PLANNING OF MASS TRANSIT SYSTEM IN CHIANG MAI, THAILAND

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abstract: The planning of Mass Transit System (MTS) in Chiang Mai; the capital city of the northern Thailand, was carried out in two stages: first a master plan was developed, then the feasibility was investigated. The project evaluation was conducted taken into account economic & financial viability and environmental impact. The final master plan consisted of a Light Rail Transit (LRT) of four lines with the total length of 27 kilometers.

1. INTRODUCTION

As a result of economic growth traffic congestion is worsening in the principal regional cities. At present Chiang Mai faces traffic congestion problems in a number of areas, especially at Nawarat Bridge and Tha Phae Road and also within certain business areas in the municipalities west of the Mae Ping River. Government road construction cannot keep up with the growth in traffic demand. Car registration rates growing at 13% per year will lead to a growth in traffic demand which exceeds the capacity of the road network as in Bangkok. The Chiang Mai Light Rail Transit system (LRT) is intended to address this problem and lessen the traffic congestion in the city.

The objectives of the Mass Transit System in Chiang Mai (MTSC) Feasibility Study were: to select the optimum alignments for a mass transit network; to determine the economic and financial feasibility; to prepare preliminary engineering designs and investment plans; and to conduct an environmental study. The study covered an area of 430 km^2 within eight administrative units (one municipality and seven sanitary districts). These are: Chiang Mai Municipality; Chang Phuak Sanitary District; Mae Rim Sanitary District; Mae Jo Sanitary District; San Sai Luang Sanitary District; Ton Pao Sanitary District; Yang Noeng Sanitary District; and Hang Dong Sanitary District. The boundary of the Study Area is shown in Figure 1. The scope of work covered three main studies: (a)An Engineering Study (b) An Environmental Impact Study of the alternative networks which also considered mitigating measures, a monitoring program and action plans for the construction and operation phases; and (c) An Economic and Financial Feasibility Study which included the preparation of a phased MTSC implementation plan and an investment plan with analysis and recommendations on funding sources and mechanisms.

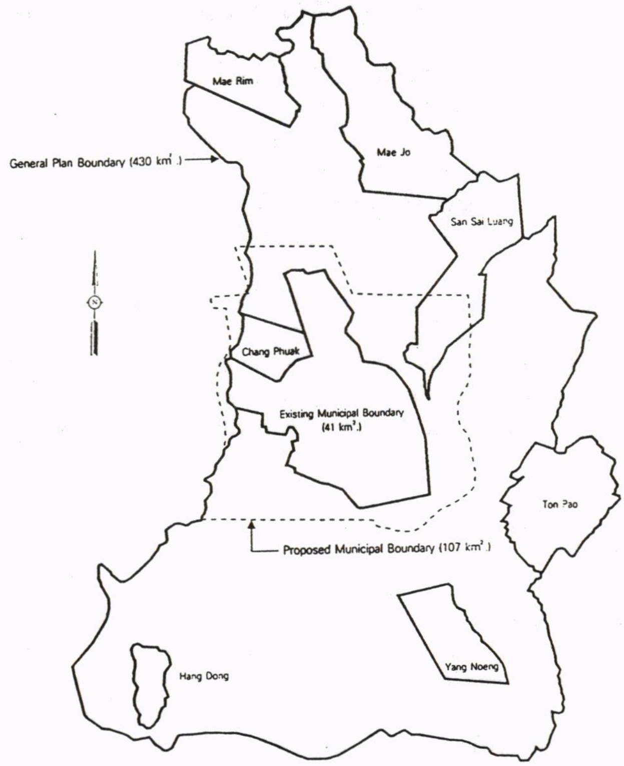

Figure 1 STUDY AREA

2. STUDY SEQUENCE

The Study was carried out in two stages: the Master Plan selection and the Feasibility Study of the MTSC alignments.

2.1 Master Plan

To improve traffic conditions in the Study Area, the Master Plan recommended that the mass transit system should service the whole Study Area and link the urban area with the six outlying districts. The mass transit system was therefore designed with 6 branches arranged in a radial form; the lines are all linked to the city's ring road system. The districts of San Sai and Mae Jo are served by the same line.

