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NATURAL RESOURCES &
SCIENCE AUTHORITY
OF
SRI LANKA

PROCEEDINGS : SRI LANKA
TRANSPORTATION FORUM.
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A NOTE FROM THE CO-CHAIRMAN

The idea of holding the first Sri Lanka Transportation Forum evolved during a casual conversation about a possible short course on Advanced Transportation topics.

The main motivation for holding the Forum is the encouragement of

- (i) the study of transportation problems in Sri Lanka by our own experts,
- (ii) the reporting of the results of such studies in written form,
- (iii) the mutual education of the transportation professionals and scholars through discussion of the papers, and
- (iv) the provision of solutions to some of the pressing transportation problems facing us today.

We further hope that through this Forum (i) the formulation of a national transportation policy and (ii) the formation of a Transportation Society of Sri Lanka will gain some impetus.

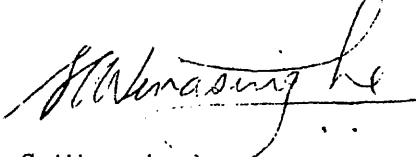
We wish to thank the Vice Chandellor, Professor C.Patuwathavithane; the Dean of the Faculty of Engineering, Professor D.S.Wijeyesekera; and the Head of the Department of Civil Engineering, Dr.B.L.Tennekoon, of the University of Moratuwa for their encouragement of this venture.

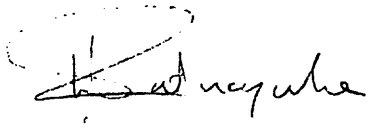
This Forum would not have been possible without the dedicated work of the Organizing Committee consisting of Messers A.Wijeratne; S.A.S.Kulathileka; J.M.S.J.Bandara and A.Seneviratne, all of whom are Assistant Lecturers in Civil Engineering at the University of Moratuwa.

Thanks are also due to Miss Gayanthri Fernando for cheerfully typing over a period of nine months, the numerous documents necessary for organizing this Forum.

Finally, we wish to thank the University of Moratuwa, the Sri Lanka Export Development Board and the Central Freight Bureau for generously providing financial assistance for the Forum.

It is our fervent hope that this will be the first of many Sri Lanka Transportation Forums.


S.C. Wirasinghe
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University of Moratuwa, Sri Lanka.


L.L. Ratnayake
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June 20th 1983.

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OPENING REMARKS

BY

PROF.S.C.WIRASINGHE, FORUM CO-CHAIRMAN

1. Honourable Minister of Transport, Transport Boards and Private Omnibus Transport; Vice Chancellor of the University of Moratuwa; Secretaries to the Ministries of Transport, Transport Boards and Private Omnibus Transport; Distinguished invitees; members of the organizing committee; colleagues and friends.
2. It is indeed an honour and a privilege to have you present here today for the ceremonial opening of the very first Sri Lanka Transportation Forum. I believe and I hope that today will mark a historic turning point in the development of the subject of Transportation in Sri Lanka.
3. Hon. Minister, We are proud that this Forum, which is about Transportation in Sri Lanka, has been organized by Sri Lankans; We are justly proud that the papers being presented are by Sri Lankan experts and scholars; We are also proud that the Forum is sponsored by purely Sri Lankan Institutions; namely, the University of Moratuwa, Sri Lanka Export Development Board and Central Freight Bureau. We should all, be very proud, that a re-developing country such as ours, has the will, and the expertise, to have a highly specialized Forum of this nature.
4. There are several reasons for holding this Forum:

One: to encourage the study and open discussion of transport problems and issues, and I stress the word "Open",

Two: to mutually educate professionals, administrators and scholars through discussion, and

Three: to provide reasonable solution options to some of the pressing problems of Transport today.
5. Hon. Minister, We have plans for developing the subject of Transport in Sri Lanka:
 - * To set up a Transport Society of Sri Lanka
 - * To hold the Sri Lanka Transportation Forum on a regular basis
 - * To offer post graduate degrees and diplomas in Transportation.We hope, that this first Forum, and your presence here, will give added momentum to these projects.
6. Hon. Minister, Basic and safe transportation facilities are a fundamental right of a free people. Transportation, and I think all of us will agree, is as important for modern living as housing, education & water supply.

I sincerely hope, that the Sri Lanka Transportation Forum will help towards giving the subject of Transportation, and the right that people have to basic, safe transportation services, their rightful recognition and place in today's society.

I thank you all very much.

Opening Address by the M.H. Mohamed Hon. Minister of Transport
Transport Boards and Private Omnibus Transport.

SEMINAR ON TRANSPORT

I thank the organizers of this Seminar for inviting me to address you today.

This is the first Seminar of its kind organized at University level. Transport is a special discipline and I am happy that some of the universities in our country have included transport as a subject in their curriculum. Seminars of this nature which bring together not only academics but also the providers and users of transport help to foster and develop an interest among all, and also afford an opportunity to the participants to exchange views and discuss the problems of the transport sector, which is one of the key sectors of the economy.

Transport and economic development are very closely linked. In fact the provision of transport infrastructure should precede other development activities. The contribution transport is making to the Gross Domestic Produce (G.D.P) of the country has always been significant and to increase this contribution it is necessary to make further investment to meet the demands of development. This is because transport by nature is a capital intensive industry. Heavy capital costs have to be incurred to keep our railways moving and to develop our highway network and for the Transport Boards to provide additional capacity to meet the growing demand for travel.

Railway

The importance of the railway in our transport system hardly needs emphasis. It is the oldest established form of mechanical transport in the Island and from the outset has played a significant role in the development of the country. It is no less important today specially with the rise in the cost of other conventional forms of transport using fossil fuels. This fact had not been appreciated in recent times.

By 1977 railway services both on the passenger and freight side had been curtailed drastically. This was due to the railway being starved of investment over the last few decades. The entire system was run down and was subject to heavy strain. Track capacity had reached a point of saturation and the track itself had been so badly neglected that speed restrictions had been imposed. The locomotives and rolling stock available were thoroughly inadequate to operate the services. Maintenance standards were poor and the output in the workshops had dropped alarmingly. The signalling system was archaic.

However, since that time considerable progress has been achieved in improvement of the infrastructure, strengthening the fleet and the modernisation of the workshops. Much more has to be done to increase capacity and in the future electrification of the railway network will be inevitable to increase capacity further. This, however, will depend on the availability of energy and the resources to meet the high capital cost which electrification involves. Energy-wise rail transport is the most economical form of land transport and, in the long run, with the world's oil resources running out the railways will be called upon to play a more important role in the transport system of the country.

C.T.B.

The CTB was also in the same predicament. Public dissatisfaction with the state of the passenger services provided by the CTB was evident. The total fleet of buses was inadequate to meet the passenger demand. During the last six years more investment has been made in developing the passenger transport services than at any given period before in the history of the CTB. In 1980, an agreement was signed with the World Bank to provide assistance to the Transport Boards to the tune of nearly 53 Million U.S. dollars. With this assistance we hope to augment the fleet of the Transport Boards with nearly 2100 new vehicles. Five Provincial Workshops and several new depots have been constructed to meet the needs of the expanding fleet of buses. Apart from this, structural changes were made to the organization which from the very inception had been operated as a single unit from the center. The deterioration of the services was mainly due to the unwieldy nature of the organization. In 1978 a significant step was taken to decentralise the organization by the creation of 9 Regional Transport Boards and to delegate to these Boards the responsibility of providing services in their areas. The Boards were intended to be autonomous but, unfortunately, during the last 2 years there had been a tendency to centralise their functions and to run the Central Boards as if the Regions never existed.

This development which had been adversely commented upon even by the World Bank has now been corrected and Regional autonomy has once again been restored.

Private Operators

Until 1979, road passenger transport was the monopoly of the State. The capital resources for the development of this sector were not forthcoming. How was the Government in a position to grant financial assistance or fund the development plans of the Board. This resource constraint compelled me to think in terms of harnessing private sector investment. Another reason which influenced my thinking was that I firmly believe that monopolies in general create inefficiency, lethargy and indifference. As you all know this Government is committed to an open economy policy and competition between public and private enterprise is the corner stone of this policy.

With the liberalisation of imports, several individuals had imported passenger vehicles and, in order to harness this capacity, the Government decided to invite private sector participation for the provision of passenger transport facilities. The private sector responded magnificently and has made an investment of nearly Rs 1800 million up to now. This was achieved by granting incentives to these investors. There are today nearly 7000 private buses supplementing the services provided by the nationalized venture. This development has been hailed as a great boon by the travelling public. During the formative years of this scheme there have been some shortcomings which I am mindful of. These could not have been avoided as it was not the intention of the Government to impose controls and restrictions for fear that such restrictions would discourage the entry of private operators. We have today reached a stage when steps have to be taken to promote the orderly growth of this sector.

Legislation will soon be introduced to regulate the activities of the private operators, to avoid wasteful competition among themselves and with the nationalised sector and also to give the travelling public a better deal. The proposed legislation will provide for system of voluntary regulation by the operators themselves who will be required to form district operators associations - one Association for each administrative district in the island - and a central federation to co-ordinate the activities of the district associations.

In addition a separate department of Private Omnibus Transport will be established to handle all matters connected with private omnibus operations. I must mention that the policy that will be followed will be one of minimum state intervention. It is by no means an attempt to return to the system of control that prevailed prior to the nationalization of the bus companies in 1958, which led to the growth of monopolies with all the abuses and which finally compelled the then Government to take over these companies.

Road Eaulage

Another important arm of the inland transport system is Road Eaulage or the transport of goods by road. As you know the goods transport sector is a free enterprise. Up to 1958 this sector was regulated so rigidly that it was alleged that the system of regulation in force then was acting in restraint of trade. After the regulation of the industry was abandoned, it had a natural growth. But in the 1960 an embargo was imposed on the import of vehicles by the previous Government and the growth of this sector was severely restricted and there were capacity shortages. This has now been overcome following the liberalisation of imports by this Government and today there are enough vehicles to meet the nation's road transport needs.

Highways

The highways network of the country which had been neglected prior to 1971 is also being developed. The World Bank is providing assistance for this development. Our road system was built for a pre-motorised age and most of the arterial roads are unable to accommodate the present volume of traffic. In urban areas, mainly in the Greater Colombo area, traffic congestion has become a perennial problem. The vehicle population has increased by leaps and bounds and the trunk roads are unable to cope with this volume of traffic. Government is alive to this problem. Construction of new roads in built-up areas is not possible and, even if possible, the cost can be prohibitive.

The state of the roads has a direct bearing on the cost of providing public transport facilities, as road congestion results in high operating costs and the users of transport also suffer from delays in travel time. Traffic planners must ensure that measures are taken to disentangle public transport vehicles from interference and delays caused by other vehicular traffic, because in terms of the number of passengers carried, users of public transport occupy much less road space than the other road users. This briefly summarises development of the inland transport industry and the efforts made by the Government to increase capacity to meet the growing demands of a development economy.

Transport Policy

Having solved the problem of capacity, the next step is to formulate an overall transport policy for the whole country, considering all forms of transport as parts of a single transport system. In the past the tendency has been to treat the Railway, the Transport Boards, private omnibus transport and road haulage differently. This approach is not correct. The future strategy is to make the best use of the total investment in the whole sector. The objectives of such a policy should ensure that each form of transport is allowed to develop its latest potentialities so that each could concentrate on what it can perform best, in a given state of technology, taking into consideration the all important factor of energy efficiency in operations. Each form has certain characteristics and advantages. For example, the railways are better suited to handle goods in bulk over long distances. Long distance passenger operations is another field of specialisation for the railways. Further, in urban areas, such as the Greater Colombo area where traffic densities are high, the railways can provide for more efficient facilities than its competitors. Road transport must supplement and act as feeders to the Railway in areas where both modes of transport run in competition. Finally, such a policy should bring about co-ordination between the competing forms.

Environmental Pollution

Before I conclude I wish to refer to another problem which is gathering importance. I have earlier referred to the problem of congestion. The amount of vehicle traffic has grown faster than the capacity of our road system and unless timely action is taken, the growing pressure of motor vehicle movement will damage the environment in which we live. Apart from the risk of accident, the impact of the motor vehicle on the environment is felt in several ways. Motorised transport is one of the main contributors to air pollution, which is recognised today as a major health hazard. There are other factors attributed to the motor vehicle such as noise, vibration and visual intrusion that can cause numerous ailments in man. But none is so dangerous as the polluted air which not only affects men but can also destroy property and ruin crops. The effects of air pollution in urban townships are mainly felt by pedestrians who come in contact with vehicles in congested streets, the occupants of buildings along these streets and, to some extent, by the occupants of motor vehicles. The toxic air in the atmosphere is mainly caused by petrol powered vehicles as petrol has a mixture of lead. It is recognised that the carbon or black smoke from diesel engines is not considered by medical experts as a dangerous pollutant as carbon itself is nontoxic. Its basic danger is that it can act as a medium of transmission for various toxins which invade the human body.

SRI LANKA TRANSPORTATION FORUM

Inaugural Session - June 20, 1983

THE NEED FOR A TRANSPORTATION POLICY

FOR SRI LANKA

by

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SRI LANKA.

Abstract

This paper is intended to convey a critical examination of the need for a Transportation Policy in Sri Lanka. It highlights the need for coordination of the different authorities, Ministries and Government Departments involved in Transportation. The findings of a Work-Shop on Transportation giving the approach to a policy and considerations of what a policy should contain as far as energy, urban space, economics, highway, safety etc. are indicated.

It may appear that today there is no transport policy. This may be felt by the fact that large number of personnel in three different ministries are involved in un-coordinated decision and policy making, on the aspects of surface transport. In addition to these Ministries, Highway construction and maintenance is looked after by a fourth Ministry. This would undoubtedly result in many difficulties in formulating a common policy and furthermore it could result in contradictory decisions detrimental to a well planned out transport policy. Of course the absence of such a policy would give free range to market forces of supply and demand which are expected to respond to the need of the community.

The underlying need for a transport policy is such as to decide on the allocation of resources in the bigger interest of the nation to ensure public safety, to prevent environmental damage and to curb unbridled competition. Policy should also be concerned on the appropriate use of scarce resources such as energy.

The transport policy will have to cover mainly the following needs namely :

- (a) the extent to which a citizen should be able to travel freely so as to induce a sense of satisfaction
- (b) the extent to which goods should be allowed to move cheaply so that industry and consumption may not always be so concentrated in cities.
- (c) the need for the workers to have convenient access to their work places.
- (d) the need to avoid congestion not only on urban roads but also on intercity and rural roads.

A lack of policy can lead to severe urban traffic congestion which will prevent anyone from achieving mobility irrespective of any money that one is prepared to spend.

Assuming that a policy has to be viewed, based on the need to conserve resources such as road space, urban space, generally all expensive infrastructure, energy, imported vehicles and their spare parts, the question then will arise as to how such a policy should be formulated and implemented. Usually policy is expressed and implemented through a combination of fiscal measures (taxes, parking fees, licence fees, and subsidies which may be hidden or negative subsidies) specific zones or highways, regulations on goods being carried by particular transport modes, and regulations concerning economic safety aspects. If for instance, as in New Zealand, a country feels that its railway infrastructure is there to be used and that using it, is of advantage to the overall economic, environmental safety and social well-being, then it may enforce that goods moving more than 150 km. must travel by railway unless a special permit is obtained to transport by other means. In a country like Sri Lanka where a large portion of all economic activities is operated by the State, then a mere directive by the State to its agencies such as Salt, Cement, State Plantations, Flour, Sugar, J.E.D.B. etc. to transport their products by rail, would have a similar effect. If it is desired to mitigate urban congestion then a savage increase in parking fees or fuel prices would undoubtedly solve the problem, but one would have to examine the other consequences of such measures.

Just as much as every citizen would like to claim to be knowledgeable on aspects of transport both private and public, transport policy should be a matter of concern to every citizen in the country as it affects every citizen. Transport besides other inconveniences has a direct effect on the cost of living. Although the transport problem envelopes a very wide range of activity affecting the day to day life of the people, the pity of it is that hardly any one realizes the effect on one another's action.

For instance, a motorist is only concern with the fuel cost of his immediate journey or sometimes ignores even that, if it is for a short journey or on a deviation when the fuel tank is full. Certainly he does not perceive the pollutive cost of exhaust gases, the cost of noise caused by his horn, the cost of risk to pedestrians or the cost of the delay to other motorists or citizens caused by his entering an already congested street. Even the factory which distributes its own lorry rarely preceives the full cost of depreciation which is clouded by inflation, or the cost to highway maintenance of his over loaded axles.

Finally a transport policy should consider a whole range of factors such as ownership of infrastructure and vehicles, the price to be charged for use of infrastructure who should pay for all the benefits to the urban social fabric brought about by improved public passenger transport, and whether the train or bus passenger should pay not only for his own seat but also for empty seats going even in the opposite direction, or on other vehicles; and above all, the integration of transport with urban and regional development.

In some of the findings of the workshop on Transport held at the Institution of Engineers, Sri Lanka in August 1981, it was felt that transport policy covers a wide field at Macro and Micro level of all modes of transport of goods and people. Aspects such as economic, social, engineering and institutional were considered and limitations imposed by scarcities such as energy, urban places, funds etc. were also considered.

Approach to the Policy

A dominant conclusion emerging was that there ought to be a strong firmly delineated and announced national policy on transport. It is only when such a frame work is widely known can all government agencies and others concerned with planning, construction, maintenance, regulations, enforcement, and management of operations can carry out their duties in a systematic manner, and can all private sector enterprises involved in Transport and ancillary activities can take forward steps confidently.

The need for a defined policy essentially divided the approach into two main aspects.

1. on what elements and on what details policy should contain;
2. on how policy should be formulated, adopted, monitored and reformulated as an on going process.

Considering what the policy should contain, the principle thrust of the findings were :

Energy : Energy is scarce and expensive and will become more so in the future. Hence, the policy should encourage where apt, direct preference for energy free modes such as walking, cycling, animal carts, wire chutes for energy-thrifty modes such as waterways, coastal shipping, railway, electric railway, tramways and trolley buses, mass transit passengers etc. In doing so there should be an examination of the objectives of transport and not merely the means of performing it.

Urban Space : Urban space is scarce and the pressure on it increases with development. Hence, policy should encourage restraint on the use of vehicles such as motor cars and small vans which are less in space use due to the quantity of people or goods moved. Such restraint should apply to movement, storage, and parking, whether on or off street. Complementary to restraint would be measures such as by-passes and cycle tracks, and priorities for public transport by way of with flow and contra-flow bus moving lanes. Certain streets such as Main Street should be reserved for buses and pedestrians only. These components of policy should integrate with appropriate land use planning which should preserve diversity of activities.

Economics : Economics constrain, transport policy options, firstly by scarcity of funds for capital work and for operation and maintenance, and secondly by the extent which costs both capital and recurrent, can be recovered from users and from other beneficiaries of transport infrastructure. So far as capital expenditure is concerned emphasis should be given to priorities of projects, and proper specification of strength, width and alignment etc., for both short term and long term so that subsequent up-grading would not cause undue cost and disruption. In considering economic context, it is also important for the role of the private sector to be clearly defined, so that both state and private undertakings could perform at good levels of efficiency.

Highways : The design, construction, maintenance and management has to embrace consideration of available space equity among highway users, appropriateness of construction technology safety and several other matters. Hence, coordinations at decision making level, management level and enforcement level is needed between highways department and/or authorities, Commissioner of Motor Traffic, local authorities, State Transport Board regulators and Associations of private mini-buses, UDA and the Police. Such coordination will also require systematic collection of data or processing of data. Highway Engineers should be free to design roads professionally on the basis of estimated future needs. Nevertheless, they should take into account social and engineering economics when deciding on land use.

Safety : Safety deserves higher attention than it has received in the past, at the levels of research, design, regulation and enforcement with Highway Accidents now causing a large amount of fatalities and corresponding figures for serious and minor injuries and for property and vehicle damage. There is need for systematic research, new approaches toward the prevention of accidents and mitigation of injury caused by such accidents which has continued to occur. The considerable incidence of pedestrian victims need careful study of whether pedestrian segregation or better training of vehicle drivers is the appropriate remedy.

General Observations : It was observed that transport was seen as a very complex activity within a country, with multiple stimuli as to how it works, and constant interaction between causes and results. This emphasises the need for a clear policy and also the difficulty in arriving at a satisfactory coherent set of policies. There are no panaceas or one line answers. It is important that the symptoms are not merely being cured but appropriate diagnosis and proper remedies should be applied. This, once again leads back to the pre-eminent need for a single function-wide Ministry of Authority capable of viewing all the future problems as well as the present and establishing paths

where such needs can be reconciled, priorities established and fulfilled to the extent that the country can afford to have them or afford to be without them. It is important that stream lining of Government policies on transport and providing of single transportation policy applicable to the movement of persons and goods, rather than scattered policies variously applied to different modes of transport. It is necessary to be aware of the actual technological advantages and disadvantages of each carrier type. It should be able to allocate traffic to the most efficient mode of carriage, not in general but by creating a legislative, regulatory and general public atmosphere that will encourage and permit the inherent advantages of each carrier type to be fully developed and utilized, and without artificial support in areas of technological disadvantages.

It would be necessary to make arbitrary allocation only where the public need for conservation of resources makes such allocations essential.

It would be beneficiary to grant subsidies where a carrier is required by public necessity to perform a service outside its areas of engineering utility. It would be useful to extend and support transportation research that will include all modes of carriage with particular emphasis on those carriers which are of proven technology, safety dependability, and efficiency in their field of usefulness.

The purpose of this Forum is to provoke discussion and find constructive solutions to these questions by those who have their own developed know-how in construction, maintenance and management of ways and vehicles, and by the several others who have their own special expertise in economics, regulation and operation of transport etc.

It would not be very difficult to diagnose the symptoms of the present day transport problems by not being critical on some of the ad-hoc decisions made, but prescribing the long term remedial measures which would be only possible by formulating a well defined policy after having considered the several aspects which should be the aspiration of all of us present here. I hope at this Forum the deliberations and discussions would lead to useful conclusions which could inspire the policy makers to formulate and develop a Transport Policy which would prove beneficial to the country.

A FRAMEWORK FOR A NATIONAL TRANSPORTATION
AND COMMUNICATIONS STRATEGY IN SRI LANKA

Paper Presented by MWJG Mendis at the FORUM on "Transportation in Sri Lanka", Organised by the Department of Civil Engineering, University of Moratuwa, June - 20 - 22 1983.

PURPOSE AND SCOPE OF PAPER.

The purpose of this Paper is to focus attention on the relevance of developing a strategy for a Communications Network designed to match a preferred National Development Plan. It's principal objective is therefore to determine the main features of such a strategy which would facilitate the achievement of the desired levels of economic growth. In this connection, the Paper will however confine its discussion only to the Transportation Network of the overall Communications system.

In the above mentioned context of this Paper, it will be appropriate to initially discuss the background to National Development Planning in Sri Lanka.

BACKGROUND TO NATIONAL DEVELOPMENT PLANNING IN SRI LANKA

It is now an accepted practice that national development be promoted on the basis of a "Plan". The form, content, and nature, of the latter have however varied between countries, and also within a country under different Governments. In Sri Lanka, the following "Plans" have been formulated in the post-independence period.

1948	: Short Term Development Plan
1954/55 to 1959/60	: Six Year Investment Programme
1959 to 1968	: Ten Year Plan
1961/62 to 1963/64	: Short Term Implementation Programme
1972-1976	: Five Year Plan
1979 to date	: Annual Rolling Plans.

As far back as 1952, the Government had requested the International Bank for Reconstruction and Development (IBRD) to formulate a framework for the organised development of the economy. It's Report titled "The Economic Development of Ceylon" rank as a pioneering contribution to development planning in this country. The subsequent efforts have resulted in a variety of experiences connected with different planning models. The consequences have nevertheless been the entrenchment of planning as a

vital instrument of national development. Accordingly, an elaborate and powerful Institutional System to undertake national planning has evolved over the last three decades. This System has become the focal point of all development efforts.

Presently, the Government has adopted the concept of a "Rolling Plan" to fashion national development based on an annual revision of a medium-term Public Investment Programme. The latter was first formulated for the period 1979-83 and subsequently for the periods 1980-84, 1981-85, 1982-86, and 1983-87. The main emphasis of this document is in respect of public investment for the given period; but it also includes indicative policies for promoting investment by the private sector.

The maturing national planning system has also inspired the preparation of a wide spectrum of sectoral plans and data profiles. It has, in addition, provided published Quarterly Progress Reports of the public sector development programme. Hence a Planner in Sri Lanka has an extensive volume of material to work with in the design and formulation of a National Development Plan.

Nevertheless, a significant gap in the national planning system is yet the lack of a fusion between the sectors of the economy in spatial terms. (1) Consequently, the locational dimension has not been incorporated in national development planning to rationally link places of concentrated development activity. In these circumstances, the National Development Plan lacks a spatial strategy. Hence the Communication Networks are being independently planned, based largely on assumptions of the distribution of activity centers. Accordingly, in this situation, it is opportune that a framework for fashioning a strategy for a National Transportation Network be formulated for the following reasons:

- i. to facilitate the development of a national hierarchy of settlements;
- ii. to provide a rationale for ranking the Communication Networks by level of service;
- iii. to facilitate the higher economic growth of the potentially developable areas;
- iv. to foster the formation of an appropriate pattern of marketing, storage, and distribution of goods;
- v. to effectively promote the co-ordinated use of different modes of Transport.

(1) The sectors of the economy for purposes of economic planning comprise "Agriculture, Forestry & Fisheries", "Industry", "Economic Overheads (roads, rail, ports, airports, harbours, and power)", and "Social Overheads (housing, health, education and social welfare)".

THE STRUCTURE & PATTERN OF THE NATIONAL TRANSPORTATION NETWORK

The pattern of the existing road and rail network in Sri Lanka clearly indicate the relatively widespread accessibility to the different parts of the country. It appears that the rationale of this Transportation Network has been to link the District Capitals which were centers of Administration. Hence it can be implied that the Transportation Network has been provided for the improved efficiency of administration. Thus all twenty four District Capitals are accessible by roads, and 19 of them are also accessible by rail. (vide Map I). The polarisation of such a Transportation Network can be reasonably well identified as being on Colombo, more than on other centers; again suggesting the dominance of the importance of accessibility for Administration, over accessibility for most other considerations. It can be noted that the routes selected for linking the District Capitals has nevertheless enabled the siting of economic and other business activity in the areas traversed by the Transportation Network.

By hierarchy, there are five classes of roads in Sri Lanka. They can however be distinguished as Trunk Roads and Non-Trunk Roads. The total length of the former being 3754 Kilometers of the total roads length of 26,000 kilometers.

All District Capitals are accessible by Trunk Roads which further reinforces the notion that their Planning would have been influenced heavily by Administrative considerations in development activity.

However it is significant to note that in the past five years many new road and rail proposals have emerged out of considerations to provide infra-structure support for economic activity. Some of these road proposals have even been constructed. Their inclusion in the hierarchical structure of the National Transport Network is however yet unclear; although by actual size and level of service they are more superior to some of the existing Trunk Roads.

What is relevant to note is that the additions to the Transport Network in the past five years far exceeds the additions made over a much longer period previously. Furthermore as stated earlier, the new wave of proposals for the Transport Networks have arisen not from the need to link administrative capitals, but to provide accessibility to areas of development activity. Hence, there appears to be a shift in the conceptualisation of the rationale for providing accessibility. The latter is

and for the new Administrative Capital of Sri Jayawardenepura, Kotte, Furthermore, proposals have also been contained in several Urban Development Plans prepared for the Government by UNDP Consultants. These have included transportation network proposals for the Colombo Metropolitan Region, Galle, Ratnapura, Hambantota, and Jaffna. (Vide Maps 5 and 6 for the Colombo Region and Galle respectively).

In addition two Projects undertaken for the major urban centers of Matara and Kurunegala by the Post-Graduate students of the Department of Town and Country Planning of the University of Moratuwa, have also submitted proposals for new major transportation networks in those towns to link with the national network.

In the above context what is most significant to note is that major transportation network proposals are now being made as an integral part of wholistic "Development Plans and not merely to link administrative centers. Thus, more proposals for transportation networks have emerged in the past six years than for the entire previous period upto 1952. The latter being due to the increased development activity being promoted on the basis of "Development Plans".

In these circumstances, it will therefore be relevant to focus attention on the formulation of a National Transportation Strategy to match a corresponding National Spatial Strategy. The absence of both will deny an effective overview of the current transportation network proposals now being separately submitted in different Development Plans.

A FRAMEWORK FOR A NATIONAL TRANSPORTATION STRATEGY

As indicated in the preceding section, there are proposals for the development of major road networks at the National level (IBRD : 1952), Regional level (Mahaweli Proposals : 1979, and Colombo Metropolitan Regional Plan : 1978), and Urban level (UNDP Consultants and Others : 1978-1982). The on-going situation thus clearly reflect the need to synthesize the strategic considerations of these several proposals, in order to construct a framework within which a national transportation network can develop. The latter can then be a common system to facilitate Project plans and also to determine the rank and level of service of the different components of the network.

This section will attempt to suggest a set of Planning principles which can constitute a framework for the eventual formulation of a National

Transportation Strategy.

In this connection, a key feature to recognise is that a strategic transportation network must link all major centers of development activity. In such a context, it must be noted that some centers offer greater potential to develop than others. Hence the transportation network must facilitate their growth, and also especially link those several 'growth centers', with a level of service that is much higher than elsewhere in the network.

It is in the above connection that Transportation Planners must utilize a National Spatial Strategy to guide their own work. The latter synthesizes the development potentials and constraints within a hierarchical structure of settlements. Accordingly, it comprises the 'canvas' which provides the Origins, Destinations, and Route choices for the transportation network planners.

Presently, there is no Officially designated National Spatial Strategy. However, there have been independent work carried out to design such a strategy. The Author, in 1972, conceived a bi-polar spatial strategy based on a Colombo-Trincomalee development axis (Vide Map 7). A decade later, this concept has been refined to define the actual width of the axis and to ascertain any other prominent features. This attempt has resulted in the identification of a 50 mile wide corridor between Chilaw-Kuchchaveli and Bentota-Kattankudy, and also the need to develop two separate urban configurations around Galle and Jaffna respectively. (Vide Map 8).

The above spatial strategy suggests the relevance of a high quality rapid transportation network linking Colombo and Trincomalee, and also between the development corridor and Galle and Jaffna. Such a higher - order transportation network must then be the principal arterial system to provide access to other centers of development activity.

Alternative forms of National Spatial Strategies have also been designed by the UNDP - Colombo Master Plan Project (Vide Map 9).

The national transportation network linkages to urban development areas must be made utilising appropriate concepts which blend with those used in structuring 'Development Plans for such areas. ⁽³⁾

(3) Recently, the Urban Development Authority commissioned a study to develop the Galle Road corridor in and around Colombo. This study had integrated town planning and transportation concepts quite effectively.

Against a background of the planning principles discussed so far, it is necessary that the several on-going proposals for the transportation networks be integrated into a single strategic network. Such integration is most timely and opportune.

The national transportation network (including all modes of transport), like other utilities can never be independently planned purely to satisfy administrative conveniences or an assumed pattern of development. It must be synthesized with a coherently designed National Spatial Strategy which has inherently integrated all considerations of development.

CONCLUSIONS & RECOMMENDATIONS

The main conclusions arising from the Paper are as follows:

1. The basic pattern of the national transportation network which prevailed at the time Sri Lanka gained independence, negated the need for formulating new proposals, except for filling gaps in the existing network.
2. Accessibility to District Administration Capitals appear to have dominated the pattern of the trunk road network; although subsequent development programmes began to add new major roads to this network to meet their own objectives.
3. Proposals for transportation networks are being made at a rapidly increasing pace with the formulation of "Integrated Development Plans" for urban and regional areas. These proposals are conditioned by development criteria rather than administrative parameters. Further, they have been designed to blend with the town planning concepts incorporated in the Development Plans.
4. The formulation of separate proposals for the transportation networks in various Plans and Projects in the different parts of the country suggests that it is timely and opportune to synthesize them within an integrated strategy for the national transportation network.
5. The formulation of a Strategy for the National Transportation Network presently lacks the basis of a National Spatial Strategy to unify transportation with other development sectors.

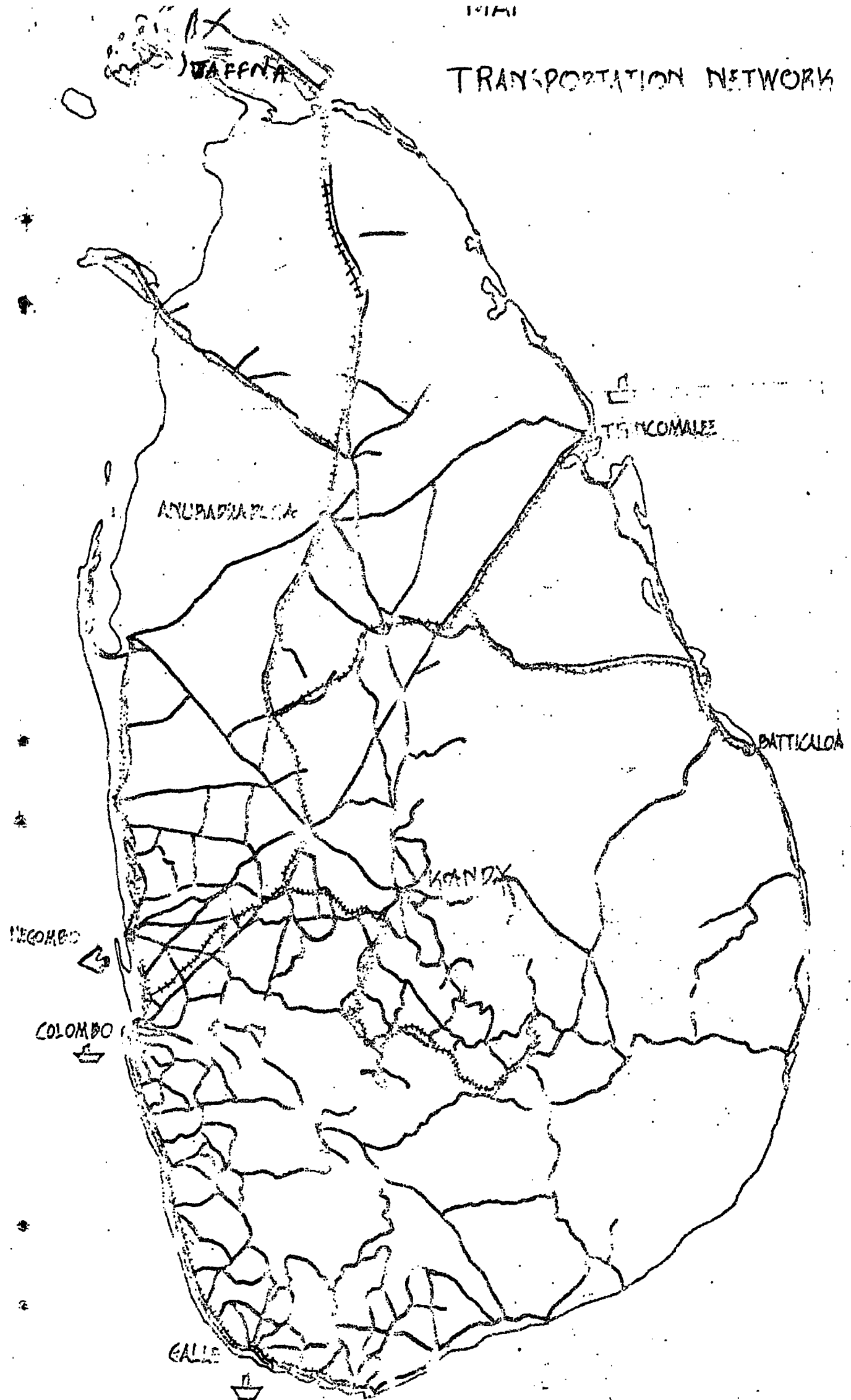
The principal recommendations are as follows:

1. It is recommended that a National Transportation Strategy be formulated for the country.
2. It is further recommended that such a Strategy be matched with a chosen National Spatial Strategy. In the latter connection, the adoption of a Colombo-Trincomalee development axis with the associated urban configurations around Galle and Jaffna should be considered as a preferred choice of a National Spatial Strategy.
3. It is also recommended that the hierarchy of the levels of service of the transportation networks should match the hierarchy of settlement structures being linked by them, within the framework of a National Spatial Strategy.
4. Further the proposals formulated for the transportation networks at the regional and urban levels should be integrated with the national network. The former must nevertheless be conceived within chosen "Development Plans" for such areas.
5. It is recommended that each Development Plan for any area which contain elements of a major transportation network, be statutorily incorporated in the national network.
6. It is recommended that continuous monitoring and on-going research be undertaken to maintain the most suitable National Transportation Strategy for the country.

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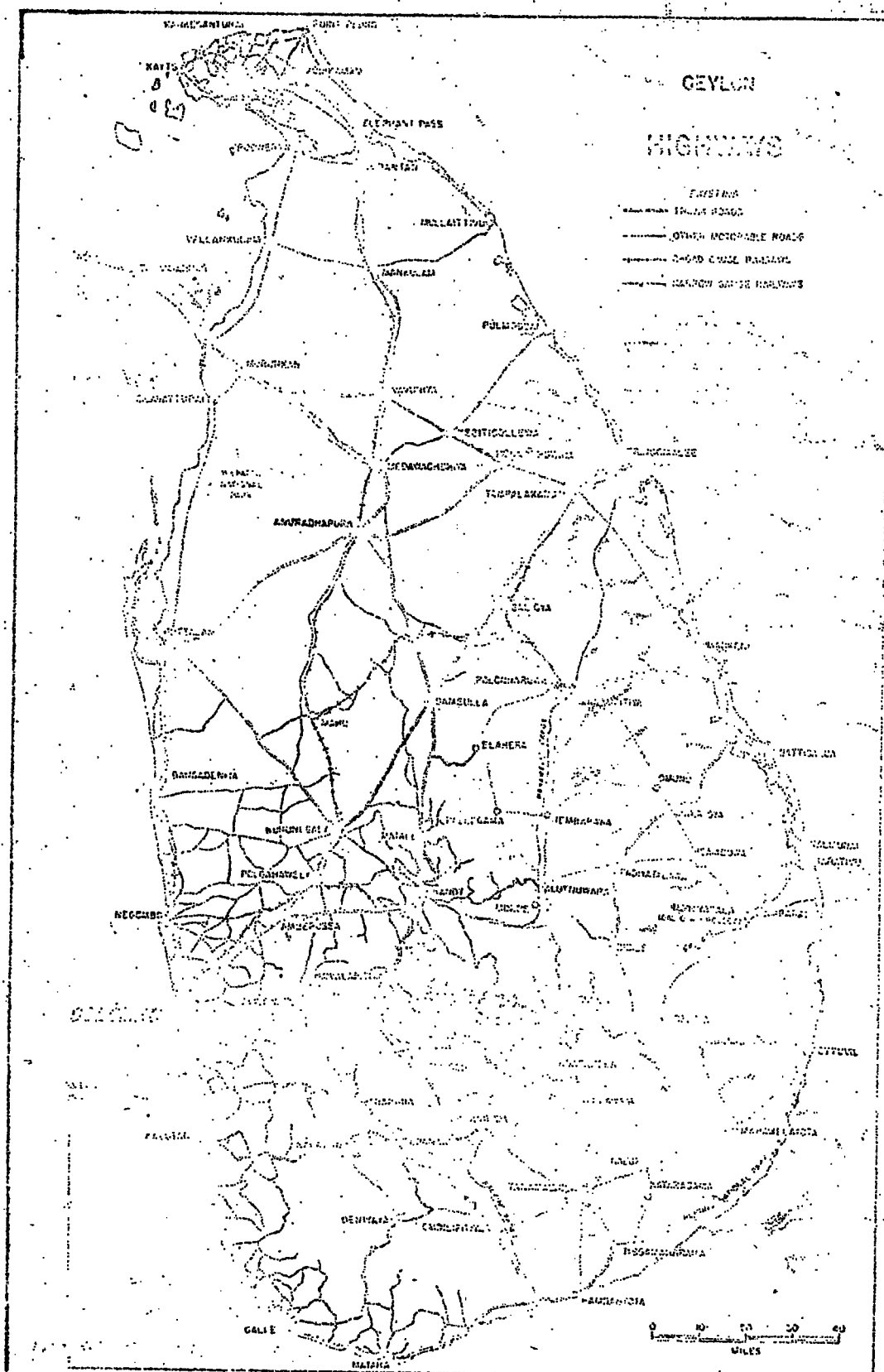
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TRANSPORTATION NETWORK



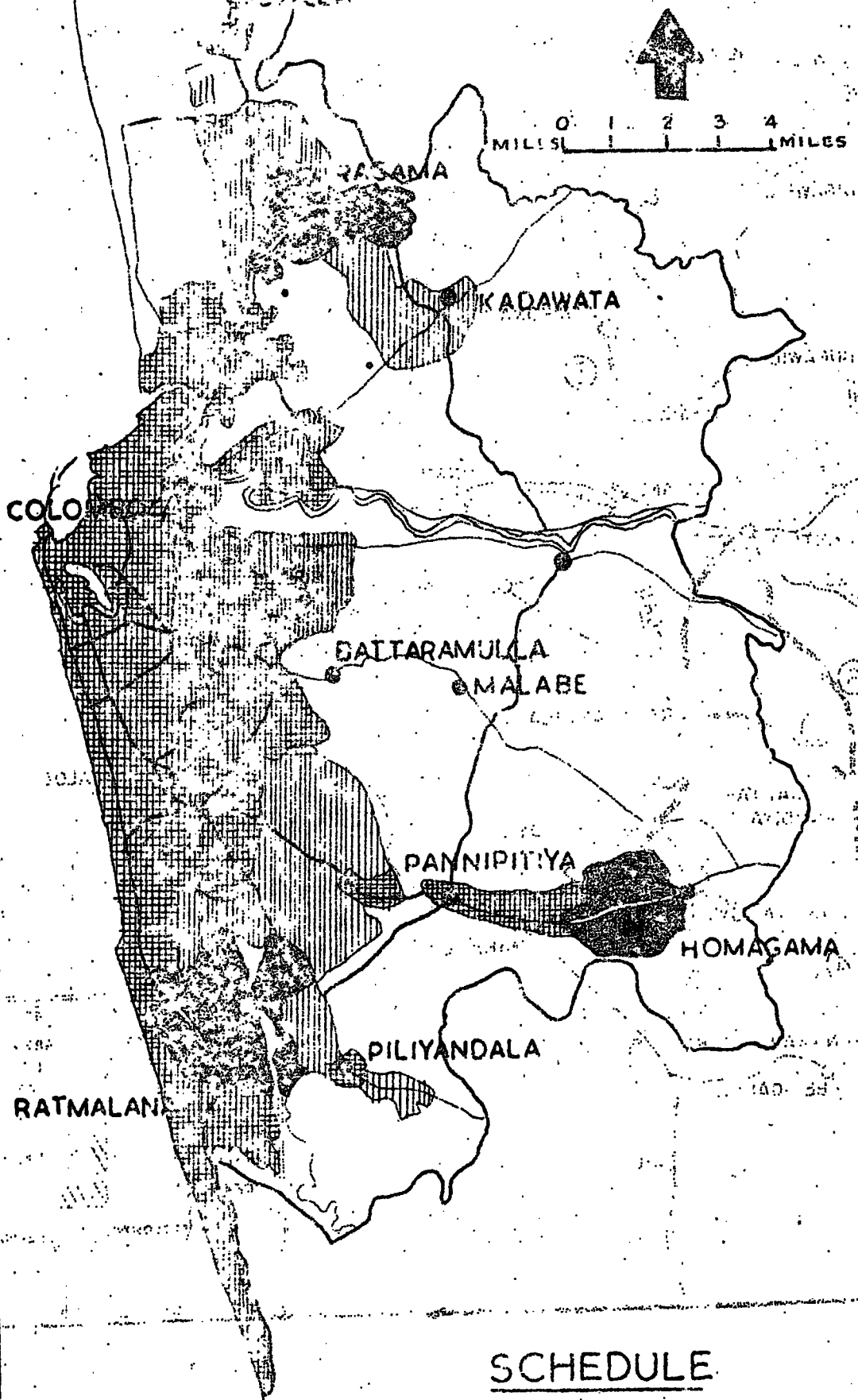
Herzogs

INLET ROAD
OTHER NOTICABLE ROAD
ROAD CASE PLANT
ROAD CASE PLANT



COLOMBO REGIONAL PLAN

ABERCROMBIE PROPOSALS



SCHEDULE

BOUNDARY OF REGION	RURAL ZONE
HOUSING ESTATES	EXISTING ROADS INCORPORATED IN REGIONAL ROAD SYSTEM
EXPANDED TOWN	EXISTING ROADS WIDENED AND INCORPORATED IN REGIONAL ROAD SYSTEM
SATELLITE TOWN ZONE	PROPOSED NEW ROADS
URBAN ZONE	
SEMI URBAN ZONE	



LOCATION OF PROJECT ROADS

MAHAWELI PROJECT



LEGEND

- EXISTING TRUNK ROADS
- ① PROJECT ROADS
- - - ROAD NETWORK TO BE DEVELOPED AT LATER STAGE
- RAILWAY

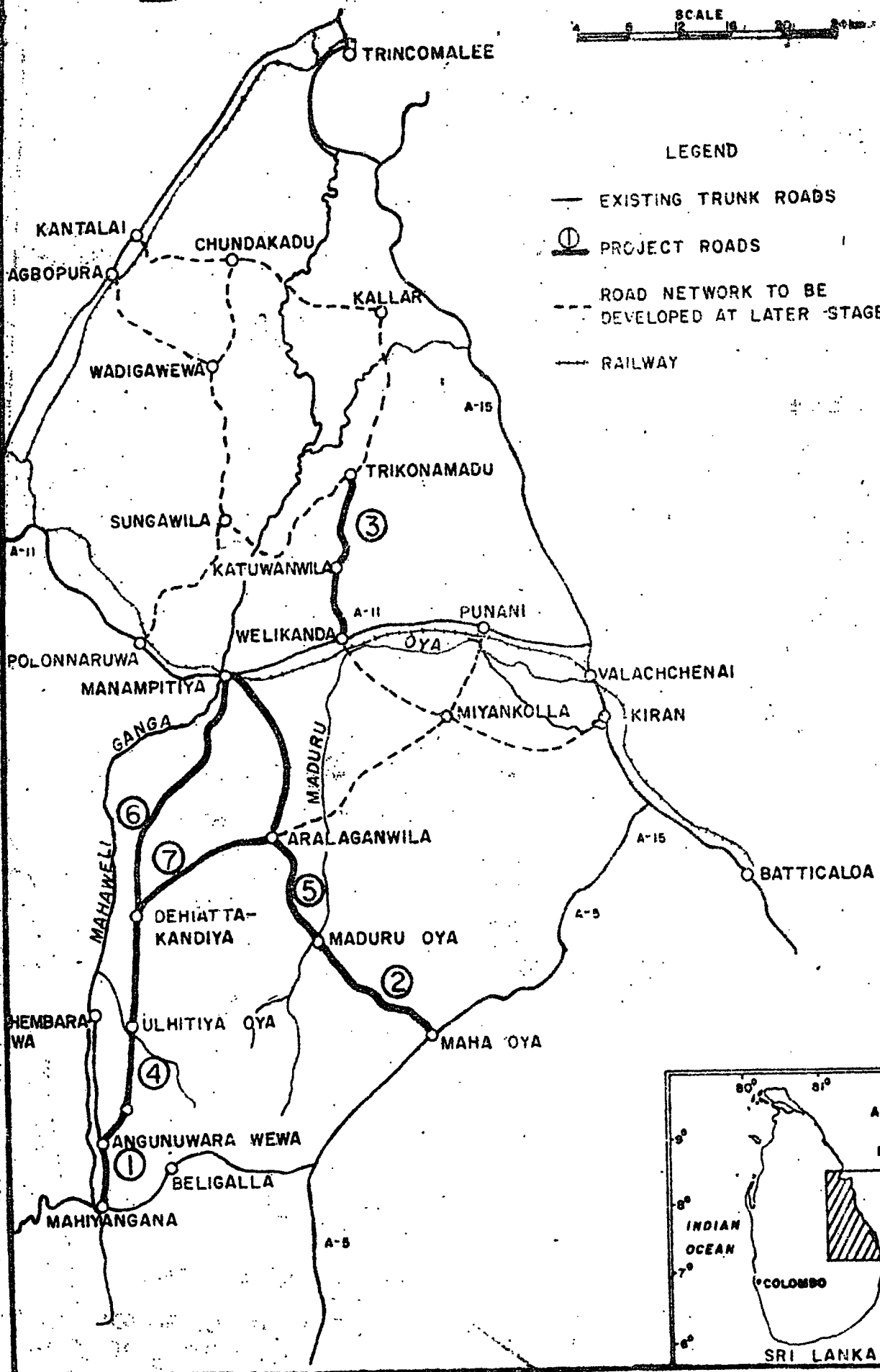
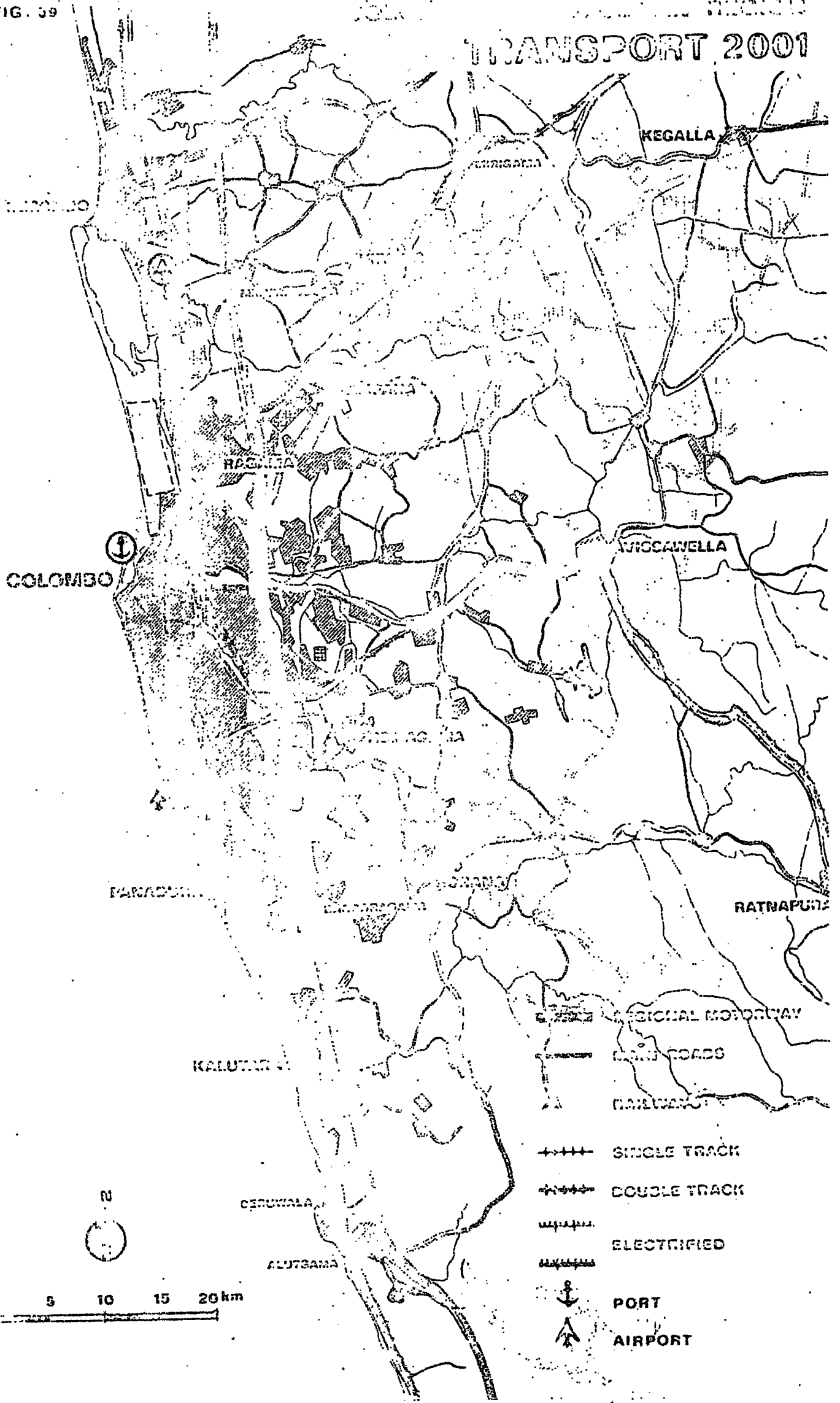


FIG. 39

TRANSPORT 2001



TRANSPORTATION

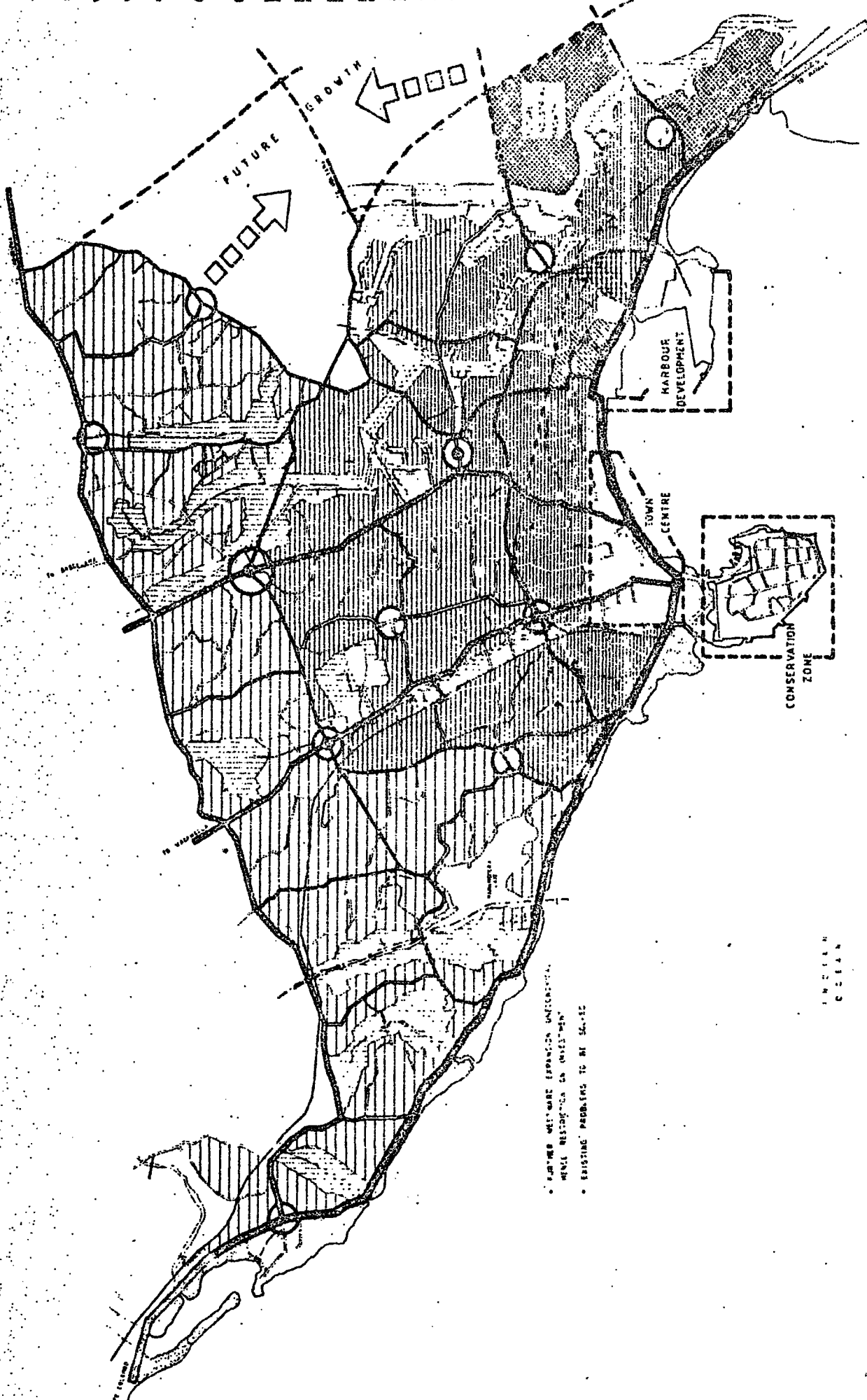
- HIGHWAY
- TRUNK ROADS
- MAJOR ROADS
- SERVICE ROADS

- TRAFFIC MANAGEMENT POINTS

LANDUSE

- HIGH DENSITY RESIDENTIAL
- MEDIUM DENSITY RESIDENTIAL
- LOW DENSITY RESIDENTIAL
- OFFICE SPACES
- INDUSTRIAL
- WAREHOUSING
- WHOLESALE COMMERCIAL
- COAST CONSERVATION
- RECREATION
- COMMERCIAL CENTRE
- COMMERCIAL SUB CENTRE

DATE: 08/05/74	SR. LARSA
GALLE H.C.	
PRELIMINARY DEVELOPMENT PLAN	
	
1:10,000	REV. 3/1977/241



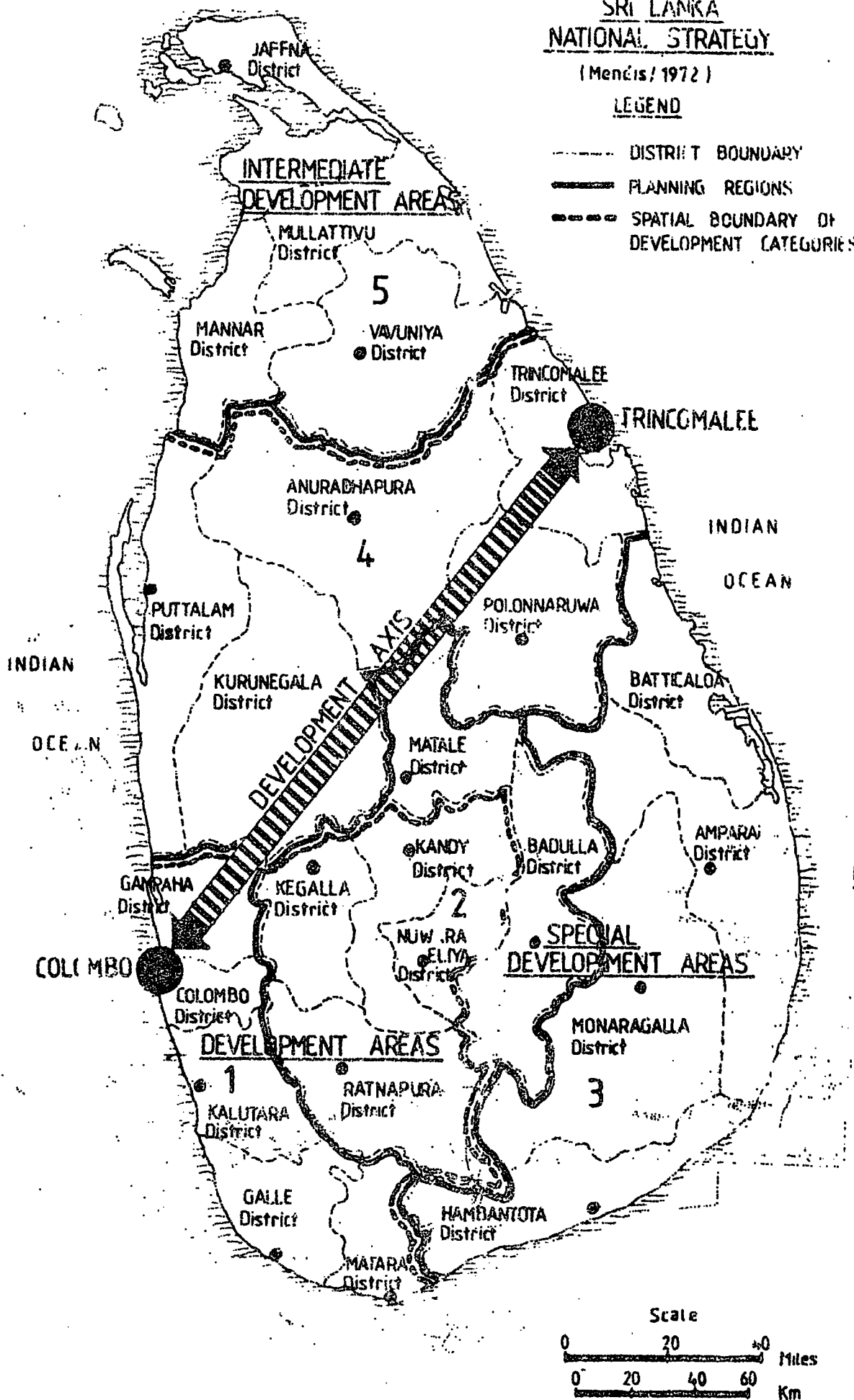
- FUTURE DEVELOPMENT (SPONSOR UNDEVELOPED)
- EXISTING PROBLEMS TO BE SOLVED

INDIAN OCEAN

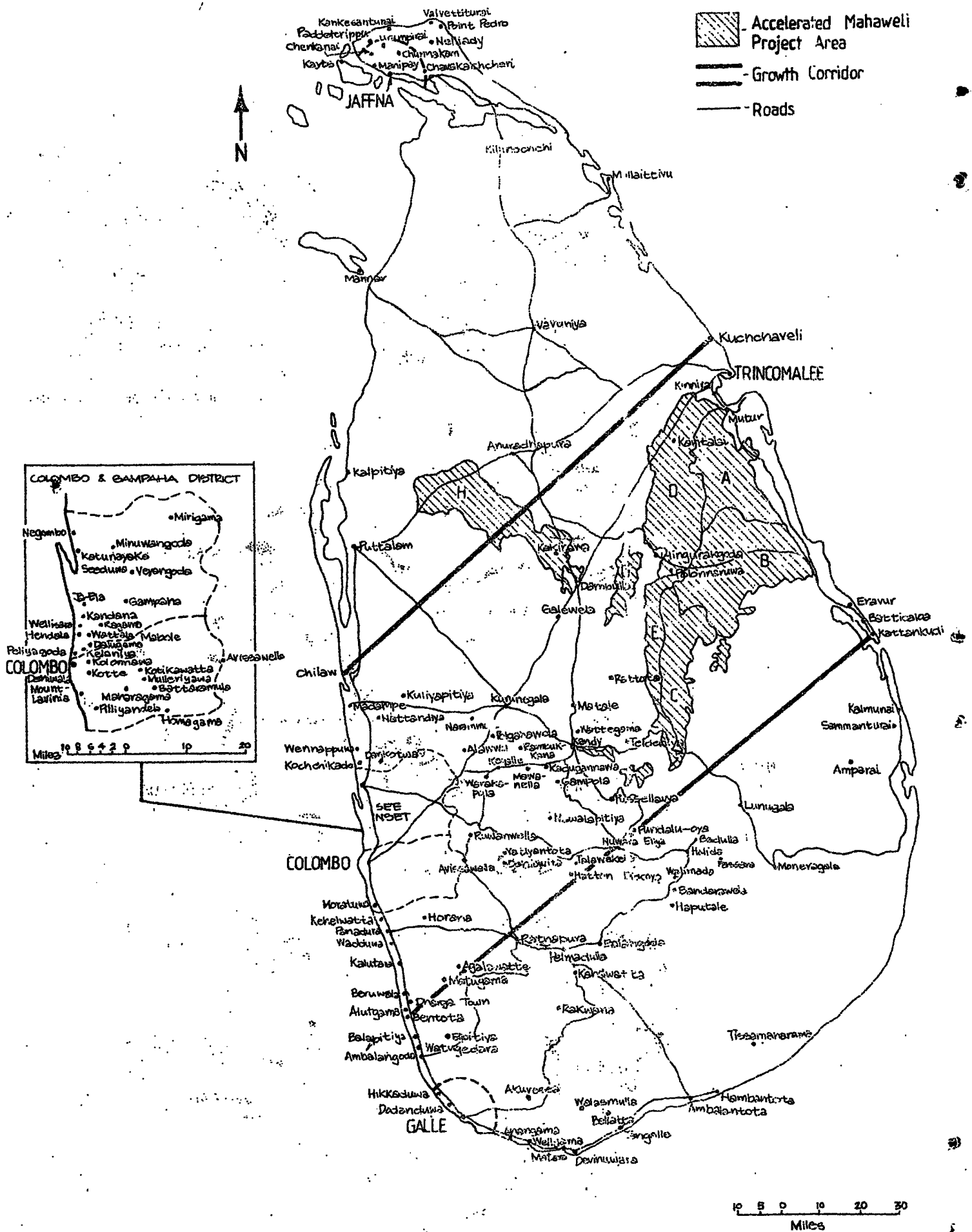
**SRI LANKA
NATIONAL STRATEGY**
(Mendis/1972)

LEGEND

- DISTRICT BOUNDARY
- ===== PLANNING REGIONS
- SPATIAL BOUNDARY OF DEVELOPMENT CATEGORIES

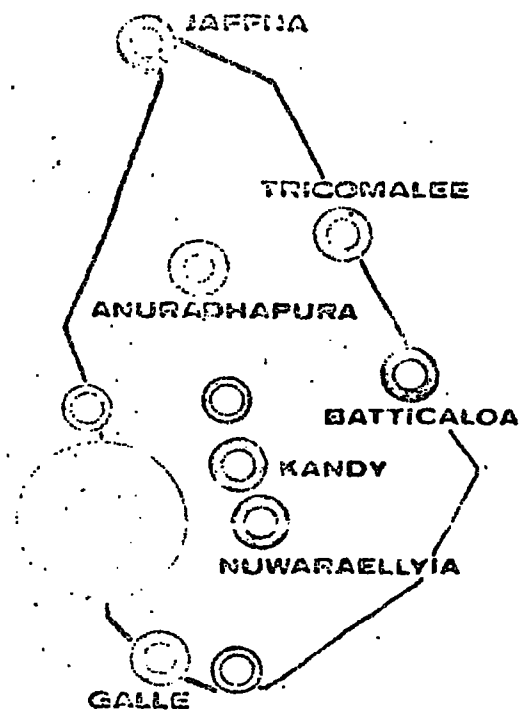


LEGEND

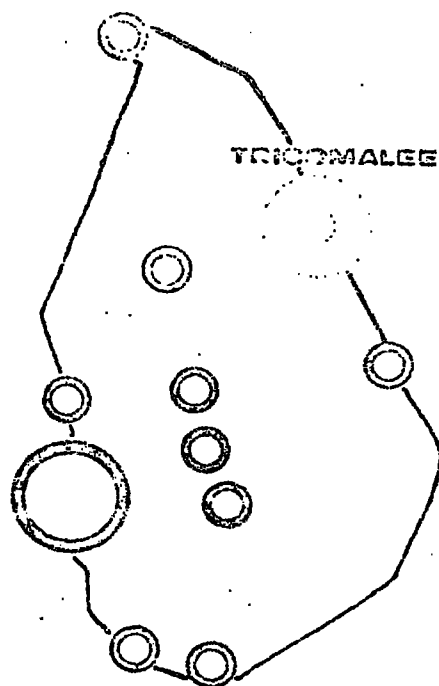


NATIONAL STRATEGIC

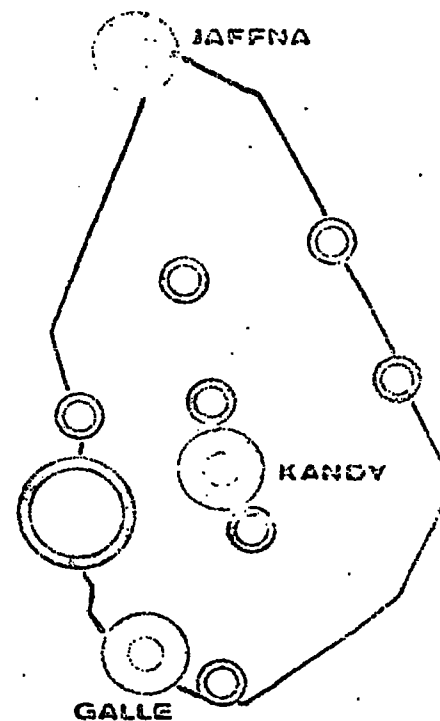
A - CONCENTRATION



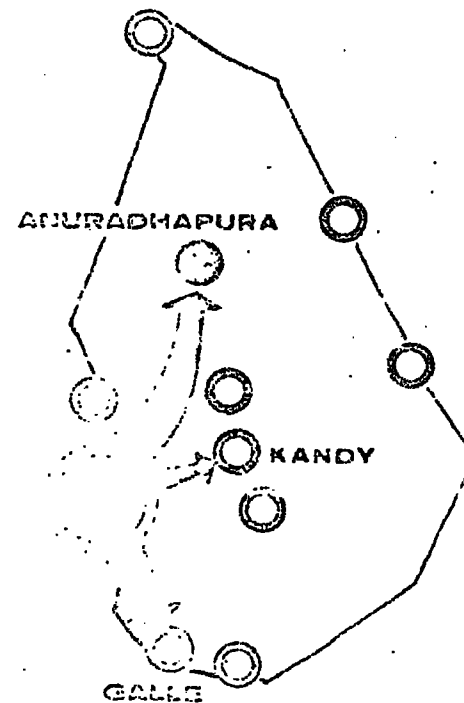
B - COUNTER MAGNET



C - REGIONAL CENTRES



D - GROWTH CORRIDORS



⊙ EXISTING TOWNS

⊙ PROPOSED GROWTH

THE NEW TRRL ROAD INVESTMENT MODEL:

RTIM2

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ABSTRACT

A computer model is described which is designed to aid investment decisions within the roads sector in developing countries.

The model calculates the construction cost of a road and predicts the condition of the road as time passes and vehicles travel over it. Having predicted the condition of the road, the model estimates the costs of road maintenance and the cost of operation of the vehicles for each year. All these costs are then discounted back to the base year and summed over the life of the road to obtain the total cost. All estimates are made in terms of physical quantities and costs are obtained by applying unit rates to these quantities.

The results of a study in Kenya were used to calibrate a prototype version of the model. This prototype was tested extensively for the appraisal of road projects in developing countries. As a result of this experience, the model has now been reprogrammed to make it easier to use and to fit onto smaller computers. The opportunity has also been taken to include in the model the results of the latest research in developing countries in this field carried out by TRRL.

The relationships built into the model allow it to be used to study the interrelationships between road design and construction standard, road maintenance policy, vehicle characteristics, traffic flow and growth rates, environment, and road deterioration. The model can be used to study various aspects of a road investment project such as the optimum maintenance standards for the road, the effects of providing an earth, gravel or bituminous pavement, or the differing benefits that can be obtained by adopting various stage construction options. The model will also allow the planner to study the consequences of uncertainties in traffic forecasts or in the discount rate.

An example of the use of the model is given in a case study.

INTRODUCTION

This paper describes a computer model which is designed to aid investment decisions within the roads sector in developing countries. The model will be of assistance to senior administrators, engineers and planners, and those responsible for developing improved techniques for road investment appraisal.

When planning investment in infrastructure it is necessary to evaluate all the costs associated with the provision of the new facility. These costs include not only the first cost of the facility and its cost of operation, but also the cost of maintaining the facility throughout its 'life'. This approach to investment evaluation is especially relevant for road projects.

The costs of building and maintaining roads are usually borne by the community as a whole, finance normally being provided from national and local taxation or duties. However the costs of operation of roads are borne by the road users themselves in the form of vehicle operating costs, the cost of time spent in travelling, and part of the cost of road accidents.

In developing countries traffic volumes are generally much lower than those in industrial countries. Incomes, and the value attached to travel time are also generally much lower. In consequence the costs of travel time and road accidents on any particular road in a developing country are usually small in relation to the vehicle operating costs, and thus they are not very significant in the evaluation of a road investment.

When planning a road investment the objective is normally to minimise the total cost to the community. In developing countries this generally means minimising the sum of the construction, the maintenance, and the vehicle operating costs.

These costs are not independent of one another. The vehicle operating cost depends on the number and type of vehicles using the road, the type of journey that they make, the geometry of the road alignment, and the condition of the road surface. For instance, if the alignment has many steep gradients, fuel consumption will obviously be higher than for a flat road. Similarly, if the road surface is very rough, vehicle components such as tyres and mechanical parts will wear out quickly, resulting in a high operating cost.

The geometry of the road alignment directly affects the cost of construction. In hilly terrain, the cost of building wide roads with flat gradients is high. Construction costs can be reduced by building a narrower road with steeper gradients, but this will be at the expense of a higher cost of operating vehicles. Likewise the cost of operating vehicles on smooth bituminous roads is less than the cost on rougher gravel surfaced roads, but roads paved with bitumen are obviously more expensive to construct than those surfaced with gravel. Hence it is clear that there is a trade-off between road construction costs and vehicle operating costs.

The condition of the road surface, besides being affected by the construction standard, is also affected by the traffic loading, the standards (and hence the costs) of maintenance, and the environment. The more vehicles that use the road and the heavier their axle loads, the more quickly will the road wear out. The road will also wear out more quickly if it is subject to heavy rainfall which weakens the structure of the road or causes erosion. However, the rate of deterioration of the road's structure and its surface condition can be slowed down by effective and timely maintenance at intervals throughout the road's life. Thus environment, traffic, and maintenance all affect the surface condition of the road and,

therefore, all have an effect on the cost and changes in cost of operating vehicles in the road (Figure 1).

In order to achieve the objective of minimising the cost of constructing and maintaining a road, and operating vehicles on it, it is necessary to know how these costs are affected by the interrelationships that have been described. A computer program has been written which makes use of these relationships to determine construction, maintenance, and vehicle operating costs over the service life of individual road links.

THE PROTOTYPE TRRL MODEL

Development of the model

The first move towards producing a model of this type was made in 1968 by the World Bank when draft terms of reference for a 'Highway design study' were produced for internal consideration within the Bank. Shortly after this, the Transport and Road Research Laboratory were approached and invited to participate in the proposed study in partnership with the Bank. From this point on, close liaison was maintained between the two organisations and the next step was taken when the World Bank commissioned a group at the Massachusetts Institute of Technology to carry out a literature survey and to construct a model based on information already available. The 'Highway Cost Model' produced by MIT^{1,2} was a considerable advance over any other methods existing at that time for examining the interactions between road costs, maintenance costs, and vehicle operating costs. However the model highlighted areas where more research was needed to replace relationships which were inappropriate to developing country environments, and to provide additional relationships.

Accordingly the Overseas Unit of the Transport and Road Research Laboratory, with the collaboration of the World Bank, undertook a major field study in Kenya to investigate the deterioration of paved and unpaved roads and factors affecting vehicle operating costs in a developing country. The performance of more than 90 one-kilometre long test sections of road was monitored at regular intervals over a period of two years. The condition of paved roads was quantified in terms of surface roughness, depth of ruts, amount of cracking, deflection, CBR and moisture content of the various pavement layers. Pavement deterioration was related to the number of passes of an 8.2 tonne 'standard' axle load and to the strength of the pavement. For unpaved roads, deterioration was related to the gravel type and the number of vehicle passes and was measured in terms of surface roughness, depth of ruts, depth of loose surface material and the depth of the gravel surfacing layer itself. An experimental study was carried out to measure vehicle speeds and fuel consumptions over the same test sections. In addition, data were collected from many commercial vehicle operators on such items as the lubricating oil consumption of vehicles, the maintenance requirements of vehicles, tyre wear, and vehicle depreciation. Relationships were then developed relating these directly to the physical operating conditions.

The results of this study^{3,4} were used to calibrate a prototype computer model (RTIM)⁵ for evaluating the costs of construction, maintenance and vehicle operation for a road investment project in a developing country. An outline flow-diagram of the model is shown in Figure 2. The model calculates the construction cost of a road and predicts the condition of the road as time passes and vehicles travel over it. Having predicted the condition of the road, the model estimates the costs of road maintenance and the cost of operation of the vehicles for each year. All these costs

are then discounted back to the base year and summed over the life of the road to obtain the total cost. All estimates are made in terms of physical quantities and costs are obtained by applying unit rates to these quantities.

Experience of use

The prototype version of the model was tested extensively by the Laboratory, and has been used by the World Bank, government departments, consultants, and other organisations. Although the model was relatively complex, it was nonetheless easy to use when reasonably efficient computer facilities were available and its application and data requirements were well within the capabilities of potential users. The model represented a significant advance in road planning methodology and has been used in many different developing countries.

In 1976 the World Bank instigated further developments of the computer model when they awarded a research contract to the Massachusetts Institute of Technology (MIT) to produce an extended version of the model capable of carrying out economic analysis directly, analysing a road link separated into several homogeneous sections, carrying out automatic sensitivity analyses of key variables such as discount rate and traffic growth, and requiring less detailed construction and maintenance input data than the prototype version of the model. This work resulted in the production of the 'Highway Design and Maintenance Standards model' (HDM)⁶.

However, experience gained by TRRL in the use of the prototype RTIM suggested that, rather than producing a more complex model, there was also a need for a different approach⁷. It was found that in many developing countries adequate computer facilities were either not available at all, or were not large enough to run a program of the size of the prototype RTIM (or HDM). When large enough computers were available, difficulties

were often experienced in gaining access to them. Consequently UK consultants using the model generally preferred to run the program in Britain using data sent from overseas by telex. Also, potential users in developing countries were often reluctant to use the model because of lack of familiarity with computer methods in general and, when personnel had been trained in the use of the model, staff turnovers often led to the subsequent loss of that expertise.

Some of these difficulties have been overcome by publishing the relationships which are built into the model as a book of tables⁸. This enables users in developing countries who do not have access to computers to utilise the relationships in the model in a manual mode. In addition, as a result of experience gained in the use of the prototype in developing countries, the TRRL road investment model has now been reprogrammed to make it easier to use and to fit onto a smaller computer. An ultimate objective is to provide a version of the model for developing countries that will run on a desk-top computer.

In reprogramming the model the opportunity was also taken to incorporate the results of the latest research into vehicle operating costs carried out by TRRL in the Caribbean. Resulting from this study new relationships have been developed for predicting vehicle speed and fuel consumption, spare parts consumption, maintenance labour, tyre wear and vehicle depreciation.

As further results become available from other studies, these will also be incorporated into the model.

THE NEW MODEL

General

A detailed flow diagram of the model is shown in Figure 3. Operation of the model starts by defining the road alignment. Construction details are then input and the cost of construction determined. Alternatively the construction cost is specified directly. For each year that the road is open to traffic, road deterioration, road user costs and road maintenance costs are predicted. Road deterioration is calculated as a function of the construction specification, the maintenance policy, the rainfall and the traffic. A vehicle performance submodel uses details of the road geometry and the road surface condition to predict the vehicles' speeds and fuel consumptions. Costs of fuel, oil, tyres, vehicle maintenance, depreciation, etc, are then determined to give the total vehicle operating costs for the year. An option is available to calculate time costs and these are based on the values of time which must be input to the model. Road maintenance requirements are found from the condition of the road surface in conjunction with the maintenance policy, and these are used to find the maintenance cost. The model then continues with its year-by-year analysis. The process continues for the selected analysis period and, at the end, the total construction costs, road maintenance costs and road user costs will be known. These costs can then be discounted at different discount rates.

An analysis period of up to 50 years can be considered and this may include up to six years for the initial construction to take place.

Traffic

The model can consider separately up to seven types of vehicle defined in four classes: passenger cars, light commercial vehicles, buses and heavy

commercial vehicles. Input is required on vehicle price and tyre price for all classes and vehicle load and equivalence factors for the heavy vehicles. The loads and equivalence factors can be different for vehicles moving in opposite directions.

Traffic growth forecasts must be made for each vehicle type and these forecasts can be specified in a variety of ways to allow any type of growth function to be simulated. The model uses relationships for vehicle speeds which were developed under 'free-flow' conditions and hence it cannot predict the speed reductions caused by traffic congestion.

Road design

The geometry of the road is defined by its horizontal and vertical alignments and its cross-section.

The horizontal alignment is specified in terms of the average degree of curvature per kilometre; this is used only in the prediction of vehicle speed. The vertical alignment is specified in terms of the rise and fall and is used in the prediction of vehicle speed and fuel consumption and also in the prediction of the loss of material from gravel roads. The road cross-section is defined in terms of carriageway and shoulder width and this affects vehicle speed, rate of road deterioration and road maintenance costs.

If the model is used to determine construction costs, then more detailed information about the vertical alignment and the cross-section must be input.

Construction cost

On many occasions that the model is used, the construction cost will already be known or an existing road will be under examination. However, the model can be used to estimate the earthworks, site clearance and

pavement costs for roads at the feasibility study stage of design.

Road deterioration

Roads will deteriorate at different rates depending on whether they are earth, gravel or paved. The deterioration relationships used in the model were developed during the Kenya study⁴.

Earth and gravel road deterioration is defined in terms of roughness, rutting and looseness of the surface material, which are all functions of the traffic volume and the type of surface material. Additionally, for gravel roads, deterioration is also expressed in terms of gravel loss, which is a function of traffic volume, rainfall and the gradient of the road. Four different types of gravel surface are considered by the model.

Paved road deterioration is defined as a function of roughness and cracking. These are functions of the pavement strengths (modified structural number) and the cumulative axle loading expressed in terms of equivalent standard axles.

The model predicts deterioration of the road surface in each year that the road is trafficked.

Road user costs

Road user costs are determined for each year that the road is open to traffic and consist of time costs and vehicle operating costs. Vehicle costs are determined from relationships developed in Kenya³ and the Caribbean^{9,10}. Time costs are found from the product of the value of passengers' time, which may be input to the model, and journey time which is found from the road length and the average vehicle speeds.

Vehicle speed is calculated separately for each type of vehicle and for each direction of travel. Speeds are used in conjunction with details of the road geometry and surface characteristics and details of the vehicle to predict fuel consumptions. Fuel costs are found from this and the prices of petrol and diesel oil. The consumption of lubricating oil is built into the model for different types of vehicle running on paved and unpaved roads. The cost per journey is found from this and the unit cost of the oil. The cost of replacement parts for a journey over the road is related to the new vehicle price, the distance travelled by the vehicle since new and the roughness of the road surface. Tyre costs are related to the roughness of the road and, for heavy vehicles only, to the gross vehicle weight. Depreciation of vehicles has been related to the vehicle's age in years. An initial age spectrum of vehicles may be input and this may be modified, if required, each year by vehicle growth and wastage. In addition, the model calculates crew costs and standing costs, all of which are related to journeys over the road being studied.

To calculate these costs, the model requires input on fuel and lubricant prices, tyre costs, new vehicle prices, crew hourly rates, and the value of passengers' time.

Road maintenance costs

Maintenance of paved roads is assumed to consist of patching, surface dressing and overlaying. For unpaved roads, maintenance is assumed to consist of grading, and regravelling of gravel roads. The model computes the cost of carrying out the maintenance that has been specified by the user. A cost of maintenance overheads which should include shoulder maintenance and ditch clearing may also be included if required.

Stage construction

As part of the maintenance routines it is possible to study the effects of planned improvements to the standard of the surface of the road. Earth roads can be gravelled, gravel roads paved and paved roads overlaid. Any number of additional layers can be added but the alignment and width of the road will remain unchanged. After an upgrading, the maintenance policy may also change.

Stage construction which involves changing the geometry of the road can only be studied by making separate runs of the model.

Costing

All calculations within the model are carried out on a quantity or non-dimensional basis and input unit rates are used to determine costs. Thus the model can be used with any system of costs or prices and its relationships do not become outdated because of the effects of inflation or changing relativities in commodity prices.

Prices should be expressed in either market or economic terms depending on the type of analysis being carried out.

An important aspect of the cost of building roads in developing countries is the foreign exchange requirement. The model has the facility to calculate the foreign exchange requirements for construction, road maintenance and vehicle operation based on percentages of components such as fuel, construction plant and materials, etc, which must be bought with foreign exchange.

