STRATEGY PLANNING FOR URBAN ROAD SYSTEM DEVELOPMENT AND MANAGEMENT

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ABSTRACT: *The paper describes the formulation and application of a Goals Achievement Methodology to evaluate alternative road transportation strategies. The method was used to develop an appropriate road transportation development strategy for Manila, capital city of the Philippines, in a project funded in part by the World Bank.*

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INTRODUCTION

This paper describes the basis of development of an Urban Transportation Strategy Plan for Metropolitan Manila, the capital city of the Republic of the Philippines.

The Metro Manila Urban Transportation Strategy Planning Project is an inter-agency study in several parts under the direction of the Metro Manila Transportation Policy Committee comprising the Minister of Transportation and Communications, the Minister of Public Works and Highways, the Vice-Governor of Metro Manila (representing the Metro Manila Commission) and the Commander-in-Chief of the Philippine Constabulary.

Pak-Poy & Kneebone Pty. Ltd. were engaged as consultants to the first two parts of this project, viz:

Part A - Policy and Program Development Studies

Part B1 - Project Preparation, Institutional Development and Other Studies

Part A was funded in part by the World Bank and was completed in May 1983. Part B1 commenced in July 1983, funded by the Australian Development Assistance Bureau and is due for completion in June 1984.

Part B2 yet to commence comprises project preparation for major new urban road and overpass projects.

The overall objectives of Part A of the project were defined as:

- Evaluate alternatives and recommend an apporpriate transportation development strategy for Metro Manila.
- Identify appropriate investment packages for the medium term (1983-1992) and high priority investment packages required before 1987.
- Recommend appropriate co-ordination and other institutional arrangements to assist in the formulation of plans and programs.

An integral part of the project was to be the updating, consolidation and logical synthesis of the many previous studies and proposals on Metro Manila's transportation problems.

It is not intended here to describe the problems or the proposed solutions to these in Metro Manila; these are described in the various reports listed in the bibliography. Rather, this paper is directed to describing the methodology used in Part A of the project, for possible application in similar projects.

During the 1970's transport in Metropolitan Manila has been the subject of literally hundreds of studies covering rail and bus mass transit, jeepney services, urban road development, transport terminals, traffic engineering and transport policy issues. Whilst a number of urban road and traffic engineering improvements have been constructed over the decade, there was no overall plan or integrated transportation development strategy. The purpose of the Part A study was therefore to synthesise all the diverse, often disparate and conflicting studies and proposals into a unified strategy understood and accepted by the key decision-makers in the concerned agencies.

METHODOLOGY FOR EVALUATION

Transportation planning for Metro Manila reduces itself to a problem of choice rather than the generation of feasibile solutions. There are many alternatives from many previous studies. Solutions abound but problems are pressing, recurring, or worsening whilst resources - financial and human - are severely limited.

A variety of techniques are available to assist planners and decision-makers in making such choices, ranging from an intuitive approach (which may be appropriate where the best alternative is easily identifiable) to comprehensive cost-benefit analysis. Cost-benefit analysis is the most popular and widely accepted technique for systematic and explicit evaluation of alternatives. The literature on cost-benefit is replete with explanations, rationalisations, and suggestions about the arithmetic of discounting, the opportunity cost of capital, the estimation of benefits, the analysis often falls short in the value judgements that are necessary when advising Governments, in capturing intangibles and externalities without dollar values and when addressing multiple objectives.

For the above reasons a Goals Achievement Method (GAM) was considered to be more appropriate for a study of this type involving selection of projects in the context of alternative objectives, strategies and projects.

For the purpose of this study, therefore, a two-stage evaluation framework was chosen (as shown in Figure 1) in order to:

(a) Sort out projects into two groups, viz:

- An action program - a list of obviously feasible projects selected in a consistent and systematic manner.
- A feasible set of projects ranked in their order of importance and worth.

(b) Provide a workable framework of evaluation under the following circumstances:

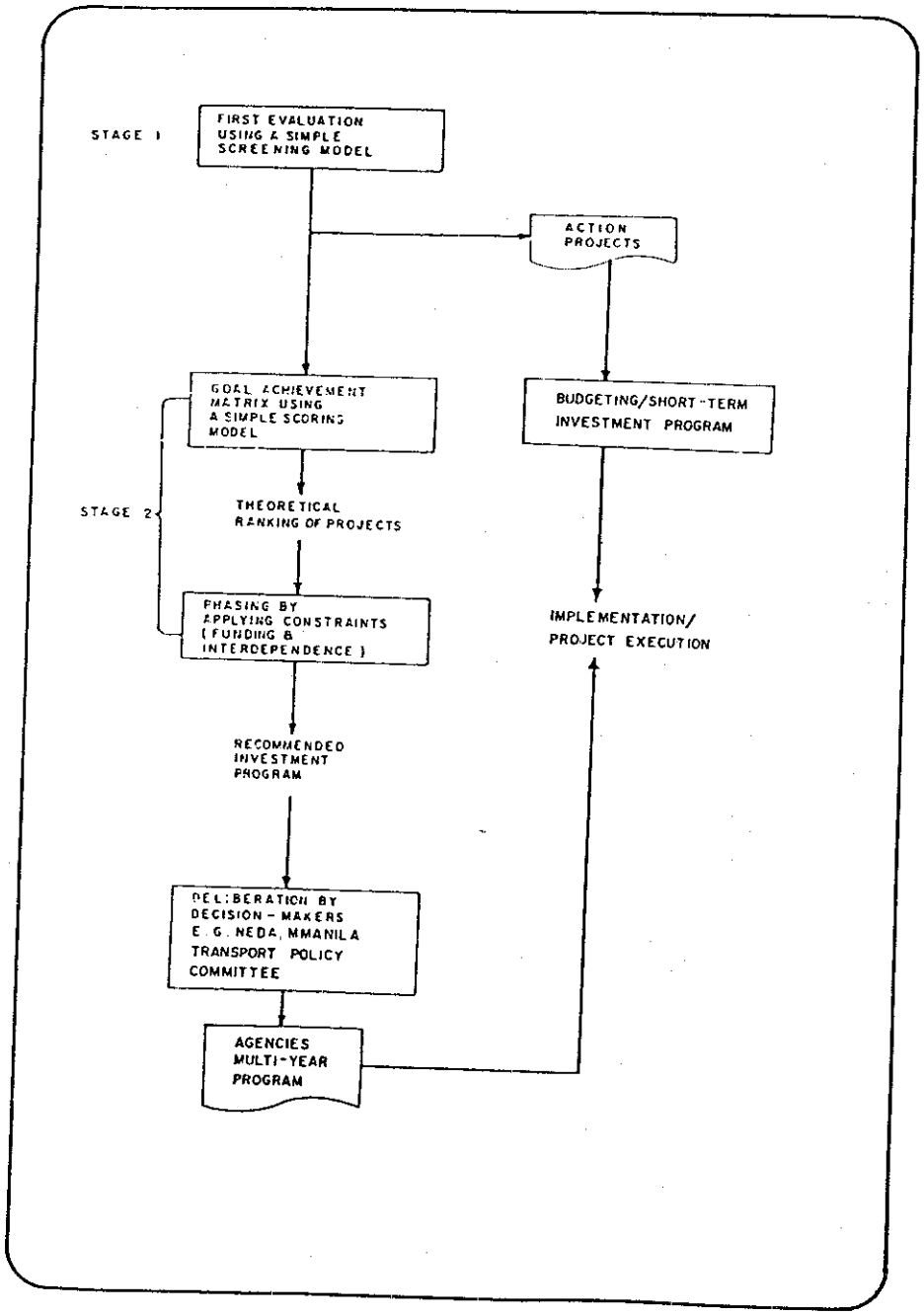

FIG. 1: MULTI-STAGE EVALUATION PROCESS

- Not all potential projects are in the same stage of preparedness. A few have full-blown cost-benefit analysis, but many are in the early proposal stage with some prefeasibility grade appraisal. Hence, the methodology should be able to compare projects with dissimilar information value.

- While the feasibility per se of a project can be established, it is no indication of high priority vis a vis other projects. The chosen methodology should be able to provide a better gauge of ranking and optimisation of benefits from a project mix over a 10-year horizon.

- In reality, not all projects undergo formal appraisal (in the traditional cost-benefit sort of way) nor should they always be subjected to one. Given the magnitude of the problems and the fluid situation in Metro Manila, a flexible and dynamic approach is imperative.

- It is not inconceivable to expect a few of the projects to be an alternative of another (i.e. not mutually exclusive).

First Stage Evaluation

The first stage in the two-stage evaluation aims to identify a set of projects that could be programmed immediately for implementation by screening proposals against four criteria (see Figure 2):

- Is it do-able?

- Is it compatible with existing policies and development plans?

- Is it economically feasible?

- Is it important and urgent?

Each of the criteria used for this Stage 1 are described below:

(a) Is it do-able? This question would assess whether the project can be done in about 3 years time or less. The required financing is not excessive as to warrant a major effort in fund generation. Also, the sponsorship of an existing agency is not counterbalanced by a major objection or doubts from another party. Finally, can it be done within the current administrative set up?

(b) Compatibility with de facto policies and development plans. The principal consideration here is that the project fits in with the existing framework plan for regional development.