The sequence of activities for the field surveys and data collection, were as follows:

(a) Six alternative mass transit networks were drawn up. These were selected after undertaking: land use and socio-economic studies; a study of existing and planned roads; an inventory survey of road characteristics and conditions. Due consideration was also given to the following in selecting the networks for evaluation: the locations of buildings; archaeological and historic sites; public utilities; traffic conditions; one-way enforcements; bus routes; business, academic, commercial, residential and industrial areas; and areas with potential for joint development.

(b) The following traffic studies were carried out: origin-destination surveys (home and road-side interviews); trip purpose by vehicle type; traffic counts; vehicle occupancy counts (by spot checks); and speed surveys on main roads during peak and off-peak times. The traffic survey data along with the data collected in section (a) above were used to determine trip characteristics and vehicle composition on major road links, the composition of forecast trips by vehicle type, and ultimately, passenger forecasts for the selected light rail transit (LRT) system.

(c) The mass transit technology study considered seven systems. Of these, the heavy rail type of mass transit was discounted since it is unsuitable for the range of service required. The remaining six systems were studied in detail. These were: Conventional Bus, Trolley Bus, Light Rail Transit (LRT), Linear Induction Motor System, New Tram, and Monorail. The study compared the systems both quantitatively and qualitatively. The advantages and disadvantages of the systems, as well as social and environmental considerations and their cost-effectiveness, were analysed. LRT was selected as the most suitable system for Chiang Mai.

(d) An initial environmental study was carried out. Home interviews were conducted to ascertain the public's attitude towards a mass transit system. At this stage the examination was comparative between the networks covering 14 subjects of the 4 categories under the Office of Environmental Policy and Planning (OEPP) guidelines and directives.

(e) A study of networks and corridors was undertaken for the master plan selection. The chosen network has a total length of 27 km and consists of four lines as shown in Figure 2.

2.2 Feasibility Study

The Feasibility Study entailed the following steps.

(a) A topographical survey was conducted using aerial surveys and town planning maps as the base maps.

(b) Land acquisition and property compensation costs and construction, operating and maintenance costs of the system were determined. A financial analysis was carried out for each line and this revealed that Lines 1 (Red line) and 2 (Blue Line) need government subsidy to be financially viable. It was also found that Line 1 gave better rates of return than Line 2.

(c) The alternative alignments for all the lines were formulated. The best alignment of each line was selected based on four criteria: serviceability and engineering requirements, investment requirements, environmental effects and the potential for development around the stations.

(d) Surveys, interviews and examinations were undertaken for each alternative and track type (underground, at-grade and elevated structures) as part of the Environmental

Study. Each alignment alternative was rated based on environmental factors and the result used in alignment selection as explained in (c) above. An Environmental Impact Assessment (EIA) was then conducted along the selected alignments.

(e) The preliminary civil works design covered: alignment, right-of-way width requirements, track structure, geotechnical designs, drainage systems, and the location of existing public utilities. Preliminary designs were made for stations and transfer stations, power supply sub-station, workshop and depot, and park-and-ride sites.

(f) Costs for all lines were then estimated based upon these preliminary design plans, including: construction cost of the light rail system and equipment procurement costs; depreciation reserve costs; operation and maintenance costs; and the environmental improvement and monitoring costs .

(g) Economic and financial feasibility analyses were carried out, including an analysis of investment and funding options. The results of the study showed that to be financially viable government support was crucial.

