EVALUATION OF EFFECT OF TRAFFIC SIGNAL COORDINATION SYSTEM ON CONGESTION

MAHMOOD MAHMOODI NESHELI

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Engineering (Transportation and Highway)

Faculty of Civil Engineering
Universiti Teknology Malaysia

May 2009

Acknowledgements

I would like to express heartfelt gratitude to my supervisor Professor Othman Che Puan for his constant support during my study at UTM. I have learned a lot from him and am fortunate to have him as my mentor and advisor.

I am thankful to UTM School of Postgraduate Studies (SPS) and Faculty of Civil Engineering (FKA) and laboratory of Transportation and Highway for their support to conduct this work.

Finally I wish to thank the most important people of my life. I express my indebtedness to my parents. Their blessings and love is always a source of motivation for me. I thank everyone in my family for their love and blessings. Thanks to all my friends for their love and constant encouragement to pursue my goals with confidence and determination.

ABSTRACT

A lot of effort has been concentrated on the development of various tools for the optimization of transportation systems. The potential benefits of studying coordination systems of traffic signal are already known in traffic flow analysis, modeling and traffic engineering design. However, presently there is a lack of information on coordination system on Malaysian roads. This study determines the coordination system pattern of traffic signal for two intersections space at 275m distance. Data for vehicles movement were collected using video camera during the morning peak and evening peak hour. A simulation model, TRANSYT, was used to evaluate the possible coordination of both signalized intersections. To calibrate TRANSYT, delay, queue and journey time practically were measured. The results show after coordinating system, the value of delay, journey time, and queue reduced. The average delay during morning peak hour in base case simulation was obtained 58sec/veh which it reduced to 32.8sec/veh in coordination system. The same result was attainable for evening where the value of delay by 60.3 sec/veh in the base case reduced to 34.4 sec/veh in the coordination system. Therefore it leads to improve the level of service from E in the base case to C for coordinated one.

ABSTRAK

Banyak usaha telah dibuat untuk penubuhan berbagai alatan untuk pengoptimuman system pengangkutan. Potensi kepada pengajian koordinasi system signal trafik adalah dikenali sebagai analisis perjalanan trafik, modeling dan desin kejuruteraan trafik. Walaubagaimanapun, dewasa ini terdapat kekurangan infomasi terhadap system koordinasi di jalanraya di Malaysia. Kajian ini ingin melihat system koordinasi system trafik untuk dua persimpangan di jarak 275 m. Data pergerakan kenderaan dikutip menggunakan kamera video semasa waktu pagi dan petang. Model simulasi, TRANSYT digunakan untuk mengenal pasti kebarangkalian koordinasi untuk kedua-dua persimpangan signal. Untuk menentukurkan TRANSYT, kelambatan, queue dan masa perjalanan di ukur. Dapatan kajian menunjukkan system koordinasi, nilai masa kelambatan dan masa perjalanan dikurangkan. Purata kelambatan semasa masa sibuk dalam simulasi kes adalah 58 sec/veh dikurang kepada 32.8 sec/veh dalam system koordinasi. Dapatan yang sama didapati untuk masa petang diman nilai kelambatan 60.3 sec/veh dalam kes dikurangkan kepada 34.4 sec/veh dalam system koordinasi. Oleh itu ia dapat memperbaiki tahap perkhidmatan dari E dalam kes asas kepada C untuk koordinasi.

TABLE OF CONTENTS

CHAPTER **TITLE** **PAGE**

LIST OF FIGURES

LIST OF TABLES

NO. TABLE **TITLE** **PAGE**

LIST OF GLOSSARY

This glossary contains some of the most common terms needed to understand traffic signal coordination.

Actuated Operation – Type of traffic signal control operation in which some or all signal phases are actuated from vehicle detectors in the pavement.

Concurrent Pedestrian Phase – A signal phase where pedestrians may cross parallel with the vehicles that have a green signal.

Controller – An electrical device mounted in a cabinet for controlling the operation of a traffic signal Figure 2-10.

Crosswalk – Any portion of a roadway distinctly designated for pedestrian crossing by lines or other markings on the surface.

Cycle Length – The time required to complete a full sequence of traffic movements.

Detector – A sensing device (usually either embedded in the pavement or from video camera locations) used for determining the presence or passage of vehicles or pedestrians. Detectors are used in an actuated or semi-actuated operation.

Exclusive Pedestrian Phase – A signal phase where vehicular traffic is stopped in all directions and pedestrians are allowed to cross in all directions.

Functional classification – Grouping of highways based on the character of service they provide. Freeways, arterials, collectors, and local roads fall under different functional classifications.