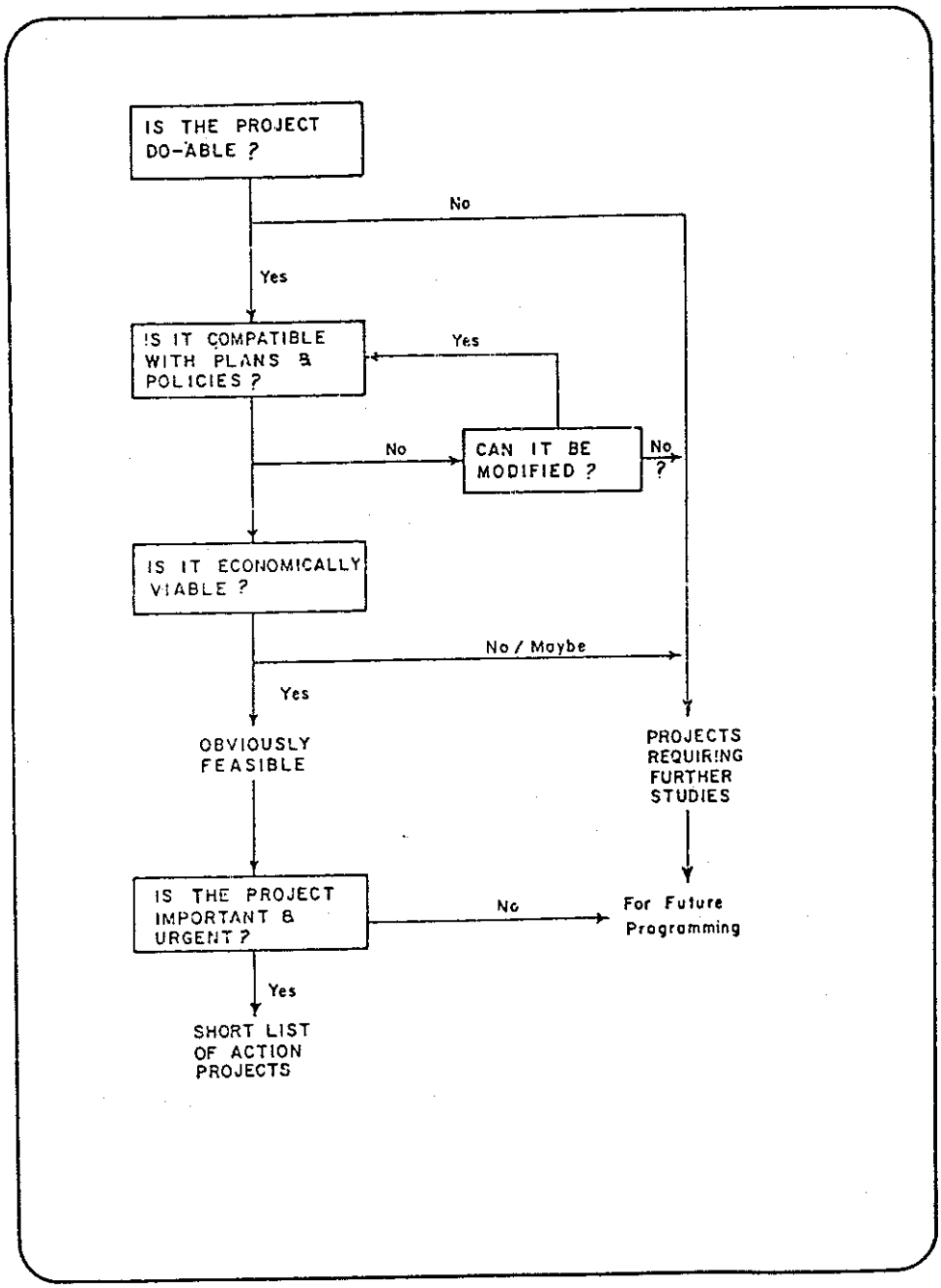

FIG. 2: SIMPLIFIED PROCEDURE FOR STAGE 1 EVALUATION

Where there are some grey areas (since the Plan is broad) conformance to the various policies listed in support of the Plan provided a satisfactory test.

(c) Economic viability. If a detailed feasibility study is available, then the answer can be secured easily. Short of a full-scale study, some rough estimates should be prepared based on a data already on hand such as traffic volume and vehicle operating costs. If one type of benefit aggregated over 3 years will already amount to more than the capital cost of a project whose life exceeds 6 years, then the viability of a project can be assumed. Discounting and shadow pricing need not be resorted to.

(d) Does the project address an important and urgent issue? More than any other criterion, this one gauges the pressure to implement a particular transport solution or project. Importance is measured by the leverage or key role of the project, once completed, in the realisation of an overall transport development plan and in opening future possibilities and new options. It is equally important if it locks in a particular strategy and prevents the consideration of other alternatives. Urgency, on the other hand, is indicated by an impending problem which would have high public visibility, and where deterioration of existing services would be politically intolerable.

Second Stage Evaluation (GAM)

For Stage 2 evaluation, a Goal Achievement Matrix of the form

$$Ui = \sum_{jk} Vj\ Wjk\ Cjk$$

was adopted

Where

Ui = the aggregate worth or combined point scores of project 1 towards the achievement of objectives j = 1 to n

Vj = weight of objective j, where

$$\sum_{j=1}^{n} Vj = 1.0$$

Wjk = the weight or relative importance of criterion k in measuring objective j, where

$\Sigma Wjk = 1.0$ for every j

Cjk = criterion as one measure of objective j, where one objective may have more than one criterion (range, say 1 to 10)

(a) This method will generate "scores" for each project, thus automatically implying a descending order (from highest scores to lowest) of priority. A change in policies and circumstances could be translated into a different set of weights, thus producing a new ranking. The process can be repeated to determine the sensitivity of the program to policy changes.

(b) To arrive at a recommended phasing over the 10-year planning period, the scoring results can be adjusted by the application of two constraints:

- Funding constraints - the likely availability of funds over a given period imposes a ceiling which may necessitate pushing of the next group of high-scoring projects to the next period.

- Interdependence - the sequencing of implementation where one project must or should precede another becuase of physical limitation, technical requirements, or as pre-requisite to success.

- Timing linkage of other development projects with the transport program. For example, the excavation of roads for utilities should preferably precede the upgrading or concreting of roads, to avoid double costs.

Figure 3 is a flow chart showing the various steps involved in the evaluation.

OBJECTIVES AND CRITERIA

An explicit treatment of objectives is central to the Goal Achievement evaluation method used in this study. Each project must be rated in terms of its worth against a set of objectives and corresponding criteria, rather than against other projects.

The national development goals enunciated in the (National Economic Development Authority) NEDA Plan document (Philippine Development Plan for 1983-1987) were taken as intrinsic goals, i.e. the long term idealised state. These are:

(a) Sustainable economic growth

(b) More equitable distribution of the fruits of development

(c) Total human development

In practice, the intrinsic goals have to be translated into operational terms and lower-level measurable objectives and performance criteria. As a first approximation, a tentative list of transportation objectives were generated through a consideration of such values as:

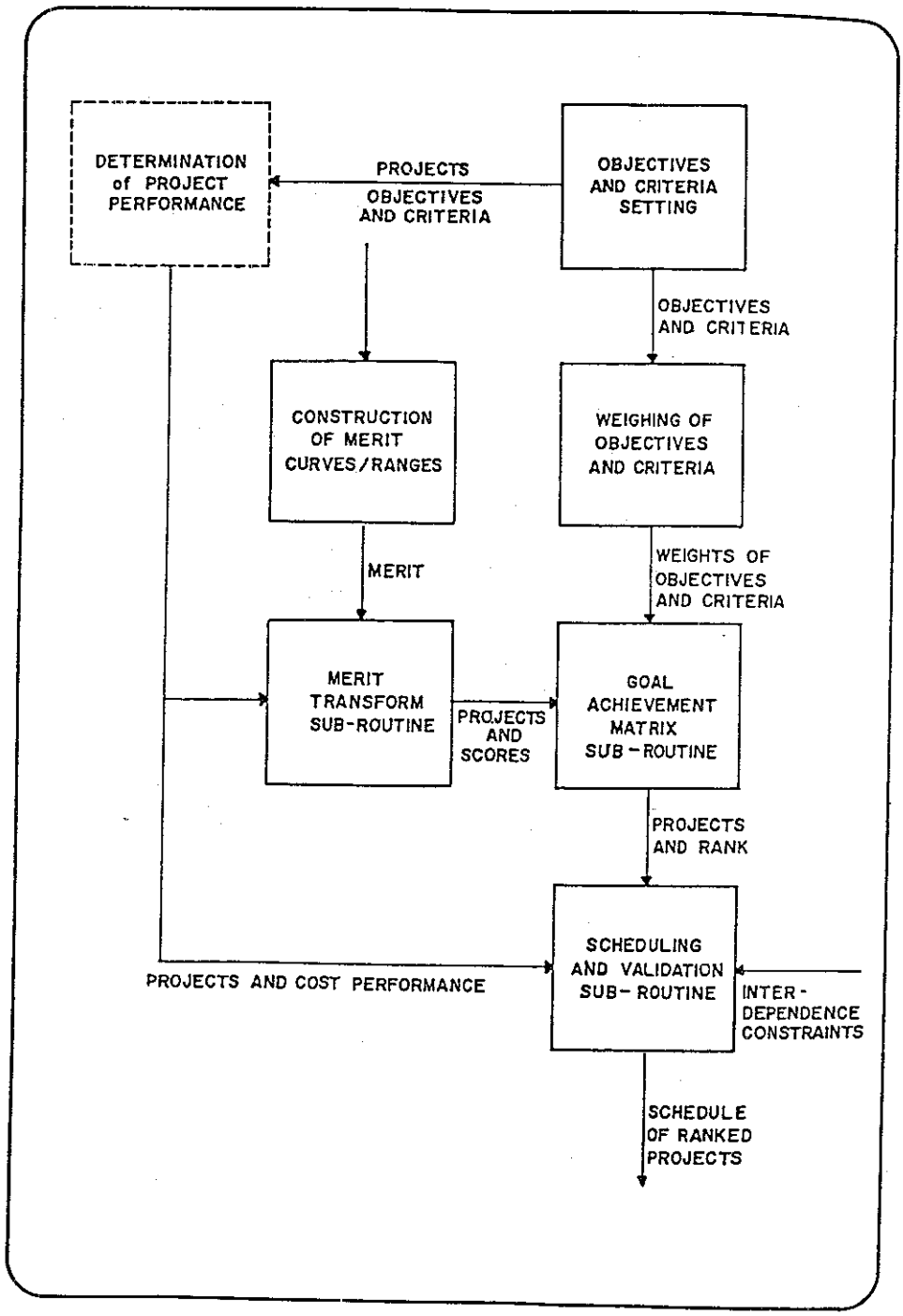

FIG. 3: FLOW DIAGRAM FOR STAGE 2 EVALUATION

(a) To Commuters: Safety
Mobility
Dependability
Cost
Time
Amenity

(b) To Providers: Economy
Flexibility
Efficiency
Equity

(c) To Society: Preservation
Conservation
Accessibility
Development

These broad objectives are directed towards the progressive development of the urban transportation systems of Metro Manila via:

- Provision for the economic, convenient, safe, reliable and efficient movement of persons and goods.
- Provision of an adequate public transportation service that is accessible and affordable.
- Promotion of a more desirable urban environment which enhances social, physical and economic activities.

Based on analysis of interactions and similarities of the objectives, goals and constraints (see Figure 4), nine important objectives were crystallised (which may also be looked at as primary strategies of the policy objectives). These are defined in Table A.

The weightings shown in the right hand most column of Table A against each objective reflect the relative importance for each objective as perceived by a panel of Inter-Agency Advisors. To develop these weightings, a questionnaire was distributed to each Advisor with a request to indicate the importance of each objective in the urban transport environment of Metro Manila.

On this questionnaire, a rating of 0 was meant for objective that 'can be omitted', while a rating of 1 referred to objective that is 'not important but should be considered'. At the upper end of the range, a rating of 10 was defined as "If all objectives were eliminated except one, this one would remain". Several iterations with controlled feedbacks were conducted before the weightings shown in Table A were finally established.

For project evaluation, it is necessary to assess the potential contribution each project is likely to make towards each of the defined objectives. This is achieved by assessing the merit of each project against relevant criteria as listed for each objective.