Computer requirements and availability

The computer program (RTIM2) and user manual are available at the cost of a nominal handling charge from:

Computer Section
Transport and Road Research Laboratory
Crowthorne
Berkshire RG11 6AU
United Kingdom

The program is written in Standard FORTRAN and consists of 6,000 statements. The total size of the program is 130k bytes. On the ICL 4/70 computer the program has a system overhead of approximately 29k giving a total program size of 159k bytes. This can be reduced in size by using a simple overlay structure which would result in a total program size of approximately 92k.

The program requires input in card image form and a separate input device may be used for input of the ground data. Three sequential files are required for use as backing store and these may be magnetic tapes or disk files. The program prints output to a lineprinter.

The run time of the program on the ICL 4/70 is of the order of only a few seconds.

CASE STUDY: THUCHI-NKUBU ROAD, KENYA

Background to the study

RTIM2 has been used as part of an evaluation of the Thuchi-Nkubu road project in Kenya for Britain's Overseas Development Administration.

The road traverses an area of dense population and high agricultural potential on the eastern slopes of Mount Kenya. The topography in the area is rugged and includes ten mountain rivers and thirty streams. The new alignment shortens the direct road length by 30km, from 84.40 to 54.38km. The principal benefits considered are the economic value of road user savings

resulting from shortening the route and improving the road surface. These are principally vehicle operating cost savings for the expected 'normal' traffic over the life of the project, but the value of time savings for this traffic is also considered. A further source of benefits is a reduction in road maintenance costs as a result of the project. The effect of generated traffic is also considered.

The existing road has a gravel surface and follows the contours of the ground having a tortuous horizontal alignment, but relatively flat gradients. The new road has gentle horizontal curves and steeper gradients and involves the construction of substantial earthworks. It is provided with a paved surface. Predicted traffic levels are approximately 750 vpd in the first year rising to over 2600 vpd after 20 years. Generated traffic on the new road is expected to increase from just under 400 vpd to in excess of 1600 vpd over the same period.

The original feasibility study assumed that a high level of maintenance would take place whether or not the new road was built and the analysis using RTIM2 has been carried out on this basis. It is however believed that the levels of maintenance considered, particularly for the 'without project' case, are unlikely to be achieved in practice.

Road user cost savings

The vehicle operating costs of traffic on the road will be affected by the severity of the road geometry and the condition of the road surface (roughness). On the existing road, roughness varies from 3500mm/km when the road is newly maintained up to about 5500 mm/km. On the new project, roughness rises steadily from 2500mm/km in the first year of trafficking to 3750mm/km in the last. Vehicle operating costs are also affected by

the age of vehicle. It was estimated that vehicles would achieve higher utilisation on the new project which implies that, on average, vehicles will be older in terms of the total number of kilometres travelled.

The differences in road user costs for the 'with' and 'without' project situations are illustrated in Table 1 which shows costs for the first year of trafficking. There is a reduction in vehicle operating costs per kilometre for all vehicle types following the construction of the project. The reduction is of the order of 30 per cent for cars, 35 per cent for light goods vehicles, 15 per cent for trucks and 35 per cent for buses. In addition, there is a reduction in time costs of between 45 and 50% per kilometre of road. These changes in cost are caused by the reduction in road roughness and the increase in speed and vehicle utilisation. All these costs savings will be increased further because of the shortening of the road length.

Fuel consumption rates on the existing road and the new project are similar because the effect of the reduction in road roughness is offset by the increase in vehicle speed. The use of lubricating oil is halved because oil changes are needed much less frequently on paved than on gravel roads. Tyre wear is affected by the reduction in road roughness and is reduced by over 50 per cent for cars and light goods vehicles and just under 20 per cent for trucks and buses. Spare parts replacement and maintenance labour hours are affected by two components. The reduction in road roughness reduces the cost, but the increased vehicle utilisation increases the cost. Depending on the relative magnitude of these effects, the cost may therefore increase or decrease. In the case of cars and light goods vehicles, there is a reduction in cost of just under 50 per cent. There is a 2 per cent increase for trucks and a decrease for buses of nearly

70 per cent. Both vehicle depreciation and crew costs per kilometre run have reduced in direct proportion to the increased vehicle utilisation on the new road. The reduction in time cost per km is entirely due to increased vehicle speeds.

There will be further savings in total road user costs due to the shortening of the length of the road.

Tables 2 and 3 show the undiscounted cost streams for all cost components for both the new project and the existing road over the analysis period. The foreign exchange component of these costs has not been included in this analysis.

The vehicle operating cost and time cost columns show clearly the gradual increase in these costs over time for both normal and generated traffic. This increase is due both to the growth in traffic over time and to the effect on vehicle operating costs of the deterioration of the road surface condition with time.

Engineering costs

Table 2 shows how the construction cost has been spread over the five years 1980-1984. These figures have been provided by the User and RTIM2 has not been used to evaluate the construction cost in this example. Clearly, no construction cost is incurred on the existing road (the 'do-nothing' case).

The inputs of periodic maintenance can be clearly seen in the 'Maintenance' columns of Tables 2 and 3. Table 2 shows the cost peaks where surface dressing will be carried out in 1990, 1995, 1998 and 2001. The cost of KS 79856.70 represents the cost of drainage and shoulder maintenance plus the cost of maintenance overheads. The slight escalation of

maintenance cost in 1988, 1989 and 1994 represents the cost of patching cracks and pot-holes. Notice that the need for this is eliminated following a surface dressing. Table 3 shows that regravelling will be carried out in 1984, 1988, 1990, 1993, 1995, 1997, 1998, 2000 and 2002. This is based on the Consultant's estimate of regravelling needs because of the rate at which gravel will be worn away by traffic and rainfall. The remaining costs represent drainage and overhead costs plus the cost of grading the road which is carried out at a steadily increasing frequency through the life of the project.

Benefits

Tables 4 and 5 show the discounted cost streams for the project and the existing road. The base discount used is 12 per cent but RTIM2 has also been used to evaluate the sensitivity of the result to discount rates of 10 and 14 per cent.

At a 12 per cent discount rate, the vehicle operating cost saving of the project is KS Million 213 and the maintenance cost saving is KS Million 6 for an expenditure of KS Million 171. The total discounted cost of the project (construction plus maintenance plus vehicle operating cost for normal traffic) is KS Million 367 compared with KS Million 416 for the 'do-nothing' alternative, giving a net present value of KS Million 49. Thus there is a benefit/cost ratio of 1.28. Additionally, there is a time saving for normal traffic of KS Million 44. If this is included, it increases the benefit/cost ratio to 1.54.

The vehicle operating costs and time costs for generated traffic have been printed in Table 4. These are normally included as a benefit by taking half of their value. However, it should be noted that all costs used in this example are in financial (economic) terms and the benefits

due to generated traffic should normally be related to the 'perceived' cost which is related more closely to the market cost than the financial cost. Thus, half of the tabulated values for vehicle and time costs for generated traffic may well be an underestimate of the true benefits. More information about the relationship between 'perceived' costs and 'financial' costs is needed in order to assess these benefits properly.

It is interesting to note that the maintenance cost of the new project is only 1 per cent of the construction cost and only $\frac{1}{2}$ per cent of the total cost (construction plus maintenance plus vehicle operating cost). For the existing road, maintenance still represents less than 2 per cent of the total cost.

Clearly, at a 12 per cent discount rate, the project is justified whether or not time costs or generated traffic are taken into account. This result still holds for discount rates of 10 or 14 per cent as the internal rate of return is approximately 15 per cent. When generated traffic benefits and time cost savings are taken into account, the rate of return increases substantially above this. The first year rate of return is 9 per cent, excluding time and generated traffic benefits.

In all of the above cases, the residual value of both the existing and new roads should also be included in the appraisal.

Discussion

The example has been chosen to illustrate the way that RTIM2 can assist in the evaluation of economic benefits for a road project. Note that no economic analysis is carried out by RTIM2 but, by producing computer runs for the 'with project' and 'without project' cases, tabulations are produced which can be used to determine the net present value, benefit cost

ratio, internal rate of return, first year rate of return, or any other economic test that is required. These calculations are all straightforward and allow the user to carry out the economic analysis in whatever way is appropriate to the situation under consideration.

The example also illustrates how the factors of road condition, vehicle age and utilisation affect the vehicle operating cost and, in particular, how some cost components can actually increase when the road is improved. This emphasises the importance of collecting good information about these factors when appraisals are being carried out. Of further interest is the fact that generated traffic actually increases the unit vehicle operating cost because it increases the rate of road deterioration.

In a normal appraisal, many further runs of the program would be carried out so that several different design options could be evaluated. Further runs should also be carried out to enable the effect of uncertainties in the data to be fully investigated which will reduce the element of risk in the project appraisal. In particular sensitivity analysis should be carried out of key variables such as traffic, road roughness, vehicle age, vehicle utilisation and road maintenance inputs in addition to the sensitivity to the discount rate which has been illustrated here.

SUMMARY

In developing countries, investment in rural and inter-urban roads continues to represent a large part of national development programmes. It is therefore important that decisions about such investments are made on the basis of the best possible information. An attempt has been made to obtain a better understanding of the interaction between road construction and maintenance standards and the cost of operating vehicles in order to improve

the quality of decisions made at the planning stage of road investment projects. The relationships derived from various studies have been built into a computer model which may be used to aid investment decisions within the roads sector in developing countries.

The relationships in the model allow it to be used to study the interrelationships between road design and construction standards, road maintenance policy, vehicle characteristics, traffic flow and growth rate, environment and road deterioration. The model can be used to study many aspects of a road investment project such as the optimum maintenance standards for the road, the choice of an earth, gravel or bituminous pavement, and the benefits of adopting any number of different stage construction options. The model will also allow the planner to study the consequences of uncertainties in traffic forecasts or in the discount rate.

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TABLE 1

R ROBINSON MAY 1983 EXAMPLE FOR ODA ROAD SECTOR MANUAL (RDATA1)
THUCHI-NKUBU PROJECT ***COSTS IN KENYA SHILLINGS***

TRRL ROAD INVESTMENT MODEL
RTIM2/83/2 PAGE 12

VEHICLE OPERATING COSTS PER KM

VEHICLE TYPE CLASS	FUEL	LUBR OIL	TYRES	MAINTENANCE SPARE PARTS	LABOUR	CREW TIME	DEPREC IATION	TOTAL RUNNING COST	STANDING COSTS	TOTAL VOC	TIME
1 CAR	.1553	.0132	.0250	.1981	.0391	0.0000	.1325	.5632	.0563	.6195	.5475
2 LIGHT GOODS	.2629	.0197	.0250	.3202	.0481	.2571	.1790	1.1121	.2224	1.3345	.0763
3 TRUCK	.3544	.0439	.1698	1.2205	.2442	.9500	.2810	3.2638	.6528	3.9166	.0643
4 BUS	.3758	.0439	.1887	.1950	.0195	.4444	.3891	1.6563	.3313	1.9876	.4087

R ROBINSON MAY 1983 EXAMPLE FOR ODA ROAD SECTOR MANUAL (RDATA1)
THUCHI-NKUBU EXISTING ROAD ***COSTS IN KENYA SHILLINGS***

TRRL ROAD INVESTMENT MODEL
RTIM2/83/2 PAGE 18

VEHICLE OPERATING COSTS PER KM

VEHICLE TYPE CLASS	FUEL	LUBR OIL	TYRES	MAINTENANCE SPARE PARTS	LABOUR	CREW TIME	DEPREC IATION	TOTAL RUNNING COST	STANDING COSTS	TOTAL VOC	TIME
1 CAR	.1498	.0263	.0535	.3830	.0484	0.0000	.1766	.8376	.0838	.9214	.9996
2 LIGHT GOODS	.2711	.0395	.0535	.6335	.0522	.3913	.3181	1.7593	.3519	2.1111	.1543
3 TRUCK	.3564	.0878	.2095	1.1989	.2193	1.3702	.4053	3.8473	.7695	4.6168	.1228
4 BUS	.3685	.0878	.2328	.6133	.0553	.6667	.5837	2.6079	.5216	3.1294	.7652

TABLE 2

R ROBINSON MAY 1983 EXAMPLE FOR ODA ROAD SECTOR MANUAL (ROATAT)
THUCHI-NKUBU PROJECT ***COSTS IN KE

COSTS IN KENYA SHILLINGS

TRRL ROAD INVESTMENT MODEL
RTIM2/83/2 PAGE 75

ANNUAL COST MATRIX

YEAR	CONSTRUCTION	MAINTENANCE	VEHICLE OPERATING COSTS		TIME COSTS		FOREIGN EXCHANGE
			NORMAL TRAFFIC	GENERATED TRAFFIC	NORMAL TRAFFIC	GENERATED TRAFFIC	
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	87393600.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	65545200.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	65545200.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	12138000.00	79856.70	23038750.91	11623409.84	2816582.98	2021083.52	0.00
1984	12138000.00	79856.70	24704652.36	15109666.84	3076654.74	2514626.29	0.00
1985	0.00	79856.70	26782363.90	16435439.91	3345777.35	2751690.33	0.00
1986	0.00	79856.70	28120174.75	17327609.56	3639224.37	2983835.27	0.00
1987	0.00	79856.70	30544862.72	18647186.37	3950069.26	3220964.15	0.00
1988	0.00	97937.87	33541185.70	20401544.15	4278710.08	3480791.75	0.00
1989	0.00	286987.55	37095053.86	22592221.07	4622299.26	3756855.99	0.00
1990	0.00	2715200.96	40868642.87	25088056.21	4964957.75	4073413.95	0.00
1991	0.00	79856.70	44495807.15	27375961.59	5335119.32	4351813.70	0.00
1992	0.00	79856.70	48730114.15	29956642.43	5717897.49	4668829.77	0.00
1993	0.00	79856.70	53024396.43	32660689.29	6106762.12	4991414.72	0.00
1994	0.00	247262.85	57704603.06	35582338.47	6530645.18	5316927.90	0.00
1995	0.00	2792366.18	62471427.62	38553836.73	6941873.91	5666253.55	0.00
1996	0.00	79856.70	66559896.80	41221019.28	7362919.52	5988080.27	0.00
1997	0.00	79856.70	71581009.68	44421953.54	7792637.52	6353034.24	0.00
1998	0.00	2635341.59	78477573.26	46771073.30	8308460.77	6637909.46	0.00
1999	0.00	79856.70	81465779.05	50679497.50	8661885.86	7057516.27	0.00
2000	0.00	79856.70	87799530.58	54596316.07	9111284.50	7416644.09	0.00
2001	0.00	2757433.74	94601942.10	58882174.56	9560803.70	7770846.29	0.00
2002	0.00	79856.70	99155358.08	61862124.07	9976874.36	8112687.21	0.00
	242760000.00	12570667.82	1090733125.05	669788760.78	122101440.04	99135218.70	0.00

TABLE 3

R ROBINSON MAY 1983 EXAMPLE FOR ODA ROAD SECTOR MANUAL (RDATA TO)
THUCHI-NKUBU EXISTING ROAD ***COSTS IN KENYA SHILLINGS***

TRRL ROAD INVESTMENT MODEL
RTIM2/83/2 PAGE 106

ANNUAL COST MATRIX

YEAR	CONSTRUCTION	MAINTENANCE	VEHICLE OPERATING COSTS		TIME COSTS		FOREIGN EXCHANGE
			NORMAL TRAFFIC	GENERATED TRAFFIC	NORMAL TRAFFIC	GENERATED TRAFFIC	
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	0.00	246304.74	50668470.78	0.00	8208579.22	0.00	0.00
1984	0.00	4038159.58	56350507.04	0.00	9216075.06	0.00	0.00
1985	0.00	282419.50	57788164.93	0.00	9620226.14	0.00	0.00
1986	0.00	282419.50	61354092.36	0.00	10691160.10	0.00	0.00
1987	0.00	282419.50	67948150.89	0.00	11940777.87	0.00	0.00
1988	0.00	4074274.34	76805223.96	0.00	13437751.78	0.00	0.00
1989	0.00	354649.02	77453598.89	0.00	13201216.26	0.00	0.00
1990	0.00	4145503.86	86045221.18	0.00	14426203.22	0.00	0.00
1991	0.00	390763.78	91940016.57	0.00	15258868.91	0.00	0.00
1992	0.00	390763.78	101382362.67	0.00	16631941.72	0.00	0.00
1993	0.00	4182618.62	111546156.16	0.00	18139167.42	0.00	0.00
1994	0.00	426878.54	117556451.69	0.00	19027894.18	0.00	0.00
1995	0.00	4218733.38	128061973.26	0.00	20636603.35	0.00	0.00
1996	0.00	462993.30	134421467.82	0.00	21542969.60	0.00	0.00
1997	0.00	4254848.14	145819297.32	0.00	23251849.35	0.00	0.00
1998	0.00	4290962.90	155770498.20	0.00	24558602.51	0.00	0.00
1999	0.00	535222.82	159163583.54	0.00	25139413.14	0.00	0.00
2000	0.00	4327077.66	171392775.99	0.00	26859423.70	0.00	0.00
2001	0.00	571337.58	179198672.05	0.00	27814830.48	0.00	0.00
2002	0.00	4363192.42	191866935.66	0.00	29535214.85	0.00	0.00
	0.00	42122542.92	2222523620.97	0.00	359138768.85	0.00	0.00

TABLE 4

R ROBINSON MAY 1983 EXAMPLE FOR ODA ROAD SECTOR MANUAL (RDATA1)
THUCHI-MKUBU PROJECT ***COSTS IN KENYA SHILLINGS***

TRRL ROAD INVESTMENT MODEL
RTIM2/83/2 PAGE 76

DISCOUNT RATE = 12.00 PER CENT

YEAR	CONSTRUCTION	MAINTENANCE	VEHICLE OPERATING COSTS		TIME COSTS		FOREIGN EXCHANGE		
			NORMAL TRAFFIC	GENERATED TRAFFIC	NORMAL TRAFFIC	GENERATED TRAFFIC			
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
1980	69669642.96	0.00	0.00	0.00	0.00	0.00	0.00		
1981	46653778.70	0.00	0.00	0.00	0.00	0.00	0.00		
1982	41655159.55	0.00	0.00	0.00	0.00	0.00	0.00		
1983	6887427.17	45312.84	13055783.18	6595434.90	1598204.82	1146817.07	0.00		
1984	6149488.55	40457.89	12516145.72	7655027.45	1558729.04	1273987.94	0.00		
1985	0.00	36123.12	12114981.30	7434558.35	1513459.76	1244724.96	0.00		
1986	0.00	32252.78	11357266.95	6998330.88	1469821.69	1205121.02	0.00		
1987	0.00	28797.13	11014783.71	6724362.34	1424434.57	1161511.96	0.00		
1988	0.00	31533.37	10799364.12	6568751.20	1377630.13	1120721.79	0.00		
1989	0.00	82502.06	10663941.57	6494723.70	1328800.58	1080006.32	0.00		
1990	0.00	696924.46	10489962.71	6439479.16	1274380.99	1045543.90	0.00		
1991	0.00	18301.09	10197290.57	6273863.82	1222671.65	997323.38	0.00		
1992	0.00	16340.26	9971146.83	6129722.56	1169935.11	955335.07	0.00		
1993	0.00	14589.52	9687358.98	5966985.82	1115682.61	911912.81	0.00		
1994	0.00	40333.93	9412870.75	5804250.18	1065289.69	867306.11	0.00		
1995	0.00	406692.33	9098609.90	5615148.14	1011044.65	825257.76	0.00		
1996	0.00	10384.53	8655421.70	5360364.45	957471.04	778687.50	0.00		
1997	0.00	9271.90	8311040.32	5157689.85	904778.03	737630.33	0.00		
1998	0.00	273197.34	8135516.15	4848605.87	861311.25	688130.60	0.00		
1999	0.00	7391.51	7540440.87	4690874.61	801740.79	653240.97	0.00		
2000	0.00	6599.56	7255973.62	4511976.62	752979.42	612930.09	0.00		
2001	0.00	203465.40	6980483.92	4344795.29	705472.16	573394.86	0.00		
2002	0.00	5261.13	6532563.55	4075606.85	657297.47	534480.90	0.00		
			171015496.83	2005732.14	193790946.41	117690552.05	22771195.46	18414065.35	0.00

DISCOUNT RATE = 10.00 PER CENT

180627775.71	2635599.49	248102022.22	150999595.62	28938657.01	23422887.36	0.00

DISCOUNT RATE = 14.00 PER CENT

162129706.98	1544453.19	153579612.02	93060761.29	18170964.38	14679346.13	0.00

TABLE 5

R ROBINSON MAY 1983 EXAMPLE FOR ODA ROAD SECTOR MANUAL (RDATATO)
THUCHI-NKUBU EXISTING ROAD

COSTS IN KENYA SHILLINGS

TRRL ROAD INVESTMENT MODEL
RTIM2/83/2 PAGE 107

DISCOUNT RATE = 12.00 PER CENT

YEAR	CONSTRUCTION	MAINTENANCE	VEHICLE OPERATING COSTS		TIME COSTS		FOREIGN EXCHANGE
			NORMAL TRAFFIC	GENERATED TRAFFIC	NORMAL TRAFFIC	GENERATED TRAFFIC	
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	0.00	139759.92	28750651.06	0.00	4657768.30	0.00	0.00
1984	0.00	2045857.32	28548920.56	0.00	4669150.44	0.00	0.00
1985	0.00	127752.24	26140431.06	0.00	4351701.75	0.00	0.00
1986	0.00	114064.50	24779888.87	0.00	4317980.25	0.00	0.00
1987	0.00	101843.30	24502784.39	0.00	4305954.21	0.00	0.00
1988	0.00	1311807.30	24729226.55	0.00	4326596.43	0.00	0.00
1989	0.00	101953.12	22266058.86	0.00	3795034.22	0.00	0.00
1990	0.00	1064304.26	22083665.14	0.00	3702847.05	0.00	0.00
1991	0.00	89552.97	21070278.84	0.00	3496938.92	0.00	0.00
1992	0.00	74958.01	20744840.05	0.00	3403224.80	0.00	0.00
1993	0.00	764148.78	20379065.69	0.00	3313958.07	0.00	0.00
1994	0.00	69633.14	19176003.76	0.00	3103861.72	0.00	0.00
1995	0.00	614434.64	18651501.69	0.00	3005604.49	0.00	0.00
1996	0.00	60207.46	17480112.58	0.00	2801438.94	0.00	0.00
1997	0.00	494016.70	16930608.62	0.00	2699697.28	0.00	0.00
1998	0.00	444830.24	16148223.64	0.00	2545910.88	0.00	0.00
1999	0.00	49540.02	14732119.49	0.00	2326894.32	0.00	0.00
2000	0.00	357600.56	14164329.28	0.00	2219730.20	0.00	0.00
2001	0.00	42157.83	13221965.80	0.00	2052399.48	0.00	0.00
2002	0.00	287456.29	12640597.28	0.00	1945842.08	0.00	0.00
	0.00	8360878.62	407143273.21	0.00	67042543.83	0.00	0.00

DISCOUNT RATE = 10.00 PER CENT

0.00	10517538.60	518717872.27	0.00	85186286.91	0.00	0.00

DISCOUNT RATE = 14.00 PER CENT

0.00	6738090.32	324161009.98	0.00	53507277.88	0.00	0.00

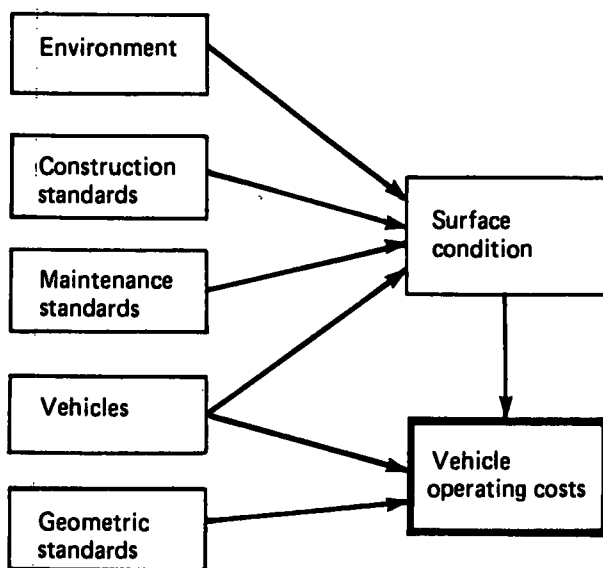


Fig. 1 Interrelationships between factors affecting vehicle operating costs

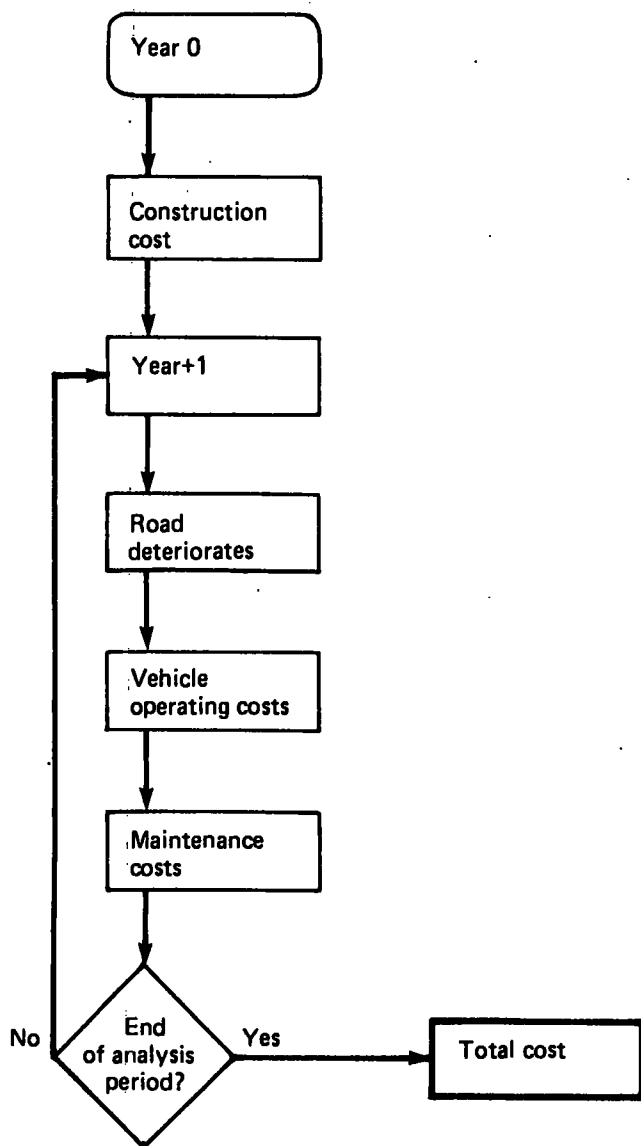


Fig. 2 Outline flow-diagram of the TRRL Road Investment Model

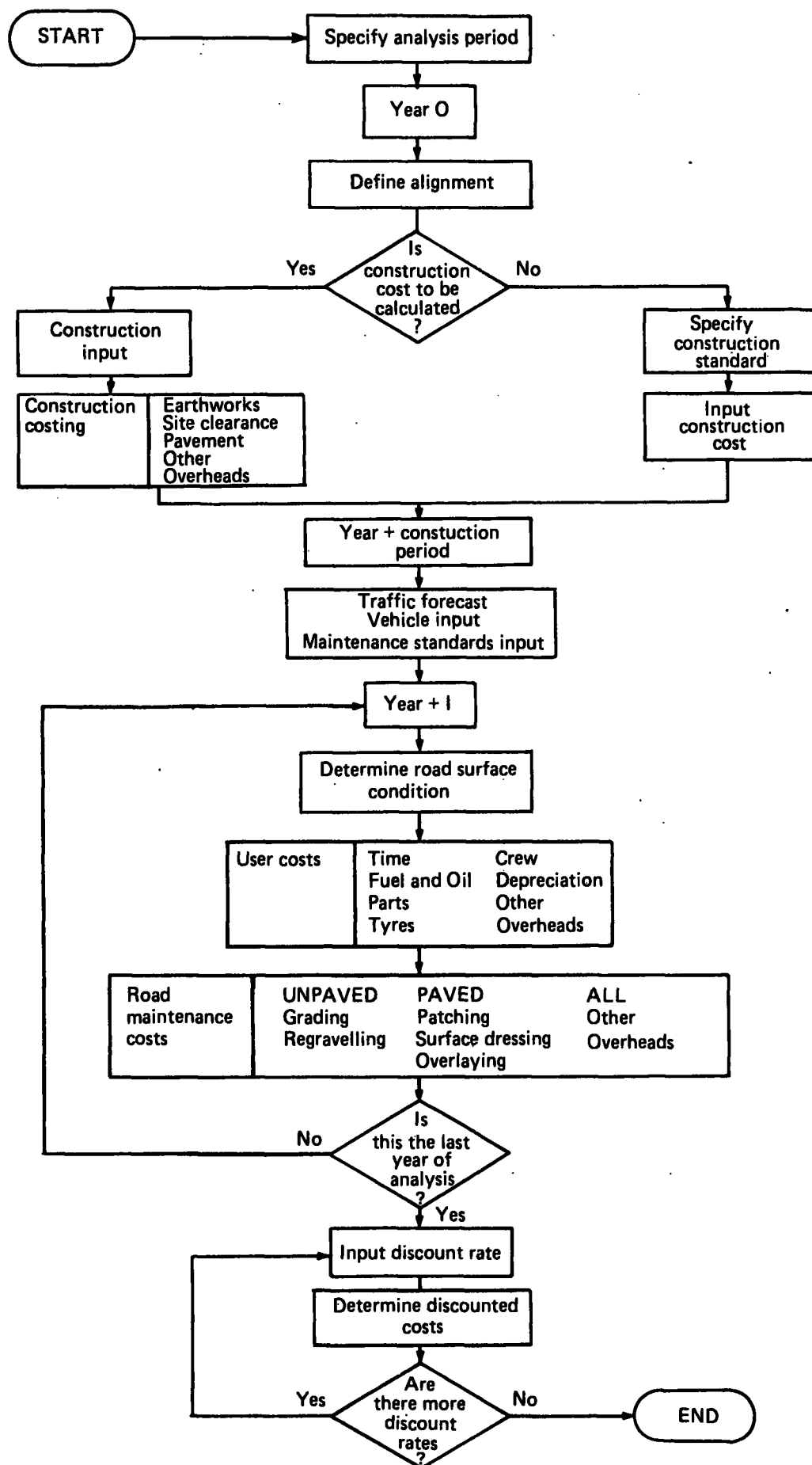


Fig. 3 Detailed flow-diagram of TRRL Road Investment Model

METHOD OF TRAVEL DEMAND FORECASTING IN TRANSPORTATION PLANNING

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The conventional four-stage modelling process is still the most commonly used technique for estimating travel demand. Trip generation - the initial stage of the process is a significant determinant of the form of the final output or the basis for decisions on investment in the transportation sector. Despite the fact that they have received considerable attention over the two decades, the various techniques of trip generation analysis have only marginally improved their predictive accuracy validity and policy sensitivity. The main trip generation analysis techniques are reviewed with respect to their advantages and disadvantages. A more flexible approach that would provide the decision makers with a density of estimated values rather than a single value is discussed.

1. INTRODUCTION

Transportation planning involves the study and understanding of an unsurmountable number of factors that are often not clearly identifiable. Some facts are not only obscure but are also very much interdependent. As described by Paquette et al (1) "... the chief problem comes from the fact that unlike most engineering problems, the solution which is selected will affect the environment of the problem itself. This change of environment will change the demand upon the system, possibly invalidating the criteria and input used in the initial design". The cyclic interdependence of the demand for transportation and the factors influencing the demand is shown in Figure 1.

For decades, researchers have been involved with transportation planning although the emphasis has changed from attempting to design for the efficient movement of automobiles to the operation of the optimal mix of automobiles and public transit modes. The travel demand aspect of the transportation planning process was considered initially as an abstract exercise. It was soon realized though that travel demand has to be an integral part of the total planning process. It has, to date, remained as a part of the process, but consisting of four sequential sub-stages, or phases: trip generation, trip distribution, modal split and trip assignment.

This paper deals with one of the four phases - trip generation analysis. Trip generation analysis is the most critical phase of travel demand forecasting because it supplies the input for the subsequent stages. The quality of this input would, therefore, determine the quality of the output in subsequent stages on which major investment decisions are based. The earlier methods used in trip generation analysis are discussed here with respect to their validity, predictability and policy sensitivity. Methods of improving these characteristics are discussed in the sections following that.

2. TRADITIONAL TRIP GENERATION ANALYSIS

The ultimate objective of trip generation analysis is to arrive at an estimate of the number of trip ends generated by each analysis unit in the study area. It is usually performed by identifying the major factors influencing travel demand and establishing relationships between these factors and trip generation intensities.

Travel needs of individuals are determined by a multitude of factors. Information on these factors is not readily available for two basic reasons. Firstly, it is difficult if not impossible to clearly identify all factors as they themselves are functions of several other variables. Secondly, even where a few sufficiently significant factors are fairly apparent, the cost element involved often prevents the collection and analysis of the pertinent details.

Techniques of travel demand forecasting have undergone significant development over the past few decades. Transportation engineers now have available to them techniques ranging from simple projection of highway traffic volume counts to sophisticated computerized mathematical models for particular applications.

However, the first generation of models have created a fairly good first impression on most engineers, despite the criticisms regarding the assumptions underlying the models and their overall structure. Hence, they are yet in widespread use all over the world.

The most commonly used factors in the earlier studies were demographic and socio-economic variables of the analysis units. Trip ends estimated using only these variables, however, varied significantly from observed values. The more recent studies have incorporated transportation system characteristics and accessibility measures into the analysis. This approach has shown marked improvements in the predictive.

Due to the varied behavioural patterns of the constituents of an analysis unit, it has been found that there is also a strong correlation between the reliability, and the accuracy of the above-

mentioned relationships and the level of disaggregation of the employed data. In other words, the predictive accuracy and stability of a relationship established at the micro level (e.g. for a particular trip type for females of a certain age category) is higher than that of a model based on all persons in an analysis unit. The first step should, therefore, be to classify the factors influencing demand into smaller groups.

2.1 Categorization of trip purposes

Trips made by a person for a certain purpose or the trip rate is the value to be derived or estimated in trip generation analysis. One may categorize these trips into a desirable number of groups. It usually depends on the amount of time, money available and the level of accuracy required. A typical categorization procedure is shown in Figure 2.

The terms 'internal' and 'external' in the figure are defined with respect to the analysis units. If either the origins or the destinations of trips are outside the analysis unit, they are external-internal trips, while if they are both outside, a trip would be a through trip. A home-based trip is one where one end of the journey is the person's home. Therefore, a journey to work in the morning would be defined as a home-based work trip.

2.2. Categorization of trip makers

The trip makers may be categorized according to gender, age, race, socio-economic status (i.e. level of income, car ownership, type of employment) or the location of residence. Once more, the extent of disaggregation will depend on the ^{availability of} time and cost. Although the earlier trip generation analysis concentrated mainly on land-use variables when developing the above-mentioned relationships, more personal and socio-economic variables are being considered today.

2.3 Categorization of demographic data

Despite the findings that confirm the superiority of disaggregate trip maker characteristics over aggregate land-use variables in trip generation analysis, the disaggregate models have not replaced the latter on any large scale. The primary reason is the difficulty involved in obtaining disaggregate data. Conversely, information on land-use variables is, more readily available. There is a tendency to use land-use data collected for other purposes and research. One should, however, be extremely cautious when using such data in order to avoid undue biases.

Land-use is often categorized as:

- (a) intensity of land-use: this is the concentration of dwelling units or population within the analysis unit. The population may be further sub-divided according to the trip maker types described above;
- (b) character of land-use: accessibility, quality of land-use, socio-economic status of population;
- (c) location of land-use: distance from major generation centres.

At the disaggregate level, land-use variables can be further categorized according to type of dwelling unit.

2.4 Selection of independent variables

The type of trip generation model and the dependent variable chosen to be analyzed will determine the independent variables. Often, however, the converse is the case. That is, the independent variables dictate the dependent variables and the type of model. Either way, certain conditions have been established over the years that should be satisfied when selecting the independent variables.

The two most widely used trip generation analysis techniques are (a) category analysis or cross-classification analysis, and (b) step-wise multiple regression analysis. Land area trip rate

analysis, household travel diaries and variations of regression analysis and category analysis are some of the other techniques used. Their practical applications have, however, been very limited.

With all techniques, the selected independent variables have to satisfy a few basic conditions. Firstly, their trip generation intensities should be normally distributed random quantities. This enables the use of mean values of the variables in the analysis. The second condition is, since the above models are used for estimating future trip generations, one should select the variables whose horizon year status or magnitude could be estimated with reasonable accuracy. The other selection criteria will depend on the type of analysis technique used.

(1) Multiple regression analysis:

The most commonly used trip generation model is the multiple regression model. This technique is of great value to engineers and planners due to its ability to test a variety of regression equations with various combinations of dependent and independent variables using high-speed electronic computers. The final equation will be chosen depending on the extent to which it satisfies the statistical or subjective criteria of the engineer. A typical regression model is of the form

$$Y = A_0 + A_1X_1 + A_2X_2 \dots + A_nX_n$$

where Y is the dependent variable

$X_1, X_2, \dots, X_n$ the independent variable

and $A_0 \dots A_n$ the regression coefficients

The dependent variable is the number of trips generated by a particular analysis zone for a specific trip type, as defined under categorization of trips. The independent variables will be the socio-economic or trip maker variables discussed earlier. The regression model developed for Rapid City, Iowa, to predict home-based

personal business trips was:(1)

$$Y = 0.45 (\text{population}) + 1.16 (\text{cars} - 1.38 (\text{Labour force}) \\ - 0.39 (\text{public and semi-public acres}) \\ - .0.03 (\text{undeveloped acres}) + 38.63$$

The dependent variables usually represent the 12-hour or 24-hour daily trips or peak period trips except in instances where the demand during a specific time period is desired.

With multiple regression analysis the independent variables selected for testing should satisfy another condition in addition to the two mentioned earlier; they should be non co-linear. This means that the independent variables should be independent of each other. Although not critical, causality is a further condition that has to be examined. It is the apparent relationship between the dependent and independent variables. One may obtain a relationship with a high r^2 value. However, a closer examination of the equation may reveal that the relationship is not a reality or hard to explain in any logical way.

Multiple regression models usually used are of two types - the zonal regression models and household regression models. The distinction is based on the level of aggregation. Where more data at the micro-level is available, household analysis is preferred.

A major disadvantage of this technique is the problem of stability. The assumption that the regression coefficients associated with independent variables are invariant over time does not always hold. It is more than likely that policy, spatial and social changes will alter the trip making characteristics and hence, the regression coefficients. The method does not provide any scope for testing the impact of changes in the behaviour of independent variables on model parameters.

(2) Category or cross-classification analysis:

This technique enables one to estimate the value of a dependent variable at various levels of one or more independent variables. The

method is not purely mathematical as in regression analysis, in that it simply consists of one or more matrices that are combined together to estimate trip ends. A trip rate matrix developed for the Southeastern Virginia Regional Transportation Study (Paquette, 1972) is given below:

Home-Based trip generation and income level

Relative Income Level

Trip Purpose	I	II	III	IV	V
Work	0.38	0.44	0.48	0.48	0.52
Personal Business	0.15	0.17	0.21	0.22	0.23
Shopping	0.23	0.28	0.38	0.46	0.54
Social Recreation	0.28	0.36	0.38	0.42	0.47
School	0.07	0.13	0.24	0.32	0.25
All Purposes	1.45	1.95	2.42	2.80	3.14

Compare to multiple regression analysis, this approach does not require the same amount of consideration be given to the independent variables. For instance, non co-linearity does not seriously impair the final result because no statistical relationships are being established. However, the assumption of normality of the independent variables is important. The cell values in the trip rate matrix is assumed to be the mean value of the observations within that category. Often the distribution of observed values of a category is unknown. If the distribution is highly skewed or the sample size is not significantly large, employing the mean value would induce a certain bias.

Although the significance of each chosen independent variable cannot be statistically tested, a family of curves can be derived which would indicate the response of the dependent variable to one independent variable while other independent variables are held constant. It is also useful in situations where the relationship between dependent and independent variables is non-linear, and avoids the problems of transformation required in regression analysis.

Overall, category analysis has an advantage over the regression techniques for two reasons. Provided sufficient data is available, the former technique has a definite edge over the latter. However, the quantity of data required to establish stability with respect to time or area is unlikely to be available in most transportation studies. As summarized by Lewis & Douglas (2), "the current policies tend towards small home interview samples, and a plea is, therefore, made for coordinating of home interview data from various sources". The combining of data from all sources is not as straight-forward as one would like it to be. Furthermore, category analysis has been used with some reservations because of the difficulties of incorporating new independent variables.

3. ALTERNATIVE METHOD OF TRIP GENERATION ANALYSIS

As discussed earlier disaggregate modelling can significantly improve travel demand forecasting and also reduce the data requirements. Nevertheless both of the above techniques and others such as direct demand models, household travel diaries, etc., all provide only point estimates. This estimate is assumed to be the most likely value for a given set of variables.

One of the major problems with these variables is the uncertainty about their future or even existing magnitudes. For, instance car ownership and income levels are based on small samples from the analysis units. Therefore, using point estimates is likely to produce wide variations from the actual conditions.

On the contrary if the distributions of variables are considered the engineers will be better equipped to provide the decision makers with a range of possible outcomes, with known probabilities of occurrence. Kanafani (3) was one of the first to apply a similar approach to estimate travel demand. Bayesian statistics was used to estimate the probability distribution function of trip ends, assuming that the distributions of the variables are of some known form.

For example, it was assumed that the trip generations at any given income level is Poisson distributed. Also assuming that the findings of Wooton and Pick (4) that income is a gamma distributed random quantity is valid, Kanafani (3) derived the Bayesian distribution on trip generations which can subsequently be modified to handle changes in income. Considering income as a continuous variables, the problems associated with grouping incomes is also eliminated.

Similarly, if the distributions of other variables is known the compound probability distributions can be easily obtained using Bayesian statistics. These distributions can also minimize the statistical and inherent uncertainty in addition to being able to be modified as the initial conditions change.

4. CONCLUSIONS

Compared to methods of multiple regression and category analysis in trip generation analysis, a probabilistic method has the ability to test the sensitivity of trip generating intensities to several variables. It can also minimize the biases introduced by small samples and uncertainty the future status of the variables used.

If the probability density function of the trip generations is known one can generate several alternatives to satisfy the estimated demand. Consequently the cost of satisfying the anticipated demand or the inability to accommodate the demand can be assessed more objectively.

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FIGURE 1

CYCLIC INTERACTION BETWEEN TRANSPORTATION & CHANGES IN TRAVEL DEMAND

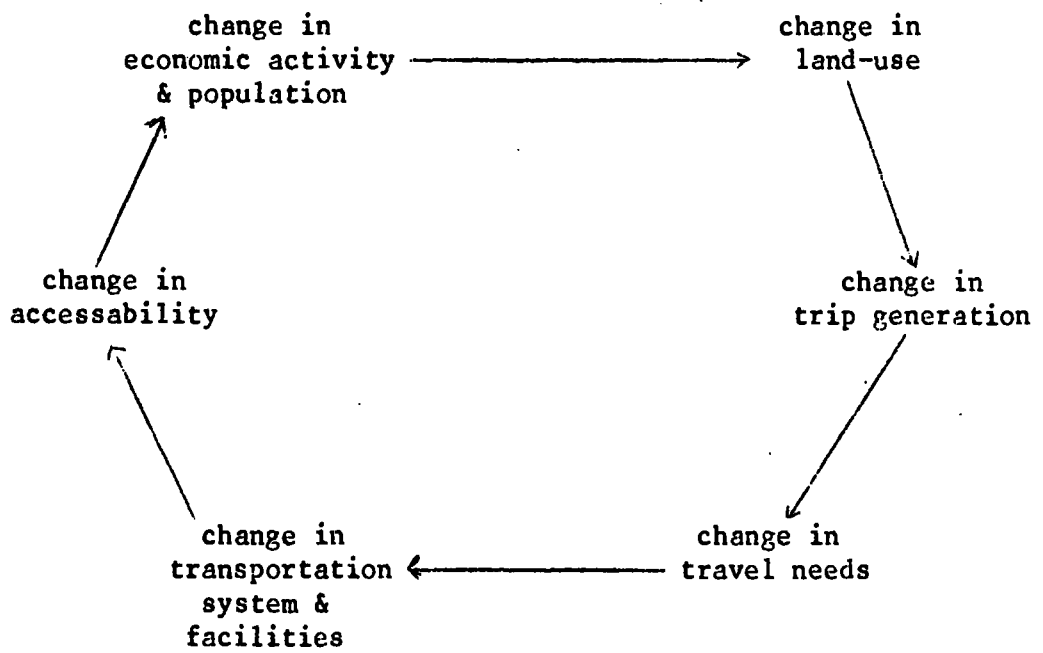
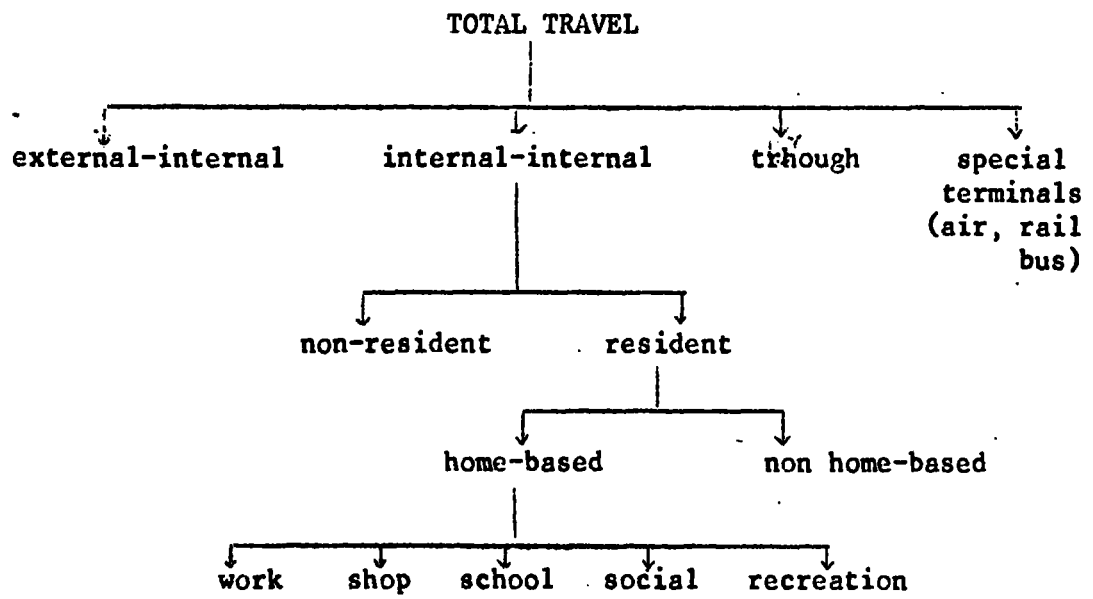


FIGURE 2

CATEGORIZATION OF PERSON TRIPS



ESTIMATING THE TOTAL DEMAND FOR AND SUPPLY OF GOODS
TRANSPORT IN SRI LANKA: 1964 - 1971

by

J. Diandas

Abstract

There is no known estimate of total goods transport effort in Sri Lanka. Total goods produced and imported was first tabulated, including considerable estimation. Out of this a proportion was deducted for husk, seed and local consumption. The balance needing transport was converted to ton-miles by applying an estimated average haul distance to each commodity. Total demand for ton-mileage was aggregated. Supply was estimated by estimating the average active vehicle fleet of lorries, agricultural tractor-trailers and bullock carts, and applying estimated average annual mileage and estimated average payloads. Railway data was included to give total supply. Although many estimations were needed for both demand and supply, the aggregates showed remarkably close matching over the 10 years studied. However this may be due to compensating errors and cannot be regarded as more than tentative.

1. Background

This paper is drawn from Chapter 6 of a forthcoming publication "Sri Lanka Transport Sector Study" sponsored by the Friedrich Ebert Foundation. (Reference (1)) It is to some extent an update of material in four earlier papers published or presented between 1975 and 1981. (Reference (2), (3), (4), (5))

2. Methodology

There would appear to be no previous estimates of the total quantity of transport (tons and ton-miles) in Sri Lanka, and of the modes by which this transport was performed.

Data of total tonnage produced in or imported into Sri Lanka was extracted from principal statistical sources. (Reference (7), (8), (9); (10)) Estimates for some missing items were made as described in para 3 of this paper.

This tonnage data was converted first into tons seeking transport, and then into ton-miles of transport as described in para 4 of this paper.

Total ton-miles was arrived at and compared with the total estimated supply of transport developed in the Transport Sector Study. (Reference (1))

Supply of transport includes rail ton-miles as reported by the railway (Reference (11)) and estimates for lorry, agricultural tractor/trailer and bullock cart. These latter were derived from

a set of assumptions made after examining three reports of TRRL (Transport Road & Research Laboratory, England) issued recently. (Reference (12), (13), (14))

The assumptions were briefly as follows :-

Active vehicles as the number on the Register of Motor Vehicles less the following percentage of the number on register 10 years earlier :-

vehicle	%
Lorry	20
Tractor	100

In the case of bullock carts the number was extrapolated intuitively from the fleet estimated by TRRL for 1975.

(Reference (14))

Miles per vehicle per annum :-

Vehicle	Miles
lorry	8,000
tractor/trailer (for transport)	2,000
bullock cart	1,000

Average payload taking account of empty backhauls :-

Vehicle	tons
lorry	1.5
tractor/trailer	1.0
bullock cart	0.27

3. Total Tonnage of all goods

The transport sector has to carry, for various distances, the output of agriculture and industry as well as the goods imported into the country.

Growth in these quantities are set out in the following table and corresponding graphs :-

- 1 agriculture, forestry, fish & animal;
- 3 industrial products;
- 5 imports (all ports)

Imports at each port are set out in Tables 6 (Colombo), 7 (Trinco) & 8 (Galle).

There are considerable gaps in the data as well as inconsistencies. These have been filled in or adjusted by the best judged interpolation or extrapolation or estimation.

The construction industry generates a large amount of transport of its input materials. They include bricks and tiles made in scattered factories. Others are metal (granite) sand, clay, and timber. Unlike industrial goods these need only inward (or raw material) transport, since the product of the construction industry remains on the location of construction. There was particular difficulty in estimating the quantities of construction materials, for which some data of sand, bricks, tiles and clay was available only for 1980. For this an estimate was made by indexing backwards on the basis of the average of the indexes of GNP and reported timber sales. Value added at constant prices by the construction industry might have been a better basis. In any case metal (granite) has not been included.

Another important sector needing transport in one direction only is energy. Oil has been included in industrial products.

Electricity's transport is by transmission lines, and is not included in conventional transport studies, though it is worth noting that electrification (of villages, industry, or transport itself) usually reduces the need to transport liquid fuels.

Firewood is the other significant source of energy which needs transport. Here too data is lacking. It has been estimated that between 3 and 5 million tons of firewood are used per year, to provide about 60% of the country's energy usage. However not much is known about the trend in firewood use. In urban areas its use may tend to fluctuate in inverse harmony with kerosene oil prices. In rural areas it needs little transport. However even if only 5% of firewood moves from source to town, at least 200,000 tons would need to be transported, which is as large a quantity as total tea production. Ultimately firewood quantities has been estimated at 311 kg per capita annual derived from TL Sanker and GBA Fernando. (Reference (6))

Although the Katunayaka Export Promotion Zone has generated considerable visible transport on the Negombo Road, about which little data is available, it is not likely to make a large impact on national transport effort up to 1981 because most of the goods are light-weight in nature, and are moved only a short distance to and from the Colombo harbour.

The growth in overall quantities may be summarised as follows

(million tons) :-

	1964	1970	1975	1980
agriculture etc.	9.4	10.4	11.1	11.4
industry & mining	1.3	2.0	2.5	3.5
imports (dry)		2.1	1.5	2.6
totals		14.5	15.1	17.5

Typical agricultural changes are as follows (in million tons) :-

	1964	1970	1975	1980
paddy	1.1	1.6	1.2	2.1
manioc	.4	.4	.9	.5
c'nut	3.0	2.6	2.7	2.1
tea	.2	.2	.2	.2
firewood	3.5	4.0	4.3	4.3
fish	.1	.1	.1	.2

Typical industrial and mining products have changed on the basis of the estimations used as follows, in million tons :-

	1964	1970	1975	1980
cement	.08	.27	.39	.62
building materials	1.11	1.39	1.54	2.27
mineral sand	.05	.08	.07	.04

Imports as reported in Port Statistics (Reference (7)) have changed as follows, in million tons :-

	1964	1970	1975	1980
rice			.4	.2
flour			.4	.3
wheat			.1	.2
oil		2.2	1.5	1.9

Product substitutions have occurred. For example as paddy crops have increased, rice imports have decreased. As wheat imports have grown, so flour imports have declined.

4. Total Demand for Ton-miles of Transport

The conversion of tonnage into demand for transport requires three important factors to be first estimated. They are :-

1. an estimate of the percentage of the recorded quantity that is retained in the vicinity of origin for reason of waste, driage, seed, manure or local consumption. This applies mainly to agriculture;
2. an estimate of the quantity of raw material needing inward transport in relation to the output quantity of finished goods. This applies mostly to industry;
3. as estimate of the average distance over which the relevant quantities need to be transported.

The methodologies used and the results of their application are set out in the three tables, and shown in the corresponding graphs, in million of ton-miles as follows :-

- 2 agriculture etc., (excluding on-farm or local transport up to miles);
- 4 industry & mining (excluding petroleum refinery products);
- 9 imports, excluding petroleum and bulk wheat. (Graph 6)

5. Matching Demand and Supply

Finally Table 10 and Graph 6 summarise ton-miles in two sections:-

1. summary of demand based on Tables 2, 4 and 9 together with estimates for local (4 - 6 mile) transport and petroleum refinery products;
2. the potential supply of transport by lorry, rail, bullock cart, tractor-trailer.

The potential or available supply of transport is based on the estimated performance of lorry, bullock cart and tractor/trailer railway performance.

Since both the computed demand for transport and the computed supply of transport are based on many assumptions in sequence, it ought to be surprising if the aggregate demand and aggregate supply so calculated are within 50% of each other. In fact Table 10 shows remarkable agreement with supply exceeding demand in two years by 6½ and 8½% which would not be regarded as statistically significant. In all other years the difference is quite insignificant.

However this does not necessarily lead to a conclusion that the estimation processes are thereby justified. It can be that some significant errors in the data or the processes are off-set by other such errors in the demand or the supply side or both.

Notwithstanding this substantial qualification, it is believed that the outcome displayed in Table 10 is a useful starting point for better studies of the transport effort actually undertaken in the past and needed in the future to carry goods in and about Sri Lanka.

Acknowledgements

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14. Bullock cart haulage in Sri Lanka. Plumbe & Savage. LR 1006.
TRRL 1981.

TABLE 1. AGRICULTURE, FOREST, FISH & MINING PRODUCTION 1954-1981 IN THOUSAND TONNES (KT)

Year	C O C O N U T										EXPORT CROPS										FOREST PRODUCT				A N I M A L		TOTAL	
	C O C O N U T					EXPORT CROPS					FOREST PRODUCT					A N I M A L		Tot	PROD- EXCET									
	Prod	Area	Yield	Area	Yield	Prod	Area	Yield	Area	Yield	Prod	Area	Yield	Area	Yield	Prod	Area			Yield	Area	Yield						
1954	1254	369	71	107	347	559	109	10	676	2273	3.0	929	1494	598	3021	219	112	22	353	119	3390	85	3475	100	150	43	293	9,421
55	945	320	52	116	457	572	112	8	692	2134	2.7	935	1337	535	2707	228	118	24	370	106	3433	94	3577	91	163	41	295	9,353
56	954	269	70	117	476	586	114	5	709	2179	2.5	762	1229	492	2463	222	131	26	379	110	3545	102	3647	113	136	44	293	8,981
57	1946	591	85	137	613	605	115	7	728	2427	2.4	729	1205	483	2418	221	143	26	392	95	3639	106	3745	120	132	41	293	9,335
58	1546	629	94	126	649	615	119	12	848	2842	2.6	788	1301	520	2508	225	149	30	404	114	3732	101	3833	140	140	43	331	9,920
59	1374	433	95	135	531	622	122	4	758	2753	2.4	731	1218	489	2435	220	151	32	403	105	3825	138	3963	144	139	45	329	9,894
60	1616	551	104	142	567	606	147	5	855	3173	2.4	690	1322	489	2561	212	159	34	405	113	3887	130	3867	106	141	46	292	10,315
61	1336	589	85	147	603	616	150	5	775	2774	2.6	505	1309	524	2730	218	142	35	396	113	3950	80	4030	91	150	50	291	10,229
72	1212	318	67	171	576	531	153	9	753	2681	2.3	1014	1447	579	3040	214	140	45	400	112	4043	98	4139	107	211	56	374	10,654
73	1312	550	111	189	550	547	156	12	809	2971	2.1	606	1048	419	2133	211	153	38	404	113	4105	102	4205	106	219	49	374	10,090
74	1602	702	134	192	644	542	153	12	829	3472	2.0	594	1015	405	2115	204	152	42	378	113	4167	116	4223	112	156	56	312	10,553
75	1154	890	221	201	4512	629	153	3	622	3263	2.8	879	1292	517	2588	219	149	37	405	110	4230	107	4337	137	184	42	363	11,091
76	1287	718	214	220	4182	635	152	23	850	3265	2.3	793	1165	456	2474	195	152	36	396	110	4292	106	4398	145	221	40	305	10,597
77	1817	547	157	215	925	645	140	23	602	3240	1.9	620	510	354	1894	208	146	39	351	92	4354	74	4428	148	233	39	520	10,343
78	1850	586	182	201	949	654	142	26	622	3461	2.2	751	1104	462	2297	199	156	47	402	98	4415	59	4674	159	231	37	437	11,471
79	1517	534	106	224	944	664	145	20	629	3490	2.4	814	1198	479	2489	206	153	50	409	90	4478	88	4566	178	226	41	647	11,401
80	2133	500	178	235	517	475	146	27	648	3698	2.0	689	1013	405	2107	191	133	25	349	252	4572	180	4752	260	246	31	477	11,383
81	2229	526	225	220	571						2.3	740	1129	452	2361	219	124	52	335		4634			207				

Notes:

1. For 1964 and 1967-70 onions may be included in vegetables as well as highland crops, the double count ranging between 30 and 40 kt.
2. Actual firewood is estimated at 311 kg per capita.
3. Coconut:kernel per Statistical Abstracts¹ husk @ 500g,shell @ 250g per nut.
4. Other export crops 1972-80 per Central Bank² others estimated by extrapolation from 1972-80.

Source: Statistical Abstracts of Sri Lanka³ (various years) except as indicated in notes.

TABLE 2. ESTIMATE OF AGRICULTURE, FOREST, FISH TRANSPORT 1964-1971 IN MILLION TON-MILES (MTM)

(excluding bullock cart and tractor-trailer range of 4-6 miles local transport)

YR	mid year pop	CONSUMPTION ORIENTED CROPS										C O C O M U T				EXPORT CROPS				FOREST				A N I M A L				GRAND TOTAL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
		Highland Crops					Other Crops					veg	oth	veg	oth	tot	veg	oth	tot	fire wood	tim ber	tot	pi sh	si lk	beast + egg	tot																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
		veg	oth	veg	oth	tot	veg	oth	veg	oth	tot																veg		oth	veg	oth	tot	veg	oth	tot	veg	oth	tot	veg	oth	tot	veg	oth	tot																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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W	40	30	30	40			-	-	-	-																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

NOTES:

TM = ton-miles = $\sum [Y - (\sum of Y + \sum of population \times k)]$; k = $\sum (1-0/100)$ ($1-0/100$)

Notes:-

d = distance in miles of transport

Y = tons as in Table 1.

U = % of crop weight distributed as seeds, seed etc., and transported for average 4 miles.

P = % of population within 5 miles of growing areas.

K = per capita annual consumption in kilograms.

V = per capita consumption varied with population.

V = per capita consumption varied with population.

TABLE 2. ESTIMATE OF AGRICULTURE, FOREST, FISH TRANSPORT 1964-1971 IN MILLION TON-MILES (MTM)

TABLE 3 INDUSTRIAL PRODUCTS 1964 - 1991 IN '000 TONS (MT)

STATE INDUSTRIAL CORPORATIONS																				BUILDING MTL				TOTAL	
YR	percent				sales				St no 1	gro phi to	co to ci co	va en 1	vl ou 1	vl ou 1	ol fat 1	B C C	P ch em	ph co ph st	Tot ol	FER TIL IS ER	PL US & mate	final esti mate			
	IGAS	PAL	GAL	Tot -al	EP	PAL	HAH	Tot -al															wood	brk ok	tile
19																									
64	80			30			45	5		1	2		2				1		138		1248	80	1328		
65	73			73		14	47	6		1	2		7				1		467		424	90	1504		
66	24			84		13	54	7		1	3		10				1		295		553	90	1633		
67	82			32		63	53	9		1	1		4				1		254		1713	82	1745		
68	150			206			46	3		2	3		7				2		454		1454	10	2364		
69	155			240			74	8		3	1		8				2		536		1454	10	2364		
70	158			268			79	9		3	1		9				2		624		2015	10	2025		
71	184	92		340			95	9		3	1		13				2		695		1464	10	1474		
72	191	140		385			85	15		7	4		7				2		802		2184	70	2254		
73	186	122		424			96	21		8	4		12				3		663		2065	350	2415		
74	190	234		475			84	18		10	4		19						651		2215	365	2580		
75	166	176		392			67	20		8	4		18						565		2106	375	2491		
76	192	137		422		44	87	18		8	6		24						712		2276	385	2501		
77	169	165		532		10	88	20		9	13		23						534		1433	215	2143		
78	192	320		574		31	48	25		11	7		17						593		2254	205	2459		
79	227	335		592		31	74	23		10	13		20				5		1003		2635	110	2745		
80	290	373		622		28	38	22		7	15		26				5		1010		3276	200	3476		
91	260	380		695			97	49		7	14		24				5		1084		3441	625	4066		

Source:

Various Central Bank and other reports.

Note:

Since sources rely on sometimes different primary sources, any difference arises in year and treatment and output definition, and because gaps in one source's time-series data have been filled in from other sources, all of these above figures, except perhaps for cement, should be regarded as indicative with fair margin for error.

Outgoing materials provided on ERP and Timber Industries based on 1990.

* PLUS = addition for missing items including Colombia flour 10 MT (1973-1981) and PRIMA flour 190 MT 1980 and 500 MT 1981

TABLE SUMMARY OF TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS 1964-1981 IN MILLION TONS (MT)

YR	STATE INDUSTRIAL CORPORATIONS										BUILDING MTS				TOTAL		
	COAL					OIL					BRICK	CLAY	LIME	CEMENT	IRON	STEEL	OTHER
	PROD	CONSUMED	EXPORT	IMPORT	NET	PROD	CONSUMED	EXPORT	IMPORT	NET							
1964	173	173	2	2	110	200	15	10	50	150	120	20	80	10	50	100	51
1965	175	175	2	2	110	200	15	10	50	150	120	20	80	10	50	100	53
1966	176	176	2	2	110	200	15	10	50	150	120	20	80	10	50	100	54
1967	177	177	2	2	110	200	15	10	50	150	120	20	80	10	50	100	55
1968	178	178	2	2	110	200	15	10	50	150	120	20	80	10	50	100	56
1969	179	179	2	2	110	200	15	10	50	150	120	20	80	10	50	100	57
1970	180	180	2	2	110	200	15	10	50	150	120	20	80	10	50	100	58
1971	181	181	2	2	110	200	15	10	50	150	120	20	80	10	50	100	59
1972	182	182	2	2	110	200	15	10	50	150	120	20	80	10	50	100	60
1973	183	183	2	2	110	200	15	10	50	150	120	20	80	10	50	100	61
1974	184	184	2	2	110	200	15	10	50	150	120	20	80	10	50	100	62
1975	185	185	2	2	110	200	15	10	50	150	120	20	80	10	50	100	63
1976	186	186	2	2	110	200	15	10	50	150	120	20	80	10	50	100	64
1977	187	187	2	2	110	200	15	10	50	150	120	20	80	10	50	100	65
1978	188	188	2	2	110	200	15	10	50	150	120	20	80	10	50	100	66
1979	189	189	2	2	110	200	15	10	50	150	120	20	80	10	50	100	67
1980	190	190	2	2	110	200	15	10	50	150	120	20	80	10	50	100	68
1981	191	191	2	2	110	200	15	10	50	150	120	20	80	10	50	100	69

IN A COMPARISON OF (T X 25 X 25) + (T X 25 X 25) WITH THE TOTAL OF FINISHED PRODUCTS AS IN TABLE 2.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

THESE ARE THE SUMMARY OF THE TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS (EXCLUDING CEMENT) IN MILLION TONS (MT) FOR THE PERIOD 1964-1981.

TABLE SUMMARY OF TRANSPORT OF PRINCIPAL INDUSTRIAL AND MINING PRODUCTS 1964-1981 IN MILLION TONS (MT)

TABLE 5. IMPORTS ALL PORTS 1964-1991 in MT (Thousands Metric Tons)

	F O O D				G E N E R A L				COAL	TOTAL DRY CARGO	BULK	W E T C A R G O				GRAND TOTAL
	Rice	Flour	Sugar	To- tal	Sub- food	Sugar	Feet- ing	Com- ent				Con- ent	Sub- ing	Total	CRUDE OIL	
15																
64																
65																
66																
67																
68																
69				821							1366					
70				1075							1071					
71				936							973					
72				756							817					
73				916							825					
74				787							725					
75				910							847					
76				749							785					
77				840							779					
78				850							807					
79				887							841					
80				798							789					
81				489							483					

Source: 1. Port Statistics Series 1 & 2 (from 1959 for Total Food, Total General, Total & Total Dry & from 1975 for Wet & Bulk: from 1991 for all others except Wet Cargo & Bulk.)

2. General Data Reports for wettest figures except Wet Cargo
3. Petroleum Statistics for all Wet Cargo data 1976-1991 and Wet Cargo details 1975-1991

4. There is considerable difference between sources for the later years.

5. Transshipment (1981-1991) 1990 MT dry earlier years about 17 20 and later transshipment 19704. 17 & 37 in 1990 & 79 not included.

6. Ash cargo imports are included with cargo categories.

7. Totals do not always tally because of rounding.

TABLE 5. IMPORTS ALL PORTS 1964-1991 in MT (Thousands Metric Tons)

TABLE 3. **WATER COLLECTED FROM 1954-1957 IN AT VARIOUS PLACES**

ID	1954				1955				1956				1957				TOTAL	CRUDE OIL	WATER	TOTAL	CRUDE OIL	WATER	TOTAL
	Flow	Surf	70-100	Sub-surf	Flow	Surf	70-100	Sub-surf	Flow	Surf	70-100	Sub-surf	Flow	Surf	70-100	Sub-surf							
10																							
54																							
55																							
56	494																						
57	301	557	225	1,204																			
58	344	555	220	923																			
59																							
70	335	269	240	957	157																		
71	254	280	204	638	202	575	3																
72	250	235	214	700	282	474	23																
73	291	300	207	800	280	329	1																
74	271	437	40	740	377	325																	
75	350	379	63	802	177	353	11																
76	304	310	17	639	219	357	23																
77	514	480	95	1,089	214	424																	
78	141	572	197	910	434	572	21																
79	151	571	242	964	510	565	310																
80	142	335	175	652	505	657	282																
81	125	77	205	405	252	645	147																

1. These figures represent the water collected from the various places during the period 1954-1957. The figures for 1954 are based on the data collected during the period 1954-1955. The figures for 1955 are based on the data collected during the period 1955-1956. The figures for 1956 are based on the data collected during the period 1956-1957. The figures for 1957 are based on the data collected during the period 1957-1958.

2. The figures for 1954 are based on the data collected during the period 1954-1955. The figures for 1955 are based on the data collected during the period 1955-1956. The figures for 1956 are based on the data collected during the period 1956-1957. The figures for 1957 are based on the data collected during the period 1957-1958.

3. The figures for 1954 are based on the data collected during the period 1954-1955. The figures for 1955 are based on the data collected during the period 1955-1956. The figures for 1956 are based on the data collected during the period 1956-1957. The figures for 1957 are based on the data collected during the period 1957-1958.

4. The figures for 1954 are based on the data collected during the period 1954-1955. The figures for 1955 are based on the data collected during the period 1955-1956. The figures for 1956 are based on the data collected during the period 1956-1957. The figures for 1957 are based on the data collected during the period 1957-1958.

TABLE 3. **WATER COLLECTED FROM 1954-1957 IN AT VARIOUS PLACES**

TABLE 7. IMPORTS TRINIDAD DRY 1954-1981 IN MT (THOUSAND METRIC TONNES)

	T O U O				U S C N E R A				C O A L				TOTAL	BULK		U E T		C A R G O		GRAND TOTAL
	Rice	Fls	Gr	To	Sub-	Sun-	Port	Co-	Co-	Sub-	Total	COAL		DRY	SEA	CRUDE	Ref-	Av-	Total	
19																				
64																				
65																				
66																				
67																				
68																				
69																				
70																				
71																				
72																				
73																				
74																				
75																				
76																				
77																				
78																				
79																				
80																				
81																				

Source: Food Statistics Series 1 & 2

Notes

Totals do not always tally because of rounding.

TABLE 7. IMPORTS TRINIDAD DRY 1954-1981 IN MT (THOUSAND METRIC TONNES)

TABLE 5 EXPORTS GALES PORT 1954-1957 IN KT (Thousand Metric Tons)

	F O O			C E H E A			S O L K			W E Y			L U -			GRAND TOTAL
	Rice	Wheat	Barley	Sub-Total	Wheat	Barley	Wheat	Barley	Wheat	Crude Oil	Refined Oil	Crude Oil	Refined Oil	Crude Oil	Refined Oil	
19																
20																
21																
22																
23																
24																
25																
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Source: Foreign Statistics Series 1 A 2 1

Notes:

Totals do not always tally because of rounding.

TABLE 1. ESTIMATE OF TRANSPORT OF IMPORTS FROM ALL PORTS 1964-1981 IN MILLION TON-MILES (1981)

(excluding categories imports which are free port by shipping, and with what which is passed from ship to adjacent port within

19	F O O D				G E N E R A L					TOTAL
	Rice	Flour	Sugar	Tea	Subs-	Port-	Com-	Com-	Sub-	
	US	US	US	US	US	US	US	US	US	
64	100	110	110	110	110	110	110	110	110	5
65	40	40	40	40	40	40	40	40	40	
66	30	30	30	30	30	30	30	30	30	
67										
68	49									
69	38	56	25	129						
70	34	39	25	97						
71	29	34	22	85						
72	35	43	25	104	19	18				154
73	28	32	21	92	30	20				167
74	27	27	21	78	25	20	1			154
75	31	39	22	92	14	20	5			151
76	28	39	22	81	14	20	5			155
77	38	43	27	88	12	18				151
78	35	36	15	74	12	22				151
79	12	20	11	57	11	22	2			155
80	15	22	11	64	11	24				153
81	17	27	11	83	19	23	4			159
82	16	24	27	69	19	20	28			163
83	13	3	1	45	19	25	15			152

19 = 1964-1981 = 19 x 64 + 18 x 18 + 17 x 17 + 16 x 16

Source:

1 = 1964-1981 = 19 x 64 + 18 x 18 + 17 x 17 + 16 x 16

2 = 1964-1981 = 19 x 64 + 18 x 18 + 17 x 17 + 16 x 16

3 = 1964-1981 = 19 x 64 + 18 x 18 + 17 x 17 + 16 x 16

TABLE 2. ESTIMATE OF TRANSPORT OF IMPORTS FROM ALL PORTS 1964-1981 IN MILLION TON-MILES (1981)

TABLE 10 TOTAL ESTIMATE OF INTERNAL CROSS TRANSPORT IN MILLION TON MILES (MTM)

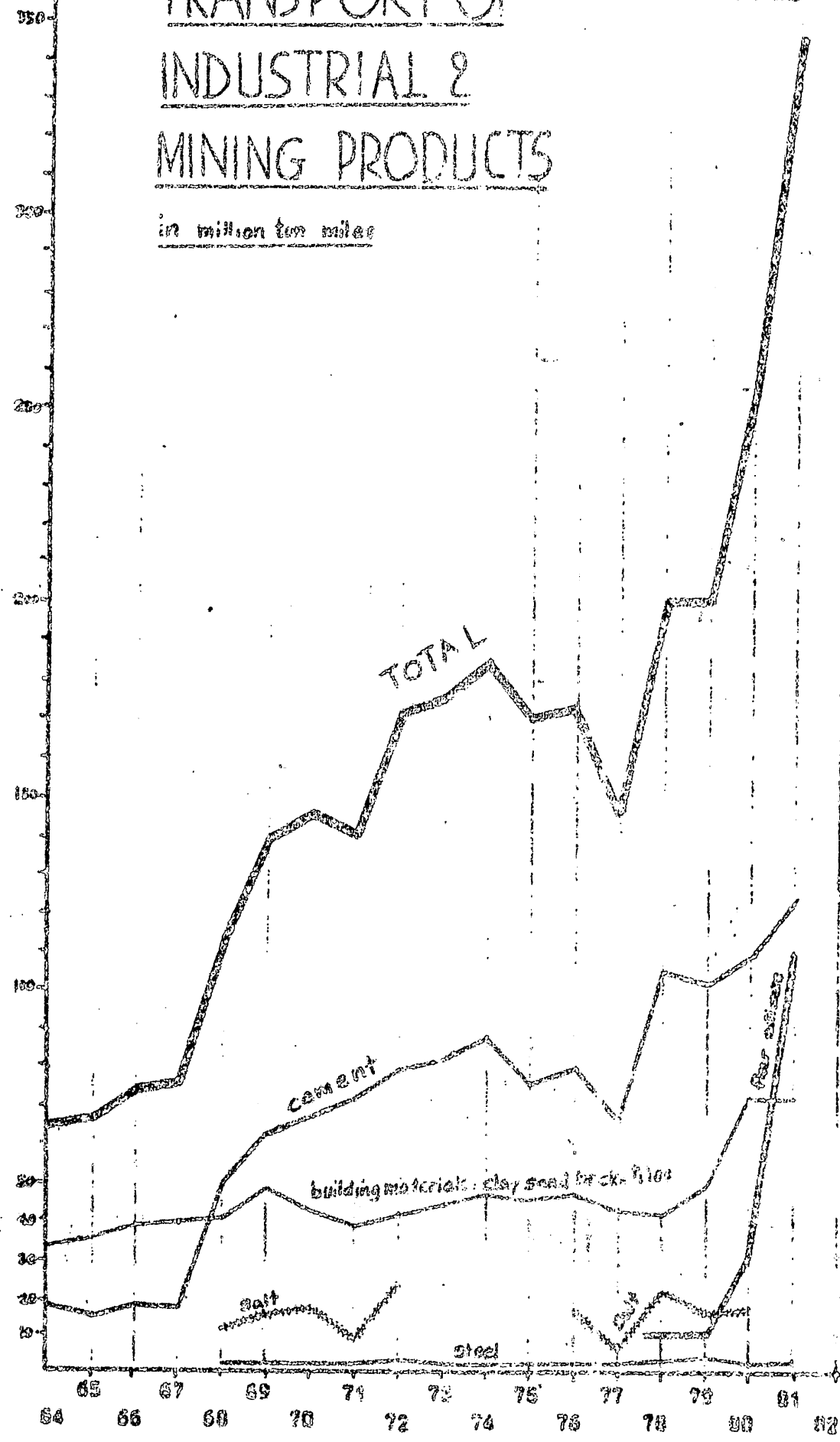
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TRANSPORT SECTOR STUDY

GRAPH 4

TRANSPORT OF INDUSTRIAL & MINING PRODUCTS

in million ton miles



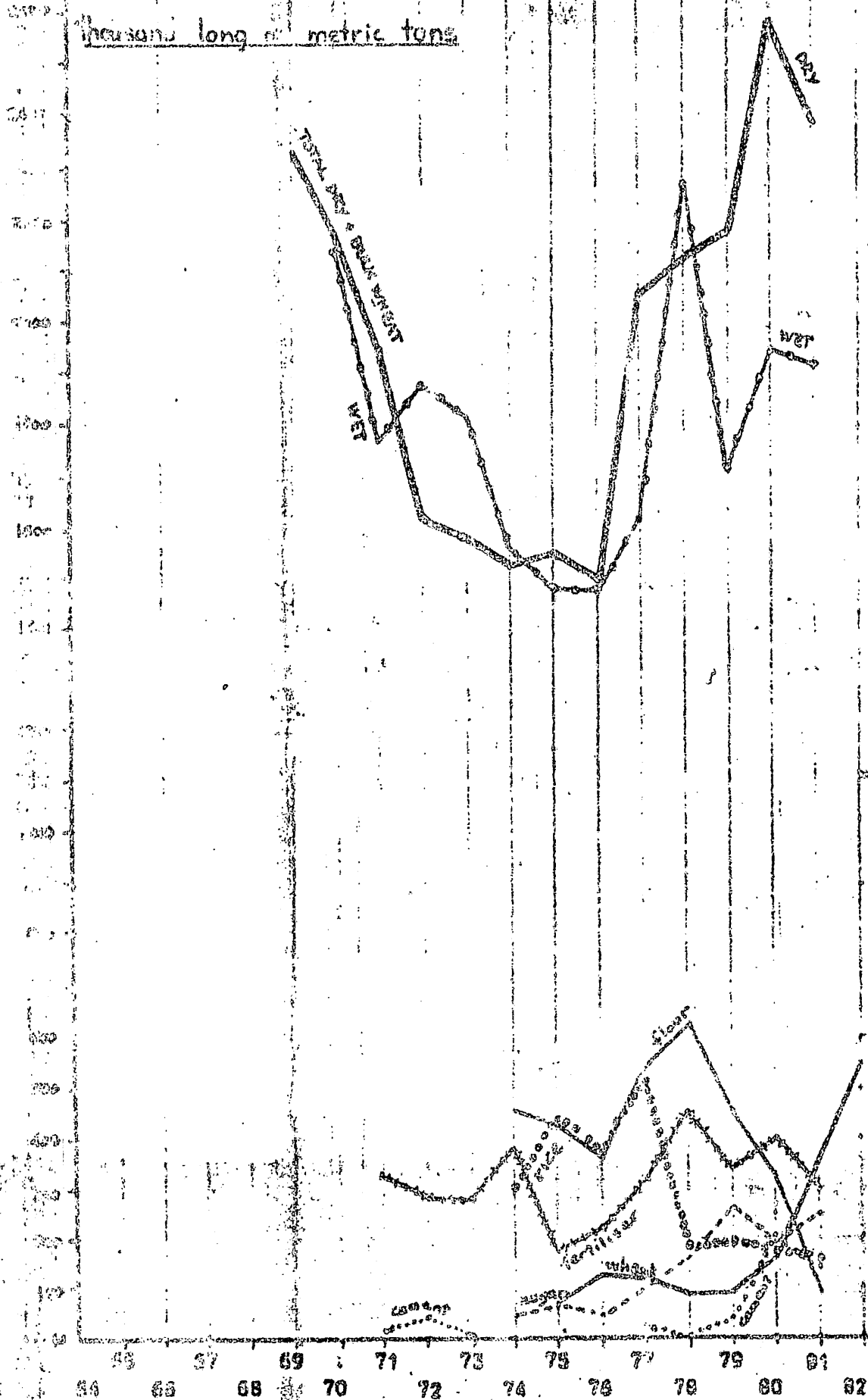
SOURCE based on Table 4.