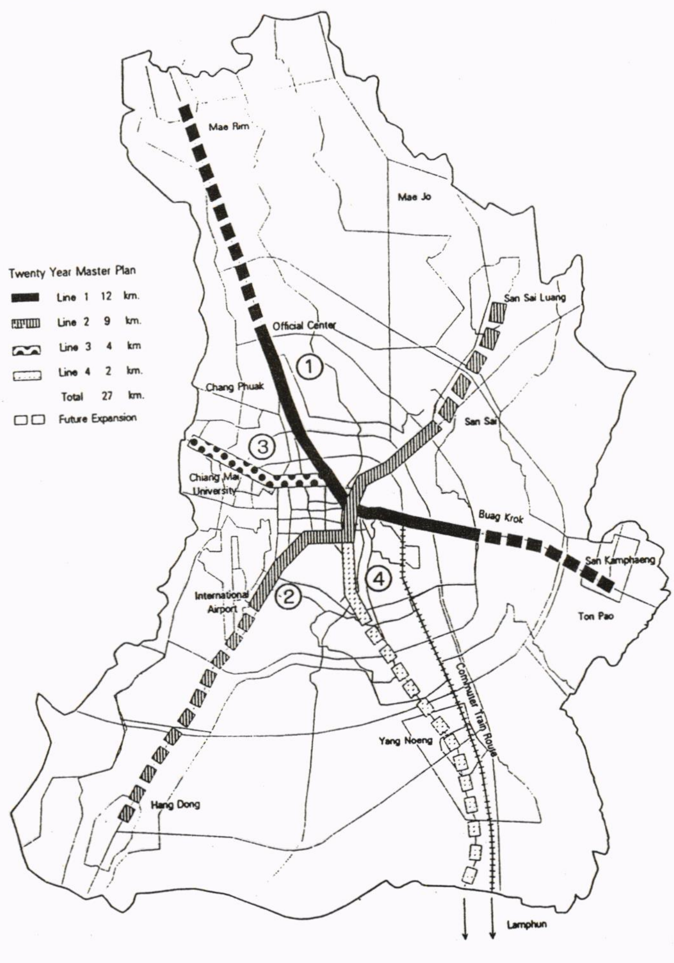

Figure 2 MASS TRANSIT MASTER PLAN

3. MASS TRANSIT TECHNOLOGIES

Characteristics and performance of seven types of mass transit system were studied and analysed. These were: Conventional Bus; Electric Bus; Light Rail Transit; Linear Induction Motor Transit; New Motor Tram; Monorail; and Heavy Rail Transit.

The Heavy Rail Transit system was deemed to be too large and expensive for the forecast ridership in Chiang Mai and hence it was rejected at the start as inappropriate. The remaining six systems were analysed and compared as follows: Technical Aspects; Social and Environmental Aspects; and Cost-effectiveness. A qualitative comparison of the technical aspects of each type of system is shown in Table 1. The social and environmental effects are more or less the same for at-grade and underground transit systems, except for linear induction motor systems which use a proprietary technique.

The passenger trip forecasts for Line 1 will be 7,700 people per hour per direction during peak times (equivalent to 216,000 people per day) in 2004, and 14,800 people per hour per direction during peak times in 2014. Therefore the most suitable system for Line 1 is one that has a capacity ranging between 5,000 and 20,000 people per hour per direction. Light Rail Transit systems offer this capacity flexibility.

4. PROJECT COST

4.1 Construction Cost

The construction cost is shown in Table 2 broken down into a number of categories: land and compensation costs; design costs; civil works, system costs (track, signalling, power system, electrical and mechanical and workshop and depot); station costs; rolling stock; administration and supervision; and miscellaneous and contingency costs.

4.2 Annual Operating and Maintenance Costs

The annual passenger figures, in terms of million persons per year, were used to develop the operation and maintenance costs summarized in Table 3. Operating and maintenance costs were calculated separately for at-grade and underground sections of the system.

4.3 Environmental Improvement Cost

The costs of environmental mitigation measures, environmental monitoring and annual environmental examinations were estimated in the EIA. The overall budget for these items is expected to be 66.3 million Baht (1 Baht = USD 0.04) for the four lines over 20 years with the bulk of the outlay being in the early years. If only Line 1 (Red Line) is constructed then the budget is 17.5 million Baht over 20 years. These costs are less than 1% of the total project cost and considered highly worthwhile.

