses every 20 minutes between Celaya and Leon, taking a great share, about 85 percent of the total number of passengers utilizing bus services between cities in the State. Furthermore, Omnibus de Oriente (second grade) operates buses every 20 minutes between Celaya and Irapuato. Some other first grade companies also have operating routes through the Bajio Industrial Corridor.

Users of first grade buses are limited only to long-distance travellers, because those buses have reserved seats and charge a high fare and the number of buses being operated is limited.

In the major cities, bus terminals are well established. Those terminals are operated and managed by the bus terminal companies jointly owned by bus service companies in Celaya, Irapuato, Silao, and Leon.

Both first and second grade interurban buses make it their primary duty to serve passengers from terminal to terminal of each major city at the best possible speed. Passengers who proceed to each city terminal must leave this long-distance bus and take either a city bus or a taxi from the terminal to destination in the city. This seems to be very similar to the case of railway passengers.

1-2-2 Present and future problems

Because the existing railway within the State of Guanajuato is operated mainly for freight transport, the passenger traffic depends entirely upon road traffic by private cars and public buses.

In fact, however, it is undeniable that the bus traffic is generally less punctual, especially for arrival and departure times. People often find it very difficult to squeeze themselves into the crowded buses, the buses are poorly maintained, and running buses are very noisy. Unfortunately, the road traffic frequently causes accidents because of poor safety facilities and the many drivers who customarily neglect speed limits.

The State of Guanajuato is situated at the key point of the nation's traffic and therefore has heavy traffic in transit through its territory.

Especially, with increased large lorry traffic, traffic is congested and accidents occur at the outskirts of large cities. It is estimated that such traffic volume will increase further, proportional to the national economic growth. Road traffic volume measured at an intermediate location between Celaya and Leon amounted to about 12,000 vehicles a day in 1982. This is estimated to further increase to about 40,000 by A.D. 2000. The increase in transit traffic volume would result in congestion problems affecting the interurban transportation system within the State. On the other hand, as the State Government's development progresses, there will be a growing demand for interconnection traffic between the existing cities and the new residential town and the new industrial complexes. In particular, traffic demand during peak commuting hours is expected to increase significantly.

Therefore, according to the present plan, it is predicted that the existing roads and highways would become saturated by ever-escalating demand by 1995 between Silao and Leon and by A.D. 2000 between Irapuato and Silao. This would require investment to establish a new traffic system.

1-3 Railway Development Plan in the State of Guanajuato

As stated earlier, the State of Guanajuato, as represented especially by the Bajio Industrial Corridor, is being rapidly industrialized and urbanized, not only because of its geographical predominance, but also because of the effect of national plans to modernize and disperse both industrial facilities and population. Therefore it is expected that the population of this area will continue growing. At present, that population is concentrated into a few cities, especially Leon City. Because of this, the State Government intends to stimulate the well-balanced growth of each city by decentralizing urban functions now concentrated in specific cities into other cities existing in the Corridor and also by developing both a new town and industrial complexes.

In order to accomplish this plan, many problems must be solved. These include how the interurban traffic system should be developed most efficiently and how the traffic capacity at daily peak commuting hours should be established to meet peak demand. Conventional transportation systems which depend chiefly upon road traffic have the disadvantages that it would

be difficult to obtain extra transport capacity at peak hours and that traffic does not flow punctually and rapidly because of the mixture of both intra-state and inter-state traffic.

Meanwhile, the railway is the most highest capacity mode of mass transport as compared with any other means of transportation, as shown in Table 1-3-1. It excels in rapidity, punctuality, and efficiency.

The State Government is therefore considering urban development projects introducing a new passenger railway between Apaseo el Grande and San Francisco del Rincon in the Bajio Industrial Corridor to develop interurban traffic as well as the commuting traffic in suburbs of large cities.

Table 1-3-1 Transportation Capacity per Hour at Peak Hours by Mode

Mode	Unit Capacity per Vehicle (Persons)	Average Congestion Rate (%)	Vehicles per Formation	Hourly Frequency (Trip)	Transportation Capacity (Persons)
Bus	80	100	1	120	10,000
Streetcar	100	150	2	34	10,000
New transit system	75	100	6	24	11,000
Monorail	120	150	4	24	17,000
Rapid transit	140	150	10	24	50,000

Note: As for the bus, it is assumed that one of the three lanes is used as a priority lane for buses.

