THE MANILA PUBLIC TRANSPORT MODEL

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ABSTRACT: *The paper describes the evolution, calibration and application of the public transport assignment model used in recent studies of the Manila (Philippines) public transport system.*

The primary problem facing modellers in Asian cities is the multiplicity of public transport modes with different characteristics plying the same routes. These range from conventional heavy rail, through fixed-fare, guaranteed-seat, airconditioned "love bus", to jeepneys running cheap jitney services on fixed routes.

General income levels are such that travel time/fare/comfort tradeoffs are clearly relevant in the perceived cost of public transport, and income differentials are such that different user-groups should be recognised and integrated into the planning process.

The resulting model, consisting of three programs, provides an iterative headway-revision search for demand/capacity balance (as in TRANSEPT) using multiple-path assignment techniques (as in UTPS) to allow differentiation between different public transport modes on the same or similar routes, and to carry out sub-modal split between them.

The generalised cost equation comprises walk, wait, load, transfer, travel time, fare and overloading discomfort features and facilities are provided for a user-group weighting system to differentiate the generalised cost equation for different user groups.

The paper describes how the model was successfully implemented, calibrated and used in studies in Manila, particularly the light rail network extension feasibility study.

INTRODUCTION

Manila, Philippines, as with other major urban areas in developing countries, has an extensive range of public transport modes operating under different fare structures and under different route franchises or structures and often in direct competition on the same routes.

The modes have been classified as follows:

(a) Heavy Rail (PNR)
(b) Light Rail (LRT - under construction)
(c) 'Love Bus' high fare, guaranteed seat, high quality buses
(d) Large Bus
(e) Small Bus
(f) Jeepney.

As traffic volumes on Manila's congested streets are composed predominantly of public transport vehicles, the problem of transit service rationalisation is a primary policy and operational feature of transport planning.

While population and trip-making continue to increase, there is no current evidence that mode choice is increasing in favour of private vehicles as income levels have not kept pace with increasing fuel prices in recent years. In consequence, increased gross transit patronage must be anticipated during at least the medium term planning horizon.

During 1980, the Ministry of Transportation and Communications, Republic of the Philippines, commissioned Japan Overseas Consultants to conduct the Metro Manila Urban Transport Improvement Project (MMUTIP), which focused primarily on:-

(a) A home-interview survey and its analysis, and
(b) A plan for the rationalisation of bus and jeepney services.

Parallel with this project, the Ministry also commissioned Electrowatt Engineering Services (of Switzerland) to study the initial feasibility of extending the first LRT line (currently under construction) into a network serving the whole urban area.

These studies were to co-ordinate with each other and with the current Traffic Engineering And Management Project (TEAM) being carried out by P.G. Pak-Poy and Associates Pty. Ltd. Co-ordination was facilitated through the appointment of P.G. Pak-Poy and Associates as sub-consultants to the LRT Network Extension Study and with the appointment of R.J. Nairn and Partners to both this study and the MMUTIP Study.

This paper, therefore, draws upon experience from each of these three studies, but focuses upon:-

(a) The design of the public transport computer model commissioned under the MMUTIP Study, and
(b) The calibration and use of this model in the MMUTIP Study and the LRT Network Extension Study.

Cordon count: 80% of vehicles are PT
PT causes the congestion

The next section describes the model's features in some detail, whereas the subsequent section provides a description of its calibration and use.

THE MODEL'S FEATURES

General Model Design Specifications

The following basic design specifications were determined for the model:-

(a) It should be designed to be fully compatible with the modelling suite TRANSTEP, which was already in use in the Philippines and installed at the Infrastructure Computer Centre (Ministry of Public Works) and the Transport Training Centre (University of the Philippines). This basically meant that it should be coded in FORTRAN 4 with the same programming standards and general input formats and specifically should create and use trip and skim files of identical format (Nairn, Field and Parker (1977)).

(b) Like TRANSTEP, it should be capable of operating in sketch-planning mode as well as for analysis of fixed networks. This meant that it should have headway-revision features seeking an equilibrium between supply (headway/capacity) and demand similar to TRANSEPT, developed by the UK Local Government Operational Research Unit (Bowyer (1979)).