Table 1
TECHNOLOGIES COMPARISON - QUALITATIVE FACTORS

Technical Considerations	Bus			Trolley Bus			Light Rail Transit			Linear Induction Motor			New Tram Motor			Monorail		
	Elevated	At Grade	Underground	Elevated	At Grade	Underground	Elevated	At Grade	Underground	Elevated	At Grade	Underground	Elevated	At Grade	Underground	Elevated	At Grade	Underground
1. Operational Considerations	Fair	Fair	-	Fair	Fair	Fair	Good	Fair	Good	Good	Fair	Fair	Fair	Fair	Fair	Good	-	-
2. Systems Expandability	Easy	Easy	-	Easy	Easy	Moderate	Easy	Easy	Moderate	Easy	Easy	Moderate	Easy	Easy	Moderate	Easy	-	-
3. Safety	High	High	-	High	High	High	High	High	High	High	High	High	High	High	High	High	-	-
4. Reliability and Maintainability	High	Moderate [1]	-	High	Moderate -High	Moderate	High	Moderate -High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	-	-
5. Passenger Amenities	Moderate	Moderate -High [2]	-	Moderate	High	Moderate	Moderate	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	-	-
6. Urban Development Implications	Moderate	Low	-	Moderate	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate	High	Moderate	Moderate	High	Moderate	-	-
7. Statutory Requirements	Some	None	-	Some	None	None [3]	Some	None	None [3]	Some	None	None [3]	Some	None	None [3]	Some	-	-
8. Constructability	Moderate	High	-	Moderate	Moderate	Low	Moderate	Moderate -High	Low	Moderate	Low	Low	Moderate	Low	Low	Moderate	-	-

1/ Cannot maintain schedule as there is no traffic signal priority nor exclusive bus lanes.
2/ High for air-conditioned bus on exclusive right-of-way (or key route bus).
3/ No law enforcement for underground rights beneath buildings or private land; therefore no direct access can be made.

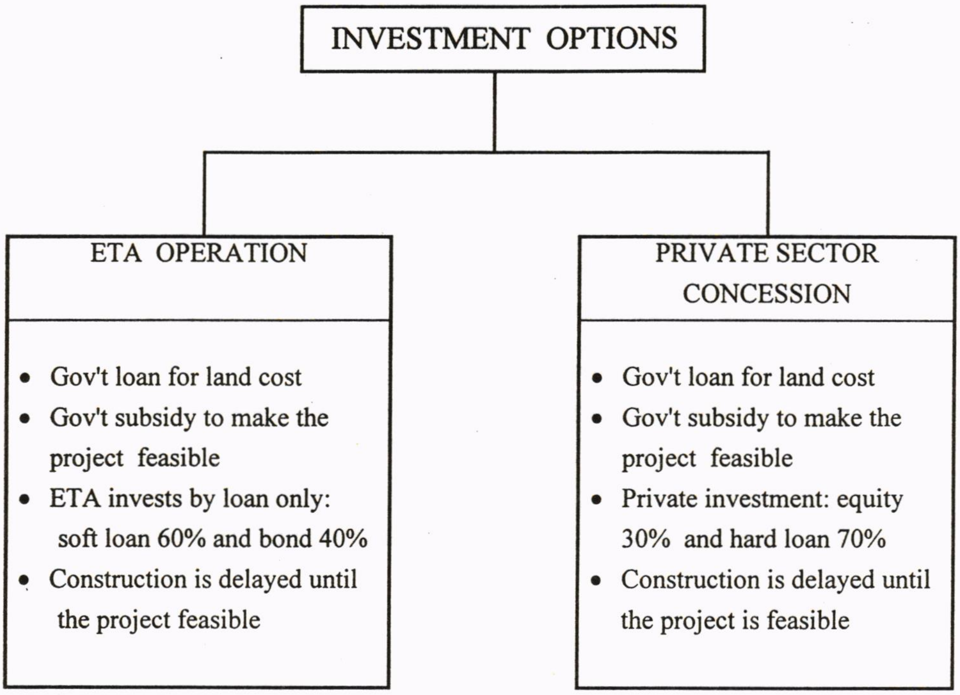

Figure 3 INVESTMENT OPTIONS

The following assumptions were made in the financial analysis:

- Financing option:
  - for implementation by the ETA, 60% is by soft loan and 40% is by bonds (there is no capital investment); and
  - for private concession, 30% is in cash investment and 70% is by commercial loan.

