Missing the Bus: An assessment of service improvements to metro-bus transfers in Bangkok, Thailand

Tristan Cherry

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______________________________________Chair
Dr. Damon Matthews

______________________________________External Examiner
Dr. Ugo Lachapelle

______________________________________Internal Examiner
Dr. Zachary Patterson

______________________________________Supervisor
Craig Townsend

Approved by ________________________________
Daemon Matthews
Graduate Programme Director

_______________2011

____
Dr. Brian Lewis
Dean of the Faculty of Arts and Science

ABSTRACT

Missing the Bus: An assessment of service improvements to metro-bus transfers in Bangkok, Thailand.

Tristan Cherry

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Bangkok's mass transportation systems lack coordination to complement overall quality of service. The relatively new MRT rail rapid transit or "metro" has been built at considerable expense yet operates without any integration for transfers (fare or physical) with the existing and extensive public bus services. Minimizing the burdens of transferring from one vehicle to another is a strategy that many transit agencies in North America and Europe have implemented to retain or attract ridership, but has not been attempted in Bangkok. This thesis identifies specific actions which could improve out-of-vehicle connections between metros and buses in Bangkok, Thailand. The assessment is based on 310 surveys that asked metro passengers to rate importance and satisfaction with specific attributes related to metro-bus transfers. The survey data was used to calibrate Importance/Satisfaction analysis and ordinal regression models to produce a concise list of improvements to service attributes at metro-bus transfers. The study finds that most passengers are unsatisfied with the conditions of intermodal connections. The improvements that would have the greatest impact on transfer experience are increased safety and security from crime and changing the location of bus stops relative to metro exits. Smaller improvements to passenger comfort and amenities are considerably less important to metro users. The findings could be applied to improve intermodal integration between two highly mismatched services to increase public bus ridership.

Acknowledgments

This thesis would have not been possible if not for the generous support and encouragement from a number of people. First and foremost to Dr. Craig Townsend who is my eminently patient and always reasonable supervisor. His funding paid for this research, he showed me around Bangkok (twice), and helped at all stages of the thesis process. Thanks to my parents, who got me through some of the tough squeezes that life throws at financially imprudent students and to my brother for mounting a fun-filled rescue mission to Bangkok in the summer 2009. Thanks to my fellow MSc students and the friends I've made here for making my time in Montreal great and to some of the wonderful professors at the GPE who helped me learn. A special thanks to Dr. Saksith Chalermpong ('Tan") and Pajaree Na Thalang for helping format and make the survey speak in Thai; to Arash Mostofi for the technical GIS assistance; and Dr. Zak Patterson for helping cultivate my interests in computational statistical modeling and for his statistical consulting. Last but not least, I'd like to thank the fine people at Chulalongkorn University Hospital for their gracious hospitality and for their fairly priced emergency health care. Thank you all!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

LIST OF ABBREVIATIONS

ACA……………………….Adaptive Conjoint Analysis
ANOVA………………….Analysis of Variance
ARL……………………….Airport Rail Link
BMA……………………..Bangkok Metro Area
BMCL…………………….Bangkok Metro Public Company Ltd.
BMTA……………………Bangkok Metropolitan Transportation Agency
BRT………………………Bus Rapid Transit
BTS………………………Bangkok Mass Transit System (Skytrain)
CAD…………………….Canadian Dollar
FAR……………………..Floor to Area Ratio
GIS………………………Geographic Information System
GPS…………………….Global Positioning System
HCSI……………………Heterogeneous Customer Service Index
I/S………………………Importance Satisfaction Analysis
ISTEA…………………..Intermodal Transportation Efficiency Act
IVTT……………………In Vehicle Travel Time
MRT……………………Mass Rapid Transit (Bangkok Metro)
MRTA…………………Mass Rapid Transit Authority
OLS…………………….Ordinary Least Square
OVTT………………….Out of Vehicle Travel Time
PLUM…………………Polytomous Universal Model
SEM…………………..Structural Equation Model
SP………………………Stated Preference
SPSS…………………..Statistical Package for the Social Sciences
SQI……………………..Service Quality Index
TCRP………………….Transportation Cooperative Research Program
TCSQM………………Transit Capacity and Quality of Service Manual

1. INTRODUCTION

Lack of coordination between different types of organizations within Bangkok, Thailand is a well-documented reality (Poboon 1997, Rujopakorn 2003). Bangkok's mass transport networks and informal para-transit services are examples of collective transport services that lack integration to complement overall quality of service. The different sizes and operational scales of Bangkok's many transit providers mean that many stations and stops are important nodes that often connect multiple systems. Between 1999 and 2011 three separately operated heavy rail services and a bus rapid transit line have commenced operations, and very little has been done integrate the new services with the existing bus system. Bangkok is a large metropolitan area of over 10 million inhabitants, and the 80 km of rail rapid transit and 53 stations that were in operation as of 2011 are insufficient in size to serve most parts of the city. Beyond this shortcoming, a lack of supportive transport infrastructure has further truncated the spatial distribution of benefits; sidewalks and bus routes which are crucial to the success of rail rapid transit are inadequate in many ways and are poorly integrated with heavy rail facilities. There is the perception that a lack of overall connectivity (both fare and physical) between transit services acts as a barrier to rail rapid transit riders making transfers from train to bus, prompting many to drive, use informal taxi services or to walk.

Lack of service coordination and unpleasant out of vehicle travel conditions between rail rapid transit stations and Bangkok's public bus service is thought to influence travelers' conclusions of the burdens involved with transfers and by extension their overall satisfaction with services and their willingness to use a specific mode of transport (World Bank 2007, Burkhardt 2003, Iseki and Taylor 2010). Although the new rapid rail transit systems command the most public attention for their symbolism to modernity and their "apex" role in the public transit hierarchy (World Bank 2007), buses remain the workhorses of transportation in Bangkok accounting for half of all motorized trips and carrying 12 times the number of passengers than the two largest heavy rail systems combined (AEC 2006a). Despite this, coordinated and inter service planning does not exist, likely depressing heavy rail ridership and further isolating bus services as a transportation mode of last resort. This research aims to evaluate the service attributes that support intermodal heavy rail/bus transfers at five busy transfers points located at three Bangkok MRT stations. The MRT is the relatively new underground heavy rail system that operates a single unconnected 18 kilometre 'loop' line serving 18 stations mostly through the dense inner suburbs of Bangkok. Using a stated importance and satisfaction survey of MRT riders, this thesis will advance a concise set of physical attributes and amenities that would improve the service quality of out of vehicle transfers between the MRT and bus system. Improving the overall transfer experience to facilitate more intersystem use between buses and heavy rail is one way to better integrate transit services.

The Handbook for Measuring Customer Satisfaction and Service Quality states that "increases to customer satisfaction translates into retained markets, increased use of the transit system, newly attracted customers and a more positive image of transit services" (TCRP 1999). Collecting data that describes how customers value and perceive quality of service can contribute to understanding how to build better transfer points around stations to accommodate greater use of existing transit services or to better prioritize improvements to increase overall customer satisfaction. (Foote 2004, Weinstein 2000).

In transit research, factors that describe service quality normally include on time performance, comfort, cleanliness, accessibility and personal security (Eboli and Mazzulla 2009). Individual service attributes that correspond to these larger factors are used to determine ‘overall transit experience’ or global measures of service. The Transit Capacity and Service Quality Manual (The TCSQM) is an industry standard for measuring quality of service in public transportation. It defines commonly used terms in transit research. The following definitions will govern the use of the listed terms;

- **Transit Performance Measure***:* A specific measurement, qualitative or quantitative, that evaluates a particular aspect of transit services, such as on time performance, service availability or reliability.
- **Service Attributes:** Measures of service quality – from both the system or riders perspective – such as comfort, convenience, personal security and affordability (Burkhardt 2003).
- **Quality of Service:** The overall measured or perceived performance of transit services from the point of view of the individual or customer.

Quality of service is a function of service and performance attributes and is always measured from the point of view of the customer. While performance measures and service attributes can be quantified from the interests of multiple stakeholders, from the point of view of customers, they are the outcome of service deliverables and shape the relationship individuals have with a given transit service (Burkhardt 2003). For the remainder of this thesis, service attributes will refer to both service and performance measures that compose available quality of service at bus transfer points around MRT stations. Transit agencies must ensure that each step a transit customer must make to access services is simple and can be made with as few sacrifices in comfort and time as is necessary. Raising the standards of service across the entire spectrum of what riders considers to be important is one way transit agencies can cement ridership, improve their image and attract new and choice users (Taylor et al 2008). Establishing levels of customer satisfaction so services may be designed to meet or exceed existing user's expectations and are of sufficient quality to draw choice users over the long term are important operational aspects of any transit service. (Foote et al 2001 and 2004; Taylor et al 2008).

1.2 Purpose of Study

One aspect of transit services important to users and non-users alike are transfer points; a survey among English motorists in 2001 found that convenient connections between modes of transport were the most import factor in convincing them to give up their cars and switch to transit for their commutes. Another study in Boston determined that inter and intra modal connectivity ranked as the third most important concern for drivers not using transit behind reliability and frequency (Guo and Wilson 2007). Not only do the quality of transfers matter in how the public evaluate overall performance, but poorly planned and disintegrated stations also affect people's willingness to use a particular mode or system (Akin 2006). At the same time, transfers are a necessity for an efficient and functional transit system as connecting all origins and destination with one bus route or a single heavy rail line is clearly impossible (Bruun 2007). A seamless transit experience, one where planners have taken into consideration the broad range of attributes individuals deem important (Taylor et al 2008), can diminish the perceived burden of a transfer, and thus enhance individual satisfaction and which can increase the likelihood maintaining customer loyalty of using transit in the short and medium term.