TRANSPORT SECTOR STUDY

Graph 5

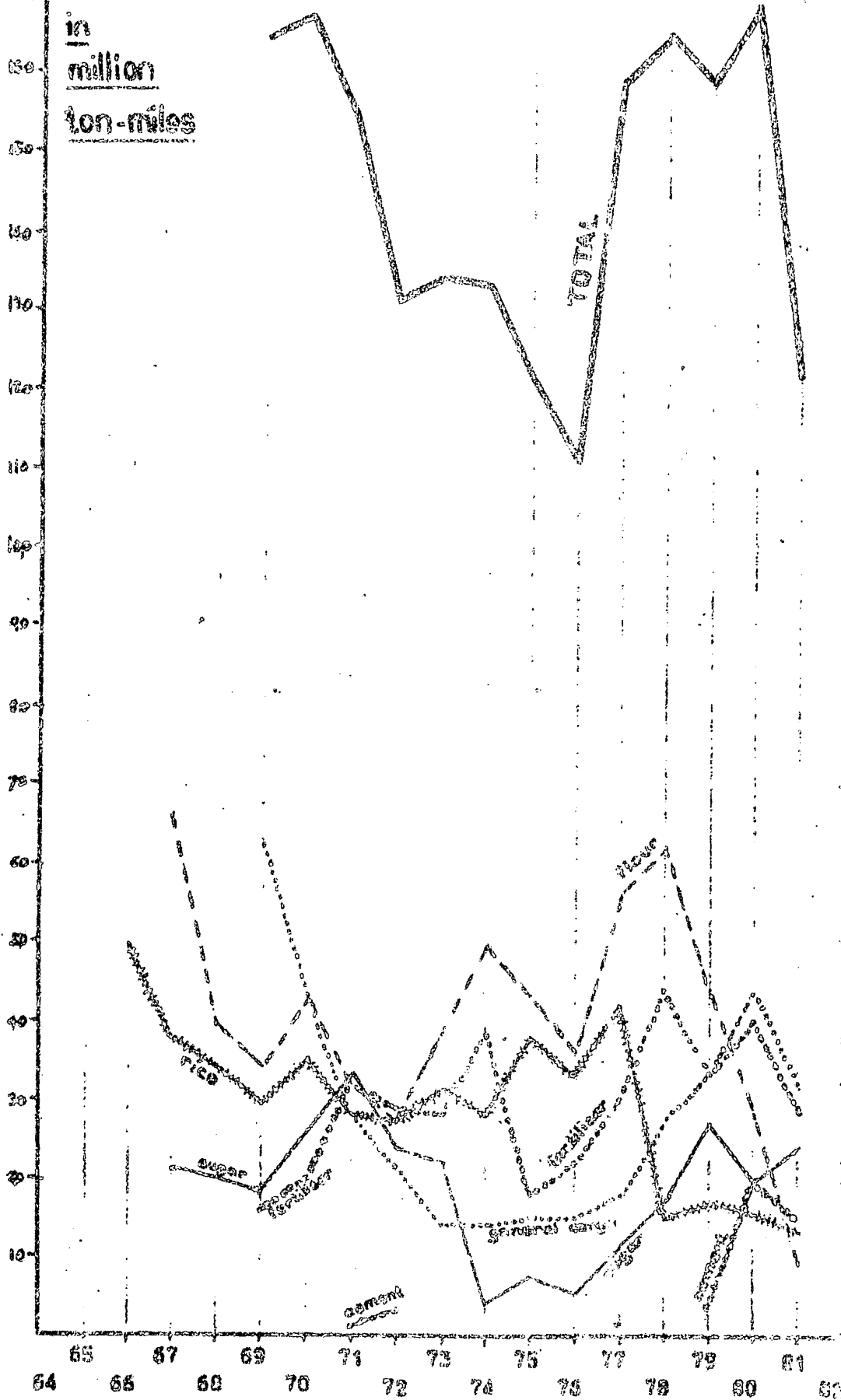
IMPORTS - ALL PORTS

thousands long or metric tons



SOURCE Based on Table 5

TRANSPORT OF DRY CARGO IMPORTS



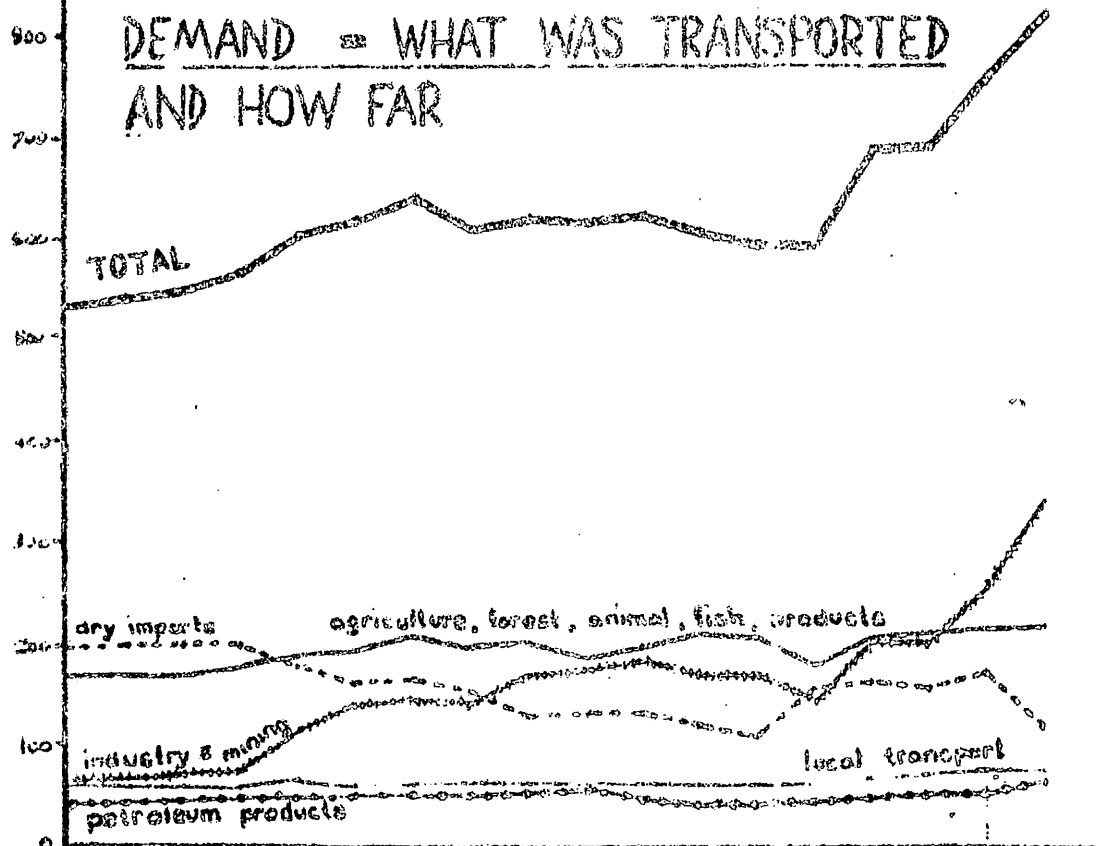
SOURCE based on Table 9

GOODS TRANSPORT DEMAND & SUPPLY

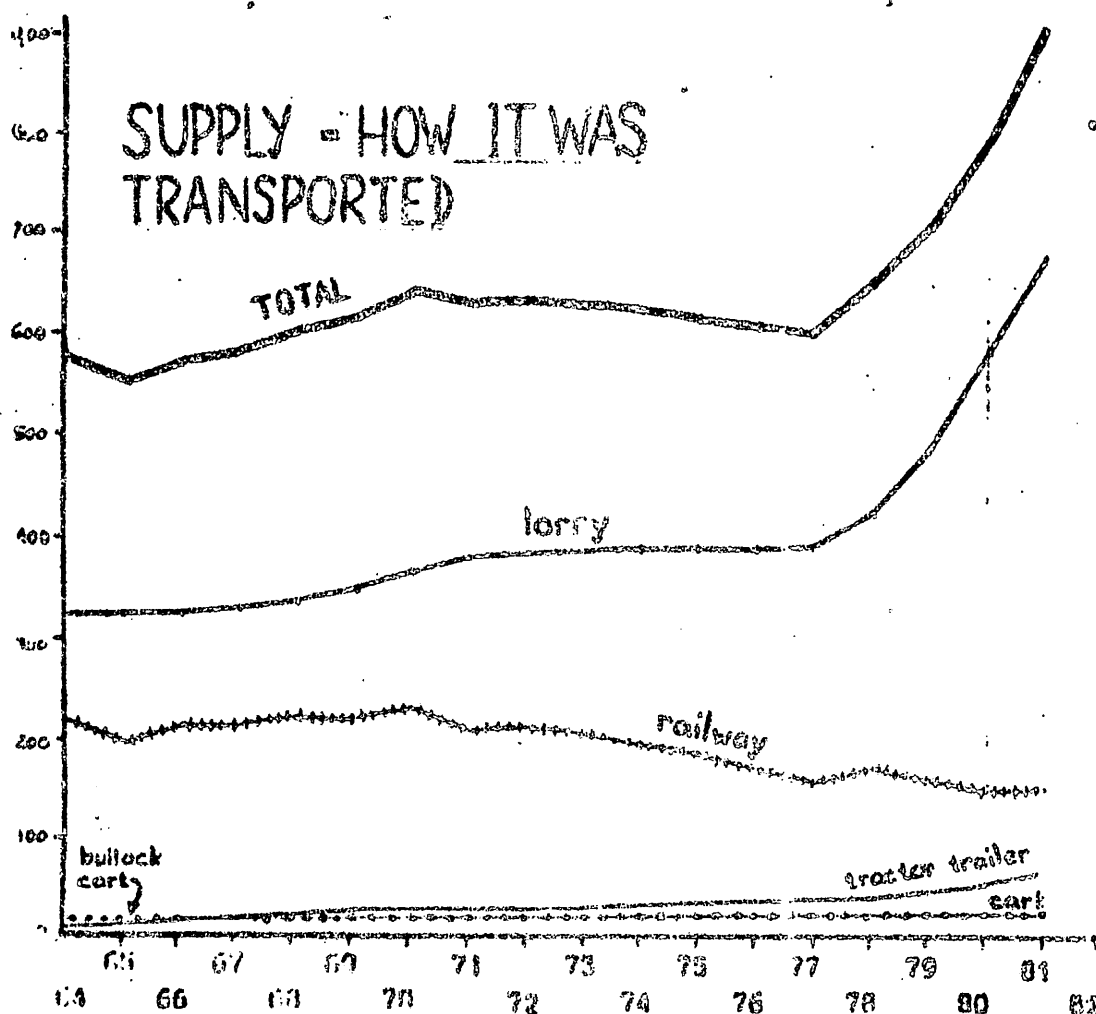
GRAPH 7

in million ton-miles

DEMAND = WHAT WAS TRANSPORTED
AND HOW FAR



SUPPLY = HOW IT WAS
TRANSPORTED



SOURCE based on estimates developed in Tables 1 to 9
and summarised in Table 10. The "discrepancy" between
the 2 totals is discussed in paras 5.3 and 5.4

TRANSPORT PLANNING AND RESEARCH
IN DEVELOPING COUNTRIES
ARE THESE NEEDED IN SRI LANKA?

By

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Transport Planning and Research functions are now well established procedures in developed countries. This paper attempts to raise the question of their relevance to developing economies particularly with reference to the Sri Lankan context.

The paper examines their relationship to the urban and rural sectors, the impact on energy conservation, the development of the infrastructure, traffic engineering and safety, increasing the efficiency of systems operations and accelerating the transfer of technology.

Transport Research, its objectives, its development, its scope for application in Sri Lanka are discussed. A number of issues relevant to the current situation in Lanka are raised.

TRANSPORT PLANNING AND RESEARCH

IN DEVELOPING COUNTRIES

ARE THESE NEEDED IN SRI LANKA?

1. INTRODUCTION

1.1. Transport forms an essential service factor in the development of a country. In inducing economic growth in increasing employment opportunities, in promoting social welfare and in raising the standards of living its role is well recognized. In developed countries it is associated with the performance of major industries and employment, in vehicle manufacture, in the refining of fossil fuel and its by-products and in the manufacture of transportation equipment.

1.2 In some developing countries this importance has been understood by the states and suitable policies are being evolved. But in others its catalytic role is not yet recognized. Perhaps its impact is felt occasionally as in times of national disaster or when bureaucrats are trapped in traffic jams.

1.3 The place of Transport Planning and Research is less apparent and understood. I shall attempt to discuss their functions and as to whether these are needed under the following application.

2.1.3 Answers to these and many other questions are important in both spatial and transport planning, in urban areas. It is at this stage that the transport planner can determine and make a additional assessment of transport needs in an area.

2.1.4 In this country the greater number of urban areas are in the south-west sector where most of the roads, railways, port facilities, air ports and industries are located and which have resulted in severe strains on the services. Townships of over 2000 people have increased from 90 (1963) to 131 (1984). To service these local road systems have to evolve. The towns in the mid-range are congested. What have we done? We have constructed by-passes - Panadura, Ambalangoda, Matara, etc. and plan to continue the practices that they have not served the purpose for which they were meant, but they have contributed only to increase the urban area. Must we continue the old planning practices? Should we continue to repeat the same mistakes? Could we not research into practices and innovate?

2.1.5 What is the form and shape of the urban areas we wish to leave for our children? How will these be distributed? Where and how will they be housed? Where and what type of industrial and commercial activities will spring up in these urban areas?

1. Planning
2. Infrastructure
3. Traffic and Safety
4. Systems Operation
5. Transfer of Technology
6. Transport Research

2.0 PLANNING

2.1 Urban Sector

2.1.1 The inter-dependence of land-use and transport is fairly well understood. In this relationship, people and where they live and work are very important factors. Access to such places and ways of getting to them are features which keep the urban scene vibrant. What work people do, where they do it, what incomes they earn and how they are disposed of and the manner they travel have direct bearing on the arrangement of spatial patterns and become powerful determinants of transport.

2.1.2 We know very little of the travel characteristics of our people who go to work, to shop, for business or recreation etc. What category of people contribute most to traffic congestion, to parking problems? At what level of income will they change from the use of public transport or walking, to the use of the cycle? In short, what are the relationships of trip making to income levels, employment and residence?

2.1.6 In finding answers to these questions it is often the present practice to complete the urban plans and design first and incorporate somehow the transport ingredient later. Perhaps this is due to a lack of trained personnel in transportation. Nevertheless this practice unfortunately bring various concerns into conflict. It is more desirable to develop urban and transport plans from the very concern stage of land-use distribution. This will allow accessibility patterns and mobility levels and their distributional affects on different groups on the young and the old, the working and non-working, the rich and the poor etc. to be evaluated.

2.1.7 Our planners still continue to think of ribbon development as the main form in the formulation of urban schemes. The Galle Road is one such area when problems are developing compounding the serious transport situation.

2.1.8 What is important for the planners to realize is that there are no ideal solutions to the practical problems and at that only one solution. There can be several options. A range of alternatives are possible. This consideration is particularly important in our context as a developing nation with limitations in resources and capacities.

2.2 Rural Sector

2.2.1 In Sri Lanka 60% of the families earn less than Rs.300 per month. The rural population is

predominant and this has hovered around 80% during the last couple of years. On the other hand, we find 1/3 of the people living on 2/3 of the land where population densities are below 300 per square mile. It is almost entirely in this area that the massive Mahaweli development schemes are located, where nearly a 1,000,000 people are to be settled on about a 1,000,000 acres of land.

2.2.2 With the intensified construction programme we are entering a very decisive phase in human settlements and rural sector developments. In this situation a distinguishable hierarchy of roads within the development region is essential from both functional and administrative angles. The extent and scope of the road network and the location of appropriate links are far more important than the construction of a few superior quality isolated limbs.

2.2.3 It is essential to consider the modes of transport, vehicle types, maximum axle loads, gross vehicle weights which have to operate in this region. We have to investigate and adopt suitable standards of design and appropriate construction techniques. What levels of service should we provide with our limited resources to suit welfare facilities, extension work etc. to bring the benefits of modern civilization within easy reach of the rural people - health care, schooling, shopping, recreation, etc?

2.2.4 The bullock cart is still with us and will, in all probability continue in a modified form. The two-wheeled tractor is being used extensively for a multiplicity of purposes. The cycle is being increasingly utilized both for person as well as goods movement. Other intermediate forms of transport in the form of connected buses, vans, tractors, are developing. Should we continue to use the big buses on rural roads not meant to carry them? Should we not design the vehicle to suit the type of road and our economy? What is the type of vehicle suited to the farm track for the haulage of seeds, fertilizer and farm produce - a modified cart, a tandem bicycle?

2.3

Energy Use

2.3.1 The South and South-Asian Region contains the largest proportion of the poor population in the world - approximately 400 million people and 90% of the poverty population. They share about 8% of the per capita income and use 17% per capita energy in relation to the world average.

2.3.3 The consumption of oil in 1978 in the Western world and Japan was 65% and the U.S.S.R. 13.48%. Together they accounted for 78.48%. In the whole of Asia consumed only 3.2%.

2.3.3 Sri Lanka imported approximately 12 million barrels of oil a year from 1970 to 1979. But the cost of

this oil rose from 21.89 to 149.89 million U.S. dollars during this period.

2.3.4 The fuel oil energy demand and distribution can be seen from table 1 below:

<u>Table 1</u>	
<u>Sector</u>	<u>Per cent</u>
Transport	50
Domestic & Commercial	30
Industry	20
Total	100

Thus 30% of the fuel oil is consumed by transport operations. The cost of this imported fuel amounts to 95% of the total export earnings of the country. The cost of fuel for transport is about 15% of export earnings.

3.3.5 Vehicle imports have risen sharply from 1961 to 1980 an increase of 137%. (See Table 2).

* Vehicle Registration

<u>Year</u>	<u>Vehicle Registration</u>
1961	192,239
1976	199,690
1980	337,382

* Department of Census and Statistics.

The greater proportion of vehicles registered are in the Colombo region. This proportion has increased gradually to over 60% by 1979.

Comparative Growth of Vehicles

In the Colombo Region

<u>Year</u>	<u>Colombo District</u>	<u>Western Province</u>	<u>All Island</u>
1961	99.2	-	100
1975	52.7	56.2	100
1978	55.8	59.0	100
1979	61.2	63.9	100

2.3.6 Though car ownership did not improve much from 6.8 per 1000 persons in 1975 to 9 per 1000 by 1980, yet this is the highest rate in the South Asian Region (See Table 3).

<u>Country</u>	<u>Passenger Cars per 1000 of population (1975)</u>

Afghanistan	3.0
Bangladesh	0.4
Burma	1.2
India	1.2
Nepal	-
Pakistan	2.8
Sri Lanka	6.8

2.3.7 On a typical day in 1961, 82,140 vehicles entered/left the city limits transporting approximately 400,000 persons. In 1980, after 20 years while the vehicles transporting increased by nearly 60% 139,390 per day the people entering/leaving the city increased to 1,280,000. The most significant feature is that 11% of the persons were transported by 40% of vehicles (cars); 82% by 15% of vehicles

(buses), nearly 19% by cycles and the rest by other vehicles.

Traffic Flow per day at the City Limits

Vehicle Type	Year 1961	Year 1980	% of People transported	% of vehicles
Cars	481,475	55,691	10.04	39.05
Buses	7,128	21,026	81.88	15.09
Heavy Lorries	7,520	13,501	2.10	9.69
Light Lorries	3,942	5,882	1.15	4.22
Motor Cycles	5,075	16,881	2.06	12.01
Cycles	10,000	24,390	1.97	18.94
Total	82,140	139,390	100	100

2.3.8 It should now be clear that it is the use of the car that brings the most congestion at the highest cost particularly in travel to work. This entails heavy street parking, high accidents and heavy vehicle operating costs not only for cars but for other vehicles also.

2.3.9 It is therefore, evident that personal transport has to be reduced and mass transport increased if meaningful reduction and control of energy usage is to be established. Adequate supplies of electrical energy will probably be available with the commissioning of power complexes at Kotmale, Victoria and Randenigala. Moreover, the electrical power requirements for transport by rail are quite small compared to other industrial uses. But the savings in

fuel oil will be substantial if mileage of bus passengers are transferred to rail travel. Since it takes about 4 to 5 years for planning and implementation of such a major scheme, should we not initiate the preparation of a proper transport plan for the city?

3.0

Infrastructure

3.1 Of the transport infrastructure the more important are the roads, harbours and airports. The railroads have remained practically unchanged while the utilization of the canal system is little. Both port and airport infrastructure are being developed under foreign assistance.

3.2 The Highways Department has under its charge 25,382 (1981) kilo meters of roads. The national and provincial roads constitute approximately 30% and carry the most traffic. However, the spread of the rest of the roads in the country is extensive. The municipal, urban and town roads extend for 14,254 kilometres, while there are 47,133 (1979) kilo metres of millage roads. Furthermore, there are several hundreds of kilo metres of roads maintained by other agencies. The performance of the secondary rural road system is therefore, very important as 80% of the population live in this area.

3.3 Our road system was not designed to carry the present day 40 ton carriers. Consequently, the kilo meters

of poor riding surface and the number of accidents are increasing and less obviously the damages to vehicles. We therefore, need to develop suitable geometric design criteria for our environment, structural designs and the use of road building materials. A certain amount of work is being done in the Highways Department. But this is not enough. We need to strengthen the technical staff and the funds allowed for such work while allowing full scale experimental work under controlled conditions.

4.0

Traffic and Safety

4.1

In this area the more important is the Urban Sector. Except for the Police Department which is more concerned with regulating speeds, collection of accident data and routine traffic control no systematic studies are conducted.

4.2

The primary aim here is to find ways and means of increasing traffic capacity of roads and junctions, minimize interruptions to traffic flow, reduce vehicle and pedestrian delays and ensure the safety of vehicles and pedestrians.

4.3

Traffic engineering and management are perhaps the most important areas of activity. We should concentrate on this as they will bring the largest net returns. Suitable continuing studies have to be conducted and techniques and skills.

developed. For this purpose scientific and engineering background are necessary.

- 4.3.1 To assess the performance characteristics of varied types of vehicles in use on urban streets for driver training and for accident analysis and pedestrian safety and to find methods to optimize available infrastructure and for the introduction of various traffic control devices require a multi-disciplinary approach.

- 4.4 Apparently there is no such approach at present, neither is there an Urban Traffic and Transport Policy spelt out nor an organization taking responsibility for Traffic and Transportation in the Urban Area. The Urban Development Authority, Department of Highways, Colombo Municipality, the Police Department carry out ad hoc studies in relation to their immediate needs. This appears to be the main cause for the poor performance in Traffic Planning and Safety operations and the difficulties faced in solving the problems of city congestion, parking etc.

5.0 Systems and Operations

- 5.1 Mass transport is managed by the bus and rail services. Until recently passenger road transport was run entirely by the state, but now the private sector has taken over a substantial proportion of operations. Meanwhile, private

bus imports rose from 1,117 (1975) to 5,757 in 1980.

5.2 In the rural sector the bus is sometimes the only mode of travel. The ratio of buses to the population was 0.9/1000 in 1975 and 15/1000 in 1980. These values are relatively low when compared to those in developed countries where the greater proportion of travel is by car.

5.3 Goods, traffic growth has been particularly intensive in recent years. Lorry imports increased from 38,593 in 1975, ^{to} 60,535 in 1980. What is significant is that these vehicles are of increasing weight and load carrying capacities. With the development of the Port of Colombo and the intensification of other construction programmes in the country the number of long haul trailers and container carrying vehicles have grown rapidly.

5.4 A facility complementary to these operations is the provision of terminal facilities, warehousing and parking. Inter-city services - buses, passenger coaches, trucks - find parking facilities poorly organized and inadequate with practically no terminal facilities.

5.5 We had several commissions on transport appointed to study the workings of various modes from time to time. But invariably they were

made when problems became critical and assumed proportions which could no longer be ignored. After all these years we have not yet learnt to look comprehensively at the entire transport sector.

- 5.6 What type of transport systems are suitable for our social and economic needs? How can we improve the performance of the public transport operations? In what way can we best co-ordinate the bus-rail services as has been done so effectively in a city such as Toronto? What limits should we set in assessing environmental impacts in relation to social and economic needs? Could we not bring new systems like electric tramways into operation using poorly utilized rail-road, as the Kelani Valley Line?

6.0' Transfer of Technology

- 6.1 We have had generous assistance in foreign aid to train large numbers of our people in various disciplines since the commencement of the Colombo Plan. We have also had large numbers of foreign experts, consultants and advisers working on various projects. What are the benefits we have got after 30 years? How many of the people trained are in the service of the country? How much of knowledge, techniques, practices have actually been transferred and adapted?

- 6.2 In the road transport sector two important decisions were made and carried out with U.S. Aid in 1961.

1. The establishment of a Road Research Laboratory

2. The creation of a Division of Traffic and Planning.

They were created within the former Department of Public Works. Their aim was to enhance the social and economic development by the transfer of necessary skills and for Sri Lanka to develop a transportation system adequate for modern conditions.

6.3 What actually happened? A number of persons were trained and the sections equipped? But both divisions were not developed fully as it should have been done nor fully utilized. The bureaucracy was not willing to accept the need to develop nor were they able to comprehend or appreciate the conditions which one would be facing today. The net result has been that most of the trained staff in transport left the country or have taken to work in other disciplines as the work in this sector was neither satisfying nor remunerative. Presently not even a handful are in the country.

6.4 Transport studies take fair length of time and are relatively costly. It looks that in the near future we will be compelled to seek foreign assistance in funds and experts to find solutions to our transport problems and train our people in skills needed. Perhaps there is yet time. Urgent and important decisions will have to be made in the immediate future if we are to save the situation.

7.1 What is Research? It is the process by which understanding or new knowledge of existing processes is obtained, how that information could be modified, and how to make rational predictions and evolve new approaches and systems. There is problem identification, observation and measurement, the analysis of data and objective and rational predictions and conclusions.

7.2 Basic research in transport - the attempt to find knowledge for its own sake - is small. The greatest area is in the application of mathematical, physical, economic and social theories and methods and engineering techniques in the planning, design, construction and maintenance of transport facilities for the movement of goods and people by land, sea and air.

7.3 Transport is affected by and affects the social and economic situation. The purpose of research is to respond to these conditions. In our country road and rail transport is more significant. Sea transport has been important from ancient times and is still a significant come back. Air transport is making inroads into the international arena. In both urban and rural sectors residential, industrial and commercial locations are making important changes in movement patterns.

7.3 Transport Research have two objectives.

1. To aid in the maintenance of existing systems, optimize their use, innovate at minimum cost

and bring about changes to accommodate expected future growth.

2. To aid in policy formulation and implementation to assess what is required, increase the level of understanding of problem areas and advice when to make these changes.

Hence the research will be problem-oriented or relate to policy decisions. It is necessary, however, to realize that it cannot provide of the shelf answers. It must be a continuing activity. Since the greatest applications are in the Public sector the state has to provide steady and increasing support if useful information and solutions are required for our vexed problems.

7.4 Transport policies have long lasting and wide spread effects on a broad spectrum of living. They have for long been guided by people's opinions. There are more commission reports than studies done in this area. Perhaps due to this lack of studies we have not been able to identify and anticipate the key problems in transport. Consequently we have not formulated policies for co-ordination of different transport modes and develop overall strategies. While the aim of research is to provide useful information and advice to aid policy formulation it is important to remember that in so doing scientific integrity and independence should be preserved.

7.5 Generally transportation studies carried out in developing countries are by foreign consultants often financed under aid projects. These are frequently sophisticated and costly. The recommendations are often not implemented

and therefore appear to serve little purpose. This is probably due to two reasons. The personnel who come for such work do not understand the patterns of social changes taking place, the educational levels, cultural background and varying political structures. Secondly, it is the lack of basic data - inventories, to travel, patterns characteristics of the transport systems and socio-economic indicators - which are a hindrance to the application of mathematical modelling and computer techniques.

7.6 It is because of these factors that the scientific community in this country urged the Government to set up a Centre for Transport Research several years ago. The prime objective was to conduct research in a co-ordinated, multi-modal, multi-disciplinary way making maximum use of resource personnel in the country. The Government responded and took the initial steps to establish such an Institution. It provided the funds for two years.

Thereafter however, funds were not provided and interest appears to have lagged. The importance of such an agency was brought to the attention of the government again. Now nothing more is known. If it functioned it would have helped us by now to have a group of people trained in new skills and techniques and we would have been in a position to undertake our own work with a minimum of foreign expertise.

7.7 At this stage it would be appropriate to mention the quantum of funds spent on research in the transport sector. The National R & D co-efficient in 1975 was 0.205 per cent

of the G.N.P. In absolute terms Rs.45.1 million was expended Research expenditure on transport and communication was relatively insignificant and was only about 2% of National R & D spent in 1975.

7.8 By 1979 we were spending approximately Rs.4000 million on petroleum and Rs.2000 million on motor vehicles and spares imports and reaching over Rs.100 million of vehicles registrations etc. Is it then too much to spend a few millions on Transport Planning and Research to train local staff and provide the facilities to solve our problems in the way best suited to us?

7.9 Perhaps by now you would probably be in a position to find some answers to the theme of this paper.

Is there a need in Sri Lanka for innovative planning, a need to develop methods for improving the infrastructure, a need for training in the skills of traffic management, a need for the better management of operating systems, a need for the increasing the transfer of technology, and a need to develop the skills for Research?

REORGANIZATION OF THE COMMUTER TRAFFIC IN THE
CITY OF COLOMBO

by

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The problems faced by the city of Colombo with regard to traffic during peak hour, demands a reorganization of the commuter traffic system. By far the most important modes of commuter transport today are mass transportation, out of which bus transport plays a major role. To relieve the pressure on public transport system, the Government has allowed institutions and individuals to operate passenger transport services since 1979. As a result, today there is a considerable number of private passenger vehicles of different sizes on the road. From observations and field investigations and also from published data, the researcher has found out that the street capacity in the city of Colombo is inadequate to accommodate the present volume of traffic, specially during the peak hours. Some of the indicators of this situation are the road congestion, consumption of more time and energy on the road, higher incidence of accidents, greater degree of environmental pollution, inconvenience to pedestrians and to the motorists, and greater wear and tear of road surfaces and also vehicles themselves. Hence, the researcher comments on the current peak hour traffic situation in the city of Colombo and make a few suggestions for the reorganization of the commuter traffic in the city of Colombo.

The purpose of this paper is to discuss some considerations that should influence the decisions regarding commuter movement in the city of Colombo.

I will analyse in some detail the pattern of commuter traffic in the city and discuss some of the problems that have arisen with a view towards revealing suitable policy measures to eliminate these conditions.

Every one of us would agree that mass transportation has a major role to play in our socio-economic system. Observations also reveal that road transportation carries the biggest proportion of our passengers. Therefore, substantial recognition should be given to the needs of the population which use it.

Some of the features which should go into the quality of a passenger service are accessibility, convenience, walking distance to the bus halt to and from the origin as well as the destination, punctuality and reliability of service, availability of service in relation to the demand, saving on travel time, safety and comfort of the travellers as well as the other road users such as pedestrians, less psychological strain and less frustration in travel.

Peak hour traffic demand

The economic activities tend to concentrate in places where the frictional cost is minimum and the accessibility is maximum. Thus, in any regional

economy the focal point of the transport network also becomes the centre of gravity of market potential, the area of maximum customer convenience and the most desirable area for the assembly of materials. Hence it becomes the main centre for employment opportunities and it also becomes the centre for the supply of factors of production - labour, capital and management. Labour supply is attracted to the centre by the comparative advantage of consumption, opportunity and social conditions. Similarly, the concentration of opportunities attracts entrepreneurial skills. This concentration of activities resulting from desire to minimize movement costs, may generate further growth. Development induced by the multiplier effect in the process of economic growth largely takes place at existing nodes; and this growth would be accelerated further by the expansion of communication and transport, and also by the development of the urban infrastructure. Traffic will be heaviest and will grow most rapidly near this centre.

Colombo represents the main nucleus of economic activities of Sri Lanka. It has the major proportion of the skilled labour force of the island. Added to this the presence of a well developed infrastructure, the location of all important finance and business undertakings, the existence of the major transportation terminals, the availability of the local market, still attract new economic ventures. Hence, Colombo city acts as the most important centre

for providing job opportunities for a major section of the working population of the island.

Thus, one could identify the peak hour demands on transport facilities which are closely related to the administrative, industrial and commercial life of the community. The peak hours, therefore, generally consist of the home to work movements in the morning and work to home movements in the evening. Added to this in Colombo, schools too place an additional burden on the morning peak hour demand.

Moreover, peak hour traffic to the city centre can be broadly divided into two types. One is the traffic especially caused by high concentration of job opportunities at the city; and the other is the transit movement through the centre. The second type of peak traffic can be minimized by supplying tangential roads and ring roads. Colombo Master Plan Project in 1978, has analysed the traffic flow in a few roads within the city centre and has arrived at the conclusion that Galle Road, Sir Chittampalam A Gardiner Mawatha, and D.R.Wijewardena Mawatha carry 50.6% of the traffic but only 22.5% goes direct to the Fort area. This demonstrates the importance of providing separate routes for the transit traffic or for through traffic.

Sri Lanka Central Transport Board bus system

Any transport planner in Sri Lanka would expect, even in future, for the public transport to handle the major proportion of the passenger transport.

Furthermore, one would hope that the buses would transport a bigger share of the passenger traffic. The Colombo Master Plan Project 1978, have estimated that per year 82.2% of the passenger kilometres are handled by the bus transport, and during the peak hour in the city 74.0% of the passenger traffic is transported by bus while only 26.0% of the passenger traffic is transported by the railway. They also had estimated that to provide a reasonably comfortable bus travelling in the city in the immediate future, taking into consideration the existing volume in the passenger kilometres, the number of buses should increase by 2.45 times the existing number.

Private passenger transport.

There had been a sudden growth in demand for passenger traffic since 1978 due to various reasons. The acceleration of economic activity, and the expansion in the field of employment, the increase in the tourist traffic, and the rise in the cost of fuel which limited the use of private vehicles for transport are some of the causes for the increase in the demand for passenger transport. But this demand could not be met by the public sector transport service. Hence, with the intension of relieving the pressure on the public transport system, the Government allowed institutions and individuals to operate passenger transport services in April 1978.

Table 1					
Number of buses on Registers and their percentage Increase					
Buses	1977	1978		1979	
	Total	Total	Increase %	Total	Increase %
SLCTB	12,859	13,465	3.9	14,212	5.5
Private	1,264	1,105	-	3,105	181.0
Buses	1980		1981		
	Total	Increase %	Total	Increase %	
SLCTB	15,000	5.5	15,024	0.1	
Private	5,752	85.2	8,068	40.2	

Source: Transport Statistics in Sri Lanka 1974-1981,
Ministry of Finance and Planning, 1982.

Table 1 shows that the increase in the SLCTB bus fleet over the last five years is very insignificant, whereas the increase in the number of private buses is very high. This implies that during the last five years a notable number of private passenger buses have entered the transport industry. The most outstanding increase in the private passenger vehicle fleet had occurred in 1979 where an increase of 181% over the previous year is recorded.

Although an additional number of vehicles have entered the city roads, the capacity of the roads have not expanded to same proportion. Thus, one has to accept that the capacity of the road system in the city of Colombo, except for one or two instances, is far below than what they were originally designed for.

Comparison between Public and Private sector
passenger transport

In order to understand the magnanimity of the peak hour traffic in the city of Colombo and also to analyse the relative roles played by public and private sector passenger services, a traffic count was undertaken at points which I think as entry points to the Colombo city. The map 1 shows the 11 traffic count points. Traffic counting was carried on during the months of March, April and May 1983. Both in-bound and out-bound traffic were counted. Counting was done by manually and by the type of vehicles. Traffic counting was done during normal working days from 6.00 a.m. - 8.00 p.m. and the counting was recorded every half hour. The complexity of the type of vehicles, especially the passenger vehicles made the observations particularly difficult.

I would like to mention here that I have analysed only bus traffic both private and public during 6.00 a.m. - 9.00 a.m. for this study.

Table 2

In-bound morning passengers Traffic 6.00-9.00 a.m.

Time	SLCTB		PRIVATE		ALL	
	Number	%	Number	%	Number	%
6.00-6.30	449	50.50	440	49.43	889	9.66
6.30-7.00	657	44.84	808	55.15	1465	15.92
7.00-7.30	913	46.11	1067	54.83	1980	21.52
7.30-8.00	895	50.05	893	49.94	1788	19.43
8.00-8.30	657	41.03	944	58.86	1601	17.40
8.30-9.00	560	37.34	916	62.05	1476	16.04
Total	4131	44.90	5068	55.09	9199	100.00

Note: In 1970 CTB had conducted a survey and had arrived at -

1. During a working day ,5.00 a.m.-8.00 p.m.
there had been 5,200 buses and 238,000 passengers entering the city of Colombo.
2. Peak hour at the Municipal Boundary was
7.00 a.m. to 8.00 a.m. and 625 buses and
42,000 passengers enter the city during this
time.

The table 2 and also Figure 1 demonstrate the in-bound morning passenger traffic to the city of Colombo. Table 2 shows that there are 4131 SLCTB buses and 5068 private passenger buses entering the City, between 6.00 a.m. to 9.00 a.m. during a normal working day. Figure 1 illustrates the excess of private buses over SLCTB buses during the same period. This indicates that a bigger number of private passenger

vehicles occupy the roads in the City during the rush hour, causing severe traffic congestion. These buses are not only the cause for traffic congestion but also subjected to the same delays and hold ups as other vehicles, and are also part of them. This means lower speed and a larger amount of exhaust pollutants for bus kilometer. Numerous stops in traffic also result in less dilution of pollutants in the immediate neighbourhood. Although there is an unconsciously accepted theory that the nature always takes care of the products discharged by our transport and industries, when too greater a number of units allow all the products of transport and industry to flow uncontrolled into the environment the effects are unavoidable. However, it is advisable from the point of view of the environmental pollution to limit the number of vehicles which consume petrol on the road at a given time.

Table 3 illustrates the Rank order of entry points to the city based on the morning in-bound passenger traffic. It is interesting to note that most of the traffic in the morning come to the city through Dehiwela bridge from the south, New Kelani bridge and the Victoria bridge from the north, and also through High Level road and through Nagalagam Street. When we analyse the total number of passenger vehicles entering the city in the morning, 62.73% enter through these five points. A bigger proportion of the SLCTB buses - 12.20% - enter the city through Wellampitiya Bridge.

Table 3

Rank order of entry points to the city based on the in-bound
Passenger traffic from 6.00 - 9.00 a.m.

SLCTB			PRIVATE			BOTH		
Rank	Point	%	Rank	Point	%	Rank	Point	%
1	11	15.95	1	3	19.69	1	11	15.72
2	4	12.20	2	11	15.52	2	3	14.62
3	8	10.86	3	1	13.04	3	1	11.86
4	1	10.40	4	2	11.48	4	8	10.90
5	2	9.56	5	8	10.93	5	2	10.62
6	5	8.61	6	10	7.30	6	4	7.82
7	3	8.30	7	6	5.91	7	10	7.07
8	6	7.16	8	7	4.97	8	6	6.48
9	10	6.77	9	9	3.68	9	57	5.68
10	7	6.41	10	4	3.54	10	9	3.68
11	9	<u>3.63</u>	11	5	<u>3.19</u>	11	-	<u>-</u>
		100			100			100

The highest number of both private as well as SLCTB buses - 16% enter the city from the south through Dehiwela Bridge along Galle Road. This infers the heavy concentration of population in the area to the south of the city, and the degree of supply of job opportunities within the city.

The highest number of private buses - 20% - enter the city from the north through New Kelani bridge. This reflects the nature of the land use within the city. Apparently a high concentration of industry and commercial activity is found towards the north of the city. This is further reinforced by the fact that at this point the heaviest inflow of traffic is between 7.00 a.m. - 9.00 a.m., where 84% of the passengers enter the city during this period. The extension of the peak hour upto 9.00 a.m. demonstrates that most of these passengers could be employees in the commercial or private sector where working day starts at 9.00 a.m.

When we consider the in-bound 6.00 a.m. - 9.00 a.m. traffic from all points, the highest number of passenger vehicles - 16% enter the city from the south through Dehiwela bridge. This again illustrates the residential nature of the land-use and the heavy concentration of people in the areas to the south of the city. It also demonstrates that this population finds employment within the city. When we look at the time variation of the peak hour

travel, the highest percentage of the SLCTB buses - 72% enter the city between 6.30 a.m. and 8.00 a.m. This suggests that the larger proportion of the commuters who enter the city are Government employees who are suppose to start work at 8.15 a.m.

The second important entry point to the city for SLCTB buses - 12% - is Wellampitiya whereas for private buses the second largest flow - 16% - enters from the south through Dehiwela bridge. If we look at the time factor of this inflow, at both these entry points the highest concentration of traffic is between 6.30 a.m. and 8.00 a.m.

Table 4 is computed by taking into consideration the highest number of in-bound passenger buses entering at each point within every half hour to locate the actual peak hour in the city of Colombo. This clearly shows that in the city the peak hour is between 7.00 a.m. and 8.30 a.m. for morning passenger traffic. Maps 2,3 and 4 indicate the flow pattern of these morning in-bound passenger traffic. The maps also illustrate the spatial variation of the traffic flow into the city from 6.00 a.m. to 9.00 a.m.

Table 4

Location of the morning peak hour

	1	2	3	4	5	6	7	8	9	10	11
6.00-6.30											
6.30-7.00			p	bs	bs	s	bsp	s	bsp	bp	bsp
7.00-7.30	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp
7.30-8.00	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp
8.00-8.30	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp	bsp
8.30-9.00	bsp	bsp	bs	p	p	sp		bp		s	

Note: b - Both types

s - SLCTB

p - private buses.

Table 5

Estimated number of passengers entering
the city

Time	SLCTB		PRIVATE		BOTH	
	Num- ber	%	Num- ber	%	Num- ber	%
6.00-6.30	33675	70.50	14080	29.48	47755	10.11
6.30-7.00	49275	65.55	25856	34.40	75131	15.91
7.00-7.30	68475	66.75	34144	33.27	102619	21.74
7.30-8.00	67125	70.15	28576	29.85	95701	20.27
8.00-8.30	49275	61.99	30208	38.00	79483	16.83
8.30-9.00	42000	58.89	29312	41.10	71312	15.10
Total	309825	65.65	162176	44.35	472001	100

Assumption: During the rush hour an average SLCTB bus carries 75 and an average private bus carries 32 passengers.

Note: Colombo Master Plan Project has estimated the average number of passengers per SLCTB bus as 70 to 80.

Table 5 shows the estimated number of passengers entering the city from 6.00 a.m. to 9.00 a.m. By 4131 SLCTB buses 309,825 passengers enter the city, while 5068 private buses carry only 162,176 passengers. Out of the total buses entering the city between 6.00 a.m. and 9.00 a.m., 44.90% are SLCTB buses while 55.09% are private buses. On the other hand, the picture formed by the number of estimated passengers is different. 65.65% of the passengers are transported by SLCTB whereas only

34.35% of the passengers entering the city during 6.00 a.m. to 9.00 a.m. are carried by private passenger transport. (Figure 1 and 2), (Table 2 & 5).

Table 6

Number of buses and the passengers entering the city - 7.00-8.30 a.m.

SLCTB				PRIVATE				BOTH	
Bus- es	%	Passen- gers	%	Bus- es	%	Passen- gers	%	Bus- es	Passen- gers
2465	45	184,875	64.55	2904	55	92,928	33.45	5369	277,803

Table 6 gives the total number of buses and also total number of passengers carried during the actual peak hour, that is from 7.00 a.m. to 8.30 a.m., by SLCTB buses and as well as by private buses. Within this one and half hours 2465 SLCTB buses and 2904 private buses enter the city from all entry points. Out of the passengers, 184,875 by SLCTB buses and 92,928 passengers enter the city by private buses. Out of the total number of 5369 buses entering the city, 45% are SLCTB buses but out of the total number of 277,803 passengers who enter the city during this one and half hours SLCTB buses carry as much as 64.55%.

The number of private vehicles entering the city are more than the SLCTB buses although they carry a lesser number of passengers. This is very uneconomical from the national point of view.

Therefore, in order to achieve more fuel economy it is better to utilize only vehicles with a bigger capacity, and limit the use of smaller vehicles for private passenger transport at least during the rush hour.

Railway against buses for commuter traffic

At present although it cannot be established by actual data, the commuter traffic to Colombo will increase further due to expansion of the job opportunities especially in the private sector. Today passenger transport system is composed of a relatively developed bus transport and an underdeveloped railway system.

If we assume that all season ticket travellers are commuters, then we can conclude that in 1980 the average travel distance of a railway commuter is 27.0 kilometers while the average trip length of a bus commuter is 9.1 kilometers. The average distance of a railway trip in 1970 is 13 kilometers while a bus trip is 8 kilometers. There is a tendency for the average trip length of a commuter to increase, as more and more people tend to live away from the city, due to the high rents and also due to the rising cost of living within the city. On the other hand, one can expect the volume of traffic to increase due to the population growth, urban area extension and the expected improvement in living conditions. Hence public transport is of special importance and it can

also act as a means to limit the use of the private car.

Whatever the changes in the bus transport are introduced it is impossible to meet adequately and satisfactorily the demand for commuter traffic at present and also in the near future. Therefore, there is very urgent need for a second system of public transport. A better proposition is to make the underutilized railway system to serve as an alternative means of commuter transport. It has been worked out that the ratio of cost per passenger mile by bus to railway is 3:2. Thus, if steps are taken to divert more commuter passengers to railway, then it also can be a saving on the national expenditure.

An integrated system of commuter transport can be formulated where individual sub-systems of bus and railway are functionally coordinated and integrated. Within the Colombo Municipality the buses should find their origin/destination at a close proximity to the railway stations. The commuters who use the railway to come to the city should be transported to their work places by bus. The fare of the ticket should cover not only the trip by railway but also the trip by bus to the work place within the city. The maximum waiting time for the bus should be on the average of 3-5 minutes.

The traffic frequency in the railway should increase. At present the traffic frequency of the railway varies from 30 minutes to one hour. The maximum interval between railway commuter services should not be more than 8-10 minutes. The train schedules should be strictly adhered to. Electrification of the suburban railway lines could save lot of commuter time and also fuel. Then the construction of double track at least to cover 25 miles radius to run this electric train service would be a necessity.

Some considerations and suggestions

Thus, in the context of the present problems faced by the commuters, the motorists and the pedestrians, I would suggest that all passenger vehicles should be stopped and alight their passengers at the boundaries of the Municipality. There should be bus bays at suitable locations along the Municipal boundary. These bus bays could be designed and located based on a plan worked out, taking into consideration the variables such as the availability of space, the number of work places and also the number of job opportunities. Entering of private cars to the city centre during the rush hour, should be stopped. One has to remember that within the Municipality alone, there is a fair number of vehicles on the road during the peak hour. For individual commuters who use the private cars, car parks should be provided along the boundaries of the Municipality.

Limiting the vehicles in the city centre at least during peak hour would help to conserve fuel. At present one has to drive a minimum of three rounds before one finds a parking space within the city centre especially during the peak hour. Environmental pollution could be minimized. Street capacity could be increased for moving traffic. Pedestrians would be safe on the road. Valuable land which are allocated for parking facilities could be diverted to more economical uses. Strain could be eliminated for the motorists and for other road users.

Connecting these bus bays and car parks there should be a bus service within the Municipal limits to reach any point within the city. In this bus service there could be a single fare or a uniform rate from any origin to any destination within the city. This will reduce ticketless travelling and also checking of tickets would be easier. The frequency of these services should be maintained based on schedules, where the interval between two buses at a given point should not be more than 8 minutes. These buses could be either run by the Colombo Municipality or by SLCTB or by any other private organization. But the Ministry of Transport should lay down the rules and regulations, and also should have frequent and close supervision.

(We may be able re-introduce trolley bus- service but I have not done a detail study of the feasibility of re-introducing trolley bus service to arrive at a conclusion.)

A transport system on these lines would save the cost and time. Cost of fuel, cost of maintaining roads, and cost of administration could be minimized and regularized. Time of the commuters as well as the bus operators could be saved substantially.

There could be added advantages. More competent and responsible drivers could be employed by offering them a higher wage or better incentives to work in this city service. This would reduce the rate of road accidents. Road rules and traffic laws could be maintained better. When there is only one authority or agent responsible for the transport service within the city limits, it is easier for the Ministry of Transport or the Police to conduct frequent tests on the physical and mental aptitudes of the drivers. A system should be introduced where annually or bi-annually the driving capability and the physical fitness of the drivers are reviewed. This in turn will help to maintain the quality of the service. Moreover, jealousy and competition among the bus operators would be completely eliminated, which would also help to reduce the accident rate.

It is very important that the transport planners should pay heed to the degree of road accidents occurring at present. Today it has become the number one killer. Statistics reveal that out of the road accidents the highest number occur in the Colombo city area, where the traffic concentration is highest.

In 1980 out of the total number of accidents occurred in the island, 25.27% is in the Colombo Police Division. Accidents not only incur economic costs but they also incur social costs. Therefore, every effort should be made to reduce the rate of road accidents especially in the Colombo city.

The right to use the road by the pedestrians cannot be ignored completely. Especially during the peak hour there is a heavy flow of pedestrians predominantly at the city centre. Along the streets pedestrian movements must be eliminated fully. Construction of over-head pedestrian crossings can be considered as a sensible idea. Pedestrian under-passes especially in the city centre could be practical. Pedestrian crossings with self-operated traffic lights should be a better proposition. This would reduce the number of accidents and also would provide more capacity on the roads for vehicles. Sidewalks should be provided almost along every roadside and these sidewalks should not be used for other purposes like payment shops.

Pollution of the environment could be minimized. When the responsibility is placed only on one authority, it is much easier to control the technical state of the vehicles. Only roadworthy vehicles could be used, at least within the Municipal limits, which would help to limit the adding of exhaust gases into the city environment.

At present illegal, irresponsible and inconsiderate parking especially during the rush hour within the city centre causes problems like traffic congestion, wasting of time on the road, burning of fuel unnecessarily and causing irritation and strain to the road users. This could be minimized if there are definite parking places in the city. These parking place could be located as off-street parking places. These parking places and also bus halts should be regularly placed within the Municipal limits, based on variables such as job opportunities and strength of work force.

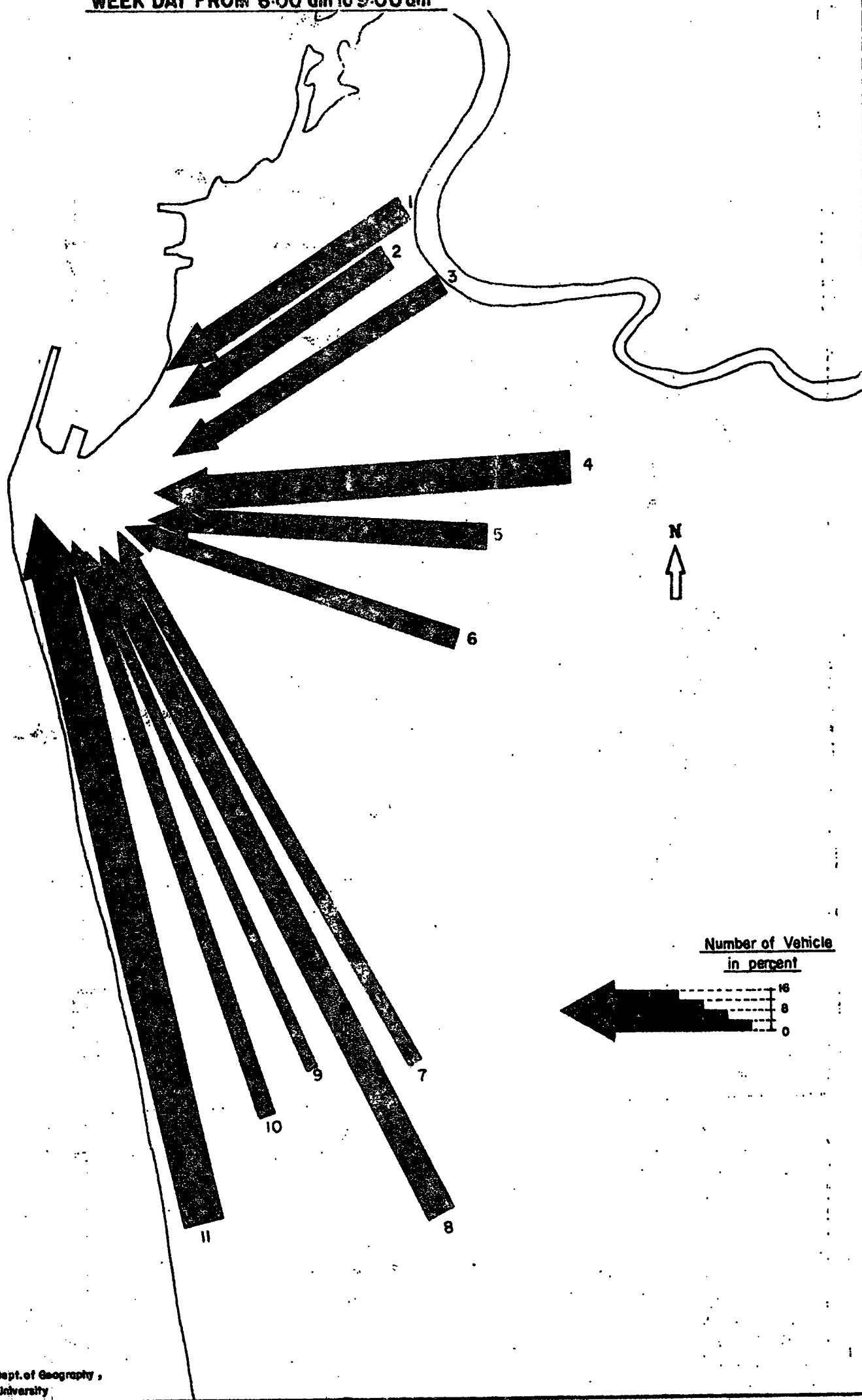
If we limit the number of vehicles on the city roads, while extending a better service to the commuter, it could be less expensive for the authorities to maintain the road network and also the capacity of the roads could be retained at present level without further expansion.

Awareness of simple facts like social consciousness and responsibility must be made to penetrate and dominate daily life and work of not only motorists but everyone who use the road. This awareness must be inculcated partly by means of education at all levels of the educational system, and partly by means of extensive information campaigns directed to the general public.

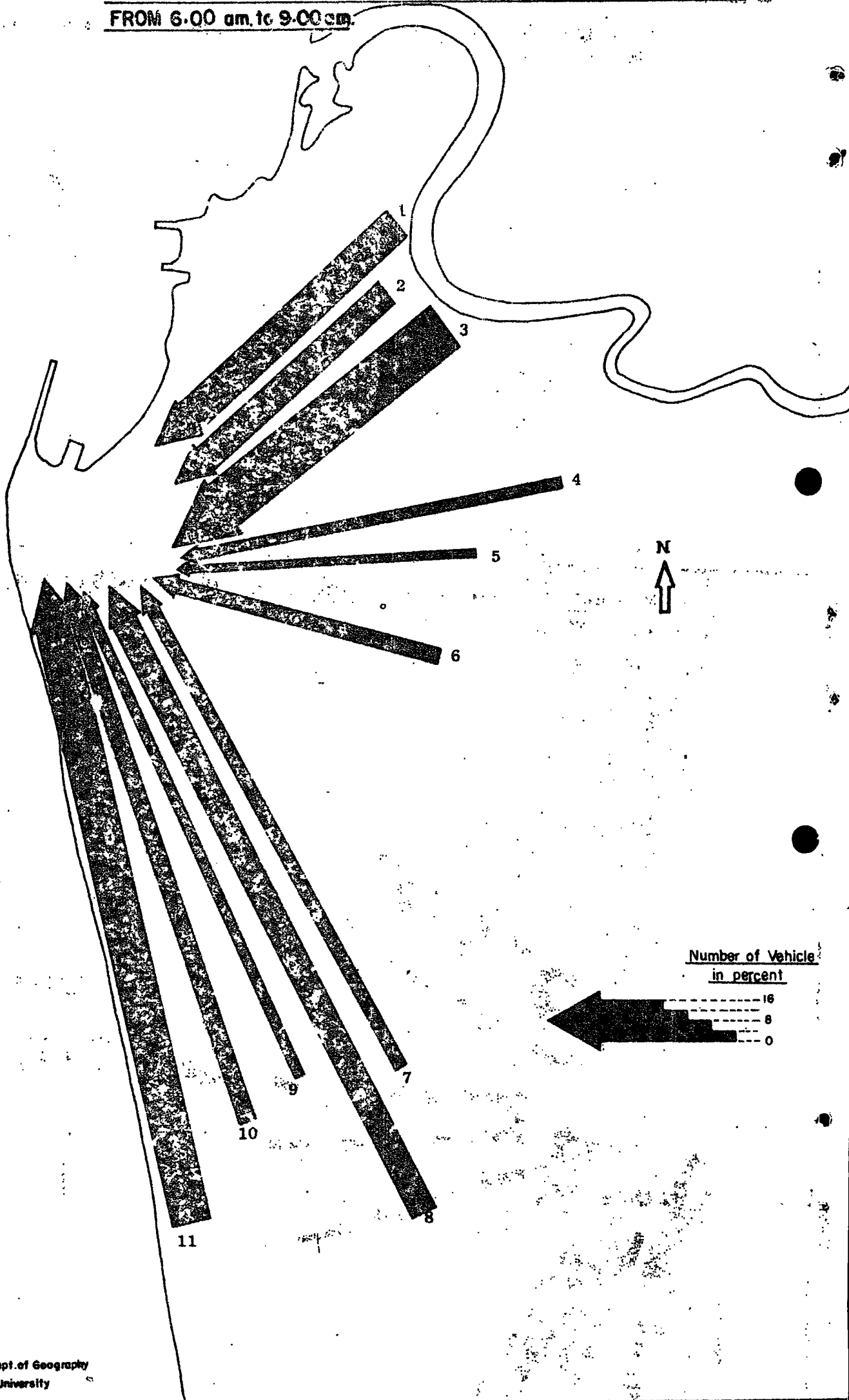
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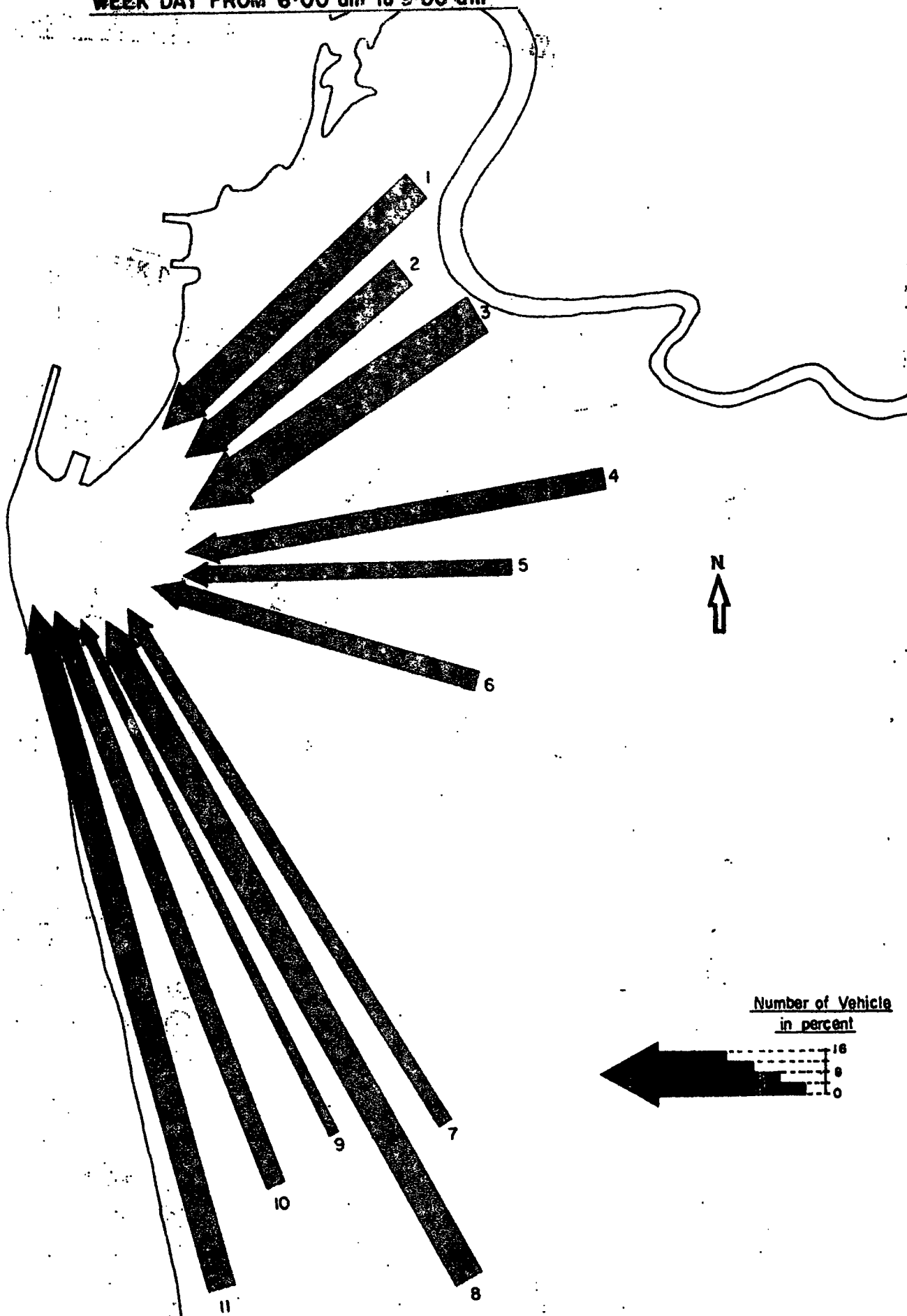
**IN-BOUND SRI LANKA CENTRAL TRANSPORT BOARD BUSES ON A NORMAL
WEEK DAY FROM 6.00 am to 9.00 am**



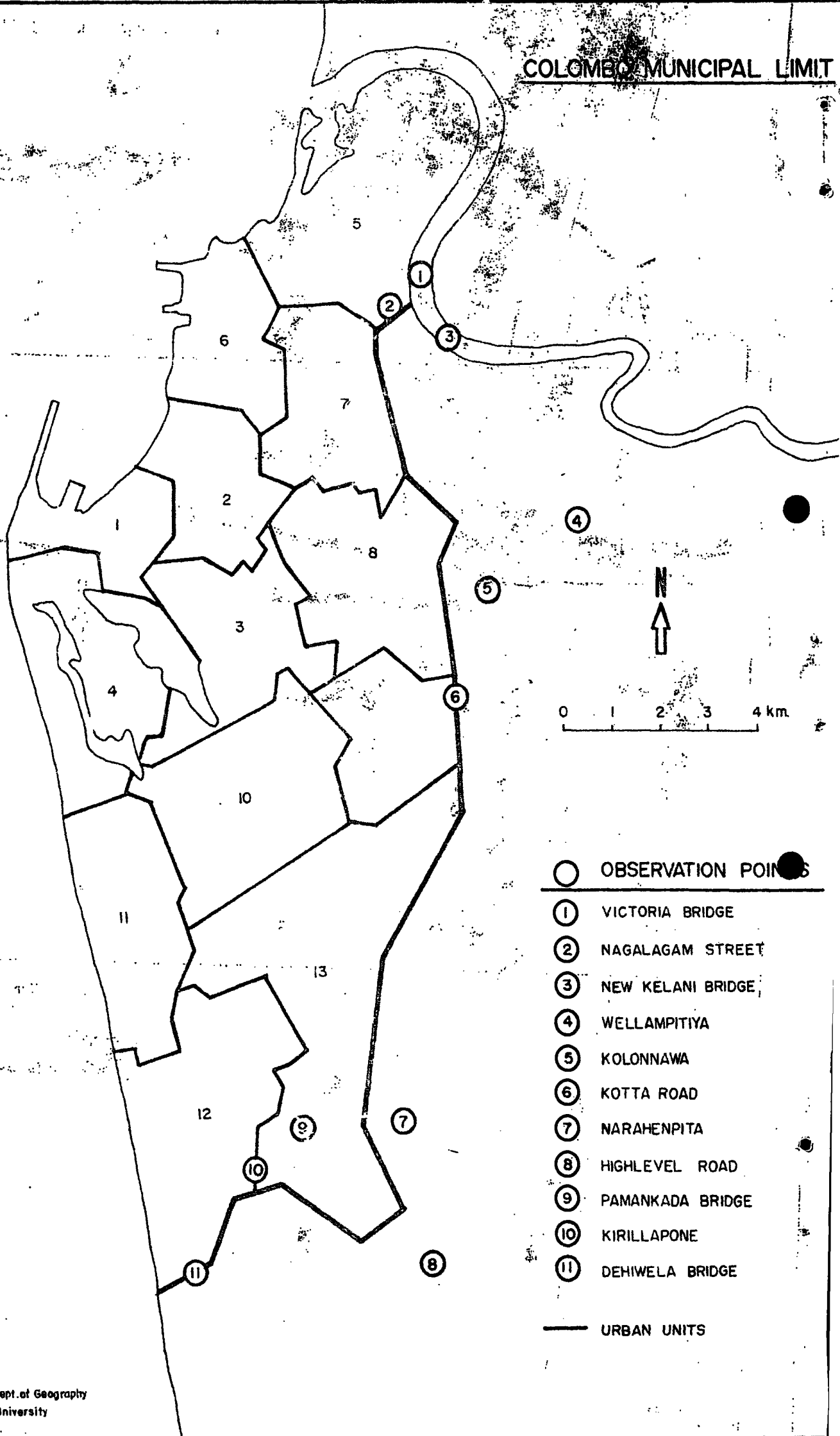
**IN-BOUND PRIVATE PASSENGER BUSES ON A NORMAL WEEK DAY
FROM 6.00 am. to 9.00 am.**



**IN-BOUND PRIVATE PASSENGER BUSES & S.L.C.T.B. BUSES ON A NORMAL
WEEK DAY FROM 6:00 am to 9:00 am**



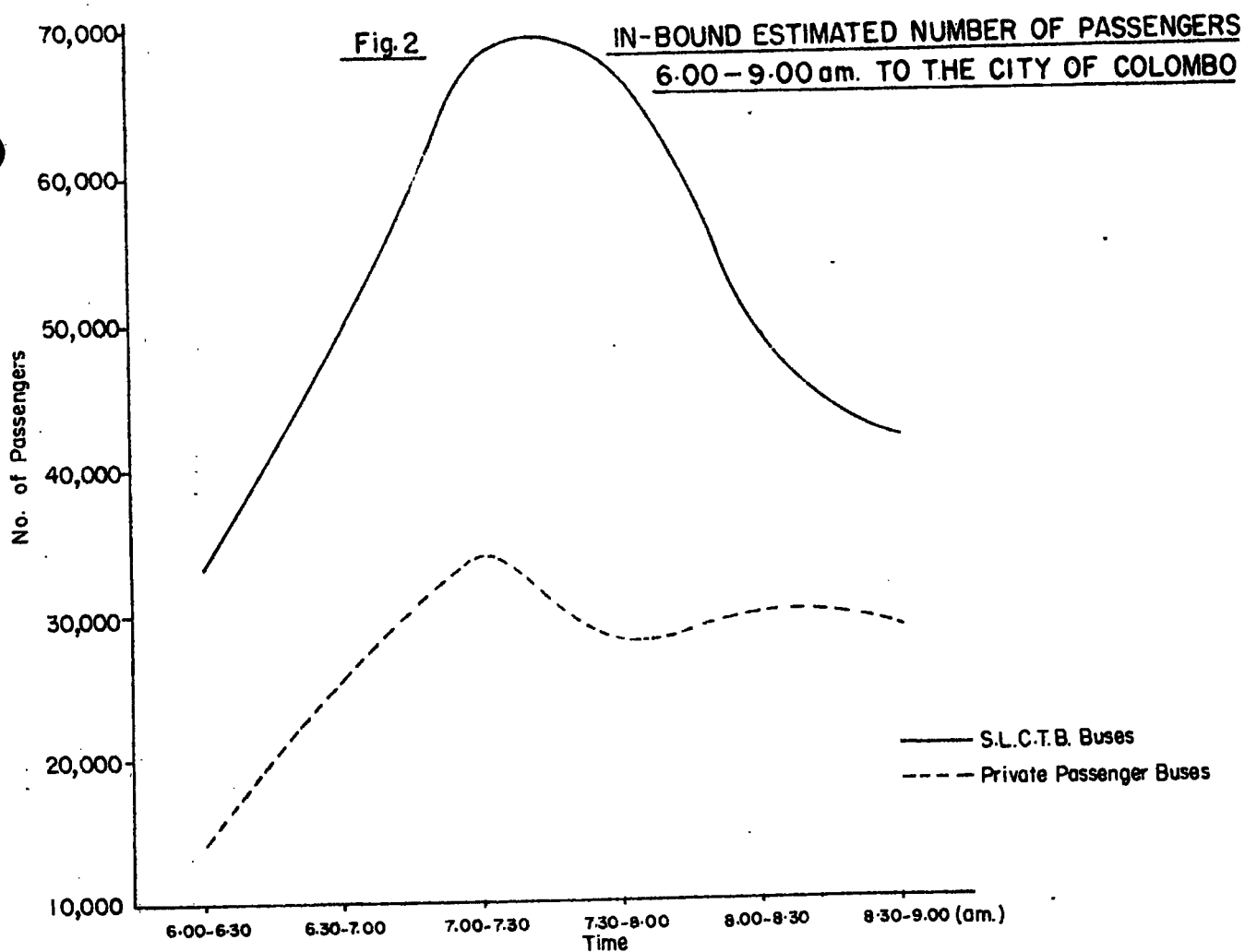
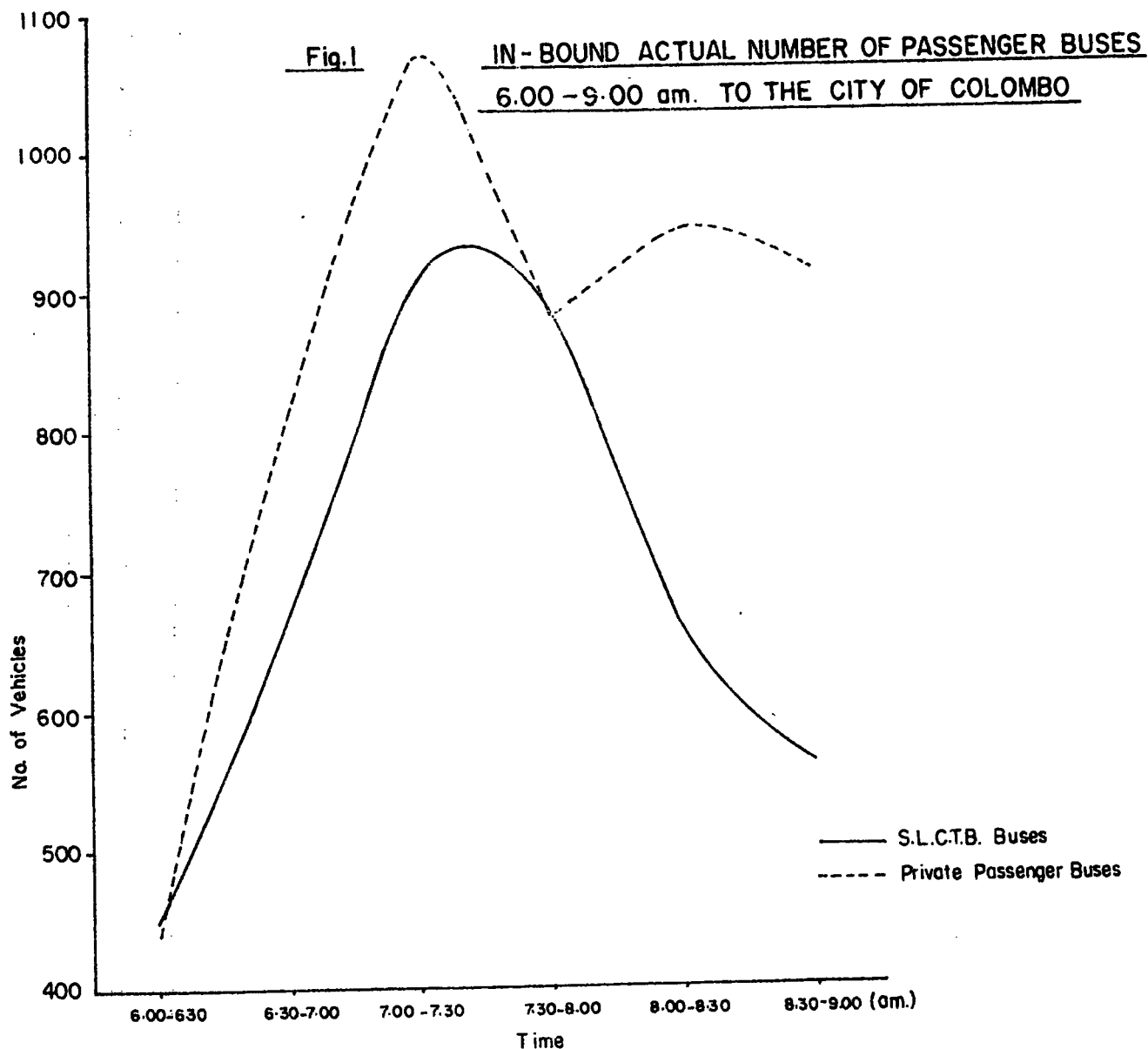
COLOMBO MUNICIPAL LIMIT



○ OBSERVATION POINTS

- ① VICTORIA BRIDGE
- ② NAGALAGAM STREET
- ③ NEW KELANI BRIDGE
- ④ WELLAMPITIYA
- ⑤ KOLONNEWA
- ⑥ KOTTA ROAD
- ⑦ NARAHENPITA
- ⑧ HIGHLEVEL ROAD
- ⑨ PAMANKADA BRIDGE
- ⑩ KIRILLAPONE
- ⑪ DEHIWELA BRIDGE

— URBAN UNITS



APPLICATION OF TRAFFIC ENGINEERING PRINCIPLES IN THE
MANAGEMENT OF TRAFFIC IN COLOMBO-PETTAH CASE STUDY

by

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The Pettah is the central wholesale market place for the island and the retail centre for the city. The concentration of the main rail and bus stations, wholesale and retail markets, the influx of mixed traffic on city routes which converge here and the recent increase in imports of motor vehicles have created undue delays, congestion and confusion in this area.

This plan is not a total solution to the Pettah traffic problems, but is a management plan designed to remove congestion and delays where they are most intense - Olcott Mawatha, Gas Works and 5th Cross Streets. The concepts involved are in disciplining both vehicular and pedestrian traffic, providing adequate and better parking and devising circulation patterns.

Pettah would tend to gradually lose its attractiveness due to mounting congestion and undue delays, with the result that people will go elsewhere. Therefore this is the most opportune time to make considered decisions and if we do not make use of this opportunity we will not have a second chance for decades to come.

SHORT TERM TRAFFIC PLAN FOR PETTAH

1. Pettah - its activities

- 1.1 The most important area of the City of Colombo is the Central Area - the Fort and Pettah. Pettah contains the wholesale market for the whole island and is also the main retail centre for the City. Imported goods are stored and distributed from here while materials for export are also collected. To perform its role and expand its functions, Pettah must retain and stabilize its importance as a commercial centre. Redevelopment of Pettah has therefore been considered a part of the Government's economic policy. A market complex is under construction and several other development projects such as the Lotus Centre and Manning Centre are being actively pursued.

2.0 Pettah traffic

- 2.1 The main highways enter the City from the Colombo Metropolitan area and almost coalesce in the Fort and Pettah. Further the main railway station, the central bus terminal, the wholesale and retail markets are all concentrated on Olcott Mawatha, Gas Works Street, 5th and 4th Cross Streets. (See Fig. 1)
- 2.2 The concentration of the activities has caused acute congestion. There is little discipline among vehicle users and other road users for which situation they are not entirely to blame. The authorities responsible for transportation have not provided road users with both the information and the guidance they need to discipline themselves and conform to appropriate standards. On the other hand enforcement has been poor, delayed and ineffective.

2.3 On the Pettah streets there is a mixture of fast and slow traffic; cars, buses, lorries, motor cycles, pingo carriers, street vendors and pedestrians. Carriageways have been widened to meet perceived greater capacity required. But this widening has been at the expense of the side walks, thus forcing the pedestrians on to the carriageway. Nearly 6 to 8 thousand people use the side walks on Olcott Mawatha per hour during the busy time. Parked vehicles and street vendors have aggravated the situation. Disorganisation is heightened by the absence of lane markings, sign and direction instructions. The paucity of properly located bus stops and pedestrian crossings have contributed to further confusion and the seriousness of accidents. In the City 70% of the injured are pedestrians and 10% pedal cyclists. Of those who lost their lives 50% were pedestrians and 15% pedal cyclists, the majority being the young ones. The increasing use of motor cycles for personal transport has added to these numbers.

2.4 Olcott Mawatha is the most congested of the City streets and carries one of the heaviest volumes of traffic. Between Front Street and Gas Works Street the daily traffic flow is about 28,000 vehicles. The congestion is so intense that on some days the queues of vehicles extend along Lower Chatham Street to York Street in Fort. Due to the proportion of heavy vehicles the effective volumes increase to about 46,000 passenger car units.

per day. During the peak hour this street carries about 1400 cars, 750 buses, 325 lorries, 200 motor cycles and pedal cyclists.

Gas Works Street is heavily used by buses and lorries and the 5th Cross Street almost exclusively by lorries. The increased use of private buses and vans have added to confusion and congestion. During the peak time it takes about 20 to 30 minutes to move from the Lotus Road junction to Gas Works junction on Olcott Mawatha. Those delays represent losses both in vehicle operations and people's valuable time.

2.5 Parking spaces for lorries, private buses, vans and cars are inadequate. Congestion is increased by vehicles circulating on the lookout for vacant parking spaces. The present parking charges are too low in relation to fuel prices and should be increased. However, increasing prices by itself will not relieve the traffic congestion as a large percentage of vehicles are owned by the state, semi-government institutions and the commercial sectors who may pay the higher rates while continuing to use the same facilities.

3.0 The short term plan

3.1 The Urban Development Authority is developing long term plans for solving the problems of traffic congestion in Pettah, but they are associated with land use and redevelopment proposals. The present Urban Development Authority proposals may be considered as a part of a traffic management plan which can be implemented immediately at minimal cost, but which will bring large savings - vehicle operating costs and great benefits to

road users. What is proposed requires minimal expenditure and non-glamorous action like painting street lines and directions, demarcation of parking lots, pedestrian paths and direction boards.

- 3.2 The essence of the strategy adopted involves introducing practices to instill discipline on vehicle operators and pedestrians in clustering transportation activities in suitable locations to minimize energy and time demands, in minimizing pedestrian walking distances and in re-designing vehicle circulation patterns. (see Fig. 2)

The traffic design will ensure

1. better and faster circulation for traffic using Olcott Mawatha, Gas Works and 5th Cross Streets.
2. better parking and immediate access to service areas for lorry operators.
3. concentrated, easily accessible and secure parking for private bus and van operators and hence convenience, easy access and safety for passengers.
4. secure, adequate and easy parking for private cars and motor cycles.
5. more space and better circulation and safety for pedestrians thus reducing potential accidents.
6. better utilization of space allowed to state transport activities.
7. Segregation of traffic and pedestrians to help in maintaining and ensuring better enforcement.

8. increase income for the U.D.A. and the C.M.C. from the operation of vehicle parks.

9. reduction of conflicts, confusion and accidents and creation of a more pleasant and ordered environment.

3.3 The short term plan has its limitations. Modifications of certain operations may be necessary after sometime, but these should not be pushed too far as other complications may arise. Further studies and development of plans for further action will be necessary.

4.0 Losses due to congestion

4.1 It would be both enlightening and helpful to make even an approximate assessment of the losses incurred due to delays and congestion.

4.2 Vehicle operating costs increase with congestion. Passengers suffer congestion through longer travel times, increased waiting and boarding times. Delays due to commercial vehicles increase total costs which would ultimately be reflected in the increase of prices to the consumer. Operational costs of all vehicles increase with increases in stops, delay and congestion.

4.3 Approximately 39,600 motor vehicles of all types use Olcott Mawatha, Front, 4th and 5th Cross Streets during 24 hours of the day (1980). Of these 15,600 use the streets during the 2 hour morning and evening peak times. During this time these vehicles move about 312,000 persons.

4.4 Presently it takes about 20 minutes to move through this area during the peak times. It is assessed that the present vehicle operating costs for a car is Rs. 1.00 per minute. On this basis the rates for heavy vehicles may be taken at least at Rs. 2.00 and Rs. 0.25 for a motor cycle per minute. It is also assumed that the average wage rate of persons transported is Rs. 24.00 per day. On this basis for a 300 day working year the losses incurred are :

Rs. 126.0 million on vehicle operations

Rs. 56.0 million on people's lost time.

4.5 However, if we assume that the vehicles are delayed for 5 minutes each during a half hour of the peak time in the morning and evening the losses are even then

Rs. 16.0 million on vehicle operations

Rs. 7.0 million on people's time

5.4 Loading bays have been allowed as most of the congestion is due to obstruction caused due to loading/unloading operations. About 25 to 30 loading bays are allowed alongside the sidewalks. A rate of Rs. 15.0 for the first half hour and Rs. 30.00 for the 2nd half hour are suggested to prevent the unnecessary use and to prevent such space for parking.

5.5 Parking space for about 125 - 150 lorries and taxis have been found space. This is adequate for the present. The CMC could obtain about Rs. 4.0 to Rs. 6.0 million on parking charges per day.

5.6 The net financial benefits of this scheme would be at least a saving of about Rs. 40.0 million and increasing revenues by at least Rs. 7.0 million a year.

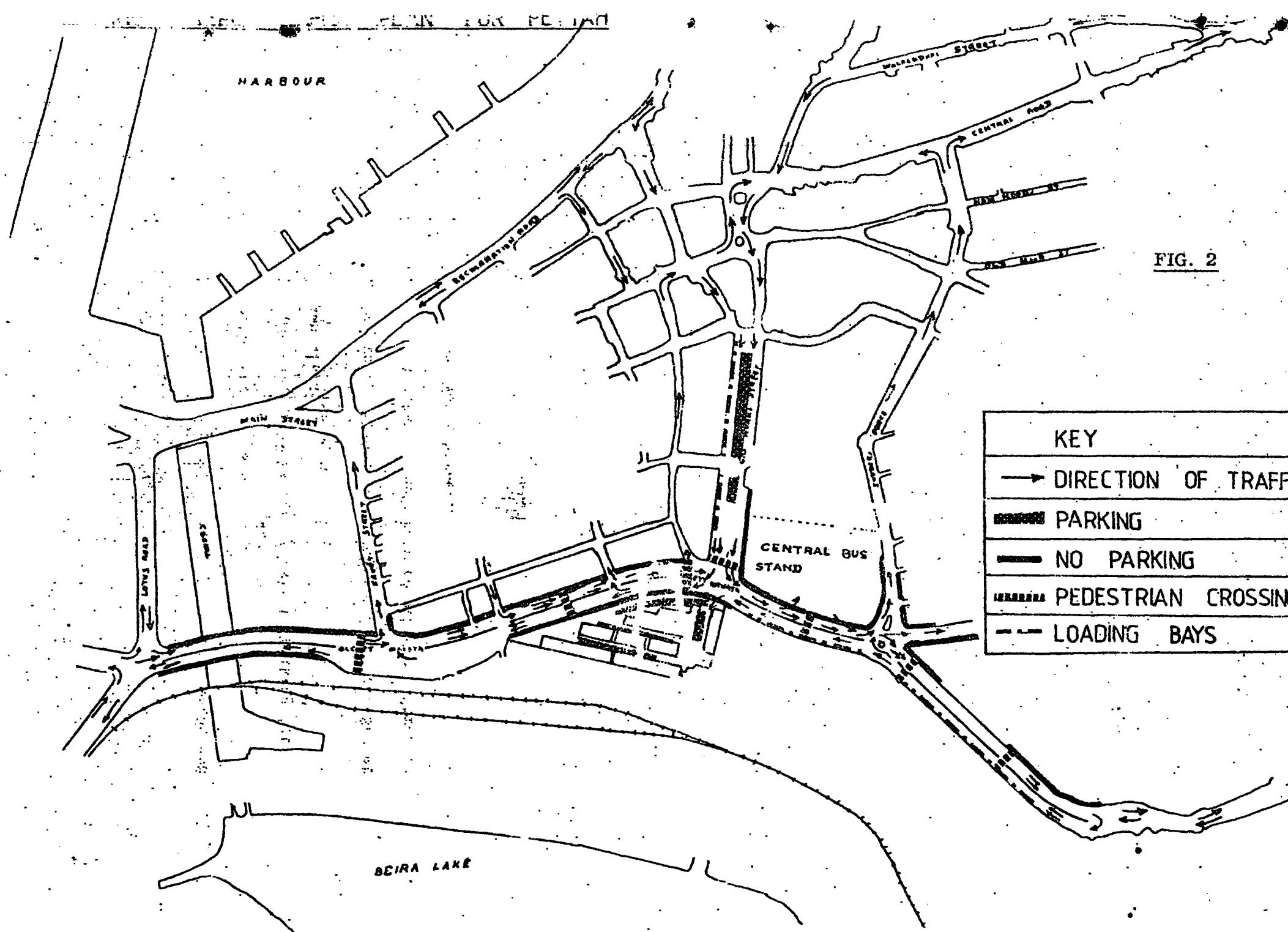
6.0 Recommendations

6.1 Traffic design

- (a) Erect barrier to divide the carriageway on Olcott Mawatha between the Bo-tree junction and Saunders Place junction.
- (b) Layout a centre median at least 3 feet wide to divide the carriageway on Olcott Mawatha between Saunders Place junction and upto the end of the street near Technical College.
- (c) Paint traffic lanes and direction signs on the road surfaces as per drawing.
- (d) Demarcate bus only lanes as per drawing
- (e) Clearly demarcate the side walks and pedestrian crossings as per drawing
- (f) Demarcate separation of the CTB bus loading bays on Olcott Mawatha as per drawing.

6.2 Traffic circulation

- (a) Reverse traffic flow on 4th Cross, 5th Cross and Wolfendhal Streets and on Centre Road.
- (b) Operate Saunders Place and Mihinda Streets as one way Streets
- (c) Prevent 'U' turns on Olcott Mawatha for vans, buses and lorries at the Bo-Tree and Saunders Place junctions.
- (d) Allow entry/exit to Central Bus Station as shown.



KEY
→ DIRECTION OF TRAFFIC
 PARKING
 NO PARKING
 PEDESTRIAN CROSSINGS
 LOADING BAYS

6.3 Parking

1. Demarcate no parking areas on Olcott Mawatha and other streets as shown
2. Show parking areas, entry/exit to parking lots and circulation patterns.
3. Demarcate lorry loading bays on 5th Cross Street
4. Demarcate taxi stands between 5th Cross Street and Gas Works Street.