- The concession project life is 35 years, 5 years for construction and 30 years for operation.

- Funding:
  - the commercial (hard) loan bears a 12% interest rate for 15 years and includes a 5 year grace period;
  - the soft loan has a 3.5% interest rate for 25 years and includes a 7 year grace period;
  - government loans have no interest for a 20 year period and payback is at a constant amount in the last 10 years; and
  - government bonds bear an interest rate of 10% for a 7 year period.

- The revenue in the analysis is only from passenger fares - joint development, advertising and retail rentals etc. are not included in the analysis.

- The costs for the system include: construction costs (Table 2); operation and maintenance costs (Table 3); depreciation reserve; interest and corporation tax payments to the Budget Bureau, which add up to 30% of the net profit for implementation by private concession and 35% of profit deduction in the case of ETA implementation .

- Sensitivity analyses were carried out using the following variable factors:
  - annual inflation rate at 4%, 5% and 6%;
  - revenue from farebox at 75%, 100%, 125% and 150% of base forecast;
  - interest rate for hard loans at 11%, 12% and 13%;
  - interest rate for soft loans at 2.5%, 3.5% and 4.5%;
  - interest rate for bonds at 9%, 10% and 11%;
  - foreign currency exchange rate variations at -20%, 0% and +20%; and
  - construction costs at 80%, 100% and 120% of the base estimate.

- For the financial analysis an inflation rate of 5% and a discount rate of 12%, for the ETA investment option, and 14% for the private sector option, were used.

Financial Study Conclusions

- Line 1 is the most feasible line. This line is 12.25 km long, of which 8.45 km is at-grade and 3.8 km is underground; a 100 rai (1 rai = 1,600 m^2) depot is provided at Mae Khao in the Buak Khrok area. For the ETA to build and operate the line a budget of 14,575 million Baht is needed. A government subsidy of 3,910 million Baht (27% of costs) is required for land acquisition and a government borrow of 2,904 million Baht is required (20% of costs) for construction of civil works. This government assistance will enable the project to achieve a 13.2% Financial Internal Rate of Return (FIRR). Should a private concessionaire construct and operate the line, then a government subsidy amounting to 9,075 million Baht (or 63% of costs) is needed for the project to yield a 14% FIRR.

- Should a larger government subsidy be available, the construction of two lines then becomes feasible. Line 1 and Line 2 would be constructed comprising a total of 20.9 km. If the ETA build and operate these lines then a budget of 31,980 million Baht is needed, of which 16,557 million Baht (or 52% of the costs) would be a government subsidy for land acquisition and civil work construction costs. This option gives a FIRR of 16%. For the private concession option, a government subsidy of 70% of project costs, or 22,087 million Baht, is needed to give a FIRR of 14%. Implementation by the ETA is the only feasible option if no additional government support is available (above that provided for Line 1 alone): with construction of Line 2 starting 1 to 2 years after Line 1 then the FIRR is 12%.

- The total length of the construction of the three lines - Lines 1, 2 and 3 - is 25.4 km. For the ETA to build and operate these lines a budget of 40,284 million Baht is needed, of which 21,181 million Baht (52% of the costs) will have to come from government subsidy to achieve a FIRR of 14%. For a private concessionaire to build and operate these lines an increased government subsidy of 28,479 million Baht (72% of costs) is needed to achieve a FIRR of 14%. With no additional support for lines 2 and 3, implementation by the ETA is the only feasible option, with a stage construction approach being taken: construction of Line 2 is begun two years after the start of Line 1 and the construction of Line 3 is three years after the start of Line 1. By doing this the FIRR decreases to 12%.