The results of an unpublished observational survey conducted by the author at three MRT stations in the summer of 2009 show a wide variability in the proportion of passengers who transfer to buses, and the distances they travel on that specific leg of their journey. The study also showed a high proportion of passengers at all stations that make transfers to an alternative form of transport, with many electing to pay a premium to ride taxis and motorcycles or to simply walk, sometimes long distances despite very poor pedestrian environments. Central to improving the attractiveness of buses is to understand which aspects of intermodal service at bus transfers are most important to MRT passengers. It has been suggested that these poor quality intermodal connections are a barrier for transit riders to easily switch from heavy rail to bus in Bangkok (World Bank 2007). There may be some merit to this assertion, as the observed transfer penalties – additional real or perceived costs in time, distance or monetary expenditures when transferring from one vehicle to another (Taylor et al 2008) - passengers assume when changing from train to bus at two of the three stations observed in the previous study are prohibitive. However, given that the quality of service and fare prices between buses and subways are extremely mismatched, there is reason to suspect that improving quality of service at the stations may yield very small changes to user satisfaction, and the limited funds available for improving transit could be prioritized elsewhere.

A user assessment of intermodal metro/bus transfer areas should be the basis for recommendations to improve overall out of vehicle quality of service. There is a broad consensus that poor connectivity – the physical and operational coordination between separate transit services or modes (Taylor et al 2008) – is highly deficient between Bangkok buses and heavy rail. Without determining how MRT users prioritize and value available or possible services, or even if there is a consensus among MRT patrons that intermodal connections are important, costly reorganization of infrastructure around stations may do little to improve customers' perceptions of the transfer environments.

The goal of this research is to determine which attributes relating to transit service could be used to improve passenger's perceptions of intermodal transfers from the MRT to buses at MRT stations. The concept for this work is adapted from a study conducted in Los Angeles by Iseki and Taylor (2010). The authors determined a sub set of service quality attributes that were most likely to influence the perceived burden of transfers at bus stops and stations in Los Angeles. Through the analysis of survey data and a corresponding meta-study of research on inter and intra modal transit, they concluded that the perceived burden of transit use can be diminished by improving the interconnectivity of transfers.

1.3 Research Questions

Broadly, this thesis seeks to address the question of which particular actions to address one shortcoming, the lack of intermodal connections, could have the greatest impact on passengers' out of vehicle travel experience in Bangkok. It focuses on the out of vehicle connections between metros and buses and evaluates riders' perceptions of a concise set of service attributes considered in supporting literature to influence overall transfer experience. It proposes a concise set of improvements and amenities at stops and stations to improve service and accessibility, to determine the perceived adequacy of bus routes and to reinforce feelings of safety and security. Specifically this research asks important questions which must be determined before any improvements are made to the service characteristics available at MRT exits: 1) Which service attributes that relate to transfers are most important to MRT users? Which are the least important? 2) Could the perceived quality of service be influenced by small improvements to amenities or passenger comfort such as through higher quality waiting areas? Or are improvements to service attributes on a larger scale necessary to satisfy customer's stated importance? 3) This research also asks if different segments of MRT patrons consider different services to be more important than others. Also, part of this research is aimed at determining if there is a need among MRT users to improve the connectivity between buses and stations and to identify what those needs are. And, 4) are there specific combinations of service attributes that could reduce some of the negative perceptions of out of vehicle travel? To answer these questions methodologies that borrow from multiple researches was adopted to measure customer satisfaction and stated importance across a set of attributes considered important to overall quality of service for out of vehicle travel(Iseki and Taylor 2010 and Eboli and Mazzulla 2009). An importance and satisfaction (I/S) survey that was fielded in Bangkok, Thailand in February of 2011. 310 MRT passengers were recruited while leaving from 5 exits and three MRT stations. The data was then analyzed using descriptive techniques of weighted importance and satisfaction and then was mathematically modelled using ordered logistic regression analysis as adapted from the work of Iseki and Taylor (2010).

1.4 Structure of Research and Outline

This research paper is organized in the following way: Section 2 will provide an outline and brief discussion of the current state of major transportation systems operating in Bangkok. In section 3 a literature review will trace the origins of research that has examined interconnectivity of transit services and the importance of intermodal coordination. The literature review will justify this thesis's focus on transfer experience by placing the research in the context of transfer penalties and how aspects internal to transit service operations have been shown to influence transit user behavior. The findings of the literature review will support the context of this research and the importance of improving overall quality of service at transfer points to expand and cement transit ridership. The literature review will also advance the methodological procedures adopted within this work by showing how a variety of other studies have operationalized and analyzed service attributes. Section 4 will contain multiple sub-headings and will explain the methods employed in this research. Section 4.1 will discuss the construction and application of the survey instrument used to collect the customer satisfaction and importance data, including a brief description of the station environments where participants were recruited. Section 4.2 will discuss the two importance and satisfaction (I/S) formulas and quadrant analysis that was used to descriptively explore the survey data. Section 4.3 will introduce and explain the steps, formulas and procedures to model and validate the collected satisfaction data using ordinal logistical regression to test how current levels of satisfaction with service attributes can predict overall satisfaction. Section 5 will contain the results for both the importance satisfaction analysis and the ordered regression models. Section 6 will compare the findings of the two analyses and will discuss implications of the findings for future policy adaptations and make a concise set of recommendations of where the BMTA and MRT organizations could best improve customer experience between heavy rail exits and bus stops.

2. Background and Context

Bangkok is the capital and primate city of Thailand. In 2009 the official population was about 11 million and growing at rate of approximately 3% per year. Bangkok's importance as the primary engine of Thailand's economic activity cannot be understated: The greater metro area contains 16% of the country's population but accounts for more than 68% the nation's economic output (PCI 2005). From the early 1960s to the mid 70's both the population and the amount of urbanized land more than doubled (Choiejit and Teungfung 2005). However, this phenomenal growth has taken place in a regulatory vacuum. Bangkok's extremely "laissez faire" land use policies and weak planning regimes have meant that growth has been unmanaged and lacking coordination or long term strategy. The lack of regulatory oversight has contributed to Bangkok's notorious traffic congestion and late development of efficient and rapid transport which is described by some as an almost existential threat to the city's future and wellbeing (Poboon, 1997, Rujapakorn, 2003). This section will briefly describe the historical development and present state of Bangkok's transportation networks, and outline some of the obstacles the city faces to providing alternative public transportation that is efficient and reliable.

2.2 Bangkok: From Canals to Cars

Bangkok was founded as the seat of a new royal dynasty following the overthrow of King Taksin in 1782, and the downfall of the earlier Chakkri monarchs who had ruled for 400 years from the old capital of Ayutthaya to the north. Water transportation had long been the primary mode of trade and travel in the region, and successive rulers extended Bangkok's administrative and economic hold over the surrounding provinces through networks of laterally dug canals running off the Chao Phyara River (Askew 2002). Although originally built for defence, the expansive canal and river borne transportation infrastructure allowed commercial enterprise to flourish in Bangkok and helped shape the grid system of roads which forms the modern layout of the old city center today (Askew 2002).

European demand for faster and more efficient trade initiated the first major program of road building in the mid 1850's which accelerated Bangkok's transformation from a feudal outpost on the Chao Phyara River to a more global center of trade and enterprise. Partially to appease the concerns of European business interests and partially out of a desire to conform to an ideal of technological modernity, Bangkok's urban environment was drastically reconfigured under the wishes of successive monarchs (Rujapakorn 2004). Between King Chulalongkorn and his successors Rama VI and VII (1868-1925) the first of the city's canals were filled in to be turned into roads, electric tramways began operations, and a French designed main rail station was constructed (Hua Lumphong) (Askew 2002). New and larger roads were extended further from the river initiating a distinctly western style of settlement patterns alongside the chaotic and piecemeal slums that began to flourish by the 20^{th} century. This growth assumed a life of its own, where unplanned dead end *'sois'* were built off of main roads producing a fragmented and uncoordinated network of city streets, particularly on the rapidly expanding urban fringes (Askew 2002).

Following WWII, Thailand enjoyed strong support from the United States owing to the military led government's strident opposition to communism. Thailand secured an early entry into the United Nations allowing the country access to World Bank funding which prompted the first mega infrastructure projects that were largely funded through foreign loans. Under American advice, regional highways were built connecting Bangkok to more distant rural hinterlands, further accelerating rapid urban growth. During this time, many of the city's canals were removed to be converted to sewer systems that drained into the Chao Phyara, and automobile transportation slowly replaced the historically dominant canal boats (Baker 2009).

It is tempting to assume that western development models proscribed a distinctly American form of urban planning that sealed Bangkok's fate as an automobile city. However, this implies that the correct regulatory forces existed to guide and plan growth in the first place (Askew 2002). Automobiles ascended to the apex of the transportation hierarchy with implicit support from industry, Thai royalty and the growing middle class who demanded the appearances commercial success and western modernity. Meanwhile, the real forces behind Bangkok's urban morphology lie in the hands of wealthy property interests that to this day, for better or for worse, shape all major development within the city (Askew 2002), and this usually in the interests of a select upper class.

Thailand's national governments have also been remarkably unstable for nearly a half century, with frequent coup d'états, often spearheaded by the military. The county's political class has been divided by the near constant power struggles, the result of unstable and short lived governments (Baker 2009). In the absence of real leadership, lasting political authority or any traditions of shared and checked powers; infrastructure development has been consumed by nondemocratic and unregulated processes, largely governed by personal interests, political connections and desire. The vacuum of effective regulation or democratic oversight has meant land use decisions have rarely been made in step with transportation investments.

2.3 Present Day Road Systems

Today Bangkok is an automobile saturated city. Urban transportation infrastructure investment in Bangkok has facilitated personal mobility and private vehicle ownership for some segments of society at the expense of collective transport. The first large scale transportation plan produced in the early 1970's acknowledged the absence of an efficient mass transit system and rapid public transportation, but those suggestions were ignored and investments were directed to a system of orbital freeways. The first freeway in Bangkok was completed in the 1982, and by 2006 over 300 kilometres of high-speed limited access highways had been built within the metropolitan area, a large proportion of these operating as private toll routes. Other priorities included elevated intersection 'flyovers', illustrated in Figure 1 to allow through traffic on busy arterial roads to bypass traffic signals. In 1992 alone, 12 of these flyovers were constructed on major inner city arterial streets. (AEC et al 2005b).