(c) While trip generation/distribution and primary (private/public) mode split would be performed in other modules of TRANSTEP, it should accurately reproduce and forecast sub-mode split between public transport modes (Nairn and Partners (1981)).

(d) Bearing in mind that several public transport modes, with different perceived characteristics, may ply the same route, the model must have multi-path assessment and assignment features similar to UTPS (De Leuw Cather (1977)).

(e) The model must be based on perceived generalised cost skim concepts to properly represent demand, but must also display the various categories of generalised cost to facilitate economic evaluation of alternative networks.

(f) The model must provide transfer matrices at transfer nodes to assist in the preliminary assessment of public transport interchanges.

(g) Various scaling specifications were determined but these will be discussed later in the paper.

Module and File Structure

It was early established that the model should compose three separate modules as follows:-

(a) Public Transport Edit - edits the route definitions, validating them against the highway network, and producing binary route and public transport network files.

(b) Public Transport Paths - builds paths from every origin node to every destination node. Since path building is done before loading, not only is the least cost path retained, but also all those for which the static cost is within a user specified degree of latitude. These paths are referred to as feasible paths

(c) Public Transport Loading - achieves balanced public transport loadings by incremental assignment. The user controls the number of increments and the size of each increment. Within an increment, all feasible paths are re-costed (taking into account the current loadings), and trips are assigned to the dynamically least cost path(s).

Figure 1, sets out the relationship between these modules and their files.

The file NETFIL is a binary file containing the network description in highway network format. In producing this file, two features are of interest as follows:-

(a) An option exists to include off-highway (rail) links in the network, and

(b) An iterative procedure exists for the pre-loading of public transport volumes on highway links so that these links are appropriately congested. If this congested link speed is less than the average scheduled running speed (for buses), then the link speed prevails.

The file PTLINE contains details of each line for each mode, specifying its initial or input headway, the route node-by-node and node qualifiers determining the amount of ingress or egress available and whether interchange (faster transfer) facilities exist.

The file PTNET contains the highway (and off highway) links used by public transport in origin-destination order.

The file ROUTES contains details of all public transport routes available in the network.

The file PATHS contains a list of feasible paths using public transport.

The INITIAL SKIM FILE contains the skimmed value of the generalised cost in normal SKIM file format. At this point the skims are approximate as load and transfer times are computed on a fixed or estimated passenger volume (rather than the incrementally allocated volume). This approximation is corrected in the FINAL SKIM FILE.

The Generalised Cost Formulation

The perceived cost of travel between any two points on the network is the primary determinant of trip generation, distribution, mode and sub-modal split and travel path selection. Perceived cost is obtained in the modelling process by measuring simulated time and fare values for different components of a trip and combining them with weighting factors which recognise that different trip components are perceived to be more or less important. This weighted perceived cost is called generalised cost.

