24th EUROPEAN TRANSPORT FORUM

Proceedings of Seminar F

Public Transport Planning and Operations

2 – 6 September 1996

PTRC

P405
ISBN 0-86050-295-3
ISSN 0266-4585

Organised on behalf of the
PTRC International Association by
PTRC Education and Research Services Ltd.

PUBLIC TRANSPORT PLANNING AND OPERATIONS

Proceedings of Seminar F
held at the
PTRC European Transport Forum
Brunel University, England
2 - 6 September 1996

VOLUME P 405

Price for Delegates:	**£24.00**
Price for Non-Delegates	**£32.00**

Published by

PTRC EDUCATION AND RESEARCH SERVICES LTD

on behalf of
THE PLANNING AND TRANSPORT RESEARCH AND COMPUTATION INTERNATIONAL ASSOCIATION

1996

ACKNOWLEDGEMENT

PTRC would like to thank members of the Public Transport Planning and Operations Programme Committee who have so willingly given their time in helping to organise the programme for this Seminar:

Chantal Duchène (Chair), Ministry of Transport, France
Botond Aba, Budapest Transport Company, Hungary
Ambrosius Baanders, Ministry of Transport and Public Works, The Netherlands
Richard Balcombe, Transport Research Laboratory, UK
David Beaman, Independent Consultant, UK
David Blackledge, Transport and Travel Research Ltd, UK
Chris Brown, MCL Transport, UK
Richard Burley, Merseytravel, UK
Pierre Laconte, International Union of Public Transport (UITP), Beigium
George Nellas, Attiko Metro AK, Greece
Bob Pinckett, Hampshire County Council, UK
Otto Schiotz, Carl Bro Group, Denmark
Michael Shields, Consorcio Transportes Madrid, Spain
Sian Thornthwaite, Independent Consultant, UK
Peter White, University of Westminster, UK

Available from;
PTRC Education and Research Services Ltd.,
Glenthorne House, Hammersmith Grove, London W6 0LG, England

Tel: + 44 (0)181 - 741 1516 / Fax: + 44 (0)181 - 741 5993
e-mail: PTRC@cityscape.co.uk
http://www.cityscape.co.uk/users/cz57/index.htm

CONTENTS

STÅHL A, Lund Institute of Technology, Sweden
Adaptation of the whole travel chain: benefits and attitudes

YOUTH AND MOBILITY

BRADSHAW R, Siân Thornthwaite Consultants and ATKINS S, London Transport Planning, UK
The use of public transport for school journeys in London

CHEUNG F Y C, Ministry of Transport, KROES E P and HAMER R N, Hague Consulting Group, The Netherlands
The evaluation of the Student Pass (new formula) in the Netherlands

GUIDEZ J M, C.E.R.T.U, France
The mobility of France's youth population within urban areas

CONVINCING THE CAR DRIVER

STOKES G, Transport and Travel Research Ltd., UK
Getting commuters onto public transport - a survey in Merseyside

KELLY P, Maunsell Transport Planning, UK
Quality Bus - buses for car owners

PARKHURST G, University College London, UK
The influence of perceptions of space and opportunity on users' responses to a new public transport system

WHERE IS THE MARKET FOR PUBLIC TRANSPORT?

MONZON A and GUERRERO M J, Madrid University School of Advanced Civil Engineering, CRISTOBAL C and SANZ C, Madrid Transport Consortium, Spain
Social appraisal of public transport in Madrid

FARWELL R G, SG Associates, USA
Evaluation of Omnilink demand driven transit operations: flex-route services

KAUFMANN V, Swiss Federal Institute of Technology, Lausanne, Switzerland
Does modal choice between car and public transport really exist?

RAILWAYS: FRANCHISING AND BEYOND

EATON B D, Coventry Business School, UK
Localised operation of passenger services under the Railways Act

STEINMETZ W R and ASHMORE D O, Railway Technology Strategy Centre, UK
Reliability - the dominant railway performance issue of the next decade

HYLEN B, Swedish National Road and Transport Research Institute, Sweden
Franchised rail services in Sweden

YOUNG RESEARCHERS' FORUM

ABBAS K A, Egyptian National Institute of Transport, Egypt
A generic system for planning activities in a bus transit company

PERSSON C P, Lund Institute of Technology, Sweden
Interregional rail travellers' assessment of station location, services provided and access

VEENEMAN W W, Delft University of Technology, The Netherlands
A process approach to public transport design

A GENERIC SYSTEM FOR PLANNING ACTIVITIES IN A BUS TRANSIT COMPANY

Dr. Khaled A. Abbas
Transportation Planning Department - Egyptian National Institute of Transport
P.O. Box 34 Abbassia - Cairo - Egypt

1. INTRODUCTION

Managers of bus transit companies have the task of managing their companies' resources (financial, human, material, fleet of vehicles) in an efficient and effective manner. This task is becoming more difficult due to tangible pressures, mainly in the form of limited available funds and shortages in subsidies resulting from budget deficits and financial cuts. In addition, in many countries, restructuring of public transport companies is taking place through deregulation and privatization. This is meant to turn companies into market-oriented organisations. Planning of bus transit activities is becoming an increasingly complex and sophisticated task. The various elements involved in managing a transit company call for coordinated approaches for future planning. Reorientation is needed in the planning of bus transit activities from the standard piecemeal approach to the holistic system approach. Efforts to develop an integrated system that considers within its framework the planning of the main activities involved in the management of a transit company ought be pursued.