Figure 1: A Flyover bridge on Petchaburi road

Despite the nearly exclusive commitment of transport resources to expanding street capacity, supply of road space has not kept up with the rapidly growing fleets of private automobiles and severe traffic congestion persists. In 2000, there were approximately 2.5 million vehicles in use on Bangkok streets (PCI et al 2001). In 2005 there were 3.1 million vehicles, with an additional 800 being registered every day (World Bank 2007). Between 1990 and 2000, for every three percent growth in the automobile fleet, road capacity was expanded by less than one percent (Cervero 2000). The major road building operations - in the absence of efficient and reliable public transport alternatives – has only induced the demand for cars which quickly eliminates any spare capacity. For example, during the most frenzied rush to build new roads, average network speeds in the city proper remained flat at approximately 10 km per hour (Sock-Yong, 2007), while the number of street segments considered seriously congested continued to grow (Halcrow 2004).

In spite of serious efforts to build their way out of congestion, the built urban form of inner Bangkok made failure a foregone conclusion. Bangkok's highly clustered commercial corridors, responsible for a great portion of motorized trip generation (Choiejet and Teunfung 2005), are located in sections of city that are still reminiscent of the pre-automobile network of streets and *sois* that were originally built alongside an extensive system of canals (Poboon 1997). To illustrate, Figure 2 shows two different street network configurations found in Bangkok. On the right is the Bangkok Metropolitan Area with all freeways and arterial streets highlighted in black. Much of Bangkok's postwar inner suburbs - a small portion is shown in the top inset of Figure 2 - can be characterized as having a 'tree' or 'fish scale' type street network (Cevero 2000), vulnerable to disruption (traffic accidents, road repair etc) because it lacks the redundancies of a grid where travellers can circumvent temporary obstacles, delays or disruptions. There is also no clear hierarchical ordering where smaller streets can efficiently feed into larger ones. The historical city center – shown in the bottom inset of Figure 2 – has more grid type street pattern, but the dense configuration of buildings and relatively narrow streets precludes accommodating high traffic volumes. Both areas are typical inner of Bangkok, and both are unsuitable for mass auto mobility and would be better served by public transit. The city's nearly complete reliance on roads has exposed the mismatch between Bangkok's historical built form and the transportation policies meant to bring the city into the future. The results have extracted enormous tolls on Bangkok society. Traffic congestion is not only a source of misery for commuters, but is also serious drain on the economy, environmental quality and the city's overall liveability (Rujopakorn 2003).

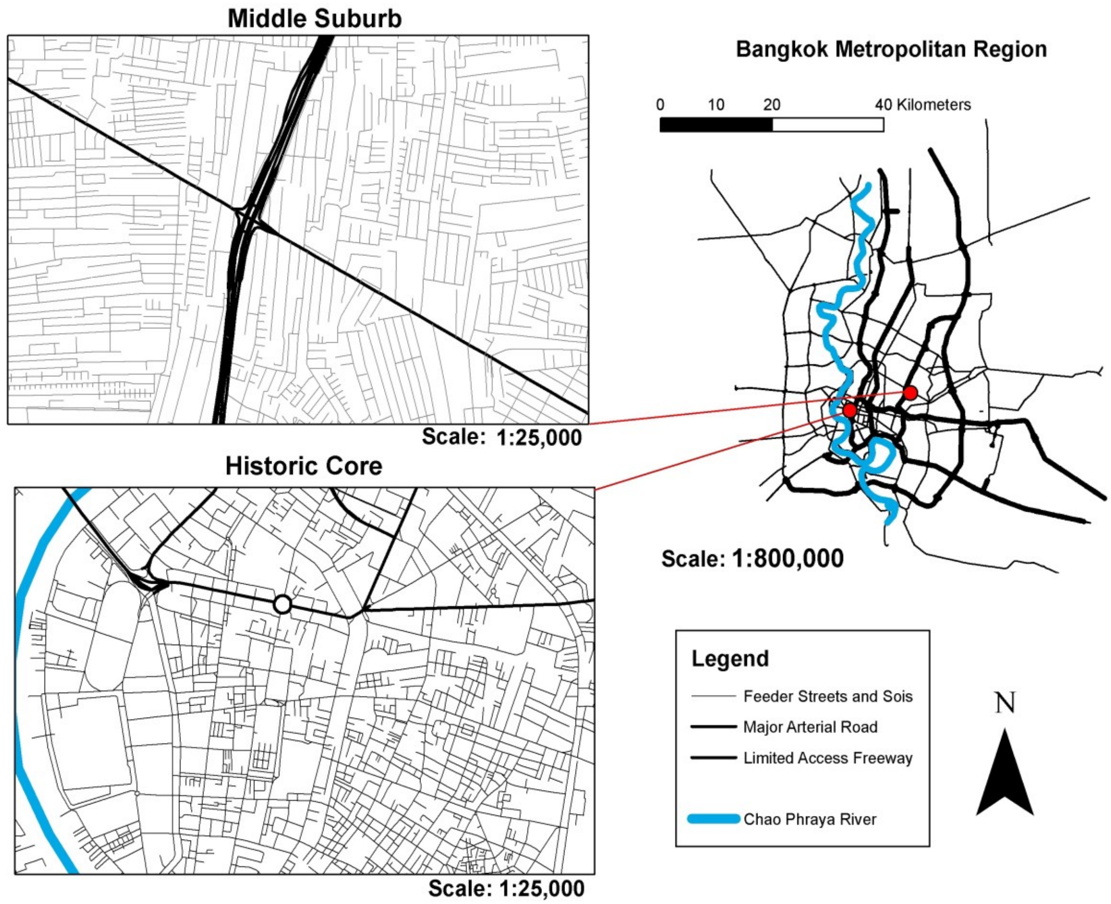


Figure 2: The BMA and example street networks

Bangkok's notoriously bad traffic has been helped along by the 'remarkable' lack of coordination between the dozen or so government agencies responsible for planning, building and tendering transportation projects within the city (AEC et al 2005a). An indicator of this is that 'Master' transportation plans have flourished; between 1988 and 2003 four have been produced, all by separate actors and each proposing grand and conflicting mega projects, often with no clear strategies for integration with existing infrastructure or acknowledgment of existing or ongoing projects.

Bangkok's traffic dilemma was a slow motion emergency for decades that became a full-fledged disaster by the 90's. Bangkok's auto oriented growth is typical of other middle income developing world cities and is a perfect example of how poor planning can cause real harm to a society (Rujapakorn 2003). However, there is reason for some optimism. Bangkok's concentrated corridors of commercial activity and long wide arterial streets are well suited for public transportation (Poboon 1997). Although the present concentration of activity nodes makes supply of road space to growing fleets of automobiles impossible, with proper prioritization and financial commitment, a greater allocation of space for buses could conceivably provide far more efficient access to currently congested city space.

2.4 Bangkok's Mass Transportation Systems Overview

Although private automobile growth has been a constant obstacle to efficient mobility, Bangkok has a wide variety of alternative transportation options that can be both flexible and affordable. The publically-run BMTA (Bangkok Metropolitan Transportation Authority) provides inexpensive, often poor quality bus services throughout the city region. Three separate, privately operated heavy rail systems offer higher quality, premium rapid transit services within inner Bangkok and to Suvarnibuhmi International Airport; the underground MRT, the elevated BTS and new Airport Rail Link (ARL) in all totalling 81 km of track and 53 stations . However, the relatively constrained size of the entire system means that rapid transit service coverage is not adequate to offer service to most Bangkok residents. Figure 3 shows a portion of the BMA with the routes and locations of the three rail rapid transit systems (the solid blue stations are the stations where the study was carried out, and will be discussed in a later chapter). In the last year, a single bus rapid transit (BRT) route has commenced operations extending relatively fast transport southward from the BTS green line. Plans to expand rail rapid transit are significant with 291 additional kilometres of track planned with some of this currently under construction. On top of these public and private systems, Bangkok also has vast and varied illegal para-transit services ranging from commuter vans for longer travel to motorcycle taxis and converted pickup trucks for shorter distances. Informal transit, in the absence of a personal automobile, is sometimes the only reasonable method of accessing some of Bangkok's sprawling, poorly connected and dense suburbs that do not have any regular transit service. The remainder of this section will briefly describe each of the major components of Bangkok's mass transport systems, and some of the service barriers between the separate systems that hinder coordination.