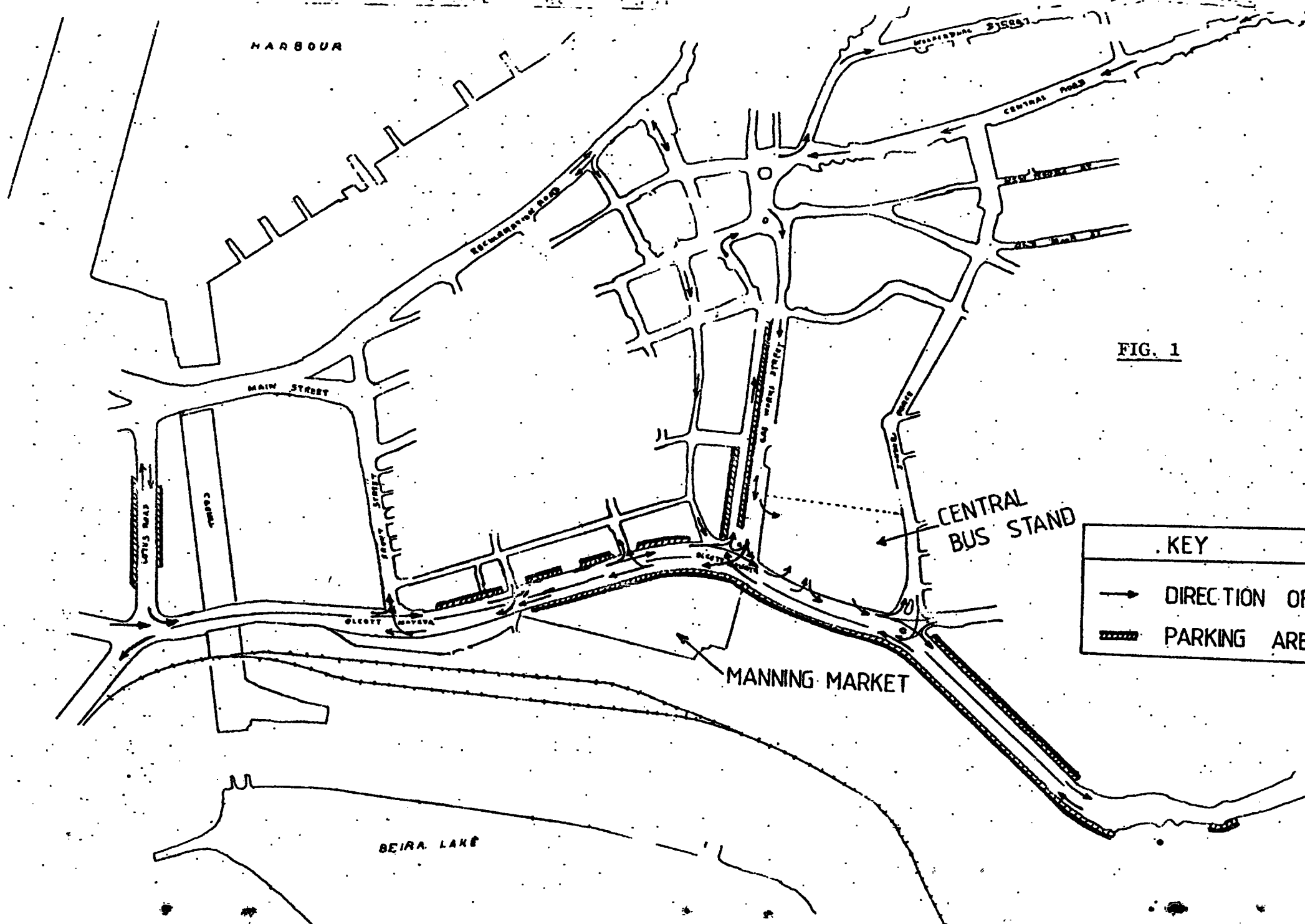


FIG. 1

KEY	
	DIRECTION OF TRAFFIC
	PARKING AREAS

TRAFFIC AND TRANSPORT PROBLEMS
OF BOMBAY METROPOLITAN REGION

by

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INDIA

Bombay, the second biggest city in India, holds a population of 8.2 million. Bombay has been growing at a very rapid rate. To retard this rapid growth the Government of Maharashtra has identified the Bombay Metropolitan Region for developing in a balanced way. CRRI has been entrusted with the task of developing a road network plan for the Bombay Metropolitan Region. To meet the requirements of the task CRRI has conducted a number of Traffic Studies in the BMR. This paper attempts to provide a background to the traffic and transport problems of Bombay Metropolitan Region.

1. INTRODUCTION

1.1 Bombay Metropolitan Region

The present day Bombay has its origin from seven small islands, (see Figure 1) originally inhabited mostly by fishermen. Over the centuries the city has grown from a chain of tiny islands into a gigantic city of today through reclamation of the land from the sea. Being a commercial and state capital, Bombay is growing in leaps and bounds. During this present century the population of Bombay had grown from a mere 9 lakhs to 82 lakhs as at the end of 1980 registering a nine fold increase. Incidentally, the state of Maharashtra has the maximum percentage (35%) of urban population compared to all other states in India. It is observed in the last three decades that the population of Bombay alone is 38 percent of the total urban population of the State. Table 1 shows the growth trends of the population of Greater Bombay. Realising the magnitude of the problems that are likely to arise from the rapid growth of Bombay and other cities of Maharashtra, the Government had set up a Committee headed by Prof. Gadgil to identify the causes and remedies for retarding the growth of the urban population in a few cities. The Committee recommended regional development as the strategy for retarding the growth of the jumbo cities. Subsequent to these recommendations the Government appointed a Regional

Year	Greater Bombay Population (in thousands)	Decadal Growth (in percentages)
1921	1380	
1931	1398	1.30
1941	1800	28.75
1951	3000	66.60
1961	4152	38.40
1971	5970	43.78
1981	8227	37.80

Table - 1 : Growth of Population in
Greater Bombay.

Planning Board to identify the developmental strategies for Bombay Metropolitan Region. The Bombay Metropolitan Region Planning Board has delineated an area (Figure 2) of about 4000 sq. kms., bound by Vaitarna river in the north, Patalganga river in the south, foot-hills of Sahyadri in the east and the Arabian Sea in the West, for proposing a planned development which will diffuse or diver the growth of Greater Bombay. Greater Bombay occupies an area of 400 sq. kms.

1.2 CRRI Studies

The Government of Maharashtra had requested the Central Road Research Institute to take up comprehensive Traffic Studies and suggest a Road Network Plan for the Bombay Metropolitan Region. According to the request the CRRI has undertaken a number of field studies to assess the present travel patterns in the BMR and also estimate the future travel patterns.

2. REGIONAL STRUCTURE

2.1 Geography

Before any traffic studies are designed to assess the present and future travel patterns it is necessary to understand the geographic and demographic features of the study area. Bombay Metropolitan Region shown in Figure 2 contains the Greater Bombay District and

parts of Thane and Raighad Districts. In the Thane District Talukas of Vasai, Bhiwandi, Thane, Kalyan, Ulhasnagar and in the Raighad District Panvel, Uran, Alibagh, Pen, Khalapur, Khopoli, Talukas are included either partly or wholly in the BMR.

The following important towns and cities as shown in Figure 2, are included in the region.

1. Greater Bombay
2. Thane
3. Bhiwandi
4. Ulhasnagar
5. Kalyan
6. Ambernath
7. Panvel
8. Dombivili
9. Khopoli
10. New Bombay

Besides these towns there are many other small towns like Alibagh, Pen, Vasai, Bayander etc. Greater Bombay and Thane are separated from the main land by the Bassien and Thane creeks.

2.2 Population

Including the rural population, the BMR contains 11 million population as per 1981 census. Of this population, nearly 90 percent are living in the urban areas and a majority of them depend on employment other

than Agriculture. Table 2 shows the growth trends of population of some of the important towns of the BMR. From the table it can be seen that the towns like Dombivili, Bayandar, Ulhasnagar etc. are registering very high growth rates. This is mainly because of the fact that the towns in the outer areas act as dormitories for the workers employed in Greater Bombay.

2.3 Employment

Employment figures are difficult to obtain since there is no one source (like census) which keeps a record of these. Table 3 gives the distribution of jobs in different regions of the BMR as recorded by the Economic census of 1977. The definition of the establishment included for enumeration varied from 1971 to 1977 census. Therefore no useful comparison can be drawn.

However the table provides a useful basis to understand the features of employment and the distribution of population. Obviously the table does not include the informal sector jobs which are not registered anywhere in the statistics and they amount to nearly a similar figures. From the table it can be seen that the employment to population ratio is higher in Greater Bombay suggesting heavy commutation of workers from the outer areas to the Greater Bombay.

Town	Y E A R		
	1961	1971	1981
Thane	1,01,107	1,70,680	3,09,271
Ulhasnagar	1,07,761	1,68,463	2,73,332
Kalyan	73,494	99,545	1,35,870
Dombivili	18,406	51,108	1,03,213
Bhiwandi	47,916	79,574	1,15,256
Panvel	18,129	26,601	37,026
Kalwa	7,659	13,744	30,388

Note : Population figures have been computed
from census of India, series 12, Maharashtra,
1981.

Table 2 : Population of Town in Bombay Metropolitan
Region.

Sectors	Population (lakhs)	Employment (Lakhs)	Pa-rticipation ratios
Island	32.8	10.6	.32
Suburbs	45.9	4.1	.09
Greater Bombay	78.7	14.7	.18
Region	25.3	2.5	.09
B.M.R.	104	17.2	.16

Table 3 Distribution of Population Employment & Participation ratios in Bombay Metropolitan Region (1979-80)

3. TRANSPORT SYSTEM

3.1 Network

The Bombay Metropolitan Region has three major modes of transport serving the needs of the people. They are Railways, Roads and Waterways. Figure 3 shows the transport network of the Bombay Metropolitan Region. Waterways have been playing a very limited role in meeting the transport demands.

Railways

It can be seen from the figure that the region is served by the Western and Central Railways to cater to both internal and external movements. As far as the internal movements are concerned, the Western Railway operates suburban Rail services from Virar to Churchgate and the Central Railway operates suburban Rail services between Karjat and Bombay VT and Titwala and Bombay VT. The frequency of these services vary from section to section because some shuttle services operate (during the peak hours) over short distances from the terminal in Bombay. Table 4 shows the frequency of services over the different sections of the railways. The inter-regional movements (between the BMR and the outside) are catered to by the inter-city rail services operating between Bombay Central and other cities of North India

Sections	No. of trains running Morning peak period of three hours
<u>Western Railway</u>	
Churchgate-Bandra	80
Khar-Andheri	71
Jogeshwari-goregaon	46
Malad-Borivali	44
Dahisar-Virar	9
<u>Central Railway</u>	
<u>I V.T. - Kalyan Main Line</u>	
Bombay V.T. - Kurla	52
Vidyavihar - Ghatkopar	47
Vikhroli - Thane	45
Kalva - Kalyan	25
<u>II Kalyan - Kasara Line</u>	
Kalyan - Ambivali	6
Telvata- Kasara	2
<u>III Kalyan - Karjat Line</u>	
Kalyan - Ulhasnagar	10
Ulhasnagar-Ambernath	5
Badlapur - Karjat	3
<u>IV Harbour Line</u>	
(A) Mankhurd - G.T.B. Nagar	9
Mankhurd-Govandi	9
Govandi-Chembur	14
Chembur - G.T.B. Nagar	17
(B) Bandra-King's Circle	13
(C) Vadala Road - V.T.	30

Table 4 Frequency of Suburban Trains in
Bombay Metropolitan Region.

on the Western Railway, and between Bombay V.T. and other cities in South, Central and Western India by the Central Railway. Some train also operate from Dadar to other cities of the country on the Central Railway. Kalyan is one of the railway junctions on the Central Railway.

Road Network

Internally the Bombay Metropolitan Region is served, besides urban roads, by a network of National Highways, State Highways, district and village roads. From Figure 4 it can be seen that Bombay is linked to NH-8, NH-3, NH-4 and NH-17 through the city roads. NH-8 is connected through the Western Express Highway. NH-3 is connected through the Eastern Express Highway and NH-4 is connected through the Eastern Express Highway and Sion-Panvel Highway through Thana-creek Bridge. NH-17 joins the NH-4 at a point beyond Panvel. The State Highways provide linkages among the major towns - Bhiwandi, Thana, Kalyan, Balapur, Uran, Panvel, Ulhasnagar etc. Major and minor District Roads connect the towns and major villages. It can also be seen that the density of roads is not very heavy. This is for reasons like spare population, difficult terrain etc. Maharashtra Road Transport Corporation, Bombay Metropolitan Transport Corporation (Erstwhile CIDCO) and B E S T operate buses to serve the needs of the commuters in the B.M.R.

3.2 Growth of Vehicles

Table 5 shows the growth trends of vehicles in Greater Bombay. From the table it can be seen that cars have increased from a meagre 40 thousand in 1962 to 150 thousand in 1978. The taxis from a mere 4000 in 1962 have gone upto 30 thousand in 1978. In so far as trucks are concerned they have been registering a constant growth of 5 percent every year and today there are about 38,000 trucks registered in Greater Bombay. These vehicles are divided almost evenly between private and public use. This shows the strong ownership of trucks for private use in Greater Bombay. BEST buses have steadily increased but the rate of growth is not so rapid as that of the passengers. MSRTC and BMIC buses have also increased over the time.

4. TRAFFIC PROBLEMS

4.1 Road Traffic Growth

In the earlier section we have seen how the transport infrastructure has been growing in the Greater Bombay. The growth of population and vehicles have increased the traffic flows on the Greater Bombay Roads. Table 6 shows the growth of traffic flows in the island city of Bombay. Bombay, being a city which has been shaped by the transport facilities movements take place

Type of vehicle	1951-52	1956-57	1961-62	1966-67	1970-71	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
Motor Cars	19707	25800	36899	46119	83360	124386	127997	132375	137176	143581	150711
Motor Cycles & Scooters	2188	2350	5325	8972	24786	53184	56621	59583	63935	68983	78474
Taxi Cabs	1495	3390	5150	7543	15951	21223	23421	21930	23768	28270	29623
Trucks											
i) Private Carrier	2317	3040	4108	6221	9817	17701	14070	14784	15416	15821	16187
ii) Public Carrier	4555	4323	7545	11114	14387	17858	18557	19584	19805	21318	22260
Stage Carriages	409	672	1067	1310	1565	2540	2715	2092	1884	1956	2133

Table 5 - Growth trend of Motor Vehicles in Greater Bombay

in the North-South direction. Therefore the screen lines are chosen to run East-West. From the table it can be observed that the traffic flows have increased tremendously. In Bombay we have three major corridors which cater to the North-South Traffic. Figure 4 shows the traffic flow in different corridors. The available road widths and their capacities are inadequate for the movement of traffic (Table 6). From the observations made it can be said that the existing road system of Greater Bombay is already overloaded and traffic delays are frustrating to the travellers. A summary of the speed and delay studies made by CRRI (Table 7) indicates that the speeds have fallen considerably from 1962-78 inspite of various improvement measures.

4.2 Mass Transport

Rail

Table 8 shows the growth trends of the daily volume of passengers traffic on the suburban railways. With the rail services extending over the space, more and more people are choosing to live in far off places, increasing further the demand for rail services. Today the peak hour trains run jam packed. Nearly 45 million commuters travel every day by suburban trains.

Screen Line	Private Car			Taxi			Truck			Total		
	1962	1979	%grwoth	1962	1979	%growth	1962	1979	%grwoth	1962	1979	%growth
1	25664	38230	48.96	18395	36461	98.10	2608	3066	17.56	46667	77737	66.57
2	74546	90015	24.77	58696	97261	65.70	8289	6657	19.68	141531	196922	39.14
3	60283	97955	62.49	60882	115471	89.66	22576	27840	23.31	143741	241206	67.89
4	53428	60145	12.57	28122	55651	97.89	25115	34062	35.62	106665	150858	41.43
5	30948	57118	84.56	23387	52200	123.20	14991	29866	99.62	69326	139184	100.76
6	29476	53697	82.17	24410	47422	94.27	13692	10550	50.08	67578	121669	80.04
7	20192	57293	183.70	11739	45839	290.70	12296	33610	173.30	44227	136742	200.18

Source : Wilbur Smith Report 1962
C.R.R.I. survey 1978-79.

Table 6 Growth of Traffic in Island City.

Road	Speed in K. h.		Corridor
	1962*	1979**	
Netaji Subash Marg	56	40	Western
Purandare Road	48	27	
Deshmukh Road	24	28	
Lajpatrai Road	48	40	
Annlebesant Road	48	31	
Veer Savarkar Marg	48	33	
Mahatma Gandhi Road	40	25	Central
D. Nauroji Road	24	24	
Mohammad Ali Road	16	14	
Jhemshedji Road	32	16	
Ambedkar Road	32	30	
Bhagat Singh Marg	32	27	Eastern
P. Demellow Road	24	18	
Nathpai Road	32	20	
Jakaria Bunder Road	24	40	

* Wilbur Smith's Report 1962

** C.R.R.I. Study, 1979.

Table 7 Journey Speeds of Major Arterials
on the Three Corridors.

Year	Daily Volume (in thousands)	Annual Growth (in percentages)
1961-62	1333	
1962-63	1455	8.7
1963-64	1601	10.0
1964-65	1752	9.4
1965-66	1873	6.9
1966-67	1984	5.9
1967-68	2040	3.1
1968-69	1972	(-) 0.96
1969-70	2126	7.8
1970-71	2330	9.6
1971-72	2445	5.0
1972-73	2651	8.3
1973-74	2759	4.0
1974-75	2621	(-) 0.95
1975-76	3085	17.7
1976-77	3335	8.1
1977-78	3622	8.6
1978-79	4026	11.2

Table - 8 : Growth of Suburban Rail
Passengers in Bombay
Metropolitan Region.

BEST

Table 9 shows the growth trends of the daily volumes of passengers on the BEST buses and also the BEST buses. The figure indicates the increasing gap between supply and demand. This effect can be seen at the BEST stops where passengers do not wait in queues as they used to do in the past and for which Bombayits were well known earlier. Nearly 4.0 million trips are made by the passengers travelling in Greater Bombay by BEST buses.

4.3 Goods Transport

The most important aspect of goods transport activity in Bombay is its location. The entire goods transport activities are located in the eastern part of the island city (Figure 5) where, the port, Railway yards, Transport operators, wholesale markets are located. The heavy on-street parking and the difficult manoeuvres of the goods vehicles in the Masjid Bunder area frighten the travellers who wish to use the Eastern Corridor. Idle parking of vehicles on P. DeMello Road hinders the traffic movements.

4.4 Pedestrians

Bombay streets are full of pedestrians and they out number the vehicles by many folds on almost all the

Year	Average Daily Passengers (In thousands)	Number of Buses
1972-73	2481	1402
1973-74	2921	1478
1974-75	2954	1530
1975-76	3093	1639
1976-77	3301	1667
1977-78	3536	1817
1978-79	3946	1884
1979-80	4164	1929
1980-81	4295	2049

Table - 9 : Growth trend of B.E.S.T
Buses and Passengers.

roads in South Bombay. Facilities given to the pedestrians are very inadequate and need to be evaluated properly for advocating better facilities to them.

4.5 Parking

The road space of Bombay island is very limited and carry huge volumes of vehicular traffic. These vehicles need parking spaces at their destinations. Parking problem is acute in the Central Business District of Bombay. Nearly two-thirds of the road space is occupied by the parked cars on the streets. As mentioned in an earlier section the idle parking of trucks is causing in efficiency in the circulation system.

5. CONCLUSIONS

In the foregoing sections an attempt has been made to highlight the traffic problems of Greater Bombay which needs short term and long term solutions involving major policy decisions. To quantify these problems and understand the travel patterns the CRRI has conducted the following traffic studies:

1. Household Survey
2. Car Travel Survey
3. Taxi Travel Survey
4. Goods Transport Survey (slow moving)
5. Inter-regional Travel Survey
6. Speed and Delay Study

7. Screen Point Study
8. Intersection Study
9. Railway Terminal Studies
10. Goods Transport Study (fast moving)
11. Pedestrian Study
12. Bus Focal Point Study
13. Work Place Study

On the basis of the data collected from these field surveys Transport sub-models have been successfully developed to simulate the existing traffic flows. Attempts have also been made to estimate the future traffic flows by different modes of travel. Currently the road net-Work Plan is being finalised for recommending it to the Govt. of Maharashtra.

A C K N O W L E D G E M E N T S

The author places on record his deep sense of gratitude to Prof. C.G.Swaminathan, Director, Central Road Research Institute, for all the encouragement provided to him and for the permission to present this paper at the inaugural session of the Sri Lanka Transportation Forum. Thanks are also due to the Government of Maharashtra for sponsoring the project Planning of Road System for Bombay Metropolitan Region.

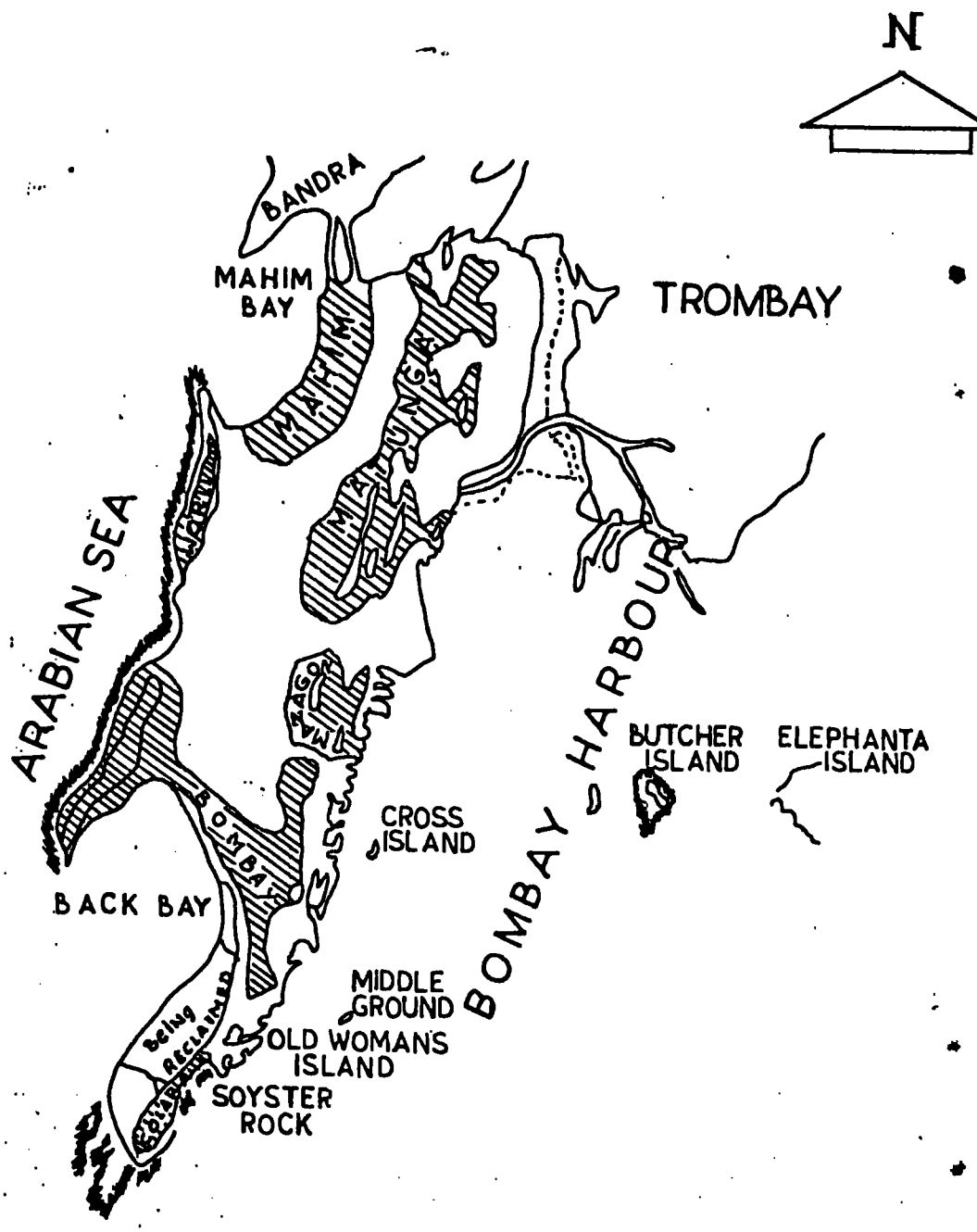


FIG.1 - BOMBAY IN 1660 AND LATER TIMES

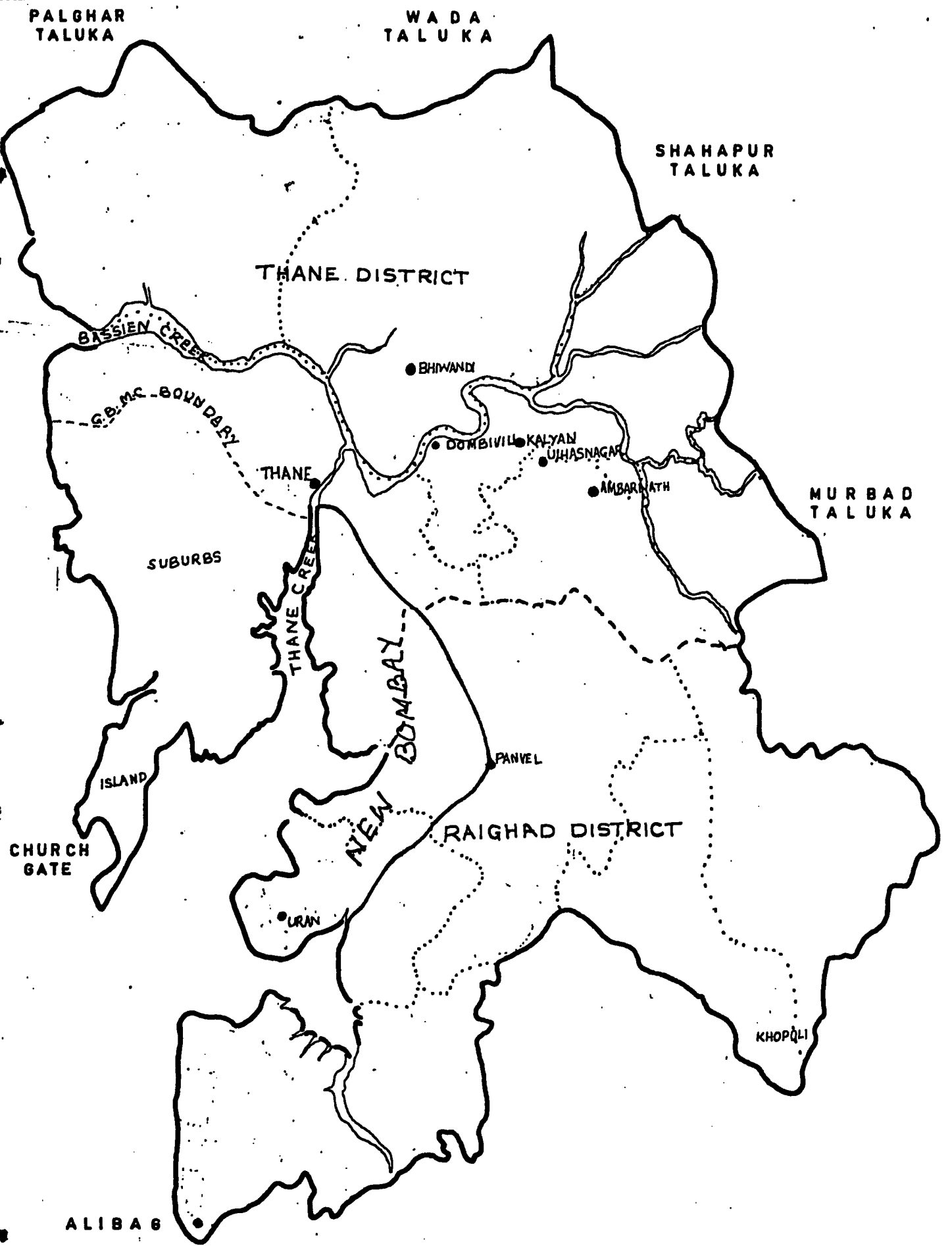


FIG 2 : BOMBAY METROPOLITAN REGION

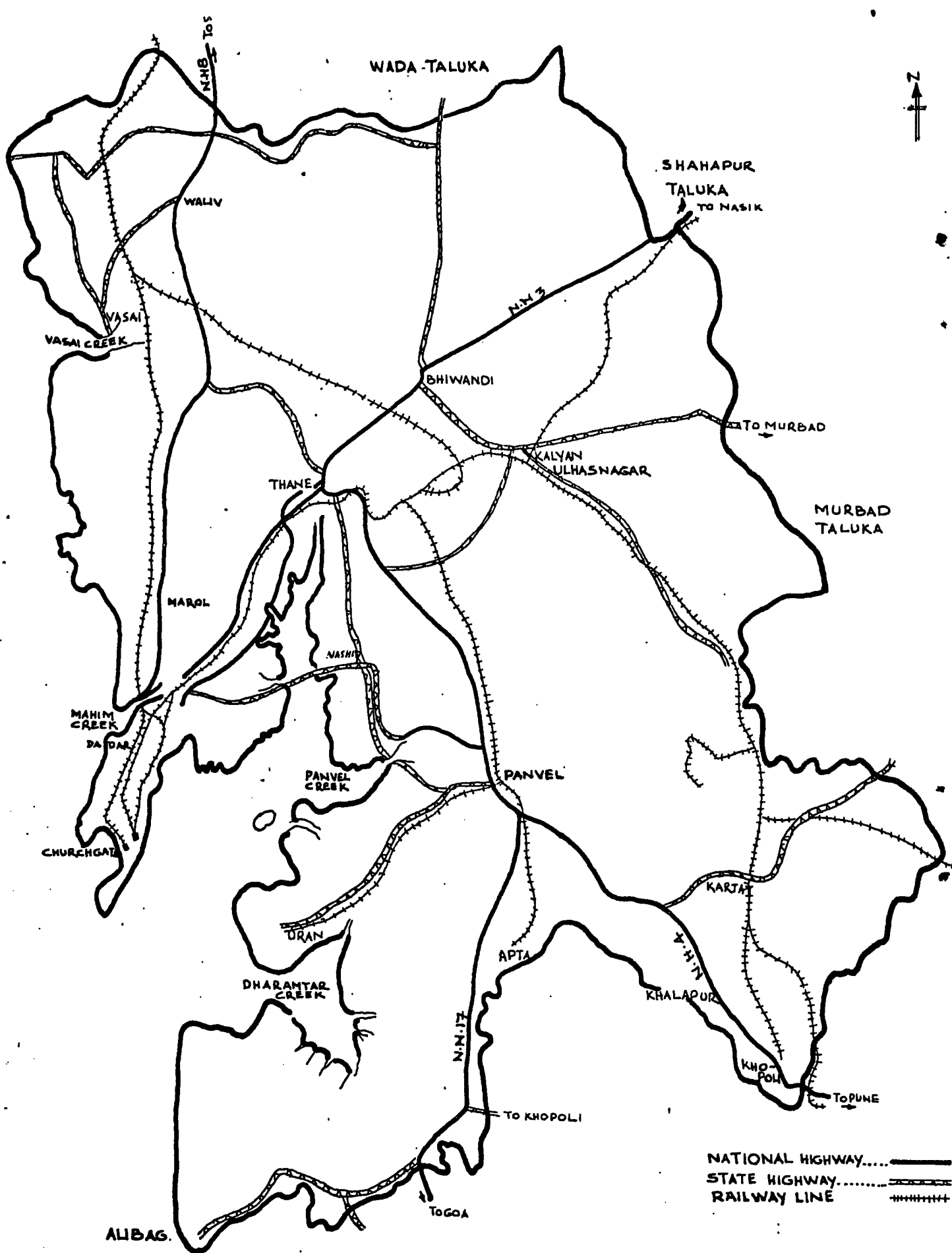


FIG. 3

TRANSPORT NET-WORK OF BOMBAY METROPOLITAN REGION

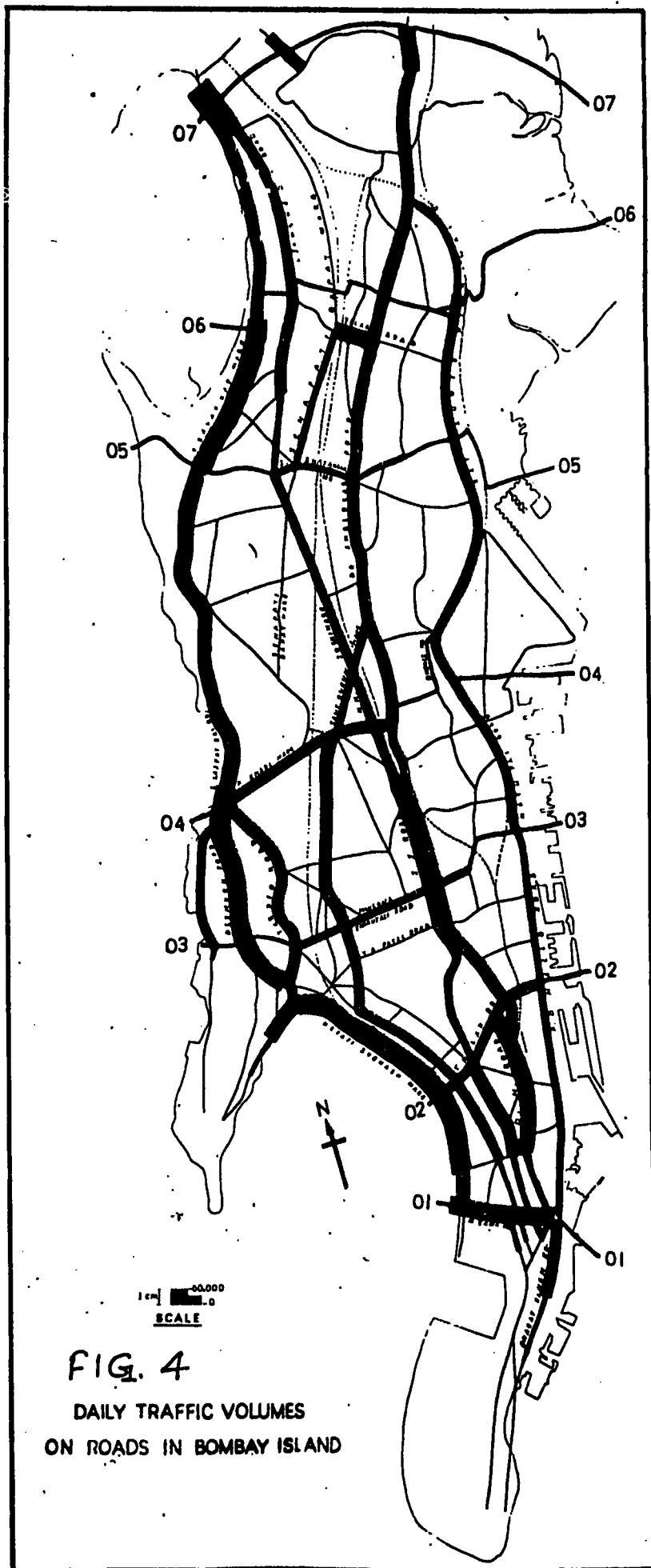


FIG. 4
DAILY TRAFFIC VOLUMES
ON ROADS IN BOMBAY ISLAND



**FIG. 5. GOODS ACTIVITIES AREAS
OF GREATER BOMBAY**

THE HIGHWAY MAINTENANCE & THE ASSOCIATED PROBLEMS

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A B S T R A C T

The paper discusses the significance of the maintenance aspects of Highway Engineering. This aspect has been highlighted even by lending Authorities such as the World Bank. The method of assessing payment performance for maintenance purposes could be carried out on a more scientific basis by the use of relevant instruments in comparison to the traditional method of visual inspection.

In fact there is a similar study being carried out at present in the Department of Highways jointly with a reputed Consulting Firm and funded by World Bank. The greatest beneficiary in the proper maintenance of the Country's road network is the vehicle operator and the nation as a whole, and not the Highway Agency.

THE HIGHWAY MAINTENANCE AND THE ASSOCIATED PROBLEMS

1.00 Introduction

- 1.01 During an international seminar on Highway Maintenance, one Engineer asked the Highway Expert, 'What are the most important causes of road failures'. The expert unhesitatingly retorted. 'Water, Water and Water'. If a Sri Lankan Highway Engineer was present, he would have quickly added another important factor applicable to our local situation namely, the poor funding for road maintenance. In general, the causes of road failure are wide and varied and even the science of Highway Engineering as developed today is unable to identify the precise cause of a road failure. It is a combination of several factors contributing in various degrees.

The arresting of impending road failures and highway maintenance are costly programmes and one may question why, so much funds are diverted towards this objective. Three main purposes why a road should be maintained properly are to prolong life span of a road, to lower the vehicle operating cost and to offer a regular and safe transport services to the community. Surprisingly the largest beneficiary from the funds invested on road maintenance is vehicle operator and not the highway authority. (Greatest saving is in the tyre wear and motor spares) If adequate funds are not allocated for road maintenance then the cost to the country first in the form of extra operating costs (with a substantial foreign exchange component) for road users, and soon after in the form of claims on the government funds for rehabilitation and reconstruction become much higher.

There is an abundant evidence, supported by recent research that the economic returns from maintenance of existing highways are extremely high.

Recent report (4) produced by the World Bank shows the overall economic returns to proposed maintenance projects; at an average of 40% or higher, compared with an average of 24% for all new construction for which the Bank made loans for 1978.

The paper discusses the methods of assessing pavement performances for maintenance purposes on a scientific basis alongwith the Highway Maintenance Programme carried out in Sri Lanka jointly by the Highways Department and World Bank Consultants.

All Highway Authorities are poorly funded but large amount of revenue on roads is collected by R.M.V.'s office in the form of Vehicle Licences, etc. There is an argument that all taxes raised by R.M.V's office should be spent on the road authorities. By extending this principle, another sector may argue that, all the taxes raised on selling arrack should be spent on improving taverns in the country. Motor vehicle Licencing and taxes on licquor are two efficient methods of indirect taxation. Hence all taxes raised in these departments could not finance only those departments.

However, there is a very strong case for the Highway Authorities obtaining a good share of cake from the coffers of R.M.V's office. It is in the Highway Authority which provides the service and they should be compensated adequately for the services rendered. The large contractors plying their heavy machinery on the National road network regularly have an obligation to contribute, in some way to the Highway Authorities. It is common in large contracts, that there is a provision for maintaining the existing traffic routes when used by the Contractor. We hope that there is a similar clause on the countracts covering accelerated Mahaweli Development Project. and someone would see that the contractors comply with these regulations.

2.00 The Cause of Road Failures

2.01 As mentioned earlier the road failures are primarily due to water in one form or the other. Refer to the road cross section on Appendix (1). The water may reach a road in three different ways.

- (i) Direct rainfall - 'Surface Water'
- (ii) Flow from the surface of nearby ground 'Catch Water'
- (iii) Percolation through the soil under the road;
this may be lateral from the sides of the road,
or upwards through the sub-grade from ground water-
'Subsoil Water'.

The purpose of drainage is to remove the water from the road area as quickly as possible, before it reaches the pavement structure causing failure in many ways. It is quite evident that the major pavement failures occur during the wet season. Hence the consideration for drainage is of paramount importance both in the construction stage and maintenance stage. Sri Lanka has inherited a system of road network designed and constructed during the colonoil period when both the design and construction standards had been very poor. Certainly, the system is not designed to carry the heavy container traffic of present day. The drainage system provided particularly by the side ditches are very poor. During the rains, it is frequently observed that the water flow, follows the edge of the main carriageway due to the side ditches being choked after a long period of negligence. The poor standard of construction in combination with inadequately maintained roads have resulted in a dilapidated network of roads.

Whenever the subsoil water is detected, the pavement breaks away more often than not. The situation could only be remedied by providing subsoil drains (or French drains) which although appear to be costly at the beginning but may prove to be good long term investment.

Bituminised surface cracks up when exposed to fluctuations of temperatures and hence requires resurfacing fairly regularly.

3.00

The purpose of road maintenance.

3.01 : Road maintenance has three main purposes : -

- (1) To reduce the rate of deterioration of road and thus prolong life.
- (2) To lower the operating costs of vehicle.
- (3) To enable, greater regularity, punctuality and safety of road transport services.

Even with proper adherence to construction material standards, roads deteriorate over time. The rate of deterioration may vary widely depending on the climate, the strength of pavement, underlying subgrade, traffic volume and the axle weight. However the rate of deterioration could be checked and the need for full rehabilitation could be postponed, by periodic resealing and recurrent patching, etc.

The empirical analysis has shown that a paved road surface in reasonably good condition can save on vehicle and tyre-wear and maintenance so as to cause total vehicle operating costs to be some 15% lower than they would be, if the surface was being poorly maintained. For gravel roads the saving per vehicle can be about three times this.

A road is a major capital investment which is expected to show an adequate return on expenditure. The failure to maintain the road properly leads to rapid deterioration, with consequent increases in vehicle operating costs and accidents, and the need for expensive reconstruction. Maintenance is therefore an important and worthwhile contribution to the economic well being of the country and an effective road maintenance is a valuable part of its economy.

4

The Assessment of Pavement Performance for Maintenance Purposes

4.01

The methods of road construction and their development is highly advanced today, but it is not the case with the methods of assessing pavement performance. Until recently, the standard practice was for the Maintenance Engineer to assess the condition of the road network by visual inspection during the course of his routine work. This system had numerous disadvantages, the obvious one being that the inspection, and thus the properties observed, are confined to the surface of road only. Any defects below the surface would go unnoticed. Secondly this method is not capable of predicting any impending road failure, so that deficiencies could be arrested at minimum cost.

In the recent past, there have been a number of instruments developed, which are extremely useful tools in measuring various properties of road structure. There are four major factors which affects the road performance, namely: -

- (a) Structural Deterioration of the pavement, threatening to impair the load carrying ability.
- (b) Poor riding quality, the riding comfort has deteriorated below an acceptable standard.
- (c) Slipperiness, the surface no longer provides an adequate resistance to skidding.
- (d) Other surface deterioration; surface revelling potholes and sealing of concrete joints etc., in the case of rigid pavements.

The state of surface and sub-surface drainage of the road, affects the above factors indirectly.

The measurements of the properties in the first three categories could be carried out by the use of relevant instruments, which are freely available in the case of developed countries. The final aim is to design a rating system in which the condition of the road is measured in numerical terms so that maintenance requirements may be assessed against a prescribed criteria. Thus the priorities could be established objectively and the funds available for the road maintenance are allotted where they are mostly needed. The following instruments are in common use today for measuring the various properties mentioned above.

- (a) Benkelman Beam : To establish the structural strength of a pavement.
- (b) Bump Integrator : To establish the riding quality of an existing road surface.
- (c) Sideway Force Coefficient Machine and Portable Skid Resistance Tester: To measure the magnitude of resistance to skidding of a road surface.

4.02A Benkeleman Beam

For a long period it was increasingly apparent that surface deflection obtained under a standard wheel load serves, as an indicator of structural capacity of a highway at a given point based on experience and performance. This basically simple data of load deflection relationship can be employed to evaluate the present and predict the future structural strength of the entire highway system. The instrument which has a worldwide use for pavement deflection measurements is the Benkelman Beam. On principle, it measures the deflection of the pavement under a standard wheel load of a lorry.

There are more sophisticated deflectometers today developed for the speedy functioning of the maintenance Engineer. It may be of interest to quote that a similar device called falling weight deflectometer was employed by a Netherland Consulting Firm recently, for assessing the condition of the runway and apron at Colombo Airport, Katunayake.

4.02B

Bump Integrator

A very common apparatus employed for measuring the surface irregularities is the 'Bump Integrator'. It consists of a single wheeled trailer which is constructed to a standard design. The apparatus measures the relative movement between the wheel and chassis of the trailer and it is recorded on a counter. Another counter measures the distance traversed. From these data an index 'R' on irregularity could be computed. Again there are more sophisticated instruments today to establish the riding quality of a road surface.

4.02C

Side Way Force coefficient Machine

It comprises a test car in which an additional wheel is located within the wheel base. On test, the wheel which is set at an angle to the direction of travel of the machine, and the sideway force exerted on it by the road, tending to push it back into line, is measured. The ratio of sideway force to the total load on the wheel known as the 'Sideway force coefficient' is used as a measure of skid resistance of the surface.

4.03 There are several apparatus in rating the pavements for maintenance purposes and one popular approach is described in the report of the committee on highway maintenance (Marshall report) (2) published in U.K. The system of rating should confirm to the following requirements

- (i) It is related to a prescribed maintenance standard.
- (ii) It indicates when action is necessary by means of critical levels of assessment.
- (iii) The system should be in a position to indicate priorities between different types of maintenance needs within individual lengths of road.
- (iv) It gives an indication of priorities between different lengths based on both traffic flow and physical conditions.
- (v) It enables the assessment in the field to be made more rapidly and uniformly by technicians, and is capable of being processed in a computer.

The method comprises two parts; the field assessment and processing in the office. A sample field assessment sheet (Form I) and a manual Data Processing sheet (Form II) are shown in the Appendices 2 & 3. The data collected in the field comprises an enormous variety of information such as surface deterioration, deformation, condition of surface irregularity skid resistance, drainage, road markings and kerbs and traffic volumes, etc, as depicted in Form I.

The processing operation in the office brings the field assessments, the weighting factors and traffic factors in order to arrive at the final rating for each item of each length of road. The entire process of rating of road system, although fairly simple to describe involves the collection of an enormous amount of data, spread over a long period of time, employing a large number of technical staff.

The assessment of maintenance requirements under the World Bank aided project carried out in Sri Lanka today

Currently there is a World Bank sponsored project carried out with the Department of Highways and an overseas Consulting Firm on road Maintenance in Sri Lanka. With the courtesy of the Department of Highways, it is possible to present a brief description of the project.

As quoted in the report produced by the joint team the Department of Highways have for many years, been denied enough resources to carry out adequate routine maintenance throughout the departmental highway network of Sri Lanka. The Government has placed emphasis on new construction. As a result the condition of the existing network has declined to a condition where the country must invest much more in vehicle fleet, where deteriorates more quickly on bad roads, then it should need to spend if the riding quality of the roads were better. In addition the drainage ditches and shoulders have often reached a state which is inadequate to protect the carriageway and road base from the effects of water, thus raising the need for routine maintenance to a higher level than it should be.

The Programme covers a wide area, from collection of data to implementation of maintenance programme over a period of five years.

As a first step, a road inventory is prepared for entire road network and a sample sheet is shown in the appendix. It contains information related to traffic flow, platform width, surface condition, drainage condition, culverts and bridges, geometric alignment and road roughness.

The field data are then processed and road system is then rated for priorities depending on the roughness value. Annual Daily Traffic (ADT) and other parameters collected during the field survey. These data are being processed at present by the joint team

of Highways Department staff and World Bank Consultants. A summary data sheet used for final rating is shown in the Appendix (4). The entire exercise is a great shot in the arm for the Highways Department, since it evaluates the maintenance priorities of roads on a scientific basis other than say political consideration and serves as a basis for World Bank funds which is desperately needed for the deteriorating road network of Sri Lanka.

The estimated budget required for the road maintenance for 1983 for example is (3) Rs. 215,327,680/=. It is interesting to compare this with the total current annual vote for the Highways Department, which is only Rs. 130,000,000/=

4.05 The authors personal opinion is that the above Maintenance Programme would have been more thorough, if the consideration was given to the following two aspects, also.

(a) The emphasis on improving the blackspots in the roads, in the way of improving the skid resistance and improving sharp bends etc., where the past accident records had been very high.

(eg) road stretch in front of the BMICH has a high accident record in the wet season.

(b) The use of load deflection criteria (eg. Benkelman Beam) in assessing the quality of the road. It indicates the structural strength of the pavement, as a whole including the condition of road base which is not normally revealed, by measurement of surface conditions. Nevertheless a special tribute should be paid for this team engaged on Highways Maintenance Programme, since the amount of data required to be collected by them is enormous and tedious and demands a great deal of patience and skill.

In general the road network in Sri Lanka are quite old and they were constructed many years ago, when the road design standards and construction techniques were not in an advanced stage. Due to inadequacy of maintenance over a period of time coupled with the inflow of heavy axle vehicles in the recent past the road network has deteriorated in many places.

At present the type of traffic plying on these roads are much heavier than those for which roads were designed. For example there are very heavy axle loads in some of the container traffic using the roads at present. Hence the need to maintain the road network is much stronger.

There are several methods by which the pavements performance could be assessed using a number of measuring instruments. It has the advantage of rating the conditions of roads in a scientific basis. The highway maintenance programme sponsored by World Bank and jointly implemented by the Highways Department serves a long outstanding need of the national road network. It covers a detailed programme incorporating the preparation of road inventory, staff training, identifying the required plants and equipment and the compiling of budgetary estimate spread over a period of five years.

The Department has its own setbacks in difficulty of retaining the experienced engineers, trained technicians and skilled labour which are common problems in many organisations today. The building up of the necessary institutional capacities is great deal more difficult than building road networks. Given the necessary funds, it is possible that the Highways Department on its own would have evaluated a satisfactory and workable programme for highway maintenance.

In the case of newly constructed roads it is advisable to adopt modern design standards such as graded

aggregates (instead of uniform size aggregates) for road base, wider and deeper side drains and provisions of sub-soil drainage when groundwater is encountered. Although costlier at the beginning, the additional costs would soon be offset by way of reduced maintenance, etc.

I deeply extend my thanks and gratitude to the Director of Highways and the other engineers in the Highways Department for assisting me by way of co-operation and providing me with invaluable information in preparing this paper.

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Reference : -

- (1) "Benkelman Beam - Auxiliary Instrument of the Maintenance Engineer" Highway Research Record 129 (1966 pp 28.52)
- (2) Maintenance Rating System Report in the Committee on Highway Maintenance (Marshall Report) London HMSO 1970 pp 129-140
- (3) 5 - Year Road Maintenance Plan 1981 - 1985 Department of Highways.
- (4) The Highway Maintenance Problem - Transportation, Water & Telecommunications; The World Bank October 1979.
- (5) Overseas Road Note 1
Maintenance Management for District Engineers.
- (6) Methods of Assessing Pavement Performance - P.H.B. Samarawickrema
Thesis, University of Sheffield, 1971

APPENDIX 2

Form I - Field Assessment Sheet

Road:

Classification:

Section:

Grid Reference:

Skidding Category site

Traffic Flow

Schedule for Improvement Yes No Office Use Only

Bad Accident Record Yes No

Item No	Item	Critical Level	Field Assessment
1	Deterioration:		
	Whole Surface	SD70:RS50:RC30	60
2	Wheel Tracks	SD70:RS50:RC30	40
3	Edges	P70; K50 :RC30	90
4	Deformation	RS50;RC30	50
5	Need for patching	P50	40
6	Camber	50	40
7.	Surface irregularity	50	40
8	Skidding resistance	50	40
9	Joints (concrete roads)	50	-
10	Drainage	50	60
11	Road markings	50	20
12	Kerbs	50	40
13	Footways	50	60
14!	Existing patching	0 or 5	5

* abbreviations under this heading

RC - reconstruction

Rs - resurfacing

SD - surface dressing

P - patching

K - Kerbing

! less than 5% 0 points

5% or more, 5 points

APPENDIX 3

Form II - Manual Data Processing Sheet

Road:

Section:

Grid Reference:

Traffic Group:

Traffic Factor: 0.8

Existing Patching: 5 (from field assessment)

Item No.	Item	Field assessment	Adjust for patching	Adjust for skidding resistance	Unweighted assessment	Critical & Satisfactory	Weighting Factor	Final RATING including traffic factor
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(j)
	Deterioration of:							
1.	Whole surface							
2.	Wheel tracks							
3.	Edges							
4.	Deformation							
5.	Need for patching							
6.	Camber							
7.	Surface irregularity							
8.	Skidding resistance							
9.	Joint (concrete roads)							
10.	Drainage							
11.	Road markings							
12.	Kerbs							
13.	Footways							

ROAD INVENTORY.

APPENDIX 4.

Road Name/Class/No.

Division/Region Mile/Km. post

Terrain

Cars	
Buses	
Heavy Lorries	
Light Lorries	
Motor Cycle	
Total	
Exp. Factor	
ADT	

[illegible]

Observed Recorded Checked Date Time

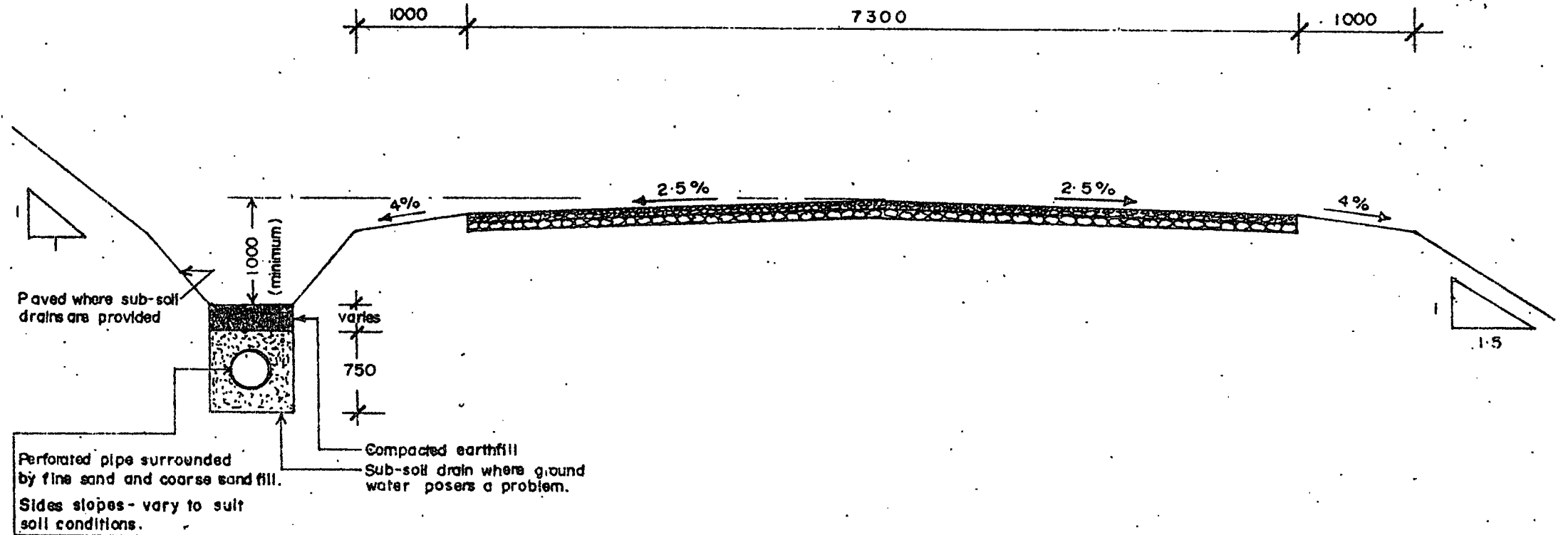
ROAD INVENTORY SUMMARY SHEET
(SECTION OF ROADS WHERE ROUGHNESS 4500)

TP/RIS

Year :-

NAME OF ROAD	DIVISION	Road Section (in Miles)	Length of Section (Miles)	Width of Carriageway (In Metres)	Roughness of Road (Section R)	24 Hours Traffic Volume (A.D.T.)	(R-2500) X A.D.T. (in 106)

APPENDIX 1



DETAIL OF TYPICAL ROAD CROSS SECTION

ANALYSIS OF SPEEDS OF VEHICLES ON
RURAL ROADS UNDER LOW VOLUMES

By

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E. VISWANATHAN**

R.K. GUPTA***

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9. Conclusions.

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SYNOPSIS

As part of Road User Cost Study - a research project sponsored by the World Bank and Govt. of India - extensive investigation was carried out on speed of vehicles under low volume rural roads. The objective was to evolve relationships between the speeds of different categories of vehicles and factors likely to govern the same. The paper describes the study carried out and the different types of analysis attempted, viz. Multiple linear Regression, Weighted Multiple Least Squares Regression; It has been shown that pavement width, rise, fall, curvature and roughness affect significantly the speeds. The results will be of use in the selection of design speed for geometrical design of roads, development of speed-flow relationship, determination of PCU factors and selection of speed for traffic regulations.

1 INTRODUCTION

The Central Road Research Institute has completed a research project entitled 'Road User Cost Study in India', jointly sponsored by the World Bank and Government of India. (Ref. 1). The cost of the project was Rs.100 lakhs. One of the objectives of the Study was to determine the effect of gradient, curvature, pavement surface type, road roughness, width of the carriageway, traffic and environmental conditions on the speed of vehicles, under low volume conditions on rural roads.

The analysis was done using Simple Multiple Linear Regression, Weighted Multiple Least Squares Regression and an Approximate Multiple Least Squares Regression.

The study was limited to rural roads under low volume conditions. A separate Traffic Simulation model is being developed for studying speeds under high volume conditions with vehicle interaction between fast and slow moving vehicles since it was felt that traffic interactions under high flows can best be studied by simulation techniques.

2. OBJECTIVE OF SPEED STUDIES

The objective of the speed studies was to develop exact relationship between the free speed (speed under low volumes) of different types of vehicles on the Indian rural roads and the roadway characteristics, and, to a limited extent, environmental factors.

The experiments were planned to determine the extent to which the type of highway, the condition of road, the geometrical features of road and some environmental factors would influence the speed at which most drivers would drive when offered a fair degree of freedom in choosing their speeds. (Ref. 2)

3. USE OF SPEED STUDIES

The determination of speed equations under low volumes will be useful for a number of purposes, as during low flows the drivers have the choice to adopt a speed depending upon the geometry of the road and the condition of the vehicle. Firstly, the speed equations will relate the speeds of different types of vehicles to the various roadway factors. Thus, it will be possible to estimate the effect of curvature, gradient, pavement width, pavement type, pavement roughness, etc. on the speeds adapted by vehicles. These equations will, therefore, enable the highway planner to select proper design standards. Secondly, the speed-flow relationships, which describe the effect of traffic on the speeds of vehicles, will have the free speed as the starting point of the Speed-flow curve. The equations which relate the speed of vehicles to the volume and composition of traffic, will have the free speed values as the intercept term. Thirdly, the free speed of vehicles will be useful in determining the passenger car equivalents (PCU values) of different types of vehicles. And lastly, the free speed relationships would be useful as an input into the simulation model which forms a separate part of the Road User Cost Study.

- 1) Cars, Jeeps and Light Vans.
- 2) Buses
- 3) Trucks
- 4) Tempos, Auto Rickshaws
- 5) Tractor-trailors
- 6) Motorised 2-wheelers (Motor cycles, Scooters, & mopeds)
- 7) Cycles
- 8) Cycle rickshaws
- 9) Bulluck Carts
- 10) Horse Carts.

As the number of vehicle types is large and the speed of non-motorised vehicles (Category 7 to 10) is more or less uniform, the study was limited to the following groups:

- (1) Cars, Vans, Jeeps
- (2) Buses (including mini-buses)
- (3) Trucks (single-units)
- (4) Two-wheelers (motor cycles, scooters and mopeds).

As regards the roadway factors, in which the chief interest of the present study lay, the important factors are listed below:

- (1) Horizontal curvature (degrees/km)
- (2) Pavement width (metre)
- (3) Roughness of the surface (mm/km)
- (4) Vertical gradient (rise/fall) (m/km)

The traffic factors which have an effect on the speed of vehicles are the volume and composition of the traffic stream. The effect of these factors has been studied separately under Traffic Simulation Modelling.

The environmental conditions which have an effect on the vehicle speeds are the time of the day (day time, night time), weather (raining/wet/dry), altitude of the place, etc.

5. EXPERIMENTAL DESIGN

The study was conducted at 76 different sites selected in different States in India and falling into cells of different road types. The description of cells and the distribution of sites into these cells are as given in Table 1 and the range of values of the road geometry is given in Table 2.

TABLE 2. RANGE OF VALUES OF INDEPENDENT VARIABLES

S.No	Independent variable	Unit of measurement	Range of value
1.	Pavement width (PW)	Metre	3.5-7.0
2.	Rise (RS)	Metres/Km	0-91.0
3.	Fall (FL)	Metres/Km	0-91.0
4.	Curvature (CV)	Degrees/Km	1-1243
5.	Roughness (RG)	mm/Km	2050-15250

4. FACTORS AFFECTING SPEED

The speed of vehicles on the road is governed by a number of factors, which can be grouped under the following main categories:

- (1) Driver characteristics
- (2) Vehicle factors
- (3) Roadway factors
- (4) Traffic factors
- (5) Environmental conditions.

A full review of the current literature on the factors affecting speed is given by Oppenlander³.

Under the driver characteristics, the factors which come into prominence are the sex of the driver, individual driving skill and judgement, health of the driver, the purpose of the trip and so on.

The vehicle factors which influence speed are the type of vehicle, condition and age of the vehicle, engine horse power, load carried, etc.

In India, there is a variety of vehicles ranging from fast moving cars to slow moving bulluck carts and are classified as below :

TABLE 1. NUMBER OF SITES CONSIDERED IN SAMPLING FRAME OF SPEED STUDIES

Terrain	Plain		Rolling		Hilly	
	Rise/Fall : 0-15m/ km		Rise/Fall : 16 to 30m/km		Rise/Fall : Over 31m/km	
Curvature	Low	High	Low	High	Low	High
Pavement	0-50 Deg/	Over 51	0-100 Deg/	Over 101	0-200 Deg/	Over 201
Width	km	Deg/km	km	Deg/km	km	Deg/km
Single Lane (3.5 - 5.0m)	14	2	-	4	-	5
Intermediate Lane (5.1 - 6.0m)	9	2	7	4	-	2
Two Lane (6.1 - 9.0m)	5	6	2	1	2	10
Total	28	10	9	9	2	18

(Total sites considered : 76)

6. DATA COLLECTION

The speed of vehicle was measured by Radar speed Meter or by Registration Number Plate method. The length of the test section was generally kept between 0.5 to 1.0 km so that the road is homogeneous in terms of curvature, vertical profile and roughness. Care was taken to observe the speed of vehicles when the flow was around 200-250 vehicles/hour and there was no interaction between vehicles. The roughness was measured by the British Towed Fifth Wheel Bump Integrator. The curvature and vertical profile were measured in a moving car by instruments mounted in the car (Gyrscope and grando-meter) (Ref. 4).

7. ANALYSIS AND RESULTS

7.1 Multiple Linear Regression Analysis based on Individual Speed Observations.

One of the possible methods of analysis of the data collected is to use each speed observations as an individual record, and regress the same against the site characteristics. The analysis was tried on the Cyber-170 computer system using IMSL package.

The equations developed from the analysis are given in Table 3.

TABLE 3. MULTIPLE LINEAR REGRESSION ANALYSIS

(Using individual speed observations)

All coefficients are significant at 1% level.

Regression Equation	R^2	Standard Error of the residual
$V_C = 55.6628 + 1.82 \text{ PW} - 0.1778 \text{ RS} - 0.1551 \text{ FL} - 0.0088 \text{ CV} - 0.0033 \text{ RG}$	0.483	11.501
$V_B = 51.1456 + 1.35 \text{ PW} - 0.2772 \text{ RS} - 0.1589 \text{ FL} - 0.0114 \text{ CV} - 0.0022 \text{ RG}$	0.587	9.390
$V_T = 46.4715 + 0.88 \text{ PW} - 0.1752 \text{ RS} - 0.0732 \text{ FL} - 0.0136 \text{ GV} - 0.0016 \text{ RG}$	0.177	17.828
$V_{2-W} = 45.7207 + 1.02 \text{ PW} - 0.1330 \text{ RS} - 0.0694 \text{ FL} - 0.0045 \text{ CV} - 0.0020 \text{ RG}$	0.281	9.403

Symbols : V_C , V_B , V_T and V_{2-W} = Mean free speeds of cars, buses, trucks and 2-wheelers respectively (in kmph).

It will be seen from the equations that the values of the co-efficient of determination vary from 0.18 to 0.59. The values, especially in respect of speeds of trucks and two-wheelers, are extremely low, viz., 0.18 and 0.28 respectively. It, therefore, appeared that this method of analysis might not yield the best estimate equations. Hence, the second alternative of using the mean speeds as the dependent variable was tried.

7.2. Multiple Linear Regression Analysis using Mean Speed as the Dependent variable.

In this approach, the mean free speeds of the four different vehicle categories at each of the 76 sites are used as the dependent variable and are regressed against the roadway characteristics of each of the sites. The analysis was carried out in Cyber-170 computer. Standard IMSL package with step-wise regression procedure was utilised.

The equations obtained from the analysis are presented in Table 4.

TABLE 4 MULTIPLE REGRESSION EQUATIONS*
(Using mean speed as dependent variable)

		R^2	Standard Error of the residual
V_C	$= 52.4202 + 1.7609PW - 0.1621RS - 0.1240FL - 0.0123 CV - 0.0025RG$	0.754	5.121
V_B	$= 52.9951 + 1.1608PW - 0.2601RS - 0.1626FL - 0.0122CV - 0.0022RG$	0.807	5.161
V_T	$= 45.9185 + 1.1853PW - 0.2099RS - 0.1420FL - 0.0131CV - 0.0017RG$	0.733	5.493
V_{2-W}	$= 46.5067 + 1.0296PW - 0.1329RS - 0.0817FL - 0.0054CV - 0.0020RG$	0.645	4.262

* All Regression Coefficients are Significant at 5 per cent level of significance.

7.3. Weighted Least Squares Regression Analysis (WLS)

The Ordinary Least Squares methodology gives unbiased but inefficient estimates, as the number of observations at the various sites differs and so does the standard deviation. In order to obtain unbiased and efficient estimates, Weighted Least Squares methodology has been performed on EC-1030, computer system, with the help of BMDP-70 package. Each observation has a weight on the basis of $\frac{n_i}{s_i^2}$, where n_i is the number of observations, and s_i the standard deviation of speeds at the i th site.

The means and standard deviations of the variables are given in Table 5. The regression equations are given in Table 6. Table 7 gives the detailed statistical results in respect of cars.

TABLE 5

Statistics of the independent and dependent variables for Speed Analysis
using Weighted Least Squares Mean Speed Analysis.

	VARIABLE	WEIGHTED MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM	MAXIMUM
Dependent Variables Statistics	1. V_C	40.11591	10.26823	0.25596	23.98999	66.92999
	2. SD V_C	7.19265	3.47538	0.48318	3.80000	25.01999
	3. V_B	35.76572	11.24726	0.31447	16.28999	64.00000
	4. SD V_B	6.23970	2.70097	0.43287	3.76000	24.95000
	5. V_T	32.93755	10.68986	0.32455	12.30000	56.96999
	6. SD V_T	7.12964	2.85021	0.39977	2.44000	30.23999
	7. V_{2-w}	37.09261	6.52858	0.17601	22.54999	56.00000
	8. SD V_{2-w}	7.14713	3.06875	0.42937	0.00000	29.10999
Independent Variables	9. W	5.58320	1.40915	0.25235	3.50000	7.00000
	10. RS	17.94920	26.78482	1.49226	0.00000	91.00000
	11. FL	13.43719	24.30627	1.80888	0.00000	91.00000
	12. CV	505.50415	398.77856	0.78887	0.00000	1243.00000
	13. RG	4508.43359	1291.61646	0.28649	2050.00000	15250.00000
No. of observations	14. NOC	76.47792	85.28152	1.11511	1.00000	438.00000
	15. NOB	58.60817	73.94797	1.26173	3.00000	389.00000
	16. NOT	80.10310	97.34612	1.21526	9.00000	481.00000
	17. NOW	50.23254	55.81723	1.11118	1.00000	272.00000

SD V_C , SD V_B , SD V_T , SD V_{2-w} : Standard deviations of mean speeds of cars, buses, trucks
and two-wheeler respectively.

NOC, NOB, NOT, NOW : Number of observations of speed of cars, buses, trucks and two-wheelers
respectively.

TABLE 6

SPEED EQUATIONS USING MEAN SPEED AS THE DEPENDENT
VARIABLE (WEIGHTED LEAST SQUARES REGRESSION)

EQN	R ²	Standard Error of the residual
$V_C = 60.5948 + 1.0462 W^* - 0.1921 RS^{**}$ (2.277) (-6.673) $-0.1845 FL^{**} - 0.0078 CV^{**} - 0.0036 RG^{**}$ (-6.213) (-4.201) (-7.002)	0.791	4.85
$V_B = 54.9748 + 0.6091 W - 0.3008 RS^{**}$ (1.346) (-10.270) $-0.2279 FL^{**} - 0.0077 CV^{**} - 0.0022 RG^{**}$ (-7.028) (-3.808) (-6.668)	0.850	4.83
$V_T = 47.3172 + 1.0565 W^* - 0.2686 RS^{**}$ (2.153) (-8.267) $-0.2649 FL^{**} - 0.0099 CV^{**} - 0.0019 RG^{**}$ (-8.251) (-3.703) (-4.330)	0.898	4.60
$V_{2-W} = 47.1932 + 0.9406 W^* - 0.1202 RS^{**}$ (2.326) (-4.682) $-0.0666 FL^{**} - 0.0048 CV^{**} - 0.0021 RG^{**}$ (-2.621) (-2.859) (-7.409)	0.712	3.84

(** denotes significant at 1% level)

(* denotes significant at 5% level)

(The figures in bracket gives the student-t values)

TABLE 7

RESULTS OF MULTIVARIATE ANALYSIS OF MEAN SPEED
OF CARS USING WEIGHTED LEAST SQUARES REGRESSION

<u>ANALYSIS OF VARIANCE</u>					
SOURCE OF VARIATION	SUM OF SQRS	DF	MEAN SQUARE	F RATIO	P (tail)
REGRESSION	6257.801	5	1251.560	53.098	0.0000
RESIDUAL	1649.938	70	23.571		
TOTAL	7907.739	75			
<u>REGRESSION COEFFICIENTS</u>					
VARIABLE	COEFFICIENT	STD. ERROR	't' VALUE	P (2tail)	Tolerance + (Index of Multi- collinearity)
W	1.04622	0.460	2.277	0.026	0.749452
RS	-0.19214	0.029	-6.673	0.000	0.528326
FL	-0.18448	0.030	-6.213	0.000	0.603308
CV	-0.00786	0.002	-4.201	0.000	0.564233
RG	-0.00364	0.001	-7.002	0.000	0.696486
V _C	60.59485				

$$R^2 = 0.7914$$

Standard Error of Estimate = 4.8549

$$V_C = 60.5948 + 1.0462 W^{**} - 0.1921 RS^{**} - 0.1844 FL^{**} - 0.0078 CV^{**} - 0.0036 RG^{**}$$

(* denotes significant at 1% level)

(**denotes significant at 5% level)

+ Since the value of each Tolerances are very much above zero indicating vary low level of Multicollinearity.

It is seen that these values are very low, when compared to speeds of vehicles in developed countries. There are many reasons for the low values of speeds of vehicles under low volume conditions, some of which are:

1) The traffic on Indian roads consists of both slow-moving and fast-moving vehicles, all occupying the same road space. Hence drivers are alert and do not adopt very high speeds.

2) The vehicles being manufactured in India are of old technology.

3) The commercial vehicles are overloaded excessively, and hence speeds drop.

9. CONCLUSIONS

1) The speeds of different types of vehicles under low volume conditions in India are comparatively lower than speeds in developed countries.

2) The low volume speeds are significantly governed by factors such as the carriage width, curvature, rise and fall and roughness.

ACKNOWLEDGEMENTS

The Paper is published with permission of Prof. C.G. Swaminathan, Director, Central Road Research Institute. The authors are grateful to him for according permission.

TABLE-8.

WEIGHTS USED IN THE APPROXIMATE WEIGHTED LEAST SQUARE METHOD
 (Illustration for some selected sites only)

Site No	Number of Times Mean Speed is repeated			
	Cars	Buses	Trucks	2 - Wheelers
1	13	15	9	1
-	-	-	-	-
3	157	87	58	43
-	-	-	-	-
7	308	43	10	10
-	-	-	-	-
12	396	124	17	24
-	-	-	-	-
22	102	68	97	13
-	-	-	-	-
47	7	4	1	2
-	-	-	-	-
57	10	1	3	13
-	-	-	-	-
63	1	7	2	13
-	-	-	-	-
65	22	7	2	1
-	-	-	-	-
76	-	-	-	-
Total	4823	2216	1163	668

TABLE.9. RESULTS OF THE APPROXIMATE WEIGHTED LEAST SQUARE ANALYSIS

		R^2	Standard Error of the Residual
V_C	= 57.7807+1.2264 W-0.1754 RS-0.1763 FL -0.0086 CV-0.0032 RG	0.769	4.9
V_B	= 51.3401+1.0403 W-0.2934 RS-0.2345 FL -0.0074 CV-0.0021 RG	0.849	4.69
V_T	= 47.9835+0.9329 W-0.2584 RS-0.2572 FL -0.0109 CV-0.0019 RG	0.899	4.467
V_{2-W}	= 46.4608+0.9948 W-0.1039 RS-0.0609 FL -0.0052 CV-0.0021 RG	0.711	3.635

presented in Table 8. The regression equations for each of the vehicle class are presented in Table 9.

It is seen that the regression co-efficients obtained by approximate method are very much consistent with that of Weighted Least Square estimation. The value of R^2 is as high as 0.79, 0.93, 0.85 in the case of car, bus, Truck and 2-wheelers respectively.

7.5. The signs of the regression co-efficients obtained from the final analysis are as expected. The free speeds increases with an increase in the pavement width and the decreases with an increase in rise, fall, curvature and roughness.

Considering the equations obtained by Weighted Least Squares analysis and taking curvature (CV) first, being the most dominant factor, it is observed that 100 degrees of curvature per km reduce the speed of cars by 0.78 kmph, the speed of buses by 0.77 kmph, the speed of trucks by 0.99 kmph and the free speed of 2-wheelers by 0.48 kmph. Thus, for hilly terrain with curvature

as high as 1,000 degree per km. the drop in the speed of cars, buses and trucks can be in the range of 8-10 kmph. In the case of rolling terrain, where the curvature is generally about 200 degrees per km, the drop in the speed in respect of these vehicles categories can be in the range of 1.6-2 kmph.

Roughness (RG) is the next dominant factor influencing speeds. From the equations it will be seen that for every 1,000 mm/km increase in the roughness values (as measured by the British Towed Fifth Wheel Bump Integrator) the mean free speed is reduced by 3.6 kmph in respect of the four vehicle categories. To illustrate, the speed drop between a black-topped road with a roughness of 5,000 mm/km and a water bound mackadam road with a roughness of 15,000 mm/km is in the range of 19-36 kmph for the various types of vehicles.

The upward gradient, denoted as rise (RS) in the equation, influence significantly the speeds for all the four vehicle types. The correlation co-efficient is negative which indicates that the free speeds drop down as the gradient becomes steeper. The regression co-efficients in the four speed equations range from 0.12 to 0.30. Thus, for a road with a 10 per cent upward gradient, the reduction in speeds in respect of cars is 19 kmph, in respect of buses it is 30.0 kmph, in respect of trucks it is 27 kmph and in respect of 2-wheelers it is 12 kmph.

As regards downward gradient, denoted as fall (FL), it is observed that the effect of a fall is slightly less than the effect of rise. This indicates that a vehicle negotiating

an upward gradient travels at a slightly lower speed than while negotiating the same gradient in the downward direction. The regression co-efficient has a negative value, again establishing that the speed drop as the fall increases. The co-efficients of this variable vary from 0.06 to 0.26. The drop in the free speeds for a 10 per cent downward gradient is 7 kmph in respect of 2-wheelers, 18 kmph in respect of cars, 23 kmph in respect of buses and 26 kmph in respect of trucks.

The effect of pavement width is to increase the free speeds as the pavement width increases. This is quite understandable since drivers would drive at higher speeds on wider roads. The co-efficients of this term in the equations are in the range of 0.61 to 1.05. The increase in speed per metre increase in the pavement width is 1.05 kmph for cars, 0.61 kmph for buses, 1.06 trucks and 1.2 kmph in respect of 2-wheelers.

8.COMPARISION OF VARIOUS REGRESSION EQUATIONS

A comparision of the results from the three methods of analysis described can now be made. It is seen that the method using the individual speed observations gives consistent sign of regression coefficients and all the regression estimates are well within the feasible range but the regression gives the lowest R^2 value. This is expected because of inherent variation in different speed observations. The R^2 values using Ordinary Least Squares technique gives unbiased but inefficient estimates though the level of R^2 increases. In order to obtain the unbiased as well as efficient estimates, Weighted Least

Squares methodology has been adopted, and the same is able to explain more variation in the dependent variables.

Table 10 presents the results of the various methodologies adopted.

It is difficult to recommend which method is the best out of these methods considered. All the four methods have their own appeal. If higher R^2 alone is the criterion for preference, the Weighted Least Squares or Approximate Weighted Least Squares can be considered as the best, as the regression coefficients obtained are unbiased as well as efficient.

The Approximate Weithed Least Squares methodology is recommended only when the Weighted Least Squares computational facility is not available in the package. It is found that the Regression Coefficients in the case of Weighted Least Squares and Approximate Weighted Least Squares methodology are very close and consistent. Also, the level of ~~exp~~planation obtained in the case of Weighted Least Squares and Approximate Weighted Least Squares Methods are higher than those of other methodologies.

Taking a good two-lane road (7.0m width) with no curvature and level vertical profile with a smooth surface (Asphaltic concreete, with Roughness: 2500 mm/km), the free speeds of vehicles work out as below from the formulae with Weighted Least Squares regression:

Car : 58.91 km/hr

Bus : 53.73 km/hr

Truck: 49.97 km/hr

Two - wheeler : 48.52 km/hr

TABLE - 10

COMPARISON OF SPEED EQUATIONS

Based on Individual speed observation, Mean Speed (Ordinary Least Squares) and Mean Speed
(Weighted Least Squares & Approximate Weighted Least Squares)

Vehicle Category	Regression Equation based on	Intercept	Regression Coefficients					No. of observations	R^2	Standard Error
			PW	RS	FL	CV	RG			
Car	Individual observations	55.6628	1.8200	-0.1778	-0.1551	-0.0038	-0.0033	2920	0.483	11.50
	Mean Speed (Ordinary Least Squares)	52.4202	1.7609	-0.1621	-0.1240	-0.0123	-0.0025	76	0.754	5.12
	Mean Speed (Weighted Least Squares)	60.5948	1.0462	-0.1921	-0.1845	-0.0078	-0.0036	76	0.798	4.85
	Mean Speed (Approximate Weighted Least Squares)	57.7807	1.2264	-0.1754	-0.1763	-0.0086	-0.0032	4823	0.7686	4.90
Bus	Individual observations	51.1456	1.3500	-0.2772	-0.1589	-0.0114	-0.0022	2527	0.587	9.39
	Mean Speed (Ordinary L Least Squares)	52.9951	1.1608	-0.2601	-0.1626	-0.0142	-0.0022	76	0.807	5.16
	Mean Speed (Weighted Least Squares)	54.9748	0.6091	-0.3008	-0.2279	-0.0077	-0.0022	76	0.850	4.83
	Mean Speed (Approximate Weighted Least Squares)	51.3401	1.0405	-0.2934	-0.2345	-0.0074	-0.0021	2216	0.849	4.69

TABLE 10 (Contd)

Vehicle Category	Regression Equation	Intercept	Regression Coefficients					No. of observations	R ²	Standard Error
			PW	RS	FL	CV	RG			
Truck	Individual observations	46.4715	0.8800	-0.1752	-0.0732	-0.0136	-0.0016	3796	0.176	17.83
	Mean Speed (Ordinary Least Squares)	45.9185	1.1883	-0.2099	-0.1420	-0.0131	-0.0017	76	0.733	5.49
	Mean Speed (Weighted Least Squares)	47.3172	1.0565	-0.2686	-0.2649	-0.0099	-0.0019	76	0.844	4.61
	Mean Speed (Approximate Weighted Least Squares)	47.9835	0.9329	-0.2584	-0.2572	-0.0109	-0.0019	1163	0.899	4.46
Motorised two-wheelers	Individual observations	45.7207	1.0199	-0.1330	-0.0694	-0.0045	-0.0020	2236	0.281	9.40
	Mean Speed (Ordinary Least Squares)	46.5067	1.0296	-0.1329	-0.0817	-0.0054	-0.0020	76	0.645	4.26
	Mean Speed (Weighted Least Squares)	47.1932	0.9406	-0.1202	-0.0666	-0.0048	-0.0021	76	0.712	3.84
	Mean Speed (Approximate Weighted Least Squares)	46.4608	0.9948	-0.1039	-0.0609	-0.0052	-0.0021	668	0.711	3.63

It is seen that this regression analysis has very high R^2 values, ranging from 0.7 - 0.85. In fact, the R^2 values using the weighted least squares regression are higher than the values obtained by ordinary least squares regressions. The Regression coefficients are all significant at 5% level.

7.4. Approximate Weighted Least Squares Regression Analysis

In the absence of a package for Weighted Least Squares an approximate Weighted Least Squares methodology could be adopted and the regression analysis performed by using ordinary least squares technique on SPSS package.

The procedure adopted was:

- (1) Calculate $\frac{n_i}{s_i^2}$ for each vehicle type and site where
 n_i = number of observations at site i
 s_i = standard deviation at site i
- (2) Divide all $\frac{n_i}{s_i^2}$ values by the minimum value of $\frac{n_i}{s_i^2}$
 Round off the result to integers (w_i)
- (3) Repeat each site observation w_i times and perform ordinary least squares regression.

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SRI LANKA TRANSPORTATION FORUM

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**USE OF SMALL AND MINI ROUNDABOUT AT
ROAD INTERSECTIONS IN TOWNSHIPS**

by

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USE OF SMALL AND MINI ROUNDABOUT AT ROAD INTERSECTIONS IN TOWNSHIPS

1. SUMMARY

Layouts with Small and Mini Roundabouts were considered for road intersections in Colombo and other Townships where the control and management of traffic had become difficult. Different combinations of such layouts were tried out, on an experimental basis, at selected sites. They are now being studied on a long term basis by the Department of Highways.

Although at the designs stage careful consideration was given to requirements of capacity and geometric layout, there were difficulties in getting them constructed as planned mainly due to non-availability of required land spaces and the funds.

Limited observations so far made at these intersections show that they are functioning satisfactorily in spite of the above mentioned shortcomings.

This paper concludes that Small and Mini Roundabouts, if properly constructed, will provide suitable solutions to traffic problems at road intersections in Townships.

2. INTRODUCTION

2.1 Background

Road intersections in Colombo and in other townships were getting into distress, not being able to cope with the sudden increase of traffic in recent years. Signalised intersections too were becoming unpopular both as a result of delays and as a result of frequent breakdowns. As such, the Department of Highways was called upon to find alternative proposals which were both cost effective and easy to maintain.

This lead to thinking in terms of Small and Mini Roundabouts on the basis of work that had already been done in the United Kingdom, in this field. Also it was observed that the road user in this country was accustomed to the presence of roundabouts at road intersections and "give way to vehicles on the right" was observed by many as a necessary traffic rule. In spite of the fact that no meaningful efforts had been made by the authorities to improve the situation at these roundabouts, the ordinary driver was always able to find his way through. As such, it was felt that the correct atmosphere existed for experimenting with small and mini roundabouts, following the United Kingdom example.

2.2 United Kingdom example

Till early Nineteen Sixties in the United Kingdom, there were no rules governing the entry and exist of vehicles into and from roundabouts. This had, at times, lead to locking conditions within roundabouts bringing all vehicles to a stand-still¹. To meet this situation, efforts had been made to increase the capacities of roundabouts and such increases had been brought about by increasing the dimensions of the weaving sections of circulating areas of roundabouts, between intersecting arms. Several emperical formula had been used to calculate capacity, on this basis, and the formula put forward by Wardrop² in 1957, had been widely accepted. The roundabouts had become larger and larger, as a result, and in spite of these efforts, locking up of traffic had not been eliminated.

This lead to the gradual introduction of priority rules for traffic entering and leaving the roundabouts and it even lead to the introduction of controlling devices, such as separate traffic light signals at points of intersection of the individual roads with the roundabout.

In November 1966, however, the offside priority rule had come into force³, specifying that entering vehicles should give way to vehicles approaching from their right, which were already on the roundabout. As a result, traffic in the roundabout were able to always exit from the roundabout and the phenomenon of locking had disappeared.

Subsequently it had been possible, to develop smaller roundabouts offering relatively high traffic capacities along with much greater efficiency of land utilisation. These comprise both Small and Mini Roundabouts covering a wide range of intersection capacities. They were also called offside priority roundabouts and the larger round that had been designed on the basis of weaving were referred to as Conventional Roundabouts.

The attached diagrams show three types of suitable layouts with Small and Mini Roundabouts.

DESIGN/CONSIDERATIONS & GEOMETRIC LAYOUT

A correct assessment of the overall capacity is of prime importance in the design and layout of Small and Mini Roundabouts. In this context, it was noted that the introduction of the offside priority rule had brought about a fundamental change in the pattern of traffic movement and intersection at roundabouts in the United Kingdom. Since then, it had been demonstrated by many,^{1, 5, 6} that capacities of Roundabouts depended more on the capacities of entries, than on the capacities of weaving sections. The concept of weaving adopted by Wardrop was no longer applicable and the basis for capacity determinations changed to a concept of gap acceptance at entries.