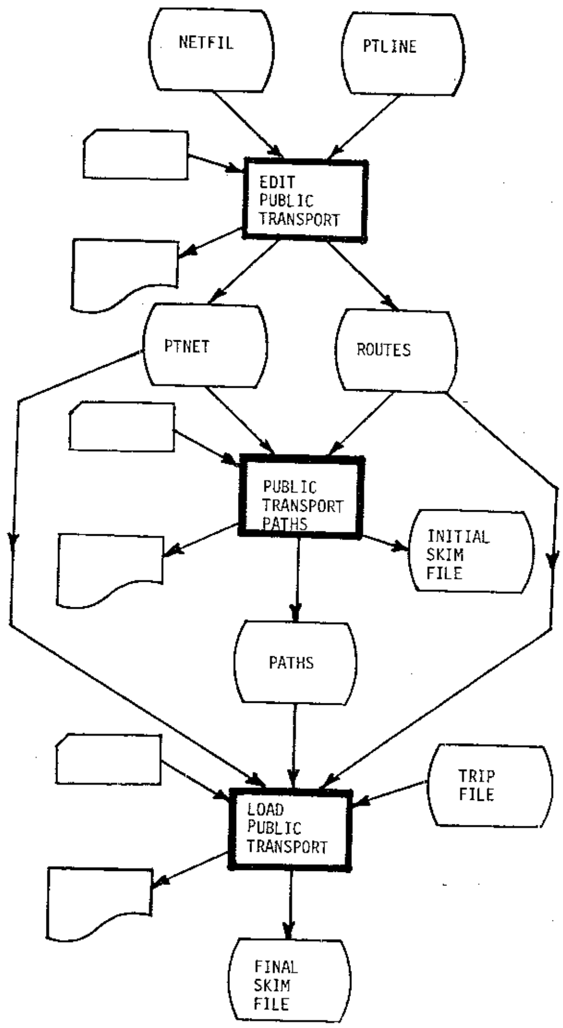

NETFIL
PTLINE
EDIT
PUBLIC
TRANSPORT
PTNET
ROUTES
PUBLIC
TRANSPORT
PATHS
INITIAL
SKIM
FILE
PATHS
TRIP
FILE
LOAD
PUBLIC
TRANSPORT
FINAL
SKIM
FILE

FIGURE 1.

Generalised cost has the following form:-

$$Cost_{m,u} = M_{m,1} \cdot U_{u,1} \cdot C_1 + M_{m,2} \cdot U_{u,2} \cdot C_2 + \ldots + M_{m,7} \cdot U_{u,7} \cdot C_7$$

where: M_m are input constants describing the relative weighting for each cost attribute for up to 10 public transport modes. (e.g. Jeepney loading times are less than buses)

and : U_u are input constants describing the relative preference of each income group (U) for each cost attribute (C)

and : $C_{1 \ldots 7}$ are the variable attributes or cost components as follows:-

1. Walk time
2. Wait time
3. Boarding or alighting time
4. Travel time
5. Transfer time
6. Fare cost
7. Overloading/comfort factor

The calculation for each of these variables is described below:-

(a) Walk time

The time to traverse the link from the home centroid to the boarding node and from the alighting node to the destination centroid. Walk speed is taken to be 5km. per hour.

The edit program allows centroid connector lengths to be varied from their highway network values towards a single fixed length of 0.1 km. according to the following formula:

distance = x*original distance + (1 - x)*0.1

(At x = 1.0, all links retain their highway distances, and at x = 0.0 all links acquire a fixed length of 0.1 km.). This option can be useful in modelling public transport policies where all routes are designed to be within a certain fixed distance of every household.

The mode factor can be used to modify the walk component where accessibility to different modes varies significantly.

(b) Wait time

The time spent waiting for the service at the boarding node is primarily a function of route frequency but takes into account pulsed interchange conditions, if they exist. Where boarding occurs at an interchange, the wait time is fixed at 1 minute; otherwise wait time is half the service headway.

(c) Boarding time

Boarding time is calculated at 5 passengers per minute. Where this is not appropriate, the mode factor can be used to vary the rate. This is particularly necessary for high-volume multi-door modes such as heavy rail.

(d) Travel time

Travel time is calculated using the practical speed determined for each link in the edit program.

(e) Transfer time

Transfer time is calculated using the WAIT TIME function.

(f) Fare cost

On boarding the services, a base fare is charged which covers the passenger for a given distance. When that distance is travelled, additional fare is charged on a per kilometre basis. Flat or distance fares can be calculated in this way, but zone fares cannot be handled at present in the model.

(g) Overloading/comfort factor

The discomfort component takes into account adverse reaction to overloading. Until the volume approaches capacity, discomfort is costed as zero additional travel time. Under overloaded conditions, the discomfort factor rises quickly. Assuming VOLCAP is the volume/capacity ratio on a certain link, the function used for discomfort is:

If VOLCAP > 0.8 then discomfort = travel time *(VOLCAP*5-4)

else discomfort = 0

Note that, under totally unconstrained headway-revision modelling, the discomfort factor, thus defined, tends to be a low number.

The mode coefficients (M_m) must have two notional components - one which relates the characteristics of each different mode (m) to the model assumption (e.g. loading rates) and the other relates the simulated time or cost values for each cost component to its perceived value.

The user coefficients (U_u) are relative values only with an average value of 1.0. They should be used as a simple set of preference values for each cost component for each user group.