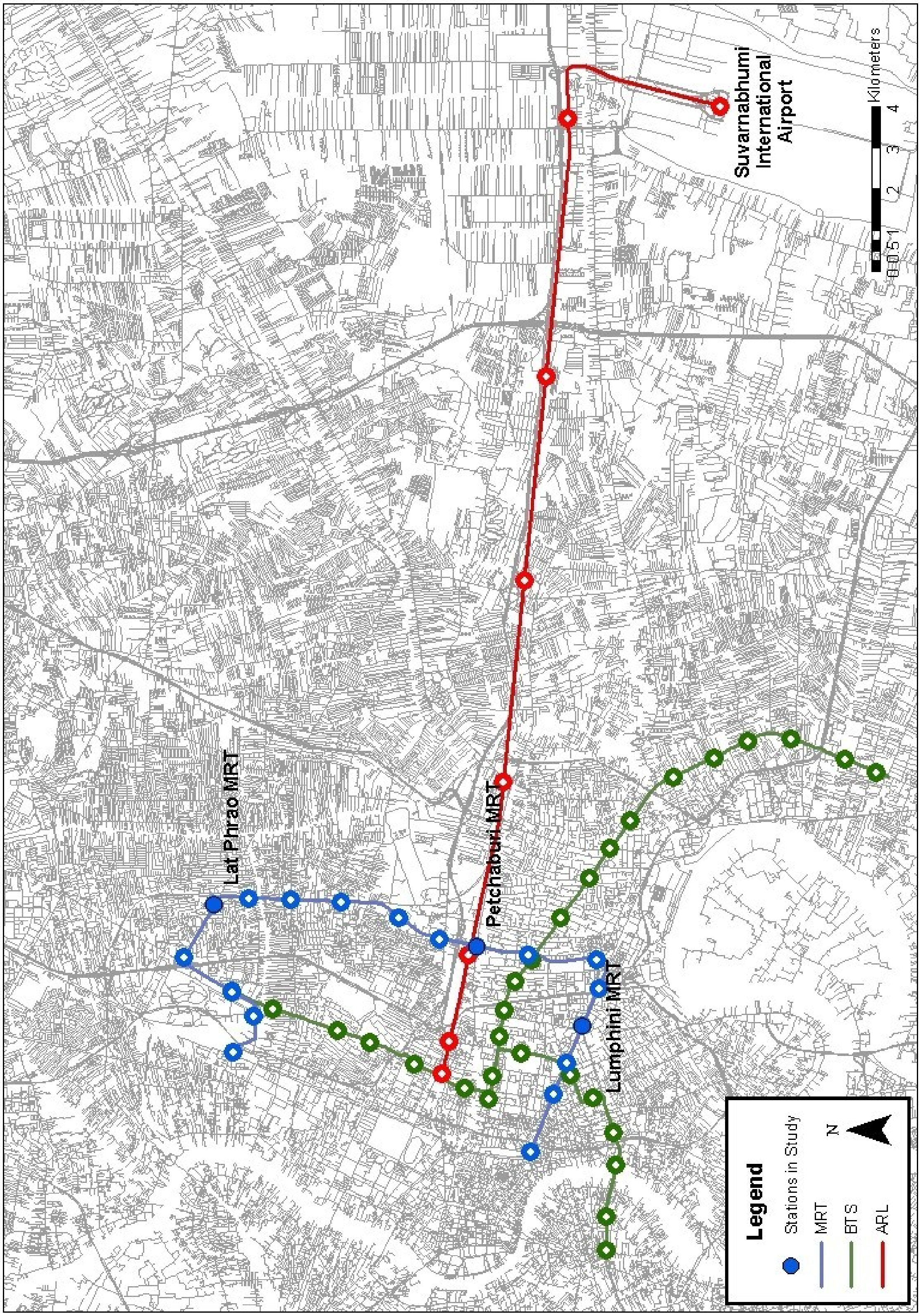


Figure 3: Bangkok rail rapid transit infrastructure with stations included in the study

2.4.2 Buses

Bangkok's bus system was reformed in the mid 1970's as the previous consortium of private companies faced insolvency from spiking energy costs and was bought out entirely by the state run enterprise, the BMTA. Currently all buses are either owned or operated by the BMTA, or routes are specially licensed by its regulatory body to private operators which run an assortment of bus types and express routes. The BMTA is responsible for all bus operations in the entire greater Bangkok region with a fleet of approximately 3500 busses, 2000 of which are newer air conditioned models (BMTA 2009). The BMTA has granted operating licenses to 3500 other vehicles under private ownership for public transit purposes, mostly smaller low quality buses (Cervero 2000). In practice the BMTA has a monopoly on the provision of all bus services, either directly operating them or licensing private operators on its routes, a clear conflict of interest in its role as regulator and operator (World Bank 2007). The introduction of heavy rail has likely not displaced the BMTA as the only choice of transportation for many of Bangkok's residents. Daily wages for many Bangkokians are insufficient to ride either the MRT or BTS and as of 2007, buses carried 12× the number of daily passengers than the MRT and BTS combined (World Bank 2007). However the introduction of more quality conscious heavy rail operators has further marginalized the bus system as a third class alternative to using the newer rail based transport and para transport options.

Buses generally operate two different vehicle types as illustrated in Figure 4; air conditioned and non-air-conditioned. Typically both types of buses operate on the same routes, with air conditioned buses charging a premium, albeit still marginal, fare.

Figure 4: Non-air conditioned (top) and air conditioned (bottom) BMTA buses

2.4.3 Informal Transit Services

Congested roads and uncoordinated street hierarchies have left some areas of Bangkok impenetrable for efficient delivery of city bus services, allowing private vehicle operators to fill gaps in service wherever they may exist.

Bangkok has a wide variety of legal and illegal entrepreneurial informal or para-transit services patrolling city streets ranging from luxurious intercity vans and converted pickup trucks (Song Taeo), privately operated mini buses running on BMTA routes, motorcycle taxis and three wheeled motorized vehicles (tuk-tuks). Generally a two- tiered service regime exists between the different varieties of service. Expressways, major roads and more distant locations are served by metered taxis, mini buses and intercity vans while more local, short distance trips on feeder roads and *sois* are provided by motorcycles (Cervero 2000).

When taken together Bangkok's informal para-transit modes have an enormous amount of service capacity with over 7000 vans and minibuses, 60,000 metered taxis and well over 50,000 motorcycle taxis operating in the BMA on any given day (ADB 2006).

Motorcycle taxis congregate on street corners, major bus transfer points and more recently at heavy rail station exits. Figure 5 shows a motorcycle taxi stand operating in front an MRT exit at Petchaburi station. The lack of coordination between the BMTA and heavy rail operators provide motorcycle taxi drivers with ideal opportunity to offer faster and more convenient services than buses at present can provide.

Figure 5: Motorcycle taxi in front of an MRT exit

2.4.4 Rail rapid transit infrastructure

Some relief to Bangkok's nightmarish traffic conditions have been provided by the addition of three rail rapid transit systems, all in the last twelve years. Rail rapid transit here refers to elevated or underground fully segregated rail borne transit services, often called metros. Rail rapid transit can be distinguished from commuter rail systems by the distance between stations, usually between 500 and 2000 meters apart. The system's tracks are for the exclusive use of the single transit provider (Bruun 2007).

2.4.5 MRT

The MRT (Mass Rapid Transit) is privately operated publically owned heavy rail system that opened in 2004. It operates on a single 21 kilometre 'semi loop' line with 18 stations. The MRT is operated by the BMCL, a private company which paid $310 million USD to equip and operate the new fully underground system for a period of 25 years, during which time they would receive all fare box revenues. Tunnelling for the new metro began in 1997, with total system costs topping $3 billion USD, or $155 million USD per kilometre of track (Halcrow 2004). Given the relatively low costs of labour in Thailand, this represents a very expensive investment and places the financial sustainability of the public/private partnership in question. Although the vast majority of those building costs were shouldered by public finances, fare schemes are structured to cover the entire operating expenses at a profit for the BMCL (AEC et al 2005b). As of 2011, there were approximately 200,000 boarding's per day, a 100% improvement over its first year of operations, but well short of the 400,000 riders per day originally projected (World Bank 2007) . Ambitious proposals exist to expand the single line MRT with three additional lines totalling 91 additional kilometres of new elevated and underground track.

2.4.6 BTS

The BTS is a private, for profit elevated rail rapid transit system that currently operates on 2 lines totalling 30 km in distance with 25 stations. The BTS was built privately in exchange that the BMA provide free access for the land and space necessary to construct the elevated system over top of some of Bangkok's busiest arterial streets, while indigenous banks and land development corporations provided the financing necessary to construct, equip and operate the system. The MRT serves the main corridors of commerce in the central city, and is considered a successful project by the city with more than 400,000 boarding's per day. As of 2011, observational evidence suggests that much of the system is operating at capacity - or crush load - at many times of the day.

The BTS, for the first time in Bangkok's modern history, provides a fast and reliable alternative to the clogged arterial streets in runs above. However, from a managerial point of view the system is a resounding failure. Lack of any clear feasibility study prevented the financiers from predicting that fare box recovery would not match the operational expenses over the span of the concession agreement. The private organizations involved won the concession to build and operate based on an agreed fare structure that would make the system relatively accessible (Halcrow 2004).

2.4.7 Fare Structures

Service quality and prices for travel on Bangkok's many alternative transportation modes are highly variable. Table 1 shows fares for each transit organization or para transit service. Price information for the new bus rapid transit (BRT), Intercity vans and *song toews* are unknown. Fares for all services are dependent on distance or the number of stations travelled. Often fares for para-transport options are negotiated between the driver and customer before the trip, and prices are generally distance based. Motorcycle taxis are often used for shorter trips, under 1 km, but are increasingly being used for longer distances, in which case prices are agreed upon before the journey. All prices are approximate and in Canadian dollars (CAD).

Table 1: Transit System Fare Structures

Mode	Fare (CAD)
Public Bus	Distance Based (1/2 km - 10 km+)
Air Conditioned	$.25 - $1.25
Non Air Conditioned	$0.10 - $0.65
MRT	Per Trip- Station dependant $.50 - $2.00
BTS	Per Trip- 5 Fare zones $0.33 - $1.50
BRT	--------
Motorcycle Taxis	Dependant on destination
Short *Soi* Trips	Starting at $0.15
Longer	Negotiable
Metered Taxi	Distance and time dependant $1.10 1st 2 km, then 5 baht per km.

2.5 Operational Challenges to Rapid Transit

A number of obstacles limit the effectiveness of Bangkok's bus and rapid transit systems. Generally a lack institutional coordination, weak or nonexistent planning regimes and non-transparent legal structures hamper the ability of systems to work together to maximize efficiency and ridership. The most obvious problems facing the system concern the lack of integration between the services, both physical and fare.

A barrier to improving the accessibility and effectiveness of all rapid rail transit systems is the lack of any physical integration between stations and the city bus network. Several evaluations of Bangkok's transportation system each point out that the lack of supportive infrastructure between the multiple systems is a barrier to overall success. The experience of other developing and developed cities show that *inter* and *intra-modality* is a key strategy to increase ridership and help achieve and extend the benefits of rapid and reliable transportation to more people. Inter and intra modality refers to both the physical and non-physical connectivity between services and systems (AEC et al 2005a) which can be evaluated according service quality attributes. A complaint among private forecasters and consultants who work alongside government regulators is that an efficient bus feeder system was assumed to be already in place during the construction phases of the MRT and BTS. The poor coordination between organizations has clearly constrained the benefits of rail rapid transit in Bangkok. Not only are buses not integrated into the operations of either of the rail transit services, but many station areas lack even basic supportive pedestrian infrastructure (World Bank 2007), this despite physical system integration has been widely shown as a critical component to successful transit operations and network efficiency (Mees 2010). Most MRT stations are surrounded by poor quality sidewalks which are often littered with obstacles such as telephone poles, phone booths and construction debris. Safe or convenient street crossings do not exist, and bus stops have not been reorganized to efficiently feed passengers to and from station exits at a minimum of time or inconvenience. The almost extreme lack of service quality that prevents easy access between buses and trains is a resounding failure of inter-operational planning and a glaring testament to Bangkok's organizational deficiencies.

Separate ticketing between systems also represents a significant barrier to the overall effectiveness and connectivity of rapid rail transit and bus services. For each system a new ticket must be purchased. This has a number of negative consequences on both transit users and providers. For the providers, it limits the number of patrons who may reasonably access each of the systems, which in turn lowers overall fare box revenues. The MRT may be particularly vulnerable to lost patronage because of its more peripheral route. For transit users, separate ticketing means that many –including middle class Thais - cannot afford to pay for the premium tickets of two separate systems as well as city bus fares. The high relative cost may force many to forgo transit entirely, perhaps over the long term to pool family resources into a private vehicle or motorcycle.

