ADVANCED MODELING FOR TRANSIT OPERATIONS AND SERVICE PLANNING

Related books

BELL (ed.)	Transportation Networks: Recent Methodological Advances
GIFFORD	Flexible Urban Transportation
HENSHER (ed.)	Travel Behaviour Research: The Leading Edge
HENSHER & BUTTON (eds.)	Handbooks in Transport Series
MAHMASSANI (ed.)	In Perpetual Motion: Travel Behaviour Research Opportunities and Application Challenges
TANIGUCHI	City Logistics
TAYLOR (ed.)	Transportation and Traffic Theory in the 21st Century
TILANUS (ed.)	Information Systems in Logistics and Transportation
TURRÓ	Going Trans-European: Planning and Financing Transport Networks for Europe

ADVANCED MODELING FOR TRANSIT OPERATIONS AND SERVICE PLANNING

edited by

Professor William H.K. Lam
Department of Civil and Structural Engineering
The Hong Kong Polytechnic University
Hong Kong, China

and

Professor Michael G.H. Bell
Centre for Transport Studies
Imperial College London
United Kingdom

Emerald

United Kingdom – North America – Japan
India – Malaysia – China

Emerald Group Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2003

Copyright © 2003 Emerald Group Publishing Limited

Reprints and permission service
Contact: booksandseries@emeraldinsight.com

No part of this book may be reproduced, stored in a retrieval system, transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without either the prior written permission of the publisher or a licence permitting restricted copying issued in the UK by The Copyright Licensing Agency and in the USA by The Copyright Clearance Center. No responsibility is accepted for the accuracy of information contained in the text, illustrations or advertisements. The opinions expressed in these chapters are not necessarily those of the Editor or the publisher.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-0-58-547522-6

ISOQAR QUALITY ASSURED ISO 9001 UKAS QUALITY MANAGEMENT 026
Certificate number .....1985.....

Awarded in recognition of Emerald's production department's adherence to quality systems and processes when preparing scholarly journals for print

INVESTOR IN PEOPLE

PREFACE

The idea for this book grew out of the organization of the Advanced Study Institute (ASI), which was sponsored by the Croucher Foundation (http://www.croucher.org.hk/) for the dissemination of knowledge and the formation of international scientific contacts on advances in modelling transit systems. While public transport (or transit) systems have arguably been in existence much longer than road traffic systems, the mathematical analysis techniques so necessary for the proper planning of transit operations have lagged far behind those for road traffic systems. For example, the body of literature available on the design of schedules for urban rail lines is miniscule in comparison to the literature on the coordination of traffic signals along an urban road.

On the other hand, transit professionals appear to have disregarded most of the wealth of insights that have been available in the literature for more than a decade. The literature on transit assignment is a good example. However, public transport operators, particularly in Hong Kong and Asia, are facing ever-greater pressure in competitive markets and transit systems are congested. The need to estimate passenger demand, to monitor the performance of individual services as well as the system as a whole, to support better planning and tighter operations management, and for external reporting has increased. The optimization of transit line frequencies and transit fares has become very important for operations and service planning. Reliability and control issues are also critical in making transit systems more efficient, supported by the introduction of Intelligent Transport Systems (ITS). As tightening constraints raise serious questions about the cost-effectiveness of existing public transport services, improvements which can be implemented in the short and long term are continuously sought. Collectively, these pressures have focused attention on advanced methods and new techniques for improving transit planning and operations.

In Hong Kong and other major cities in Asia, over 90% of people are using transit facilities for their daily travel. The recent rapid development and deployment of ITS makes it possible to improve the efficiency of transit operations. This book addresses the important and timely problems of how to improve transit operations and service planning by making use of new technologies and advanced modeling techniques. It will provide important references for determining the outcomes of introducing these technologies and methods, and thus assist transit professionals and scientists in resolving practical issues arising from the implementation of ITS. This book appears to be the first devoted exclusively to the topic of advanced modeling for transit operation and service planning.

This book consists of 12 chapters chosen to represent the broad base of contemporary themes in modeling transit systems. Scholars from America, Europe and Asia have contributed their knowledge to produce a unique compilation of recent developments in the field. Topics both in theory and innovative applications to real world problems are included. The book covers Transit Planning and Network Design, Transit Assignment Models and Solution Algorithms, Simulation of Passenger Behaviors, Effects of ITS on Passenger Choices and Transit Service Improvements, Modeling Multi-modal Transit and Urban Taxi Services.

Outline of the book contents:

Chapter 1 - Initial Planning for Urban Transit Systems
Chapter 2 - Public Transport Timetabling and Vehicle Scheduling
Chapter 3 - Designing Public Transport Network and Routes
Chapter 4 - Transit Path Choice and Assignment Model Approaches
Chapter 5 - Schedule-Based Transit Assignment Models
Chapter 6 - Frequency Based Transit Route Choice Models

Chapter 7 - Capacity Constrained Transit Assignment Models and Reliability Analysis
Chapter 8 - Dynasmart-IP: Dynamic Traffic Assignment Meso-Simulator for Intermodal Networks
Chapter 9 - Modeling Competitive Multi-Modal Services
Chapter 10 - Modeling Urban Taxi Services: A Literature Survey and an Analytical Example
Chapter 11 - The Estimation of Origin-Destination Matrices in Transit Networks
Chapter 12 - Models for Optimizing Transit Fares

Special appreciation is extended to Elsevier Science Ltd. who made possible the publication of all the contributions in the form of the present book in time to be available to participants attending the ASI workshop from 9th to 13th December 2002 in Hong Kong. Professor Mike Bell of Imperial College of Science, Technology & Medicine (U.K.) provided valuable oversight and guidance in enhancing the quality of the book. His support during this effort has been remarkable. Finally, I am thankful for the patience, availability, and dedication of the editorial staff at Elsevier Science Ltd., particularly Julie Neden and Chris Pringle.