The following relationships had been identified³ as of high relevance in the determination of overall capacity on the new basis.

3.2 Entry/Circulation flow relationship

The entry flow, which determines the entry capacity had been found to be highly dependent on circulating flow as traffic waiting to enter the Roundabout had to give way to traffic already circulating. Entry was by accepting suitable gaps and the entry capacity decreased with increase of circulating flow. This dependence of entry capacity on circulating flow was called the entry/circulating flow relationship.

The determination and optimisation of this relationship is a necessary controlling step in the proper design of Small and Mini Roundabouts.

3.3 Entry width and flare

By flare is meant the widening of the entry and the sharpness of flare (S) is defined as $S = \frac{e}{l} \cdot v$, where e = entry width, v = approach road half width and l = average effective length over which the flare is developed. (see diagrams) The sharpness of flare is a measure of the rate at which extra width is developed in the flare. Large values of S correspond to short severe flares, and small values to long gradual flares. For a given set of conditions, a maximum possible value of e and an optimum value of S has to be established, in the process of design, in order to maximise on entry capacity.

3.4 Size and shape of circulating area and centre island

Size and shape of the circulating area and the centre island affects capacity to a considerable degree.

Unlike in conventional roundabouts, the centre island in small and mini roundabouts is usually circular. Also the circulating area usually falls within/inscribed circle (diameter D in diagram). In capacity determination the diameter (D) of the inscribed circle has a direct bearing where as the diameter (d) of the centre island

plays a secondary role. However, a meaningful relationship exists between D and d in directing traffic through the roundabout.

Our experience is that D/d ratio varied between 2 and 4 in most instances and the value of d varied between 5 m and 25 m. In Mini range of roundabouts d was given a value less than 10 m.

4. Observations on experimental layout

i) The first trial layout with a Mini Roundabout was carried out in 1977 at the intersection of Nawala Road with Tilakaratne Mawatha in Nugegoda town area. It is functioning satisfactorily in spite of the fact that it was laid out in a hurry without adequate studies having been done. However, on an approximate basis, capacity requirements were catered for at the time of construction.

ii) In 1979, studies were done and two small roundabouts were proposed for the intersection along De Mel Mawatha (Duplication Road), at Colpetty, on either side of Liberty Cinema. Construction, however, was done without obtaining the required land spaces at the corners of road entries. As such, entry conditions were restricted and even the circulating areas were reduced. As at present, there is a considerable degree of queuing up during peak hours, although not intolerable.

iii) Ingram Road (from Panchikawatte to Baseline Road) was completed in 1981, and at the intersection with Panchikawatte Road and Sangarajah Mawatha, a high-volume traffic situation was created. After considering several alternative proposals, a decision was taken to adopt a layout with a properly designed Small Roundabout. At the time of construction, however, modifications had to be done as the proposed land spaces in the corners were not made available. There was a reduction of capacity, at entries as well as in the circulating area, as a result. The peak hour queueing up that is observed now, could be easily attributed to this reduction in capacity.

iv) At the intersection of Bauddhaloka Mawatha (Bullers Road), with Havelock Road, Reid Avenue and Thurstand Road, a traffic situation existed for some time, defying simple solutions. Finally, after careful studies and design, it was possible to evolve out a system of Roundabouts consisting of a Double Small and a Single Mini which has now been laid out. However, during construction, modifications to layout geometry had to be done due to difficulties of acquiring land at the corners, which is presently causing some amount of queueing up, particularly along the Havelock Road entry.

v) A double roundabout consisting of a Small and Mini was constructed at Galle Town on the Colombo Matara Road and in the vicinity of the bus stand. It is reported that the congestion that existed had eased off in spite of the fact that what had been constructed was not exactly what was proposed.

vi) A general deficiency at all these layouts were the absence of carriage/^{way} markings, sign posting and proper lighting which are essential in directing and smoothening the flow of traffic. However, at the Bullers Road intersection, some amount of work in this direction was possible and the situation there is very much improved as a result.

5. CONCLUSIONS

In spite of the various shortcomings, the layouts with small and mini roundabouts at the sites described, are functioning satisfactorily.

Observations reveal that if they had been constructed as planned, they would have functioned at the level of efficiency expected of them at the time of planning.

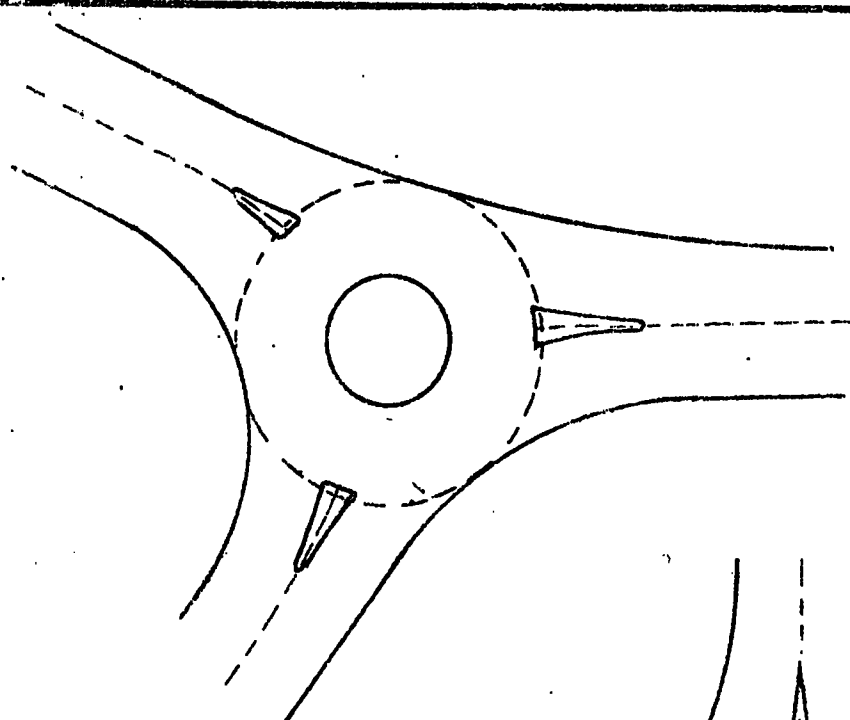
Based on the above, it is possible to conclude that Mini and Small roundabouts, constructed with due regard to capacity requirements and layout considerations, will offer cost effective and meaningful solutions to problems of traffic control and management at City road intersections.

6. ACKNOWLEDGEMENTS

Thanks go to all those in the Department of Highways, who participated in the experimental work done.

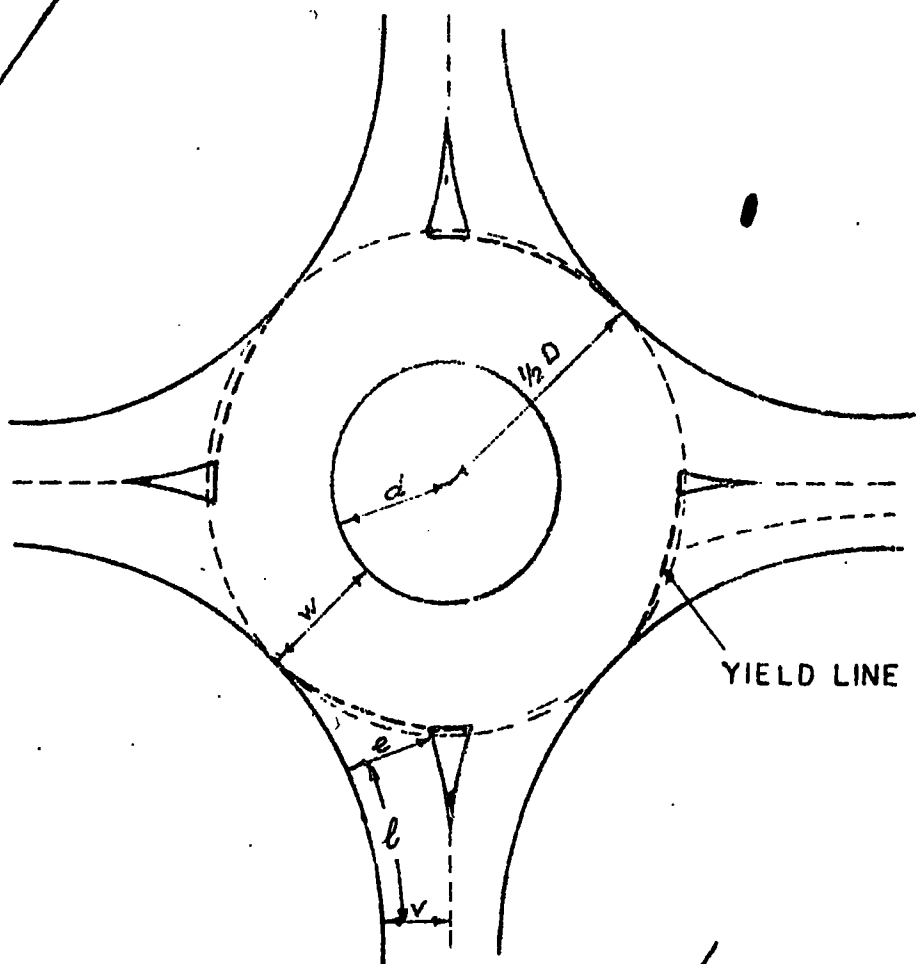
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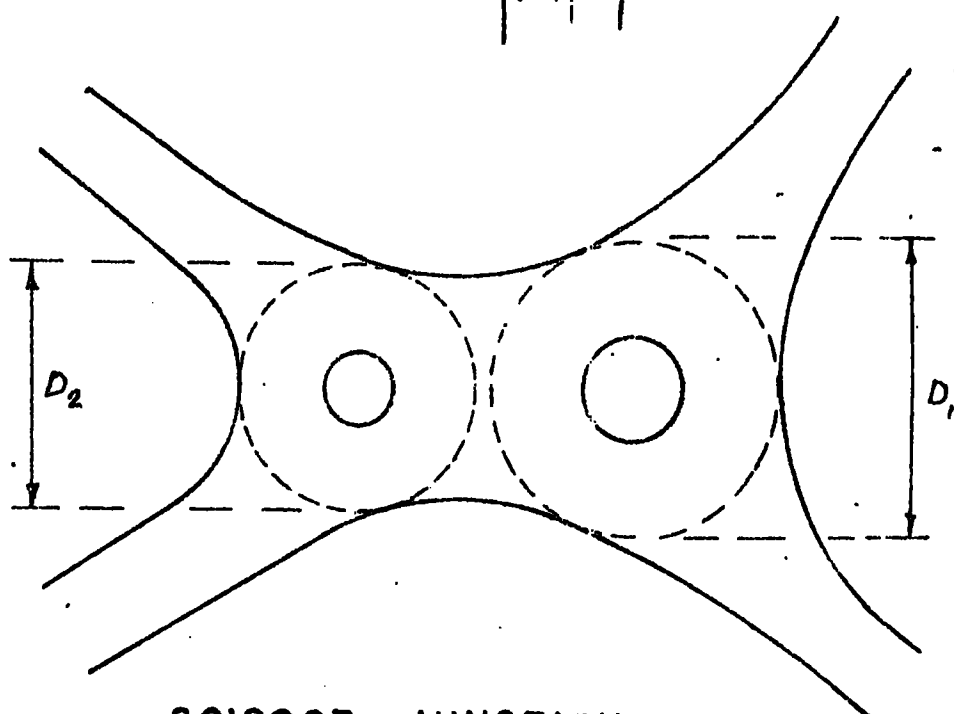


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SRI LANKA TRANSPORTATION FORUM

Inaugural Sessions, June 20-22, 1983

SOME PSYCHOLOGICAL AND SOCIAL

FACTORS OF ROAD ACCIDENTS

by

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Abstract

Research on accident causation can be regarded perhaps as the Cinderella of accident research. Despite the increased understanding of the problems involved in the road user behaviour, comparatively little research has been undertaken into the causes of road accidents. Two reasons are suggested: firstly, accidents are extremely difficult phenomena to observe directly, and secondly, the role of the road user must be considered in relation to the conditions of the road and the vehicle at the time of the accident. This paper outlines some psychological and social factors contributing to road accidents, and suggests some steps that should be taken to curtail them in Sri Lanka.

Introduction

In the recent past accident causation has been considered in terms of the vehicle - environment - road user system. Many studies have revealed that accidents tend to be caused by a combination of factors, of the which the combination of the road user and environment sub-system is the most common. Road user factors acting either alone or in combination cause about 90 percent of accidents in both developed and developing countries. Also it has been found that pedestrians and motor cyclists are involved in majority of accidents in Sri Lanka (24),. Hence there can be no doubt about the fact that the problem of the road user and its interacting environment is one of the most pressing problem in todays traffic.

Even though the motorists intruded the roads more than eighty years ago, still the road users (pedestrians and drivers) have not adopted to this environment very well. Probably the road users can not cope up with the motor vehicle dominated, rapidly changing road environment.

In spite of the relatively high car ownership in U.S.A., U.K. and other developed countries more than 65 percent of the total trips generated in these countries are on foot (2). In developing countries like Sri Lanka, India this percentage will be much more than 65. It could be as high as even 85 percent. More over every driver is a pedestrian at one time. Research on road accidents has become vast in developed countries, but relatively few studies dealing with the problem of road user behaviour in different conditions and environments have been done so far to improve the road user safety standards.

We in Sri Lanka have chosen the soft option of "playing with numbers" in most of the accident studies done so far in this country. Eventhough some use can be made with those figures, the time is quite ripe for accident researcher's in this country to do studies to evaluate the causes of accidents based on the analysis of road user errors. This is the only way to bring about a significant reduction in accident rate.

2. Psychology of Road Accidents

Driving is essentially a skilled psychometer task. In this context the concept of a three stage decision making process, consisting of perception, decision and implementation, is useful as a general framework upon which to base a model.

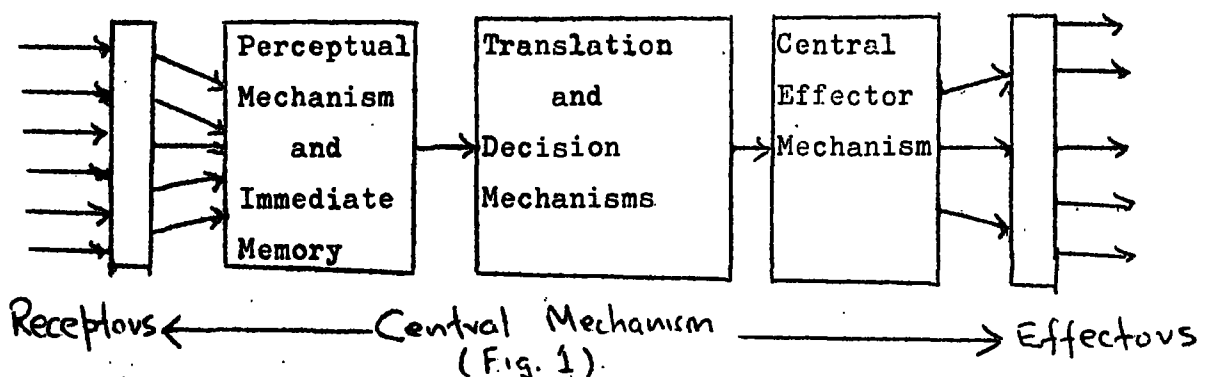
The essential problem involved in the driving task is that of the necessity for the rapid processing of perceptual information. A wide variety of stimuli may be presented to the driver, ranging from those stimuli with a high degree of expectancy to those with a very low degree. As well as changes in the type of stimuli presented, the amount of stimulation available will vary also, from the low conditions of driving on a rural highway at night, to the high stimulation provided in many Urban Traffic Environments during the day. Thus the demands of the task of driving will vary a great deal and the concept of stress may be used as specification of the demands that the environment places on the individual. In considering the degree of stress, it is immediately apparent that people do best under intermediate conditions of stress.

2.1 The Development of a Technique to Assess Road-User Failure

Many previous studies have suffered from one or both of the following criticisms: (a) the results are applicable only to a highly selected population, (b) no attempt has been made to classify the accidents according to psychological criteria.

It is suggested that the latter criticism is the main reason for the low co-relations between number of accidents and various psychological and physiological characteristics.

Consider Welford's (23) model of the psychological mechanisms underlying the performance of a skill (Fig.1)



It will be seen that it consists of three main parts, viz, the receptor organs, the central mechanisms and the effector organs.

The central mechanism is itself divided into three stages.

Stage 1 is the perceptual mechanism and immediate memory store which groups, integrates and orders the incoming sensory data, that is gives it meaning and then stores that part of the data which is not for immediate use. The translation and decision mechanisms relate the incoming data to past experience and decide what response is to be made to it. The 'decision' is then transmitted to the central effector mechanism, which in turn transmits to the effector organs.

In terms of the accident situation, the three stages may be restated as follows: (1) Perception of the situation; (2) Decision as to the appropriate course of action; (3) Implementation of that course of action. If any of these three stages is incorrectly executed, then an accident or near miss will occur.

(a) 'False hypothesis'

One tends to perceive what one expects to perceive. These expectations, which one, to some extent, the product of one's previous experience of similar situations, govern the way in which one perceives the situation and the way in which one organises the available perceptual data. Thus the holding of a 'false hypothesis' would lead to incorrect perception of the situation (stage 1).

(b) Pre-occupation

Consider the situation where several different components of the task make demands on this subject. If one component gains dominance, and the subject thus becomes pre-occupied with it, then the other components which do not possess the same degree of urgency may be neglected, or the information from these may be accepted uncritically. Thus the decision as to the correct course of action may be based as incomplete data. (stage 2).

(c) Emergency mechanism

In the face of physical or psychological dangers, the 'drivers' underlying behaviour become strange and the person's behaviour undergoes characteristic changes. The responses tend to be more readily elicited, to be elicited by less intense and less specific stimuli, and to be more forceful, extensive, rapid and irregular. Thus the implementation of the proposed course of action may be incorrect (stage 3).

Therefore it is suggested that road accidents could be grouped on a psychological basis according to the above criteria. Once this has been done; it becomes possible to test road users involved in a psychologically homogenous group of accidents to see if specific psychological or psychophysiological characteristics are present. Tests could also be made to see if inter-group differences such as age are present, as was suggested by Welford (23).

2.1.1 Causes of Accidents

Group 1 - Incorrect preception of the situation

Included in this group will be those accidents in which it was physically impossible for the road user to perceive a vital feature of the situation. However the causes of interest from the psychological view point are those in which it was physically possible for the road user to perceive the vital feature, but for some reason, such perception did not occur. Some suggested reasons are listed below.

- (a) lack of concentration. This may be due to fatigue, temporary distraction, or might be an innate quality of the individual.
- (b) visual defects. There are many of those, but those most relevant to road users are kinetic visual amity, binocular acuity, depth perception and perception of speed.
- (c) non-optic sensory defects. The exteroceptive and proprioceptive cues and also vestibular cues play an important part in driving, especially in the dark. However little is known to measure the effects of these cues.
- (d) 'false hypothesis'. This has been discussed above.

Group 2 - Incorrect Decision as to the Course of Action

The following causes are suggested.

- (a) Faults in Driving Training. Wrong techniques acquired early in driving training usually prove very difficult to eradicate and tend to reappear in moments of stress.
- (b) General Driving Experience. The more frequently a road user has experienced a particular driving situation, the more likely he is to possess an adequate response to it.
- (c) Specific Experience of the Accident site. Detailed knowledge of the site will make the driver more aware of its potential dangers.
- (d) Preoccupation. This has been discussed above.
- (e) Personality characteristics. Davis suggested that pre-occupation tends to be associated with an obsessional personality, who in all other respects tends to be tidy and efficient. It is hypothesised that the possession of certain personality traits tends to hinder the making of a logical and rational decision.

Group 3 - Incorrect Implementation of the Adopted Course of Action

Various reasons are suggested for this.

- (a) Response Time - If this is too long, then the intended consequences of the decision may not occur.
- (b) Emergency mechanisms - This has been discussed above. If the road users psychomotor co-ordination is disoriented, then the correct course of action cannot be carried out.

3. Some Social Factors of Road User Behaviour

Social factors influencing road user behaviour is one of the most important factors, even though only a few studies have been made in this field. This is a difficult task as accident records do not give many social factors. On sight and past accident research by interviewing of these people by sociologists could disclose certain social factors influencing road user behaviour.

3.1 Pedestrian Behaviour

Many researchers have found a relationship between age and accident frequency or accident proneness of pedestrians frequently. In many recorded accidents age is recorded and this can be expressed in figures quite easily. All investigations conclude by stating that children and older people - as pedestrians - are much more at risk than other age groups. Here too much research is on accident frequency and not on pedestrian behaviour at various groups.

It is important to note that these accidents and casualty rates and age is calculated on rates per million living and it is assumed that all age groups have equal exposure to risk.

Grayson (8) in his observations of pedestrian behaviour of children at four sites finds that the major influence on crossing behaviour is the social situation of the child. Children when alone make more head movements (when crossing) and have longer kerb delays than children in groups, while accompanied children hardly look at all.

Only two out of three children looked both ways before beginning to cross the road.

Another factor that has been found to influence the behaviour of pedestrians on the roads is their sex. From an analysis of the accident statistics, the accident frequency of both sexes can be seen. All investigators conclude by stating that men are exposed to a greater risk than women. Moore and Older (1965) state that risk of pedestrian accidents per 10,000 inhabitants in Great Britain is 5.1 for men, yet only 3.6 for women, for children between 0-9 years, the proportion is still more distinct: 10.7 for boys and 5.5 for girls.

Grayson (8) conclude that, despite the fact that there is a marked sex difference in the accident rates for children in this age group, no item of behaviour was found which showed a similar difference between sexes.

Jacobs (10) states that there is a difference in the behaviour of male and female pedestrians in that men cross the road more frequently between crossings than females, thus increasing their accident risk by a considerable amount.

Read (18) states that, of children, especially in the age group of 8 years, boys have considerably more accidents than girls. As a whole, the proportion of injured children upto 14 years is 1.7 boys to 1 girl. Read suggests that the "Aggressive, impetuous and venturesome behaviour of small boys brings them into trouble more frequently than in the case of the cautious little girls".

From all these studies the conclusion is drawn that male pedestrians of all age groups are more likely to be involved in accidents because they tend to take more risks in their road crossing behaviour.

Lefkowitz et al (11) found that "pedestrians violated the prohibition of an automatic traffic signal more often in the presence of an experimenter's model who violated the prohibition than when the latter conformed or was absent.

Significantly, more violations occurred among pedestrians when the non-conforming model was dressed to represent high social status than when his attire suggested lower status". The question here is not whether persons with certain social characteristics have a higher accident risk, but the influence of certain social characteristics in other persons upon pedestrian behaviour.

Lashley (12) arrives at the following result: "Under privileged, low income groups are unduly prominent in the pedestrian fatality toll".

Backett (25) in an investigation comparing fatal pedestrian accidents with a control group finds that, "the involved vulnerable family had illness, in the household, and more serious illness; there was material preoccupation of some kind for example, with outside work, with other children, or with pregnancy. It was more crowded and it did not provide protection during play".

Other factors involved in the relation between pedestrian behaviour and accident risk are alcohol and drugs.

Singer (16) states that: "even at very low levels of blood alcohol a pedestrian's ability to cross streets safely is greatly reduced".

Haddon (26) in his study of a control group found that heavily drunk pedestrians (with blood alcohol of more than 1.5) were found quite frequently in the test group. But even blood alcohol concentrations ranging from 0.1 to 0.4 increase the accident risk by a significant extent.

Clayton et al (13) on their investigation into a controlled study of the role of alcohol in fatal adult pedestrian accidents concludes that "alcohol has a major role in fatal pedestrian accidents. At BACs (Blood Alcohol Contents above 120mg/100ml. the relative risk of accident involvement increases rapidly. Impaired pedestrians comprise 27% of the male fatalities and 7% of the female fatalities who die within 12 hours of the accident". They go on to say that "for injured pedestrians with high BACs, treatment of their drinking problems would appear to be as important as treatment of their physical injuries".

The incidence of higher alcohol amongst male fatalities than females is one of the reasons for higher accident involvement for males.

It can be assumed that certain groups of pedestrians have a higher accident risk because of physical deficiencies or mental characteristics. Only a few investigators have studied this question on account of the great methodological difficulties involved in this task.

Read (18) found in his comparison of two control samples of children that the accident involved child has more frequently visual and other physical deficiencies.

Another investigation using health condition as a criterion was made by Backett: in the families of accident involved children he found more often illness than in a well selected control group. In this case there are illnesses in the family of the pedestrian, not illnesses of the pedestrian himself !

Mental characteristics in relation to accident risk of pedestrians have been investigated more often. Nejedlik (19) compared a group of accident involved pedestrians with a control group. In the test group the complex visual abilities and the amount of self-criticism were significantly lower; in addition, frequent emotional instability was observed. There were no difference observed with regard to the ability to estimate speed correctly.

Read et al (18) in their investigation the "Personality" of the accident involved children concludes "that the pedestrian accident susceptible child is best defined by age, residence and family background". Also they found that accident involved child is more frequently daring and defiant. Read and his colleagues, however, did not use a very reliable method for studying personality.

3.2 Driver Behaviour:

Literature on driving behaviour is vast. The great difference between the large amount of interest centring around the driver and the small amount centring around the pedestrian has been explained by the American Automobile Association (14): Much greater progress has been made so far with drivers than with pedestrians, in relation to modern traffic conditions.

In large measure, this is understandable because motor vehicles and their drivers are the newer elements in street and highway traffic".

Mackie and Jacobs (7) on the work on panda, zebra and light controlled crossings finds that "Out of the total number of drivers who were in a position to pass over the crossing when the signal was red, 13 percent did so at the panda crossings but only 2.5 percent did so at the light controlled crossing. This difference is statistically significant". They found that at light controlled signal crossing 47 percent of total leading vehicles and 54 percent of cars and vans leading vehicles stopped from 100 ft. Also they found that 50 percent threshold stopping distance to be 104 ft for total leading vehicles and 98ft for cars and vans leading vehicles at light controlled signal crossings. In studies on driver behaviour with pedestrians on crossing they found that the proportion of drivers illegally passing a pedestrian waiting on the nearside part of the crossing, of those in a position to do so, was 72 percent. But they have not clearly stated what they mean by "of those in a position to do so".

Quenault (15) in his work on driver behaviour concludes that "results obtained from the Picture Test, the Shipely Abstraction Test and the Mandsley Personality Inventory showed that there were no significant difference between a group of drivers who had been convicted of careless driving and a group consisting of drivers selected at random". He also concludes that "results obtained in this experiment appear to confirm the view that, when investigation complex behaviour such as possible to the 'real thing' is to be preferred to the use of

pencil and paper tests, in that significant difference between different groups of subjects are more likely to be found with the method of systematic observation of driver behaviour".

Shouksmith (17) in his work on conformity behaviour on a zebra crossings (an activity sampling analysis) finds that drivers behave differently at city centre and suburban crossings. At city centre crossings he found that "female drivers of private cars, on all counts, appear as conforming most closely to the rules for behaviour of drivers at a pedestrian crossing. Bus drivers, it would appear, ignore the rules for the most part". He also found that the bus drivers are conforming and careful in the city, but not in the suburbs. He gives the following reasons for it - for the bus driver, the suburbs represent an opportunity to make up time and so he is less prepared to slow for pedestrians waiting by a Zebra crossing, or to remain stationary till they have all cleared the road. In the city centre, however, he realises the need to be more careful, perhaps he is also under closer control. His skill allows him to be careful and conformist and his attitude directs him to be so.

4. Road User Behaviour Studies in Sri Lanka - Carried out by Moratuwa University

4.1 The following conclusions were obtained from a study of driver behaviour at road intersections in the City of Colombo (28).

4.1.1. Driver Behaviour at Roundabouts:

The driver behaviour studies were made out the following sites.

roundabout (a) : roundabout infront of the old parliament - which is a well designed roundabout.

roundabout (b) : roundabout at - Horton place - Alexander Road (CWW Kannangara Mawatha) intersection - which is and ill designed roundabout,

The following results were obtained:

- (i) There is no significance difference between driver behaviour of different vehicles (cars, motor cycles, heavy commercial vehicles, light commercial vehicles, ETC buses, private buses) with regards to disobeying the 'right hand priority rule' at both roundabouts at X^2 values of 05 and 01 percent levels, both with and without the presence of police near the intersections (a and b)
- (ii) The driver behaviour of all vehicles improved significantly (both at 05 and 01 percent significant levels for X^2 test) when the police was present near the intersection (a and b)

Roundabout	Percentage who did not conform the right hand rule	
	with police	without police
Old Parliament	99.8	97
Horton Place	95	87

(iii) The driver behaviour^{of} all vehicles is considerably better (at 05 and 01 percent significance level) at the old parliament roundabout when compared to Hortan Place roundabout, with and without police officer near the vicinity of the roundabout.

Roundabout	Percentage who did not conform the right hand rule
Old Parliament	98
Hortan Place	89

4.1.2 Driver Behaviour at Traffic Signals

The driver behaviour studies were made at the following sites

traffic signal (c) : Dickman Road - Havelock Road

intersection at Thimbirigassaya.

traffic signal (d) : F.R.Senanayake Road - CWV Kannangara

Mawatha intersection at Town Hall.

The following results were obtained:

- (i) The observations were made how many drivers passed the intersection when the red light was on. There was no significance difference between driver behaviour of different vehicles (except pedal cycles) for χ^2 test at 05 and 01 percent significance levels. There is no significance difference in behaviour between two sites.

Traffic signal	Percentage Passed when Red Lights were on
(c)	99.8
(d)	99.8

(ii) There is no significance difference in driver behaviour when police were present and not present at 05 and 01 significance level for the χ^2 test.

	Percentage passed when the red light were on
With Police	100
Without Police	100

(iii) There is a significance difference in driver behaviour of stopping the vehicle when the amber light was on, when police was present and not present. There is no difference in behaviour between drivers of different vehicles. Please refer fig.2.

4.2 The following preliminary observations have been made from a sample of accident victims obtaining treatment at the Accident Ward in Colombo General Hospital and their police records (29).

4.2.1. Observations Pedestrians Victims

(a) Sex

Sex	Percentage involved Accident	Percentage for Colombo District
Male	80	52.5
Female	20	47.5

Note: The percentage of males on the road need not be same as that household percentage.

(b)

Age Group	% Distribution for Colombo District	% Distribution of Accident Victims
0-14	35	38
15-19	11	16
20-24	10	6
25-34	16	5
35-44	10	6
45-54	8	10
55-64	5	9
> 65	5	10

(c)

Income Group (Rs)	All island % Distribution	% Distribution of Accident victims
0-300	37	50
301-600	39	33
601-900	9	5
901-1200	7	5
1201-1500	3	2
> 1501	5	5

(b) Purpose of Trip

Purpose	Percentage
Work	24
Business	24
Private or Lesure	52

(c) Age

Age Distribution of Driving License Holders is not available. Hence no comparison could be made with the drivers meeting with accidents.

(d) Income

Income Distribution of Drivers is not available.

Hence no comparison could be made with the drivers who met with accidents.

(d) Permanent Human Defects

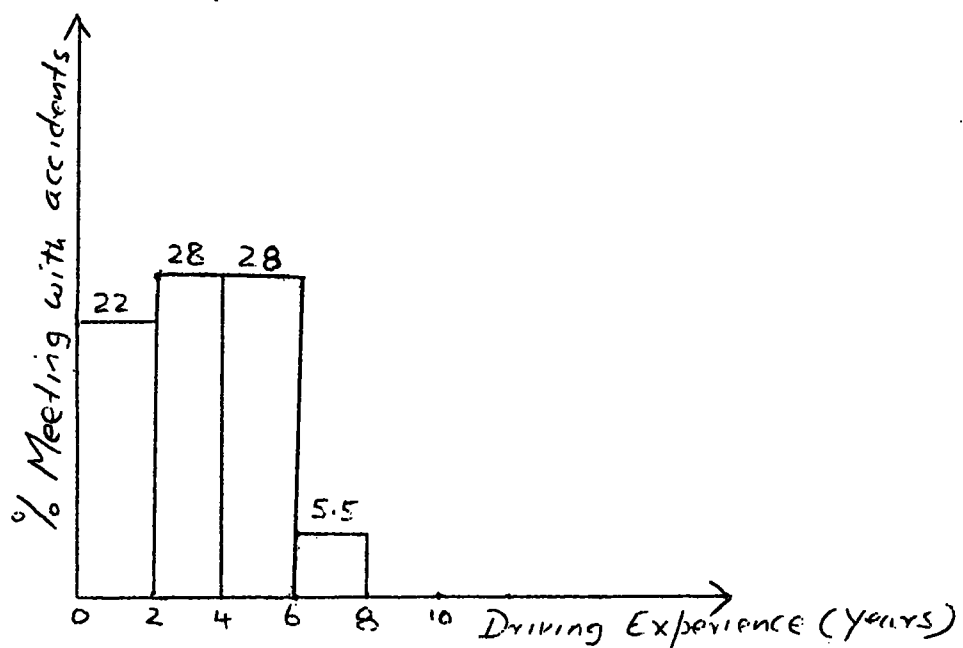
	%
With Defects	6.25
Without Defects	93.75

(e) Vehicles involved in pedestrian accident

Vehicles	% involved in accident	% on roads
Car	8	19.5
RTB Bus	31	15.1
Private Bus	15	20.5
LCV	15	14.7
HCV	8	14.6
MC	23	15.6

4.2.2. Observations made on Drivers involved in Road Accidents

(a) Driving Experience



(c) Permanent Human Defects

	Percentage
With Defects	14
Without Defects	86

(f) Vehicles involved in accidents

Vehicle	% Involved in Accidents	% on roads
Car	3	19.5
MC	44	15.1
RTB BUS	9	20.5
Private Bus	13	14.7
LCV	22	14.6
HCV	9	15.6

5. CONCLUSIONS

- (1) There is very little studies made on road user behaviour in order to check the causes of road accidents. More attention should be made to determine the road user errors in accident causation in spite of the many difficulties that may come across.
- (2) It is difficult to study the causes of traffic accidents by engineers alone. It has to be performed by a group consisting of engineers, doctors, sociologists, psychologists and police.
- (3) It is evedent that police control improves road user behaviour. Hence the government should give enough resources to the traffic police if accidents are to be reduced in this country.
- (4) All designed road intersection and road designs cause road users to disobey the traffic rules. Hence the department of highways and Colombo Municipal Council should give priority to give well designed intersections and roads.
- (5) Pedestrian and Motor cycle accidents are predominately high in Sri Lanka. Hence more work should be done to find causes of them and suggest preventive measures. Compulsory wearing of a helmet for motor cycle riders is a great step forward in this direction. But more controls over speed, overtaking, signals, lighting (head lights) are necessary to reduce the accident rate.

(6) Good road user behaviour can not be attained over night.

All efforts must be taken to teach good road manners to all school children in Sri Lanka. The police should educate and create an ~~awarene~~ awareness among the people to understand the advantages of good road user behaviour.

(7) The chances of obtaining a driving license in Sri Lanka is not difficult. The commissioner of Motor Traffic

should make more controls in issuing of driving licenses by having written tests,. It should be issued only for a short duration of about 4 years and they should have on the spot checks for good driver behaviour.

(8) It is observed that RTB buses cause many pedestrian

accident even though their overall accident rate is low

when compared with other vehicles. Studies have to be

made to determine the reasons for this abnormal behaviour.

(9) It is observed that every pedestrian has an equal chance

of meeting with an accident whether they are small,

young or old; and whether poor or rich. Superficially

men pedestrians have a greater risk of meeting with

an accident.

(10) This paper does not deal with the physiological factors

of road accidents. These factors too should be considered

if more analyses of road user error are needed.

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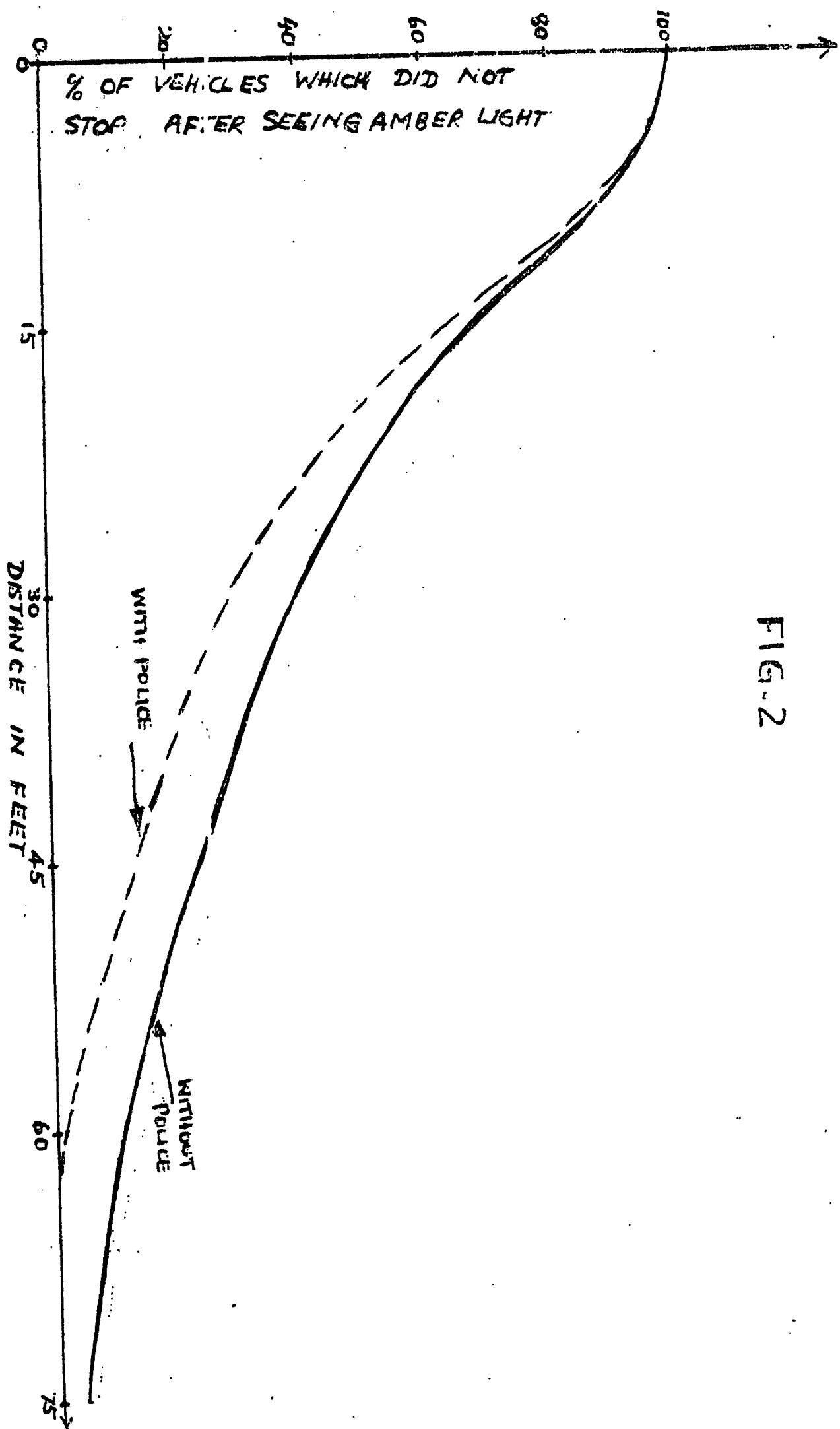


FIG. 2

SOME MEASURES FOR INCREASING THE SAFETY
AND CAPACITY OF MAJOR INTERCITY HIGHWAYS

by

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Abstract

The present level of safety and capacity on main intercity highways in Sri Lanka, and the underlying causes are discussed. The multifaceted nature of the problems is highlighted. Measures that can be taken to increase both the safety and capacity in the short, medium and long term are given with respect to the rights-of-way, vehicles and road users. Traffic management in small towns which are the major bottlenecks in the intercity highway system is dealt with in detail. Some long term scenarios regarding intercity travel in Sri Lanka and measures that can be taken to cope with them are discussed.

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1. INTRODUCTION

It is clear that both safety and capacity (the maximum possible flow of motor vehicles of a given mix per hour) are seriously lacking in sections of the main intercity highways (eg. Colombo-Galle Road) of Sri Lanka. A high capacity main highway system is an essential cornerstone of the solid infrastructure that is necessary for the rapid economic strides envisioned for Sri Lanka, while safety should be given the highest priority in the compassionate society that is being striven for.

The main intercity highways are used not only for intercity travel but for local trips as well as parking and loading/unloading of passengers and freight. It is also used for other purposes ranging from mixing of concrete to drying of fishnets and crushing of coconut husks. The highways are used not only by motor vehicles but by carts, bicycles, pedestrians and stray domestic animals as well. The mixed purpose, mixed mode use is one of the principal causes of the poor safety record and of the low capacity available to intercity traffic.

The poor safety record is also due to certain attitudes exhibited by road users, bad driving and pedestrian practises, carelessness, inadequate law enforcement, poor road surfaces and geometry and lack of vehicle maintenance. The low capacity is also due to inadequate width of the roadway, ribbon development and uncontrolled crossing of the highway by vehicles, pedestrians and animals.

A single, novel, economical solution that will increase both the capacity of the highways and the safety is not available. However, several actions can be taken with respect to people (drivers, pedestrians etc.), rights-of-way (space reserved for transportation activities, eg. highways, sidewalks, grade separated crossings) and vehicles (motor vehicles, carts, bicycles etc.) in the short, medium and long run to increase the safety and capacity of the highways. This has been noted in reference (1) and with respect to safety in reference (2). In fact, it is vital to attack the problems in

their three facets (people, rights-of-way, vehicles) and in a planned and systematic manner with respect to time.

The short, medium and long term defy strict definition, specially since they may vary for the three facets of our problems, and necessarily some overlap will occur. Loosely, we can consider 1 to 3, 3 to 8 and 8 to 16 years as the short, medium and long terms respectively, while noting that 7 years will bring us to the 90's decade and 17 years to the second millennium.

On main intercity roads priority should be given in general to intercity trucks, other heavy vehicles and automobiles. However, adequate provision should be made for local traffic in the sections where the highways pass through towns. This amounts to giving equal priority in towns to intercity and local traffic including cyclists and pedestrians.

1.1 Safety

For our purposes, a danger index I_D for a person can be defined as the weighted probability of having an injury-accident while traversing a section of highway:

$$I_D = \sum_j \sum_i K_j P(I_j/A_i) P(A_i)$$

ΓΔ+ε

Where $P()$ = a probability

A_i = accident of type i

I_j = injury of type j

K_j = a numerical weight given to an injury of type j , depending on the severity of the injury.

A safety index I_s can then be defined as the inverse of the danger index:

$$I_s = 1/I_D$$

Theoretically, I_D can range from zero to $\sum_j K_j$ and I_S from α to $1/\sum_j K_j$ when safety ranges from absolutely safe to extremely unsafe respectively. The above formulation can be further extended, for example to include the condition of the driver (e.g. inebriated).

We are not concerned with actual numerical values here. However, the formulation helps the discussion since it is clear that I_S can be increased (and I_D reduced) not only by reducing $p(A_i)$, but also by reducing $p(I_j/A_i)$, the probability of an injury of type j given an accident of type i . In Sri Lanka it appears that discussions on increasing safety have centered mostly around the reduction of the probability of an accident. The exception is the introduction of the mandatory safety helmet for motorcyclists and pillion riders. We will however consider actions that will reduce the probability of accidents and also actions that will reduce the probability of an injury given an accident.

Fatalities can be reduced significantly, even after severe injuries are sustained, by improving the para-medical and hospital emergency services, which are woefully inadequate at present. However, that aspect will not be discussed further, here.

1.2 Capacity

The main intercity highways of Sri Lanka are two-lane, two-way facilities with the exception of some sections in major cities which have four lanes. A few kilometres of the four lane sections are divided by a median.

The capacity of a two-lane highway is defined as the maximum two-directional hourly flow that can be accommodated under existing roadway, traffic and environmental conditions (3).

Under ideal conditions about 2000 equivalent automobiles can be accommodated per hour. A reduced flow in one direction does not result in a significant increase in capacity in the opposite direction. However an increased level of service (for example, a higher

average speed) can result. In Sri Lanka flows do not presently approach 2000 e.a.p.h. except perhaps in or near Colombo. Consequently the capacity should not be a concern outside major cities if one unobstructed lane is available in each direction, for motor vehicles.

However, two-lanes are not available at all locations at all times and bottlenecks abound in the intercity road system. Three types of bottlenecks can be identified: Permanent bottlenecks which are caused by inadequate road width; temporary stationery bottlenecks caused by stopped or parked vehicles and use of the roadway for non-transportation purposes; moving bottlenecks caused by slow moving vehicles. The moving bottlenecks is further aggravated when inadequate sight distance is available for overtaking. All three types of bottlenecks have to be eliminated as much as possible if an adequate level of service is to be provided on our highways.

1.3 Mixed traffic

The multiple use, multi-modal nature of the intercity highways was mentioned earlier. Motor vehicles, bicycles, carts and pedestrians are incompatible on a common right of way, for obvious reasons. However, as long as the highways serve local as well as intercity traffic, all modes have to be served. In fact, because of the worsening fuel situation, bicycling and pedestrianism for short trips should be encouraged by providing safe and adequate facilities. The only solution is to separate the modes in space and/or time wherever possible and to provide adequate rights-of-way.

1.4 Highway user discipline, beliefs & attitudes

Orderly and disciplined use of the highway can lead to more safe travel and better utilization of available capacity. The lack of discipline exhibited by drivers, pedestrians, cyclists etc. is a major cause of accidents and lost capacity and is probably due to deep seated attitudes. For example, some cyclists and pedestrians seem to take the attitude that their safety is the responsibility of motorists. Some motorists believe that they can drive safely at any speed if they placate the local deities with a coin. In general

people seem to take the attitude that their time is more valuable than other people's time and that accidents happen only to other people.

Even though attitudes and beliefs are very difficult to change, such attempts should be made for the social good.

The anti-social behaviour exhibited by vehicle-operators is cause for grave concern. It is specially so because most of these drivers are gentle, law abiding citizens when they are not driving. Partly, this is due to the relative anonymity offered by a vehicle and the ability to "get-away" after some unacceptable act has been committed. The reckless driving by bus-drivers is partly due to their attempt to keep to schedule or to increase their lay-over time (in the case of the S.L.T.B.) and to reduce the round-trip time or overtake other buses (in the case of private buses). But is the class-struggle in Sri Lanka being manifested on the highways with the mostly non-car-owning professional drivers getting "even" with the car-owner drivers? Some of these issues merit further study by Psychologists and others.

The general attitude of some officials is that motor vehicles should get priority over other road users. This can lead to misguided solutions which are worse for everyone including motorists. For example when capacity for motor vehicles is considered inadequate in towns a standard solution is to widen the roadway at the expense of the sidewalk. This results immediately in the pedestrians walking on the roadway, causing loss of capacity for motorists and cyclists and increased danger to all. Further, the pedestrians get into the habit of walking on the roadway and stop using sidewalks even when they are available.

1.5 Basic postulates

Our proposals for increasing the safety and capacity of the intercity highways are based on the following postulates:

- (i) Safety should take priority over capacity.
- (ii) Cyclists, motorists and pedestrians have to be served equally well whenever possible with priority going to intercity traffic in highway sections between cities.

Most of the proposals given in the following sections will be aimed towards specific issues. However, in general it is worth repeating that

- (i) adequate maintenance of the highways
- (ii) strict enforcement of the Motor Traffic Act with respect to all road users.
- (iii) proper signing (informational, mandatory and directional)
- (iv) improved highway geometry
- and (v) regulation of on-street parking.

is essential for the safe and efficient functioning of the highway system.

1.6 Main intercity highways

The main intercity highways, which we shall call class A*, have to be chosen from the present set of class A highways (Appendix 1). The choice should depend, among other things, on the amount of person-km of travel and on the ton-km of freight transported on various sections (present and projected), on civil defence needs and on economic developmental needs. Such a detailed analysis is beyond the intent of this paper. However, a superficial study of the latest traffic flow data map (4) shows that the following sections of routes A 1 (Colombo-Kandy), A 2 (Colombo-Hambanthota), A 3 (Colombo-Chilaw), A 4 (Colombo-Ratnapura), A 6 (Ambepussa-Dambulla), A 9 (Kandy-Matale), (Jaffna-Mankulam) are among those that would merit serious attention for class A* status.

2. SHORT TERM PROPOSALS

The following proposals could probably be implemented, given the political will, within 1-3 years. They are also relatively cheap with respect to the public-purse.

2.1 Proposals for increasing safety

2.1.1 Establishment of clearly demarcated two-way no-passing zones at bends and other low sight distance sections by drawing double white lines along the center of the road, and locating appropriate signboards at the beginning and end of the no-passing section. One-way no passing zones can also be used on either side of the two-way no passing zone, where appropriate (Fig.1). This proposal will result in reduced head-on collisions. Since overtaking is essential if an adequate level of service is to be provided on two-lane roads, the one-way no passing sections are appropriate.

Two-way no passing zones should also be located on hills with low sight distance.

2.1.2 All new imported vehicles, beginning with 14 Sri for automobiles and similar "cut-offs" for other types of vehicles, to be required to have seat-belts in the front (lap and shoulder) and rear seats (lap), and the use of seat-belts to be made mandatory in these vehicles.

While it is well accepted that seat belts reduce severe injuries, it is impractical to enforce a universal seat belt use law given the existing fleet. However, it should be enforced for new vehicles if possible legal snags regarding selective enforcement can be overcome.

2.1.3 Children under 10 years of age to be prohibited from riding in the front seat of motor-vehicles and the prohibition of any passenger riding in front of the operator on the motor cycles and scooters.

Children are specially susceptible to severe injuries when riding in the front seat with or without a seat belt. Consequently, Sri Lanka could set an example in child care by implementing this proposal.

2.1.4 Laws regulating cyclists and pedestrians to be drafted and/or amended where necessary. These and existing laws to be published and explained in a booklet and also given wide publicity in the news media.

These booklets should be issued free to school children & bicycle owners. The laws should be applied and fines imposed on errant pedestrians and cyclists as for eg. in Singapore.

2.1.5 Several short (5 minutes or less) T.V. spots on proper highway use to be produced and shown on Rupavahini.

Some possible topics are proper passing, right-of-way at intersections, pedestrian crossings, defensive driving, and bicycle riding on the highway. Rupavahini has shown one or two such spots recently, but these are aimed mainly at children. However, adults too have to be educated, even belatedly. Thus short spots are essential to prevent the channel being changed.

2.1.6 Spot checking of motor vehicles and bicycles for adequate tyres, brakes and lights.

Spot checking is cheaper and probably as effective as formal annual checks as practised in some countries. Vehicles found to be requiring work should be required to be brought back to a police station after repairs are completed.

2.1.7 Adoption of an internationally accepted set of road signs eg. the I.R.F. system (Appendix II) with minor modifications when necessary.

This becomes more urgent because of the tri-lingual situation in Sri Lanka and as "you-drive" cars are becoming available to tourists.

2.1.8 Painting of a broken white line along the center of the highway, with additional cat's eyes, in sections where passing is allowable, to maintain the separation of opposing traffic streams.

2.1.9 Motor cycles and scooters to be required to have the head lamp on at all times.

Manufacturers do sell motorcycles that are wired so that the head-lamp is on when the engine is running (5). However, developing countries tend to be neglected when safe vehicles are exported. Some bus systems run their buses with the head-lights on (dimmed) at all times. This proposal is under study in some countries for all vehicles.

2.2 Proposals for increasing capacity:

2.2.1 Carts to be allowed on the main highway in towns only during certain designated hours. These time periods may vary from town to town.

Severe congestion abounds in intercity highways passing through towns, during local peak periods. Removal of carts during these periods (in total about 4-5 hours) only will remove some bottlenecks while causing minimal disruption to cart transport activities such as the distribution of kerosene.

2.2.2 Provision of suitable alternate facilities for sidewalk vendors, thus creating space for pedestrians on the sidewalk and removing them from the vehicular right-of-way.

Sidewalk vendors reduce the available pedestrian right-of-way while increasing the number of pedestrians. However, one should not tamper with a person's livelihood and vendors should be moved only if alternate facilities are made available.

Alternate provision can be made as has been demonstrated at Pasyala on the Colombo-Kandy Road.

2.2.3 Fenced sidewalks to be provided in towns with heavy pedestrian flows.

The type of fence used in Wellawatte appears to be suitable.

This proposal will increase vehicular capacity and pedestrian safety while reducing pedestrian capacity.

2.2.4 Owners to be restricted from letting their animals run loose on the highway and strict enforcement with removal of stray animals including cattle to a pound. Thus is probably a matter of enforcing existing regulations.

2.2.5 Proper signing of intersections for control purposes. STOP or YIELD signs to be located on cross-streets ensuring priority for the intercity highway. The right-of-way rule should be superseded by STOP or YIELD signs.

- 2.2.6 Construction of parking-bays at scenic and other interesting spots on the highways, thus reducing on-street parking.

3. MEDIUM-TERM PROPOSALS

3.1 Proposals for increased safety

- 3.1.1 All drivers to be required to pass a written (multiple-choice) test before being issued a drivers license. For private automobile drivers, the test should be repeated every five years. For professional drivers, the test should be repeated every two years. Current license holders should not be exempted.

The procedure is to draw-up about 10 different examination papers and to choose one each day at random. The answers are marked on the spot. If a person fails, the test may be retaken after a specified time period. A few special tests can be made up for illiterate persons who currently possess a license. Some or all of the questions will become public knowledge after some time. However, this is acceptable because the point is to make people review the highway code. A new test can be introduced every year or so. Driving examiners are not needed to mark these tests which are a common practise in some jurisdictions. The scheme should be costed and made to pay for itself.

- 3.1.2 Children under six years of age and over one year of age to be restricted to special child car-seats when travelling by automobile, unless accompanied in the rear seat by an adult. Again, here Sri Lanka can set an example to the rest of the world.

- 3.1.3 Regular revision of the Motor Traffic Act and inclusion of sections on bicycling and walking on the highways.

- 3.1.4 At least one, preferably more, elevated or underground crossings to be provided for pedestrians in each town.

A national contest should be held to choose a few practical and aesthetically pleasing architectural designs. The problem of

non-use of elevated crossings by pedestrians due to steep ascents, increased walking distance and the problems of crime associated with tunnel crossings are well known. These however could be mitigated to a large extent by good designs, incentives/disincentives and proper enforcement. The highway capacity is also increased when pedestrian bridges are installed.

3.2 Proposals for increased capacity

3.2.1 Provision of new limited length passing-lanes when required and when land is available (Fig. 2). All trucks, lorries and other slow vehicles are required to keep left in the new lane while being passed by faster vehicles in the main lane. The distance to the next passing-lane should be indicated at strategic locations.

It is natural for drivers to undertake risky overtakings when they are held up behind slow moving vehicles for long stretches. Thus, at steep hills, on winding roads with low sight distance, and in sections with heavy opposing traffic, a passing lane adds capacity and increases safety.

3.2.2 Provision of bus-bays at bus-stops where land is available.

Sufficiently long acceleration and deceleration lanes should also be provided since the idea is definitely not to box the buses in.

3.2.3 Introduction of traffic lights at intersections where signing is insufficient.

World wide tenders to be called for the supply of traffic lights by manufactures with a proven low maintenance record in tropical and ocean-fronted locations and who can train maintenance personnel.

Most towns in Sri Lanka that are located on major intercity highways will not need traffic lights because of low cross traffic. Those that do will need two sets of lights - one at each end of town, or possibly only one set at the major junction. The timing can also be used to provide good gaps for pedestrians who wish to cross the highway.

4. TRANSPORTATION MANAGEMENT PLANS FOR TOWNS

It is in towns that the severe bottlenecks on intercity highways occur because of the high concentrations of pedestrians, cyclists, motor vehicles and business activities. By towns are meant places such as Ambalangoda, Pelmadulla, Kegalle etc. and not major cities such as Colombo, Galle, Jaffna.

Many of the transport problems facing these towns are similar, while special local problems also exist. It is necessary in the medium term to have a transport management plan for each town. This is not as difficult or expensive as it may seem at first if technical guidelines can be given to local governments and sufficient funding is available to hire an energetic, local graduate qualified in a subject such as Geography or Economics. They could easily be given a short course in Transport Management for small towns in Sri Lanka.

Some of the groups whose concerns should be considered in the transportation management plan are :

- (i) pedestrians (includes school children)
- (ii) cyclists
- (iii) motor vehicles (includes buses) that are on local trips
- (iv) motor vehicles that are on long distance trips that make a stop in the town
- (v) motor vehicles by-passing the town
- (vi) Carts
- (vii) vehicles loading and unloading goods and passengers
- (viii) local business
- (ix) local residents

Further, (i) the location of major trip generators (eg. shopping street, rest-house, main bus station, petrol-shed)

(ii) the street network

(iii) local peak periods, are among the factors that should also be considered.

Some of the steps that can be taken to organize travel in an efficient manner have already been mentioned in sections 2 to 3.2 and some others are given overleaf.

Parking fees should be charged and the income spent on transportation improvements. Variable parking fees for peak/off peak, on street/off street, weekday/weekend and so on should be used to regulate traffic. Some towns, eg. Bandarawela, already collect a fixed parking fee. Bicycle parking stands should be provided free on side streets.

The options are limited in towns in which the intercity highway is the only street. On-street parking of vehicles and stopping of buses, goods vehicles may have to be totally curtailed during peak periods and off-street space provided instead. If two-lanes are available for moving vehicles, sidewalks could be widened to cater to the very heavy pedestrian traffic. Initially, unpaved but stabilized back-lanes could be provided if space is available for the vehicles which have to load/unload goods. In the long term, another street could be constructed.

A two street town can be managed quite well and several options are available as shown in Table 1.

Option	Street A	Street B	Example
A	Pedestrians only; street end parking	2-way traffic, 2 parking lanes, 2 small sidewalks	-
B	One-way traffic (1 or 2 lanes*), 1 or 2 parking lanes*, 2 sidewalks	One-way traffic (1 or 2 lanes*) 1 or 2 parking lanes*, 2 sidewalks	?
C	2-way traffic, 2 parking lanes, 2 sidewalks	2-way "by pass" traffic, 2 parking lanes*, 2 small sidewalks	Weligama
D	2-way traffic, 2 parking lanes, 2 sidewalks	1-way traffic, 1 parking lane, 2 sidewalks.	Bandarawela

Table 1

*depending on the availability of space.

Option A clearly favours the pedestrians. It should be tried out, at least on a trial basis, in a few towns. Option B vanishes head-on conflicts. Option C favours heavy through traffic. However, care must be taken to prevent encroachment of shanty dwellers if a new by-pass is constructed. Option D favours a particular direction unless the one-way street is reversible. The management of a reversible street, while not impossible, is a difficult matter, and should be considered carefully before implementation.

One problem with limiting parking to one-lane is that of the loading and unloading of goods. Back streets should be used whenever possible. In their absence, particular time periods could be suggested for loading/unloading. Parking lanes could be for parallel parking or for angle parking if space is available. Clearly, it is easier to teach angle parking to drivers.

5. LONG TERM PROPOSALS

By the year 2000, we should be in possession of a high capacity, safe, intercity highway system connecting major cities; a fleet of safe vehicle; a properly trained population of owner-drivers as well as professional drivers and a disciplined population of road users.

5.1 High capacity highways

It is most likely that outside of metropolitan areas, 2 lane highways will be sufficient for intercity travel in the future. This is based on the assumption that high costs will restrict the ownership and use of private automobiles.

Some rough calculations (Appendix III) indicate that for the present mix of traffic, the daily two-way traffic in urban areas should remain below 16,500 for 2 lane highways to be sufficient. Thus if we assume for example, that traffic will double by the year 2000, towns with current daily traffic of 8,250 or more should be candidates for an extra lanes in each direction. Since this is difficult to provide along the present right of way because of ribbon development, 2-lane by-passes will be necessary in many cases so that the existing road will provide 2-lanes and the by-pass will provide 2 lanes.

For the present mix of rural traffic, the maximum daily two-way traffic on a 2-lane road is about 11,000 (Appendix III). This volume level is unlikely to be reached in rural sections unless present traffic is increased by factors of 2 to 4. Consequently, the construction of new 4 lane highways with central medians advocated by some consultants will be unnecessary.

It is however likely that the Moratuwa-Kalutara section of A2, the Colombo-Ambepussa section of A1, the Colombo-Katunayake section of A3 and the Colombo-Homagama section A4 will need 4 lanes by the year 2000 to cater to the local and intercity traffic.

All main intercity highways outside towns should be widened to a minimum width of 8 meters. This width is sufficient for two lorries, buses or container trucks travelling in opposite directions to pass without reducing speed (Fig. 3a).

Sections of road which are regularly used by cyclists should be further widened by 2m on either side and clearly demarcated to provide safe transportation for load carrying cyclists and to retain the capacity of the highway for motor traffic (Fig. 3b). This is essential since bicycle traffic is likely to increase in the future.

A 1 to 2 meter wide gravel or grass shoulder should be provided for pedestrians (Fig. 3a, b). In sections with heavy pedestrian traffic a raised sidewalk of 1 to 2 m width should be provided on both sides (Fig. 4c).

Bus-bays should be provided at all bus stops to keep two clear lanes open for traffic. Passing lanes should be provided as indicated in sub-section 3.2.1.

Only highways with the above characteristics could in my opinion be considered class A*.

Other intercity highways should be widened to 7 meters to allow an automobile and a bus travelling in opposite directions to pass without reducing speed. In this case a center line cannot be indicated.

Sections where class A* road width as indicated above cannot be provided should be by-passed with new roads.

In certain cases such as the Panadura to Galle section of A-1 it may be that several by-pass sections have to be built. In such cases careful consideration should be given to the construction of new toll highways for the full length of the road. This is discussed further in the next section.

5.2 Safe vehicles

The proposals given under the short and medium term headings should result in a safe vehicle mix by the year 2000 if not earlier. Safety systems which are developed in the future should be required on vehicles imported to Sri Lanka where appropriate and economical.

5.3 Trained drivers

As above, the proposals given earlier should result in a trained pool of drivers. Further, incentives should be given to driver training centres to provide an overall training including lectures on defensive driving as well as practical driving in modern vehicles.

5.4 Disciplined road users

Only a few of the technical solutions proposed above will be useful, unless our road using public practices self discipline. This is the main problem with respect to road safety.

It will clearly be beneficial to teach road manners for pedestrians and cyclists to children in lower grades and to give the fundamentals of defensive driving to young people in the higher grades of school. However, proper, disciplined use of the highways, by pedestrians, cyclists and motorists will come only if our general concern for others and our self discipline increased ubiquitously in all aspects of life. This is really a matter for political religious and educational leaders to set an example in, and to treat at a broad national level.

6. NEW HIGHWAYS

The urban Sri Lankan's desire to own a motor vehicle (auto or motorcycle) is well known. This is partly due to the fact that any journey within the country can be accomplished door to door by auto or motorcycle in one day. This is not true for many countries. The rising price of fuel has not dampened this desire except perhaps in encouraging the purchase of motor cycles in preference to automobiles.

Various scenarios can be set forth regarding the future of transportation in Sri Lanka. I believe that most such scenarios have to include the following:

- (i) The real price of gasoline will increase.
- (ii) Vehicles will be more fuel efficient.
- (iii) The desire to own a private vehicle will not diminish.

We should also keep in mind that all the industrially advanced Asian countries such as Taiwan, Japan, South Korea have highly connected modern road networks, high auto ownership as well as coordinated rail and bus transport systems.

Our future probably lies in having a good rail network for long distance travel and a coordinated bus system to provide door to door service. However, it is difficult to see a future without a good high capacity road network for bus, truck and auto transport specially since our railway network is limited.

If a high capital cost electrified rail network is to be our future, then it is difficult to justify the construction of new inter-city highways. However, the scenario of battery powered electric-cars and buses which can be charged by A.C. plug-in supply during the night or while parked cannot be neglected. Instead of petrol stations one can envision battery exchange stations very much like the natural gas cylinder exchange stations. However, the batteries could be recharged at the station itself. It is likely that most one way intercity trips in Sri Lanka will be manageable without changing batteries.

Thus it is premature to rule out travel by such vehicles even if our future energy supply is to be hydro-power based.

Consequently, I believe that the planning, initial design and right-of-way acquisition for new 2-lane highways between Colombo and Galle, Ratnapura, Kandy, Kurunegala and Chilaw should begin, since acquisition is a time consuming matter and people should be given the maximum possible notice. Whether construction should begin and when could be decided at a later date, perhaps in 1990.

6.1 Economic justification

Each highway has to be justified economically. Because of the high expenditure involved, an origin - destination related toll will have to be charged for using the highway. However, it should be noted that the traffic flow will decrease with increased tolls. Consequently the toll has to be chosen carefully. Further, the toll should depend on the vehicle type (not per person) to encourage high occupancy vehicles. In adding up the benefits, the increased safety resulting in a reduced loss of life, injuries and property damage; the increased economic activity and employment during and after construction; the savings in fuel and time; increased civil defence, should be considered.

6.2 Environmental impact

A major highway necessarily impacts on the environment. The noise factor and air pollution should be considered in locating the highway. The fauna and flora should be protected where necessary by route deviations and special efforts should be made not to block traditional migratory paths of animals. This issue will surface specially if the highways are extended further inland. Further, sites of archeological interest should be skirted by the highway routes.

6.3 Routes

Several routings should be explored with the aid of existing aerial photos. All towns should be bypassed, and connectors built to major towns.

6.4 Highway geometry and pavement design

While keeping with geometric standards of the highways high, they should be designed for a maximum speed of about 80 km./h. and a recommended speed of about 65 km./h. This will ensure the optimum use of energy. The highways should be grade separated with limited interchanges. Our highway pavements are notorious for failing and giving rise to pot-holes. Thus, the pavement design, necessarily of asphaltic concrete (not cement concrete) for economic reasons should be given special attention.

6.4 Roadside development

No Ribbon development should be allowed. Initially, no development should be allowed even at interchanges, to shield the existing business in towns that will be skirted by the highways.

7. IMPLEMENTATION

Scarce resources have to be utilized for all projects and this one is no exception. However, it is apparent that relatively minor public expenditure will result in the short-term. The medium-term proposals some of which involve land acquisition, and one which requires the large scale testing of drivers will be more expensive to the public purse. In general, the funding of public sector transportation activities should be examined in the light of the fact that transportation, as with housing and education, is a basic right of a free people and that these services cannot always turn a direct monetary profit. It is obvious that even the basic maintenance of highways is severely underfunded at present.

Earmarking of portions of funds, taxed from private passenger and goods transport services, and of funds collected from licensing of

vehicles, traffic fines and parking fees, for use in public sector transportation activities should be seriously considered.

Construction of new highways is clearly capital intensive and will invariably entail foreign aid.

One can envision the Dawson Highway to Kandy with British aid, the highway to the historic Dutch fort in Galle with Dutch aid and the Fa-Hien highway to Chilaw (which may eventually be extended to Anuradhapura), in memory of the famous pilgrim, with Chinese aid. A Marco-Polo highway to Ratnapura with Italian Aid is not beyond the realms of possibility.

The technical know-how for planning and designing the highway projects is available in Sri Lanka. I am confident of the ability of our engineers and planners to handle the projects, with minimal foreign help, if proper facilities are made available to them and if all specialized human resources available in Sri Lanka, in the public and private sectors and the universities, are utilized.

8. CONCLUDING REMARKS

It is obvious that a safe and adequate highway system can be accomplished only by the cooperative endeavours of many public sector agencies, private companies and the general public.

Clearly, some of the suggestions given here are not totally new or unknown. What has been done, however, is to present a comprehensive set of proposals dealing with all the three aspects: rights-of-way, vehicles and road users, during the short, medium and long term.

Further, the suggestions made here are not in any sense rigid. The intention is to set them down in writing to enable a healthy discussion to take place at the Sri Lanka Transportation Forum and elsewhere.

9. ACKNOWLEDGEMENT

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APPENDIX I

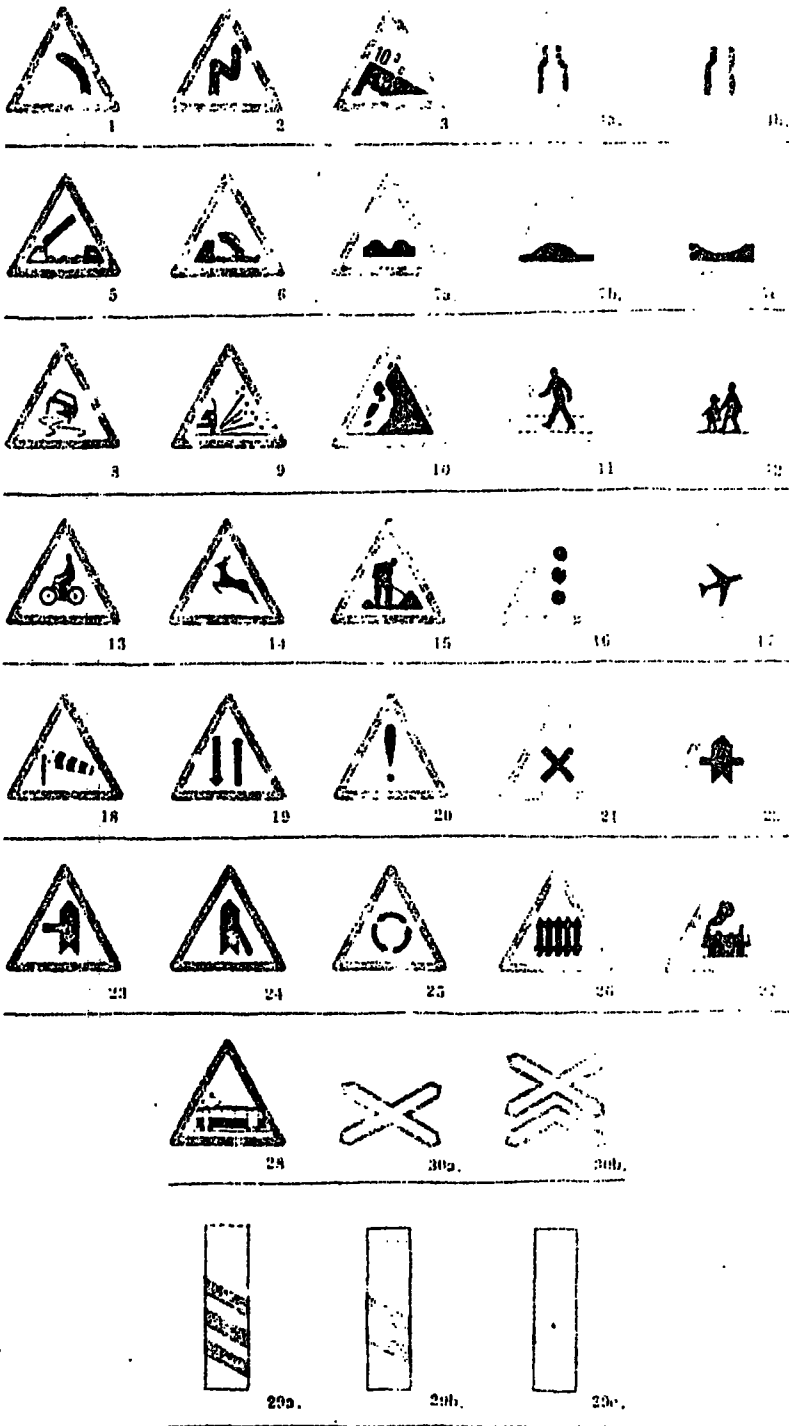
- A 1 Colombo-Kandy
- A 2 Colombo-Wellawaya
- A 3 Peliyagoda (Colombo) - Puttalam
- A 4 Colombo-Batticaloa
- A 5 Peradeniya (Kandy) - Chenkaladi (Batticaloa)
- A 6 Ambepussa (Colombo) - Trincomalee
- A 7 Avissawella (Colombo) - Nuwara Eliya
- A 8 Panadura-Ratnapura
- A 9 Kandy-Jaffna
- A 10 Katugastota (Kandy) - Puttalam
- A 11 Maradankadawala-Valaichchenai (Batticaloa)
- A 12 Puttalam-Trincomalee
- A 13 Anuradhapura-Galkulama
- A 14 Talaimannar-Medawachchiya
- A 15 Trincomalee-Batticaloa
- A 16 Dickwella-Haldummulla
- A 17 Madampe-Galle
- A 18 Pelmadulla (Colombo) - Nonagama
- A 19 Jaffna-Kankesanturai
- A 20 Anuradhapura-Rambewa
- A 21 Trikkandimadu-Valaichchenai

APPENDIX II

INTERNATIONAL ROAD SIGN SYSTEM

As adopted by the International Road Conference

Warning signs

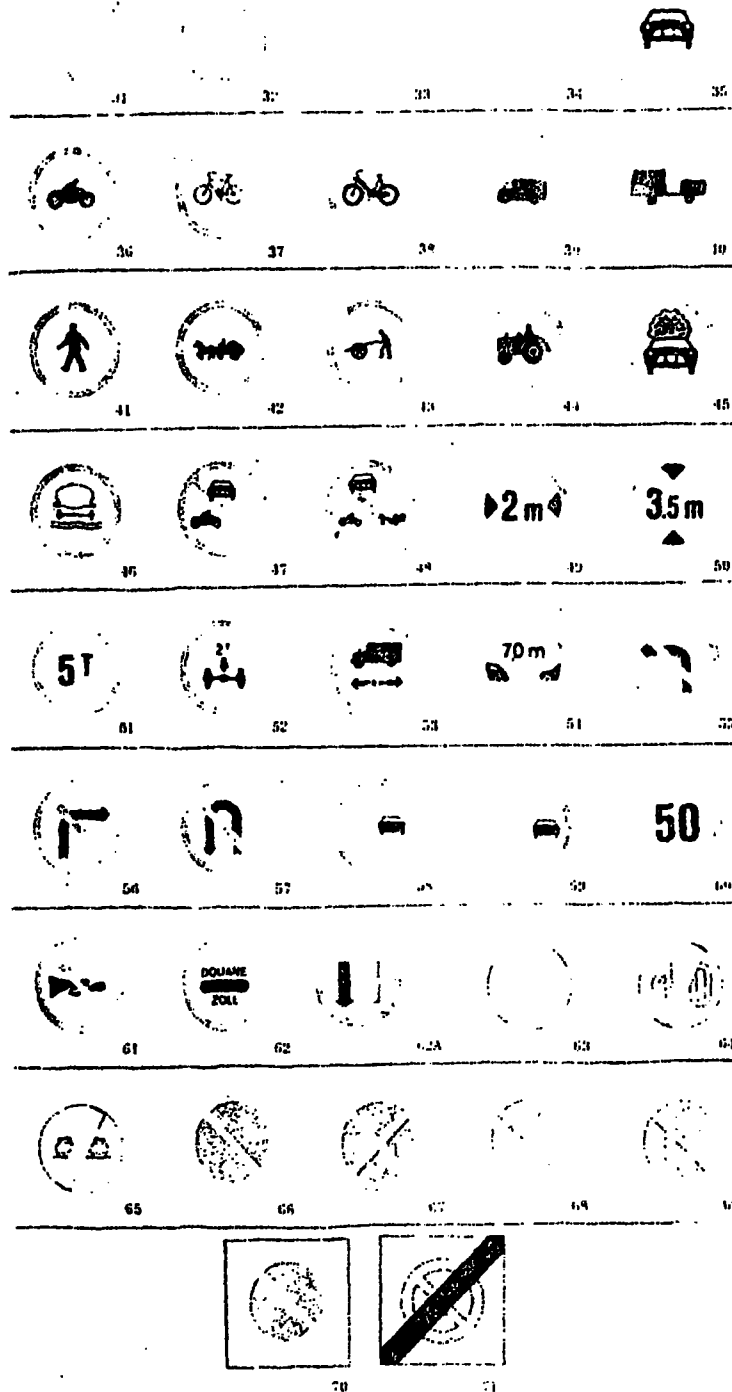


1. Dangerous bend to left
2. Dangerous bend to right
3. Steep descent or ascent: dangerous descent
- 4a. Carriageway narrow
- 4b. Carriageway narrow
5. Swing bridge
6. Road leads on to quay or river bank
- 7a. Uneven road: bad condition
- 7b. Uneven road: hump bridge or ridge
- 7c. Uneven road: dip
8. Slippery road
9. Loose gravel
10. Falling rocks
11. Pedestrian crossing
12. Children
13. Cyclists
14. Animals crossing
15. Road Works
16. Light Signals
17. Airfield
18. Cross Wind
19. Two-way traffic
20. Other Dangers
21. Approach to intersection: general priority rule
22. Approach to intersection
23. Approach to intersection: side road
24. Approach to intersection: merging traffic
25. Approach to intersection: roundabout
26. Level crossing: with gates or staggered half gates
27. Level crossing: without gates
28. Intersection with tramway line
29. Count-down posts
- 30a. Location of level crossing without gate or barrier: one track
- 30b. Location of level crossing without gate or barrier: at least two tracks

International Road Signs continued on next page

Regulatory signs

31. Give Way
32. Stop
33. No entry
34. Closed to all vehicles in both directions
35. No entry for any power-driven vehicle except two-wheeled motorcycles without side cars
36. No entry for motorcycles
37. No entry for cycles
38. No entry for mopeds
39. No entry for goods vehicles
40. No entry for any power-driven vehicle drawing a trailer other than a semi-trailer or a single axle trailer
41. No entry for pedestrians
42. No entry for animal-drawn vehicles
43. No entry for handcarts
44. No entry for power-driven agricultural vehicles
45. No entry for vehicles carrying more than a certain amount of explosives or readily inflammable substances
46. No entry for vehicles carrying more than a certain quantity of substances liable to cause water pollution
47. No entry for power-driven vehicles
48. No entry for power-driven vehicles or animal-drawn vehicles
49. No entry for vehicles having an overall width exceeding . . . meters
50. No entry for vehicles having an overall height exceeding . . . meters
51. No entry for vehicles exceeding . . . tons laden weight
52. No entry for vehicles having a weight exceeding . . . tons on one axle
53. No entry for vehicles or combination of vehicles exceeding . . . meters in length
54. Driving of vehicles less than . . . meters apart prohibited
55. No left turn
56. No right turn
57. No U-turns
58. Overtaking prohibited
59. Overtaking prohibited by goods vehicles
60. Maximum speed limited to the figure indicated
61. Use of audible warning devices prohibited
62. Passing without stopping prohibited
- 62a. Priority for oncoming traffic
63. End of all local prohibitions imposed on moving vehicles
64. End of speed limit



65. End of prohibition of overtaking 66. Parking prohibited 67. Standing and parking prohibited 68. Alternate parking: prohibited on odd number dates	69. Alternate parking: prohibited on even number dates 70. Limited duration parking zone 71. Exit from the limited duration parking zone

International Road Sign

APPENDIX III

Urban Traffic

Based on the first line of data for each Route given in Table 10 of reference (6), which are representative of urban traffic, the urban traffic mix for Sri Lanka is

Vehicle Type (i)	Percentage (P_i)
Automobiles	49%
Buses	18%
Heavy Lorries	17%
Light Lorries	6%
Motor Cycles	10%

Table I Urban Traffic Mix

We shall assume that the hourly capacity of a two-lane road for various vehicles is as follows:

Vehicle Type (i)	Capacity (C_i)
Automobiles	2000
Motor Cycles	4000
Buses and Heavy Lorries	800
Light Lorries	1600

Table 2 Capacities

Then the hourly capacity in motor vehicles per hour for the above mix of vehicles is $\sum C_i P_i / 100$

$$= 1756$$

We shall take the capacity to be 1750 vehicles per hour.

For urban traffic, the 30th highest hourly volume to ADT ratio is 0.106 [reference (3)]. Therefore the limiting ADT for urban two-way traffic on a two-lane facility is $1756/0.106 \approx 16,500$.

Rural Traffic

Based on the lowest flow data line for each route given in Table 10 of reference (6), which are representative of rural traffic, the rural traffic mix for Sri Lanka is

Vehicle Type (i)	Percentage (P_i)
Automobiles	41%
Buses	19%
Heavy Lorries	29%
Light Lorries	6%
Motor Cycles	5%

Table 3-- Rural Traffic Mix

Calculating as before, the capacity is 1450 vehicles per hour.

For rural traffic, the 30th highest hourly volume to ADT ratio is 0.136 [Reference (3)].

Therefore the limiting ADT for rural two-way traffic on a two-lane road is $1450/0.136 \approx 11,000$.

The above calculations are very rough and based partly on certain U.S. data and on the assumption that the traffic mix remains unchanged. The Table 2 Capacities are approximate estimates.