2.6 Operational Challenges to Buses

Bangkok's bus system is also in many ways dysfunctional and is not unique among other developing world city bus services struggling to maintain ridership and demand for transit service against a backdrop of rising affluence and growing automobile dependence (Badami and Haider 2007, World Bank 2007). The BMTA system is experiencing a loss of 5% of customers per year with serious consequences for overall service (World Bank 2007). As patron numbers dwindle less money is available for upkeep, route expansion and vehicle replacement prompting even more residents to abandon the bus and resort to other transport options. The result is a negative feedback cycle where, if left unchecked, the public bus system will become the fall back transport mode for only the poorest of residents willing to accept inadequate service and unsafe conditions (Badami and Haider 2007). Although no studies exist that have determined the proportion of captive riders in Bangkok, research has shown that over the long term bus users in other cities will make long term choices to abandon city buses for more reliable if less accessible alternatives such as private vehicles. In 2005, the bus system had approximately 5,000,000 boardings every day (AEC et al 2005a), the majority of trips are for the purposes of commuting to and from work. Although buses represent less than one percent of vehicles on the road, their services account for nearly 40% of all trips (Allport 2004). Choijiet and Teungfung (2005) found that as income levels rise, it is less likely a

Bangkok resident will utilize bus services. They also found that in absence of walking, poor commuters, who are the most numerous income demographic to commute entirely within central Bangkok, use bus services as their primary mode of travel with average commute times in excess of one hour, even at relatively short distances. Despite offering poor quality of service, buses will remain the backbone of public transport for the foreseeable future, however remaining a viable service will require the BMTA to improve many aspects of service quality.

The bus system is also threatened by the flexibility and relative on demand services provided by Bangkok's many informal and para transit services. Private -and illegal - operators often engage in what is called 'cream skimming' where the most profitable and in demand routes are aggressively covered by informal van, taxi and motorcycles services taking ridership that may otherwise be contributing to fare box recovery and further clogging already saturated road space. Publically-funded transit operations such as the BMTA partially operate under the logic that profitable routes will help cover the expenses of less profitable ones (Cervero 2000). Without adequate enforcement or regulation, private infringement on what is essentially a public investment may place buses at a further disadvantage.

To become a reliable and efficient service, the bus system in Bangkok is in need of drastic reform. Many of the fleet's vehicles need to be replaced and routes must be reorganized to more effectively feed into the existing MRT network to realize the rail system's full potential (World Bank 2007). Disintegration with other higher quality transport options also poses a serious challenge to maintaining or expanding ridership. A key challenge in achieving sustainable transport is making bus services attractive enough to dissuade those who have the option of driving while simultaneously remaining a viable transport option for Bangkok's poor.

2.7 Conclusions

Despite the overall bleak transportation picture, there has been a slow but steady realization in Bangkok that planning for the future does not necessarily mean planning for cars. Although there are no indications that consumers in Bangkok will slow their relentless demand for private vehicles any time soon, there is growing momentum towards more efficient and better planned mass transportation. Bangkok has placed considerable investments into rapid rail transit projects opening three separate systems within twelve years. Future plans for heavy rail are hugely ambitious with 291 additional kilometres of track envisioned to be in operation within the next five years (World Bank 2007). While this pace of development is clearly impossible, it is at the very least a clear indication that many people in Bangkok have finally recognized that mass transportation is key to a successful and economically competitive future.

However, to make the most of these future investments, more emphasis will have to be placed on better planning and network integration. Heavy rail transit is the most expensive of all mass transportation projects, and maximizing the efficiency and capacity of these new systems will mean that better integration with existing infrastructure will have to be given much greater consideration.

3 LITERATURE REVIEW

This literature review will isolate the influence out of vehicle service attributes have been found to contribute to overall satisfaction and modal choice in transit research. Although a great amount of research has been undertaken to establish the best worst aspects of or travel with transit according to the user, very little has directly approached how the out of vehicle aspects of transfers are perceived by riders. In an extensive literature review conducted by Taylor et al (2008), they found only a handful of papers that focused exclusively on transfers or incorporated multiple features of transfers within their analysis (Han 1987, Liu et al 2007 and Guo and Wilson 2008). Most research has aggregated all aspects of transfers or out of vehicle components into one or two attributes that are tested alongside more common service attributes such as on time performance, cleanliness, driver courtesy and comfort (Weinstein 2001). This represents a gap in the otherwise rich variety of transit service oriented research given that out of vehicle components to transit service are a key deterrent for many to make more use of transit (Guo and Wislon 2008). This literature review will take a broad look at transit research, focusing on specific aspects that relate to transfers and out of vehicle service.

3.1 Inter-modalism in public transport; USA and Bangkok

Inter-modalism refers to the multi-modal nature of urban transportation systems and the physical and organizational structures that connect the different parts of that system (Vuchic 2001). Transit providers in major cities must operate and plan their service to be inter-modal as direct routes across large or dispersed urban areas are impossible to provide (Levinson and Krizek 2008). Providing service that is both efficient and attractive to customers across large urban areas often means that multiple operators must coordinate their services to minimize the barriers that may stifle passengers' ability to move from one mode or system to another (Lui et al 1997). Achieving multiple system integration has received considerable attention as it has been widely recognized by planners and researchers alike that better transit is necessary to offset some of the negative consequences of cars in cities.

Transit ridership in the United States declined precipitously from 1945 onwards as suburban centers mushroomed and major road and freeway expenditures made public transportation a less viable alternative to automobiles. To help struggling transit operators across the country, in 1991the U.S. Congress passed the Intermodal Surface Transportation Efficiency Act (ISTEA), accompanied by the Transit Cooperative Research Program (TCRP) which sparked broad interest in improving intermodal transport connections with the motivation of improving customer service and increasing the operating efficiency of transport agencies (Liu et al 1997). The ISTEA proposed a number of strategies and research priorities to 'seamlessly' join the services of multiple services and transit organizations within metro areas to minimize the amount time, discomfort, sacrifices and monetary expenditures transit customers must make when switching modes or vehicles (Vuchic 2001).

Although some of the proposals made by the ISETA would likely benefit transit operations in the United States, larger more entrenched obstacles to growing ridership exist. The door to door, no wait, and no transfer service provided by private automobiles places transit at disadvantage to car ownership, one that is exacerbated in the United States by five decades of road capacity expansion coupled with growth policies that have promoted dispersed and segregated land uses. However, as the negative impacts of cars in cities became more apparent, the need to address some of the problems has become a priority for many transportation researchers and planners. Densification, or lowering the ratio of road space in relation to the amount built residential and commercial property, has been widely proposed as the best way to increase the demand for transit while lowering the practicality of automobiles (Pushkarev and Zupan 1977; Kockelman and Cervero 1997). However, reorganizing the urban space of America to better suit transit is not only politically unrealistic (Levinson and Krizek 2008) but the investments required to counteract the cumulative endowment of six decades of automobile centered growth would be enormous (Pickrell 1999). Instead, the ISETA and transit research for the past two decades in United States has focused on smaller but more realistic improvements internal to the direct influence of transit services and managers such as in vehicle performance, intermodal integration and service benchmarks (Taylor et al 2008). This is not to say many improvements to transit cannot be made; but without more controlled land use planning and reductions in road capacity, growth in US transit ridership will likely remain incremental (Pickrell 1999). However, what has been applied in the United States with only mediocre results may be more effectively leveraged to boost transit ridership in different urban contexts.

In some ways Bangkok shares some of the same dilemmas many major American cities face to improve transit operations; a historical over-expenditure on roads, no centralized planning (Vuchic 2001), deficient public transit investment and a wide scale reliance on automobiles by the general public. However, there are key differences that make the application of improved intermodal service quality more likely to result increased levels of transit ridership; Bangkok is much denser than most American cities, there is low overall road network density and nodes of business, commerce and industry are highly clustered (Poboon 1997). These are all characteristics highly conducive to efficient and effective transit (Levinson and Krizek 2008). However, in Bangkok, well designed transfers to and from public transportation do not exist. Improving transfers may increase transit usage, something that has been recognized by the National Ministry of Transport which commissioned a study in the early 2000's to make specific recommendations to improve inter service coordination (AEC 2005a). Despite this, intermodal connectivity remains fragmented in Bangkok, yet a great volume of research has been conducted in North America and Europe which has determined intermodal connections can be a cost effective way to increase operating efficiencies while extending accessibility of transit services to as many riders as possible (Currie and Loader 2010, Phillips and Guttenplan 2005, Vuchic 2000).

Intermodal connectivity can relate to number of operational and service characteristics (integrated fare schemes, timed transfers, joint facilities etc) but in many researches it is studied by how out of vehicle barriers can influence transit rider behaviour. The different components of every transit journey - access, travel, egress and arrive – and the disutility each of these steps can have on passengers has been recognized as an impediment to service which has prompted research that has examined inter-modalism and its relation to mode choice and transit use.

3.2 Transfers

The most obvious barrier to seamless transit services are transfers. A typical journey using transit involves chain of steps that can include a walk and a wait to access a vehicle, a ride, followed by a transfer that usually includes another walk and wait to board the next vehicle, a second ride, and finally an egress trip where the passenger walks to his/her final destination, illustrated in Figure 6.