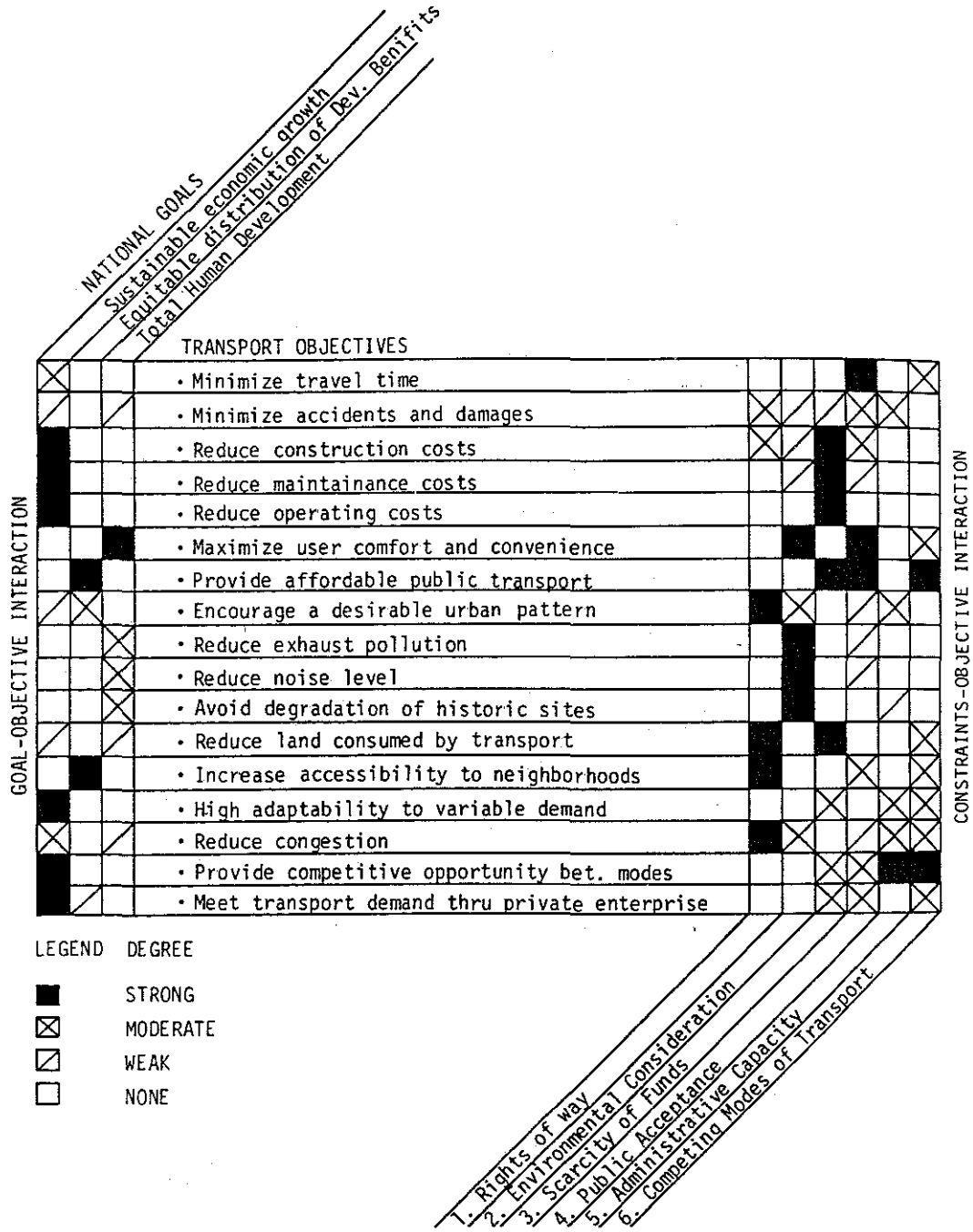

FIG. 4: GOALS, OBJECTIVES, CONSTRAINTS MATRIX

TABLE A: OBJECTIVES AND CRITERIA

No.	Objective	Criteria	Weight	
1	Minimize Travel Time and Congestion - Travel time is not productive and time saved has a perceived value to the road user (for both passenger and goods movement). Door to door travel time is a function of distance, delays due to cross traffic and route congestion, and terminal and transfer times.	. Route directness . Congestion and delays . Location and design of terminals . Effect during construction	15 45 10 30	V_1=17.5%
2	Reduce Direct Financial Costs of Construction, Operations and Maintenance - A lower cost figure in any item is desirable per se all other things being equal	. Acquisition area, cost of land and compensation Cost of construction Ongoing infrastructure maintenance costs (pavements, workshops etc.) . Operating and maintenance costs of vehicles and systems (labor, consumables, fuel and overheads)	20 50 10 20	V_2=16.4%
3	Promote Environmental Balance - Achievement or maintenance of a natural order of things which is sustainable and contributory to good health and life	. Motor vehicle emissions . Noise levels and proximity to dwellings . Aesthetic quality of construction; obstruction of views . Protection of historic sites . Through traffic in residential areas	10 20 10 30 30	V_3=10.4%
4	Minimize Accidents, Damages and Casualties - Refers to the desirability of protecting human lives and society's investment in properties from unnecessary loss	. Exposure of pedestrians and property to accident risk . Exposure of vehicles and occupants to accident risk	70 30	V_4=14.1%
5	Maximize User Comfort and Convenience - A commuter wants not only safety but comfort, reliability, minimum or no transfers, and other amenities to make travelling generally pleasant	Accessibility to PU transport . Frequency of PU service . Congestion, affecting variability of travel time . Number of transfers between services . Passenger loadings on PU vehicles Other criteria such as seating comfort, quality of ride, etc.	10 10 20 30 20 10	V_5=13.0%
6	Provide Competitive Opportunity - Refers to equalizing the opportunity to compete among bus jeepney, cars, etc. consistent with the mode's internal economics and congestion impact	. Fares regulation . Profitability . Regulation/licensing of vehicle/operators	33 33 33	V_6=6.7%
7	Improve Spacial Arrangement of Land Uses - Change favoring an urban growth to the south and north of existing built-up area; residential areas nearer to places of work; including compatibility with other plans	Direction of induced development or compatibility with projects Land use accessibility	40 60	V_7=10.4%
8	Improve Adaptability to Variable Demand - Desire for utmost flexibility; capacity to adjust and modify the transport system in accordance with demand	. Route flexibility . Capacity flexibility by mode . Regulatory flexibility	33 33 33	V_8=6.3%
9	Direct Supply of Transportation through Private Enterprise - Desirability of free enterprise in the business of urban transport	. Public sector expenditure . Incentives to private sector	50 50	V_9=5.2%

To assist in this assessment, a worst case (merit score of 0) and a best case (merit score of 10) situation are described for each criteria, as shown in Table B. Midway between the worst and best case, a neutral or a moderate score of 5 applies.

APPLICATION

It may be argued that application of the Goal Achievement methodology is very subjective. This may be the case if the assignment of merit scores is done haphazardly, i.e. similar to an election. On the other hand, the scoring process can be conducted in a very controlled manner - where the inter-agency panel of technical experts jointly assess the performance of every project against objective criteria. The scores are decided as a group consensus on the basis of information or evidence available to all, thus relying on firmer ground. Errors in absolute value are not as important as the consistent judgemental estimates of locations or relative positions on the criterion dimension.

The five-step procedure (shown in Figure 3) lies at the heart of the Goal Achievement Matrix, and consist of the following:

(a) A merit rating between 0 to 10 is assigned to each of the 31 criteria taking each project in turn.