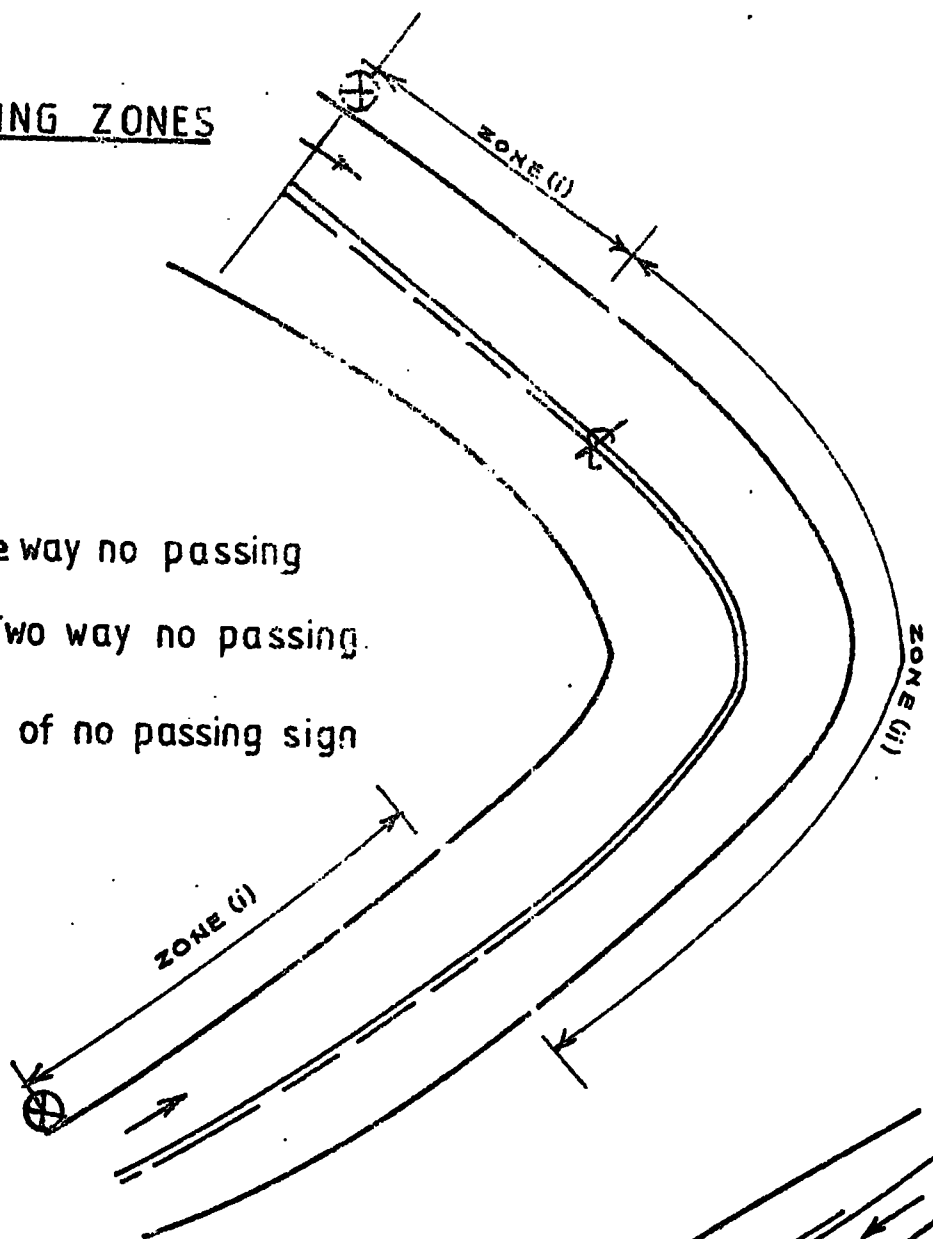
NO PASSING ZONES

FIG. 1

Zone (1) - One way no passing

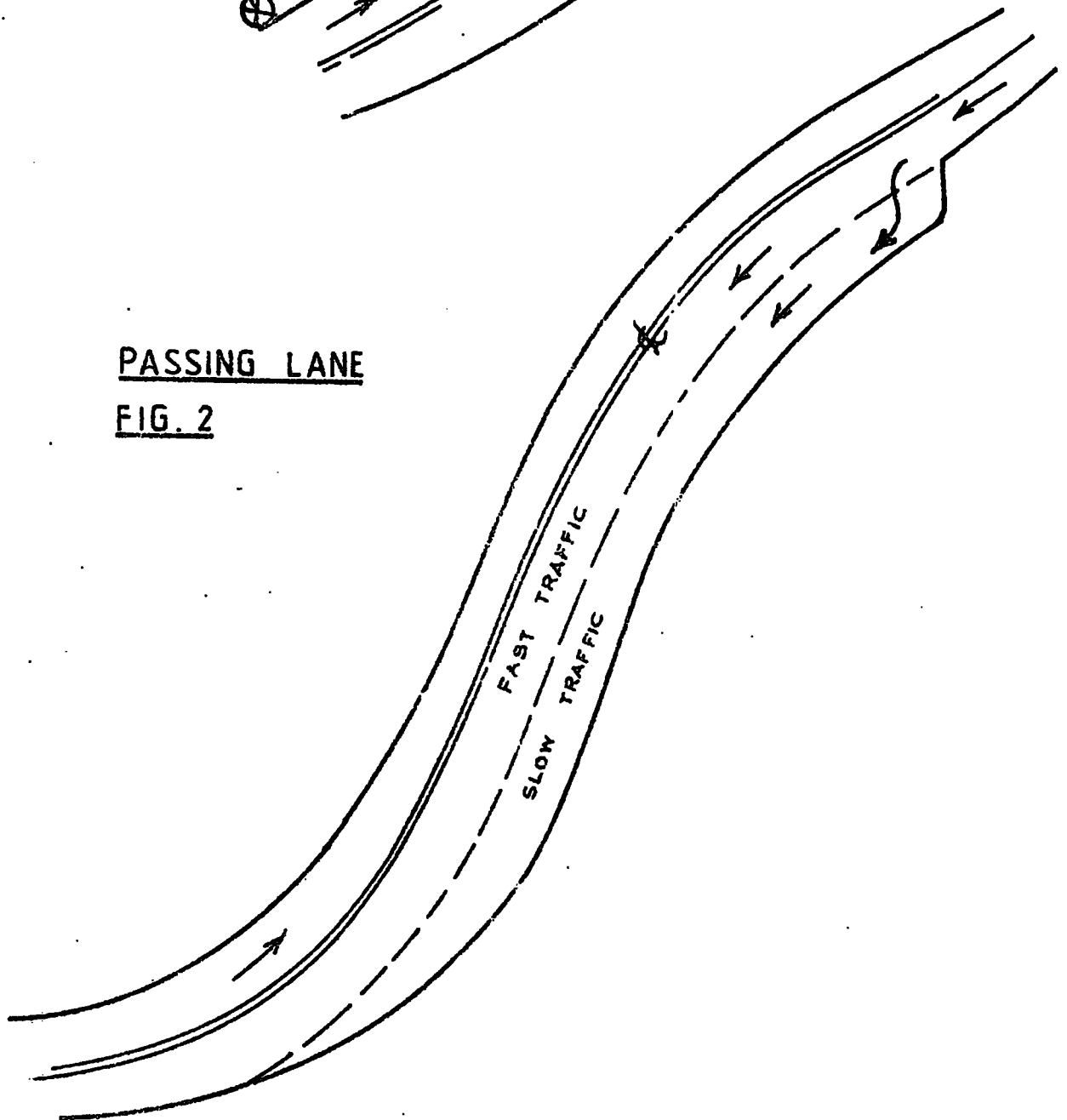
Zone (11) - Two way no passing

⊗ Location of no passing sign



PASSING LANE

FIG. 2



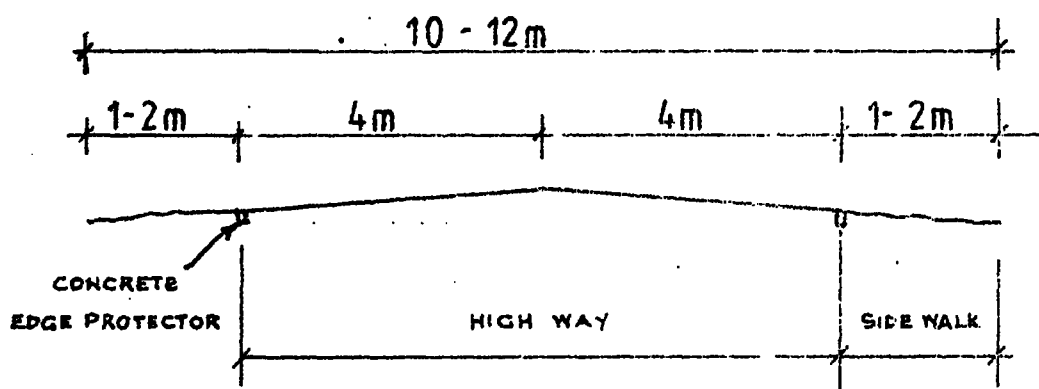


FIG. 3a

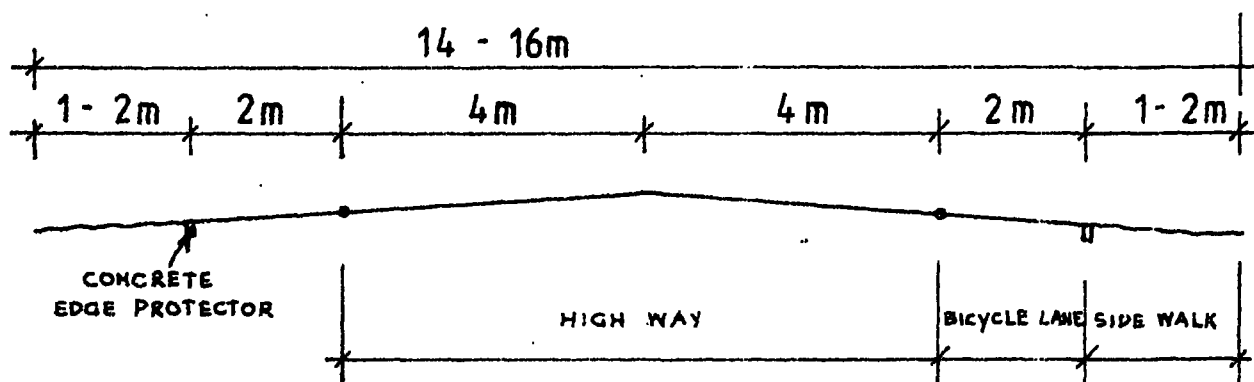


FIG. 3b

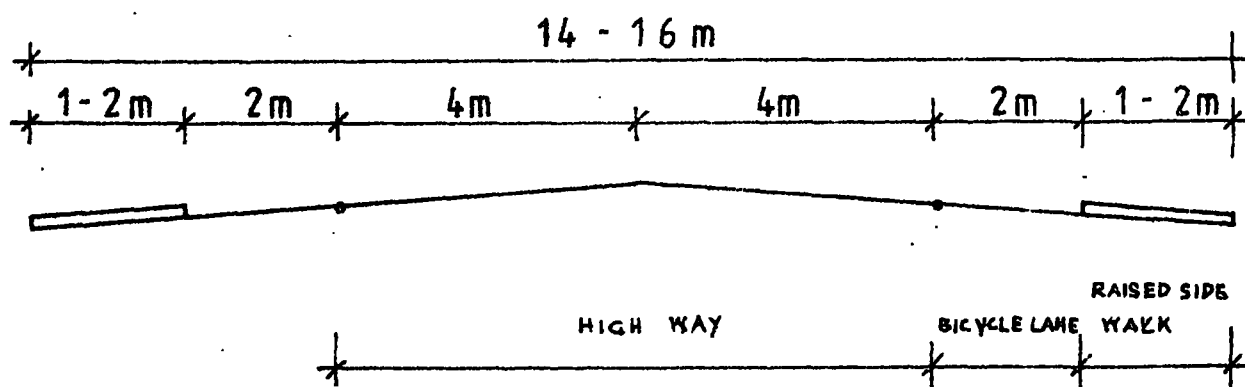


FIG. 3c

HIGHWAY CROSS - SECTIONS

FIGS. 3a, b, c

CO-ORDINATION, INTEGRATION AND PROXIMATE INTERCHANGE
FACILITIES IN PUBLIC PASSENGER TRANSPORT

by

J. Diandas

1. INTRODUCTION

1.1 Operators of buses or trains see passengers as demanding service at the points where they present themselves, and rarely examine where or how far away are the real points of origin and whether passengers are in fact interchangees from some other bus or train.

1.2 This limited understanding of demand has often led to curing symptoms rather than causes. For example a problem of unmanageable queues at Kosgashandiya up to about 1963 was always met by increasing the number of buses plying from that point to Borella and Bambalapitiya, whereas the later cure of running buses directly from the Negombo Road to Baseline Road and Borella eliminated the problem altogether, or at least transferred it elsewhere.

1.3 Regrettably the problem of interchange inconvenience has been ignored more by planners and higher decision-makers than by operators, so that conditions have become worse rather than better over the last decade or so, as for example at Town Hall, Colombo, where walking distance has increased as interchanging bus-stops have become very faraway from each other.

1.4 The purpose of this paper is to examine the problem of interchange and to illustrate it by reference to the current state-of-the-art in Colombo.

CO-ORDINATION INTEGRATION AND PROXIMATE INTERCHANGE FACILITIES IN PUBLIC PASSENGER TRANSPORT

by

J. Diandás

ABSTRACT

A simple journey by public transport involves walking from point of origin to the bus or train stop, waiting, riding the bus or train, and walking again to the final destination. Many journeys are not so simple. At least one interchange is often necessary between bus and bus, bus and train or train and train. Inconvenience in interchange arises from the acts of alighting and boarding and is enhanced by temporal and spatial unproximity. The inconvenience can be lessened by greater complexity of route networks to give more direct journeys and so avoid some interchange. This has advantages and disadvantages. Alleviation of the inconvenience can also be achieved by schedule co-ordination or close spatial placement of stops and by comfort facilities such as covered connections. Many planners and operators ignore the problem of interchange. Improvement can come by surveys, systematic approach, and persistently drawing attention to the problem.

CONTENTS

1. Introduction
2. The whole journey
3. Avoiding interchange
4. Minimizing the discomfort of interchange
5. Temporal disadvantage
6. Spatial disadvantage
7. Attitude of planner and operator
8. Conclusions

2. THE WHOLE JOURNEY USING PUBLIC TRANSPORT

2.1 A journey using public transport rarely starts at the bus-stop or station. Some walking is needed from point of origin such as home, or workplace, or school, or market, to the place where buses or trains stop.

2.2 Having walked to the stopping place, the patron must next wait until an appropriate bus or train arrives, or until such a vehicle arrives with room to accommodate him.

2.3 Third stage in the whole journey is the actual ride from boarding point to alighting point. From the operator's viewpoint this is often thought to be the trip or journey because operation effort is spent only on this part of the whole journey. Unfortunately many planners and decision-makers also think likewise.

2.4 After alighting comes the fourth and final part of the simplest of journeys involving public transport, namely walking from the alighting point to the final destination.

2.5 However, many public transport journeys are not so simple, because they involve two or more rides. In the case of two rides the journey sequence is :-

- .1 walk from origin to transit stop
- .2 wait for transit vehicle
- .3 ride from boarding stop to interchange stop and alight
- .4 walk to stop for next transit vehicle
- .5 wait for transit vehicle
- .6 ride from interchange stop to alighting stop and alight
- .7 walk to final destination

2.6 The purpose of this paper is to discuss the avoidance of interchange, or where it is impossible or undesirable to avoid it, the amelioration of the disadvantage caused by interchange.

3. AVOIDANCE OF INTERCHANGE

3.1 The original bus route system in Colombo before nationalisation was a basic radial or wheelspoke system. Nearly all buses ran from a suburban point to the centre, which was either Fort or Pettah. Just a few routes linked the spokes of the wheel in circumferential pattern.

3.2 Under this system any journey across to city needed interchange, and any journey beginning on or near one radial line and ending on another, needed one or two interchanges.

3.3 However the constraints of the system also constrained choices of residence and workplace, and in simpler days of one earning member per family interchange was to some extent limited by these constraints. In other words families selected their residence to enable simple journeys to work and thereafter chose schools, shopping places etc to suit the chosen radial route.

3.4 During 1958 to 1970 three significant developments occurred

- .1 bus routes were linked, merged, diverged etc to form a systematic complex network, one aim of which was to minimise interchange
- .2 work places spread out from Fort and Pettah to all the inner suburbs
- .3 more families became dual or multiple earner families.

3.8 Multi-earner families arose partly from economic need, partly from female emancipation (wives and daughters go out to work) and partly from delayed marriage and child-bearing itself occasioned by economic constraints. In this connection it is interesting that multi-earner families defeat the ideals of simplistic physical planners (from Ebenezer Howard onwards) who would locate housing and workplaces in close proximity in order, among other things, to avoid or minimise the need to travel, one of the so called non-transport solutions to transport problems. Rarely do the several earners in one family obtain, or even seek to obtain employment in the same location. Hence they have separate travel needs at point of origin.

3.9 The objectives of bus-route planning here, as elsewhere, are multiple, and include improving productivity of the economic inputs to transport (vehicles, ways, workers), reducing the cost of providing transport, increasing and evening out the revenue to be obtained from passengers as well as improving the convenience for passengers. However most of these objectives run together, so that avoiding the terminal turn-round of buses in Fort or Pettah, simultaneously increases productivity of buses and crews, unburdens some roadway congestion in the centre, reduces the cost of operation, induces some high-revenue passenger journeys, and improves the lot of some passengers who would otherwise have to interchange buses at Fort or Pettah.

3.5 In most big cities bus-route development is both a stimulant to workplace-spread and multi-earner families, and the result of demand-pressures arising from workplace-spread and multi-earner families. But in Colombo it so happens that bus-route development was a CTB initiative launched by a group of thinkers including Messrs Edward de Saram, RE Fernando and M.Y.M. Raoof (this writer was privileged to be among them) who were influenced by bus route patterns found abroad in cities like Sheffield, Lyon, Zürich, Essen, Toronto and London.

3.6 Workplace-spread and multi-earner families would have developed in any case, but the planned bus-route development which was implemented in Colombo from 1958 onwards, and more vigorously from 1963-1970, undoubtedly stimulated and encouraged these other developments.

3.7 Typically, the Petroleum Corporation was one of the first to establish itself in Galle Road Kollupitiya. Subsequently large government corporation offices have spread down the Galle Road as far as Wellawatte (Cement), in Gregory's Road (Textiles and Land Reform) at Narahenpita and Kotahena, and many other places. An immediate consequence of such workplace shifting, is the need for some workers at these establishments to travel across the face of Colombo to places between quarter mile and two or three miles beyond the centre. Bus-routes like 132 (Karagampitiya -Mawaramandiya) and 195 (Nugagode-Mutuwalle) helped them to do this

3.11 Others which also connect far sides of the city, but avoid the Fort-Pettah centre by using circumferential roads like Dharmapala-Sangaraja, or Bullere-Baseline, include the following, most of which are still intact :-

- 104 Bambalapitiya - Wattala - Katunayaka
- 154 Dehiwala - Kiribathgoda
- 155 Ratmalana - Mattakkuliya
- 193 Dehiwala - Kadawata
- 194 Milagiri - Ragama
- 195 Nugegoda - Mattakkuliya
- 176 Dehiwala - Hettiwatta
- 178 Narphenpita - Mattakkuliya
- 167 Dehiwala - Tottilanga
- 131 Kohuwala - Kolonnawa
- 135 Nugegoda - Kelaniya

3.12 In addition to these, a number of linked circumferential routes starting at coast-line railway stations, were developed. These include :-

- 140 Kollupitiya - Wellampitiya
- 175 Kollupitiya - IDH - Kohilawatte
- 179 Bambalapitiya - Angoda

3.13 The net effect of these route developments has been that many people who would have had to interchange buses one or more times during their journey, can now enjoy a direct bus ride. In fact such long routes as 132 (Karegam-pitiya - Mawaramandiya) are multi-purposeful in that they provide facilities for many different journey types, short or long, at different times of day, very few of which, if any, comprise a terminus-to terminus ride.

3.10 Typical of the through (also called cross-city or linked) bus services which traverse Fort and Pettah introduced after nationalisation in 1958 are the following, (some of which have changed since)

- 101 Lunawa - Ja-Ela
- 102 Galkissa - Kotahena
- 103 Narahenpita - Kotahena
- 105 Attidiya - Kotahena
- 106 Galkissa - Wattala
- 107 Maharagama - Ellekanda
- 109 Kohuwala - Wattala
- 111 Narahenpita - Boliagala
- 112 Maharagama - Kaduwala
- 116 Piliyandala - Mattakkuliya
- 132 Karagampitiya - Mawaramandiya
- 133 Panadura - Kolonnawa
- 134 Panadura - Angoda
- 137 Wellawatte (Vihara Lena) - Ja-Ela
- 138 Homagama - Kadawata
- 160 Batteramulla - Mattakkuliya
- 166 Angoda - Mattakkuliya
- 168 Nugagoda - Kotte - Kotahena
- 170 Athurugiriya - Mattakkuliya
- 173 Narahenpita - Totallanga
- 177 Kaduwala - Mahawatta
- 187 Moratuwa - Katunayaka

3.14 There are limits to interchange avoidance by route development. For example people cannot always board a bus on the route of their choice because it is already full. Such people board any bus in the desired direction and change bus down the line. In today's context, this may entail a bigger total fare.

3.15 In planning terms, there are limits to the number of places which can be connected by direct services. These limits include :-

.1 a concept that bus headway on any given route should not be sparser than ten minutes.
(i.e. a frequency not less than 6 trips per hour)

.2 a concept that the route system as such should not be too complex (i.e. it should be cognisable by most travellers). This concept would limit the number of routes in a big city to perhaps 80 or 90, giving an added advantage that all route numbers could be expressed in two-digit numbers.

.3 a recognition by systematic bus firms that it is uneconomic to run small vehicles on thoroughfares where demand can support high intensity services of larger vehicles.

3.16 In the context of this discussion, Colombo enjoys a very good network of bus services. Other cities in Sri Lanka less so. Yet it is surprising that many big cities of the world have failed to develop such networks. For example such cities as Melbourne, Calcutta, Toulouse, Plymouth, Sheffield, Athens, Denver, Bangkok, Bangalore, Rome etc have a very large proportion of their purely local tram or bus services terminating at a large central station or place, whereas other cities, such as Chicago, London, Hyderabad, Adelaide, Torino, Milano have most of their routes criss-crossing the city in a systematic pattern.

3.17 The reason for this divergence of practice does not appear to be topographical in most cases, but accidental and historical, and is perpetuated by the failure of transport professionals to study how these things are done in other cities with a view to adopting and adapting the best practices.

4. MINIMISING THE DISCOMFORT OF INTERCHANGE

4.1 When interchange cannot be avoided by taking direct journeys, it has to be endured. Interchange itself involves a number of components or steps from the state of being seated (or standing) in the one transit vehicle, to the point of obtaining a place in the next transit vehicle.

4.2 These components, or steps, comprise :-

- F.1 getting up from the seat
- F.2 moving towards the exit
- F.3 stepping down from vehicle to street or platform
- F.4 ascertaining where the next vehicle will stop
- D.1 walking along the footpath towards that point
- D.2 crossing the road or roads
- D.3 walking to the actual stopping point
- T.1 joining the queue
- T.2 waiting for the next vehicle
- F.5 hailing the next vehicle
- F.6 boarding the vehicle
- F.7 purchasing a ticket
- F.8 moving to a seat or place.

4.3 These components can be classified as arising from :-

F the fact of interchange	8
D the distance between vehicle stopping points	3
T the time between arrival and departure at the interchange	2
total	<u>13</u>

4.4 Of course time is also involved in all the steps, including those that involve distance. The time, or temporal disadvantages of interchange are discussed in Section 5, and the distance (or spatial) disadvantages in Section 6.

4.5 The eight components arising purely from the fact of interchange, that is those arising from alighting and boarding, are mostly shared with all persons alighting from and boarding buses. Yet obviously urban buses are much more involved with these problems and their design should take account of them.

4.6 For example, to facilitate alighting and boarding, urban buses should have the following features :-

- .1 wide uncluttered gangways or corridors
- .2 easily reached grab-rails along the gangway
- .3 low floorboards
- .4 separate exits and entrances
- .5 wide exits and entrances
- .6 easy step heights
- .7 grab-rails on both sides of steps.

4.7 To enable interchangees to move quickly to their next stopping place, clear information systems would be helpful.

4.8 To enable easy hailing of the next bus, good route and destination indication is useful at front and rear. The rear indicator would indicate to some interchangees whether or not to run or quicken the pace if moving forward from one stop to the other.

4.9 Irrespective of the distance between the stopping places, it would obviously help if there was a covered passage-way at least part of the distance, like those connecting the wards of the general hospital.

5. TEMPORAL DIS-ADVANTAGE OF INTERCHANGE

5.1 Supposing a passenger has to interchange from bus or train on to a bus service operating regularly at 10 minutes intervals, then the time loss would be at most $T_d + T_f$

where :-

- : T_d is the time taken to cover the physical distance from one vehicle to the other
- : T_f is the frequency of the ongoing bus service .

5.2 Assuming randomness in arrival of the bus in which the interchangee arrives in relation to departure of the ongoing bus, the average time loss will be $T_d + \frac{1}{2} T_f$.

5.3 Usually when headways are 10 minutes or less, no attempt is made by transport operating firms or planners to dovetail schedules of connecting routes. However in many North American cities with declining demand for public transport, services are timetabled on the basis of near simultaneous arrival of buses on all routes in both directions at focal points. Buses are then held for all possible interchangees before setting off towards their next focal points.

5.4 Many persons who have been concerned in the past with rail/bus interchange, have used the word "co-ordination" to define the timetabling or holding of buses at a railway stations to take train arrivees on to their further destinations, and timetabling buses to arrive at the same station a few minutes before train departure. This type of co-ordination is primarily suited to long distance travel and to bus services operating at headways sparser than 10 minutes.

5.5 In urban situations with intense regular-interval bus services, the time lost at interchange is already defined above in para 5.1 and 5.2. This time loss can be minimised:-

- .1 by planners ensuring that service intervals are kept down to 10 minutes or less.
- .2 by operators ensuring regularity of each service
- .3 by minimising the distance between interchanging stops.

5.6 In current days in Colombo, private operators tend to fill the gaps between SLCTB services, and so for non-season-ticket holders help to minimise the time-loss at interchange. This might not be the case if private operators were forced to use separate bus-stops.

6. SPATIAL DISADVANTAGE OF INTERCHANGE

6.1 The spatial disadvantage of interchange arises from:-

- .1 the distance as such between the two points
- .2 the obstacles in the path between the two points
- .3 other inconveniences on the way.

6.2 The distance as such is sometimes caused by physical features, and sometimes by mere lack of consideration of the problem by planners, operators and others in charge of traffic.

6.3 An extreme example is Thunmulla Junction. On the south-bound stretch of Reid Avenue between Thurston Road and the main junction, there used to be a common bus-stop for buses plying towards Havelock Town along Havelock Road and towards Bambalapitiya along New Bullers Road. This was a very popular interchange point with no distance at all between the stopping points. When highway engineers widened this stretch of carriageway two decades ago, there should have been more room, not less room, for bus-stops, but in point of fact the stops were moved back into Thurston Road and Reid Avenue respectively and the corresponding bus-stops in Bullers Road, New Bullers Road, and Havelock Road were also shifted backwards away from the junction, on the obsolete theory that bus-stops obstruct

junctions. The result is that bus interchange does not take place at this junction any more. The problem has not gone away altogether. Whether looked at from the view-point of traffic engineer, policeman, bus operator or bus passenger, the problem has shifted itself to other locations including Town Hall and Jawatte Junction (outside Irrigation Department).

6.4 Another case is Maradana. Interchange from train to bus was impeded for some by a pedestrian bridge enforced by barricades. When forcing pedestrians off the carriageway did not seem to cure the symptom, there was a move to shift the Fort-bound bus-stop into the tip of Deans Road, thus increasing the distance from train and creating the need for crossing Deans Road by interchanges between say 140 and 103.

6.5 Town Hall was a place where all buses had stops just before arriving at the roundabout complexes, and just after as well, with the added advantage that the pair of stops for each bus was treated as a single fare stage. However, over the years since 1970, the stops have been shifted little by little further away from the junction. So that interchanges are constantly having to increase their walk-distance between stops.

6.6 Still another case in Colombo is that of interchange between train and bus at the Fort Railway Station. Bus-stops were judiciously placed on the pavement abutting the station canopy, so that alightees from the train could board buses to Fort without crossing any carriageway. This stop, after 1970, has progressively shifted across one carriageway, then another, and now does not exist.

6.7 Colombo is not alone in thus making public transport travel inconvenient. Milan's Central Station has a superb undercover concourse used by taxis, but not buses or trams which have their stops a little distance away. And at a brand new Metro Station, N. Cologno, out in the suburbs, cars and taxis and arriving buses have under-canopy stopping places, but departing buses are deliberately placed some way away.

6.8 On the other hand many Dutch and Danish rail and metro stations have bus-stops on the train platform itself, and Hannover has several cases where even the doorways of buses and trams get aligned across a narrow platform for easy interchange, usually under cover.

6.9 Distances as such can be overcome by placing bus-stops as close to junctions as physically possible, and by proper arrangements of stops which are split for different groups of routes. Distance can also be alleviated by having pedestrian crossings also at the lip of the junction.

6.10 Bridges and under-passes do not mitigate distances because they introduce an additional vertical distance. Generally people prefer to spend time waiting for a gap in traffic than in climbing and descending stairs or ramps.

6.11 Of course, in third world countries people who use public transport are used to being imposed upon. In Kampala for instance a lot of people walk up to 10 km to work. In general the concept that public transport riders should get priority over other road-users is unknown in the third world. Hence distance reduction at bus interchanges cannot be expected. But there is need for some data to be gathered and some research done.

6.12 What is the actual distance involved in the important cases? How many people interchange? How does their walking obstruct the pavement or the carriageway?

7. ATTITUDE OF PLANNER AND OPERATOR

7.1 There are very few transport planners as such in Sri Lanka, either in terms of training or qualification, or in terms of professional experience, or even in terms of functioning designation. The few who are extant, are naturally concerned with interchange because they are trained to consider the whole journey from points of origin to point of final destination, whether it be to or from work, or for education, or business or shopping or pleasure, or social whatever.

7.2 On the other hand there are many ad-hoc planners, those who make or influence decisions. Those people look at symptoms and prescribe remedies with hardly any diagnosis.

7.3 Take for instance the highway engineers who "planned" the huge space-consuming complex of big and small roundabouts at Thunmulla. Did they take bus-stops into account at all before entering upon the layout for which they exercised designing but not planning brilliance.

7.4 Or take the people who built the pedestrian bridges. Did they take pre-observation of bus-stops, bus boardings and alightings, pedestrian movements, origins and destinations, before deciding upon where, when and why to locate their bridges?

7.5 The problem is that most ad-hoc planners see the issues from their own eyes. To move the Ward Place bus-stop from outside the Dental Institute towards the junction of Norris Canal Road is seen as a gain to all carriageway users at the cost of a trivial extra walk for bus-passengers. They do not know how far these bus travellers have already walked to reach the Dental Institute, nor how far they walked to get to their original bus, nor how far they will walk to reach their final destination. On the other hand once they have shifted the bus-stop, cars will park in the very spot outside the Dental Institute, and the ad-hoc planners will not even see them, let alone perceive them as a problem.

7.6 In recent years, largely because traffic literature is full of discussion, photographs and diagrams about bus priorities, planners (both professional and ad-hoc) have been inclined to pay lip service in general terms in Colombo to the needs of buses and their passengers. But whenever a particular matter comes up they argue against buses on "practical grounds". It is a pity that they cannot be taken to see the centres of many cities today where buses or trams share shopping precincts with pedestrians and where bus-stops are at the line of the junction.

7.7 Until recently bus operators in Sri Lanka were in a sellers' market. With notable exceptions most operators took passengers for granted and assumed that they needed service at the points where they presented themselves. How far they walked was of little concern. The operator seemed harassed by his own inability to cope with demand, and just a few realised that better routing, better bus-stop placement, and better interchange facilities might ease the problem of supply.

7.8 But today's operator is in a different quandary with the public sector thoroughly demoralised by the collapse of a systems approach to planning and operation and the private operator almost by definition incapable of taking a systems approach. At Maradane on the Police Station side, the SLCTB meekly accepts the police ban on Borella buses stopping outside the police station, leaving private operators to stop where they like to pick up the ex-train passengers.

7.9 The railway operator in Sri Lanka is frankly unconcerned, and has always been unconcerned, about where bus-stops lie in relation to railway stations.

7.10 The attitude of planners and operators abroad is mixed. Cities like Toronto, Den Haag, München, Manchester, Bradford, Hannover, Paris etc develop and foster the closest possible juxtaposition of train and bus stops with "cross-platform" interchange the favoured word. Yet other cities are strangely neglectful of this need, even in Rome or Stuttgart, where all operators, rail, subway, tram and bus, present a single federated face to the public and issue all-system tickets for single linked journeys or ride-at-will.

8. CONCLUSIONS

8.1. As long ago as November 1972 the European Conference of Ministers of Transport conducted an experts Round Table on the influence of terminals and interchanges on the choice of passenger transport mode. The report on the Round Table written by Wagon & Collins (1) cites many research reports on this subject, including especially a French report (2) which discusses all the possible ways in which bus-stops could be brought into close proximity to minimise the walking distance between them, and to avoid the need for interchanging passengers to cross roads.

8.2 Despite this, progress in minimising the inconvenience of interchange has been very gradual, even slow, except in a few cities. In third world cities there is little visible or reported progress. In Sri Lanka progress has been backwards, in as much as bus-stops at important interchange locations, such as Galle, Maradana, Town Hall, Pettah etc have gotten further away from each other than they were before, and pedestrians at some places are faced with the fatigue and indignity of climbing steep flights of steps to cross roads.

8.3 Hence there is need for :-

- .1 Systematic surveys of the extent of interchanging and the distances, time losses and other impediments involved in interchanging
- .2 Systematic planning of train station exits and bus-stops aimed at minimising interchange inconvenience
- .3 Persistent clamour drawing attention to existing inconveniences and the potential for improvements.

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BIOMASS ENERGY FOR OUR PUBLIC TRANSPORTATION

by

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Abstract

The fuel cost of our public transportation accounts for an appreciable part of our import expenses. We are compelled to find quickly a cheap and local fuel for our public transportation. Electrifying the urban public transportation would require large foreign capital, and is not a complete solution. The use of fuel gas obtained by the gasification of biomass is an economically viable and technically feasible solution. The use of gasified biomass as fuel would require only moderate capital and the pay back period is about 1 - 2 years. Changing from imported oil to locally produced biomass will bring in ecological advantages and will help to solve the unemployment problem as well.

1. Oil Crisis

The oil crisis which started in 1973 has affected our economy in two distinctive ways. First it resulted in an increase in the cost of oil and many other items such as fertilizer, milkfood, wheat flour, sugar & machinery. The second impact is the relative increase in the prices of our exports being very much lower than the increase in prices of our imports. To purchase 2.6 bushels of wheat we needed 10 lbs. of tea in 1970; 13.5 lbs. in 1974, 10.5 lbs in 1979 and 44 lbs. in 1982. (Reference (1)). This in turn has resulted in the net oil import bill to rise from 5.3% in 1972 to 40% in 1982 and is expected to rise to 45% in 1985. (Reference (2)). Therefore we have an immediate necessity to produce our own needs utilizing our own resources. But we must make sure that the resources we utilize are genuinely local.

2. Energy Crisis

Realising the importance of self-reliance we are making attempts to attain self sufficiency in vital items such as rice, sugar, milk, fertilizer, cement, textile, steel, tyres etc. But in a competitive world, self-reliance becomes meaningful only if (i) most of the inputs used are obtained using locally available resources and (ii) the cost of the final products is competitive with imported substitutes. Two examples will illustrate these points. We have been told that either we are on the verge of attaining self sufficiency in rice or we have just achieved this goal. Most of us are very proud about this achievement. We believe that we need not depend on any other country for our requirements of rice. This belief is totally incorrect. Because most of the resources used in the production of rice comes from other countries. Fertilizer, agrochemicals, agricultural machinery, fuel etc. come from other countries. According to the Economic Review October/November 1982 (Reference (3)), a recent survey has revealed that fertilizer, agro-chemicals and machinery account for 77 - 78 percent of the cost of production of paddy. Also the cost of water used from the major irrigation schemes has a very high foreign component. Most of the major irrigation schemes are built on borrowed foreign capital. Therefore nearly 90% of the cost of production of rice

is foreign. Therefore we are only 10% self-sufficient in rice. Let us take another example - the steel industry. We thought it will be cheaper to produce a part of our steel requirements from scrap steel available in our country rather than importing steel. So we went ahead with the installation of an electric arc furnace and collected and transported steel scrap to Athurugiriya. Now we find that the cost of electricity in our country is so high, that an electric arc furnace is no longer viable!

Most of our industries such as steel, cement, paper, tyre, fertilizer etc. all depend on a cheap source of energy for their viability. Therefore we are compelled to produce our energy needs not only utilizing locally available resources but we must make sure that the final cost of the energy we produce is cheap enough to make our industries economically viable. When we speak of cheap energy with local resources, we think of hydro power. Many of us think that hydropower is relatively cheap. But this is not true. The average initial capital cost of on-going hydropower projects are about Rs. 50,000 per KW. A further Rs. 20,000 per KW will have to be spent for the transmission and distributions equipment. Most of these are foreign cost. Taking into account of 25% energy loss in generation, transmission and distribution, a unit of electricity (Kwh) from these schemes will cost a consumer over Rs. 2/- per Kwh., whereas a diesel engine installed at the point of use will deliver energy at a cost of Rs. 1.25 per Kwh! Therefore hydro power is not as attractive as we think.

Energy cost accounts for about 40% of the cost in our public transport systems. Hence, we have to look for an energy source which is cheap and truly local, and which could be utilized for our public transportation. And this source of energy is Biomass.

3. Biomass Energy

3.1. Introduction

Biomass is defined as plant and animal material which can be converted into energy. Biomass is produced by plants using solar energy through the process of photosynthesis. Although the efficiency of such conversion is very low, generally about 1%,

the cost of producing biomass for energy generation is very very small. Biomass is available in many different forms - trees, shrubs, grasses, energy plantations, algae, aquatic plants, agricultural residues, forest residues, manures, solid waste, waste water and human waste.

3.2. Energy Plantation

In an energy plantation, crops are intentionally grown primarily for the production of biomass energy generation. If an industry intends to use biomass for energy generation, it is prudent to depend on its own energy plantation for the production of biomass instead of relying on a by-product of an entirely different industry. For example if the Ceylon Electricity Board intends to generate electricity from biomass, then it must establish an energy plantation to produce the necessary biomass and should not depend on coconut shells produced from the coconut industry. Because, the coconut industry might decide to dispose the coconut shells in a manner which is more profitable such as, activated carbon.

There are many factors to be considered when designing an energy plantation. First, the characteristics of the crop. It should be a fast growing variety. An energy plantation with fast growing trees will require less land than a plantation with slow growing trees. When the land area is small, the management costs of the plantation are also less. Hence, a fast growing kind has a definite advantage. Further more, since the population density in Sri Lanka is high compared to most other countries, we have to utilize all available land optimally.

Second, the tree should not demand much nutrition from the soil, particularly from the top soil. In this respect a leguminous and a deep rooted variety is ideal. A leguminous tree, in partnership with soil bacteria of the genus Rizobium makes use of atmospheric nitrogen for its growth. Hence it does not require any nitrogen fertilizers. This is a very important matter because, the manufacture of nitrogen fertilizers by chemical means require large quantities of high grade energy. A deep rooted tree makes use of the nutrients and moisture available in the deep soil which are leached from the top soil.

In these respects, Leucaena Leucocephala commonly known as Ipil-Ipil has all the desirable characteristics. It belongs to the leguminous class of trees and it fixes atmospheric nitrogen in its leaves. It is estimated that a hectare of Leucaena fixes nitrogen equivalent to 1 tonne of urea. It can grow reasonably well in marginal land and can withstand prolonged drought. It is a very fast growing tree. Measurements taken at a small plantation in Maha Illuppallama show an annual yield of 25 tonnes of wood/ha/year. It could be harvested many times a year. After each harvest the stem quickly coppices. The fodder yield is about 8 tonnes/ha/year (Reference (4)).

4) Fuel from Biomass

Biomass could be converted into usable energy forms by many different ways. For example, the wood portion could be burnt in a conventional boiler to generate steam or the leaves could be fermented anaerobically to produce methane or the wood portion could be gasified by partial combustion to produce a combustible gas consisting of CO , H_2 and CH_4 , etc. or the wood could be made into a liquid fuel under high temperature and pressure and in the presence of a catalyst or vegetable oil could be obtained from certain parts of trees by simple extraction processes and the oil could be used as fuel with or without refinement.

Taking into account the technical status of the different processes available and their economic viability in the industrial/agricultural environment available in Sri Lanka, the following three methods are appropriate for our public transportation. 1. Thermal gasification of wood for the production of producer gas. 2. Bio gasification of leaves of trees and animal manure for the production of methane. 3. Extraction of vegetable oil.

4.1. Thermal gasification

The usual method of making use of wood as a fuel is to burn it in a conventional boiler or furnace. For this purpose adequate air is supplied to facilitate complete combustion. Wood could be used as a fuel for reciprocating internal combustion engines. For this purpose wood is first partially burnt in a gasifier to produce a combustible gas. Then the gas is cleaned and cooled and could be used as a fuel

Third, the tree crop should yield useful by-products. From Sri Lanka's point of view, two important by-products we expect from an energy plantation are fodder and fertilizer. We are spending nearly Rs. 700 million yearly on the import of milk food. Our per capital milk consumption is far inadequate. Also our population is expected to increase by about 50% by the end of the century. Realising this need the Department of Rural Industries has shown interest to develop the dairy industry. Hence, an energy plantation which could provide fodder as a by-product will be extremely useful.

The other useful by-product expected from an energy plantation is nitrogen fertilizer. ~~The cost of nitrogen fertilizer.~~ The cost of nitrogen fertilizer manufactured from fossil fuel has been increasing in the recent past. Unfortunately the price of agricultural products has not gone up in price in the same ratio. Hence, the financial gain obtained by the use of nitrogen fertilizers has been diminishing over the years and may vanish in the near future. A possible solution to this problem is to make use of nitrogen fixing plants to produce organic fertilizer. By proper co-ordination with the dairy industry, the leaves from an energy plantation could be made into useful organic fertilizer.

The other desirable characteristic of the crop for an energy plantation is its ability to coppice after a harvest. Most of the expenses incurred in the establishment of an energy plantation are in the initial stages of the plantation. At the initial stages land has to be prepared, a nursery may have to be maintained seedlings have to be planted and watered and the trees are adequately protected till they have grown out of reach of grazing animals. Trees with the ability to coppice many times have to face these problems only once. By cutting the trees at optimum height above ground, all the problems associated at the initial stages could be eliminated.

The trees should be able to grow reasonably well in marginal land not suitable for agriculture and be able to withstand prolonged drought.

for IC engines. In gasification of wood the air supply is restricted to prevent complete combustion. The fuel gas produced by this method is called producer gas and has a typical composition as follows: (Reference (5)).

% CO ₂	:	2.8	-	11.3
% H ₂	:	5.0	-	10.8
% CO	:	13.8	-	27.8
% CH ₄	:	1.0	-	2.5

The average heating value of the gas is about 1233-4983 KJ/m³.

The gas has to be cleaned to separate the solid particles and tarry liquids. These will otherwise damage the engine

components. The gas has to be cooled to accomodate adequate gas in the cylinders of the IC engines to obtain maximum power.

The cleaned cooled gas contains about 60% of the total energy

input. To start the production of producer gas, an air blower is used to provide the air supply. Once the engine starts to

operate the suction of the engine is sufficient to provide the air supply. Producer gas could be used to operate a spark

ignition engine or a compression ignition engine. A spark

ignition engine could be operated on 100% gaseous fuel, but a

compression ignition engine will require a minimum of about

6 to 7% of liquid fuel as pilot fuel. The reasons for using liquid fuel are as follows: (Reference (6)). First is to

lubricate the injectors so that they will be in good condition

all the time. Second is to cool the injector nozzle tip so it

won't burn prematurely and destroy its ability to maintain the

designed fuel spray pattern. Third is to control the ignition

to maintain the flame front in an orderly manner which will

enable the engine to deliver its rated power.

A spark ignition engine has the advantage of low capital cost

and the ability to operate without a liquid fuel. But from an

operational flexibility point of view, a compression ignition

engine is preferable. In view of this advantage, it is

desirable to retain the existing compression ignition engines in

our existing public transport vehicles.

An SLCTB bus has an engine rating of about 100 Kw. A wood gasifier for such an engine could be installed in the space available on the left side of the engine or at the rear of the bus. Adequate precaution should be taken to prevent the spread of a fire breakout from the gasifier or a leakage of gas.

In respect of the railway engines, it is not practicable to use a single gasifier for one engine. It is appropriate to think of separate gasifiers for each cylinder of the engine. Each cylinder is rated around 100 Kw and an engine will have about 12 cylinders. The gasifiers will have to be installed in a separate compartment and the cleaned cooled gas could be fed to the engine cylinders through flexible steel hoses.

4.2. Bio gasification

Another method of converting biomass into a useful fuel for our public transportation is bio gasification. In this method easily digestable biomass such as leaves and animal dung is fermented in anaerobic condition to produce a gas consisting mostly of about 65% methane and 35% carbondioxide. Gas produced by this method is commonly known as biogas.

The conditions desirable for the production of biogas are as follows: (Reference (7)).

- a) The carbon/nitrogen ratio of the biomass used should be close to 30. The leaves of Leucaena and cattle manure have carbon/nitrogen ratio close to 30.
- b) The biomass should be made into a slurry with water. The total solid content in the slurry should be in the range of 10 - 12%.
- c) The temperature of the digester should be maintained either at about 35°C for mesophilic operation or at about 55°C for thermophilic operation. Operation at mesophilic temperature is easy. Mesophilic bacteria can tolerate minor changes in temperature, concentration of feed, pH of the slurry etc. but thermophilic bacteria are extremely sensitive to such variations. However, the gas production rate is much higher at thermophilic temperature. Hence for large digestors, it is economical to operate the digester at the thermophilic temperature. Arrangements should be

made to maintain the conditions of the digester within specified limits at all times.

- d) The pH of the contents of the digester should be maintained close to 7.

The carbondioxide in the gas could be removed by scrubbing the gas with water. The resultant gas is almost pure methane. In order to use methane as a fuel for vehicles, this gas should be compressed to a pressure of $200 \text{ kg}_f/\text{cm}^2$ and stored in steel cylinders. Steel cylinders used to store oxygen could be used for this purpose. A standard cylinder with a capacity of 6.4 m^3 weighing 62 kg could hold methane equivalent to 6.4 liters of diesel. 15 such cylinders would be needed to hold the fuel required for a days operation of a standard SLCTB bus. In view of the very large quantity of gas required, the use of methane for rail transport is not practicable.

The use of methane as a fuel for IC engines is similar to the use of producer gas as explained in the previous section. For better flexibility in operation, it is desirable to retain the compression ignition engines of the SLCTB buses.

4.3. Vegetable Oils

Most vegetable oils possess interesting characteristics for use as fuel in diesel engines. The following oils are very promising in this respect. Coconut, sunflower, soya bean, peanuts, palm and castor oil. (Reference (2)).

Although commercial vegetable oil could be used directly as a substitute for diesel in IC engines, for satisfactory performance the oil should be treated prior to use. Gums and water must be removed followed by filtering. Good results are obtained when particles greater than $4 \mu\text{m}$ are removed. Waxes can be removed by chilling the oil or letting it settle for an extended time. Gums are removed by addition of water followed by centrifugation.

5) Economic viability

5.1. Producer Gas

Producer gas generators commercially available in the Europe and in the United States of America cost about Rs. 5,000/- per

the electric
kw_e without the engine and/generator. Gas generators available in the Philippines cost about Rs. 2,000/- per kw_e. The National Engineering Research and Development Centre (NERD) in Sri Lanka has produced gas generators entirely on its own. These generators have given very satisfactory results. Commercial production of gas generators in Sri Lanka should bring down the cost to atmost Rs. 1,000/- per kw_e.

5.1.1. Bus transport

The cost of providing a gas generator for a CTB bus will be about Rs. 100,000/-. To calculate the operating cost the following assumptions are made:

- (a) A CTB bus operates 400 km/day and 250 days/year.
- (b) A CTB bus consumes at present 100 liters of diesoline/day.
- (c) After the installation of a gas generator, the diesoline consumption will be 25 liters/day.
- (d) The gas generator consumes 4 kg of wood to replace one litre of diesoline.
- (e) The cost of wood is Rs. 300/- per tonne and diesoline is Rs. 6.40 per litre.

On this basis the pay back period is one year.

5.1.2. Rail transport

The following assumptions are made:

- (a) The total cost of installing a gas generator for a 1000 kw_e locomotive is Rs. 1,500,000/-.
 - (b) A locomotive consumes 130,000 liters of diesoline per year at present.
 - (c) After the installation of gas generators,^a locomotive will consume 32,000 liters of diesoline per year.
 - (d) Other assumptions are as in bus transport.
- With these assumptions, the pay back is about 3 years.

5.2. Biogas

For a bus depot operating a fleet of 100 buses, 7500 m³ of methane gas will be required daily. This is to replace 7500 liters of diesoline. The estimated cost of digester, storage cylinders, compressors etc. is Rs. 20,000,000/-. The operating cost is estimated at Rs. 4,000,000. On this basis the pay back period is about 1 year. (Reference (10)).

5.3. Vegetable Oil

The present market price of vegetable oils is much higher than the equivalent amount of diesel oil. But the price has been constantly decreasing. Also from the point of view of self-sufficiency, it is worth while producing adequate vegetable oil to meet at least a part of our fuel requirements.

6) Electrification of the Railway

The proposal to electrify a part of our railway is estimated to cost about Rs. 5,000 million. In addition the Ceylon Electricity Board will need about 2,000 million to provide about 60 MW electrical power. The total cost is about Rs. 7,000 million. Also the electrical energy generated by the Ceylon Electricity Board has a very high foreign cost component. Hence the electrification of railway is neither a move towards self-sufficiency nor it is economically attractive.

A better alternative to this is to utilize the Rs. 7,000 million to purchase 10,000 Nos. of producer gas powered buses. This means that the CTB could increase its passenger load to 2.5 to 3.0 times the present value. This is in fact the long term expectation of road transportation.

7) Safety

The changeover to gaseous fuels of our buses and trains has to be done very cautiously. Following are some of the hazards.

(a) Fire

The temperature inside a producer gas generator is about 1,000°C. Unless adequate precautions are taken, very nasty and expensive accidents could result. Care should be taken to prevent backfire of the gas generator and the engine. Care must also be taken to prevent any gas leak. Another aspect to be looked into is the situation in the event a vehicle encounters an accidental collision.

(b) Air Pollution

Wood contains virtually no sulphur or radio activity. But burning of wood can lead to very serious air pollution. Small and low temperature wood burning units tend to produce more

undesireable atmospheric emissions than the large combustion units which operate at higher temperature and with greater turbulence. The emissions include Polycyclic Organic Matter (POL) which are believed to be carcinogenic. However, in a well designed and properly operated wood gasifier, such polluting matter can be made to crack and yield harmless products. But extreme care should be taken to properly dispose the residues collected in the filters of wood gasifiers. (Reference (9)).

8) Recommendations

The changeover from diesel to fuels from biomass is very appropriate to Sri Lanka. But effecting such a change should be done very cautiously.

First of all we must be able to produce good wood gasifiers on a commercial scale. For this purpose adequate fund should be made available to the National Engineering Research and Development (NERD) Centre. Also an initial subsidy should be given to the local manufactures of wood gasifiers. The CGR and CTB should at least partly meet these expenses.

Secondly the CTB and CGR should immediately commence trial runs with producer gas.

Thirdly, the CTB and CGR should establish energy plantations at suitable locations.

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AN EVALUATION OF RAILWAY CHARGING POLICY

by

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Fares policy is a paramount strategy in achieving the objectives of a transport operator. Setting fares in varying market conditions should be determined in accordance with the fare elasticity of demand. The reduced fare strategy promoted by British Rail provides an example of a successful case of low fares in the optional market where fare elasticity of demand is found to be substantially high.

In micro economic theory the relationship between demand (Q) and price (P) is interpreted so that

$$Q = f(P) \quad (1)$$

For a transport operator, the volume of demand for travel is determined by the fare charged by him. However, the response to fare changes vary according to the fare elasticity (e) of demand, which is defined as the relative change in demand ($\frac{\Delta Q}{Q}$) divided by the relative change in fare ($\frac{\Delta P}{P}$) so that

$$e = \frac{\Delta Q}{Q} \cdot \frac{P}{\Delta P} = \frac{\Delta Q}{P} \cdot \frac{P}{Q} \quad (2)$$

In the notion of calculus (2) may be written as

$$e = \frac{dq}{dp} \cdot \frac{p}{q} = \frac{d \log q}{d \log p} \quad (3)$$

There is of course one class of demand functions of the form

$$Q = ap^{-e} \quad (4)$$

Where (a) and (e) are constants for which elasticity is -e and is therefore independent of price. But on the convention adopted in the present paper a fare elasticity is a negative number indicating that demand (Q) goes down as fare (p) goes up. However, the situation faced by an operator who is expected to satisfy a given objective function subject to some financial constraint is much more complex than the functional relationship given in equations (1). In such a context, setting fares according to varying demand elasticities in different sectors of the market will add further difficulties.

Introduction

In order to set management objectives and formulation of policies it is necessary to know the passenger response to changes in the fare structure. But there is very little information available on rail fare elasticities upon which the passenger response can be measured. Tylor and Hassard (1975) have carried out a study on demand, for inter-urban rail travel. But the elasticities found in their study have been subject to criticism. Consequently, it has not been established a clear picture of passenger response which produces reliable predictions of the effect of fare changes.

Data

From 1971 BR has been operating a computerised system for recording passenger flows and this has made possible detailed analysis leading to more soundly based computations than those derived in the past. The information available to us were the ticket issues, receipts and journeys for six flows in the inter-city service.

The NPAAS* contains highly disaggregated data, eg. the BR fare manual records over 50 types of full fare tickets and over 150 types of reduced fare tickets. For the purpose of this study, eight major types of reduced and full fare tickets have been chosen.

Specification of the Model

Having done the appropriate preliminary analysis to define the important variables, the model used in the present analysis takes the form of elasticity type based on Multiple Regression. The coefficients of the explanatory variables, therefore, represent the elasticities of those variables.

* National Passenger Accounting Analysis System.

In the most general form

$$T_{ijk} = RF^{\alpha} U^{\beta} P^{\gamma} \dots \ln(D_{t_1} \dots D_{t_n}) D_b D_c \quad (1.1)$$

(i = 1 n)
(j = 1 m)

Where

T_{ijk} = Journey from i to j by mode k

α = elasticity in terms of real fare.

U = Unemployment (socio-economic variable)

β = elasticity in terms of unemployment

P = time

γ = elasticity in terms of time

$D_{t_1} \dots D_{t_n}$ = seasonal dummy variables

D_b = dummy variable representing competitive reduced fare offers of BR

D_c = dummy variable representing competitive coach fares.

There were eight main fare types of both reduced and full fare in the selected sample. Number of regression equations in the model amounted to 48. The weighted mean elasticities were estimated using the following formulae

$$\bar{X} = \frac{\sum X_i / SE_i^2}{1 / SE_i^2} \quad (1.2)$$

$$SE(\bar{X}) = \frac{1}{n-1} \left[\frac{\sum ((x_i - \bar{x}) / SE_i^2) + n}{\sum 1 / SE_i^2} \right] \quad 1.3$$

Where

x_i = fare elasticity of flow i

SE = standard error of fare elasticity x_i

n = number of flows

Formula (1: 2) weights each estimate by the inverse of the square of its own standard error that provides a measure of confidence. If the estimates are normally distributed there is 95 per cent probability that the true elasticity lies within the range $x_1 \pm 2SE$.

Reduced Fare Strategy

Reduced fares have been promoted to achieve the following objectives:

- i. to increase revenue by exploiting the consumers' surplus
- ii. to maintain the rail fares low enough to compete with road.

This has now become a paramount strategy of BR's fares policy and is well supported by the low marginal cost of carrying an extra passenger in the off-peak where excess capacity is available.

It has been observed that the reduced fares were used by travellers mostly in optional travel which usually takes place in the off-peak. This is an encouragement for BR to offer reduced fares to capture that market.

Although known as reduced fares they are somewhat higher than coach fares of competitive routes. However, due to the other decisive factors such as comfort, convenience and journey time there is a high rail patronage in the inter-city market. By introducing reduced fares in this context BR's strategy is to reduce the difference in journey cost between rail and road travel.

Fares Policy in achieving objectives

It is important to consider the objectives in the formulation of a fares policy. It is generally believed that the demand is basically

dependent on price in the ceteris-paribus demand function. Similarly in transport there is a good apriori case to assume that the demand in terms of passenger miles (Q) is a function of fare per passenger mile (P) and the number of train miles operated (T); that is

$$Q = f(P, T) \quad - \quad (1:4)$$

It is usually assumed in the cost function a constant utilization per train and total cost (C) proportional to train miles operated.

$$C = cT \quad - \quad (1:5)$$

In rail transport there is a diversity of objectives. Even without this diversity of objectives widely different financial results could occur. It is therefore inappropriate to examine them without financial objectives being set for each individual sector. It has now become obvious that the inter-city service of BR is expected to pay its own way. If BR were to maximise passenger miles subject to a given financial constraint the fares policy employed to achieve this should be somewhat different from a commercial revenue maximisation. To elaborate this point further possible management criteria are given below.

Profit Maximisation

This is derived from the concept of marginal revenue = Marginal cost ($MR=MC$) in the theory of firm.

$$\text{Max } G_1 = Pf(P, T) - cT \quad - \quad (1:6)$$

As permitted when the first derivative of equation (1:6) with respect to P and T set equal to zero price at each period is lowered until the marginal revenue equals zero assuming the marginal cost of carrying an extra passenger in the off peak is zero. This objective

will lead to a higher peak fare as against off-peak fare. This is because at any given fare the peak fare elasticity appears to be less than that of off-peak.

Social Surplus Maximisation

The idea is to maximise the area under the demand curve. This includes both the consumers' and producers' surpluses.

The mathematical expression can take the following form

$$\text{either } \left[\int_0^{Q^P} f_P(TP, QP) dQP + \int_0^{Q^O} f_O(TO, QO) dQO - C \right] \quad (1.7)$$

$$\text{or } \text{Max. } G_2 = \int_0^Q f^{-1}(Q, T) dq - CT \quad (1.8)$$

For maximising the social surplus zero fares have to be charged. This does not make any sense without charging positive fares. On the other hand, to do this the objective should be evaluated subject to a budget constraint.

Maximisation of social welfare functions subject to a budget constraint:

$$\text{Max } G_3 = \int_0^Q f^{-1}(q, T) dq - CT - \lambda(CT - Qf^{-1}(QT) - D) \quad (1.9)$$

λ = shadow price of public funds in terms of social surplus.

The marginal conditions of the above criterion can be worded as follows:

- i. Reduce fare as long as fare exceeds the revenue lost by the reduction necessary to attract one extra unit of traffic multiplied by the shadow price of public funds.
- ii. Increase train mileage as long as the extra social surplus generated exceeds the reduction in profit/increase in loss multiplied by the shadow price of public funds.

The extent to which the social surplus maximisation exercise can be carried out under the above criterion is dependent on the demand elasticities.

Fare reduction attracts additional traffic. So that

$$\frac{(\partial P(Q) \cdot Q)}{\partial Q} = MR = P(1 + \frac{1}{e}) \quad - (1:10)$$

This can be rewritten as

$$P - \lambda P(1 + \frac{1}{e}) = 0 \quad - (1:11)$$

$$\text{or } \frac{1}{\lambda} - 1 = \frac{1}{e} \quad - (1:12)$$

e = demand elasticity

This would encourage the operator to increase fares where demand elasticity is below unity and to decrease fares where demand elasticity is above unity.

It is worth noting the special case of "Bannol-Bradford" rule in the optimal departure of marginal cost pricing where prices should be set so that

$$\frac{P_1 - MC_1}{P_1} \bigg/ \frac{P_2 - MC_2}{P_2} = \frac{1}{e_1} \bigg/ \frac{1}{e_2} \quad - (1:13)$$

if $MC_1 = MC_2$ this reduces to

$$\frac{1}{e_1} = \frac{1}{e_2} \quad - (1:14)$$

for each product the percentage deviation of quasi - optimal price from marginal cost must be inversely proportionate to its price elasticity of demand. This result holds only where cross-elasticities of demand are zero.

Between the two extremes of profit maximisation and social surplus maximisation there can be alternative criteria. Among those objectives the maximisation of train mileage and maximisation of passenger mileage are the most common ones. The latter is the criterion adopted by London Transport.

Practical difficulties

In the pursuit of maximum profit, price discrimination is a way of exploiting consumer surplus by monopoly providers. In the case of BR if the ultimate objective is to maximise social surplus price discrimination provides an effective tool to achieve it while satisfying a budget constraint.

BR operates on a highly differentiated fares policy although there are practical difficulties of operating such a fare structure. For the operator discrimination is feasible if he can separate the market into distinctive segments each having different price elasticities which will then make it possible to charge different fares. Although little is known with certainty about price elasticities, due to the complexity of the transport market any progressive fares policy for satisfactory exploitation of the market would undoubtedly be operated with a great deal of differentiations.

Although BR is a monopoly provider in rail passenger transport its ability to exploit the consumer surplus of rail travellers by way of price discrimination is theoretically limited because of the availability of substitute modes. The degree of substitution is measured by the cross-elasticities between modes and along with the competing modes background factors are largely outside the control of BR such as growth in incomes, car ownership and household characteristics. Therefore, understanding the

relationship involved with the above is clearly essential in determining the fare structure. Unfortunately, because factors such as income and car ownership are so intimately tied to each other and other demographic characteristics and they themselves have changes slowly and monotonically with time. The resulting interactions are therefore extremely difficult to measure reliably.

Results and Conclusions

The mean real fare elasticities obtained in respect of full and reduced fares are given in Table (1.1)

Table (1.1)
Standard error weighted average real
fares for all flows sampled

	Mean Elasticity	Standard deviation of mean
Full fare	- 0.49	0.01
Reduced fare	- 0.83	0.01

As expected demand elasticity of reduced fares was much higher than that of full fare and yet significantly less than the unity. In the full fare category the elasticities differed between first and second class travel. As shown in Table (1.2) first class travel is more price elastic than second class travel.

Table (1.2)
Standard error weighted mean fare
elasticities for first and second
class travel

	Mean Elasticity	Standard deviation of Mean
First class	- 0.57	0.05
Second class	- 0.46	0.01

The elasticities also varied a great deal depending on the trip length. This is equally true in both ticket types although no obvious reason is found. It is believed that this relationship between trip length and elasticity is a reflection of high inelastic demand for short distant inter-city travel.

Coach fares and bargain offers

The dummy variables used to model the effect of bus and coach deregulation and bargain offers introduced by BR do not appear to have shown a significant negative effect on rail travel demand on individual ticket types. However, the overall negative effect of low coach fares on rail travel may be fairly significant. The same conclusion can be drawn in the case of bargain offers, i.e. there is a substantial transference of journeys from traditional reduced fare offers to recent bargain offers.

The elasticity obtained in respect of increasing unemployment on rail travel demand was substantially high. The elasticities were -0.39 and -0.59 for full and reduced fares respectively. A classification of elasticities by route has shown a higher negative elasticity of unemployment on short travel than long distant travel.

Apart from fare elasticities there is the cost structure that requires consideration in drawing any conclusion. Nonetheless, on the basis of the fare elasticities obtained in the present analysis a complete agreement with the BR's reduced fare policy is possible.

In order to make the best use of present fare policy BR must administer this complex system to make sure that the right fare is charged from individual passenger to achieve the objective of revenue maximisation. In other words the purpose of differentiated fares policy will not be achieved if any substantial transference of journeys from full fare to reduced fare is allowed to take place. As far as would be travellers are concerned the purpose of reduced fares strategy will not make any sense if the journeys are allowed to be made on reduced fares that would otherwise be made on full fare.

ECONOMICS OF THE
SRI LANKA RAILWAY SYSTEM

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The state of the Railway is critically analysed. It is seen to be on a declining trend. The causes are identified and a solution offered to reverse the trend.

ECONOMICS OF THE SRI LANKA RAILWAY SYSTEM

1. A HISTORICAL SKETCH

The first steam-powered train in the world was run in Britain in 1825. In 1825, George Stephenson introduced the 'Rocket', a locomotive capable of attaining a speed of 29 miles an hour. Up till then, the best record for speed was the stage coach, reaching under 15 miles an hour. The Rocket accelerated the development of the Railway in Britain. By 1860, when railway construction had begun in earnest in our own island, British Railways had developed to over 10,000 route miles. In 1962, just prior to the cut back in route miles, it was about 17,500 miles. Today, it is about 11,000 route miles.

In Ceylon, a Railway Company was formed in 1845. The Company was dissolved in 1861, giving birth to the Ceylon Government Railway. The first train ran from Colombo to Ambepussa - a stretch of 34½ miles - on December 27th, 1864. Three years later, the line to Kandy was opened. Traffic which took seven days or more to reach Colombo was moved within a matter of hours. In 1946, just before Independence our Railway was 913 route miles in extent. Today, it is just 902 route miles, 866 route miles of broad gauge of width 5'6" and 36 route miles of narrow gauge of width 2'6".

2. THE STATE OF THE RAILWAY

2.1 Freight - It is a well known fact that the Railway's interests are best served by moving traffic in bulk, over a long distance - the greater the tonnage of commodity and length of haul, the better for the Railway.

In 1981, the Railway moved 1.56 million tons and 134 million ton-miles of freight. Freight traffic had been on a declining trend from 1970. In that year the

the Railway moved 228 million ton-miles. Thus, in 1981, the Railway had transported only 59% of the ton-miles moved in 1970. In other words, in about 10 years the Railway had lost 40% of its traffic. The following tabulation which compares the tons and ton-miles of 1981 with the peak years for the same parameters also reveals another ominous trend:

	(Million)		
	<u>1970</u>	<u>1974</u>	<u>1981</u>
Tons	1.84	1.94	1.56
Ton-Miles	228	193	134
Average length of haul (miles)	124	99	86

Not only the tonnage and ton-mileage have declined but also the average length of haul. The trend has been set towards short distance traffic which itself is a trend towards uneconomic operation.

It might not be well known that the Railway is becoming increasingly dependent on two customers, the Petroleum and the Cement Corporations for traffic. In 1974, the peak year for tonnage, the two together provided the Railway with 58% of its tonnage and in 1981, with 83%. Traffic from these two Corporations are on a rising trend while almost all the traffics from other sources are on a declining trend. When Fertiliser, Rice and Flour are added to the traffic from the two Corporations, the tonnage adds up to 92% of the total. All the other traffic account for just 8%. Tea traffic which, at one time, was a major commodity provided less than half per cent of the total tonnage.

Not only rail traffic is confined to a few commodities, it is also confined to a few stations. A study made in 1975, a year when traffic was more diffused than at present,

showed that 25 stations out of about 140 stations opened for freight traffic accounted for two-thirds the traffic moved. In other words, in just 20% of the stations opened for freight traffic, almost 70% of the traffic was moved.

The pattern, then, of freight traffic is of traffic where customers and commodities moved are few, where movements to and from are confined to a few stations. The trend is one of continuous decline in tons, ton-miles and average length of haul.

2.2 Passenger - Passenger traffic presents an equally dismal picture of decline and of restricted patronage. It rose steadily up to 1973, declined and rose to a higher peak in 1979. Thereafter, between 1979 and 1981, within a two-year period, it dropped sharply by more than 25%. The following tabulation will make this clear:-

	(Million)		
	1979	1981	Decline
No of passengers	89	70	21%
Passenger-miles	2555	1850	27%
Average Journey Length (miles)	28	26	

It is well known that the main reason for this drop is the advent of the private coach. This drop in passenger mileage is equivalent to a wiping out of the gains from growth of about 10 years.

Though the Railway Passenger Service extends to the length and breadth of the Island, the average journey length is only 26 miles. It will be noticed that even with the steep drop in passenger-mileage, the average journey length had not significantly altered. There are two reasons for this. Firstly, about 60% of the total number of journeys undertaken is the short distance

season ticket traffic of average length of only 17 miles, while the corresponding average of the other 40% is 41 miles, which is still a short journey length. Secondly, most of the passenger traffic is restricted to a small area, more so than freight traffic, but to a different pattern. The following tabulation, which is a summary of a computer study made in 1975, reveals the concentration of passenger journeys according to Divisions:-

<u>DIVISION</u>	<u>ROUTE MILES FOR PASSENGER</u>	<u>% ROUTE MILES TO TOTAL</u>	<u>% WHOLE JOURNEYS TO TOTAL</u>
Colombo	253	30	80
Anuradhapura	419	50	4
Nawalapitiya	157	20	7
	<u>829</u>	<u>100</u>	<u>91</u>
Inter-Divisional Journeys			<u>9</u>
			<u>100</u>

Whole journeys are journeys which originate and terminate within the Division itself. It is now seen that 80% of the people who travel on the Railway System, travel within the Colombo Division. Close the other two Divisions, the Railway would still cater to 80% of its passengers. To repeat in another way, 80% of the passengers use 30% of the system. Within the Colombo Division itself, there is a further concentration. Half the number of whole journeys lie within a radius of 16 miles from Colombo, an area accounting for 37 route miles or just 4½% of the total. In this circle lies Gampaha, Panadura and Ja-ela. Passenger traffic, then, has the pattern of a short journey length, of a patronage received mostly from commuters, and of a movement mostly restricted to a narrow segment of the Railway System. The trend is one of a steep decline in passengers and passenger miles.

2.3 Finance - In 1981, the Railway earned from all sources Rs.409 million. This was more than double the income earned just five years back. Since both passenger and freight traffic had been declining during this period, it might come as a surprise as to how this could have been. In actual fact, an analysis of the situation during this period will probably reveal that the Railway suffered the worst setback in recent years, within this period.

Consider the following facts relating to the years from 1979 to 1981. It was already shown that passenger miles dropped by 27%. Likewise, ton-miles which was on a declining trend from 1970 lost 22% during the two years. Passenger revenue rose by 50% due to steep increases in fares, which over compensated the loss in traffic. But freight revenue suffered a setback. It fell by 18%. Here, the steep increases in rates had accelerated the flight of traffic. This is a rare case where an increase in the tariff brings about a reduction in revenue. Then again, during the same two years, revenue increased by 31% but operating expenses by 54% and the gap between revenue and operating expenses had widened so steeply that the operating loss more than doubled itself.

To those interested in the actual figures, the following tabulation will help:-

	(Million)		
	<u>1979</u>	<u>1981</u>	<u>Increase %</u>
<u>REVENUE</u>	312	409	31%
<u>EXPENDITURE</u>			
Operating	420	645	54%
Total (including annuities)	565	891	58%
<u>LOSS</u>			
Operating	108	236	119%
Total	253	482	91%

From the above data it also follows that in 1981 the Railway was losing at the rate of Rs.1.3 million a day. Then again, using the widely used concept of operating ratio - the ratio of expenditure over income - in 1981, for every Rs.100/- earned, the Railway spent Rs.158/- to run the services and another Rs.60/- as annuities to pay for capital invested, totalling to an expenditure of Rs.218/- for every Rs.100/- earned. The Railway was spending more than twice as much as what it was earning. Of course, this steep increase in losses is not entirely the Railway's fault.

During the two year period from 1979 to 1981, the cost of fuel and lubricants rose from Rs.85.7 million in 1979 to Rs.246.3 million in 1981 - thanks to the price increase of the Petroleum Corporation. Thanks again - this time to the Treasury - the bill for pensions and gratuities rose from Rs.57.4 million in 1979 to Rs.82.9 million in 1981. On these two items of expenditure alone over which the Railway has no control, the increase in spending was a staggering Rs.186 million in two years. With expenditure of this magnitude and rising convulsively, budgeting cannot be controlled.

2.4 Break-even Analysis - The Railway's operating expenses can be separated into movement cost and fixed cost. The movement cost which is made up of the cost of fuel, of crew, of maintenance of rolling stock, is the variable component in the operating expenses. With this data it is easy to calculate the extra volume of traffic which will be needed, in any one year, for revenue to break-even with operating expenses. This parameter gives in one value, a measurement of the long road to viability. Furthermore, its trend over the years will indicate whether the Railway is moving towards viability or away from it. It

is an useful parameter to calculate and monitor. This exercise was done for the first time for the year 1975, separately for passenger and freight services.

In 1975, for revenue to break-even with operating expenses passenger mileage had to be doubled and ton-mileage had to be increased by about 25%. These were impossible targets. Then, freight traffic was actually dropping at an accelerating rate from the peak reached in 1970, and though passenger traffic was increasing, the rate was so slow that it would have taken, at least, 10 years for the traffic to increase by only 50%. Besides, if by some miracle the passenger mileage could have been doubled, the Railway would not have been able to meet the demand without substantial increases in fixed and capital costs. What of the following years? Had the situation improved or worsened? Unfortunately, detailed statistics are not available separately for the two services. Nevertheless, a simplified comparison could still be made with the available figures. A tabulation is given below for the years 1975, 1979 and 1980.

In 1975, the break-even level required was an average increase in both traffics by about 70%. In 1979, it was 100% and in 1980, almost 300%.

	Rs. (Million)			
	<u>Revenue</u>	<u>Movement Cost</u>	<u>Fixed Cost</u>	<u>Factor-%</u>
1975	196	126	120	70 %
1979	312	207	213	100 %
1980	359	298	237	290 %

$$\text{FACTOR : } \left(\frac{\text{Fixed Cost}}{\text{Revenue} - \text{Movement Cost}} - 1 \right)$$

If one is asked to explain the decline of the Railway with just one reason: then it is in the ~~continuation~~ into the current day of attitudes deeply rooted in history, while the much blamed contemporary forces of inflation, competition and what-not have only accelerated, not started, the process of decline. This section of the Paper will try to identify a few of these inherited attitudes prevalent even today.

There are five parties directly or indirectly involved in the activities of the Railway. They are the Government, the Operator, that is, the Railway, the user, the competitor and the general public.

3.1 The Government - The Government provides a subsidy equivalent to the Railway's deficit at the end of the Financial Year. Thus, the level of financial support is determined after the event. This is a defective system as it gives no incentive to the Railway to improve its financial results through economic or productive measures. A lump sum subsidy doled year after year, decade after decade, undoubtedly acts as a disincentive towards viability.

One arm of the Government controls expenditure in the manner already explained, while the other arm controls policy. This control is inflexible and has been expanding over the years, into the nooks and corners of the system. One could, perhaps, say, that in the situation of today, about 80% of the total financial and operational activity of the Railway is controlled directly or indirectly by Government policy. One example of this is found in the Government's attitude to the Tariff.

Pricing, anyone will acknowledge, is a continuous process and should be related to cost. However, the Railway tariff

is governed by an Ordinance. It cannot be raised without Government approval.

The Railway has the discretion to lower the tariff up to a point, with Government approval. But why should the Railway push for tariff changes when the Government automatically cancels the entire deficit?

In the twenties and thirties, there was only one tariff revision each; in the forties, four revisions; and in the fifties again, one revision. There was no revision in the sixties. In the seventies, because of the fuel price increases by fuel exporting countries, there were three revisions. A period of about 60 years is covered by ten tariff revisions. If the last decade is left out, there were only 7 revisions in fifty years - an average of one every 7 1/3 years. Again, these tariff revisions have been on the whole mere ad hoc percentage revisions to the tariff, just previous. The tariff of today is derived from the tariff of 1950 by a series of percentage additions, which tariff itself was an adaption of the tariff of 1926. More on this matter later.

Another example, taken at random, is found in the Government's attitude towards passenger services. Some of these services had been introduced at a time when costs were low, when resources were available in plenty and when competition was hardly noticed. But this situation had changed long ago and these services had long ceased to be viable. Nevertheless, Government will not let them be touched.

The net result of such an attitude in a background of rising costs, is to make all such uneconomic services more and more uneconomic. Then, they tend to be over-used because the user is under-charged, and they tend to

become more and more difficult to uproot. Funds which could be used for better purposes in the system are locked up for the provision of these services.

3.2 The Railway - The Railway is, perhaps the oldest commercial and the oldest subsidised institution of the Government. Resulting from this, the Railway had gradually shifted from the position of being a commercial Railway to becoming an over-subsidised, social Railway.

Being under the protective influence of successive Governments right from Colonial times, it has hardly changed its traditional posture. It was shown, for example, that the tariff is still basically a repeat of an exercise done in colonial times. It will now be shown using the same example of the Tariff, that this attitude in this age of cost consciousness will not work.

Is the tariff adequate to recover, at least, the directly variable costs? Movement cost is a directly variable cost. This cost, already defined, is made up of cost of fuel, crew and maintenance of rolling stock. The cost of providing a vehicle to carry the traffic, is the other directly variable cost. Traffic must first be loaded into a vehicle before it can be moved. This element of directly variable cost is exclusive to the traffic and should be the first charge on the revenue, unlike the other element which is shared.

To calculate the provision cost of vehicle for a service one must know the cost of the vehicle, its life, interest paid on capital borrowed, the number of days of operation of service, availability of vehicle, turnaround time, length of haul and loadability of commodity. A mathematical model can be designed to study the problem. By applying the data of 1975 to this model an interesting

set of figures emerged. In the three groups of commodities given below, the cost of vehicle was the same.

COMMODITY	PROVISION COST	AVERAGE REVENUE
	PER TON-MILE	PER TON-MILE
	Cts.	Cts.
Oil	19.5	44
Cement	21.6	16
General	54.3	32

It is seen that for the same cost of vehicle, the provision cost per ton-mile yet varied widely from 19.5 cts. to 54.3 cts. and ^{that} oil had the lowest provision cost and the highest revenue.

Oil is loaded almost throughout the year, unlike the other traffics which are not loaded on Sundays and holidays. Then again, the turnaround time of oil tanks is faster and their availability higher when compared to the covered wagon in which the other traffics move. These favourable factors in oil transport had brought its cost down to 19.5 cts. Cement though sharing the same inefficiencies with the general traffics has a lower cost because of its long haul and maximum loadability. The revenue per ton-mile has exceeded provision cost only in the case of oil. Adding the movement cost which in that year was 19.6 cts per ton-mile, the revenue from oil covered the two directly variable costs. However, the revenue from oil was not enough to meet its share of the cost of locomotive and brake needed to haul the commodity. This cost incidentally, when added to the other two elements, form the haulage cost. This little presentation relating the tariff to costs raises several issues. Oil traffic with the best revenue and lowest provision cost could meet its directly variable cost but not its haulage cost, let alone the other costs. The other traffics cannot even meet the cost of vehicle.

The Railway is subsidizing traffics from Government owned organizations. Through improvements in operational efficiency the cost of vehicle can be brought down. The tariff bears no relation to cost and is out-of-date. It is not necessary to produce data to prove the same point with respect to the other activities of the Railway.

3.3 The User and the Competitor - They are the parties who have benefitted most from the situation. The user has the choice of modes and he is under-charged. He has the service he has been used to for several decades and he has the influence to prevent changes in the service if to his disadvantage.

The competitor is not restricted, not anymore, from competing with the Railway. His break-even level is low, so that he can always ensure a surplus on his operations. The Railway has not^{had} the same freedom to act.

3.4 The General Public - They pay the Railway's deficit and suffer in other ways. The Railway's losses are met from taxes and dues collected from them, because the Railway is considered to be of social importance. But there are other services also of social importance, some of which affect the quality of life of the Nation itself. An increase in the Railway's losses, decrease the resources available for these amenities. At a certain stage, a halt is called on Railway expenditure.

The Railway then manages in ways it knows best, cutting down expenditure here and there, to the detriment of the system, as a whole.

4.

THE SOLUTION

4.1 A Review - But first a brief review of what had been stated already and a comment before proceeding further.

The Railway's revenue, for a good many years, had not been enough to meet its recurrent expenditure, let alone the cost of annuities. In 1981, the Railway incurred a loss of Rs.236 million on operations and another Rs.246 million on annuities, totalling to a loss of Rs.482 million.

Granted that the Railway, like most other Railways, cannot meet all its expenses, the question has still to be asked as to how much of these losses are avoidable.

More traffic will bring in more revenue. But freight traffic has been decreasing from 1970, and by 1981, it has dropped by 40%. The average length of haul had declined and the Railway was left with only two patrons worth mentioning. Passenger traffic had dropped drastically by more than 25% between 1979 and 1981. Competition had become very severe. Most of the journeys were derived from season tickets where fares are low and journey lengths short.

Even if by some device the declining trend is reversed, the Railway will still not be able to break-even with recurrent expenditure, let alone the annuities, because the level of traffic needed to break-even is very high.

The other possibility to increase revenue is by increasing the tariff. However, the tariff is not cost-based and is still a repeat of an exercise done in colonial times. Again, a steep increase in freight tariff had already resulted in a loss of freight revenue. In 1981, the Railway earned Rs.409 million and lost Rs.482 million.

How much of this loss can it be said be bridged by a tariff revision? Why should the traffic which still patronises the Railway be made to cover the loss of revenue from traffic which had moved to other modes?

Since costs go up each year, should the tariff be revised each year?

4.2 Proposals - What then should be done to reverse the declining trend in the Railway? Three lines of action are proposed. Firstly, the Railway's autonomy to run its day to day affairs should be increased, and it should be helped to manage its affairs like a private sector organization. The Government, the Railway, specialists in transport economics and Managers in the private sector may be brought together to design an appropriate infra-structure. Secondly, the lump sum subsidy should be done away with; instead, the social aspects of Railway operation must be quantified and subsidised. Those will be identified now.

A train hour has the potential to produce only a certain amount of ton-miles or passenger-miles to earn revenue. It can be shown that on the Up-Country Division and on the K.V.Line, because of low train speed and low haulage capacity of locomotive and train, about 2 train hours and $3\frac{1}{2}$ train hours respectively are the traffic equivalents to one train hour on the flat territory of the broad gauge. Thus, it costs much more on these two lines, to move the same traffic or earn the same revenue, than in flat territory. Then, in the Anuradhapura Division, enclosing 50% of the route miles, only about 25% of train miles are operated, indicating a low use of track and of other items of fixed costs. Again, in the Colombo Division, the track and the somewhat sophisticated signalling system is considerably used to convey commuter traffic, which provides scant revenue to the Railway but keeps the traffic off the public highway.

Again, the Railway system terminates in 9 different directions, with each terminal and a section of line leading to the terminal having a low traffic level. Nevertheless, these sections when totalled form a substantial proportion of the route miles.

Despite these constraints, the Railway being a social concern, is compelled to operate services throughout the entire system.

Superannuation should also be treated as a social amenity requiring Government's assistance. In 1981, the Railway spent Rs.83 million on pension, while, say, in 1975, it spent only Rs.37 million on this account.

In 1981, the Railway incurred an annuity bill of Rs.246 million. Ten years back it was only Rs.37 million. This phenomenal increase in this item of expenditure is due to the high rate of interest charged on capital loaned to the Railway, to the period of the instalment which ranges from 30 to 50 years, and to inflation. It can be demonstrated, though it is not necessary, how these factors had piled up the bill on annuities.

The second proposal is, then, to subsidise the capital cost of track and signalling and, say, half the cost of superannuation and to charge, if at all, a nominal interest on capital loaned. This proposal is justifiable for the other reason that the private competitor does not pay for the building of roads, has little or no superannuation to contend with, and has had the advantage of LSD to purchase his vehicles.

The third line of action is to make the Railway cost-oriented. Its principal services and activities must be costed, and published. How far is the Railway from making the best use of its resources will then become evident.

This Paper will cease to be an objective exercise on Railway economics if it were to start listing the numerous parameters of operation which should be costed and monitored. Marketing strategy and pricing should be based on costs, and so also the tariff. The introduction

of a new service, or the termination or modification of an old service must be based on costs. In short, costs should be used as guidelines to policy and to improve operational efficiency. Traditional practices will become suspect, if they are costly.

4.3 Effect on Cost - What would be the effect on cost if the Railway were to improve its efficiency and the Government were to meet the cost of social obligations imposed on the Railway. A sample study was made for the year 1975. In this study, the Railway was expected to improve its efficiency on certain specified lines and the Government was expected to meet the capital cost of track, half the cost of superannuation, and to charge a nominal interest on capital loaned.

The result of this study, which was for traffics moving in covered wagons, is given below:

<u>ITEMS OF COST</u>	<u>COST PER TON-MILE</u>	
	<u>ACTUAL</u>	<u>PROPOSED</u>
	<u>Cents</u>	
Recurrent -		
Movement	19.6	18.6
Fixed	19.4	16.4
Total	39.0	35.0
Capital -		
Provision cost of vehicle	54.4	9.0
Provision cost of locomotive & Brake Van	14.0	7.0
Track and signalling	5.0	-
	112.4	51.0

Average revenue of these traffics was -/34 cts per ton-mile.

It will be seen that the proposals reduced the cost of the service to less than half the actual cost. Even then, the revenue earned was two-thirds the revised cost. One of the ways to bridge the gap would be to raise the tariff.

However, the lines of action proposed, if effectively implemented, should find a solution to problems of this kind.

(I would like to take this opportunity to thank the University for giving me this opportunity to present this Paper on Railway Economics.)

OPTIMAL TRANSPORTATION PROBLEM - SUPPLY FROM LOCAL & MULTI IMPORT POINTS

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ABSTRACT : In order to balance the demand of a commodity at different locations within a country, it may be necessary to supplement stocks produced locally at different production points, by importing the deficit amounts to import points, such as harbours and air parts. To work out the transport schedule to different demand points from the supply points (which are the locally manufacturing and import points) to keep the total internal transport cost minimum possible, the management decision makers are faced with two related problems. These are,

- 1) What quantities are to be assigned to each import points, and
- 2) how could the optimal transportation strategy be worked out.

This paper attempts to answer the above problems, by keeping the quantities to be assigned to different import points as unknown variables, and then by constructing the optimal transportation strategy and with it the total cost as a linear function of these unknowns. The values that minimises the cost function is next sought.

The above model is applied to a case study of assignment of sugar imports to Sri Lanka for the year 1981, to the harbours Colombo and Trincomalee to supplement local production and to schedule transport to the nine provinces, in order to minimise the total cost of internal transport.

INTRODUCTION

The well known linear transportation problem is formulated in terms of supply points $S_1, S_2, \dots, S_n$; which could supply $S_1, S_2, \dots, S_n$ units of a commodity to points $D_1, D_2, \dots, D_m$ that demand $d_1, d_2, \dots, d_m$ units with $\sum S_i = \sum d_j$.

If the cost of transporting per item from S_i to D_j is C_{ij} for all such connections the optimal strategy of scheduling amounts Z_{ij} from S_i to D_j in order to minimise the total cost $\sum_{i=1}^n \sum_{j=1}^m Z_{ij} C_{ij}$ is sought by the use of the well known stepping stone method (ref. 1.).