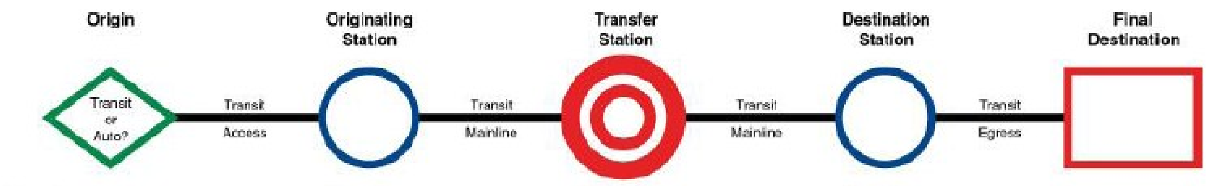


Figure 6: The typical components of a transit trip (Taylor 2008)

Each step in Figure 6 can have a unique influence on a customer's perception of a particular trip. (Bruun 2007). A common formula that considers each step in a transit journey as un-weighted may take the form of Equation 1 ;

Equation 1: Un-weighted Transit Journey

$$\mathbf{T_{O\text{-}D} = t_a + t_{wa} + T_1 + t_e}$$

where $T_{O\text{-}D}$ is the total trip time from origin to destination, t_a is the time from the riders's origin to the bus stop or station, t_{wa} is the wait time, T_1 is the in-vehicle time, and T_e is the time spent from the egress point to the final destination (Bruun 2007, pp 57). Improvements to intermodal service are sometimes justified by customer satisfaction, but more commonly by the amount of time or money it would save individuals using a particular combination of modes or transit systems. The out of vehicle components of the trip in Equation 1 -such as walking and waiting - are not normally considered as 'un-weighted' or actual (i.e. the actual amount of time spent walking or waiting). Transportation research normally expresses these out of vehicle components in how they are perceived by a user or customer. Determining how quality of service attributes can influence a transit riders mode choice and their perception of costs is called 'disutility analyses' and has been studied so extensively, relative OVTTs (out of vehicle travel times) can be considered rules of thumb for transport agencies (TCRP 1997) depending on circumstances specific to each transfer. Understanding how transfers can influence passenger behaviour is an important aspect of improving intermodal service.

Each out of vehicle component in Equation 1 is called a transfer penalty and can be represented by a weighted measurement that reflects the perceived cost it represents to a customer during a journey. Transfer penalties are used to represent the time, labour or monetary expenditures experienced when waiting, walking, and worrying about comfort and safety when accessing or egressing transit, or transferring from one vehicle to the next (Bruun 2007).

The disutility that each component of every transit journey poses is often reported as relative in vehicle travel time (IVTT). Li (2003) justifies using private automobile travel time as the benchmark for which all other modes are compared against because private vehicle travel is a door-to-door service, avoids transfers, provides a real (or imagined) sense of security and utilizes the driver's cognitive processes that may otherwise be left idle and bored. For these reasons a commute in an automobile may be perceived as faster than using transit. Pioneering the work in examining the individual's sliding scales of time perception during travel was Alan Horowitz, who hypothesized that the value of time "is a surrogate measure of the time, comfort, convenience and reliability of the travel experience" and that the perception of costs is fluid across a range of factors concluding that one minute spent driving in a car is not equal to one minute spent standing on a bus which in turn is certainly not equivalent to one minute spent walking in the rain (Horowitz 1978). Later work included the use trade off experiments that asked bus riders to rate their journeys compared to their immediate transit experience. Although the experiment controlled for travel experiences by surveying riders on routes where only a limited number of transfers were possible, it did not directly estimate the magnitude of disutility. The research determined that even short transfers significantly diminished the overall satisfaction with transit services. He also found that doubling the time spent transferring, from 5 to 10 minutes, did not significantly change the overall satisfaction with transit (Horowitz and Zlosel 1981). Although, in this particular instance, actual magnitudes of IVTT time were not estimated, his findings formed the foundations for numerous studies on transfer penalties.

Other studies have advanced the work of Horowitz by using mathematical models to determine how individuals perceive time across the spectrum of transfer situations and environments. Han (1987) uses a disaggregate demand modeling approach to determine the average disutility individuals in Taipei, Taiwan experienced when making a single transfer from one bus to the another. The study was an early example of a choice experiment carried out within a transportation context. Data was modeled based on the assumption of economic rationality and utility maximization. Well-designed experiments - where attributes and itinerant levels are systematically distributed among choice sets - force respondents to choose the alternative that yields the highest personal utility. The utility present in each alternative is assumed to depend on the utilities associated with its constituent attributes and levels (Mangham et al 2009). Stated choice surveys simulate the trade-offs people make when selecting a service or product, allowing the values those of preferences to be mathematically estimated. Modeling revealed behaviour as a function of economic rationality has distinct advantages; first, it simulates actual choices people make on a daily basis and, second, the resulting coefficient from the multinomial, nested or mixed logit formulation reveals marginal rates of substitution which may be expressed as a customer or users' willingness to wait or willingness to pay for different services. Pioneering these methods in transportation context, Han concluded that riders would transfer from one bus to another only if it saved them the equivalent of 5 minutes of walking, 10 minutes of waiting or 30 minutes of in-bus travel time. Han's choice experiment and discreet choice modeling methods has since become a widely adopted form of analysis in deriving transfer penalties across separate transportation modes and market segmentations.

Additional work on transfer penalties has been carried out to determine how the perceived burdens can vary under specific circumstances. Liu et al (1997) assessed how mode choice can be influenced by travelers who must transfer from one train to another or from their car to a commuter train. The authors concluded that inter modal (car-to-rail) transfers were in almost all cases considered far more onerous than switching between a single mode (rail-to-rail). Liu et al (1997) found that customers changing from one train to another experienced a transfer penalty of approximately 5 minutes of IVTT, while individuals' perceived car to rail transfers were perceived to take 15 minutes or more of IVTT equivalents. The results are supportive of providing transfer environments that minimize the effort and discomfort traveler's experience while switching modes or vehicles. The number of actions involved with a switch from car to rail and the uncertainty that users experience when having to find a parking spot, buy a ticket, walk to a platform and wait for a train, is a clear cause of disutility.

Guo and Wilson (2004 and 2007) examined how characteristics of the built environment exert influence on users' willingness to change metros or to walk. It was found that across all estimated models that metro users will on average only transfer if doing so saves them approximately 10 minutes of walking. Factors thought to influence the quality of the pedestrian environment included sidewalk width, presence of open space, land use and topography (hills to climb). These studies are the only researches this author is aware of that integrate station environmental characteristics within a transfer penalty framework. Guo and Wilson (2004) acknowledge the difficulty of including variables that quantify station or surrounding area pedestrian accessibility within a choice model and limited their selection of attributes to an arbitrary number of four that were thought to influence walking behaviour. They found that quantitative attributes (wait time, walk time etc) were the most influential factors that persuaded people not to walk. However, after controlling for these, poor walking environments increased the transfer penalty by an additional 6-9 minutes. Guo and Wilson (2004) conclude that qualitative variables, such as the pedestrian environment, are important components of transfer penalties that individuals consider before transferring. Therefore previous estimations of the true cost of transfers that do not control for these factors may over or underestimate the true cost of transfers.

The fluidity the perceived penalties transfers can have on transit journeys are interactive and multi layered; the results of both performance and qualitative attributes that shape an individual's perception of one service over another. More recent studies have used choice modeling to directly estimate the effects incremental service improvements have on customer's willingness to wait or to pay. These studies have shown that service attributes are important for both transit users and non users, giving some transit agencies reason to invest in specific improvements that can result in better service quality and increased revenues.

Hess et al (2004) determined that UCLA students will wait an average of 5.7 minutes for the use of a free bus over a bus that costs $.75. Both buses contained roughly the same quality of service. They also found that perceived wait times were exaggerated by a factor of 2 when the students were unaware when the next bus would arrive, but students accurately assessed their wait times when schedules were available. The results are consistent with similar studies that found people value their time while waiting for transit at approximately one half of their hourly wages (Lam et al 2001, Bruun 2007)

In a Thai context Park et al (2010) modeled choice behaviour of 1500 commuters accessing canal boat services on the Nonthaburi Pier in Northern Bangkok. The study aimed to determine the causal forces prompting people to drive, take a bus, or walk to access commuter boats. The results using maximum likelihood estimations determined that cost and walking distances were the most significant factor informing modal choice. In vehicle travel time was valued at approximately $1.40 per hour, while OVTT were evaluated as significantly more costly at $3.30 per hour. This is not particularly surprising as walking conditions in Bangkok can be exceedingly poor and can aggravate the perceived costs of having to walk to access services. The study also found that improvements to bus services by upgrading pedestrian access would expand the catchment area buses can draw passengers from as well as increase the market share of bus modes relative to mini buses and taxis. Significantly the study also found that many passengers would be willing to pay for some of the incremental service upgrades. The findings of Park et al (2010) mesh with research conducted by Townsend and Zacharias (2010) who examined the egress trips of 1500 MRT and BTS passengers at 6 stations in Bangkok. They found that walking distances involving a modal change were higher than expected, despite poor quality of pedestrian infrastructure.

Stated and revealed preference data has also been used to determine how customers value individual improvements to transit stations, transfer facilities and bus stops. Litman (2011) reports the findings from a comprehensive study of station environments in Vancouver, BC. The study found that passengers would be willing to pay between $.01 and $.07 per trip for improvements to waiting areas, upgraded amenities and increased security presence. The improvements are reported on a standalone basis, not controlling for one another. It cannot, therefore, be said with certainty how much passengers would be willing to pay in total, or how combinations improvements could be best leveraged to increase customer willingness to wait or pay.

Falzerano et al (2000) quantified access improvements to Chicago rapid transit stations. The study included an adaptive conjoint analysis (ACA) survey portion and a stated preference (SP) experiment. ACA is a computer based survey method that estimates participant's preferences of selected attributes as the survey progresses and adapts the questions so the primary effects of each attribute can be estimated. Falzerano et al (2000) determined that rapid transit riders would pay $.23 to $.37 per trip for access improvements depending on the combination of upgrades. Participants considered protection from adverse weather and security improvements as the most important attributes among other features to improve access to stations. Specifically, participants would pay the most for increased police presence and better exterior lighting, reflecting the importance of safety and security attributes as the most important aspects of service to be controlled for.

Many studies have shown that transfers are widely perceived as an impediment to using public transport and that many passengers may be willing to pay for incremental upgrades that minimize some of the penalties (Litman 2011). Users often exaggerate the quantitative aspects of travel, perceiving that OVTT is greater than the actual time passengers are forced to wait or walk (Horowitz 1978 and Horowitz and Thompson 1995). More recent studies have also shown that pedestrian environment and qualitative variables are also barriers to making transfers or utilizing different modes or services (Liu et al 1997 , Guo and Wilson 2004). These penalties are well understood and clearly demonstrate that while transfers are a necessary part of an efficient transit system, transit providers can control to some extent the negative aspects of OVTT and switching vehicles. Discrete choice models have estimated that specific improvements to OVTT can make transfers less onerous with improvements to some service attributes (Hess et al 2004, Litman 2010, Park et al 2010). Given the disproportionate effects transfers and OVTT can have on a user's willingness to use a service, controlling as best possible the negative aspects of a transfers could increase overall satisfaction with a transit journey and thus attract additional customers while cementing existing ridership (Iseki and Taylor 2010).   Diminishing the penalties associated with transfers can be done by improving the services attributes that transit users identify as both deficient as well as important.