Green Band – The amount of green time available to a group of vehicles in a progressive signal system.

Interval – A portion of a signal cycle where signal indications do not change.

Offset – The time duration between the initiation of the progressed movement (phase) common to any two signals at the two intersections. It is generally measured at the downstream intersection relative to the upstream intersection.

Patterns of Operation – A set of cycle lengths, splits, and offsets part of a signal coordination plan.

Permissive Mode – A mode of traffic control signal operation in which, when a green light is displayed, left or right turns may be made after yielding to oncoming traffic and/or pedestrians.

Phase Sequence – The order of appearance of signal phases during a signal cycle.

Platoon – A group of vehicles traveling together as a group, because of traffic control signals, roadway geometry, and other factors.

Pre-emption Control – A change in traffic signal operation from normal to a special mode. This type of control is most commonly used for emergency vehicles such as fire, ambulance, and police to give them priority in an emergency.

Pre-timed Operation – Type of signal control operation where a signal cycle follows a fixed sequence, the intervals of which are of fixed length.

Progression – A time relationship between adjacent signals permitting continuous operations of groups of vehicles at a planned rate of speed.

Protected Mode – A mode of traffic signal operation in which left or right turns are protected from oncoming vehicular traffic. Under this operation, a “GREEN ARROW” is displayed and opposing traffic must stop.

Red Interval – A very short period in a signal phase where traffic is stopped in all directions and all signals display a “RED BALL” or “RED ARROW”.

Semi-actuated Operation – A type of traffic control signal in which at least one, but not all, signal phases function on the basis of actuation.

Signal Coordination – The establishment of timed relationships between adjacent traffic control signals.

Signal Phase – The portion of a signal cycle that serves a combination of traffic movements.

Signal System – Two or more traffic control signals operating in signal coordination.

Signal Timing – The amount of time allocated for the display of a signal indication.

Split – A portion of the cycle length allocated to each phase that may occur.

Time-Space Diagram – A two-dimensional representation of the spacing of various signals along a roadway and the signal indications of each of these signals as a function of time.

Walk Time – The time provided for a pedestrian, crossing in a crosswalk, to safely cross the roadway. A “WALK” and “DON”T WALK” signal is displayed to direct pedestrians to cross the roadway.

Yellow Interval – This interval follows the green interval and is a warning for motorists to slow down before the red interval is displayed.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Intelligent Transportation Systems (ITS), which apply advanced technologies to surface transportation systems, are widely viewed as the solution to the transportation problems that our society faces. In many areas, a steadily increasing demand for mobility is confronting economic, social, and physical constraints on transportation infrastructure. These constraints include reduced funding for transportation projects, social and environmental concerns about infrastructure expansion, and, in urbanized areas, a lack of physical space to devote to such projects. ITS applications, in which technology is used to increase the operating efficiency and capacity of transportation infrastructure, can supplement or even replace infrastructure development, providing more effective mobility solutions at less of a cost to society (Austroads, 2003). Urban traffic control is a major area in which ITS can be applied. At the local level, traffic signals are designed to manage vehicle conflicts at intersections, allocating time among the conflicting traffic streams which must share the use of the intersection. The logic by which the signal controller allocates usage of the intersection can range from basic fixed-time methods to intelligent strategies that detect and respond to traffic conditions in real time.

At a higher level, however, traffic signals can part of a broader control strategy. In this case, signal controllers are used as tools for managing traffic flow, either along a corridor or throughout a network, to provide a more efficient use of the urban street network. ITS applications for transit, or Advanced Public Transportation Systems (APTS), have the same goals, namely improvements of efficiency without the need for major infrastructure enhancements (Booz et al., 2003). One such application is Bus Rapid Transit (BRT), a transit concept that uses buses to provide a high level of service usually associated with rail transit. The reason that rail transit can provide such a high level of service, however, is that it operates on a right-of-way that is fixed and exclusive. This is typically not the case for city buses, which instead operate on a shared right-of-way in an open and more chaotic system. In such an environment, buses face delays caused by interactions with other vehicles and by the presence of traffic signals at intersections. These two factors can have a significant negative impact on operations (Roger et al., 2001).