Feasible Paths

A basic premise of the model is that for any origin/destination, there exists a set of one or more paths by which it is feasible to travel. The selection of feasible paths is viewed as static - that is, independent of dynamic factors such as loadings on particular routes. For this reason, pathbuilding can be pre-calculated, and the paths stored in a file for use by the program which loads public transport trips onto the network. Note that the final selection from amongst the feasible paths is done dynamically by the load program.

The algorithm used to build paths from a given origin centroid can be summarised as follows:

```
Enter every accessible route onto a list
While list is not empty
. Take next route from list
. Initialise generalised cost
. For each link in route
. . update generalised cost for link
. . if alighting at end of link allowed
. . . if limit on transfers is not exceeded
. . . . if new route is accessible
. . . . . if cost to board new route is within limits
```

11 . . . . enter new route onto list
12 . . . if destination centroid is accessible
13 . . . . if cost to destination is within limits
14 . . . . . . save path to that destination

Note that in step 8, a limit is imposed on the number of transfers that are considered in the path-building process. The software currently is based on a practical limit of two transfers, but has no limit in principle.

A second limit to the path-building process is expressed in steps 10 and 13 above. The 'cost is within limits' requirement has the effect that any path to a node (or destination centroid) for which the cost is greater than x% of the least-cost-so-far is abandoned. The parameter x (set by the user to a value such as 1.2) is effectively a path generation factor, since it controls the number of paths generated and retained - (e.g. at x = 1.25, the least cost path and all other paths up to 25% greater in cost are found).

When feasible paths are finally written to disk, a further preset defined limit governing the maximum number of paths for any origin/destination trip is imposed. (e.g. A maximum of the 3 cheapest paths are retained).

Submodal Split

The trip file which is fed into the load program contains passenger trips for all public transport modes combined.

Submodal split is carried out dynamically within the load program through the use of multiple user groups. Each user is described by a set of user coefficients for the generalised cost components.

Although there are various different strategies according to which user groups might be chosen, the basic split into rich/poor will be used to simplify this discussion. A rich person will attach significance to time and comfort, whereas the most relevant cost component for the poor person will be the fare. This difference in priorities can be reflected in two sets of user coefficients.

Given two sets of user coefficients each feasible path will have two costs associated with it. The model compares the least cost path for each user group, and then splits trips between user groups as a function of the ratio of costs. Note that in many cases, the least cost path will be the same for both user groups.

Calibration of submodal split is affected by adjustments to both the mode and user group coefficients and, of course, the price of time, which is a parameter input to the model.

Calibration in this iterative form is tedious and expensive, but more direct forms of calibration would involve extensive and theoretically demanding surveys, with no guarantee of a more suitable result.

Incremental Loading

Trips are loaded onto the public transport network incrementally, with the user specifying 'how many' and 'what size' increments. The smaller and more numerous the increments, the greater the accuracy in the final equilibrium loading, but the heavier the demand on processing resources.

Within each increment, the model loads from each O-D (origin-destination) cell of the trip matrix either an absolute volume, or a percentage volume. The minimum absolute number of trips which must be loaded on each increment is 1. Therefore O-D cells with less trips than there are increments, can be fully loaded in the early increments, and ignored in subsequent increments. This feature significantly reduces computing costs, since a large proportion of the cells in the trip matrix are exhausted within one or two increments. The user may specify a larger absolute volume if desired. O-D cells with less than (number of increments x absolute volume) will always be loaded in absolute increments, and all other cells in percentage increments.

When calculating a percentage increment, the model rounds up to ensure that an integer number of trips is always loaded.

Within each increment, every O-D cell of the trip matrix is scanned, and a calculation made to determine how many (if any), trips are to be loaded. Trips loaded early in an increment do affect the boarding time and discomfort components of generalised cost, as it is calculated for trips loaded later in the increment.

The logic used to control the loading process can be summarised as follows:

```
For each increment
. For each origin
. . Read row from trip matrix
. . For each destination
. . . Calculate % of trips to be loaded this increment
. . . Read O-D feasible paths
. . . For each path
. . . . For each user personality
. . . . . Cost path
. . . Split trips between user personalities
. . . For each user personality
. . . . Split trips between all least cost paths
. . . Load trips onto all selected paths
. Review route headway (see below)
```

Headway Revision Equilibrium

The load program includes an optional facility which attempts to balance public transport supply with demand by modifying route headways.