This paper presents a generic procedure for planning bus transit activities. This procedure is developed within a system approach framework. It contains eight subsystems namely: a vehicle maintenance management system, a vehicle operation management system, a new vehicles procurement management system, frequency setting, cost accounting, fare determination and subsidy computation, travel demand prediction and performance evaluation. The proposed planning approach provides a better understanding and insight into the inter- and intra- structural feedback relationships that exist among the various components involved in the overall management of a bus transit company. It is meant to achieve an integrated tactical planning of activities constituting the management of a bus transit company. It is also meant to provide practical and credible support to transit managers, so that they can make more rational and informed planning decisions. Decisions should be targeted towards achieving an efficient and effective management of bus transit activities, so as to sustain and maximize benefits obtained from resource utilization.

2. A SYSTEM APPROACH FOR PLANNING BUS TRANSIT ACTIVITIES

"Transit service plans rely greatly on service planning guidelines that are mainly based on the practical experience and professional judgment of transit planners than on theoretical considerations", Shih, 1994. However, it was pointed out by Baaj, 1990 that most transit service planning approaches fail to incorporate practical guidelines, and consequently have difficulty being accepted by the transit industry. A system approach for planning bus transit activities is proposed in Figures 1, 2 and 3.

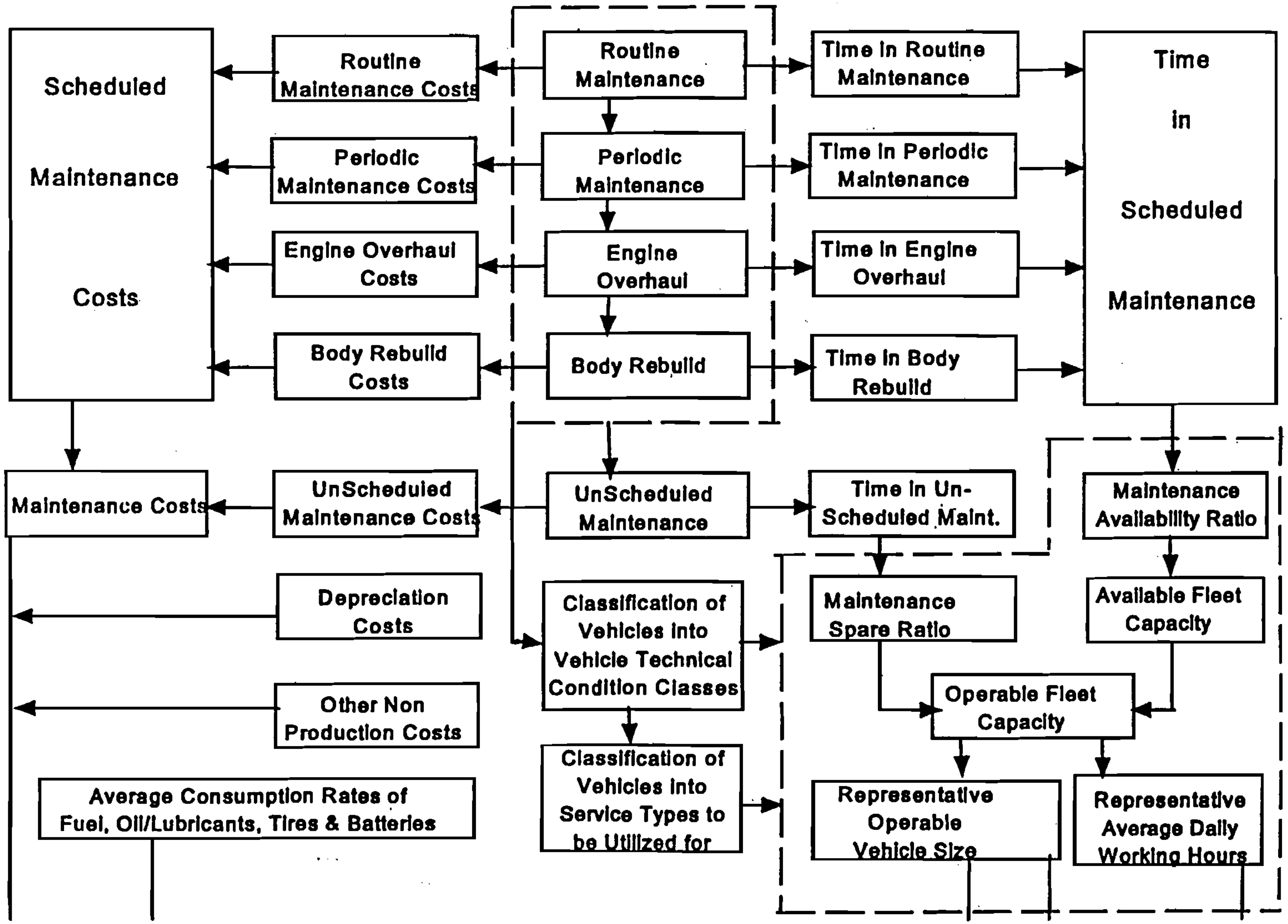

Figure 1: Vehicle maintenance management system