3.3 Measuring Service Quality and Customer Satisfaction

Service quality has been identified as an important component in any transit journey that will help determine if a customer will choose one transit mode over another (Phillips and Guttenplan 2003). The TCQSM (Kittelson and Associates et al. 2003) divide the considerations one makes to use transit into two broad categories. First, service must be accessible and available at each end of the journey. Acceptable thresholds for service availability depend on many factors including walking distance, wait times and trip purpose, but as a rule of thumb transit is considered inaccessible if walking distances are greater than 400 meters (Crowley et al 2009). If this condition is met, the user will then consider the service quality of transit versus other available modes considering factors such as relative comfort, convenience, accessibility, the ease of making transfers and the overall costs (Kittelson and Associates et al 2003). Measuring quality of service and customer satisfaction has been standardized in two widely cited monographs (Kittelson and Associates et al 2004, TCRP Report 47, 1999), but many variations in the literature exist.

Service quality attributes have been used to study both global service measures of a transit operation (Eboli and Mazzualla 2008 and 2009) as well as specific segments – such as transfers, station environments and waiting platforms (Iseki and Taylor 2010, Geetika 2010). Decomposing total service quality into attributes is one way transit operators can identify cost effective methods to enhance user access, improve passenger comfort and diminish the penalties associated with transfers (Iseki and Taylor 2010). Determining customer satisfaction with individual attributes that make up an entire service is a common method for evaluating service delivery (Iseki and Taylor 2010, Eboli and Mazualla 2008, TCRP 1999, Tyrinopoulis and Antoniou 2008).

Studying quality of service using a customer satisfaction approach should be distinguished from other ways that quantify transit operations such as economic and vehicle performance measures. In a broad sense quality of service in public transit reflects the customers perception of transit performance (Tyrinopoulis and Antoniou 2008). Tyrinopoulis and Antoniou (2008) group the different approaches to determining quality of service into three categories;

1) **Customer Satisfaction**; quantifying how successfully a transit organization fulfills the expectations of its customers. This is normally measured as the percentage of the customer's expectation that have been filled. Many studies that measure customer satisfaction rank satisfaction as a function to the overall stated or derived importance of a particular attribute (Eboli and Mazzula 2009, Weinstein 2001).

2) **Customer Loyalty**; generally a function of customer satisfaction that is related to a customer's willingness to invest in a long term relationship with a transit service. Customer loyalty as a transit measure is not well defined, but has never the less been the focus of major transit service evaluations (Foote 2001). Since increasing ridership in the United States and many other parts of the world is tied to convincing choice riders – those who could use a car - to board buses and trains, determining which customers are loyal to transit service and why is one way some agencies have experimented with attracting new riders.

3) **Benchmarks**: Sets of measures that compare quality of service across different times or against separate organizations. Benchmarked service quality is sometimes done using performance measures as a proxy for how well a transit agency delivers service to customers. Accoring to Bertini and El-Ghenehi (2003) and supported by Hensher (1995), the TCSQM (1999) emphasizes that global measures of satisfaction from the point of view of customers are driven by the performance (availability and convenience) of transit services provided by operators.

Many service evaluations are measured from the supply side of services representing the performance aspects of service quality with which customers must directly interact, such as wait times, hours of operations and routing decisions (Phillips and Guttenplan 2003). Other supply side metrics are benchmarks used to evaluate system performance and may include financial or productivity measures (Hensher and Daniels 1995) or other vehicle and network performance evaluations such as scheduling compliance, average trip lengths and the application of accessibility metrics in relation to network coverage (Bertini and El-Geneidy 2003, Strathman et al 2001).

Demand side studies, such as customer satisfaction metrics, evaluate attributes from all aspects of service that customers must interact with. However, focus has tended to concentrate on in-vehicle travel experience (Metropolitan Transportation Authority 2007, Foote 2004) with very few studies specifically examining out of vehicle travel components as it relates to customer satisfaction.

There are a number of benefits to using customer satisfaction as a means to determine service quality at any resolution. First, customer satisfaction data can be directly measured using customer derived surveys on individual systems without the added work and complexities of benchmarking service standards at different times or across multiple systems or operators. Next, there are a rich variety of studies to draw from that have collected and analyzed customer satisfaction data, while relatively few have studied customer loyalty. And last, customer satisfaction data can be used to determine which attributes of transit service most affect an individual's transfer experience by revealing which attributes are considered both important and deficient.

Determining customer satisfaction is an important aspect of transit operations. In Bangkok, where much of the population relies on some form of transit or para-transit service, facilities that are unsafe, inconvenient and difficult to access have negative impacts on the lives of many, a fact of life for many transit users in developing world cities (Beimborn et al 2003). For consumers of public transport, their perception of overall service quality greatly influences their willingness to use buses or trains. Choice riders will make the decision to use transit when the overall costs in time, comfort, security or money are perceived to be less than any available alternative. Captive riders - who make up the majority of MRT users in Bangkok (Choijiet and Teungfung 2005) - may also be influenced to shift travel behaviour over the long term if their basic needs are not met. Transit agencies also benefit from understanding customer satisfaction as it relates to their services. Transit users satisfied with overall services can remain loyal customers and are more likely to recommend services to friends and family (Foote et al 2001). Past research has shown that transfers can be made significantly more attractive to customers when quality stations and interconnections act to reduce the perceived penalties or out of vehicle travel (Geetka 2010, Taylor et al 2008, Liu et al 1997).

Little attention has been paid to determining which service attributes would contribute most to diminishing the negative aspects of transfers. Although the importance of seamless travel has been recognized as an important component to global service quality for decades, little attention has been directly focused on customer interaction with transit interchanges (Taylor et al 2008). More recent studies have examined service quality from a global perspective. (Foote 2004, Weinstein 2001, Kittelson and Associates 2004). Many more studies have used a variety of methods to measure service quality at different scales from the customer's point of view. Isolating service attributes that have been shown to improve customer experience with OVTT and transfers is one way to researchers can lower the disutility of transfers.

Eboli and Muzulla (2008) divided studies to determine customer satisfaction into two broad camps; statistical studies that use various methods that evaluate services or relate them to customer satisfaction, and studies that make use of mathematical modeling procedures to determine coefficients for service attributes.

In the latter category of descriptive studies, methods include importance/satisfaction analysis or quadrant type analysis which usually considers attributes related to service quality as a function of stated importance and stated satisfaction (Iseki and Taylor 2010). Quadrant analysis is a method of illustrating how well a given transit service provides services as expressed by customers. Examples include methods that assess the ratio of scaled attributes according to importance and satisfaction (Christopher et al 1999), scatter plots that illustrate the bivariate correlation of derived importance values and service attributes (Weinstein 2001), plotting normalized importance scores and zone of expected tolerance ratios to identify service aspects that require immediate attention (Hu 2010) and by comparisons of gap scores of selected service attributes to the overall frequency that problems with those attributes that are reported (Kittelson and Associates et al 2003). Each of these studies are derivatives of the methods outlined in the TCRP (1999) and are a relatively straightforward way of determining deficiencies and gaps in service quality to transit managers and planners.

Other methods used to determine customer satisfaction of a descriptive statistical nature include longitudinal studies that compare customer satisfaction with service attributes over multiple years (Foote 2000, Foote et al, 2004). In both studies a series of surveys were administered to Chicago bus users to gauge the effect of improvements to services and their impact on customer satisfaction. Other common methods include factor analysis to isolate specific service dimensions that are most important to rail and bus users (Geetika, 2010, Weinstein 2001 Tyrinopoulos and Antoniou 2008). Although factor analysis has widespread application, individual service dimensions that form factors can be counter intuitive and not obviously related making their application difficult from any managerial perspective (Weinstein 2001).

In another descriptive type satisfaction study, Eboli and Mazulla (2009) propose a retooled version of the customer service index (CSI) called the heterogeneous customer service index that (HCSI) that calculates overall satisfaction scores based on stated importance and satisfaction data that discounts attributes that have been evaluated heterogeneously by respondents. The results allow transit managers to prioritize service improvements that have been identified as important by the widest portion of surveyed individuals.

Statistically descriptive studies have a number of advantages over more the more complicated modeling procedures. First, they are simple to prepare and replicate, and findings can be easily conveyed to a broad audience. Second, transit agencies can often mount and design these studies using ‘in-house’ expertise without relying on the expensive assistance of private consultancies. However, without advanced or experimental sampling procedures, or in absence of OLS (ordinary least squares) or maximum likelihood estimations, the findings cannot be considered statistically significant in relation to other attributes, nor do they control for the presence of other relative variables.

In the second category of research are studies that contain mathematical models that predict satisfaction given set of relevant service attributes that describe overall service. Eboli and Mazulla (2008) and Stuart et al (2000) compiled 16 and 23 attributes respectively and asked respondents on buses and subways to rate the provision of services according to 10 point scale. The results of the surveys were used to calibrate structural equation models (SEM) which combine factor analysis, regression and analysis of variance (ANOVA) to determine the presence and relative strength of unobserved latent variables that shape customer perceptions of transit. The findings of both papers suggest global measures of service can be categorized into five factors that include network planning, service reliability, comfort and safety. The findings of the papers point to the most significant drivers of satisfaction to overall bus and subway services.

Tyrinopoulis and Antinou (2008) use both factor analysis and ordinal regression models to determine customer satisfaction across multiple transit systems operating three different modes in Athens, Greece. Importance data was used to calibrate factor analysis that collapsed service attributes into relevant and unobserved dimensions, while the satisfaction data was used to construct ordinal regression models that revealed attributes most likely to influence customer satisfaction with transit services. In a similar study, Iseki and Taylor (2010) divided service attributes at bus transfers in Los Angeles into 16 variables and used stated satisfaction data scaled from 1-4 to build ordinal regression models that determined which services and attributes available at bus transfer points increase the odds of an individual being satisfied with transit.