The concept of equilibrium is illustrated in Figure 2.

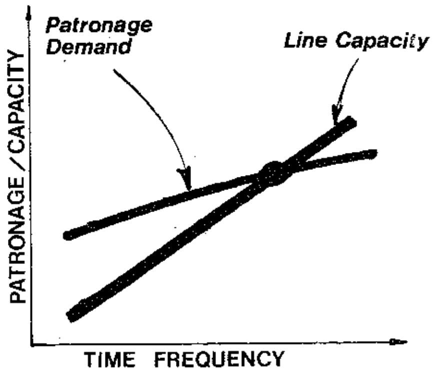


Figure 2:

At the end of each increment, the program looks at the most heavily loaded segment on each route and taking into account the total proportion of trips already loaded, calculates the service frequency which would give a volume/capacity ratio of 1.0 on that link. The frequency is then adjusted x% towards the 'ideal' frequency, where x is a user supplied value.

The model requires that any changes to service frequency are all in the same direction - this is a guard against instability. A further safeguard is the user specification of both maximum and minimum headways for each mode. The minimum headway being a practical safety requirement and the maximum headway being the limit above which the service would be removed for economic reasons.

The Model's Outputs

There are basically four reports generated by the model as follows:

(a) The Line Report, which, for each line and direction (UP/DOWN) reports the passengers alighting, boarding or transferring on at each node and the passengers carried forward and the volume/capacity ratio of each line segment.

(b) The Line Summary Report, which, for each line, reports the following:
- The revised headway,
- The maximum volume/capacity ratio on the line,
- The route-hours and route-kms. carried out on that line by that mode,
- The total passengers carried and the passenger-hours and passenger-kms on the line, and
- The totals of each of the perceived passenger cost components as follows:

- total walk (hours)
- total wait (hours)
- total load (hours)
- total fare ($)
- total travel (hours)
- total transfer (hours)
- total discomfort (hours)

(c) The Mode Summary Report, which further summarises all of the data in (b) above except (1) and (2) for each mode, and

(d) The Transfer Report, which is in three parts as follows:
- o A report on the number of passengers transferring from each mode to each mode,
- o A report on the number of transfers by frequency of transfer, giving the % of passenger trips with 0, 1, 2 or more transfers, and
- o An optional report giving the inter-segment transfer occurring at specified nodes.

The model therefore provides very comprehensive data for the analysis of each line segment or transfer interchange or summarised data for network planning and economic evaluation purposes.

CALIBRATION AND USE OF THE MODEL

Introduction

This section selects certain aspects of the installation, calibration and use of the model, without attempting to be comprehensive, which should be of interest to the researcher or practitioner using the model.

For this reason a detailed description of the model's application is not presented - this can be found in Electrowatt Engineering Services Ltd.(1981) and Japan Overseas Consultants Co. Ltd. (1981).

However, the essential user problems are discussed and presented so that the reader can form an overall impression of the real value of the modelling suite.

Installation of the Model

Caution must be exercised in selecting the computer and problem dimensions (network size, etc.) before installation.

This caution is necessary because seeking and storing public transport paths in a multi-path, multi-modal, highly competitive environment can be fairly consumptive of core space and computing resources generally.

The search for multiple shortest paths essentially consists of a 'try-everything' approach, but with attention paid to early cut-off. A less rigorous path finder can make approximations, but this approach was not adopted.

Core storage requirements escalate much more rapidly than problem size (in terms of zones, links and routes) and in the context of Manila a 110 zone-200 line problem set used 64K words and required run times of just less than one hour on a UNIVAC 11/10 computer.

Subsequent installation on a FACOM M140 with virtual storage eliminated operating problems associated with memory and approximately halved the run times.

Therefore the model is really only suitable for medium to large computers in its present form.

After suitable installation, the first step is the calibration of the model.

Calibration is inevitably specific to a particular city, but may also be specific to a particular problem set, since zone-size may vary and the user assumptions may be different.

For this reason, the assumptions made for the LRT Network Extension Feasibility Study in Manila are first described before continuing with the model's calibration.