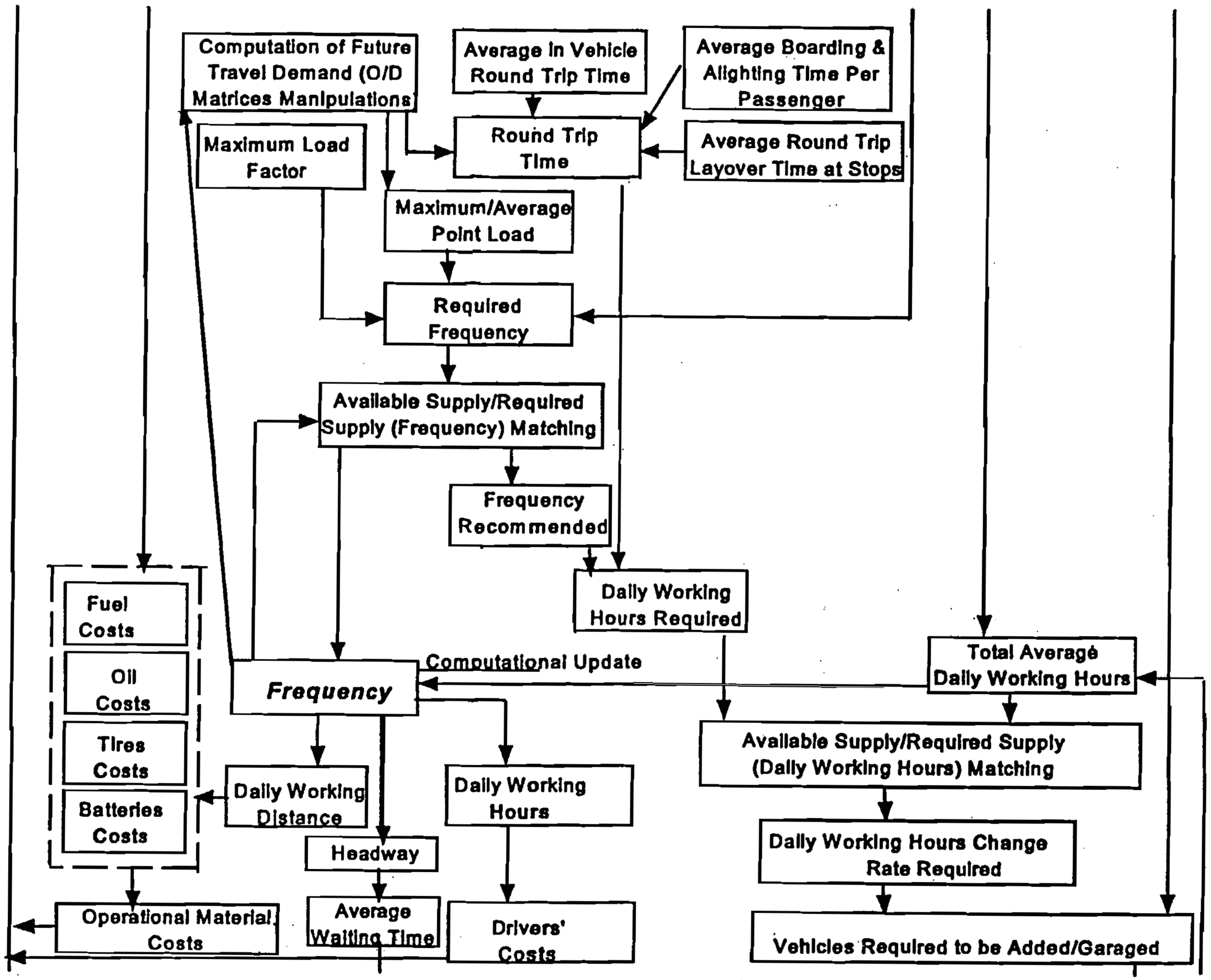

Figure 2: Vehicle operation management system

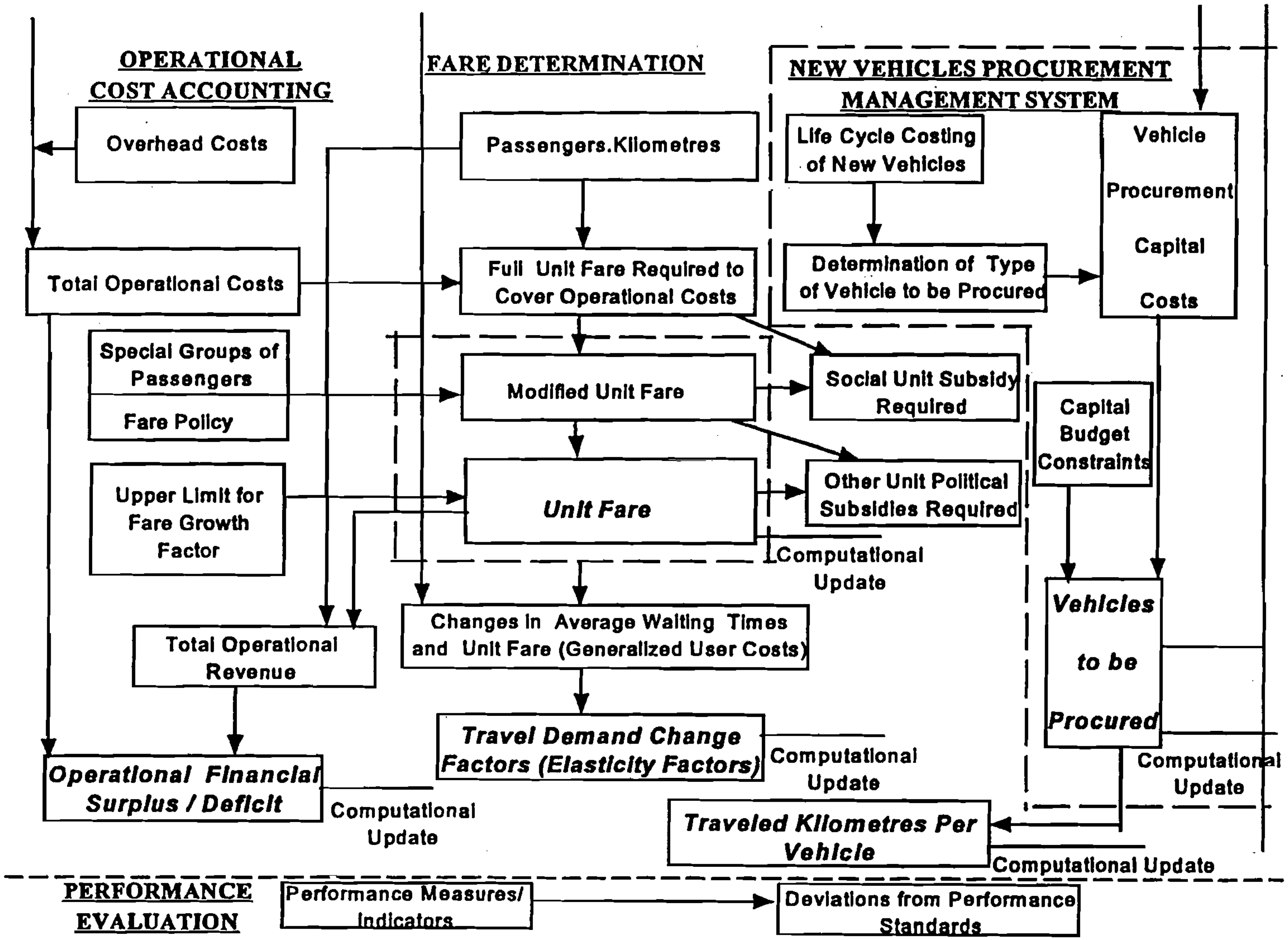

Figure 3: New vehicles procurement management system, cost accounting, fare determination and performance evaluation

The Figures show the steps to be performed in succession during each planning increment. The proposed procedure is heuristic in nature. It is meant to incorporate practical guidelines and transit industry rules of thumb. These have primarily evolved through experience, data collection and analysis. In developing this procedure, the research was partly guided by Benz, 1988 and Odoni et al., 1994. It includes:

- Vehicle maintenance management system
- Vehicle operation management system
- New vehicles procurement management system
- Frequency setting
- Cost accounting
- Fare determination and subsidy computation
- Travel demand prediction
- Performance evaluation

These sub-systems include the main variables, the causal interactions and the feedback loops that constitute the management of a bus transit company. Each sub-system builds on the previous ones, and influences the next ones. These are discussed in the following sub-sections where reference is made to Figures 1, 2 and 3.

2.1 Vehicle Maintenance Management System

A fleet of vehicles is a complex group of individual units. Maintenance requirements, in terms of time and financial resources, should be traced on a vehicle by vehicle basis. This would help in producing a more accurate and sound availability factors. In addition, it would help in conducting the accounting of operation costs on a vehicle by vehicle basis. Eventually, this would provide guidelines for the future procurement of certain types of vehicles that proved to be efficient in terms of maintenance costs.