There are numerous extensions to the above classical problem. Some of these are the sensitivity analysis, where cost changes are studied for moderately small changes in the supply and/or demand values (ref. 1). Other extensions are to keep supply, demand values and cost values within limits rather than at specific values.

The objective of this paper, is to study rather a complex situation where the amounts to be made available at specified supply points are to be determined in order that specified supply points are to be total demand balances the supply and also the transport strategy to be worked out to minimise the total cost of transport.

This situation could arise in a country attempting to meet the demand of a certain commodity at different regions from produce manufactured locally at different locations and also from imports. These imports also have to be received at a number of points in the form of harbours or air ports. The question is knowing the requirements, availabilities at production points, together with transport costs, in order that ^{total} demand balances the supply, (which is now the local production and imports), to decide on two matters. Firstly, how much of the items are to be assigned to each import point and secondly how could the optimal internal transport strategy be worked out, to keep the total cost of internal transport as least as possible.

MATHEMATICAL FORMULATION

Even though it is possible to examine the problem for more than two import points, let only two such points be considered for the purpose of keeping the model as simple as possible.

Let S_1, S_2 be import points, and $S_3, \dots, S_n$ the points of local supply with the figures $S_3, \dots, S_n$ and the other notations remain as stated earlier in the introduction. The unknown amounts X, Y are to be assigned to S_1 and S_2 respectively, but since the total demand is to balance the supply

$$X + Y + \sum_{i=3}^n S_i = \sum_{j=1}^m d_j$$

Thus Y can be expressed as a linear function of form $Y = a - x$. The problem could now be formulated as to determine x , $a - x$ to be assigned to S_1, S_2 respectively and to work out Z_{ij} from S_1 to D_j for all $i = 1, 2, \dots, n$ $j = 1, 2, \dots, m$, so that the cost

$$\sum_{i=1}^n \sum_{j=1}^m C_{ij} Z_{ij}$$

is minimum possible.

The standard practice in using the stepping stone method as in Froberg's (ref. 2) where S_1 and d_j have prescribed values is to first construct a matrix F which gives a feasible solution. In attempting this with variables $x, a-x$ at S_1, S_2 , different matrices F are obtained for different ranges of x . It means that in each of these ranges, the structure of the problem remains the same. It is evident that no term of F can be negative.

The optimal transportation strategies have to be now worked out, for each of these ranges of x , and hence for each strategy the total cost can be formulated as a linear function $C(x)$.

The function $C(x)$ is seen to be piece-wise continuous, for feasible values of x . Thus when the value of x which minimises $C(x)$ is determined, the optimal transport strategy could be worked out for that value of x .

SEEKING THE OPTIMAL STRATEGY AND THE COST FUNCTION

In order to find a feasible solution matrix $F = \{Z_{ij}\}$ for some x , in the cost matrix $\{C_{ij}\}$, the smallest number is found for some row I and column J , where I belongs to the set $\{1, 2, \dots, n\}$ and $J \in \{1, 2, \dots, m\}$. Suppose $I = 1$, in which case the value x and d_j have to be compared. If $x \leq d_j$, then Z_{1j} is set as x with other terms of that row Z_{1i} are set 0, $j = 1, 2, \dots, m$, $j \neq J$. The value d_1 is reduced by x . If $x > d_j$, then Z_{1j} is d_j and other terms of column J is set 0, d_j set 0 and x decreased by d_j .

If $I \geq 2$, a similar procedure is adopted. The next smallest term is considered, and if the corresponding Z_{ij} term is already available, the next smallest term is reached, other wise this is dealt in the same manner.

Clearly the procedure will result in a $n \times m$ feasible matrix F . It is hence clear, that when terms in the first and second rows of the cost matrix $\{C_{ij}\}$ are dealt with, for different ranges of x , different feasible matrices are obtained.

For each feasible matrix F , a matrix called K has to be constructed as follows. Corresponding to each non-zero term z_{ij} in F , find α_i and β_j such that

$$\alpha_i + \beta_j = C_{ij} \quad \text{This could commence by taking } \alpha_i = 0, \text{ and looking for a}$$

non zero term in the first row of F .

The matrix $A = C - K$ is next constructed. If all terms of A are non-negative the feasible matrix F gives the optimal transport strategy from which the cost function

$$C(x) = \sum_i \sum_j c_{ij} z_{ij} \quad \text{can be constructed as a linear}$$

function of x , for that range of x for which the matrix F is defined.

If a term a_{IJ} of A is negative, from the matrix A , a polygon with sides parallel to rows or columns is chosen with vertices at a_{IJ} and all others zero, giving a set of points with row - column co-ordinates as $(I, J), (I, J_1), (I_1, J), (I_1, J_1), \dots$. Looking at the F matrix, it is seen that $z_{IJ} = 0$, and all the other terms z_{IJ} etc; are positive. A positive value ϵ is selected so that $z_{IJ} = \epsilon$ and when other terms are set $z_{IJ} - \epsilon, z_{IJ} - \epsilon, z_{IJ} + \epsilon$, all these terms should be non-negative. This could give different sub regions of the interval x to which F is defined. With the new matrix F , the matrices K and A are computed as described earlier, and the procedure repeated, until a matrix A with all terms non-negative is reached. The corresponding matrix F gives the optimal strategy from which $C(x)$ is constructed.

CASE STUDY - IMPORT AND DISTRIBUTION OF SUGER IN SRI LANKA

Figures of import and production of suger in Sri Lanka in 1981 (ref.3) have been taken to apply the model, to indicate how the imports could have been distributed and the transport strategy worked out to keep the total cost of inland transport at the minimum level. The present work is an extension of an earlier study by de Silva and Alhip (ref. 4) where only local production and distribution has been studied with out imports.

In 1981, the total amount of suger in 1000 M.tons distributed in Sri Lanka had been 193. This has come from figures of 13 produced at Hingurana, 11 at Kantalai and rest from imports. Two main harbours one at Colombo (western province) and the other at Trincomalee (Eastern Province) serve as import points.

The distribution of suger to the geographic 'Capitals' of the nine province is considered. It is assumed that the demand of a province is proportional to its population. Both Hingurana and Kantalai are located in the Eastern province, and the capital Batticaloa roughly lies mid way between the two production locations. Thus the total production is lumped to an imaginary supply point at Batticaloa. Figures of population, suger consumption at the rate assumed, etc; are given in table 1.

Obviously, produce of one province is distributed inside its own territory and the excess forwarded to other demand points. Thus of the 24 units of production of the Eastern Province, the amount of 12 is consumed within that province and this province acts as a supplier giving out 12 units of the commodity.

Western Province with its largest population requires 51 units. Since Colombo is in western province, it is reasonable to assign 51 units of the total imports of 169 to be imported through Colombo for distribution to that province even though Trincomalee is in the Eastern province, since that province is more than self sufficient in sugar, it is assumed that this harbour is an independent supply point. Thus if a value of x is assigned for imports at Colombo, the amount for Trincomalee is $169 - 51 - x = 118 - x$ units.

Since the requirements of western and Eastern provinces have been dealt with, the remaining seven provinces are considered as demand locations with amounts proportional to the populations.

Transport cost per unit item is taken to be proportional to the distance from the three supply points Colombo, Trincomalee and Batticaloa. The cost matrix formed of the distances (ref. 5) together with supply and demand values shown in table 2 indicate the basis of the linear transportation problem of this study.

The cost function for different ranges of x , and its graph is shown in table 3.

It is seen that $C(x)$ has a minimum value at $x = 95$ units which implies that

$95 + 51 = 146$ units are to be imported to Colombo of which 51 units are to be distributed to the Western Province, and the rest distributed to other seven provinces. Trincomalee should receive $118 - 95 = 23$ units, which are available for distribution to the seven provinces.

The optimal strategy for the above supply figures is given in table 4.

Table I - Statistics of Sugar Requirements, 1981.

Province	Geographic Capital	Population (1000 s)	Sugar requirement according to population (1000 M tons)	Sugar production (1000M)	Excess (1000M tons)
1. Western	Colombo	3968	51	-	-
2. Central	Kandy	2177	28	-	-
3. Southern	Matara	1977	25	-	-
4. Northern	Jaffna	1080	14	-	-
5. Eastern	Batticaloa	916	12	24	12
6. NWP	Kurunegala	1698	22	-	-
7. NCP	Anuradapura	712	9	-	-
8. Uva	Badulla	931	12	-	-
9. Sabaragamuwa	Ratnapura	1530	20	-	-
Sri Lanka	-	14,988	193	24	12

Table II - Cost Matrix

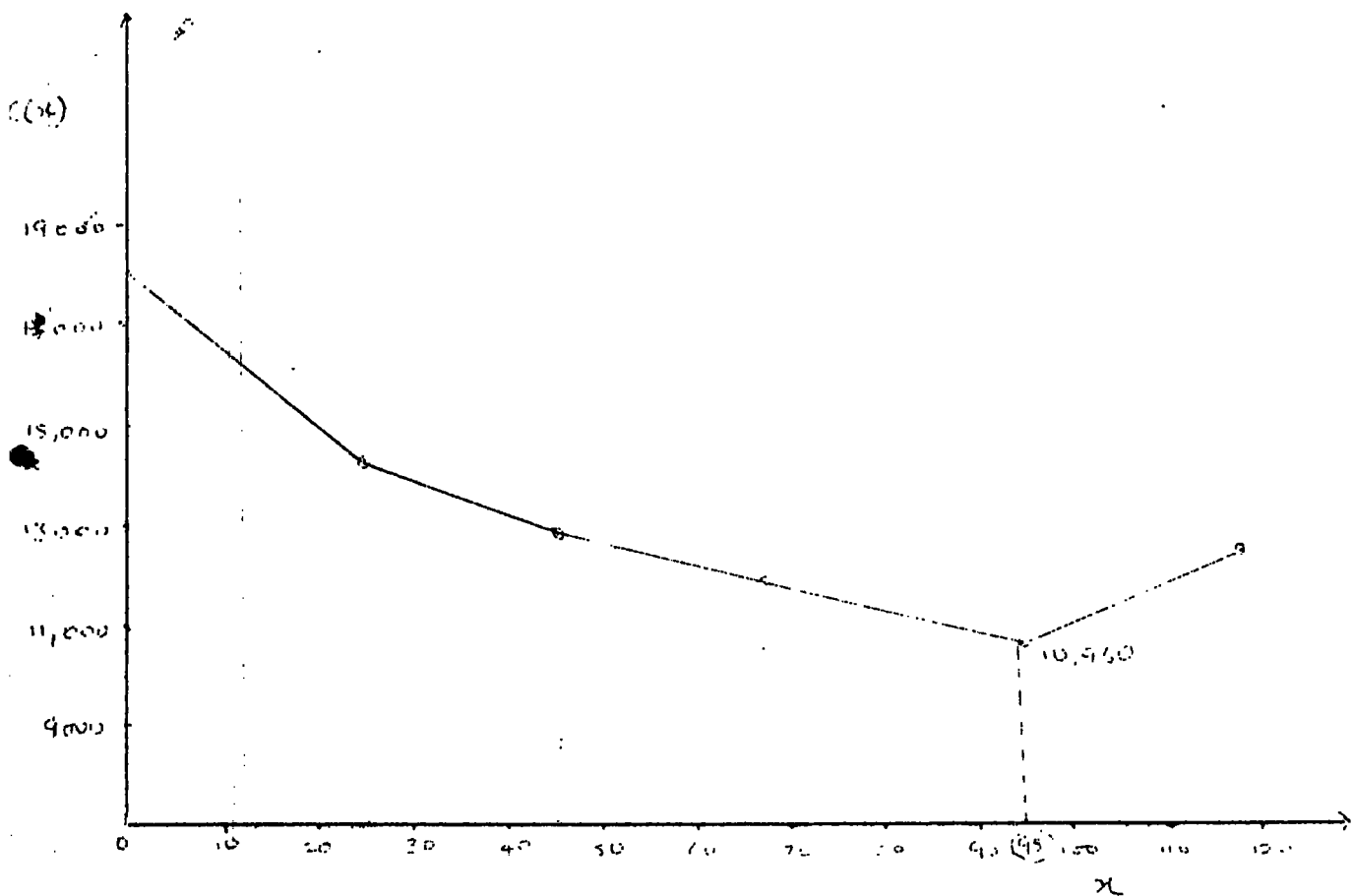
Demand

Supply	Central (28)	Southern (25)	Northern (14)	NWP (22)	NCP (9)	Uva (12)	Sabaragamuwa (20)
Colombo (x)	72	100	246	58	128	143	63
Trnco. (118-x)	113	260	148	102	66	172	112
Batticaloa (12)	116	237	235	135	122	104	184

(In brackets demand, supply values in 100 M. tons)

Table IIICOST FUNCTION

$C(x)$	$= 18062 - 160x$	when	$0 \leq x \leq 25$
	$= 15287 - 49x$	when	$25 \leq x \leq 45$
	$= 15062 - 49x$	when	$45 \leq x \leq 67$
	$= 5076 - 62x$	when	$95 \leq x \leq 104$
	$= 1332 - 98x$	when	$104 \leq x \leq 118$



Minimum Cost = 10,960 at $x = 95$

Table IV

	Central (28)	Southern (25)	Northern (14)	NWP (22)	NCP (9)	UVA (12)	Sabaragamuwa (20)
Colombo (95)	28	25	0	22	0	0	20
Trincomalee (23)	0	0	14	0	9	0	0
Batticaloa (12)	0	0	0	0	0	12	0

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CONTAINERISATION AND HOW IT AFFECTS

SRI LANKA

BY

H K JAYANETTI
CEYLON SHIPPING CORPORATION

Since its inception Containerisation has revolutionised transportation. It made possible the handling of large uniform containers at each interface without handling the individual packages over and over again, causing damage and pilferage. Containers were introduced to Sri Lanka in early 1970s and since then Sri Lanka has risen to a major traffic area in the region. Due to its efficient and reliable nature Sri Lanka imports & exports as well as the National Shipping Line and the Port of Colombo have immensely benefitted.

1. WHY CONTAINERISATION

There has been only a few aspects of modern transportation that has been given as much prominence as the container. From the day it was first introduced by Malcolm McClean, the container pioneer it was a revolution in transportation.

The world liner trade was increasing both in quantity and complexity resulting in undesirable characteristics for conventional general cargo ships. These included :

- (i) Longer port stays going up to as much as 80% of the total productive time of vessels.
- (ii) Damage to cargo in handling.
- (iii) Pilferage.
- (iv) Cargo lost due to mis-routing, over carriage and inadequate sorting facilities at terminals.
- (v) High cost of insurance.

The advent of the container closed this awkward technological gap that existed in transportation and brought about a new concept

2. CONCEPT OF CONTAINERISATION

Containerisation concept is evolved around the ISO containers which are mainly of two diamentions, the 20ft. and the 40ft container. Other sizes as 10ft. 35 ft. containers are used, but only for exclusive trades or shipping companies and are not universally accepted.

Heterogeneous cargoes are now packed into homogeneous containers and transported by road, rail and sea standardising the handling equipment and speeding up the intermodel transfers. This uniform nature of the cotainers have accelerated the acceptance by all modes of transport and a 'Through Transport Concept' has evolved, which is also known as Multimodal or Combined Transport Concept. Purpose built container carrying ships, rail and road trailers have been developed to serve this industry.

Customarily 'Full Containers' are packed by the shipper at his door-step and transported to the door-step of the buyer possibly passing through many modes of transport. Less than container loads are 'Consolidated' at the port or at 'Inland Container Freight Stations' with cargoes going to the same destinations.

Shipowners have spread their activities by-passing the traditional boundaries and have accepted responsibility for the 'Total Transportation' issuing 'Through Transport or Combined Transport Bills of Lading'.

3. INTRODUCTION OF THE CONTAINER IN SRI LANKA

The first container shipping line to call at Colombo was the American President Lines (APL) in the early 1970s. APL launched a very limited operation to lift containers to the US market using their own land based equipment. The vessels that called at Colombo were fully equipped with on-board gantry cranes to handle containers as shore based ship to shore gantries were not available in Sri Lanka.

Since then the number of container shipping lines calling at Colombo has increased tremendously. The Throughput of containers in the Port of Colombo has increased from 17,680 TEUs in 1979 to 106,155 TEUs in 1982. Present monthly through put is about 9,000 TEU.

The biggest container operation in the Port of Colombo is handled by the Sri Lanka National Shipping Line (Ceylon Shipping Corporation) (CSC). The biggest transshipment operator over Colombo is COBRA (Continent Britain Asia Container Service). CSC, Lloyd Triestino, Blue Star Line, APL & Gold Star Line are the other major transshipment operators via Colombo.

I shall now discuss the impact of Containerisation on the National Shipping Line, Ports, Imports, Exports and industries emerging to serve containerisation.

4. NATIONAL SHIPPING LINE (CSC)

In Sri Lanka CSC was one of the first to realise the potential of Containerisation to CSC as a shipping line and to its customers, the Shippers and Consignees. The principle underlying the dynamic outlook at CSC was that 'unless you make your own services obsolete with introduction of new concepts, somebody else will'.

By beginning of 1980 CSC had eight dry cargo conventional ships. In June 1980 CSC containersied its major route Colombo/Europe by introducing two Time Chartered Geared fully container vessels. Simultaneously CSC launched an ambitious new building project to build nine container vessels in South Korea, Japan and Argentina. Six ships out of the nine are already in operation and three are expected to be completed before end 1981. additionally three time chartered container ships are operated.

By these programmes CSC is able to compete effectively with world's major shipping lines calling at Colombo and provide container services to and from Europe, Middle East and Far East, effectively taking the roll of the Market Leader.

5. PORTS

All Ports in Sri Lanka are grouped under the Sri Lanka Ports Authority (SLPA). SLPA has recognised the trends in Containerisation and has concentrated its containerisation activities in Colombo.

Three distinct stages of infrastructure development and a two fold commercial strategy has emerged from SLPA.

5.1. Infrastructure Development

The first stage consisted of lengthening the Queen Elizabeth Quay (QEY) by 304.8 meters and demolition of the QEY 4 warehouse to make room for containers.

The second stage consist of erecting a Tanco 80 Ship to Shore Gantry Crane at QEY 4 which was leased and erected by SLPA in September 1982 and the erection of two more Liebherr 5115 L gantry cranes purchased at a cost of US\$ 5.8 million. These two cranes will come into operation in June 1983.

The third expansion project is to be carried out with Japanese collaboration. Specially designed for sole use as a Container Terminal this project consist of three phases. The first phase to be completed before and 1985 will have a berth of 300 meters, a depth alongside of 12 meters and a backup area of 97,500 M. Two years thereafter the second phase will be completed with a fur ther Quay length of 300 meters. Another two years later a further 300 meters addition is to be completed giving a total quay length of 900 meters. ACFS and a fleet of full size transtainers for stacking duties is expected to be commissioned.

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These infrastructure developments have certainly encourage the Containers for Sri Lanka Trade. SLPA also has activity sort ways to develop Port of Colombo as a major transshipment port in the South Asia, which is the brainchild of the Hon. Minister of Trade & Shipping Mr. Lalith Athulathmudali.

The accelerated development projects attracted many shipping lines to use Colombo as a transshipment Port for Container traffic and today almost 50% of the Container throughput are transshipment containers.

6.1. Exports

The main export commodities from Sri Lanka consist of Tea, Rubber, Dried Coconuts, Fibre, Garments and Spices. Containerisation has changed the trading pattern of these Commodities considerably. Generally Tea, D/C, Rubber and Spices are mostly sold now on the basis of container loads making use of the advantages of the door to door concept. The general purpose (G.P.) Container is not suitable for carriage of all Sri Lanka exports and now the shipping lines have an assortment of different type of containers.

Whilst Tea, D/C, Garments and Fibre move in GP Containers, Smooth Sided Containers are provided for Sheet Rubber, Spices go in Special Ventilated containers while fresh coconuts are shipped in Open Top Containers. Frozen Seafoods and fruit juices are exported in Refrigerated containers. Another facility afforded by containerisation is the possibility of shipping containers with optional destinations. The port of discharge can be advised by the Consignee or by the Shipper at a later stage once the goods are sold to the final consumer.

Tea Trade has gone a step further and ship tea for off-shore Auctions in London. The auctions are held whilst the tea is still on the ship and the final buyer is able to declare the option after the purchase.

Packing of cargoes have also been effected by Containerisation. Traditional Full Chest for tea has changed from '20' x 20" x 24" to 16" x 20" x 24" (40 cm x 50 cm x 60cm) to accommodate 200 full chests on 10 pallets into a 20' container. Damages due to weak packing in conventional days have also been eliminated as the stress on packing has been reduced. Pilferage has also reduced and specially the garments trade have immensely benefitted.

Due to fast transit times, reliable schedules and safety to cargo, Sri Lanka exports can now effectively compete in the world markets having an edge over the other producing countries.

6.2 Imports

With the liberalisation of imports the volume and the complexity of imports have dramatically increased. Containerisation has helped imports by reducing congestion, damage and pilferage providing the consumer with cheaper products.

The movement of construction equipment and material for the large number of development projects in Sri Lanka has immensely benefitted by the container. Timely arrival and delivery of material unpacking of the containers at the work site completely avoiding loss and damage are few of the far reaching benefits.

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Containerisation brings with it a host of other requirements these include -

- Container depots - to store empty containers on behalf of Shipping Lines and Container Leasing Companies
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THE ROLE OF CONTAINER FREIGHT STATIONS IN SRI LANKA'S
IMPORT - EXPORT TRADE

by

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P.O. Box 2200, Colombo.

The introduction of multimodal transport based on the door-to-door transport of containers require an appropriate physical infrastructure not only for the inland carriage of containers but for the handling and positioning of containers at inland points. Inland Container Depots and Container Freight Stations promote the concept of multimodal transport as consignments can remain unbroken from a place close to the consignor to a place close to the consignee. Apart from changing the concept of transport, both in physical and organisational terms, inland container depots or distribution centres have a beneficial effect on the trading and industrial activities of a country or region.

1. INTRODUCTION

The past decades have been characterized by important structural changes in general cargo shipping, which included technological as well as organizational changes. In an attempt to cut down the costs of maritime transport -- mainly by reducing transport handling costs and ship's time in port and by realizing economies of scale -- unitization, especially containerization, was introduced in international shipping in the late 1960s. After having been confined for a time to the trades among developed countries, which are characterized by relatively large cargo volumes and balanced trade flows, these new methods of shipment were also introduced in developing countries' trades.

The main reason for the introduction of container transport can be seen in the increasing cost of labour in developed countries. The need to increase productivity of labour called for capital intensive transport systems in which quantitative labour inputs were minimized. These technological changes not only brought about a process of capital/labour situations, but also increased the efficiency and speed of transport, mainly by speeding up handling operations in port through greatly reduced packing requirements and handling processes at all transfer points.

In international trades the new transport technology can be employed at its best if the transport units (containers) remain unbroken for as long as possible and, most important, if they are carried under multi-modal transport arrangements. These two conditions have far reaching implications for the physical infrastructure needed as well as for the administrative and political framework within which the operators are acting.

At present, container carried in the seaborne foreign trades of developing countries do not in most cases move beyond the port boundaries into the country. This is largely due to inadequate inland transport infrastructure, but partly also administrative shortcomings, especially with regard to customer procedures, which have not yet been adapted of the needs of container through-transport.

2. THE ROLE OF CONTAINER DEPOTS

As stated above, the introduction of multi-modal transport based on the door-to-door transport of containers require an appropriate physical infrastructure not only for the inland carriage of containers but also for the handling and positioning of containers at inland points. The volume of infrastructure investment necessary for the inland carriage itself cannot be generally established, since it depends on the state and degree of capacity utilization of existing road, rail and inland waterway connections. However, the physical requirements and resulting costs of investment for container depots can to a large extent be generalized and, most important, costs and benefits are directly attributable to containers.

Inland container depots (ICD) promote the concept of multi-modal transport as consignments can remain unbroken from a place close to the consignor to a place close to the consignee. An ICD can perform all or a combination of the following major functions and many more auxiliary functions:

- customs clearance of containers;
- transfer of containers between various modes;
- temporary storage of containers and cargoes;
- stuffing and stripping of containers;
- consolidation of LCL cargoes;
- positioning of containers;
- maintenance and repair of containers.

A Container Freight Station (CFS) can be distinguished from an ICD, in that, the functions of a CFS are mainly confined to stuffing and stripping containers. Therefore an ICD connotes a wider range of activities as noted above, including the functions of a CFS.

Apart from changing the concept of transport, both in physical and organizational terms, inland container depots or distribution centres have a beneficial effect on the trading and industrial activities of a country or region. Trading activities will be promoted firstly by offering improved LCL facilities, but also because participation in trade of intermediaries previously engaged in local trade and transport will be facilitated.

The establishment of ICD's or CFS's will enhance the attractiveness of a region for industrial settlements. This attractiveness is based not only on the functions directly performed within the

ICD, but to a large extent on the infrastructure surrounding the depot, such as transport infrastructure, communications networks, public utilities etc.

Although inland container depots create employment possibilities, in certain cases they also give rise to immediate employment problems. One such problem is that part of the work formerly performed in the port is removed from the port premises, which means relocation of labour. The employment problem, however, appears to be temporary and should be balanced against employment advantages gained, including the possibility for government to pursue an active policy of regional equilibrium in economic and social development and, consequently, in employment opportunities.

2.1 The development of ICD/CFS activities in Sri Lanka

The Ministry of Trade and Shipping promoted the development of ICD/CFS along with its plan for developing the port of Colombo and converting the Ceylon Shipping Corporation from an operator of Conventional tonnage to a fully-fledged container vessel operator. Although it was initially envisaged that foreign collaboration would be needed for this purpose, the local interest confirmed that the necessary investment and exercise could be found from within.

There are at present 14 ICD/CFS which have received operating approval from the Ministry of Trade and Shipping. Among these it could be said that at least three offer sufficient facilities to be categorised as ICD's. The names and addresses of the existing CFS operators are given in annexure A.

Since the services offered by the different operators tend to vary significantly, it is difficult to speak in general terms about the services offered by these organisations. It is necessary therefore select an operator at the top rung of the ladder (operator X) and an operator providing only basic services (operator Y) in order to highlight the contrast in the level of services provided.

Operator X could provide the following services to Shipping Lines and Shippers/Consignees :

Shipping Lines - Export Containers : Receiving empty containers at stuffing bay terminal, checking container condition and cleanliness, loading with cargo (FCL or LCL lots), securing and dunnaging as necessary, tallying, obtaining customs seal and finally transporting loaded container to port stack.

Shipping Lines - Import Containers :- Receiving the import container from port laden stack, transporting to the terminal, destuffing container after Customs inspection at warehouse/ destuffing bay using folk lifts if required and issuing tally, cargo condition certificates on damaged cargo if necessary. Also cleaning and sweeping of containers and issuing estimate of damages on damaged containers, storing them at the damaged stacks until repair approval is obtained from Principals.

Shippers :- Receiving cargo break bulk, warehousing if necessary (variable period allowed), unitising/palletising (pallet/skids usually supplied by shipper), stuffing into container, securing cargo, providing container condition certificates, transporting container to shipping line stack in port.

Consignees :- Receiving the import container from the port laden stack, transporting same to the terminal, destuffing of same at warehouse/unloading bay using forklift if required and issuing cargo condition certificates on damaged cargo if necessary.

As opposed to the services that Operator X could offer, Operator Y can provide only the following facilities: Stuffing, tallying and customs examination of export containers; transport to the wharf of the laden containers; transport of empty containers from port/depot, washing and drying containers and storage of containers.

Since the operation of ICD/CFS in Sri Lanka are not strictly regulated, the operators are able to formulate their own tariffs. There is now a healthy level of competition among the different operators that have accrued to the benefit of the users of ICD/CFS services.

2.2 Planning Container Depots

The fundamental issue in determining the location of depot is whether to establish the depot with its basic functions inside or outside the port area. While infrastructural deficiencies may require the location of a depot inside the port area, the realization of a door-to-door service or any other service approaching this ideal will necessitate the construction of inland container depots.

The introduction of inland container depots has far reaching implications for infrastructure requirements and transport organization. It relieves the port of storage problems but at the same

time, requires a certain minimum standard of road or rail connection between the port and the depot. Unless ICD's are built, transport of cargo to and from the port will take place through a one-leg distribution system which has the disadvantage of suboptimum use of inland transport vehicles, increased strain on the road network, and reduced possibilities of realizing economies of scale.

Apart from alleviating overloading of handling facilities within the terminal, two additional major reasons can be identified for locating CFS or container depots outside the port area in respect of local cargoes as well. Firstly, they can act as buffers between manufacturers' premises and terminals or between terminals and cargo destinations; secondly, they can fill the need for personal services, which a large terminal cannot accommodate because of its prime need to serve the requirements of the ship rather than those of the shipper.

The most basic planning criteria in determining the location of a ICD/CFS are the following:

- easy access to overland road and rail connections;
- integration with the regional or community road network for final distribution or collection of cargo;
- availability of sufficient land for the inland container depot, not only to the extent needed for initial construction, but also for possible future extensions;
- adequate soil quality, in order to avoid expensive underground reinforcement to reach sufficient bearing capacity;
- availability of, or easy access to, public utilities, mainly electricity, water and sewage;
- proximity to living quarters and social institutions to attract employees and avoid excessive commuting costs;
- easy connection with existing or planned industrial areas;
- possible alternative uses of the chosen location.

In surveying the location of CFS's in and around Colombo it cannot be said that adequate planning has been done in determining the most suitable location in many cases. Two CFS' are located at Mattakkuliya using the narrow and busy Centre Road as the access road. The access road runs through a heavily populated area making

prompted the Sri Lanka Trade Facilitation Committee (SRILPRO) to form a Sub-Committee on Container Documentation and Procedures to look into such problems.

One of the initial tasks of the Sub-Committee was to persuade CTS operators to form an association in order that many of the documentation/procedures adopted presently on an individual basis, could be implemented in an uniform manner.

The Committee consists of representatives from the CTS Operators' Association, the Ceylon Association of Steamer Agents, the Sri Lanka Shippers' Council, the Sri Lanka Ports Authority, the Sri Lanka Customs, the Sri Lanka Freight Forwarders' Association, the Export Development Board and the Central Freight Bureau of Sri Lanka.

***** " ***** " *****

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- * International multimodal transport operations and their implications for the customs administrations of developing countries, UNCTAD DOC. TD/B/AC.15/16.
- * Port Development -- a handbook for planners in developing Countries, UNCTAD DOC. TD/B/C.4/175 and Corr.1.
- * "An evaluation of the development of inland container depots and container freight stations in Sri Lanka" Central Freight Bureau of Sri Lanka, monthly Newsletter, No. 109 (Nov. 1982).

ANNEXURE A

CONTAINER FREIGHT STATIONS

1. Aitken Spence & Co., Ltd. 170, Sri Wickrema Mawatha,
Colombo 15.
2. East-West Enterprises Ltd. P.O.Box 678, Colombo.
346/3, Dutugemunu Mawatha,
Peliyagoda, Kelaniya.
3. McLarens Services, 123, Baudhaloka Mawatha,
776, Negombo Road, Matumagala. Colombo 4.
4. Bartleet Freighters Ltd., 262-264, Nadarajah Building,
651, Bloemendhal Road, Colombo 3.
Colombo 13.
5. Cargo Boat Despatch Co. Ltd. P.O.Box 178, Colombo 1.
(a) 97/1, Negombo Road,
Peliyagoda.
(b) 15, Braybrooke Place,
Colombo 2.
6. Ceylon Shipping Lines Ltd., P.O.Box 891, Colombo.
Urugodawatte.
7. Maritime Agencies Ltd. P.O.Box 765, Colombo 10.
54, Centre Road, Matakuliya.
8. Majullah Agencies Ltd., 69/1, Janadipathi Mawatha,
234, Bloemendhal Road, Colombo 1.
Colombo 15.
9. Anglo Asian Co., Ltd. P.O.Box 1034, Colombo.
10. Ceylon Containers Ltd., 101, Kew Road, Colombo 2.
(a) 210, Siri Dhamma Mawatha,
(b) 110, Dematagoda Place,
Colombo 10.
11. Asha Agencies Ltd., 72, Bullers Road, Colombo 4.
90, Canal Road, Hendala.
12. Ceyhas Ltd., P.O.Box 1857, Colombo.
104, Nawala Road,
Narahenpita, Colombo 5.
13. Trico Maritime, 351/3, R.A. de Mel Mawatha,
414/18, Bloemendhal Road, Colombo 3.
Colombo 13.
14. Tainerport (Pte) Ltd., 61, Sir Earnest de Silva
97, Negombo Road, Mawatha, Colombo 7.
Mahawatta, Peliyagoda.

transport of container along this stretch of road a hazard to both persons and property. Lately however, the necessity in obtaining planning permission from the Urban Development Authority (UDA) has made it virtually necessary to locate CFS' either at the outskirts of the City of Colombo or further inland. From the point to the above criteria it could be said that some of the CFS' located in the Wattala-Mollisara Area bordering the Negombo road and within relatively close proximity to the Katunayake IPZ are ideally situated.

A brief survey conducted by the writer to determine the extent of CFS facilities confirms that the present provision in terms of land utilization (subject to possible relocation of some existing CFS') is sufficient to cater to the growth of containerisation in Sri Lanka at least for the next 4 - 5 years. Since it is also necessary that existing investors in CFS facilities obtain an inadequate return on investment in order to improve their facilities, it is suggested that the Ministry of Trade and Shipping does not grant any new approvals for ICD/CFS until a proper study is undertaken to assess the future transport requirements of Sri Lanka's import-export trade. If not, one could see the mushrooming of dubious CFS' with only very basic mechanical equipment and other facilities which could offer unhealthy competition to existing operators.

3. THE CFS AND THE PORT

In most developing countries, where containerisation is still at an early stage and where individual consignments tend to be rather small, LCL containers constitute a considerable share in total container movements. In order to avoid undue strain on the stacking area and the CFS in the port, it is necessary that FCL shipments can, to the largest extent possible, also be shipped through inland terminals. While this generally creates no problem with regard to the physical movement of containers, in many cases organisational problems may arise because the customs procedure necessary for the through transport of LCL containers may not have been worked out.

The position in Sri Lanka, at least for export containers has moved beyond the situation noted above. Most exporters' now tend to sell on the basis of container loads and this has greatly increased the volume of FCL containers. Whilst many of the bigger exporters tend to load containers at their own stores/warehouses a number

of others utilize CFS facilities. A growing proportion of LCL containers are also now stuffed at CFS', particularly in the case of shipments on CSC vessels, which almost exclusively use the facilities offered at the CFS operated by their subsidiary the Ceylon Shipping Lines (CSL) at Orugodawatte.

Even the Sri Lanka Ports Authority (SLPA) will acknowledge that if not for the storage space offered at inland points, the port of Colombo would have faced very serious problems due to lack of stacking space within the port. The inland depots allow the port to proceed with its plans to promote Colombo as a transshipment centre pending the completion of the port development programme which would include ample stacking area behind the new container terminal. However, if the present growth rate for transshipment cargo is maintained, it would still be necessary to divert much of the import/export containers to inland points since the expanded stacking area would be taken up by transshipment containers. Therefore, the strengthening of IDC/CFS facilities must be treated as a parallel movement to port development.

In order to improve Sri Lanka's hinterland container facilities it is suggested that further flexibility be adopted in allowing import containers to move directly from under the vessel's hook to inland depots without intermediate stacking in the port. This will not only make more space available for stacking of export/transshipment cargo but will reduce pressure on the SLPA's container handling equipment.

This proposal is unlikely to cause any difficulty to the Customs Authorities who have already stationed their officers at a number of container freight stations. The addition of banking facilities at these points would enable importers to make their payments at the IDC/CFS. It is possible for the SLPA to come to an arrangement with the Customs to collect SLPA charges. If the SLPA feels that some supervision is necessary they could station a member of their staff at the CFS. Furthermore, the SLPA could place the onus on the CFS operator to collect and remit the charges.

4. CO-ORDINATING CFS ACTIVITIES

The growing involvement of container freight stations in the export process has brought in its wake a number of problems. This is mainly due to each CFS adopting its own procedures and requirements. This and other connected matters in relation to containerisation

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COASTAL SHIPPING SERVICE FOR SRI LANKA

NEEDS & PROSPECTS

by

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COASTAL SHIPPING SERVICE FOR SRI LANKA -NEEDS & PROSPECTS

The Coastal Shipping Service in Sri Lanka was inaugurated possibly by chance because when the Food Commissioner commenced the production at the Prima Flour factory in Trincomalee, thought that they would not be in a position to provide for all transportation needs of the production output in the factory with the modes of road and railway.

The Ceylon Shipping Lines Ltd., who were requested by the Ministry of Trade & Shipping to operate the Coastal Shipping Service barely had two months notice to initiate, plan and inaugurate the service.

6th of November 1980 on which day the Coastal Shipping Service was inaugurated might not be the first time Sri Lanka initiated Coastal Shipping Service around its ports.

There is evidence that a regular Coastal Shipping Service has existed as far back as the dawn of this century where not only goods but passengers too travelled regularly from several points of the coast of Sri Lanka. The service was run by Ceylon Steam Ship Company Ltd., with the Managing Agents being Walker & Sons Ltd., and two vessels operated in this service which were named, "Lady Macallum" and "Lady Blake." The vessels called at Galle, Hambantota, Batticaloa, Trincomalee, Point Pedro, Jaffna and Paumban.

Inaugurating and operating a Coastal Shipping Service in modern times was difficult. The main factors contributing were,

1. The physical distribution system in Sri Lanka is not designed to accommodate Coastal Shipping. For example all warehouses, distribution centres etc are either alongside roads or railway, but never alongside a port. This would entail that cargo which is discharged from a coastal ship would once again have to be carried by road transport in order to be stored which would mean double handling, additional transportation cost etc resulting in additional expenditure and damages to consignments.

2. The thinking of all organisations which engage in transportation is geared towards road most of the time and railway in rare instances. To impress upon them that Coastal Shipping is also cheaper, efficient alternative is a difficult exercise.

3. Initially the cost of transportation through Coastal Shipping became rather expensive since, (a) The Sri Lanka Ports Authority treated

Coastal Shipping as a deep sea service and levied the same charges applicable to deep sea service. Naturally, the Coastal Shipping Service was not able to bear such high port and stevedoring cost.

(b) Due to lack of infrastructure designed to cater the Coastal Shipping, additional transportation etc has to be undertaken resulting in extra expenditure.

After long drawn out battles with various authorities, Coastal Shipping Service has been successful and getting differential pricing from the Sri Lanka Ports Authority under a Ministry of Trade & Shipping directive which has made a big difference in cost of transportation by Coastal vessels. At the moment the Sri Lanka Ports Authority gives 65% discount on rates applicable for stevedoring and has waived off many other port charges for Coastal vessels.

An exercise was carried out to compare the real cost of transportation by Coastal vessels as opposed to road haulage in order to determine the viability of a Coastal Shipping Service. Following are the assumptions used in this study.

Assumptions:

1) Cargo movement possible by sea from Trincomalee per month is as follows:

10,000 tons to Colombo

5,000 tons to KKS

3,000 tons to Galle

The comparison therefore is done according to this quantity of movement. Naturally there will be a large balance out of the total production of Prisha Mills which still have to be moved by road and railway.

- 2) If the above quantities are carried by the road, it travels the following distances:

Trincomalee/Colombo 160 miles

Trincomalee/KKS 170 miles

Trincomalee/Galle 242 miles

Although the cargo effectively will be moved to various other destinations, it is felt that the distances will average out to these levels.

- 3) The road haulage units used are of 7 tons capacity.

- 4) The fuel consumption of a road haulage unit is approximately 15 miles for a gallon of diesel.

- 5) The desired cost of maintaining A class roads is Rs. 15,200 per mile per year (the marginal or incremental cost of maintenance is not known and available).

- 6) The present traffic flow per day on the A6, A12 roads, which are the only main approaches to Trincomalee are as follows:

A 6 Habarana/Trincomalee 200 vehicles per day

Anuradhapura/Trincomalee 200 vehicles per day

- 7) Cost of environmental damage, congestion on roads and accidents caused by road vehicles is assumed at Rs. 5/- a ton-mile.

- 8) Contract rates paid by the Food Department for transporters are as follows:

Trincomalee/Colombo Rs. 1/60 per ton per mile

Trincomalee/Galle Rs. 1/60 per ton per mile

Trincomalee/KKS Rs. 1/40 per ton per mile

However, it is a well known fact that the actual market rates of transport for an average consumer is around Rs. 2/- per mile.

9) The natural availability of lorries (i.e. lorries which carry cargo to Trincomalee or surrounding areas and which fall free to lift cargo from Prima) is estimated to be not more than 20 units a day. The balance demand has to be supplied by lorries positioned in Trincomalee after a long empty run. Those lorries which will move empty for less than 100 miles to Trincomalee is also estimated to be around a 30 units per day.

This 50 lorries could carry only 350 tons a day, which is about the same as the original estimated liftings by road.

Therefore, if the 18,000 tons are to be carried by road it is expected that the lorries will return empty, the full distance.

COMPARISON OF CAPITAL COSTS

Cost of a lorry = Rs. 250,000 = US\$ 13,888

No. of lorries required a day = 85.7

Assuming a turn-round time in excess of 24 hrs for
50% of lorries,

Total no of lorries fully employed = 128.6

Assuming a life period of 5 years per lorry,

No. of lorries required for 20 years = 514.4

Therefore the total cost at today's price - US\$ 7,143,987.2

Assuming the cost of a vessel to be US\$ 1,500,00

Cost of four vessels required for operation = US\$ 6,000,000

difference = US\$ 1,143,987

difference per ton = Rs. 4.78

add cost of capital @ 25% = Rs. 1.19

Therefore total capital cost difference = Rs. 5.97

P.S.

The price of road haulage vehicle is assumed to be
static over a period of 20 years and discounting
method has not been used.

TRINCOMALEE/KKS MOVEMENT

* 5,000 Tons to KKS per month.

* 714.29 Trips per month.

* 23.81 Trips per day

Traffic will increase to 247.61 vehicles per day.

Increase = 23.8%

Additional cost to maintain roads

per mile per year (15,200 x 23.8%) = Rs. 3,617.60

Additional cost to maintain 170 miles

of road per year = Rs. 614,992.00

Road maintenance cost allocated per ton

(5,000 tons per month) = Rs. 10.25

Additional cost of environmental damage/congestion

on roads @ 5 cts. per ton mile for 170 miles = Rs. 17.00

Total fuel consumption by road = 16,190.57 gls. = 62.27M/T

Total fuel consumption by sea = 18.77M/T

Difference = 46.50M/T

Opportunity cost of addl. fuel consumption

@ US\$ 390 per ton = Rs. 4,105.00

Cost per ton = Rs. 83.42

Additional cost of capital per ton

= Rs. 5.97

Visible cost of carrying cargo from Trincomalee/KKS = Rs. 238.00

(170 miles @ 1.40 a ton mile)

Additional handling costs

= Rs. 15.00

Therefore the total cost of transportation by Road = Rs. 369.64

The total cost of transportation by Sea = Rs. 264.92

TRINCOMALEE/GALLE MOVEMENT

* 3,000 Tons to Galle per month

* 428.57 Trips per month.

* 14.28 Trips per day.

Traffic will increase to 228.57 vehicles per day.

Increase = 14.28%

Additional cost of maintaining roads

per mile per year (15,200 x 14.28%) = Rs. 2,170.56

Additional cost to maintain 242 miles

of road per year = Rs. 525,275.52

Road maintenance cost allocated per ton

(3,000 tons per month) = Rs. 14.59

Additional cost of environmental damage/congestion

on roads @ 5 cts. per ton mile for 242 miles = Rs. 24.20

Total fuel consumption by road = 13,828.53 gls = 53.19M/T

Total fuel consumption by sea = 16.37M/T

Difference = 36.82M/T

Opportunity cost of addl. fuel consumption

@ US\$ 390 per ton = Rs. 330,275.40

Therefore cost per ton of addl. fuel consumption = Rs. 110.09

Additional cost of capital per ton

= Rs. 5.97

Viable cost of carrying cargo to Galle

(242 miles @ Rs. 1.60 a ton mile) = Rs. 387.20

Additional handling costs

= Rs. 15.00

Therefore the total cost of transportation by Road = Rs. 557.05

The total cost of transportation by Sea = Rs. 361.26

TRINCOMALEE/COLOMBO MOVEMENT

* 10,000 Tons per month.

* 1,428.57 Trips per month.

* 47.61 Trips per day.

Traffic will increase to 295.23 vehicles per day.

Increase = 47.61%

Additional cost to maintain roads
per mile per year (15,200 x 47.61%) = Rs. 7,236,72

Additional cost to maintain 160 miles
of road per year = Rs. 1,158,094.40

Road maintenance cost allocated per ton
(10,000 tons per month) =Rs. 9.65

Additional cost of environmental damage/congestion
on roads @ 5 cts. per ton mile for 160 miles =Rs. 16.00

Total fuel consumption by road = 30,476.16 gls = 117.22M/T

Total fuel consumption by sea = 79.55M/T

Difference = 37.66M/T

Opportunity cost of addl. fuel consumption
@ US\$ 390 per ton = Rs. 337,810.20

Therefore cost per ton of addl. fuel consumption =Rs. 33.78

Additional cost of capital per ton =Rs. 5.97

Visible cost of carrying cargo to Trincomalee
(160 miles @ 1.60 a ton mile) =Rs. 256.00

Additional handling costs =Rs. 15.00

Total cost of transportation by Road =Rs. 336.40

The cost of transportation by Sea =Rs. 348.08

There are additional benefits of transportation by Coastal vessels.

1. Security - Coastal Shipping Service can act as an additional means of transport as and when road and railways are blocked or damaged due to various reasons like cyclones, floods or riots.

This service also serves as a "Coast-Guard" around the Sri Lankan waters. Saving the lives of six fishermen who were in distress, in 1981, magnifies this.

2. Saving in fuel:- It has been found that with a gallon of gasoline one ton can be moved for 40 miles by road and one ton can be moved for 75 miles on the railway. The comparative figure in Coastal Shipping is one ton for 125 miles with a gallon of gasoline. Therefore coastal shipping proves to be the answer to the future generations when oil is going to be scarce and expensive.

Furthermore, when the fuel prices are increased the comparative cost increase of transportation would be least on coastal shipping. Therefore if goods are moved more via coastal ships this would help stabilise the cost of living, in general, for Sri Lanka.

3. Road maintenance:- Daily, Sri Lanka government is spending large sums of money on construction and maintenance of roads. By diverting more and more cargo to coastal vessels, tremendous savings can be made on road maintenance which is now calculated at about Rs. 15,200/- per mile per year for a 'A' class road. It has to be remembered that a coastal ship carries a load that is normally carried by 100-200 lorries. Coastal ships travel in the high sea which needs no maintenance.

4. Environmental protection:- There is a tremendous awareness in the world today of the damages caused to the environment by thousands of vehicles on roads. The excessive of carbon-dioxide and carbon-monoxide upsets the ecological balance, leave alone the lead fumes which causes cancer and death. Coastal shipping helps to at least reduce the danger, if not eliminate it.

5. Congestions:- Today Sri Lanka is facing a tremendous problem with road congestion which definitely will grow to be a major nuisance in the future as it has happened in many developed countries. The coastal shipping will help a great deal in avoiding road congestions.

The future

It is imperative that coastal shipping should play an important role in the transportation sector of Sri Lanka in the future years.

For coastal shipping to foster, it is necessary for the government policy makers to decide in encouraging coastal shipping and also to give every assistance possible to induce cargo to be carried on coastal vessels. It is on record that during the British colonial times, the then Ceylon Government paid a subsidy annually of £ 5750/- to operate Coastal Shipping Service vessels, and a further sum of £ 5750/- by way of compensation for the Port and Harbour dues payable by the coastal vessels.

Today with the present differential pricing on port charges, the Coastal Shipping Service can operate viably in competition with road and railway modes. Perhaps the State should consider subsidising organisations which are responsible for large transportation movements, like the Fertilizer Corporation, Cement Corporation, Salt Corporation etc to build up infrastructure facilities to undertake transportation by coastal vessels. Examples can be like warehousing complexes adjoining coastal shipping terminals.

The Defence Ministry also may consider the possibility of using coastal vessels which possess useful instrumentation like radar and high frequency radio communications for patrolling the territorial waters of Sri Lanka.

With the expansion of trade and industry in the next decade in Sri Lanka, the transportation planners seems to have no option other than to develop coastal shipping within Sri Lanka.

THE NEED FOR PROFESSIONALISM
IN THE MARKETING OF SHIPPING & TRANSPORT SERVICES

by

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"The success of any business requires a variety of skills; skills in finance, production, buying and retailing, together with skill in human relations and in many other fields. But the basis for success of any business undertaking is its ability to "sell" the product or service it provides. Unless this ability is present, there will be no business to be organised.

PROFESSIONAL APPROACH TO MARKETING

- 1.1 In his book 'Dynamic Business Management', Harold Norcross F.B.I.M. - Management Consultant and Visiting Lecturer, University of Birmingham and Cambridge University, had the following to say:
- 1.2 The success of any business requires a variety of skills; skills in finance, production, buying and retailing, together with skill in human relations and in many other fields. But the basis for success of any business undertaking is its ability to "sell" the product or service it provides. Unless this ability is present, there will be no business to be organised.
- 1.3 This is because things are very different today. Competition is more severe and profit margins much smaller. Certainly the firm which today launched a new product or service, without adequate knowledge and research of the potential market, and without having sensible plans for penetrating that market, would be asking for trouble and would probably get it.
- 1.4 Professional Marketing methods offer an exciting future to those companies, who have the energy and vision to exploit them, and for the others the outlook may be very dismal indeed. Too many of us 'face the past and back into the future'. If we turned round, we might see that we are going down the wrong path. For this reason, a broad appreciation of the rather extensive and specialised subject of marketing is a logical foundation on which to build a system of management control".
- 1.5 Sadly, there appears to be a lack of understanding, appreciation and skill in marketing management, vis-a-vis the Sri Lankan Transportation Community except perhaps in the Airline Sector. This handicap needs to be corrected early, if we are to build a healthy transport industry. Organisations who lost money or failed to gain

their estimated market shares in recent years, may well find the answers on examining the marketing policy adopted by them.

- 1.6 The marketing policy pursued by any Transport Operator has a profound influence on the overall annual results of that company.

MANAGEMENT BY OBJECTIVES

- 2.1 The old English saying tells us "The impossible we do immediately, but miracles take a little planning".
- 2.2 Successful Management is not achieved haphazardly, it is characterised by the development and application of an analytical approach to the process of decision making. From this sound base the deployment of resources can be effectively organised and a corporate strategy evolved. Analysis, planning and control are vital, therefore, to achieve the objectives of an organisation, irrespective of whether it is a profit oriented commercial company, marketing consumer products or a public services utility etc. Organisations of all kinds require the skills of professional management in general, and marketing management in particular.
- 2.3 In the specialised activities related to the marketing of goods and services the disciplined techniques of modern management are particularly relevant. To survive against world competition Transport organisations must become increasingly aware of the need to closely define their trading objectives and to relate their resources to the developing needs of their markets.
- 2.4 Planning is essential to modern Transport Management in that it maximises profitability over the long term and permits management to harness the resources of the business in the most effective way possible in the pursuit of its chosen objectives.

- 2.5 The basic purpose of planning in our industry, as elsewhere, is to identify commercial opportunity and to exploit them by providing the necessary resources in the right place at the right time. Misjudgement of the market place is one of the greatest threats to profits and growth; and the ability to adapt capacities to changing demand is a requirement ranking high in the planning process.
- 2.6 An increasing number of Transport Organisations are now operating within the context of a company business plan which forms the basis of a strict system of budgetary control. It sets out the aims of the company for a period of five or ten years depending on the nature of the business.

THE SALE OF TRANSPORT

- 3.1 Being a "service" industry transport cannot have selling points that appeal towards desire for possession, like in the case of a commodity. For example a commodity like soap may sell because it pleases certain senses such as its fragrance (smell), velvety surface (touch), colour, shape etc. The soap Salesman can work on the desire for possession partially created by the product itself, but transport is "intangible" and selling must be based on its value as a service to the potential user.
- 3.2 Upto a point transport would sell itself without much effort; where the purchaser requires a service out of necessity or self generated desire to move his goods or himself. The organised marketing of transport arises mainly when supply exceeds demand. The principal factors contributing to the effective sale of transport are:
- (1) Adequate representation by qualified staff
 - (2) Good and sufficient publicity
 - (3) Maintenance of good public relations.

REPRESENTATION

- 4.1 Owing to its special features of operation and use, it would be more appropriate to identify a transport sales person as a Transport Sales Representative rather than a transport salesman. This is due to the Representative's work not being the same as that of a commodity salesman. The commodity Salesman usually aims at selling a product the "knowledge of which can be gained in the factory or at a "briefing" Conference with the Sales Manager. And whenever this Salesman travels throughout his territory, his product remains the same and his "sales story" does not vary from place to place or from one customer to another.
- 4.2 In selling a transport service one must be able to satisfy a variety of demands within a particular sphere of operation. Deferring demands may however arise at each point of contact in a Representative's area. A major responsibility of the Transport Sales Representative is that he has to promote Goodwill and provide After Sales service as opposed to the ordinary salesman. If we take the case of a machine salesman (selling a non consumable product) he is not directly concerned with its maintenance after sale. This is carried out by a separate Technical or Service Department which has no direct interest in selling. In this instance, both Departments have to combine and maintain Goodwill between the selling firm and the customer. Goodwill between the transport provider and its customers is more closely allied to the provision of transport services. It is the Representative's job to maintain Goodwill by dealing with complaints and suggestions- perhaps at the same time he calls to solicit business.

PUBLICITY AND PUBLIC RELATIONS

- 5.1 "Creation" or regulation of demand are important features in the sale of transport. This is possible by employing good publicity. However, when demand is "natural" it may be necessary to regulate demand. A created demand may also require adjustments from time to time.

- 5.2 In modern commercial practice "publicity" is simply defined as a scientific means of communicating facts for a persuasive purpose. Publicity can take two forms i.e. direct or indirect. Examples of direct publicity are television, newspapers, posters etc. Indirect publicity is defined as a method of propaganda not easily recognisable by the persons it is designed to influence.
- 5.3 Generally the control of direct publicity may be the responsibility of an Advertising Manager or a Commercial Officer etc. Indirect publicity may fall within the scope of the Secretaries or Administration Department. However, if the work load is heavy a Public Relations Officer should be appointed, to liase as the sole contact with the press and the public. Typical examples of indirect publicity are: to provide information about your undertaking, arrange visits by interested persons, make official policy statements, explanations, contradictions etc.

TRAFFIC ADVERTISEMENTS

- 6.1 The form of publicity closely concerned with the traffic/operations and marketing departments is known as traffic advertising. Generally speaking advertising to ones own account is known as traffic advertising and third party advertising is referred as commercial advertising. Examples of traffic advertising are: use of distinctive tokens or name plate, on buildings, vehicles, containers, ship funnels etc. Also literature and traffic signs used on or away from premises. Other examples are time tables, sailing schedules, posters and brochures etc. Broadly the work of the traffic advertising department is defined into (A) production and (B) distribution. Production of advertising must be usually initiated by the marketing and or traffic department which conveys its requirements to the advertising department for the purpose of creating traffic or travel (new routes/services etc.) or to attract traffic to a planned special service etc.

6.2 When traffic has been created it must be sustained by suitable methods adopted by the Advertising Department in coordination with the Traffic Department, as required. The success of traffic advertising depends on the quality of the substance or material produced, to arouse interest and persuade prospective users to gain advantage of the service or facility offered. The manner in which distribution is made to reach potential customers is vital in order to achieve positive results.

MARKETING POLICY AND ESSENTIALS OF MARKETING

7.1 Marketing came into prominence as a profession by itself during the last three of four decades. Whether the need is to market a consumer product, or a service as in transport or shipping, the principles which have to be followed are the same. Before I close it is perhaps prudent to consider these aspects which are shown in annexure I to III. They are:-

- 1) Marketing policy
- 2) Main trends influencing the marketing of goods and services
- 3) Essentials of marketing
- 4) Important tools of marketing
- 5) Goal setting
- 6) Product knowledge
- 7) Quality of the sales force
- 8) Dynamic salesmanship.

7.2 Therefore it is little wonder that the professional approach to marketing is paramount, if a transport organization engaged in road, rail, sea or air, transportation wishes to survive and make profits in a world of fierce competition. We read often in several international transport and shipping journals how some companies who were nearly in the red transformed their fortunes to make profits by employing aggressive marketing methods. Companies who lost money and failed to get their expected market shares would undoubtedly find the answer if they examine whether they adopted a proper marketing policy at all. Those who disregard the importance of marketing would undoubtedly perish, whilst the ^{competitors} ~~others~~ steal a march on them.

MARKETING POLICY

- (1) Have a suitable mental approach in a world of constant economic change.
- (2) Recognise that a clear marketing policy is essential.
- (3) Has far reaching effects on production, services, finance, personnel recruitment, training etc.
- (4) Must come from Top Management i.e. Managing Director in consultation with Marketing Director and the Board.
- (5) Ensure the policy serves the interests of the company best.
- (6) A Budget for Marketing costs must be laid down.
- (7) Proper judgement of the size and nature of Market.
 - a) Amount of prevalent and expected competition.
 - b) The practical pace to increase production capacity.
 - c) The tempo on the assault of the market.
 - d) Choice of advertising media.
 - e) Pattern of distribution and selection of outlets.
 - f) Siting and composition of the Sales force.

MAIN TRENDS

INFLUENCING THE MARKETING OF GOODS AND SERVICES

Effect of Government action

Technical changes

Rising productivity and distribution of purchasing power

Speed of movement and speed of communication

ESSENTIALS OF MARKETING

The size of the market in which it operates.

The Actual share of the market-which it is getting, and the proportions going to its Main competitors.

Ascertain whether its own share is growing or shrinking.

Prospecting where and How the company's existing market could be expanded.

IMPORTANT TOOLS OF MARKETING

- a) Advertising - Proper choice of advertising methods and media and attention to costs.
- b) Use it as-a powerful and rapid means of presenting products and services to the Public at Large or to specialized sectors. Must be based on a sound marketing policy and it gives Best Value for money.
- c) Public Relations - Creates favourable image of the company. It is a important factor in marketing operation.

GOAL SETTING

Goal setting is the stepping stone towards a purpose.

Goals are:-

- * Specific, Measurable & Concrete.
- * Challenging & Realistic.
- * Has a Time Scale.

PRODUCT KNOWLEDGE

- * Vessels/vehicle details
- * Schedule
- * Rates
- * Plus points.
- * Knowledge of competitors.

THE SALES FORCE

"The main burden of selling the Product or service rests with the sales force.

A successful sales force will have :-

- * A Sales Manager who is an effective man at his job.
- * Carefully selected men
- * Training
- * Organisation
- * Professional Approach to marketing.

SALESMANSHIP

"Is the Art of persuading people to Buy".

"It is the core of the whole marketing structure".

A success oriented Salesman;

Will set goals and work to a plan.

Have sound product knowledge.

Have enthusiasm and Ambition.

Have optimism to succeed.

Have motivation to achieve targets.

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WHO SHOULD PAY AND HOW FOR THE BENEFITS
CONFERRED BY PUBLIC PASSENGER TRANSPORT

BY J Diandas

ABSTRACT

Transport enables society to function. Specific groups in society other than travellers and society as a whole derive benefits from the proper functioning of public passenger transport. Passengers as a whole used to pay for the whole perceived cost of public transport albeit with some cross-subsidy from some groups of passengers to others. Improvement in remuneration to transport workers, and traffic congestion caused by private vehicles has raised the cost of public transport to the extent that 'profitable' passengers are no longer willing to pay cross-subsidy for others. Public passenger transport is but a sub system in a total urban settlement system. Examples are given of Japanese electric railways, German underground trains, and last late night buses. It is concluded that who pays is not a critical question and that society can pay a share through a variety of taxing methods, but that the more important issue is the provision of adequate transport cost effectively to enable economic and social development to take place.

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1. Introduction
2. The benefits
3. The beneficiaries
4. Passengers used to pay the whole cost
5. Why passengers were willing to pay then but not now
6. Urban settlement systems
7. Should society pay?
8. By what means could society pay?
9. The example of underground trains in Germany
10. Conclusions

WHO SHOULD PAY AND HOW FOR THE BENEFITS
CONFERRED BY PUBLIC PASSENGER TRANSPORT

BY J Diandas

1. INTRODUCTION

1.1 Once agricultural settlements lost their essential self-sufficiency they become interdependent with other rural settlements, with towns and cities and to some extent with the world at large.

1.2 Transport, (of goods and people) was both a causative factor and a resultative factor of this interdependence. In fact transport is the bonding material of all society. Passenger transport is part of the bond and provides for social cohesion.

1.3 In this sense the very existence of organised society is the chief benefit bestowed by passenger transport. Public passenger transport is predominant in third world countries where private car population ranges from .01 to .1 cars per capita. But even in high car populations, such as the US with .55 cars per capita, public passenger transport is still an essential part of mobility.

1.4 As society as a whole benefits from the mobility provided by public passenger transport, so does every segment of society, though some segments benefit more than others.

1.5 The scope of this paper is to identify the segments of society which benefit and argue that each such segment should pay its due share of the cost of providing it, or even if it does not do so, should be aware of the benefit it is receiving.

1.6 The arguments in this paper are applicable to all modes of public transport, although in Sri Lanka it is the bus which is the primary mode.

2. THE BENEFITS

2.1 The existence and cohesion of organised society is, in broad terms, as has been stated, the chief benefit bestowed by public passenger transport along together with other social instruments.

2.2 In narrower terms the mass social mobility ensured by public passenger transport gives rise to such social transactions as trade, commerce, education, interchange of ideas, sports, cultural events and so on. The development of each of these socio-economic activities is then a benefit.

2.3 The general benefit of good medicine, good education is shared not only by recipients but impartees of these goods, but also by society as a whole, which thrives better when everyone is in good health and well educated. This is one of the reasons why healthy tax payers, or tax payers without children, are always ready to pay for the health or education of others.

2.4 Yet both health and education services depend upon public passenger transport to bring the parties together. Hence the benefits of national good education and national good health also flow from good public passenger transport.

2.5 Likewise trade takes place where parties meet together and prosperous commerce is a benefit arising in part from good public passenger transport.

3. THE BENEFICIARIES

3.1 In a shopping transaction both the buyer and seller are beneficiaries. Both are therefore beneficiaries of the means which brings the parties together. This is the reason why in many places shops or associations of shops provide some transport facilities for their customers, such as free parking places, free trolley carts, free elevators or escalators inside buildings and, in special cases (e.g. Fort Worth Texas and Basel in Switzerland), free bus and tram services from outlying parks.

3.2 At a cinema, or a theatre, both the provider of entertainment and the recipient are beneficiaries. Thus both are beneficiaries of the means which bring the viewer to the entertainment. Here again some cinemas provide free parking space and others free bus services to the cinema.

3.3 In the case of work, both employer and employee benefits from the work performed. Here too, both parties benefit from the transport facilities which enables the employee to attend work in timely fashion and without undue fatigue. Thus is the reason why many employers, here and elsewhere, provide free transport to and from work for their employees, and why, for example, employers in Paris and elsewhere are willing to pay a payroll tax dedicated to the urban transport system.

3.4 We have so far identified three pairs of beneficiaries of Public transport in which one of each pair usually rides to the point of mutual benefit by public transport viz -

- .1 Sellers and buyers of retail goods
- .2 Providers and consumers of entertainment
- .3 Employers and employees

3.5 Some other classes of beneficiaries include the following -

- .1 Retailers situate close to train stations and bus-stops.
- .2 Owners of property along the line of public transport routes.
- .3 Those who normally ride in private vehicle, but who might occasionally need public transport in case of breakdown.

3.6 These are all direct or primary beneficiaries. Secondary beneficiaries include all those persons who benefit by virtue of the successful interaction of the primary beneficiaries. Whereas a villager might be able to exist on his own, every urban dweller is dependent on the active continuity of the whole of the urban settlement in which he dwells or works.

3.7 What this all amounts to is that the beneficiaries of public transport include many other people as well as the passengers.

4. PASSENGERS USED TO PAY MORE THAN COST

4.1 It is generally assumed that passengers used to pay, through their fares, the whole of the cost of providing public passenger transport, and that, whenever public passenger transport is operated today by private entrepreneurs, the passengers still pay the whole cost through their fares.

4.2 In fact, to the extent that private and public enterprise used to show profits and private enterprise still apparently does, passengers used to and still do pay more than the cost of providing the service.

4.3 However these assumptions need considerable qualifications. First there are external costs, such as wear and tear to the way occasioned by the passage of vehicles. Trams, although mostly publicly owned and operated, used to pay more than the cost attributable to them. Segregated railways paid the cost. Buses generally paid less than cost.

4.4 Second is the question of business failure. The history of private enterprise in public transport business, as in the construction industry, is full of failures. Many entrepreneurs have retired after incurring losses for which they paid either by selling off private property or by declaring bankruptcy. In the latter case part of the cost of providing the service falls on to bankers and other creditors, who increase their own rates and margins to cover the loss and thus pass on the cost to their customers.

4.5 Third comes the question of cross-subsidy. Even if passengers as a whole paid for the whole of the cost of service, every individual passenger did not do so. For example the two or three passengers riding in the last bus at night cannot have paid the cost of operating the last trip. Riders outward during the morning peak do not pay the whole cost of the outward trip. Passengers in the outer segment of a suburban route rarely pay the full cost of

serving the outer segment. Even passengers riding in the prevailing travel direction during the peak are thought not to pay the full cost because a peak direction trip entails the use of a bus and crew for only one or two useful journeys during the paid for day. Then school children usually pay half-fare or less, though often occupying a full seat.

4.6 On the other hand passengers on long distance bus or train services, which are faster and less costly to run are generally well patronised in both directions at all times of day, generally pay much more than the cost of the service they receive, and thus cross-subsidise those travelling in less profitable services.

4.7 It is not easy to ascertain how much cross-subsidy does take place. Some costs are apparently easy to attribute to given routes or services or trips. Other attributions are arbitrary, especially in the case of railways which have many fixed costs such as track and signal maintenance, which are incurred whether trains run or not. Yet even when cost allocation appears simple, there are philosophical doubts. Is the outward trip during the morning peak run for the passenger who rides in it, or for those waiting for the next inward ride?

4.8 What the question often boils down to is whether a passenger should pay for the cost of providing the seat he occupies, or for a proportionate share of the un-full bus in which he rides, or for a proportionate share of the whole service of which the bus in which, and the seat on which, he rides are a part.

4.9 Whatever the answer to these questions of perception, attitude and philosophy, the fact remains that some passengers have always paid more than cost. Moreover in the past those other passengers have appeared willing to pay more than cost. As long as that willingness was manifest, the question of calling on the non-travelling beneficiaries of public passenger transport to pay for their benefits did not arise.

4.10 Let us end this section with a paradox. Express services, whether bus or train, generally cost less to provide than stopping services, primarily because more mileage is obtained out of the crews' paid time. Yet passengers perceive the express service as of higher quality and are usually willing to pay a premium for it.

5. WHY PASSENGERS WERE WILLING TO PAY THEN BUT NOT NOW

5.1 In earlier days bus and train crews were relatively poorly paid in terms of their total reward. They worked long and awkward hours for which no special consideration went into their remuneration. Hence the crew cost was only a small proportion of the total cost. This circumstance alone made transport services cheap to provide, and those passengers required to pay sufficient to cross-subsidise the others, perceived the price to be worthwhile. To a good extent too, the subsidised passengers were able to pay a higher relative fare so that the cross subsidy was less.

5.2 Since then, crews have demanded, and rightly received, better consideration. Their total pay has risen more or less to the level of other skilled and responsible workers, and consideration is now given to some extent, to the unsocial hours which they have to work. Hence the proportion of cost attributable to labour has risen enormously. This is why so many developed countries have one-man operations of trains and buses, notwithstanding the several consequent problems.

5.3 Another factor increasing the cost of bus transport is the worsening impediment on the road caused by private traffic. In earlier days bus and tram moved smoothly and regularly. As more and more cars entered the roads, speed and regularity of bus and tram flow deteriorated. In consequence more vehicles and more crews were needed to provide the identical service. This too caused disproportionate increase in the cost of providing service. In affluent countries this had the further effect of diverting patronage from public transport into the very private vehicles that caused the deterioration. However this deterioration and

cost-increase has occurred even in cities like Colombo which have comparatively few cars per head of population, because those private vehicles, however few, concentrate in the very areas where public transport is most needed.

5.4 The greater consideration paid to transport labour and the impediment of traffic congestion have naturally increased the cost of providing public transport more than proportionately with other types of goods and services. The premium payers on profitable services have shown reluctance to pay increased fares in proportion to the increased cost. This reluctance shows itself through declining demand where alternate travel opportunities exist (such as private cars), or through political opposition to fare increases. Bangkok and Kampala are two places where fare increases imposed in 1981 were reversed or reduced by government intervention.

5.5 However to some extent today, passengers as a whole appear to be willing to pay the whole of the apparent cost of bus service provided by private entrepreneurs. In this case however, even if this is a correct and full assessment, private entrepreneurs are paying less for their labour than public bodies and are selecting the routes, segments and times of plying their vehicles, so that there is less need for cross-subsidy than is the case with a total network organised as a system.

6. URBAN SETTLEMENT SYSTEMS

6.1 The last point leads on to the question of the systems approach. Large passenger transport operators, such as the SLCTB, or London Transport, tend consciously or unconsciously to regard their network as a single system in which each route, or family of routes, or route segment or trip feeds or interacts with the rest. Hence such operators do not pay too much attention to the revenue and cost of each separate component or subsystem.

6.2 Large urban settlements should also be regarded, and organised as systems, in which such activities as trade, social intercourse, residence, recreation, street lighting, law and order, utilities (electricity, gas, water, telephone, sewerage) public thoroughfares and public transport are essentially sub-systems. Each one interacts with the other.

6.3 By way of example where law and order is poor (eg. Kampala and New York) public transport at night lacks demand. But surface public transport, as well as street lighting, are aids to the law and order surveillance sub-system.

6.4 An illustration of transport networks as a system is given by the last bus trip at night. This is usually poorly patronised. But its existence gives rise to satisfactory demand for the penultimate and pre-penultimate trips. If each trip is looked at on its own merits, the last trip is unworthy, and certainly no private operator in his senses would run it. But if the last three trips, or better still the route or service as a whole, is looked at as a system, then the last trip is fully justified. Indeed, if the last three trips are regarded together as a sub-system, they may well induce trips earlier in the day or abstract peak hour outward trips, thereby balancing loads throughout the time segments of service.

6.5 An illustration of the systems effect of urban settlements and the impact on public passenger transport is seen by a short examination of Japanese private electric railways. Take the Keio Teito Electric Railway Company. Its trains run out from Shinjuku on the perimeter of downtown Tokyo along a suburban swathe for 50 or 60km with 5 branches. It has a second line from Shibuya (also on the Tokyo perimeter) and many of its trains run through onto the Tokyo subway system, thus providing direct service to the heart and to the other side of Tokyo. In addition the Keio Teito Electric Railway Company owns other income-earning assets including :-

- .1 Keio Department Store at Shinjuku
- .2 Keio Plaza Hotel near Shinjuku
- .3 Health and recreation resorts in the suburbs
- .4 Local bus feeder services.
- .5 Houses and Shops all along the line
- .6 Urban development projects and complexes.

6.6 By owning and operating this assortment of enterprises along the line of its railway, the Keio company is able to capture most of the benefits which the railway confers on its environment. The Keio company will be indifferent, as a matter of principle, whether its profits come from its transport services, from house rents and property development, or from recreational enterprises. It can manipulate the prices of each activity in order to maximise its overall profit. For consumers it matters little whether they pay higher house rents and lower train fares or vice versa. If on the whole the system works better with lower transport fares (because this may attract absolute outsiders to fill empty seats), compensated by higher rents and bigger property development profits, it could be categorised as cross-subsidy between sub-systems of the urban swathe settlement system; yet if the sub-systems were owned and operated by separate undertakings, or even by individuals, the categorisation would be either 'support' to use modern American or European terminology, or 'subsidy' to use English terminology. Yet whatever the terminology the system as it works in Japan is nothing more or less than joint operation of connected activities planned and accounted as a whole. The non-travelling beneficiaries of the railway are indeed paying for their benefits, and travellers as such are probably paying the value of the benefits they receive.

6.7 There are quite a lot of services provided for the public good, such as law and order, street lighting, leisure parks, general sanitation, paid for by public purse, which means in effect by direct and indirect tax payers. The justification for recipients of these services receiving them free of specific charge generally fall into two categories :-

- .1 The user and the quantum of use are difficult to identify and reckon
- .2 The cost of collecting a due charge would be out of proportion to the amount collected.

6.8 To some extent public passenger transport in developed countries is falling into both of these categories and the move towards free service is advancing slowly. Though the rider can be identified as well as the distance he rides, the other beneficiaries and their benefits are more difficult to identify and quantify, and the cost of collecting on-vehicle fare is rising disproportionately, both in terms of cost of crew-man employed to collect them and in the delay caused by the driver acting as fare collector.

6.9 Yet whether fares are suppressed altogether, or reduced to simple ride-at will passes, the fact is that public passenger transport is being increasingly perceived in the developed world, especially in the so-called free economy developed world, as part of the urban and social infrastructure which must be maintained to keep the system as a whole at work. In this context it is largely irrelevant who pays and how, so long as the service is suitable, the cost is commensurate with value, and adequate patronage is generated.

7. SHOULD SOCIETY PAY

7.1 If the beneficiaries of public passenger transport cannot be fairly charged for the benefits that others receive, should society as a whole take over the whole or part of the cost.

7.2 There are many economist's arguments that free transport would lead to exorbitant joyriding and thus to artificially stimulated demand and a resultant misallocation of society's resources. This argument is extended also to situations as in Paris and New York for example, where riders as a whole pay less than 50% of the cost of providing the service.

7.3 Yet several demonstration projects have convincingly shown that joy-riding is a very temporary phenomenon even on free services such as in Trenton NJ, Albany NY and Seattle. The deterrence to travel by public transport is much more its inconvenience than its price. However such results might not apply in third world countries. Moreover the higher level of rail fares in Britain than in Europe seem to have lowered patronage levels. In other words, there is some elasticity attached to transport fares.

7.4 The more general consensus appears to be that passengers should pay what they are willing to pay in a manner that minimises the cost of fare collection, and that society should pay the balance.

8. BY WHAT MEANS COULD SOCIETY PAY ?

8.1 If indeed society should pay part or the whole of the cost of public passenger transport, what are the devices available for the public purse to extract the cost from the conglomeration of private purses ?

8.2 In Sri Lanka in recent years the SLCTB and railway losses have been absorbed by the general budget in much the same way as the cost of health, education and police services. However from last year the Education Department, through its votes has paid for the difference in cost of students season tickets, though the ultimate collection from the general public is through the same basket of direct and indirect taxes.

8.3 In Britain, railway 'losses' are mostly absorbed by the national government, though in the great conurbations the net cost of rail and bus service is provided by the Metropolitan County Governments by 'purchase of service' contracts, financed out of property rates.

8.4 In Paris, public passenger transport is financed mostly by a payroll tax.

8.5 In North America a variety of taxes are levied, after voted citizen approval, which are then dedicated to capital investment and operating cost of public transport. Some of these taxes are imposed or surcharged on tobacco sales, gasoline sales, general retail sales or city income taxes.

8.6 It would appear that citizen opposition to taxes levied to pay for public transport arises mostly (if not solely) when the tax is levied or subvented on rates or property tax.

9. THE EXAMPLE OF UNDERGROUND TRAMS IN GERMANY

9.1 As a final example it is worth looking at recent developments of big city public transport in West Germany. The Federal Government there is willing to pay up to 80 or 90% of the cost of transport infrastructure provided the expenditure leads to segregation of public from private transport.

9.2 This ostensibly enables public transport to operate much faster and therefore to the advantage of public transport passengers.

9.3 However much of the money has been spent on digging tunnels to put German tramways underground. Physically this is downgrading, though it is usually termed upgrading. The results however are mixed and include :-

- .1 Faster journeys for longer distance riders
- .2 Sparser stop spacing, hence longer walking distance to and from stops.
- .3 Inferior access to transport generally.
- .4 Elimination of spontaneous travel on public transport
- .5 A less interesting outlook on tunnel walls for those riding or waiting for underground trams.

9.4 The implication of the whole can be interpreted as the willingness of German motorists to pay, through federal taxes, for the cost of putting public transport below ground and keeping the surface for themselves. If this interpretation is correct, the cost of the underground infrastructure is not really a public transport cost at all, but a cost rightly paid by those who have thereby 'bought' the surface for themselves.

9.5 This aspect is well illustrated in Rome, where a street tramway running on a broad grassed median reservation for nearly 15 km has been replaced by an admittedly ultra-modern underground railway beneath the street. Yet the original grassed median has been quickly taken over by parked cars.

9.6 If amortisation of the tunnels is charged to the underground railway, and the fares charged do not cover this amortisation, will economists complain that Roman public transport passengers are subsidised, and hence resources misallocated?

10. CONCLUSIONS

10.1 The main conclusion is that whether passengers as a whole do or do not pay for the whole of the cost of public passenger transport is not a critical question in itself.

10.2 There are more important questions such as :-

- .1 Public transport should grow in line with economic and social 'growth' and hence should not become a constraint on development.
- .2 Public transport should be operated cost-effectively in resource terms. That is to say that excessive costly resources such as energy should not be consumed irrespective of ownership or profitability.
- .3 Fares for using public transport should be in line with, or a reasonable proportion of incomes.
- .4 High fares should not inhibit the utilisation of available resources (such as empty seats) nor inhibit reasonable social mobility which is one of the ingredients of national cohesion and pride.

10.3 In given circumstances, such as in any third world country where labour costs are comparatively low, it should be possible to run most transport services cost-effectively in such a way that reasonable fare levels can pay for the whole service. But this should not be an article of faith.

10.4 Where societies or their governments specifically require the granting of cheap fares, or season ticket concessions to students, or government employees, or any other class of preferred persons, then the value of the concession should be specifically met by payment to the transport operator. This should be regarded as part of the operator's revenue.

10.5 Where societies or their governments specifically require services to be run, for example to open up new development areas, or to help depressed or remote areas, or to equalise travel opportunities between rural and urban areas, then too specific payments should be made to the transport operators.

10.6 If these measures are not sufficient to defray the cost of providing adequate public transport services, then government must support the transport operators either by levying cesses or taxes which go direct to the operator or by making support or purchase-of-service payments.

10.7 Whatever the mode of payment, and mode of collection from society, such support for public passenger transport should not be categorised as subsidy, nor should the net cost of operation be classified as a loss, nor indeed should the appearance of losses be regarded as synonymous with inefficiency. Efficiency must be measured by more efficient indicators of cost-effectiveness and service rendered.

10.8 In as much as passengers will not or cannot, (as perceived by political authorities who decide upon fare levels) pay for the cost, attempts should be made to obtain payment from the other beneficiaries of public transport, such as abutting property owners or trade, or employers.

10.9 In as much as support has to be collected from the general public, it is preferable to charge an ad-valorem tax, such as a percentage or portion of sales or value-added taxes, which would be credited direct to the authority supervising public transport operators, in much the same way as the Coconut Development Authority receives certain cesses.

10.10 The tax should be ad-valorem so that increases in value of the item taxed automatically increases the support for the operator whose own costs will also be rising. For example if public transport support is to come from a special levy on gasoline, it should be at a percentage of sales value and not at a levy per litre.

10.11 To end at the beginning, the real issue is a need to adjust to realities, and not follow articles of faith about profitability, efficiency and allocation of resources.

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A Preliminary study of Bus Service on a
Major Street (Galle Road) with many over-
lapping Routes and Operators.

by

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Sri Lanka

The supply of bus service on Galle Road which has many overlapping routes, one major public bus system and many private bus operators is analyzed, using data collected from a one day survey carried out at Bambalapitiya.

The share of the total supply of buses (frequency of service) seats and passenger-spaces, provided by public and private systems is noted.

The Colombo - Panadura route is analyzed in further detail. It is shown that bus arrivals during the peak period is a purely random process, and the possible reasons are discussed.

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1. INTRODUCTION

Galle Road is one of the six intercity roads which radiates from Colombo CBD. This runs almost along the western and southern coasts of Sri Lanka and runs upto Kataragama, which is about 300 km away from Colombo. It connects a large number of cities in this coastal belt.

The Galle Road section from the city of Colombo to Panadura (28 km) goes through a densely populated area with commercial business and trade activities on either side of it. Also, there are many light engineering industries, hotels, places of worship, educational institutions etc. at very frequent intervals. This road section has a large number of major activity centres (Fig.1). There are 4 lanes from Colombo to Moratuwa and then it is only 2 lanes upto Panadura.

Eventhough this road is one of biggest corridor of transport in Sri Lanka, there is no literature available to ascertain the demand or supply of transport facilities. The Department of Civil Engineering, University of Moratuwa is conducting a project to study the supply side of the transport facilities from Colombo, upto Panadura. This paper outlines some preliminary analysis of the bus survey work carried out by the study team for the above project.

Currently, bus transport in Sri Lanka is provided both by the state and private organisations. The state is providing the facilities through the Sri Lanka Central Transport Board (SLCTB) and its Regional Transport Boards (RTB). The private buses are owned by a large number of individuals and organisations.

The state bus service on this sector of road is provided by the Colombo North (05 depots) and Colombo South (06 depots) Regional Boards (Appendix 1). In this section there are many overlapping routes (Fig. 1). There are three types of services available; viz - limited stop, all stop and flat rate standee*. The state buses have four different passenger carrying capacities. There is a bus schedule for the each depot, eventhough there is bunching in both peak and off-peak times of the day. The fare structure is generally fixed by the government, but the fare stage distance is not a constant along the route. For the first three consecutive sections, the fare is 50 cents each and then it is reduced to 25 cts. per each section. RTB issues monthly season tickets for all commuters and charge only 65% of the total cost. For school children and students of other higher educational institutions the charge is only 50% of the total cost. The destinations are generally well exhibited.

The bus service provided by the private sector organisations is extremely complex. There are a large number of owners. Some owners own just one bus and others own 2 or more buses. The seated passenger capacity of private buses (without over-loading) generally ranges from 17 to 42 seats. Most of the buses in this section have 26 seaters. There is no express private bus service in the study section.

The private bus operators do not follow the RTB fare system. For some sections they charge more than the RTB, and in other sections, the charges are equal or less. An example is given overleaf.

*This service was not available during the time of survey.

Origin	Destination	Fare	
		private	RTB
Colombo	Bambalapitiya	Rs. 1/50	Rs. 1/50
Colombo	~~Moratuwa~~ <i>Mt Lavi</i>	Rs. 2/00	Rs. 2/50

Table 1

There are no season tickets nor any other concessionary tickets and in general no tickets are issued.

Sometimes the private operators mislead the public and complicate the fare structure further more by changing their destinations half way the journey. For example, from Colombo they have Dehiwela as their destination and take passengers for all points upto Dehiwela. However when they reach Bambalapitiya the destination is changed to Moratuwa, to maximise the profit. This has arisen due to the fact that, they are allowed to operate in any section of the road from Colombo to Kataragama.

There is no fixed bus schedule nor fixed origin and destination for private buses. The following features were observed in their departure times in the study section:

- i. the buses move when they are fully loaded.
- ii. 'first come - first go' at crowded times
- iii. when there are a large number of buses at the origin, there is pressure within them to take the buses off.
- iv. In general, they try to go just before RTB buses leave.

Private bus operators are allowed to operate during the peak times and take them out during the rest of the time.

2. METHOD OF DATA COLLECTION

In order to collect data it was decided to carry out a 24 hour survey both on RTB and private buses, at Bambalapitiya junction, where you get the highest number of overlapping routes on Galle Road, and we were interested in collecting as much information as possible with the help of the resources available.

By taking into account the above considerations, it was decided to obtain the following information -

- * Actual arrival and departure times of the buses.
- * The origin and the destination of the buses.
- * The number of operators, operating on Galle Road.
- * Approximate number of passengers transported.
- * The actual passenger spaces provided by RTB and private buses.