Assumptions and Scope of Testing

In describing the LRT Network Study it was necessary to impose some constraints on the modelling process in order to achieve relevant results within time and budget limitations. These constraints were primarily as follows:

(a) The models were utilised at "sketch-planning" level to provide relevance without excessive detail. The land-use activity pattern was represented by 100 zones, the on-street network was approximated and the public transport system was represented by 200 franchised lines.

(b) The assumptions were made that traveller's choice for travel by private car or taxi rather than public transport modes, and the influence of street congestion, is constant for all land-use or LRT network patterns in any analysis period.

The scope of alternative test patterns was determined as follows:

(a) Network Testing - in which the six LRT network patterns, supported by bus, jeepney and PNR modes, were tested to determine:
    (i) Approximately how much the LRT network should grow by the year 2000; and
    (ii) Whether a radial or circumferential growth path should be adopted.

(b) Fare Testing - in which the three LRT fare policies were tested to determine:
    (i) The effect of higher fare level; and
    (ii) The effect of free transfer policy between different LRT lines.

(c) Land-use Testing - in which the interaction between land-use and LRT network development was tested to determine:

(i) The effect of a lower population estimate by the year 2000; and

(ii) The effect of the distribution of employment and other activities caused by the development of the LRT network.

Calibration of Trip Demand

Although not directly relevant to the public transport model itself, a brief comment on the calibration of the TRANSTEP demand curve for public transport travel in Manila, is useful background.

The demand curve expresses the relative probability of a public transport trip being demanded at different skim cost values. In the calibration process (NAIRN, FIELD and PARKER (1977)) the demand curve is derived from the relative opportunity curve (the spectrum of attraction opportunities at different skim costs) and the actual trip cost frequencies detected in the MMUTIP Home Interview Surveys.

Calibration was derived from all production zones with sufficient trips to make a trip cost frequency distribution meaningful. The regional curve was then averaged from that for all zones. In these circumstances the mean variance provides a satisfactory gauge for calibration reliability. (See Table 3.1)

TABLE 3.1

DEMAND CURVE CALIBRATION

Manila - 1980 Public Transport

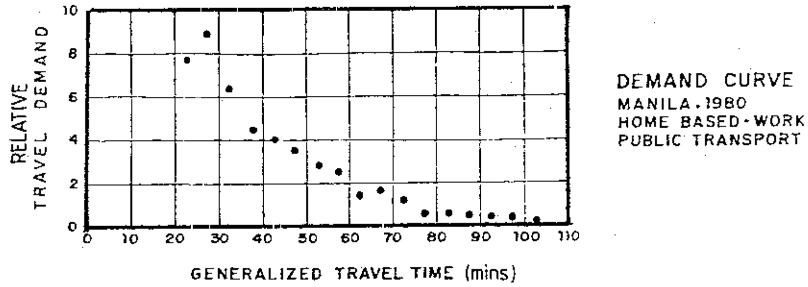
	Mean Variance	Standard Deviation of Variance
HB - Work	0.139	0.061
HB - School	0.219	0.076
HB - Shop	0.347	0.126

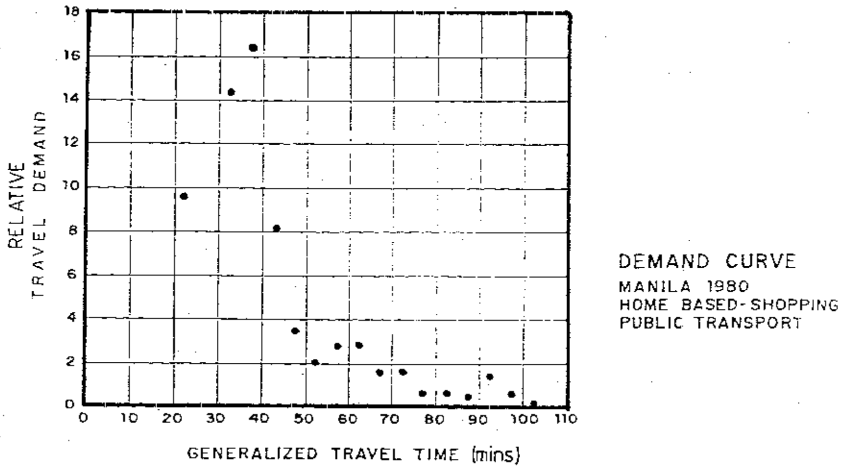
Source: LRT Network Study (ELECTROWATT (1981))

A relatively low mean variance illustrates that the demand curve is reliable. A low standard deviation indicates that the demand curve is equally reliable throughout its range.