The vehicle maintenance management system is displayed in Figure 1. This represents the start of the system planning process, where scheduled and unscheduled maintenance requirements are determined for each vehicle in the fleet. Scheduled preventive maintenance include routine and periodic maintenance, engine overhaul and body rebuild. Routine and periodic maintenance are warranted based on pre-specified frequencies. Engine overhaul and body rebuild are warranted based on pre-specified thresholds intervals of operated kilometers. Unscheduled maintenance is warranted based on pre-specified expected frequency for road calls resulting from breakdowns occurrences.

It is to be noted that performing preventive maintenance on time would minimise the frequency of breakdowns and hence road calls. Vehicles can then be classified into pools of vehicle condition classes in accordance with pre-set technical condition criteria. Vehicles in these pools are further re-assigned into service types that these vehicles can provide. The total time expected in scheduled maintenance activities is used to compute the maintenance availability ratio and hence the available fleet capacity by service type. On the other hand, the time expected in unscheduled maintenance is used to compute maintenance spare ratio. The spare ratio is a ratio of the capacity of vehicles that is left aside as a stand-by with respect to the available capacity. This stand-by capacity is meant to cover for the occurrence of emergency situations such as road calls resulting from breakdowns. Using the maintenance spare ratio and the available fleet capacity, the operable fleet capacity for each service type can be computed as follows.