- The four lines together comprise 27.4 km. Should the ETA build and operate all four lines a total investment of 44,020 million Baht is needed of which 22,961 million Baht (52% of costs) must be in the form of government subsidy to achieve a FIRR of 13%. For a private concessionaire to build and operate the four lines, a total budget of 43,240 million Baht (73% of costs) is needed of which the government must subsidize 31,476 million Baht in order to achieve a FIRR of 14%. As with the above scenarios, the only feasible option is for the lines to be implemented by the ETA using a stage construction approach. The rates of return vary according to the degree of government subsidy as follows:

    - the FIRR is 12% if the government subsidizes land costs and offers a loan (government borrow) for the civil work construction commencing with Line 1 in 1997, Line 2 in 1998, Line 3 in 1999 and Line 4 in 2001; and

    - the FIRR is 12% if the government subsidizes both land costs and civil work construction of the four lines commencing with Line 1 in 1997, Line 2 in 1999, Line 3 in 2000 and Line 4 in 2001.

Figure 4 shows the sensitivity of the financial investment in relation to various factors. Some lines are more sensitive to the chosen variables than others.

7. ENVIRONMENTAL STUDY

An environmental study was carried out to assist in selection of the most suitable and viable mass transit system for Chiang Mai; the findings of the environmental study were used along with engineering design studies and economical and financial analyses in selecting the most appropriate system for the city. The environmental study has been divided into two parts: the first part covers the initial environmental examination (IEE), and the second deals with environmental impact assessment (EIA).

The IEE looks at the environmental parameters relevant to the preparation of the Chiang Mai mass transit master plan. These parameters were taken into account during the screening process of the six alternative mass transit networks. Based on the first public hearing and the IEE, the following issues were considered when preparing the master plan of the mass transit system network:

- Within the 2.5 square kilometres of the moat area, the construction of the network line should be underground. The preferred alternative would be no construction within the moat area in order to avoid any negative impacts on ancient monuments and important historical places and to preserve the look of the area;

