THE STUDY OF THE DEVELOPMENT OF BUS ROUTING PLAN FOR THE WESTERN PROVINCE

R.M.N.T. SIRISOMA

This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfilment of the requirement for the Degree of Doctor of Philosophy.

Supervised By

Professor J.M.S.J. Bandara

Department of Civil Engineering

University of Moratuwa

Sri Lanka

December 2006

DECLARATION

The work included in this thesis in part or whole, has not been submitted for any other academic qualification at any institution.

R.M.N.T. Sirisoma

UOM Verified Signature

Prof. J.M.S.J. Bandara

ABSTRACT

Effective design of transit routes and service frequencies can decrease the overall cost of providing transit services, which generally comprises passenger costs and operator costs. Usually route design is done with route scheduling and efficiency of the service is significantly depends on the route network. However, the route design problem is not straightforward due to its multi-objective nature, non-linearity and non-convexity of the objective function. The relation of the constraints and decision variables to the objective function are non-linear. Non-convexities are illustrated by the fact that more buses can be deployed without decreasing total travel time by changing the route length. Non-availability of reliable passenger demand data is another constraint.

At the first stage of this study, primary bus routes that operate between Divisional Secretariats Divisions were considered. Primary route network was developed based on the passenger demand distribution in the existing system. An algorithm was developed to generate the route network with the condition that all nodes (zone centroids) have to be served at least by one bus route. In this algorithm, the maximum demand O-D pair in the demand matrix is considered first. Routes were assigned along the minimum path between those two zones assuming all the passengers would select the shortest travel path. Any inter-zonal travel demand between zones that falls within the route under consideration is also added to this route and taken off from the demand matrix. After generating the primary network, user is given the choice to fine-tune the network by using a set of algorithms for route merging, adding links and route sprouting. Fleet requirement, passenger transfers saving after each modification, revenue and operating costs per bus trip were calculated to evaluate route network.

To determine the passenger demand distribution, an Origin-Destination matrix was developed based on bus passenger interviews and available socio-economic information. Passenger demand distribution over the study area was obtained based on a model calibrated using household & roadside interview data and travel costs between node pairs in the selected zones. It can be seen that most of the existing routes are operating in the high demand corridors. But there are new routes to be introduced to newly developed zones in the study area.

ACKNOWLEDGEMENT

I express my sincere gratitude to Prof. J.M.S.J. Bandara, research supervisor, for his guidance and constant encouragement given in completing this project. I am also grateful to Prof. Amal Kumarage, Professor of Civil Engineering, University of Moratuwa for the encouragement given and the supervision the research during the absence of Prof. Bandara in year 2000.

My gratitude extends to the National Science Foundation for providing financial support for this research. I extend my sincere thanks to Prof. Mrs. N. Rathnayake, Former Director, Postgraduate Studies of University of Moratuwa for arranging financial assistance and conducting research assessment program. In addition, I would like to thank the Dean, Faculty of Engineering, Current Director Postgraduate studies Dr. Nanda Munasinghe, Head of the Department and the Research co-ordinator of the Department of Civil Engineering, for providing me the opportunity to complete this research.

I would like to extend my thanks to Dr. Upali Vandibona, Senior Lecturer from the University of New South Wales providing much needed research papers on Public Transport to make my research a success. A special thank go to Mr. Indika Ekanayake for his kind kelp on preparing the computer program on bus routing. In addition, I wish to thank my external examiner Dr. T.L. Gunaruwan from University of Colombo for giving me valuable ideas and comments during my progress reviews.

I would like to thank all the staff members of the Transport Engineering Division, Western Province Transport Authority and National Transport Commission for their assistance extended for this research. My thanks go to Mr. Nimal Perera who helped me in editing this report in a very short period. Finally, my thanks go to my spouse Manjula, my parents and my brothers for their constant encouragement and support extended throughout the study to make this research a reality.

CONTENTS

CHAPTER 5: DATA ANALYSIS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
CMC	Colombo Municipal Council
CMR	Colombo Metropolitan Region
CMRSP	Colombo Metropolitan Regional Structure Plan
CUTS	Colombo Urban Transport Study
CUTS-1	Colombo Urban Transport Study - Stage 1
DSD	Divisional Secretariat Division
HH	Household
O-D	Origin - Destination
TED	Transportation Engineering Division
UoM	University of Moratuwa
CTB	Ceylon Transport Board
HO_i	No. of HH + Other Buildings in zone i
HO_j	No. of HH + Other Buildings in zone j
b_f	Bus fare per km
BAC	Boarding/Alighting Cost
$dist_{ij}$	Distance between two DS divisions in km
VOT	Value of time per passenger per hour
$Time_{ij}$	Travel time between two DS divisions
wt	Waiting time in Hrs
OCH	Outer Circular Highway to City of Colombo
WP	Western Province
C_w	waiting time cost
C_v	in-vehicle cost
F	Fleet size
RTT	Round Trip Time
H_B	Head-way
O_c	Operating cost per km
l_1 , l_2 , l_3	Length of each link in the route
D_1 , D_2 , D_3	Passenger Demand in each link
BRAP	Bus Route Analyser and Planner