$$DCVSM_S = (SCVRM_S * ATVRM) + (SCVPM_S * ATVPM) + (SCVEO_S * ATVEO) + (SCVBR_S * ATVBR) \quad (1)$$
$$DCFV_S = SCFV_S * YWD \quad (2)$$
$$DCAFV_S = DCFV_S - DCVSM_S \quad (3)$$
$$MAR_S = DCAFV_S / DCFV_S \quad (4)$$
$$DCSV_S = SCVUM_S * ATVUM \quad (5)$$
$$MSR_S = DCSV_S / DCAFV_S \quad (6)$$
$$DCOFV_S = DCAFV_S (1 - MSR_S) \quad (7)$$

S = Service type e.g. express, luxurious, ordinary
$SCVRM_S$, $SCVPM_S$, $SCVEO_S$, $SCVBR_S$ = Static Capacity of Vehicles in Routine Maintenance, Periodic Maintenance, Engine Overhaul, Body Rebuild
ATVRM, ATVPM, ATVEO, ATVBR = Average Time a Vehicle Stays in Routine Maintenance, Periodic Maintenance, Engine Overhaul, Body Rebuild
$DCVSM_S$ = Dynamic Capacity of Vehicles in Scheduled Maintenance
$SCFV_S$ = Static Capacity of Fleet of Vehicles
YWD = Yearly Working Days
$DCFV_S$ = Dynamic Capacity of Fleet of Vehicles
$DCAFV_S$ = Dynamic Capacity of Available Fleet of Vehicles
$SCVUM_S$ = Static Capacity of Vehicles in Unscheduled Maintenance
ATVUM = Average Time a Vehicle Stays in Unscheduled Maintenance
$DCSV_S$ = Dynamic Capacity of Spare Vehicles to account for possible road calls
MAR_S = Maintenance Availability Ratio
MSR_S = Maintenance Spare Ratio
$DCOFV_S$ = Dynamic Capacity of Operable Fleet of Vehicles

As a result of planning maintenance activities, the following information are computed:

- Representative operable vehicle size for each service type i.e. seating capacity.
- Representative average daily working hours per vehicle serving a particular service type.
- Accumulation of maintenance, depreciation and other non production costs on a vehicle by vehicle basis.
- Average consumption rates of operational material (i.e. fuel, oil/lubricants, tires and batteries). These are averaged over each group of vehicles capable of offering a particular service type.

2.2 Vehicle Operation Management System

The vehicle operation management system is displayed in Figure 2. This constitutes the following steps to be carried out in order for each service type offered within a period of travelling pattern on a particular route:

1. Determining the necessary supply in terms of frequency required to meet expected travel demand.
2. Carrying out matching computations to compare available supply, in terms of frequency, versus required supply.
3. Based on this comparison an operational policy can be reached in terms of frequency recommendation.
4. Determining the necessary supply in terms of daily working hours required to meet expected travel demand.
5. Carrying out another matching computations to compare available supply, in terms of daily working hours, versus required supply.
6. Based on this comparison, a fleet procurement policy can be reached in terms of recommending the number of new vehicles to be added to provide the necessary working hours and the recommended frequency.

2.2.1 Frequency computation

The number of vehicles required to satisfy different service types offered at different periods of traveling patterns during the day are determined through an examination of the maximum/average loads expected relative to the loading standards. A loading standard is the average seating capacity multiplied by the maximum load factor.

Expected future travel demand matrices are manipulated to compute the maximum point load for each route in the bus transit network. This is the point along a transit route at which maximum loads occur on vehicles. The frequency required to satisfy a maximum point load is determined using the following classical equation:

$$RFREQ_{R,P,S} = TDMAX_{R,P,S} / (SV_S * LF_{R,P,S}) \qquad (8)$$

R = Route
P = Period of travelling pattern e.g. A.M./P.M. peak/off peak
$TDMAX_{R,P,S}$ = Travel Demand (Maximum)
SV_S = Size of Vehicle (Average Seating Capacity)
$LF_{R,P,S}$ = Load Factor
$RFREQ_{R,P,S}$ = Required Frequency

In this equation travel demand is usually taken to be equal to the maximum or average point load. Size of vehicle is taken equal to the representative operable vehicle size (obtained as an output from the vehicle maintenance management system). Load factor is pre-specified to represent the ratio of the maximum number of passengers (seated and standing) allowed on a bus versus the seating capacity. This is an indication of offered level of service (in terms of comfort and convenience).

There is a need to provide sufficient service of the right type at the right time and right place for the right passenger. Current operable frequencies representing available supply of service are compared with required frequencies. Three possible outcomes can result of this comparison:

- Sufficiency of supply (Available supply = Supply required to meet travel demand).
- Over-sufficiency of supply (Available supply > Supply required to meet travel demand).
- Insufficiency of supply (Available supply < Supply required to meet travel demand).

As a result of this comparison an operational policy in terms of frequency recommendation can be reached, see Table 1.