The actual calibration of trip demand is shown in Figure 3.

FIGURE 3.





Source: LRT Network Study (Electrowatt(1981))

Calibration of Sub-mode Split

The calibration process for sub-mode split is achieved by iteratively adjusting the coefficients for each mode and user group and the results are summarised in the following table, Table 3.2.

TABLE 3.2

SUB-MODE Split Calibration

Manila 1980 - AM PEAK

% Passenger Trips by Predominant Mode*

Mode	Model Predictions	MMUTIP HIS Survey Results
Big Bus	30.14%	29.05% (Big Bus, Love Bus, Mini Bus)
Love Bus	0.01%	
Mini Bus	10.92%	
Jeepney	57.55%	70.74%
PNR	1.38%	0.21%

Source: LRT Network Study (ELECTROWATT (1981))

* Predominant Mode is the highest mode used for each trip in the mode hierarchy presented on page 1.

Clearly the sub-mode split calibration was not very good with a bias away from jeepney travel to the heavier modes.

These results reflected the time and cost constraints on the study, but also reflected the relative difficulty in modelling representation for lighter, more flexible public transport modes. Where almost every big bus and love-bus route was individually represented, the jeepney franchises were approximated by combining many services into representative routes.

Similarly, many jeepney trips were intra-zonal trips and detected in the Home Interview Survey but omitted from the model predictions. These factors were dominant in the calibration process and could not be overcome with substantial changes in the mode or user coefficients.

For these reasons, screen-line counts for public transport vehicles were then conducted and calibration was continued by comparing sub-mode split model assignments with observed results.

Manual Adjustments to the Results

The model assumes that a service will be provided for the entire length of each line irrespective of the passengers carried, but, of course, with revised headways (up to the maximum headway).

In practise many of the minor lines can be converted from competing line-haul functions into feeder functions or it is often apparent that a line could be truncated for other reasons.

In these instances the model could be re-run with revised line in-puts or alternatively a manual adjustment for route-hours and route-kms should be made to correct the costs of the public transport service.

A further manual adjustment is necessary to convert perceived costs to economic values, when computing the real user costs in an economic evaluation As perceived costs are necessary for demand evaluation in the model, and for user benefits, there is no facility for this conversion.

Commentary on the Results of the Model

The model's outputs permit a detailed examination of each public transport line to establish how it might best be changed to fulfil its best role in the network. In this sense, the model can be used for fairly detailed planning.

For each line, the patronage, service costs and revenue per vehicle km. (an indication of profitability) can be assessed.

The mode and transfer reports enable a detailed examination of relative inter-modal competition and feeder-service role allocation and the aggregated results can be used for assembling the benefit/cost ratio for the entire public transport system improvement when compared with a 'base-case'.

These forms of evaluation can be carried out for:

(a) different network changes,
(b) changes in fare levels or structures, including discriminating fares between modes, and
(c) for different land-use/growth patterns.

The model, therefore, in its background setting of the TRANSTEP suite, provides a fairly comprehensive range of sketch-planning to detailed evaluation modes of operation covering most of the public transport policy and operational planning problems likely to be encountered in a major multi-modal urban area.

Commentary on Economic Evaluation Derived from the Model

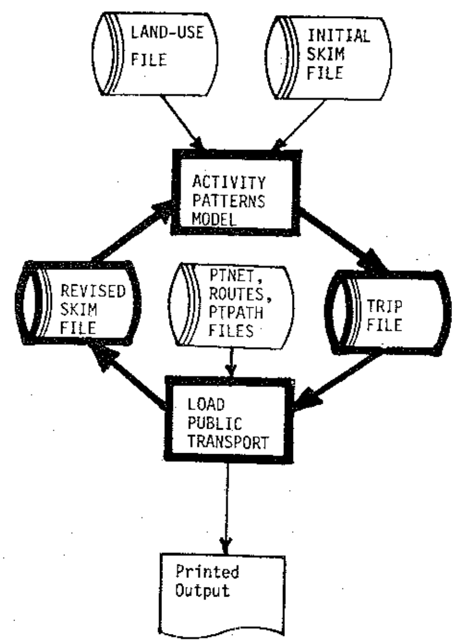
Under normal circumstances it is the case that total trip generation in a multi-modal network increases with lower average network travel cost. However, when different user groups (rich/poor) are introduced this is not necessarily true in the aggregate, since higher trip generation can occur on higher cost modes if these were not previously accessible to the richer user group.