One method of addressing these operational challenges is by the use of infrastructure solutions such as exclusive bus lanes. While often effective in reducing delays due to congestion, these solutions can be prohibitively expensive or, in many urban areas, infeasible due to inadequate street space. Another method is the use of control strategies, which use the existing traffic signal control system to give priority to transit vehicles. This convergence of APTS and urban traffic control is known as transit signal priority. Transit signal priority strategies can be categorized into two basic types: passive and active. Passive priority strategies are those that use static signal settings to favor streets with transit routes. These rely on signal timing plans that are prepared off-line and are designed to impede transit vehicles as little as possible. Active priority measures are those which employ dynamic detection and response to transit vehicles, altering signal settings in real-time in order to reduce delay. Implementing transit signal priority can offer many challenges. One major concern is how to implement transit priority within the existing signal control system. Another is determining what impacts the priority implementation will have on other traffic. Most fundamental, however, is the question of what benefits the priority implementation offers and whether these benefits outweigh the costs.

In these cases, simulation can be used to evaluate a proposed strategy before it is implemented determining whether field implementation will have beneficial results. Traffic simulation is an ideal tool for these evaluations, as it simulates vehicle movements at a detailed level, modeling interactions with other vehicles and response to traffic control devices.

Traffic signal coordination is a method of timing groups of traffic signals along a major roadway to provide for a smooth flow of traffic with minimal stops. The goal of coordination is to get the greatest number of vehicles through a system a group of coordinated traffic signals with the fewest number of stops. While it would be ideal if every vehicle entering the system could proceed through without stopping, this is not possible even in a well-spaced, well-designed system. Coordinated traffic signals also result in less stop-and-go traffic. This can reduce driver frustration and stress levels, and may reduce a driver’s potential to take risks on the road (McShane et al., 2004).

1.2 Problem Statement

The rapid deployment of intelligent transport systems in practice requires serious evaluation of new construction projects. Traditional transportation evaluation methods are insufficient to capture the new features of intelligent transport systems, particularly the applications of recently developed information technologies.

Traffic congestion has a number of negative effects such as following aspects that could be occur when systems are design inappropriate, for this study could be happen when system consider as uncoordinated system.

(i). Wasting time of motorists and passengers. As a non-productive activity for most people, congestion reduces regional economic health.
(ii). Delays, which may result in late arrival for employment, meetings, and education, resulting in lost business, disciplinary action or other personal losses.
(iii). Inability to forecast travel time accurately, leading to drivers allocating more time to travel and less time on productive activities.
(iv). Wasted fuel increases air pollution and carbon dioxide emissions which may contribute to global warming owing to increased idling, acceleration and braking. Increased fuel use may also in theory cause a rise in fuel costs.
(v). Wear and tear on vehicles as a result of idling in traffic and frequent acceleration and braking, leading to more frequent repairs and replacements.
(vi). Stressed and frustrated motorists, encouraging road rage and reduced health of motorists.
(vii). Emergencies: blocked traffic may interfere with the passage of emergency vehicles traveling to their destinations where they are urgently needed

There is a need to resolve or minimize congestion effects which counted by an uncoordinated traffic signal system. The current system is unable to cope with the high volume of traffic flow in the congestion conditions.

1.3 Aim and Objectives of the Study

The aim of the study is to evaluate the effect of traffic signal coordination system on congestion. Using computer software known as TRANSYT7F to simulate system. To achieve this aim, the study was carried out based on the following objectives.

(i) To evaluate travel time, speed, delay and maximum back of queue in the case study
(ii) To evaluate effect of coordination based on simulation model

1.4 Scope of the study

The study focused on application of TRANSTY7F for coordinating system. The test site consists of two signalized intersections spaced at about 275 meter apart. The measures of performance used in the analysis are journey time, delay, queue length and speed of the system.

REFERENCES

Arahan Teknik (Jalan) 13/87(1987). *A guide to the design of traffic signals*. Jabatan Kerja Raya Malaysia: Ch. 6.

Akçelik, R. (1981) "Traffic Signals: Capacity and Timing Analysis," *Australian Road Research Board (ARRB)Research Report* 123, Victoria, Australia

Austroads (2003) Economic evaluation of road investment *proposals: valuation of benefit of roadside ITS initiatives,* Sydney

Booz Allen Hamilton (2003) Assessment of benefits relative to costs of ITS facilities, VicRoads, Melbourne

Bretherton, D. (1996). Current Developments in SCOOT: Version 3. *Transportation Research Record 1554,* pp. 48-52.

Crawford, A. (1963). The Overtaking Driver. *Ergonomics*. Volume 6, No. 2: 153-169.

Christopher O. Nwagboso., Bolton Institue., (1997). *Advanced vehicle and Infrastructure Systems* UK:John Wiley & Sons

Denos C. Gazis. (1995). congestion abatement in its through centralized route allocation *Journal of Intelligent Transportation Systems*. **2** (2). 139-158.