Table 1: Operational policy in terms of recommending frequency changes

Difference in Frequency	Available Supply Versus Required Supply	Recommended Operational Policies
No	Perfect matching	Theoretically, do nothing Practically, increase frequency by a percentage buffer to account for uncertainties
Positive	Oversupply	Reduce frequency but maintain the frequency buffer value and reduce beyond
Negative	Undersupply	Increase frequency and maintain the frequency buffer value

2.2.2 Daily working hours computation

In order to achieve these recommended frequencies, sufficient daily working hours should be provided by vehicles. Daily working hours required is computed by multiplying recommended frequencies by average round trip times of routes serviced by the bus transit company. The average round trip time is defined as the time taken for a vehicle to travel forwards from a main origin station to a main destination station and backwards from the destination terminal to the origin terminal. Average route round trip time and daily working hours required can be computed as follows:

$$ARTT_{R,P,S} = TAIVRTRT_{R,P,S} + [(TD_{R,P,S} / FREQ_{R,P,S}) * (ABT + AAT)] + TALOTSRT_{R} \quad (9)$$

$$RDWH_{R,P,S} = RFREQ_{R,P,S} * ARTT_{R,P,S} \quad (10)$$

$TAIVRTRT_{R,P,S}$ = Total Average In Vehicle Running Time for a Round Trip
$TD_{R,P,S}$ = Travel Demand
$FREQ_{R,P,S}$ = Current Frequency
ABT = Average Boarding Time per Passenger
AAT = Average Alighting Time per Passenger
$TALOTSRT_{R}$ = Total Average Layover Time at Stops for a Round Trip
$ARTT_{R,P,S}$ = Average Round Trip Time
$RDWH_{R,P,S}$ = Required Daily Working Hours

The available supply in terms of daily working hours is also computed as an accumulation of the average number of daily working hours available by each vehicle weighted by a size factor. This size factor represents the seating capacity of each vehicle in relation to the seating capacity of the representative vehicle.

The available average daily working hours is then compared with the required average daily working hours. As a result, daily working hours required to be added can be reached. Hence, a fleet procurement policy in terms of new vehicles required to be procured is recommended, see Table 2.

Table 2: Recommended fleet procurement policy in terms of new vehicles to be added

Difference in Daily Working Hours	Available Supply Versus Required Supply	Recommended Operational Policies
No	Perfect Matching	Theoretically, do Nothing Practically, improve maintenance and procure new vehicles to maintain pre-specified buffer for vehicle utilization rate
Positive	Oversupply	Theoretically, decrease average daily working hours Practically, maintain the buffer value and reduce beyond
Negative	Undersupply	Improve maintenance and procure new vehicles to maintain a pre-specified buffer for vehicle utilization rate

2.3 New Vehicles Procurement Management System

The new vehicles procurement management system is displayed in Figure 3. Vehicles are procured for two reasons:

1. To replace existing vehicles that have reached the end of their useful lives (economic obsolescence)
2. To add new vehicles to existing active fleet so as to cater for the insufficiency of supply and to meet the increase in expected future travel demand.

The first step in procuring new vehicles is to perform a life cycle cost analysis for types of vehicles that can be potentially procured. A study that used life cycle cost analysis in transit capital overhaul/replace decisions was reported in Schaevitz, 1988. To perform this analysis the following data and information by type of vehicle should be available:

- Capital procurement price
- Percentage increase in vehicle prices
- Discount rate
- Salvage value (resale value if applicable)
- Importation taxes for procurement of new imported vehicles
- Maintenance requirements and costs
- Depreciation costs
- Expected operation and operational material costs
- Licensing fees and road tax
- Insurance premium

Capital, and depreciation costs are relatively high for new vehicles, while operation and maintenance costs are relatively low. On the other hand, old vehicles that have reached the end of their predetermined economic useful life, have no capital cost and almost no depreciation costs. However, the operation and maintenance costs of these vehicles are high. Older vehicles should be kept as long as their total cost is less than the total cost of new vehicles.

As a result of life cycle costing analysis for new vehicles the types of vehicles with lowest life cycle costs are selected as potentials to be procured. The vehicle procurement capital cost can be computed by multiplying the number of new vehicles required to be added (an output from the vehicle operation management system) by the capital procurement price required for the particular types of vehicles. The actual number of new vehicles to be procured depends on the amount of capital funds available in budget.

2.4 Updating Current Operable Frequency

The operational plan should then be updated to take into account the new vehicles to be procured and added to the fleet. This is meant to increase the supply of total average daily working hours available, and hence the potential for frequency increase. Figures 2 and 3 show this feedback relation. Current operable frequencies are updated for every route differentiated by service type and period of travelling pattern. Once operable frequencies are determined, four key variables can be computed:

- operable daily working distance (operable frequency multiplied by round trip distance)
- operable average daily working hours (operable frequency multiplied by average round trip time)
- headways representing the time interval between any two vehicles operating in the same direction and route. Headways are determined by dividing the traveling period by the operable frequency
- the average wait time for a passenger is also calculated as half of the headway.

$$ODWD_{R,P,S} = OFREQ_{R,P,S} * RTD_R \quad (11)$$
$$ODWH_{R,P,S} = OFREQ_{R,P,S} * ARTT_{R,P,S} \quad (12)$$
$$HEAD_{R,P,S} = (END_{R,P} - START_{R,P}) / OFREQ_{R,P,S} \quad (13)$$
$$AWAITT_{R,P,S} = HEAD_{R,P,S} / 2 \quad (14)$$

$OFREQ_{R,P,S}$ = Operable Frequency
RTD_R = Round Trip Distance
$ODWD_{R,P,S}$ = Operable Daily Working Distance
$ODWH_{R,P,S}$ = Operable Daily Working Hours
$END_{R,P}$ = End of period of travelling pattern
$START_{R,P}$ = Start of period of travelling pattern,
$HEAD_{R,P,S}$ = Headway
$AWAITT_{R,P,S}$ = Average Waiting Time per Passenger

2.5 Cost Accounting

Cost items can be grouped into either capital or operational costs. Capital costs mainly involve the money spent in the procurement of new vehicles. Operational costs are composed of five main elements:

1. Maintenance costs
2. Depreciation costs
3. Other non production costs
4. Operational material costs
5. Staff costs

Maintenance costs include costs incurred in performing scheduled and unscheduled maintenance, see Figure 1. These are kilometre and time related variable costs. Other non production costs include: license fees, taxes and insurance.