Ideally, the analysis should be carried out for each user group to overcome the apparent anomaly this presents in the economic evaluation, but this segregation is not currently available in the model.

Equilibrium Between Trip Generation and Public Transport Assignment

Whereas the PUBLIC TRANSPORT PATHS module creates the initial SKIM file, this file is updated by the LOAD PUBLIC TRANSPORT module to take account of the effect of revised headways and actual passenger loading effects on load and transfer times.

This revised SKIM file is created to facilitate iterative investigation of the effect of revised SKIM values on trip generation and distribution, which are performed in the ACTIVITY PATTERNS MODEL in the TRANSTEP suite. This is illustrated in Figure 4.



TRIP GENERATION/ASSIGNMENT EQUILIBRIUM

FIGURE 4:

Clearly if the initial skims are underestimated, then Trip Generation will be overestimated and excessive patronage loaded on the public transport lines. This excessive patronage will cause the revised skims to be over-estimated, and if the above iterative process is applied, the number of trips generated will be different for each iteration.

This process was applied in Manila to test for convergence and, fortunately, convergence was found to be rapid and stable - the difference between iteration 1 and 2 being 12% of trips and between 2 and 3 being less than 4%.

Summary

In the first major applications of any modelling suite as ambitious as the Manila Public Transport Model, the user is bound to have mixed feelings about the model.

The model will not do everything that all users require or for all problem sets and it is necessary to stay within the discipline imposed by the model itself.

Nevertheless, in its present form, the Manila Public Transport Model does provide the essential working tools for a fair range of problems and should provide a suitable basis for further research and improvement as time and funds permit.

CONCLUSION

In its present form the model could be expensive to operate unless care is exercised in the selection of a suitable computer. Nevertheless, by comparison with the multiple runs necessary to achieve approximately the same result with U.T.P.S., it is cost-effective.

Similarly, the calibration process leaves much to be desired, but this comment is also true of TRANSEPT and U.T.P.S. There are several computing design alternatives, which have not been tested, and which may improve cost-effectiveness and there is probably scope for algorithm improvement to achieve the same ends.

Nevertheless, having combined the headway-revision attributes of TRANCEPT with the multi-path attributes of the U.T.P.S. model in this area and added a user coefficient concept (which, if combined with current disaggregated modelling features, would provide greater modelling insight), the Manila Public Transport Model represents a step forward in public transport network modelling.

The requirements that led to the formulation of this model are generally not found in Australian cities, which are served by fewer modes and with greater inter-modal rationalisation and with a more egalitarian income structure. Nevertheless, the model could find wide use in cities in most of the world's developing countries.

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REFERENCES

Bowyer, D.P. (Ed) (1979) "Bus Network Planning TRANSEPT Appraisal" Australian Road Research Board, Research Report No. 88.

De Leuw Cather and Co. et al (1977) "The Characteristics of Urban Transport Systems". A Handbook for Transportation Planners U.S. Department of Transportation.

Electrowatt Engineering Services Ltd. (1981) "Manila Metrorail Network Extension Final Report". Ministry of Transport and Communications, Republic of the Philippines.

Japan Overseas Consultants Co. Ltd. et al (1981) "Metro Manila Urban Transport Improvement Project" - reports. Ministry of Transport and Communications, Republic of the Philippines.

Nairn, R.J., Field, J.F. and Parker G.R. (1977) "Land-use/ Transport Interaction Modelling with TRANSTEP" Australian Transport Research Forum Papers.

R.J. Nairn and Partners Pty. Ltd. (1981) "TRANSTEP Land-use Transport Interaction Model" General Description and User Manual