Federal Highway Administration (1996). *Traffic Control Systems Handbook.* Report No.FHWA-SA-95-032, U.S. Department of Transportation, Washington, DC.

Gartner, N.H., P.J. Tarnoff, and C.M. Andrews (1991). Evaluation of Optimized Policies for Adaptive Control Strategy. *Transportation Research Record 1324*, pp. 105- 114.

Gartner, N.H., C. Stamatiadis, and P.J. Tarnoff (1995). Development of Advanced Traffic Signal Control Strategies for Intelligent Transportation Systems: A Multi- Level Design. *Transportation Research Record 1494*, pp. 98-105.

Goldschmidt, J. (1977). Pedestrian Delay and Traffic Management. *TRRL Supplementary Report SR356*. Transport and Road Research Laboratory, Crowthorne.

Homburger, W.S. and J.H. Kell (1988). *Fundamentals of Traffic Engineering, 12th Edition*. Institute of Transportation Studies, University of California at Berkeley, Berkeley, CA

Institute of Transportation Engineering (1982). *Transportation and Traffi Engineering Hand Book*. 2nd Edition. Englewood Cliffs, New Jersey: Prentice Hall Inc.

Institute of Transportation Engineering *Institute of Transportation Engineers,5t Edition, 1999*).

Kell, J.H. and I.J. Fullerton (1982). *Manual of Traffic Signal Design*. Prentice-Hall,Englewood Cliffs, NJ.

Kingsley E. Haynes., William M. Bowen., Carlos R. Arieira., Sara Burhans., Pofen Lin Salem and Hadi Shafie. (2000). Intelligent transportation systems benefit priorities: an application to the Woodrow Wilson bridge. *Journal of Transport Geography*. 8 (2). 129-139.

McTrans (2000). *Highway Capacity Software*. Transportation Research Center. University of Florida. Volume 21 Fall 2000 Newsletter**.**

McShane, W.R. and R.P. Roess. (1990). *Traffic Engineering*. Prentice Hall, Inc., Englewood Cliffs, New Jersey.

McShane, W.R., Roess, R.P., Prassas, E.S. (1998). *Traffic Engineering*. 2rd. ed. Prentice Hall, New Jersey.

National Transportation Operations Coalition, *Traffic Signal Standards*, (1976), USA

Nicholas J. Garber, Lester A. Hoel. (1999). "*Traffic and Highway Engineering*". West Publishing Co.

Othman Che Puan (2004). Driver's Car Following Headway on Single Carriageway Roads. *Jurnal Kejuruteraan Awam.* Universiti Teknologi Malaysia. Volume 16, No. 2: 15-27.

Ogden, K. W. (1999). Planning and Designing for Trucks. *In Traffic Engineering and Management*. eds Ogden, K. W. and Taylor, S. Y., Institute of Transport Studies, Monash University. 387-411.

Richard Whelan., (1995). *Smart Highways, Smart Cars*. Boston: Artech House

Roger R. Stough, George., (2001). *Intelligent Transportation Systems, Cases and Policies*.USA: Mason University.

Salter, R.J. (1989). *Highway Traffic Analysis and Design*. Revised Edition. MacMillanEducation Ltd, London.

Taylor, M. A. P., and Young, W. (1988). *Traffic Analysis: New Technology & New Solutions*. Hargreen Publishing Company, Australia.

Taylor, M.A.P., Young, W. and Bonsall, P.W. (1996). *Understanding Traffic Systems: Data,Analysis and Presentation*. Avebury Technical, England.

Transportation Research Institute (1996). *Background Paper No. 9 : Signalized Intersection Spacing*. Oregon State University.

TRANSYT-7F User’s Guide (1991). U.S. Department of Transportation, WashingDC.

TRB (1998). *Highway Capacity Manual*. 3rd Edition, Transportation Research Board. Special Report 209, National Research Council, Washington, D. C.

TRB (2000). *Highway Capacity Manual*. Transportation Research Board. National Research Council, Washington, D.C.

Wardrop, J.G. & Charlesworth, G. 1954. A method of estimating speed and flow of traffic from a moving vehicle. *Proceedings of the Institution of Civil Engineers, Part II,* 3: 158-171.

Webster, F. V. Traffic signal settings. Road Research Technical Paper No. 39, Department of Scientific and Industrial Research, Road Research Laboratory,1958, London, U.K.

White, J(2000). *Traffic Signal Optimization for Tyson's Corner Network Volume I Evaluation and Summary*. March , Virginia DOT

Ying Li RuiMing Wu and Wu Li. (2004). The Coordination Between Traffic Signal Control Agents Based on Q-Learning. China. *World Congress on Intelligent Control and Automation*