Operational material costs include: fuel costs, oil/lubricants costs, tires costs, and batteries costs, see Figure 2. These are kilometre related variable costs, where quantities are computed by dividing the kilometers expected to be operated by the average consumption rates of fuel, oil, tires, and batteries (obtained as an output from the maintenance management system). The resulting quantities are then multiplied by the current unit costs to obtain the final operational material costs.

Staff costs include: maintenance staff (engineers and mechanics), operation crew (drivers and conductors), unskillful labor, and management personal. Maintenance staff costs was included in the maintenance costs as a time dependent variable cost. Drivers' costs can be also computed as a time dependent variable cost, see Figure 2. Conductors, unskillful labor and overhead management costs all are computed as fixed costs i.e. predetermined monthly salaries.

2.6 Fare Determination and Subsidy Computation

Fares are computed for every route depending on the type of passenger riding a particular service type during a particular period of time during the day. Fares are supposed to generate an operational revenue that can cover the operational costs and induce an operational financial surplus. However, in many cases bus transit is regarded as a form of social service and fares are intentionally kept below the level of even covering the operational costs. This strategy is practiced more often in urban transit systems. On the other hand, most of the intercity bus transit systems are either deregulated or privatized with an overall strategy aimed at profit maximization.

A fare structure can be either flat fare structure (i.e. unit fare per passenger regardless of travelled distance) or distance related fare structure (i.e. unit fare per passenger.kilometer). The unit fare required to cover unit operational costs can be computed, see Figure 3. This unit fare is modified to take into account the pre-specified fare policy. As stated, a typical fare policy for urban bus transit systems is for operational costs to cover a pre-specified percentage of operational revenue. This means that all passenger trips are being subsidized. The unit subsidy can then be computed as the difference between the required unit fare to cover the unit operational costs and the unit fare modified to cover the pre-specified percentage of unit operational costs. In addition, there exist three other main fare policies, namely:

- Operational revenue to break even with operational costs
- Operational revenue to cover operational costs and to achieve a specified financial efficiency ratio
- Operational revenue to cover operational costs and to achieve a specified rate of return on invested capital

If any of these three fare policies are specified, this means that there will be no direct subsidies. However, there could be still a form of cross subsidy where full fare passengers can cross subsidize other special group passengers e.g. handicapped, students, elderly.

The final unit fare is further constrained by a pre-specified upper limit for fare growth factor. The value of this upper limit would probably reflect other political and social pressures (constraints) on the bus operators. The difference between modified fare and the final fare is known as other political subsidies.

2.7 Travel Demand Prediction

Travel demand is predicted on every route for the types of passenger riding a particular service type during a particular period of time during the day. As previously indicated, incremental changes in average waiting time per passenger and in unit fare are computed. A reduction in average waiting time is representative of a level of service improvement. Travel demand is known to be sensitive to changes in these two parameters.

The elasticity of travel demand to these changes can be considered in one of two ways:

- two separate elasticity values, one representing the elasticity of demand to fare changes and the other representing the elasticity to waiting time changes.
- an elasticity value combining the effect of changes in fare and waiting time (i.e. generalized user costs changes). For simplicity, demand change factors can be assumed equal to the average generalized user cost change factor, see Schaevitz, 1988.

Several studies have looked into elasticities of travel demand to fare and level of service changes, see Mayworm et al., 1980 and Eash et al., 1993. For simplicity, demand change factors (elasticity values) can be assumed to be equal to the average generalized user cost change factor.

2.8 Performance Measures

Performance indicators are meant to describe the state and development of the system at any point in time. Performance indicators should be clear, objective, non-redundant, applicable, manageable and easy to measure. Indicators can be absolute and/or relative values. They could be qualitative or quantitative in nature. Relative performance indicators are of great importance. They can be best used in comparison and evaluation. Many decisions concerning the bus transit system can be made on the basis of such performance predictions.

A framework for categorizing bus transit performance indicators into sets of performance measures was proposed by Fielding, 1992. This framework includes three sets of measures. The first known as cost efficiency measures which includes indicators that measure the service inputs (labor, capital, fuel) to the amount of service produced (service outputs: vehicle hours, vehicle miles, capacity miles, service reliability). The second is known as the cost effectiveness measure which includes indicators measuring the level of service consumption (passengers, passenger miles, operating revenue) against service inputs. Finally, the third is known as the service effectiveness measure which include indicators that measure the extent to which service outputs are consumed. A report by TCRP, 1994 has indicated that typical groupings of transit performance measures include cost efficiency, cost effectiveness, service utilization, vehicle utilization, service quality, labor productivity, and service accessibility.