(b) For each project, the resultant merit ratings are weighted using the average values derived from an aggregation of views of Inter-Agency Officials and then added to give a single merit (i.e. Goal Achievement) index for each project. The score is then normalised to give an index of 100.0 for the highest ranking project.

(c) Projects of similar nature and order of scale are grouped in the following categories:

- Institutional reforms
- Enforcement reforms
- Traffic management projects
- Public transport terminals projects
- Rolling stock/equipment projects
- Road projects

(d) All hardware-type projects (roads, rolling stock, terminals, equipment) are then scored against each of the 31 criteria and then ranked from the highest to lowest merit index. The software-type projects are then prioritised on the basis of them needing to fit into and support the projects in the "hard" categories and to the logic of the transport development strategies.

TABLE B: GUIDELINES ON MERIT RATING

	Worst Case (Score = 1)	Best Case (Score = 10)	REMARKS (Change from present situation "with" the project)
1. TRAVEL TIME AND TRAFFIC CONGESTION	• Average trip length increased significantly	• Average trip length reduced significantly	Projects impact could be either positive neutral or negative
	• Average vehicle speed reduced significantly	• Average vehicle speed increased significantly	–do–
	• Average walk distance increased significantly	• Average walk distance reduced significantly	–do–
	• Significant delays caused during construction	• No delays caused by construction	Almost always negative impact; thus score of 10 applies for neutral case, 5 for moderate disruption & 1 for total closure of traffic
2. FINANCIAL COSTS OF CONSTRUCTION, OPERATION AND MAINTENANCE	a) Acquisition		
	• Significant area required (i e majority of ROW), and • High property values and • Significant other compensation or relocation costs	• No land acquisition required or • Minor compensation or relocation costs only	Cost items are always negative to the accomplishment of objective Thus score of 10 applies to minimal cost incurrence and 1 for very high expenditures
	b) Construction		
	• New construction of structure or comparable high cost works, or • Major expenditure or new rolling stock and equipment	• Minor construction work only, or • No significant expenditure on new rolling stock or equipment	–do–
	c) Maintenance		
	• Significant net increase in maintenance cost of transport infrastructure	• Significant reduction in maintenance cost of transport infrastructure	Direction of benefits could be on the negative or positive side Thus assign score of 1 for adverse effects, 10 for significant benefits and 5 for neutral impact
	d) Operations		
	• Significant increased vehicle maintenance costs due to wear and tear from increased distance, stops and starts, etc and/or new technology, and	• Significant reduction in vehicle maintenance costs, due to less wear and tear and/or new technology, and	
	• Increased operating staff and wages and	• Reduced operating staff and wages, and	–do–
	• Increased expenditure on premises, and other overheads, and	• Reduced expenditure on premises, and other overheads, and	
	• Increased expenditure on fuel, oil, tyres due to increase in distance or congestion	• Reduced expenditure on fuel, oil, tyres due to improved operating conditions	

TABLE B: GUIDELINES ON MERIT RATING

(CONT'D)

	Worst Case (Score = 1)	Best Case (Score = 10)	REMARKS (Change from present situation "with" the project)
3. ENVIRONMENTAL BALANCE	• Significant increase in concentration of toxic emissions to air,	• Significant decrease in concentration of toxic emissions to air, and	Impact could be positive, negative, or neutral. High positive benefits get 10; neutral effect is 5; negative impacts get 1.
	• Maximum number of dwellings likely to be affected by road or rail noise	• No dwellings likely to be affected by road or rail noise	
	• Unsightly structure or works or obstruction of significant existing views	• No structure involved, or attractive structure or works with no obstruction of significant views	–do–
	• Protection of historic sites or neighborhood seriously prejudiced	• No historic sites or sense of neighborhood affected (by demolition or access)	If significant traffic volume is diverted away from residential streets, assign score of 10; if into residences, score of 1
	• Undue reduction in residential amenity from through traffic	• No residential areas affected by through traffic	
4. ACCIDENTS AND SAFETY	• Increased hazard to pedestrians or personal property	• Reduction in hazard to pedestrians or personal property	Benefits could be positive (10 for highest), none (5 for neutral), negative (1 for very adverse case)
	• Increased hazard to motorists and passengers	• Reduction in hazard to motorists and passengers	
5. USER COMFORT AND CONVENIENCE	• Physical accessibility at origin or destination reduced for users	• Physical accessibility enhanced for a significant number of users	Introduction of project may lead to *betterment* of user comfort and convenience (highest benefits get 10); or a *worsening* from the present condition (most negative effect get lowest score of 1)
	• Frequency of service reduced for users	• Frequency and capacity of service enhanced to meet demands	
	• Reliability of service reduced through congestion	• Reliability of service increased through priority or other measures	
	• Proportion of passengers needing to transfer between services increased,	• Proportion of passengers needing to transfer between services decreased	
	• Passenger loading (persons per vehicle) standards lowered	• Passenger loading (persons per vehicle) standards improved,	
	• Deterioration of other passenger comfort factors (access, seating, ride etc.)	• Improvement in other passenger comfort factors	

TABLE B: GUIDELINES ON MERIT RATING

(CONT'D)