Source: From data issued by the Ministry of Transportation of Japan

The following advantages, stated briefly earlier, can be expected if a railway is used as the new transportation mode instead of bus service.

(1) The railway excels in mass transport capability. This advantage, coupled with rapidity as mentioned in the next item, makes the transport capacity more powerful during peak commuting hours.

(2) High speed saves travelling time between cities. Time thus saved can be utilized most effectively.

(3) Scheduled operation is possible. Because of definite setting of departure and arrival time, any business can be conducted strictly as originally planned.

(4) It excels in safety. Because all equipment is designed for "fail safe" operations accidents arising from human error can be prevented.

(5) The train can serve passengers with good riding quality and make a railway journey enjoyable and relaxing.

(6) Less gas and noise pollution from electric cars.

(7) The railway saves energy consuming less oil than buses and private cars.

(8) The railway is flexibly capable of meeting any future increasing demand. Track capacity will be sufficient after conversion into double track. Any demand increase can be met easily by operation of extra trains or addition to the train formation.

(9) The railway is flexibly adaptable to any future structure reform of energy demand and supply. For instance, it becomes fully adaptable to the era of nuclear energy by changing the power generating source from fossil-fueled power to nuclear power.

URBAN DEVELOPMENT PROGRAMS IN THE PROJECT RELATED AREA

CHAPTER 2

CHAPTER 2 URBAN DEVELOPMENT PROGRAMS IN THE PROJECT RELATED AREA

The State Government has plans for urban development programs, housing development programs, and industrial location plans in nine cities in the project related area. Based on these plans, a survey was conducted to establish the route plan and transportation demand forecast.

2-1 Urban Development Programs

Area and population in each city under its development plan are specified in Table 2-1-1.

As noted clearly from those tabulated figures, the urban area in each city expands a relatively small percentage compared with the population increase rate. This fully reflects the basic attitude taken by each municipal authority toward development of the urban area, to prevent further urban area sprawl by increasing the urban population density.

Thus, it is absolutely necessary to increase the population density in urban areas in each city surrounded by good farm land.

In the meanwhile, securing high efficiency in urban functional services by compact development of the urban area is also one of the objectives aimed at by the municipal policy for urban area development.

In Leon City, which has a large population, the municipal authority intends to develop a new residential town to prevent sprawling of its central urban area, in addition to steps taken to enhance the population density in the central urban area. (Refer to 2-2.)

As there are rapid population increases also in other cities, it is necessary to positively develop existing settlement areas outside the central urban area as well as to increase population density of the central urban area. (Refer to Appendix 2-1 for details on future development of urban area, structure of urban area, and urban land use.)

Table 2-1-1 Urban Population and Area

	[A] Urban Area (ha)			[B] Urban Population ($\times 10^3$ persons)			[B]/[A] Population Density (Person/ha)		[C] Population in Municipio ($\times 10^3$ persons)		[B]/[C] Concentration Rate of Population (%)	
	1980 (A)	2000 (B)	$\frac{(B)}{(A)} \times 100$ (%)	1980 (C)	2000 (D)	$\frac{(D)}{(C)} \times 100$ (%)	1980	2000	1980	2000	1980	2000
Apaseo el Grande	110	180	162	11	21	186 (3.1)	98	113	46	78	24	26
Celaya	810	1,870	231	133	367	276 (5.2)	164	196	216	474	62	78
Cortazar	340	600	174	33	62	189 (3.2)	95	103	61	119	54	52
Villagran	130	150	116	13	25	186 (3.1)	104	167	30	51	45	49
Salamanca	910	1,480	162	95	260	273 (5.2)	104	175	157	374	61	70
Irapuato	1,020	2,160	212	162	410	252 (4.7)	159	190	254	635	64	65
Silao	410	580	142	43	72	169 (2.6)	105	125	84	113	51	64
Leon New Residential Town	—	1,000	—	—	160	— —	—	160	642	1,942	—	8
Leon	4,000	8,000	200	617	1,600	260 (4.9)	154	200			96	82
Sn. Fco. del Rincon	340	550	160	36	57	160 (2.4)	105	105	65	102	56	56
Total	8,080	16,580	205 (3.7)	1,143	3,033	265 (5.0)	—	—	1,554	3,887	74	78

Note: Parens. indicate annual increase rates.

Source: The State Government

2-2 Housing Development Program

A new residential town is now being planned at the eastern end of Leon Municipio, under the urban development policy formulated to mitigate population concentration pressure upon Leon City.