In order to achieve these requirements the buses were divided into the following categories according to their sizes.

- R.T.B: A - The buses having two or more rows of seats after rear entrance
B - The buses having only one row of seats after rear entrance
C - The buses with one entrance
D - Double decker buses.

- Private: A, B, & C - As for R.T.B
R - ROSA and mini type buses (26 seaters)
V - Vans like ELF, HIACE, FARGO etc.

To facilitate the calculation of the number of passengers transported the following loading code was considered. (Here the surveyors have to estimate the amount of passengers in the bus).

Empty - E
 1/4 seats taken - S1
 1/2 seats taken - S2
 3/4 " " - S3
 All " " - S
 1/4 normal standing room taken - H1
 1/2 " " " " - H2
 3/4 " " " " - H3
 Full (normal standing room is occupied) - F
 Packed (no one can get into the bus) - P

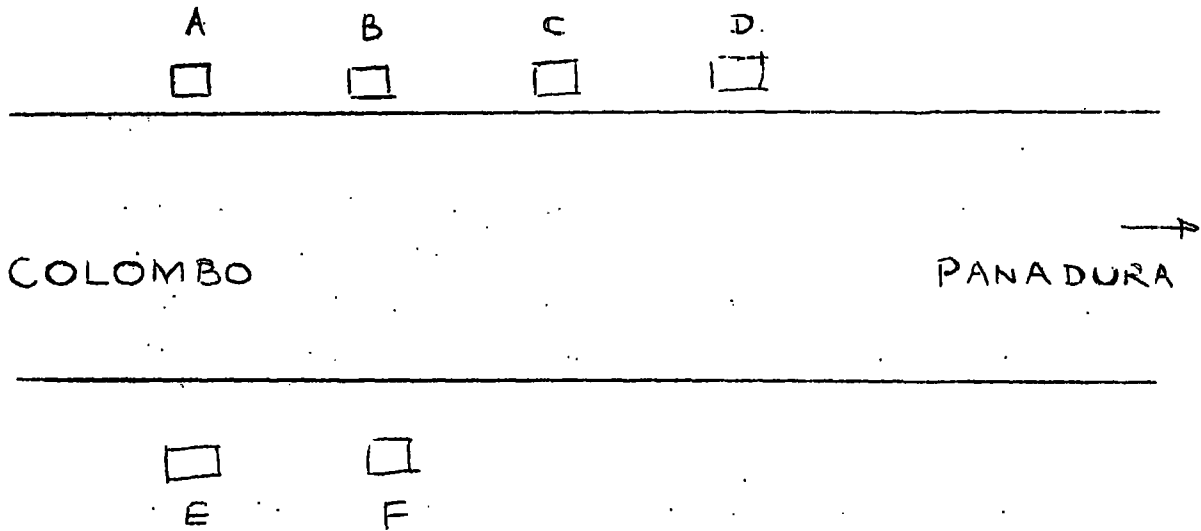
To represent these groups by a actual number a sample passenger count was carried out at Pettah main bus stand for about 7 - 10 buses of each catagory and the mean of those were taken to represent the groups, as shown below. (Table 2).

BUS TYPE	LOADING CODE									
	E	S ₁	S ₂	S ₃	S	H ₁	H ₂	H ₃	F	P
A	5	10	21	32	42	54	64	76	92	115
B	5	9	19	28	38	49	54	62	72	92
C	3	8	16	24	32	39	47	54	61	67
D	5	10	21	32	42	54	64	76	92	115
R	3	7	13	20	26	30	32	34	38	42
V	3	5	9	13	17	20	22	23	24	26

Table 2

Then a priliminary survey was carried out at Bambala-pitiya junction (At all the six bus halts, both North and

South bound (Fig. 2).



This preliminary survey was done for about 15 min. at each and every bus halt. From this we were able to decide on the number of surveyers required for the full survey and also to get an idea about the limitations (difficulties).

It was decided to have two hour shift for each person and depending on the work force available the survey was restricted only to the south bound flow. But the arrival time, route number and bus number for the north bound flow were to be collected. So it was decided to collect the following information:

Arrival Time, Route No., Destination, Origin, Bus No. or B.R.No., Bus Code, Loading Code, Departure Time, Depot or Company Name.

From the preliminary survey it was found that there is a difficulty in taking down the departure time and the company name of the buses. Since the other data is more important than those mentioned above it was decided to

leave these two out.

Since the origin and the destination for R.T.B. buses are almost the same for one particular route number it was decided to take down only the destination which is given in front of the buses, and to assume the origin depending on the route number.

But it was seen that most of the private buses did not have any route number so it was decided to take down the route number wherever available and to get the origin from the conductor whenever possible.

First it was decided to use the bus number for S.L.C.T.B. and B.R. number for private buses to identify each and every bus, and if they are not available to take down the license plate number. But later it was found that the B.R. number indicated the ownership of the buses and not the bus itself. So half way down the survey we had to take down both the license plate number and the B.R. number for private buses.

The bus count was carried out on 3rd May 1983 at Bambalapitiya junction as decided. With the help of the final year civil engineering students of the University of Moratuwa. (This mid week day was selected in order to collect normal stabilized flow data).

The survey was started at 4.00 a.m. and was continued till 12.30 a.m. of the next day. At the commencement of each shift the wrist watches of the surveyers were synchronized and the surveyers were allowed to do a trial survey for about 15 min. before they started their first shift, in order to get them familiarized with the work.

3. TOTAL SUPPLY

As a gross indicator of the supply of bus service on Galle Road at Bambalapitiya, we shall consider the combined supply on all urban, suburban routes. Since 83% of these routes pass Wellawatta, this may also be considered an indication of the bus service via Bambalapitiya to Wellawatta from points North of Bambalapitiya. This analysis also helps in understanding the amount of congestion at the main Bambalapitiya bus halt, which is really three halts located close to each other.

3.1 Frequency of service

The frequency of service, g_i , (buses per unit time) is a common indicator of the level of service provided to passengers. The average headway between buses to destination i , h_i , is the inverse of the frequency of service ($h_i = 1/g_i$), and the average waiting time per passenger* is $h_i [1 + (C_h^i)^2]/2$.

Where C_h^i is the coefficient of variation of the headway between buses to destination i . [Reference (17)]

The frequencies of service in buses per hour at the Bambalapitiya bus stop for regional transport board buses (RTB), private buses (P) and all buses (A) between 4 a.m. and 1 a.m. are shown in Fig. 2a.

It is clear that private buses provide a better frequency of service* (average : 69 per hour) than RTB buses (average : 51 per hour) except between 1.00 to 1.30 p.m. during the day, 4 a.m. to 6.45 a.m. in the morning and after 9.30 p.m. at night. The RTB school bus service accounts for the high frequency between 1 to 1.30 p.m. Only 43% of the buses are RTB buses.

* It is assumed that passenger arrivals at the stop is independent of the bus arrivals.

The maximum frequency of 225 per hour during the morning peak (8.30 - 10.30 a.m.) is higher than that of 210 per hour during the afternoon peak (4.30 - 7.00 p.m.) for RTB and total Southbound supply. This is caused mainly by buses returning from the Northbound morning peak.

The frequency of service is above average from about 7.00 a.m. till about 8.30 p.m., indicating the high level of supply on Galle Road. During the midday "off peak" the frequency of service is 150 buses per hour. It also appears that the private operators are trying to straddle the RTB afternoon high frequency service between 5 to 5.30 p.m. by providing their beat service from 4.30 to 5.00 p.m. and 6.00 to 6.30 p.m.

The share of the bus service in terms of frequency for the RTBB and private buses is shown in Fig. 2b.

3.2 Seat Supply

In general, private buses are smaller than RTB buses. Further, there are several sizes of RTB buses. Consequently, the supply of seated capacity has also to be analyzed to get a better picture of the supply of bus service.

The supply in terms of seats per hour for RTB, private and all buses is shown in Fig. 3. The percentage share is shown in Fig. 3b. It is immediately clear that the RTBB are supplying more seated capacity (average 2050 seats/hour) than private buses (1860 seats/hour).

On the Galle Road, the average seated capacity of urban RTB buses is 40 seats (~2050/51) while the average seat capacity of urban private buses is 27 seats (~1860/69). The RTBB supply 52% of the seated capacity.

There is no difference between peak periods in terms of bus supply and seat supply. For both bus and seat supply, the private buses pick up the slack just before the second bus peak (1.30 - 2.00 p.m.) when the RTBB pullout buses

from normal routes to despatch to the schools. In general we can conclude that while the RTBB supply the bulk of the seated capacity, the private operators increase the level of service to those who can pay by providing more seats and lower headways.

3.3. Supply of Total capacity

On an extremely heavily travelled corridor such as Galle Road, one cannot really expect to supply seats to all passengers at a reasonable cost. Consequently, the supply of seats plus reasonable standing space inside the buses (total capacity) is the proper indicator of the supply of bus service.

The RTBB supply the major portion of total capacity, as shown in Figures 4a, b, except before the school bus peak at 1.30 p.m. and between 3.30 and 9.00 p.m.

The average supply of total capacity is 4175 spaces per hour for the RTBB and 2880 spaces per hour for the private buses. The RTBB supply 59% of the total capacity. The average passenger-spaces per bus is $82 \sim (4175/51)$ for the RTBB and $42 \sim (2880/69)$ for private buses.

3.4 Season-ticket holders

Season ticket holders are restricted to RTBB* buses. Thus, by paying 35% less than other RTBB passengers, on average they get excluded from 57% of the buses, 48% of the seats and 41% of the available passenger-spaces.

* They are also excluded from the recently introduced flat-fare-standing only RTE buses.

4. COLOMBO - PANADURA ROUTE

Data is available from our survey for all bus routes passing Bambalapitiya. The service and the way it is shared between private and RTBB buses varies from route to route. For example, the CNRTB provides the bulk of the supply on Route 154 while private buses dominate Route 155. A detailed analysis has not yet been performed for any route. A preliminary analysis of the Colombo-Panadura Route is given below.

The buses between Colombo and Panadura (via Bambalapitiya) have several starting points. Route 100 buses start from Pettah, Fort, Kollupitiya or Bambalapitiya while Route 111 starts from Eye hospital junction. However, to a passenger originating at the main Bambalapitiya bus stand, the origin of the route is immaterial. We shall combine all these buses and use the name: Route 100.

4.1 General analysis of Route 100

The frequency of service, the supply of seats and the supply of total capacity on Route 100 is illustrated in Figs. 5a,b; 6a,b; 7a,b respectively.

4.2 Afternoon peak service

The afternoon peak at Bambalapitiya for Route 100 is from approximately 4.30 to 6.00 p.m. The bus supply data for the peak period are shown in Table 3.

Bus Type	Frequency (buses/hr.)	Average headway (minutes)	Std.Deviation of headway (minutes)
RTBE	15	3.94	3.92
Private	18	3.37	3.74
All buses	33	1.86	1.80

Afternoon Peak - Route No.100

Table 3

The RTBB service averages a headway of approximately 4 minutes while private buses provide a marginally better headway of approximately 3 1/2 minutes. The combined average headway is approximately 2 minutes.

Superficially, it appears then that the mean waiting time for season ticket holders (who are limited to RTB buses) is 4 minutes and that for other passengers is 2 minutes as calculated using Eq.(1).

However some of the buses arriving at (parking) the Bambalapitiya bus stop are already filled to capacity and do not take in passengers. These are non-buses as far as the passengers originating at the Bambalapitiya bus stand are concerned. So, the above mean waiting time estimates are really lower bounds. Since data on "packed" buses is available, further analysis is planned.

4.2.1 Random bus arrivals

The fact that the mean headway is approximately equal to the standard deviation, for all three cases in Table 3, caused us to perform a Chi-square (statistical) test to see if the headways followed a Negative Exponential probability distribution [Ref.(3)].

The critical significance level at which the hypothesis, that the headways follow a negative exponential probability distribution, with probability density

$$f(x) = \lambda e^{-\lambda x}, \quad x > 0 \quad (2)$$

and mean headway of $1/\lambda$, is accepted is 65%, 3% and 9% respectively for RTB, private and all buses. Thus it is easy to assume that the headways for RTB buses and all-buses are negative exponential while the hypothesis for private buses can be rejected at significance levels 3%.

The major implication of the headways being Negative exponential is that it follows that the bus arrivals are purely random. Surprisingly, this is more true for RTBB buses

which are supposed to be scheduled, than for private buses which are dispatched loosely if at all. The fact that route 100 buses have several starting points and the possibility that these are scheduled independently probably cause the random arrivals at Bambalapitiya and consequently at points downstream. The randomness exhibited by the combined (RTB and private) bus arrivals points to the lack of association between RTB and private bus arrivals. Since the passenger demand is very high during the peak the private bus operators probably see no reason to match and be just ahead of RTB buses as alleged by some.

4.3 Afternoon off-peak service

Calculations for off-peak service are not completed yet. However, initial values seem to indicate that arrivals are not random. Thus, the RTB buses are probably keeping to some schedule and the private buses may be attempting to pre-empt RTB buses. However, no firm conclusions can or should be drawn as yet.

5. CONCLUDING REMARKS

Since the survey was held on 3 May 1983, only a very brief look at the vast amount of data collected has been taken. However, a detailed analysis of the data is planned if funding is available.

Each route will be analyzed in detail with respect to the supply side. We hope to obtain the number of operators, the fleet size of each operator, the approximate daily demand, the round trip times etc. for private buses, and equivalent data for RTB buses.

Further collection of data in the field and from various organizations is planned.

If possible, it is hoped to relate the number of licenses issued to private operators for a particular route

to the actual frequency of service. Thus an invisible control could be exercised on the private operators.

6. ACKNOWLEDGEMENTS

The sabbatical assistance provided by the University of Moratuwa to S.C. Wirasinghe is gratefully acknowledged. The assistance given by the Civil Engineering fourth year students (1982/83) of the University of Moratuwa, and in particular Mr. S. Jayanatha and Mr. W. Jayasiri, in organizing and performing the survey is acknowledged.

The assistance given by Mr. P. Seneviratne with the statistical calculations and tests is appreciated.

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Appendix 1

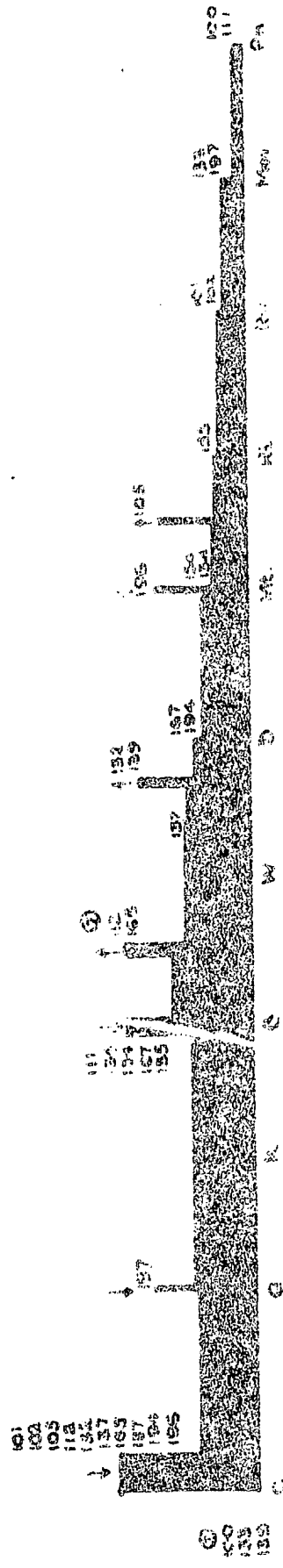
Depot's providing service along Galle Road through B'pitiya
Colombo South Regional Transport Board.

<u>Depot</u>	<u>Bus Route</u>
Panadura	100, 111, 133
Moratuwa	100, 197, 187, 133
Ratmalana	100, 101, 102, 105, 132, 137, 133, 196
Maharagama	112
Kesbawa	139
Udahamulla	(7)

Colombo North Regional Transport Board.

<u>Depot</u>	<u>Bus Route</u>
Kadawatha	154, 132
Kelaniya	154
Mattakkuliya	155, 167
Meethotamulla	134, 135
Ja-Ela	194

- C - COLOMBO - FORT - PETTAN
- G - GALLE FACE
- K - KOLLUPITIYA
- B - BAMBALAPITIYA
- W - WELLAWATTE
- D - DEHIWALA
- M. - M. LAVANIA
- R. - RATMALANA
- RW - RAWATAWATTE
- M. - MORATUWA
- PA - PANADURA



BUS ROUTES THROUGH BAMBALAPITIYA

(Fig. 1)

NUMBER OF BUSES / HOUR

S.L.C.T.B.
PRIVATE
TOTAL

NO. of
BUSES
/ Hr

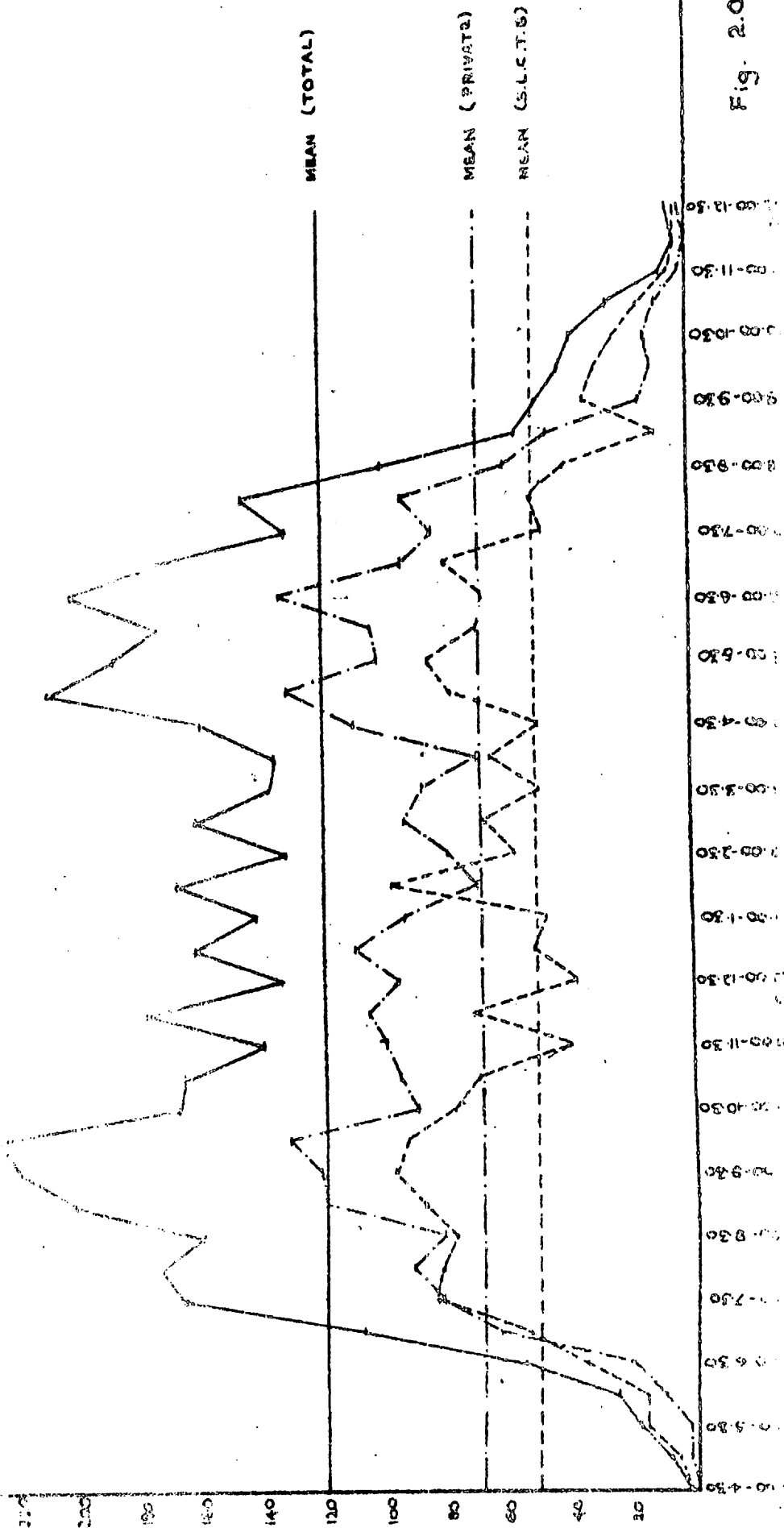
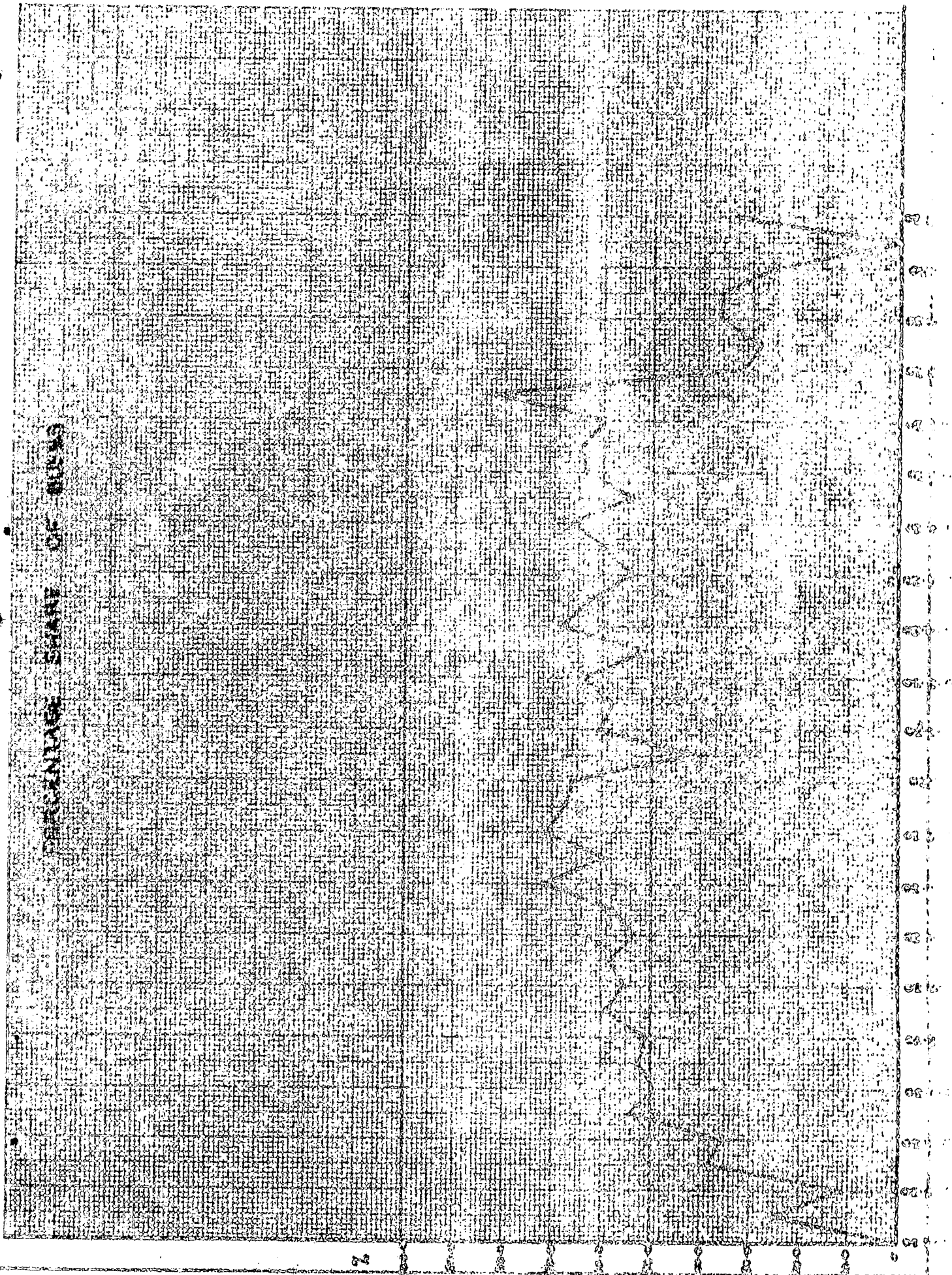


Fig. 2a.

PERCENTAGE SHARE OF RUMS



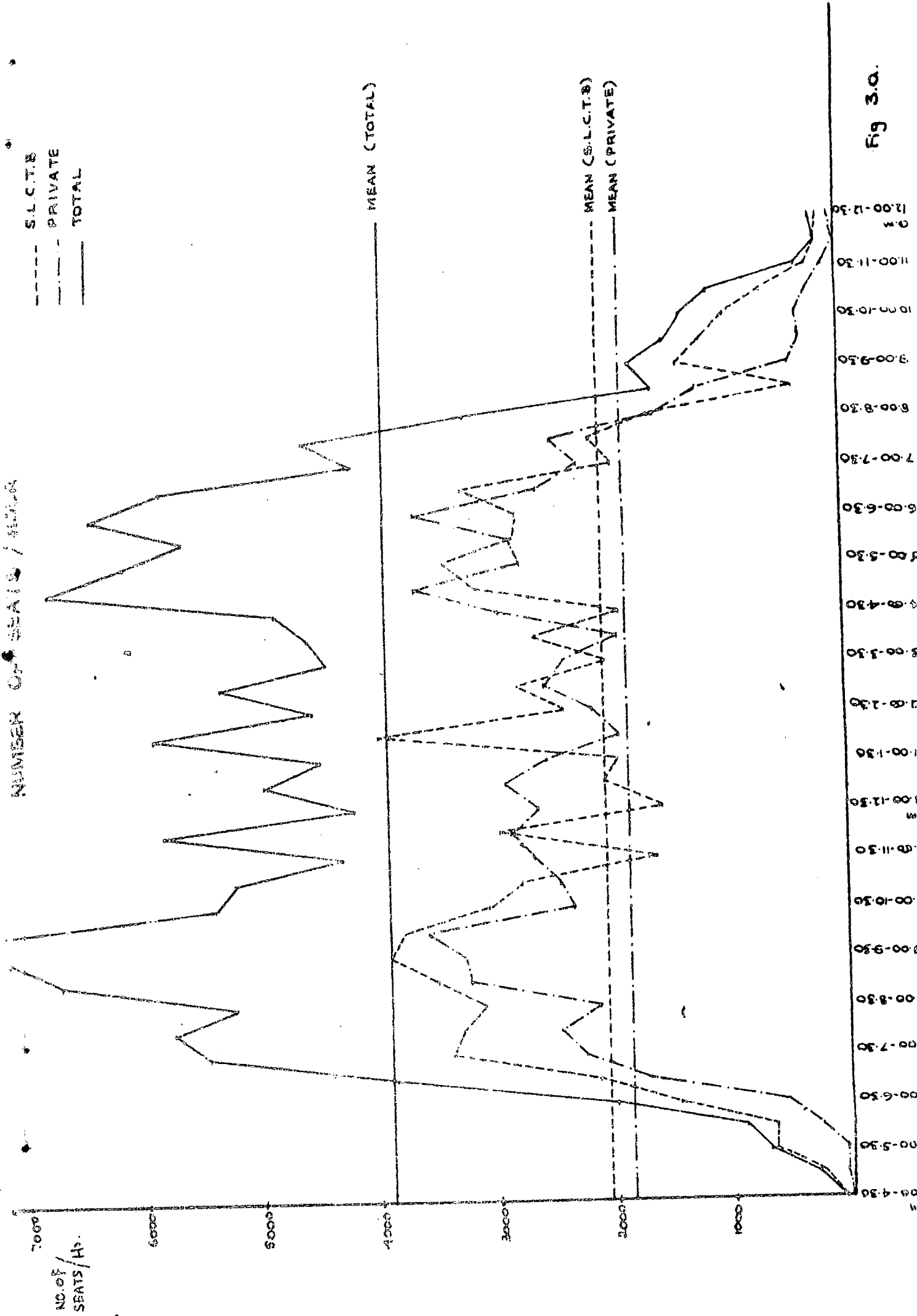
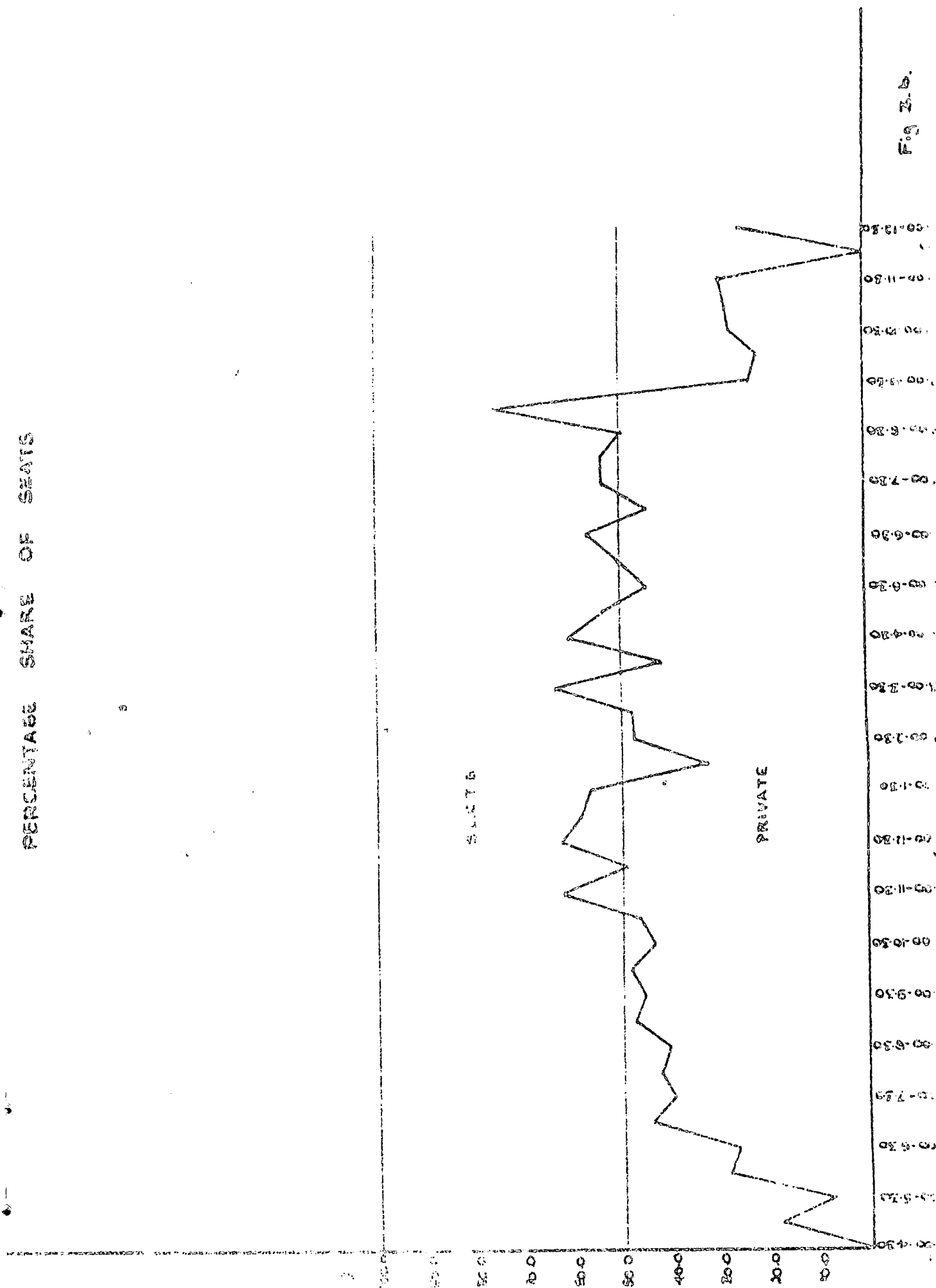


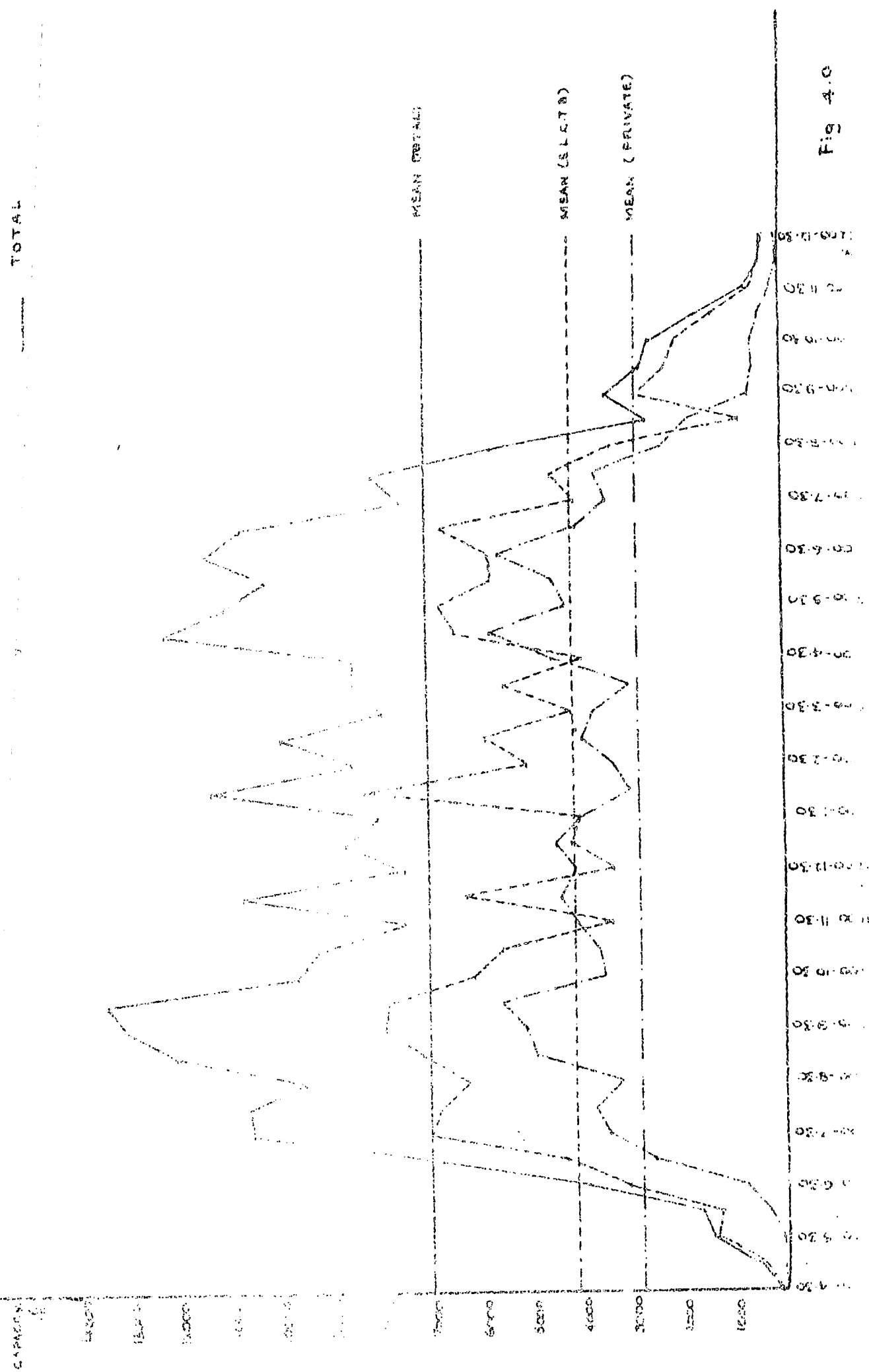
Fig 3a.

PERCENTAGE SHARE OF SEATS

5

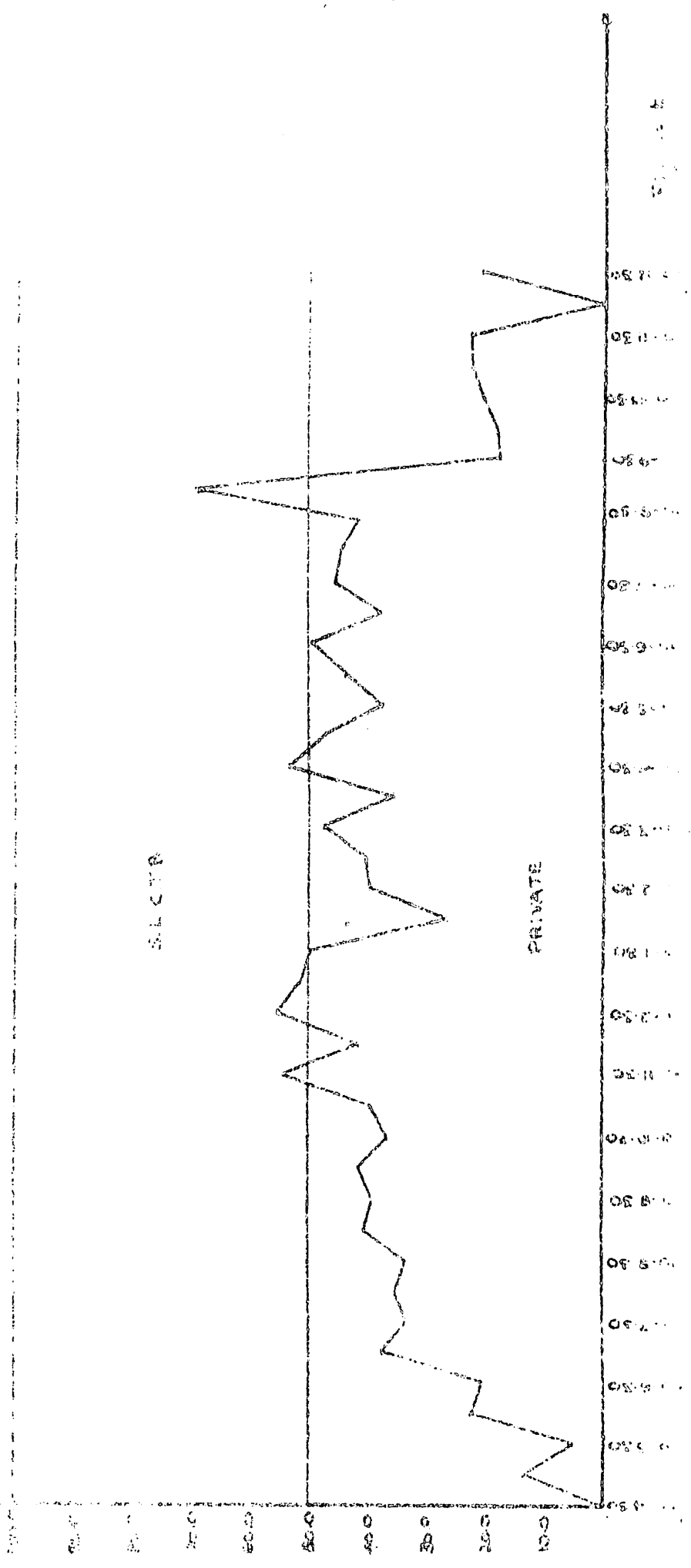


-----	SLC.F.B.
-----	PRIVATE
-----	TOTAL



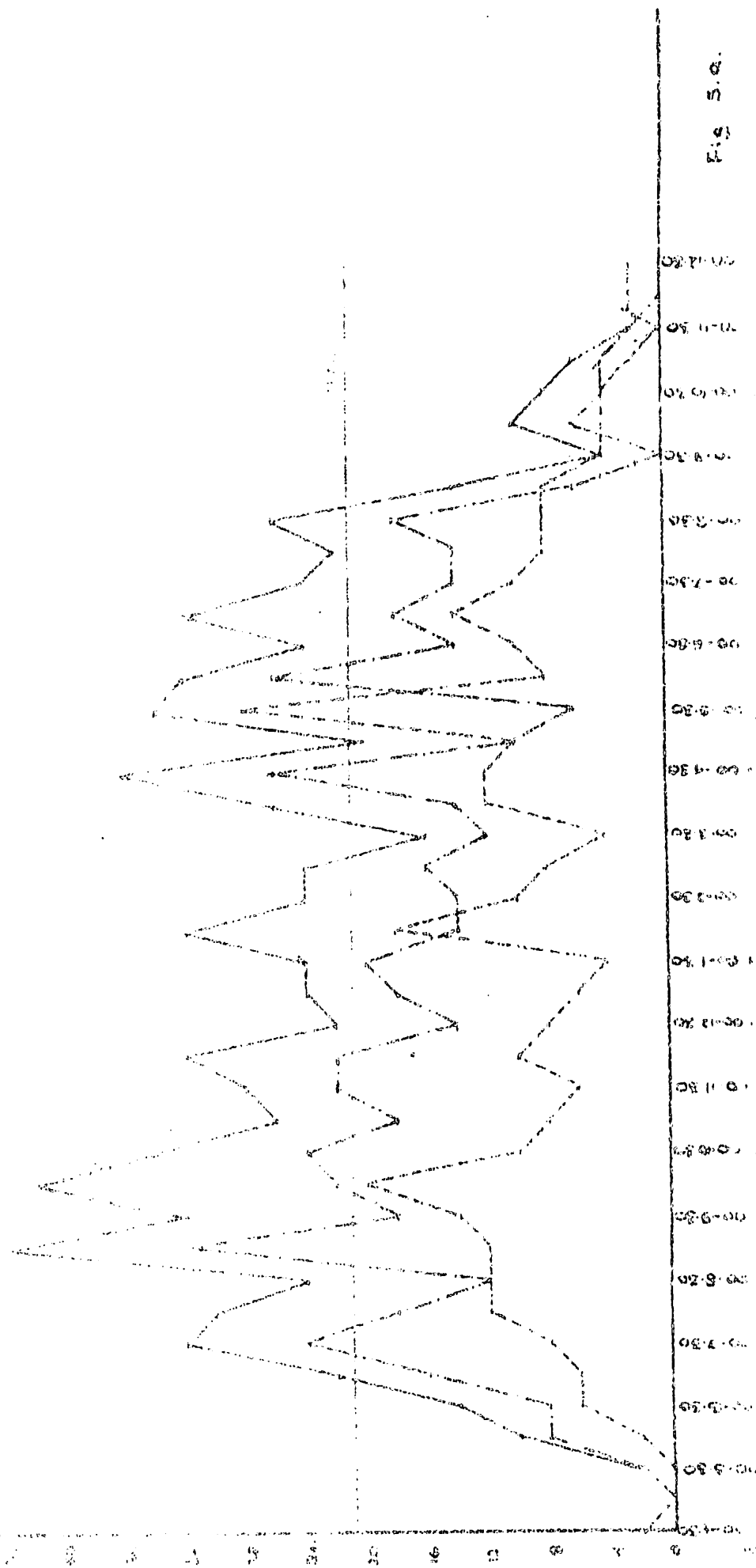
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SECRET



NUMBER OF BUSES/HOUR (ROUTE NO. 100)

PUBLIC
 PRIVATE
 TOTAL



10
 9
 8
 7
 6
 5
 4
 3
 2
 1
 0

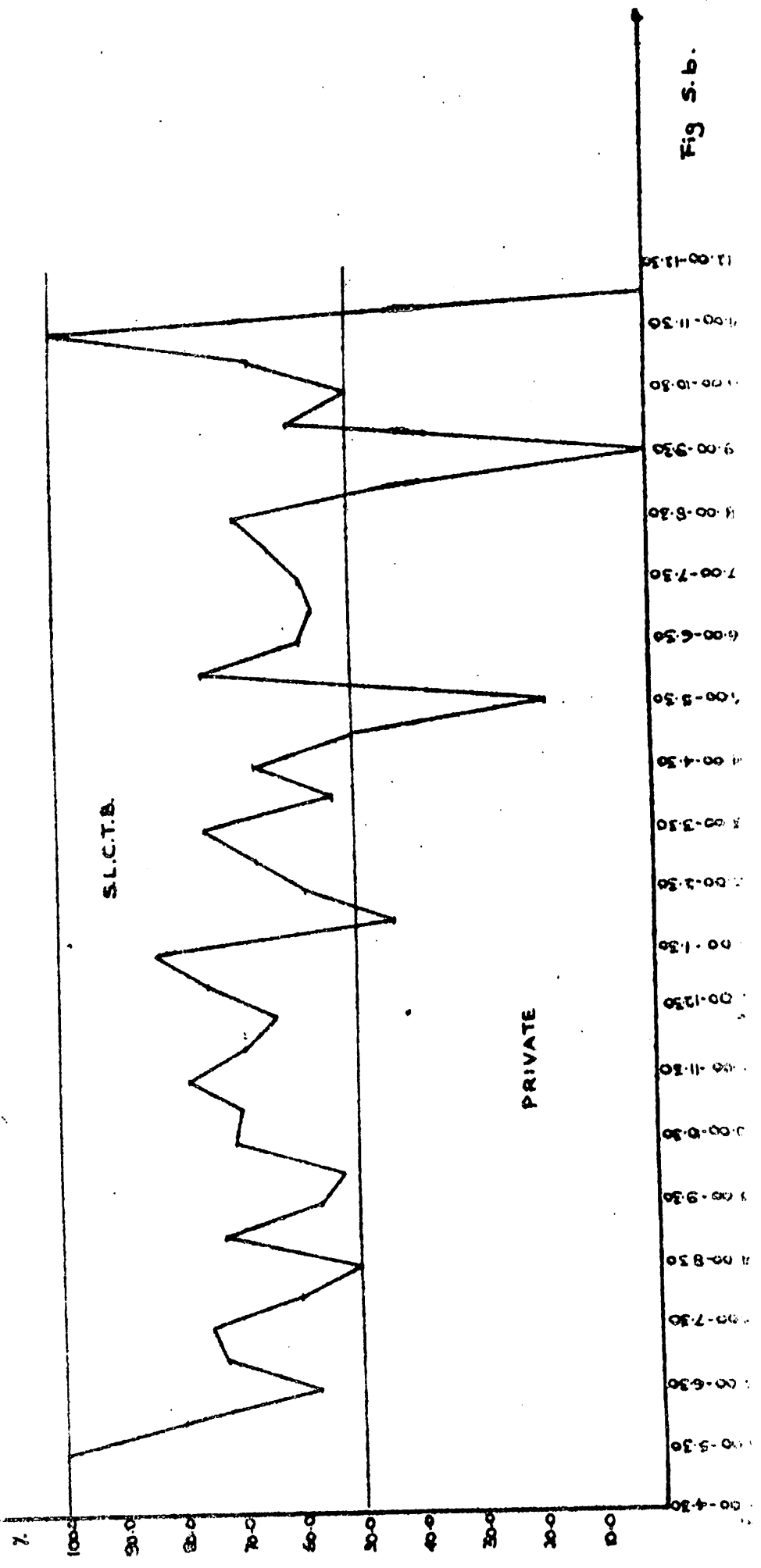


Fig 5. b.

NUMBER OF SEATS/HOUR (ROUTE No. 100)

--- P.S.L.C.T.B.
--- PRIVATE
--- TOTAL

SEATS/H

1400

1300

1200

1100

1000

900

800

0

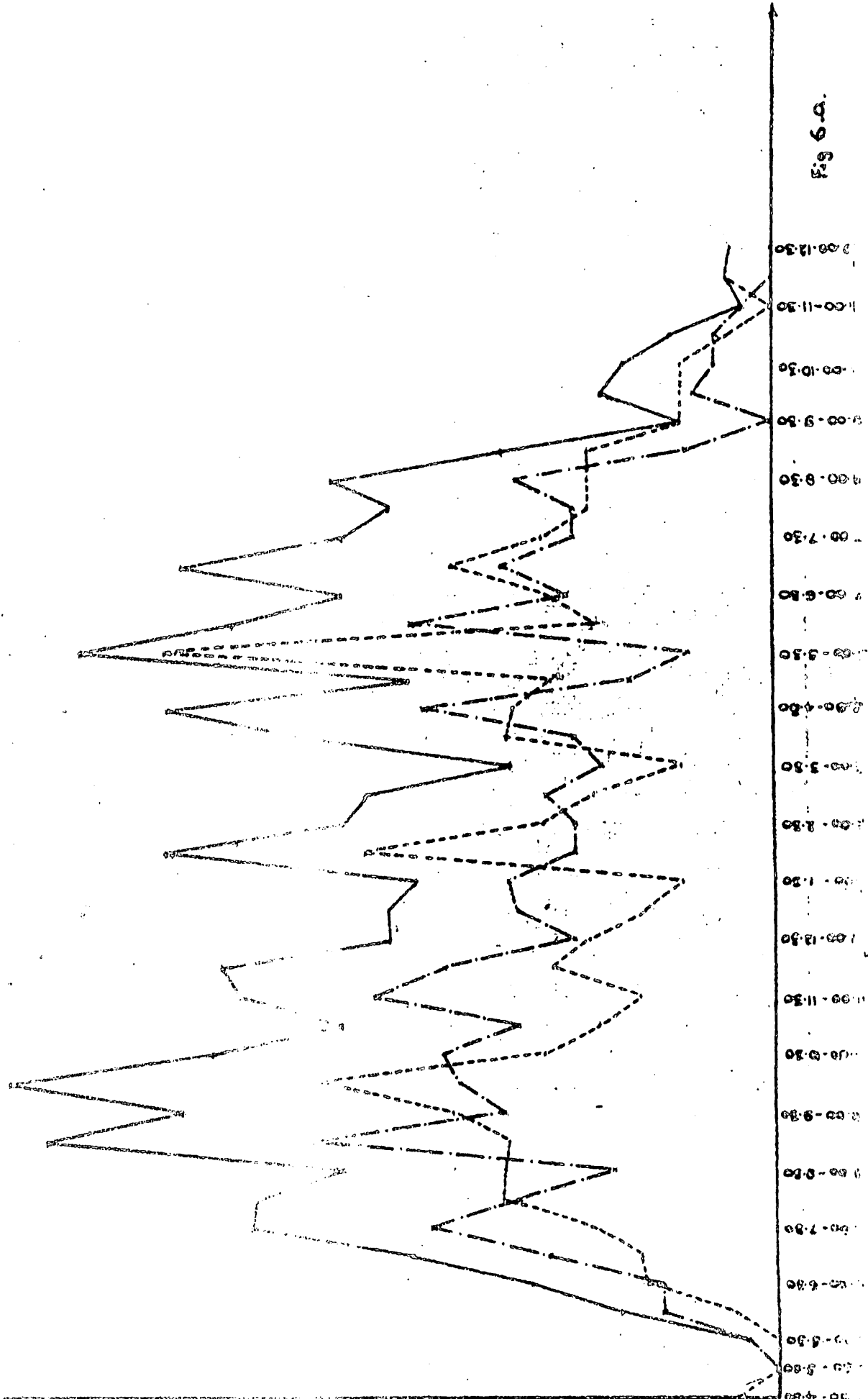


Fig 6.a.

PERCENTAGE SHARE OF SEATS (ROUTE NO. 100)

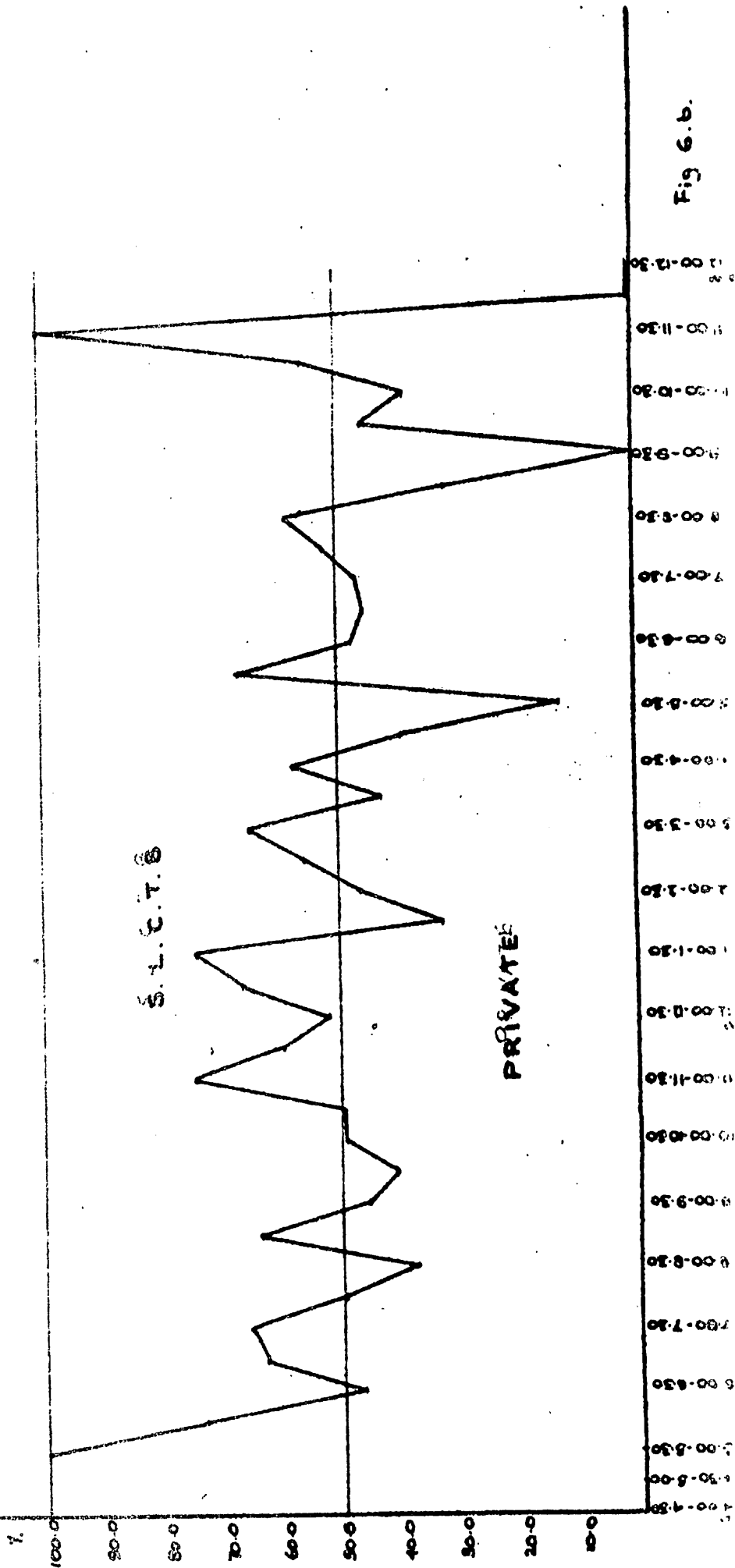


Fig 6.b.

TOTAL CAPACITY / HOUR (ROUTE NO. 100)

S.L.C.T.B.
PRIVATE
TOTAL

CAPACITY / No.

2500
2000
1500
1000
500
0

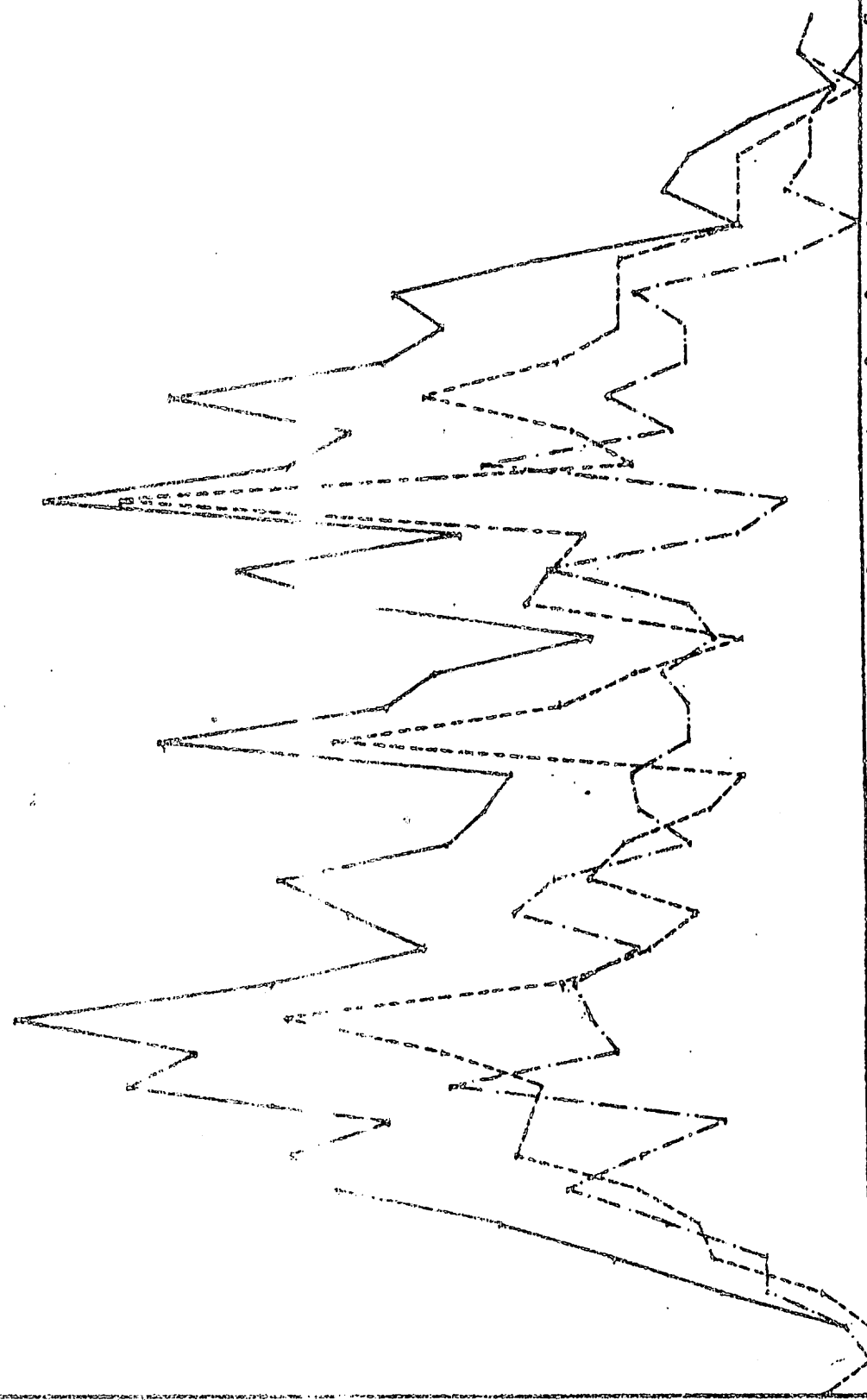


Fig 7.2.

PERCENTAGE SHARE OF CAPACITY (ROUTE NO. 402)

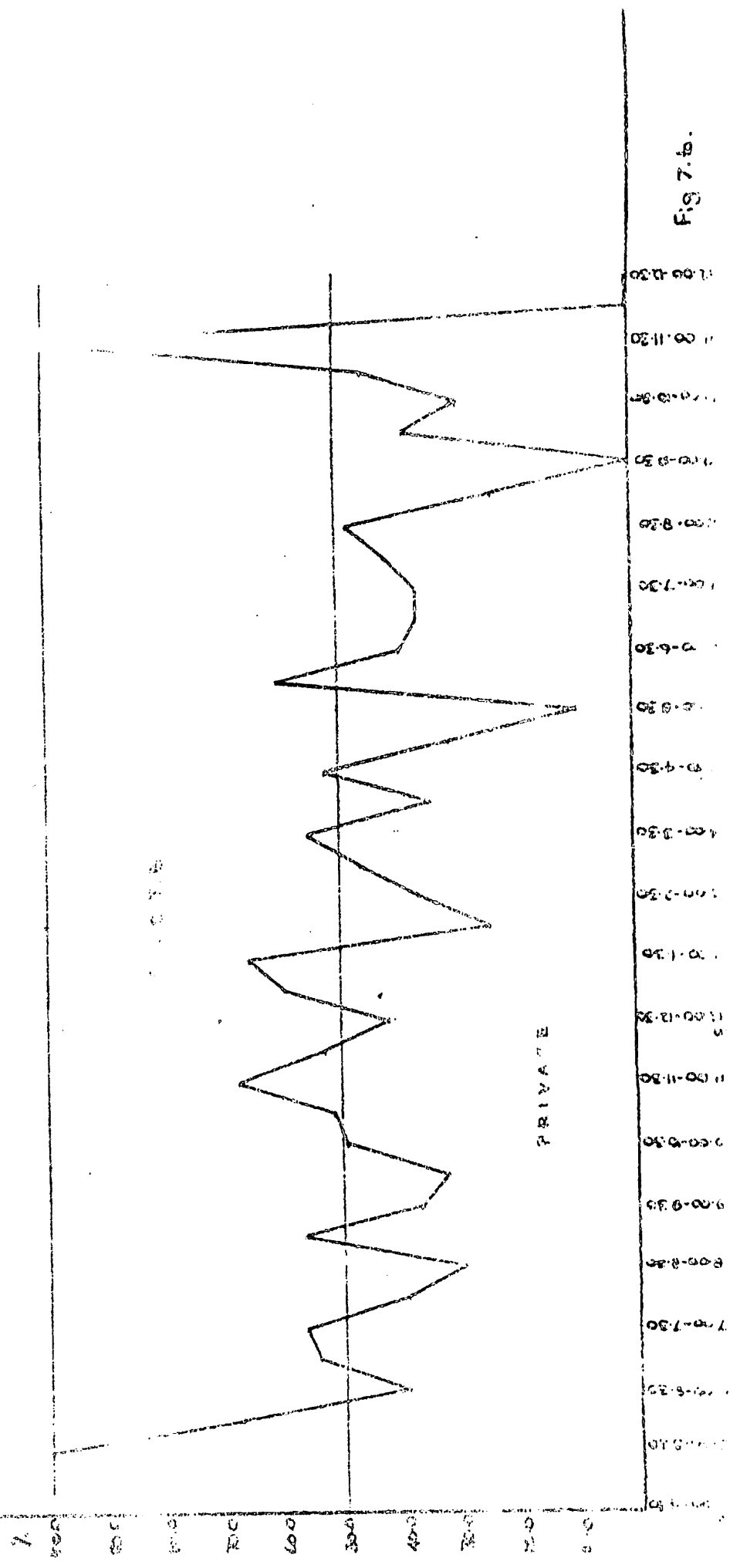


Fig 7.b.

**The Electric Trolleybus as a Mode of
Transportation within the City of Colombo**

by

Shakar Mohideen

**441 1/1, Galle Road,
Colombo 4.**

ABSTRACT

The history of trolleybus transport in Colombo is traced. With a view to reintroduction of trolleybuses services in Colombo, the advantages and disadvantages are outlined. The energy costs of running trolleybuses and diesel buses are compared. Given the abundance of hydro-electric power in Sri Lanka, a return to trolleybuses is advocated.

1. INTRODUCTION

Some very cogent reasons as to why the Trolleybus should be re-introduced to Great Britain are given in reference (1). In his resume the author states that by 1950 the United Kingdom was operating far more trolleybuses than any other country. "By 1972, the last year of Trolleybus operation in this country there had been 40 systems in England, 5 in Wales, 2 in Scotland and 1 in Belfast. London alone had about 1800 of these vehicles vastly more than any City in the World. It seems strange that the country which so much favoured this clean, fast, reliable form of transport should get rid of it completely in the 1960s and early 1970s."

Let us look back at our short lived Trolleybus service in the City of Colombo. The service was begun on the 22nd July 1953 and we had trolleybuses operating on the following routes:-

Fort	-	Grandpass
Fort	-	Galpotta
Fort	-	Borella
Borella	-	Galpotta

The service was operated by the Colombo Municipal Council who had taken over the running of the Tramways in 1944. The Tramways ceased to operate on 30.6.1960. The Trolleybuses were very popular and efficient, but what made the Colombo Municipal Council to suspend the service? I understand that the major problem was due to strikes. Another factor appears to be the fight for a more considerable tariff from the Electricity Board. Numerous strikes paralysed the service which was just getting into its strides. It was really an unfortunate decision to close down the Trolleybus service even before the vehicles reached the end of their economic life.

Now that all forms of transport have been nationalised it is time to take a second look at the Trolleybus as a means of transport within the City. We have five major hydro projects in hand. It has been stated that the Victoria project will have the largest hydro

potential - 780 Giga Watt Hours. Besides the Victoria project we have the Kotmale, Maduru oya, Randenigama and Moragahakanda projects - well in hand. Perhaps enough power for the Island's needs for the next twenty years.

In reference (2), the author states that the demand for energy could increase between 50% to 100% by the end of the century. Oil has long been used as it has been comparatively cheap. Now other forms of energy are being pursued. The U.K. Advisory Board is looking into the possibility of using liquid hydrocarbon synthesised from coal and electric traction. The author goes on to say 'Although the re-introduction of a Trolleybus service would be expensive it would be valuable to lay on a demonstration project.' Developments of a new system would take some twenty years, so it needs to be pressed ahead as a matter of urgency".

Unfortunately we in Sri Lanka do not plan ahead to such an extent - let us make our plans right away - immediately - to re-introduce the Trolleybus service within the City. It will take at least an year after approval to get started. By the time the infra-structure is ready we should have all the electrical energy that will be needed. Prices are escalating and now is the time to launch this project. In most countries where electricity is being produced by hydro power they are going ahead in introducing or expanding the trolleybus services. There is no ceiling to the rising price of fuel oil, but with our 'home made' energy we can estimate our costs fairly confidently.

Ecological consideration do not appear to have been given a thought at present in our Country. buses have been taken for granted. Exhaust emission has been considered a health hazard in advanced countries and legislations have been formulated to control air pollution.

2. THE ADVANTAGES OF USING TROLLEYBUSES

1. Electrical energy required will be drawn from the Ceylon Electricity Board.
2. No drain on Foreign Exchange for fuel.
3. There is not much difference between the chassis used for diesel engined buses and that of the electric trolleybus. The main difference is that the engine and gearbox will have to be replaced with an electric motor and suitable controls.
4. The electric trolleybus is the simplest form of road service vehicle. The power unit has only one rotating member, the armature.
5. Owing to the simplicity of its working parts there is considerable reduction in wear and tear.
6. The smoothness with which the drive is taken up is an advantage.
7. Low maintenance costs are exhibited by trolleybus systems.
8. Spares for motive power is at a minimum and when a motor needs overhauling it could be done in a short period of time.
9. A lubricant is only required for the differential unit against the vast quantities required for internal combustion engines and gear boxes.
10. Tyre life is increased owing to the smoothness of the drive and absence of jerks due to gear changes.
11. With the use of a six wheel dual axle double deck trolleybus a tipping angle of 30 degrees from the vertical is perfectly safe. The six wheeler has excellent riding qualities as the load is distributed evenly over two axles, the weight on each axle is halved and the pressure of the load on the road is correspondingly reduced and of course a larger seating capacity is obtained.
12. There is a complete absence of pollution and noise.
13. Regenerating braking equipment is more or less standard on trolleybuses. This means that the driver does not have to apply

the brakes to slow down the vehicle. A retarding effect is obtained by the motor which acts as a generator returning current to the line. Brakes are only required when the speed has dropped to about 6 m.p.h. A great saving on brake lining and drum wear is the result.

14. There is always a reserve of power. Motors are capable of 100% overload for short spells, such as when starting.

3. THE DISADVANTAGES OF USING TROLLEYBUSES

1. As the trolleybus has to collect its motive force from an overhead line it is naturally limited to a specific route. This is not such a disadvantage as the bulk of passenger transport in a city is on regular routes. Although the trolleybus is anchored to specific routes it is as mobile as an I.C. engined bus. It has a lateral deviation from overheads as much as 18', can move from the curb to the centre of the road easily, loads and unloads passengers at the curb side and in the unlikely event of a breakdown the trolleybus can be parked by the curb side and not interfere with other vehicles using the same route.
2. Capital expenditure is high. Necessary poles have to be installed all along the routes and overhead wires have to be drawn with necessary safety precautions. This is by far the most expensive item in installing a trolleybus service. By taking a long term policy in this and considering that electrical energy, provided locally with an immense saving in foreign exchange is used, this alone would be sufficient reason to offset the initial expense on installation.
3. The unsightly lines, points and crossings at junctions of the overhead wires.
4. The maintenance of the overhead equipment. The wear and tare of overhead lines is quite low and has been proved to be trouble free.

5. Inability to reverse. For this reason turning circles have to be installed at the end of each route.

By going around a block at the terminus this can be overcome but at certain points provision will have to be made for adequate turning facilities. The latest type of trolleybuses are being equipped with their own batteries. Energy can be drawn from these batteries to run for short distances such as for turning around and getting around unforeseen road blockages. Naturally such equipment increases the cost of operation and adds to the tare of the vehicle.

6. Failure of power. In this instance provision can be made to switch on to a standby power supply.
7. Possibility of trolley poles leaving lines. This is very unlikely with present day developments.
8. Vehicles cannot overtake each other on the same route. This is a disadvantage at peak traffic.

4. COMPARISON OF ENERGY COSTS

It has been found that a fully laden 66 passenger double deck trolleybus consumes about 2.5 units of energy per bus mile while a single deck bus consumes about 2 units. Further economy of energy consumption is obtained with the use of regenerating motors which return current to the line when the vehicle is slowing down on going down an incline. The motors then act as generators. Power is not consumed when the vehicle is stationary.

Let us compare the running cost of a diesel engine bus with a electric trolley bus of the same seating capacity. For a normal single deck bus, figures obtained from the Central Transport Board give an average mileage of 155 miles per vehicle for City operation with a fuel consumption of 10 m.p.g. at a cost of Rs.30/69 a gallon of fuel.

Average miles per day	155 miles	
Fuel consumption per gallon	10 m.p.g.	
Cost per gallon	Rs.30.69	
Fuel require per vehicle per day	15.5 gallons	
Cost per day	Rs.475.695	
Cost for one year (taken as for 300 days)	Rs.142,708.50	
Cost for one year for 100 vehicles	Rs. 14,270,850 -	
	14.27 m	
Trolleybus operating as above.		
Cost per unit of energy	Rs.1.26	
(Govt. Gazette 24.4.1982 - industrial tariff cts.-/60 per unit plus fuel adjustment charge of 110%)		
Cost of energy per mile	Rs.2.52	
Against cost per mile on diesel	Rs.3.07	
Savings per mile using electrical energy	cts./55	
Savings on 155 miles	Rs.85.25	
Savings on 300 days	Rs.25575	
Savings on operating 100 vehicles	Rs.2557500	2.557 m.

Table 1.

The savings on energy cost obtained by running trolley buses are shown in Table 1.

Besides the saving of fuel there is the considerable saving on the cost of engine and gear oil, fuel and oil filters and the maintenance cost of the diesel engines.

Recently the CTB Vice Chairman estimated the loss of fuel oil due to pilfering at between Rs.180 million to Rs.275 million per annum. There is no opportunity for such pilfering when electrical energy is used.

In just a short period of between two to three years the whole cost of installation of overhead cables and terminal garages could be covered on the savings effected.

5. CONCLUSION

My main contention in advocating the switch to the operation of trolleybuses is that locally produced energy will be consumed with an immense saving in foreign exchange. Capital expenditure is high but once the infra-structure is completed the saving in running cost will be considerable. The Ceylon Transport Board purchases hundreds of new vehicles annually. Let us begin with 100 trolleybuses - the cost will be more or less the same as the normal diesel engined vehicles. Trolleybuses have a longer life span and they will operate only on routes with a high density of traffic. Our Government is spending millions on new schemes for the benefit of the nation. The re-introduction of the trolleybus will be an investment for the good of the City commuters. A 30' overall length standee single deck trolleybus can carry 100 passengers without discomfort and without being liable to be thrown about inside the vehicle. Our roads will be safer and cheaper to maintain with the absence of diesel oil presently being spilled on the roads. We will have less noise and above all it is infinitely to be preferred to the stench of a hundred diesel buses."

Some of the old trolleybus poles for the overhead lines are still in their place on parts of the former routes. We could make a start on these same routes.

When I was in Europe I was amazed to find that the electric tramway was still popular. On inquiring as to why these Cities still retained the Tramways, I was informed that wherever it was found that electrical energy could be used, maximum priority was given to this form of energy as it was produced by Hydro power.

Switzerland has a massive programme of converting motor buses and tramways to trolleybus operation. Belgium, West Germany and Holland have decided to expand their trolleybus services. Italy is

going ahead incorporating the latest technology in trolleybus design.

I understand that Russia is going ahead in strengthening their trolleybus service. It is said that the Moscow network now outnumbers the former London network of vehicles.

To increase the carrying capacity double deck trolleybuses may be used. They will take up the same space as a single deck vehicle but with an increased passenger load up to 75%. Then trailers may be attached to the trolleybus which will facilitate the quick clearing of commuters at peak times. The only problem is the combined length of bus and trailer.

There has been a proposal to electrify the railway for urban traffic. This would certainly be an asset but the cost is a major factor. Two other alternative modes of transport may be adopted. One is to construct underground tubes and operate an underground service. This would be ideal as there will be no congestion of the highways. The other is to build overhead tracks and run electric railways. All these forms of transport will need electrical energy. If one were to closely examine the different systems it will be seen that by installing the trolleybus system there will be an easier flow of traffic and probably it will be the cheapest of the proposed systems.

The Ceylon Electricity Board informs me that the present fuel adjustment charge is only a temporary measure. When our Hydro power situation improves and less thermal power is used the fuel adjustment charge will come down proportionally and will eventually be removed entirely. Then the cost of electrical energy will be cents sixty only a unit or perhaps it may go up a maximum of a further 50%. This is something that we can look forward to, but where the price of fuel is concerned there is no 'top' limit.

Let our Government adopt the trolleybus service, let us do it quickly, let us save on our foreign exchange and use our locally produced form of energy.

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BUS TRANSPORT IN INDIA

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An overview of bus transport in India is given. The social, political and Economic goals to be achieved by provision of bus transport are discussed in the context of the historical development of road passenger transport.

1. INTRODUCTION

It is often said that India lives in its villages. That this is no mere rhetoric is proved by the latest (1981) Census figures, which place the percentage of the total population still living in the villages at 78 per cent - 532 million out of a total of 683 million. Thirtythree years of relentless industrialisation, almost all of it concentrated around the bigger cities, has not changed the overall picture. All that has happened is that the industrial urban centres have succeeded in drawing the youth and the talent of the villages to themselves, since it is these centres, rather than the villages, which offer job opportunities.

The 100 per cent increase in the population of the country during the last three decades, has not been matched by a proportional increase in the means of transportation. If we were to add to this the effects of industrial and agricultural growth which create their own imperatives of mobility, we would get the picture of a transportation system which is inadequate and consequently under tremendous strain.

The country has an extensive rail network, which had doubtlessly succeeded in linking up important cities and towns. Even so, having regard to the wide dispersion of the human habitates in the country, it cannot provide the necessary links between the thousands of villages which constitute rural India, the India of 532 million people. Air transport is mostly confined to metropolitan cities and has no impact of rural transportation. In any case, it has priced itself beyond the reach of the villager.

The inability of these two modes of transport to serve rural areas meaningfully and adequately has placed motorised road transport in the unique position of being the primary, and in some cases the only, mode of transport which can provide effective links to these thousands of villages.

Roads and road transport are therefore an essential prerequisite to our attempt to open up the rural hinterland of this country, thus bringing it into the mainstream of national life. Without roads and road transport, the realisation of our national goals of socio-economic development must remain a distant dream.

Closely associated with their accessibility to passengers, rural bus services have the advantage of a more and responsive frequency of schedules compared to train services. The relatively small size of a typical rural bus makes it much easier for the operations to adjust their schedules to the needs of the traffic.

The cost of a transportation source influences a passenger's mode choice, where he has such a choice, other things being the same. The rural bus offers fares that average out somewhat below those of the other commercial passenger carriers.

2. SOCIAL, POLITICAL & ECONOMIC GOALS

Rural bus services are bound to have far-reaching repercussions on the nation's social, political and economic life:-

- (a) The Indian Society is a blend of many regional and local customs, traditions and viewpoints arising out of differing heritages, environments and problems. It is only through inter-regional contacts through travel and trade that exchange of ideas can be promoted, thus encouraging an upward uniformity in tastes, health, education and way of life in general.

(b) In sparse population, secondary education can be made more easily available to students by providing them transport to and from district schools. In the situation of a shortage of both teachers and schools, such bus services can enable the society to make a more effective use of teachers and teaching equipment.

(c) Similarly, in order to provide better medical and health facilities, the new bus transport links would enable rural populations to take advantage of hospital facilities provided at district headquarters.

(d) National unity and integrity are bound to get strengthened through the breaking down of isolation. Intercourse among the people of the nation and the exchange of ideas through the written and spoken word, build up national character and help in evolving a common code of behaviour.

In addition to the social and political benefits that accrue on account of improved rural mobility, there are considerable economic benefits that a society gains by the availability of an extensive network of rural transportation. Provision of educational and health facilities will undoubtedly result in raising the nation's productivity. This in turn will provide a reservoir of labour force and enable its mobility from place to place in search of opportunities and livelihood. The easy mobility of labour to places where its services are required is of great economic significance. In circumstances where rural labour is only partly employed by agriculture, easier mobility will enable redistribution of the labour force in lean seasons resulting in continuous employment and higher productivity.

In short, rural bus transport becomes a symbol of rural regeneration, enriching rural life for greater social, political and economic interaction. It becomes, literally, 'the tie that binds'.

3. HISTORICAL DEVELOPMENT OF ROAD PASSENGER TRANSPORT

In the absence or inadequacy of rail and air transport, bus transport became the primary mode of transport for people in the rural as well as urban areas. The inherent flexibility of bus transport, its ability to penetrate into hitherto inaccessible areas, the "promise" of a personalised service and, above all, its ubiquity have already made it an inseparable part of rural life.

Although tracks of travel, trodden by man and beast have existed in the country from times immemorial, surfaced roads and mechanised road transport are comparatively recent phenomena. The first motor vehicle came to India in the year 1898. For several years the motor vehicle remained a novelty and a luxury indulged in by the princess and the maharajas. As the number of such vehicles increased over a period of time, several provincial enactments came into existence for controlling and regulating their movement with a view to safeguarding the lives of pedestrians as also for the purposes of identifying ownership.

The first all-India enactment dealing with operational control of motor vehicles came in 1914. It is obvious that the law-makers, as well as the users of motor vehicles in the early years of the 20th century, could not have foreseen the revolution which the motor vehicle was to usher in, a revolution which has changed the life styles of people decisively and irrevocably.

Soon after World War I, the surplus military vehicles were disposed of by the Government through sale in the civil market. By the early 1920's, a large number of such vehicles were operating in several parts of the country. The growth was quick and unprecedented, and led inevitably to unhealthy competition among operators plying these vehicles for hire and reward. Once the novelty wore off and convenience became perceptible, a spurt in demand came into being and this found the then existing legislative framework totally inadequate. The Indian Motor Vehicles Act, 1914, could not cope with the new situation and had there-

fore to be supplemented by enactments made in the various provinces in order to introduce some degree of regulation and control over an activity which was growing very fast.

The Government enacted a new legislation in 1939 entitled "the Motor Vehicles Act". The stated purpose of this legislation was to ensure the growth of road transport on the basis of greater coordination within the industry on the one hand and with the railways on the other. This Act was an endorsement of the potential of motor transport in carrying people and goods for hire or reward. This legislation, which is in force even today provided for the creation of Regional and State Transport Authorities, with full powers to grant permits for stage (passenger) carriages. It also laid down conditions pertaining to routes, timings, specifications of vehicles, standards of maintenance, etc. These conditions were to be attached to the permits for the permit holders to observe.

In 1943, the Post-war Reconstruction Report of the Technical Sub-Committee to the Sub-Committee on Transport (on the future of road transport and road-rail coordination) drew the attention of the Government to the need for "regular, speedy and comfortable motor service, enforcement of maintenance and other safety measures, prevention of flooding of roads by motor transport concerns resulting in cut-throat competition" and urged that, in order to have "civilised facilities for travel commensurate with the density of the traffic and the service which that traffic can support the conditions requisite must inevitably result in the replacement of the small owner by large Companies".

This recommendation was reiterated in 1945 by the Transport Advisory Council and also by the Post-War Policy Committee on Transport. In pursuance of these recommendations, several State Governments used compulsion as well as persuasion to reorganise individual operators into bigger units. A scheme, known as the Tripartite Scheme, was introduced under which joint stock companies were to be organised in the States. The shareholders were to be (1) Indian Railways, (2) State Government, and (3) motor bus operators. Thirty-five per cent share capital was to be subscribed by the Railways,

another 35 percent by the State Governments and 30 per cent by the bus operators of the State. If individual operators could not pay for their share in cash, their buses were to be accepted in good condition in lieu thereof. Such corporations were to be organised in all the States in India and profits were to be divided among the three parties according to their share of capital. In the beginning the scheme was welcomed, but it ultimately failed because the bus operators thought that their voice would not be heard in the new organisation.

The pre-Independence scene may be summed up as a period of both the beginning as well as the blossoming of bus transport in the country. The potential of the industry was quickly realised and the Government took steps to control and regulate the industry both to avoid unhealthy competition and to protect the railways in which it had considerable financial interest.

3.1 Independence and after

One does not notice any dramatic change in the transport situation on the achievement of Independence. Attempts to unite the road transport industry under cooperative or planning viable units were however made but they did not meet with success. Among the immediate post-Independence priorities, road transport did not find a place. The Industrial Policy Resolution of 1948 made no mention of this sector. In the Industrial Policy Resolution of 1956 road transport was mentioned as the eleventh of twelve items in the Schedule B, which listed industries to be progressively state-owned and in which the State would take initiative in establishing new undertakings. There was scope left for private enterprise to supplement the efforts of the State.

The enactments of the Road Transport Corporations Act in 1950 is the first major initiative taken by the Government after Independence. This legislation created the basis for nationalisation of the industry and, at the same time, provided for the unification of the industry under Government monopoly.

The provisions of the Road Transport Corporations Act enabled capital participation of both the Central and the State Governments in case the latter considered it necessary in the public interest to form such Corporations for operating bus services. The objectives of nationalisation, as enshrined in Sections 18 and 22 of the RTCs Act, were to provide, secure or promote an efficient, adequate, economical and properly coordinated transport services to be run on business principles. Suitable amendments were made in the Motor Vehicles Act in 1956 to enable schemes of nationalisation prepared by the Corporations to be approved by the Government.

3.2 The Working of STUs

There are presently 52 State Transport Undertakings with a total capital investment of Rs. 1133 crores. These Undertakings operate nearly 70,000 buses accounting for 53 per cent of the total number of buses operated in the country. A total of 5.2 lakhs employees are presently working in State Transport Undertakings.

In spite of several resources constraints, the public sector has succeeded in increasing its share of buses from 32% in 1961 to 53% in 1981. Over the years, they have been able to register steady increase in staff productivity and resource utilisation.

The financial performance of State Transport Undertakings has, however, been causing concern. The mounting cost of operation on one side and the increasing taxes and stagnating fares on the other have mainly contributed huge financial losses. The operating ratio has been steadily around 94% during the period 1975-76 to 1979-80. This means that 6% of the total revenue is the margin that is available for STUs to meet taxes and interest and also yield a reasonable rate of return. But taxes and interest alone worked out to nearly 23.35% of total revenue (19.98% interest). These have to be set off against a gross operating margin of 6%, which is why most STUs are operating on financial losses.

The physical performance of STUs has been steadily improving. In view of the increasing realisation of its social obligations and the role it is intended to play in the overall economic development,

public sector transport industries recent improvements in performance augur well for the future.

4 CONCLUSIONS

The history of development of road transport in India clearly indicates the role it can play for building up available infrastructure for economic development. The nationalisation of the industry which prevented its fragmentation reduced unhealthy competition. It has, by and large, been able to take care of the transportation needs in less developed regions and to provide larger special benefits in terms of service, employment etc. The improvements in physical performance of STUs during the last 10 years are encouraging. The continuing importance in road transport can be further bolstered up by STUs responding to the challenges of economic development and further tightening their efficiency. In terms of financial performance however, if the fares are still kept low and taxation high, there is need for financial help and investment priorities. There is no doubt that the State Transport Undertakings will face the challenge of operating an efficient and adequate service if the government which willed its existence also wills the means they require to realise their objectives.