The literature shows a nonconcensus on whether to use multiple or single performance measures/indicators for the evaluation and management of bus transit companies. Multiple measures can include a wide spectrum of indicators that can be used for evaluating the inputs and the outputs of a bus transit firm. However, these can also open the door for dispute, uncertainty and even confusion. On the other hand, single indicators can be extremely beneficial when targeted to evaluate a specific predetermined company goal/objective. However, single measures by their nature can not cover the whole set of inputs and outputs of a bus transit company and hence produces partial evaluation. 'What is needed is a framework within which all inputs and outputs can be taken into account and in which the non homogenous nature of the inputs and outputs can be correctly accommodated", Talvitie and Obeng, 1991. 'The total factor productivity approach to performance measurement circumvents many of the problems of single indicators", Oum et al., 1992. This is used in the selection of operational performance measures in public bus transit firms.

It is worth mentioning that an important indicator that is frequently used in the financial appraisal of bus transit companies is the operational financial surplus/deficit. This value is also very important as it is considered as one of the sources of financial funds to be pumped into following years budgets. This can be computed by subtracting the operational costs from operational revenue, see Figure 3. Operational revenue is computed as the multiplication of the unit fare by the number of passengers (in case of flat fare) or by the number of passenger.kilometres (in case of distance based fare).

3. CONCLUSION

This paper presented a generic procedure developed within a system approach framework for planning bus transit activities. This procedure considers the feedback interactions among those activities involved in the management of a bus transit company. It contains eight subsystems namely: a vehicle maintenance management system, a vehicle operation management system, a new vehicles procurement management system, frequency setting, cost accounting, fare determination and subsidy computation, travel demand prediction and performance evaluation.

The proposed procedure provides better understanding and insight into the inter- and intra- structural feedback relationships among the various components involved in the overall management of a bus transit company. It is meant to provide practical and credible support to transit managers, so that they can make more rational and informed planning decisions. Decisions should be targeted towards achieving an efficient and effective management and control of the bus transit activities, so as to sustain and maximize benefits obtained from resource utilization.

The proposed procedure, when simulated over time can provide a dynamic tactical planning tool that is capable of quantifying the effects that might occur over time as a result of changes in the bus transit policies, procedures and exogenous key input parameters. Efforts to develop such a tool are reported in Abbas, 1995.

ACKNOWLEDGMENT

This paper is based on research work conducted by the author during his post-doctorate award as a Fulbright Visiting Scholar at the Department of Civil Engineering, University of Texas at Austin, USA. Acknowledgment is due to the Fulbright Commission in Egypt and to Professor Hani Mahmassani of the Civil Engineering Department, University of Texas at Austin.

REFERENCES

Abbas K. A. (1995) BTMS: A generic bus transit management system, Transportation Research Report, Center for Transportation Research, Bureau of Engineering Research, The University of Texas at Austin, Austin, Texas, USA.

Baaj, M. H. (1990) The transit network design problem: An AI-based approach, Ph.D. Dissertation, Department of Civil Engineering, University of Texas at Austin, Texas, USA.

Benz G. P. (1988) Three-step operations planning procedure for transit corridor alternatives analysis, Transportation Research Record 1202: Public Transit, pp. 66-73, Transportation Research Board, Washington DC, USA.

Eash R., Dallmeyer K., and Cook R. (1993) Rridership forecasting for Chicago transit authority's west corridor project, Transportation Research Record 1402: Public Transit, pp. 40-42. Transportation Research Board, Washington DC, USA.

Fielding G. J. (1992) Performance evaluation for public transit, Transportation Research, Vol. 26A, No. 1, pp. 483-491, Pergamon Press.

Mayworm P., Lago A. M., and McEnro J. M. (1980) Patronage impacts of changes in transit fares and services, Urban Mass Transportation Administration. US Department of Transportation, Washington DC, USA, (RR 135-1).

Odoni A. R., Rousseau J. M., and Wilson N. H. M. (1994) Models in urban and air transportation, Chapter 5 in Operations Research and the Public Sector, Pollock S. M., and Rothkopf M. H. (eds.), North Holland.

Oum, T. H., Tretheway N. W., and Walters II. W. G. (1992) Concepts, methods and purpose of productivity measurement in transportation, Transportation Research, Vol. 26A, No. 6 , pp. 493-505, Pergamon Press.

Schaevitz R. C. (1988) Use of life-cycle cost analysis in transit capital overhaul/replace decisions: an application to PATH railcar fleet, Transportation Research Record 1165: Public Transit, pp. 11-18, Transportation Research Board, Washington DC, USA.

Shih M. C. (1994) A design methodology for bus transit route networks with coordinated operations, Ph.D. Dissertation, Department of Civil Engineering, University of Texas at Austin, Texas, USA.

Talvitie A., and Obeng K. (1991) Productivity measurement: A Workshop Report", Proceedings of the First International Conference on Competition and Ownership of Bus and Coach Services, Special Issue of Transportation Planning and Technology, Vol. 15, pp. 169 - 176.

Transit Cooperative Research Program (TCRP) (1994) The role of performance-based measures in allocating funding for transit operations, A Synthesis of Transit Practice, TCRP Synthesis 6, Transportation Research Board, Washington DC, USA.