General outline of this town is summarized hereunder:

[New residential town] (Fig. 2-2-1)

Location

In the hilly area near National Highway No. 45, in the east end of Leon Municipio

About 16 km from the urban center of Leon, and 14 km from that of Silao

Area

About 1,000 ha. (A.D. 2000)

Residential population

About 160,000 (A.D. 2000)

Expected major means of transportation to and from the town

Railway to be constructed under this Project. (A railway station is to be located in the center of the new residential town. It will be a major facility in the town center.)

Compositions of land use

Residential area	55%
Roadways	28%
Forest	9%
Public facilities	8%

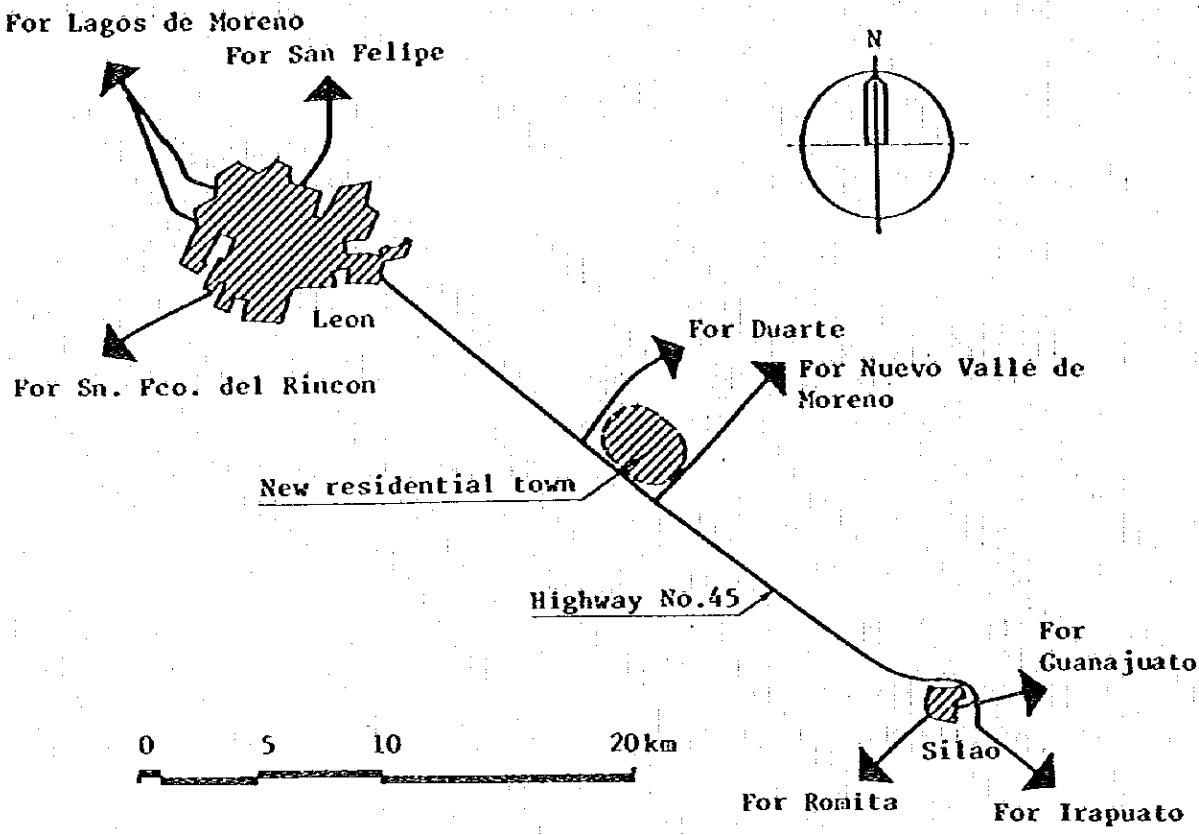


Fig. 2-2-1 Location of New Residential Town

2-3 Industrial Complex Location

Two industrial complexes are now being planned. One is to be sited in the south of Irapuato City and the other between Celaya City and Apaseo el Grande City.

The outline of each plan is summarized below.

In addition, other industrial districts are planned near or unified with each urban area under the urban development plan proposed for each city.

[Industrial complex in the south of Irapuato City (Fig. 2-3-1)]

Location

About 7 km southeast of the urban center of Irapuato

Area

About 560 ha.