	Worst Case (Score = 1)	Best Case (Score = 10)	REMARKS (Change from present situation "with" the project)
6. COMPETITIVE OPPORTUNITY	• Increased discriminatory fare regulation affects revenue to operators • Increased discriminatory regulation affecting costs to operators • Regulation encouraging increased monopolies through control of licensing/use of vehicles	• Equitable fare regulation • Equitable regulation affecting operators costs • Relocation of regulations affecting licensing/use of vehicles	Present situation faced by transport operators could be either improved or worsened by the introduction of a project. Neutral effect gets score of 5
7. LAND USE ARRANGEMENT	• Does not tend to reinforce N-S growth of built-up area • Does not assist significantly in bringing residential and other activity amenity centers closer together, and desroys existing business linkages and viability	• Strongly reinforces N-S growth of built-up area • Tends to bring residential and other activity/amenity centers (especially work centers) closer together, and enhances business viability	Project could reinforce the Regional Framework Plan (i.e. positive benefits) or the present trend of uncontrolled urbanization (adverse effects) Accessibility of residents to urban services and amenities could be improved worsen or unaffected
8. ADAPTABILITY TO DEMAND	• Fixed route technology; rerouting or alternative PU routes become extremely difficult • System's efficiency is seriously impaired by wide changes in capacity during operation • Inflexible regulation of entry, routes, and uses of vehicles	• Route of PU transport vehicles are flexible, can be easily modified or changed providing greater choice • Supply and demand balanced, and capacity easily increased/adjusted • More flexible regulations of entry, routes and uses of vehicles	Fixed-guideway systems tend to be least adaptable to variable demand. Cars and Jeepneys are the most flexible mode. Assigning of scores would therefore follow accordingly
9. PRIVATE ENTERPRISE ROLE	• Increased Public sector investment in transportation, and • Reduced incentive to Private sector to operate improved services	• Avoidance of all but essential Public sector investment in transportation, and • Increased incentive to Private sector to operate improved services	If project is fully-funded by government with no financial recovery, it gets a score of 1 vs. this objective. Full private funding gets score of 10. Project which are self-liquidating with high profit potentials may also score high. Project could either promote private sector, be neutral, or hamper its operation

(e) A simple ranked list of projects is then prepared after consideration of the project inter-dependencies, the relative levels of capital investment required, and relative ease of implementation.

SENSITIVITY ANALYSIS

It is very possible that the resulting schedule of ranked projects will not receive unanimity at the initial pass. The Goal Achievement methodology, however, allows for the systematic factoring of revised project performances. The robustness or sensitivity of a project's rating can be tested or re-evaluated quite easily. There are several ways of conducting the sensitivity analysis, viz:

(a) Change the weights of the objectives or criteria, which would imply a policy shift or a revised set of strategies.

(b) Comparison of the ranked list of projects by category and bench marking between different categories. It may be easier to accept the results for similar projects (i.e. within a single category) as being rated consistently. Between categories, the project scores may justifiably be questioned. Bench mark projects - one in each category - could be chosen, and their relative merits subjected to comparison and evaluation. The ratings of other projects on the universal list can then be scaled or weighted in proportion to the ratings or scores of the bench mark project of the same category.

(c) Variation of the raw score or ratings, from the best to a worst case, for the specific criterion in question.

POSTSCRIPTS TO RANKING USING GAM

The evaluation procedure described in this paper was used to develop a ranked list of projects. These constitute an inventory of projects which could be queued for implementation, depending on funding availability. After consideration of funds likely to be available, the output was a 10-year Transport Investment Program (as shown in Figure 5) for Metro Manila in the context of a most likely urban development scenario.

Actual scoring or determination of project performances against pre-established criteria was conducted at various times by two groups. The first technical panel was composed of the project team; while the second consisted of an inter-agency panel of experts, supplemented by the project team.

Is the goal-achievement methodology valid? The answer to this question will depend on the acceptability to the various agencies of the resulting priorities, and the perceived impartiality of the method. To the extent that it establishes the ground rules for inter-agency resource allocation and makes explicit the values underlying public decisions, and compared with the present rules on establishing priorities, the GAM-based ranking represents a quantum leap in urban