William H.K. Lam
Professor
Department of Civil and Structural Engineering
The Hong Kong Polytechnic University
Yuk Choi Road
Hung Hom, Kowloon
HONG KONG
Tel : (852) 2766-6045; Fax : (852) 2334-6389
E-mail: cehklam@polyu.edu.hk

CHAPTER 1

INITIAL PLANNING FOR URBAN TRANSIT SYSTEMS

S. C. Wirasinghe, Department of Civil Engineering, University of Calgary, Calgary, Alberta T2N 1N4 Canada

1. BACKGROUND

The current state of initial transit planning in many transit agencies could be described at best as an art and at worst as a collection of ad-hoc rules. There are many reasons for this situation. The complexity of the problems involved, the non-catastrophic mode of functional failure associated with transit systems, the lack of trained planners, political interference in detailed planning and the failure of people with alternative planning tools to communicate their ideas to front-line planners have contributed to the problem.

In the typical transit planning problem we are concerned with providing a good transit service, which has a minimal environmental impact, at a reasonable cost to the transit agency and to the users. A good level of service is provided by a transit service which is reliable, easily accessible in time and space and provides a safe, fast and comfortable ride at a reasonable price. The precise definition of the objectives to be satisfied in providing the transit service, let alone their attainment, is a difficult task. The problem is further complicated by the conflicting nature of the objectives.

A good estimate of the future demand for public transit is necessary to plan a transit system. However, the demand, in addition to being a random quantity at any given time, is also to some extent dependent on the type of transit system and its parameters. This is another dilemma faced by planners.

A transit system is a failure if the objectives with which it was planned are not met to a large degree. However, this type of functional failure, as opposed to engineering failures, is not catastrophic since the system generally continues to function and to satisfy the objectives to some degree. Further, errors in planning cannot be easily pinpointed as the major cause of failure even when this is the case.

2. THE GENERAL PROBLEM

Consider a city or a part thereof for which a public transit system is being planned. The goal of such an exercise could be stated simply as the choice of the mix of transit modes or technologies (e.g. Bus, Light Rail, etc.) and related optimal functional designs, (routes, dispatching policies, etc.) for various areas of the city for different time periods (peak, off-peak, etc.) that maximizes the expected utility to society. However, the practical realization of the goal is not a simple matter.

In theory, the above problem could be converted into four related sub-problems:

(i) Determination of the set of relevant technologies or mixes of technologies.
(ii) Estimation of the present and future demand for transit given each of the possible technologies (transit systems).
(iii) Optimal functional planning of each transit system for the related demand.
(iv) Choice of one of the transit systems as the 'best' one.

However, the sub-division does not provide us with four simple problems. Rather, each one is in itself a complex problem.

2.1 Selection of Technologies

Various available technologies can be mixed in many ways for various areas of the city, for different trip purposes and for different time periods. However, the number of possible combinations is so large that it becomes prohibitive to carry out the rest of the analysis (sub-problems ii to iv) for each technology-mix. So, a smaller perhaps more relevant set has to be chosen based on speed and capacity considerations,

compatibility with technology currently in use, environmental impact, geographical constraints, etc. The interested reader is referred to the Canadian Transit Handbook (1980), Gray and Hoel (1979), Vuchic (1981), and Parajuli & Wirasinghe (2001).

2.2 Demand Estimation

An extensive literature is available on the estimation of demand. A good introductory work is that of Ortuzar and Willumsen (1994) . For further treatment of the modal-split of demand see Domencich and McFadden (1975) and Daganzo (1979). In general, one could proceed with the functional planning aspect under the assumption that the demand for transit is given. However, in selected instances that assumption can be released in favour of the one where the demand is a random quantity with known mean and variance.

2.3 The Best System

The choice of one transit-system for implementation, out of several possible, essentially boils down to a political decision. It is the planners' duty, however, to advise the decision-maker regarding the best choice. Bayesian Decision Theory offers a rational approach by which the planner can take into account the several options available, the uncertainty regarding demand, costs, etc. and a social utility function. The reader is referred to Raiffa (1970) for an introduction to Decision Theory and to Parajuli and Wirasinghe (2001) for an example of an application to transit planning.

3. FUNCTIONAL PLANNING

We are concerned with improving the present state of the functional planning of transit and not with introducing a completely new methodology. An attempt can be made to make the planning exercise more consistent by using analytical models based on some of the more relevant and quantifiable factors that pertain to the problem at hand. An analytical model can be optimised to obtain a theoretically sound 'initial-solution' that can then be improved and 'fine-tuned' using all available hard and soft, quantifiable and non-quantifiable constraints and other information. The 'science' of transit planning can be considered to be the analytical modelling of a real system and its optimisation, while the 'art' is the conversion of an optimal analytical solution into a practical answer to a real, complex problem.