Existing industrial area:	About 210 ha.
New industrial area to be developed:	About 350 ha. (A.D. 2000)

[Industrial complex to be located between Apaseo el Grande City and Celaya City (Fig. 2-3-1)]

Location

About 6 km from the urban center of Apaseo el Grande and 7 km from that of Celaya.

Area

About 170 ha.

Existing industrial area:	About 40 ha.
New industrial area to be developed:	About 130 ha. (A.D. 2000)

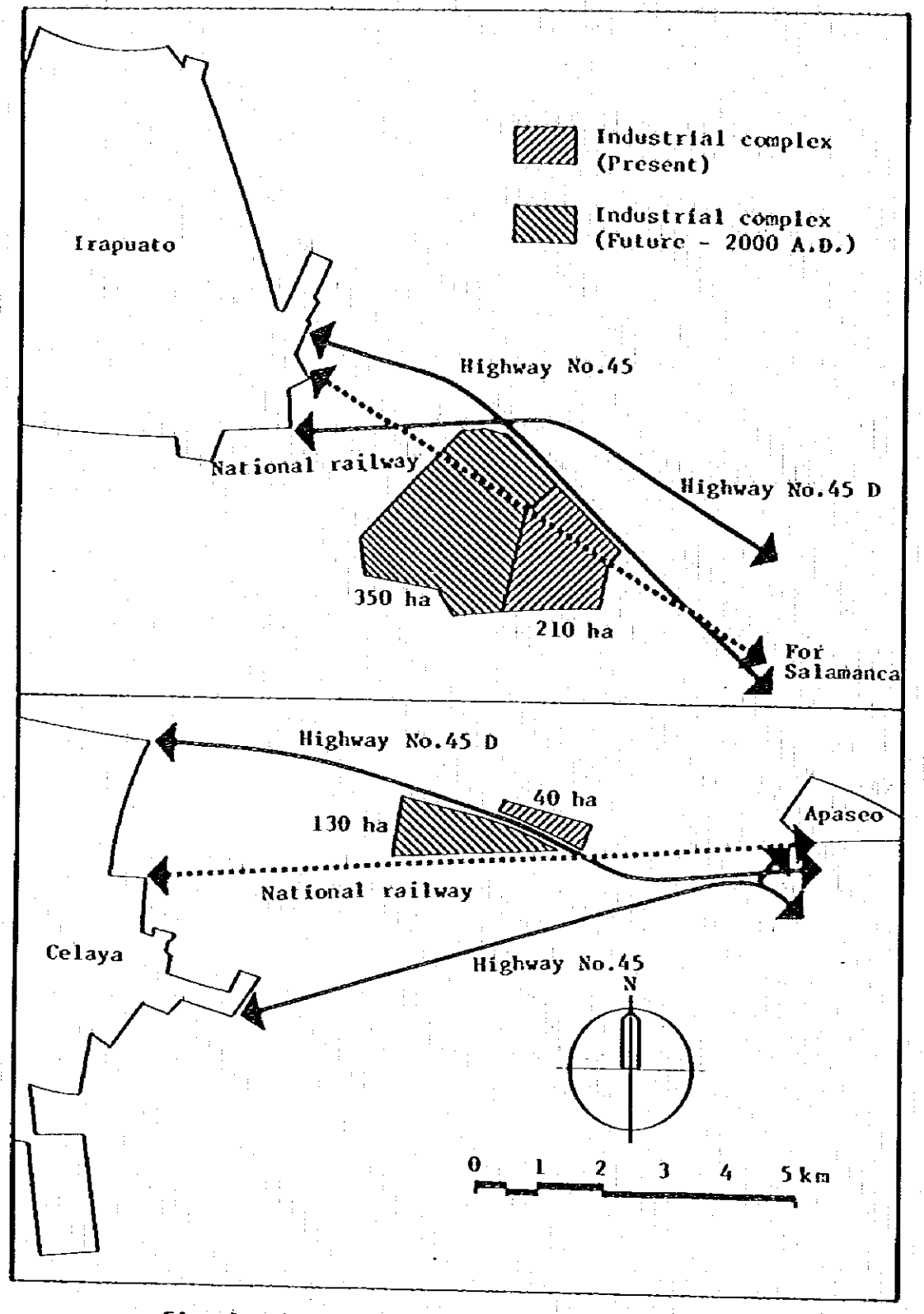


Fig. 2-3-1 Location of Industrial Complexes