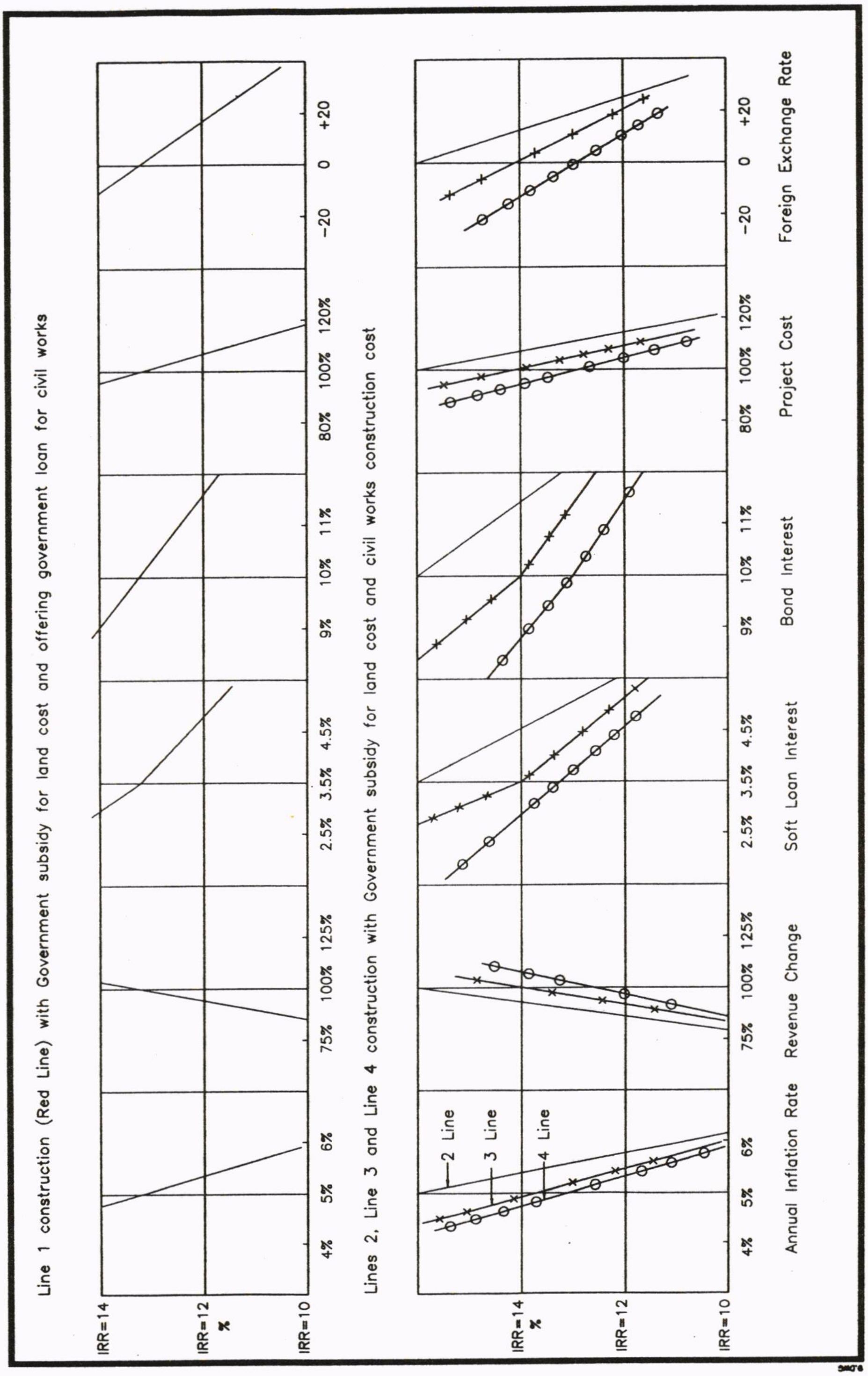

Figure 4 PROJECT SENSITIVITY TO VARIOUS VARIABLES - ETA OPERATION CASE

- The mass transit lines should be constructed alongside existing main and secondary roads. Problems with land and property expropriations must be minimised.

- The construction of the mass transit system should be regarded as a pioneer project which is but the start of further development in the city. It should be cost-effective and have no negative environmental impacts, as such it should be a model for future developments.

The EIA is a detailed study of the physical and biological resourses, human use value and quality of life along the mass transit routes, based on the guidelines of the OEPP. The EIA also summarizes the long-term environmental impact of the system during the operations phase. Recommendations for monitoring measures, impact mitigation plans and personnel requirements are also made.

8. CONCLUSIONS

The population of Chiang Mai is expected to increase steadily in the near future, from 680,000 in 1994 to 1,150,000 in 2016. The Study has concluded that a mass transit network should be developed in order to address the resulting growth in transport demand in the city and its environs. The characteristics of the recommended system are as follows.

- Bearing in mind Chiang Mai's narrow roads and their configuration, the most suitable mass transit system is the narrow-bodied Light Rail Transit new model trams having a body width 2.70 meters or less.

- Certain urban sections of the alignment should be underground to avoid unaccepatble disruption to city traffic during construction and to avoid loss of road space.

- The Study forecasts ridership levels of between 5,000 to 20,000 passengers per hour per direction.

The Study makes the following conclusions:

(a) The MTSC Master Plan network is economically feasible in all respects concerning the construction of one line, two lines, three lines or four lines at once;

(b) The financial returns are viable, for both ETA and private concession investment, if there is some government subsidy - a private sector investor would require a higher level of government subsidy than would be the case if the ETA undertakes the project. For it to be financially feasible for the ETA to build and operate Line 1 and Line 2 (Line 2 built after the start of construction of Line 1), government subsidy is needed for land and civil work construction costs. If more than the two lines are constructed then the financial risks increase. Therefore, the decision to construct Line 3 and Line 4 should be re-evaluated after the first two lines are in operation provided that revenues exceed expectations.

REFERENCES

Southeast Asia Technology Co., Ltd, Epsilon Co., Ltd, and Louis Berger International, Inc. (1996), **Feasibility Study for the Master Plan of the Mass Transit System in Chiang Mai,** the Expressway and Rapid Transit Authority of Thailand.