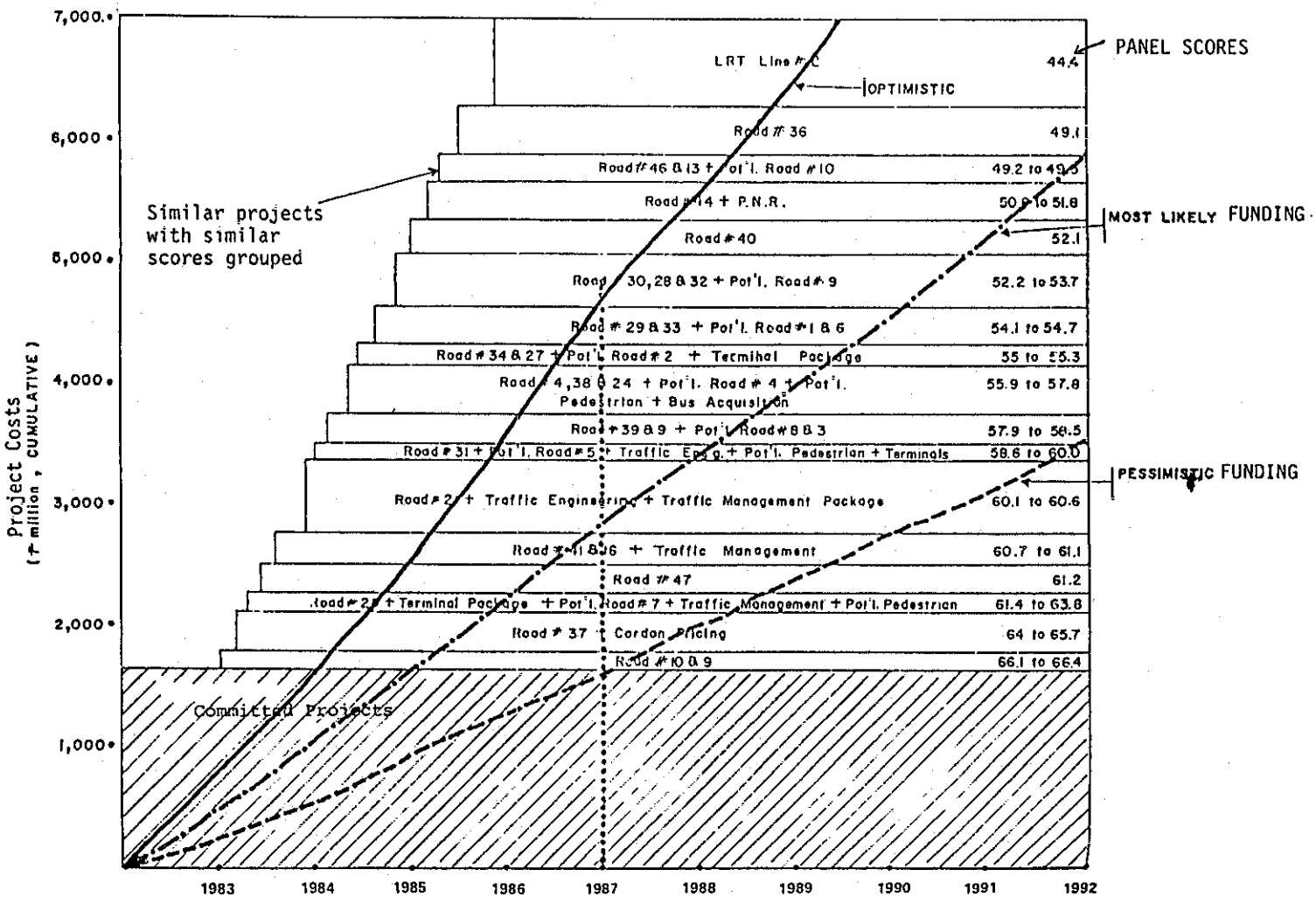

FIG. 5: RESOURCES VS. PROJECTS - METRO MANILA

transport planning and programming. The present system of prioritisation is ambiguous, if not highly dependent on personalities. Aside from generalised statements (e.g. priorities for foreign-assisted projects, energy-saving activities, etc.), there are no explicit criteria to go by. Neither is the benefit-cost ratio relied upon, as evidenced by examination of projects now committed or under construction.

The scores made by the first panel were subsequently tested as to sensitivity to changes in objective weights (i.e. changes in policies). The first set of weights gave emphasis to three objectives (for a total valuation of 64.0 per cent), viz: minimisation of cost (27.0 per cent), minimisation of travel time and traffic congestion (22.0 per cent), and promotion of environmental balance (15.0 per cent). On the other hand, a second set of weights was more evenly distributed among the nine transport objectives wherein the above three important objectives accounted for only 44.2 per cent in weight. Some of the conclusions to emerge from this sensitivity analysis are:

(a) Ranking within road projects appear to be more sensitive than other categories.

(b) Ranking within other projects (terminals, traffic engineering, transit) were generally unchanged by changes in objective weights.

(c) Relative priorities between project categories (1st - traffic engineering, 2nd - minor terminals, 3rd - roads, 4th - major terminals, 5th - transit systems) were unaffected by the change.

(d) Scores were more spread out in the first than on the second case, indicating that a more equal valuation of objectives would tend to reduce differences among projects.

As mentioned, a second panel of experts were asked to rate the projects. It should be noted that the results, particularly on the road projects, were not directly comparable because of the revised information inputs. Nevertheless, it is interesting to point out the following:

(a) The 1st group of evaluators tended to be more conservative in assessing project scores. Their indices were generally lower and bunched on a narrower band. (High of 65.7, low of 45.9). The scores that resulted from the 2nd panel were more dispersed (high of 72.3, low of 43.0).

(b) Both groups came out with the same highest-ranking project and lowest-ranking project in the overall list.

(c) Ranking of transit systems, traffic engineering, and terminals were relatively consistent in both groups of respondents. This suggests that if given the same information, another group could replicate the same priority ranking.

Two issues were raised during the evaluation process. The first one concerned construction cost as a criterion for the second objective of minimising financial cost. Unit construction cost was chosen as a better measure than total project cost because of the need for comparability, consistency with other criteria, and to avoid distortions from project-splitting.

The second issue was the decomposition of an objective into several sub-objectives, is the alleged 'bias' against one type of project. The notion that disaggregation would remedy the alleged bias is premised on the erroneous assumption that deliberate double counting would compensate. It fails to recognise the fact that other projects would similarly benefit (or disbenefit). Moreover, the weights would necessarily have to be reduced in the event of decomposition, because of the inherent structure of GAM.

CONCLUSIONS

The GAM-based prioritisation could be further improved through the following steps:

(a) Development of worth curves by criteria. Studies should be conducted to quantify the more important distribution functions of all feasible current and future projects. The domain of merit scores (0 to 10) can be correlated to actual or empirical project performance data. For example, what actual savings in travel time deserve a rating of 10?

(b) Benchmarking through paired-comparison or use of indifference curves. Is a road project with index score of 60.0 equal in priority to a transit project of the same index score? At what benchmark scores will the decision-maker be indifferent to the alternatives?

(c) Review of criteria. There are 31 criteria for 9 objectives. What other criterion should be included? Or deleted from the list? Or modified?

(d) Manner of evaluation. Will the results be better if the projects are scored by the panel members in isolation? This is possible, just as the benefit-cost ratio of a project from two economists may differ. The results reflected in this paper have been generated through a panel assembled in a room. One dominant member could influence the others. A possible improvement, though a bit more involved, is via a Delphi-process arranged in this fashion:

- Rating is done individually but based on common information and rules.
- Combined results of the group are fed back to them in the next re-evaluation cycle, identifying the projects with greatest deviation or convergence.

Successive ratings until a consensus emerge, with some projects deleted in the next cycle of evaluation.

(e) Dynamic system. The ranking has been made on the practical assumption that all the projects are independent of each other, i.e. their cross-impacts through time are omitted from consideration. In reality of course, the projects interact such that completion of one project alters the state of the system and consequently, the choice of the next project. To capture this phenomenon, the GAM should be repeated recursively.

After the highest-ranking project has been identified, the performance of other succeeding projects could then be reassessed on the assumption that the first one had been completed; the second ranking project would be identified and another re-evaluation cycle would proceed on the remaining list, and so on.