Although not specifically studying quality of service, other studies have directly modeled significant attributes that contribute to customer satisfaction or passenger safety at bus stops. Ewing (2002) analyzed a broad range of attributes at or around bus stops both internal (attributes within direct control of agency to manage) and external (attributes outside to a transit agency's direct control) attributes. The author asked participants to evaluate paired photographs of bus stops in Florida and analyzed the results using logistical regression that determined a set significant attributes at bus stops that increased respondents likelihood of choosing a particular stop over another.

Loukaitou-Sideris et al (2002) compiled a data base of geocoded police reports of crimes committed at bus stops in Los Angeles. The authors used multiple regression models corrected by spatial auto correlation that tested for environmental and built urban characteristics and correlation to the incidence of crimes such as assault, drug distribution, robbery and sexual harassment. The authors found a set of built and environmental predictors that correlated with crime. The findings suggest that transit agencies can reduce crime against their customers as well as improve transit user's perception of safety during the OVT portions of journeys by making specific improvements to the built features at transit stops and stations. Previous research has found that service attributes that relate to safety from crime are extremely important to transit customers, particularly in the United States (Ewing 2001, Foote 2004 and Iseki and Taylor 2010).

Other methods that gauge service attributes include stated preference (SP) experiments which generally, but not always, compare habitually used services with hypothetical alternatives. SP data can be used to calibrate models that estimate the likelihood transit users would choose one service over another. Hensher and Prioni (2003) propose a stated choice method to determine a service quality index (SQI) that benchmarks service standards for the competitive tendering of private bus operators. Eboli and Mauzulla (2008) propose similar methods and use mixed logit and multinomial logit models to determine the importance individual attributes have in informing customer choice. Although stated choice methods are in many ways preferable to stated importance surveys, which ask respondents to rank service according to an arbitrary scale, their use in studying service quality is restrained by the limited number of attributes that can be modelled. Stated choice surveys are also very complex, requiring intensive qualitative pre-studies to develop credible alternatives, and experimental designs to properly administer the survey. Furthermore, studies that use stated preference data often determine willingness to pay measures, which can be problematic –particularly in the developing world – where results tend to direct investments to the more affluent segments of society, which can further exacerbating already stark societal divisions of wealth (Bruun 2007)

Many authors have measured and analyzed service attributes to determine their contribution to overall service quality, or 'global' service measures. However, only one study (Iseki and Taylor 2010) modelled service quality as it directly relates to customer experience at transfers. Most studies that calculate global service metrics or customer satisfaction to transit provisions include only a few attributes that directly relate to transfers, system accessibility or out of vehicle travel. Table 2 summarizes service quality attributes that relate to bus stops, transfers and out of vehicle travel from seven studies that were discussed in the literature review. The service attributes included in the summary table were each determined to either increase the odds of selecting one service over another, increase overall satisfaction with a transit service, or are service attributes that when increased or expanded would prompt users to pay more for the transit service, lower the incidence of crime. All were determined to be statistically significant given a reported level of confidence. These papers present clear findings that show some of the most important attributes at transit stops and transfers.

Table 2: Significant service quality attributes at transfers and bus stops

	Author	Year	Data	Analysis	Significant attributes that relate to transfers & stations
1	Ewnig	2000	Visual Preference survey of users, non-users and transit professionals of bus stops	Linear multiple regression models	Advertisments, seating and benches, setback from street, lighting, and sidewalk increased the odds of selecting one stop over another*
2	Ligget,R; Loukaitou-Sedaris, A and Iseki, H	2001	Geo-coded reports of crime at bus stops	Multiple regression models controlling for spatial autocorrelation	Visability, public phones, litter and graffiti, bus shelters decrease liklihood of crime**
3	Guo and Wislon	2004	Dissagregate GIS based revealed choice data of subway to subway transfers	Multinomial logit models	Sidewalks and attractive pedestrian environment increased the odds of walking to next mode***
4	Eboli and Mazzulla	2008	Stated choice data from bus users	Mixied and mutinomial logit models	Wait time and scheduling, bus shelters and station cleanliness increases the odds of selecting one service over another
5	Tyrlnopolis and Antoniou	2008	Survey data asking stated importance and satisfaction on service attributes	Factor analysis (importance data) and ordinal logistic regression modelling (satisfaction data)	Distince between transfers, waiting environment (shelter and seats) and wait time increased the odds of overall satifaction with a trasnit service**
6	Iseki, H and Taylor D	2010	Survey data asking stated importance and satisfaction on service attributes	Importance/Satisfaction and quadrat analysis and ordinal logistic regression (satisfaction data)	Security guards, lighting, safety, ease of movement (space and side walks), schedule and information**
7	Hu, K.C.	2010	Quadrat analysis based on ZSQ methods of regular bus riders	Analyzed ratios of derived importance and states satisfaction	Wait time, bus stop locations, posted information (shedules)**

*Significant at atleast .05 1-tail, ** significant at atleast .05, *** P< .001,

By extracting findings that are specifically related to transfers and out of vehicle travel, a handful of service attributes have been repeatedly shown to significantly do one of two things; either a) influence a traveler's perception of or willingness to switch vehicles or modes or b) increase the overall satisfaction with a particular transit service. Significant service quality attributes include 1) Transit performance characteristics such as waiting times for vehicles, route schedules and overall service reliability 2) Station characteristics that can make waiting or transferring more comfortable by enhancing accessibility through such enhancements to service as reduced walking distances, amenities such as seats and shelter to mitigate against adverse weather and ensuring a pleasant and open walking environment, and 3) The actual and perceived safety and security at and around stations.

Transit agencies can take many steps to lower the generalized costs from transferring from one vehicle to the next through improvements that address these aspects to overall service (Taylor et al 2008).

A review of the literature has shown that transfers are a widely disliked but well understood component of transit use. Research has firmly established that transfer penalties have a number of negative effects that can make a journey seem more onerous depending on a variety of quantitative factors (wait time, walking distances) and qualitative factors (pedestrian environment, perceived safety from crime). The quality of public transit service at stations and transfers can be determined by a set of constituent attributes that when added together represent the total service (Eboli and Mazzualla 2008). This research proposes to evaluate service quality attributes that have been shown to influence customer's overall perception of transit services at selected MRT stations in Bangkok, Thailand. In doing so, the research aims are to provide a concise set of service attributes that could be used to improve the perceptions MRT riders have with overall transfer experience.

4 RESEARCH METHODOLOGIES

4.1 Survey Instrument

This thesis employs a survey instrument designed to measure customer satisfaction of service attributes at busy transfer points between the MRT and the public BMTA bus system. The survey design borrows from several previous studies that used importance and satisfaction ratings to gauge service quality (Eboli and Mazzualla 2009, Iseki and Taylor 2010, Tyrinopolis and Antoniou 2008) Importance and satisfaction surveys use Likert type scale that ask respondents to rate - typically out of 4, 5, 7 or 10 – how satisfied they are with the present level of a particular service and then asks respondents to rate using the same scale how important they consider that service to be.

Quality of service attributes are normally assigned of service dimensions or factors. Factors are groups of mutually independent variables that can show researchers of variables customers think of similarly (Weinstein 2001). For example, attributes such as lighting, security cameras and emergency call boxes can be collapsed into larger factors that pertain to safety or security (Geetka 2008, Iskei and Taylor 2010, Weinstein 2001). In transit research the number of service factors that contain all service attributes for a global evaluation range between 4 and 7 and are normally arrived at through structural equation models or factor analyses that determines latent categories of service or statistically grouped attributes through correlation (Eboli and Mazzualla, 2007, Tyrinopolis and Antoniou 2008, Weinstein 2001). Taylor et al (2008) conducted a review of previous transit research and determined that services at transfers and bus stops could be collapsed into five categories. Service factors and attributes for this survey were based on the dimensions identified by Taylor et al's (2008) and were organized into 4 larger categories of service dimensions shown in Table 3.

The literature review identified service attributes which in some cases have been shown to influence the perceived service quality for passengers waiting or accessing public transit or transferring vehicles. The number of service attributes used to describe global service quality varies from 44 to 7 in studies of transit systems or operators in San Francisco (Weinstein 2001), Chicago (Foote et al 2004), Sydney, Australia (Hensher and Prioni 2001), Cosenza, Italy (Eboli and Mazzualla, 2008), Athens, Greece (Tyriopolis and Antoniou, 2008) and in the Netherlands (Givoni and Rietveld 2007). Taylor et al (2008) developed a framework for understanding the causal dimensions of transfer penalties and determined a set of 16 attributes that influenced transfer experience at 12 Los Angeles bus stops. Table 3 shows the service attributes that were chosen from the literature for rating in the survey instrument. Service attributes were carefully selected with consideration to Bangkok and the particular features typically found around bus stops, as well as those that seem lacking.

Table 3: Organization of service factors and corresponding attributes

Service Factor	Service Attribute
Planning and Reliability	Waiting Time
	Bus Route Adequacy
Accessibility	Sidewalk Quality
	Bus Stop Location
	Appropriate Signage
Station Amenities	Availability of Shelters
	Availability of Seating
Safety and Security	Safety from Crime
	Safe Street Crossings

"Planning and Reliability*"* encompass waiting time and the adequacy of the connecting bus routes. Attributes included in this factor are "wait time'; the users perception of OVTT when switching to a bus from MRT. Wait times were identified as a significant service attribute in four studies (Eboli and Mazzulla 2008, Tyrinopolis and Antoniou 2008, Iseki and Taylor 2010 and Hu 2010) "Bus route adequacy"*;* how well the bus routing from the stations reflects the needs of the passengers, because many BMTA buses do not serve the smaller streets, and most routes connecting to MRT stops are trunk routes which in some cases parallel the mass rapid transit routes.

"Accessibility" encompasses attributes that describe the ease of accessing a connecting bus at a MRT station. Attributes to describe access and connectivity are "sidewalk quality"*;* the adequacy of sidewalk space that is at a separate grade from traffic that passengers can use to arrive at bus stop, found to be significant in two studies (Guo and Wilson 2004 and Ewing, 2000) and "bus stop location"*;* the accessibility of bus stops from station exits, found to be significant in two studies (Iseki and Taylor 2010 and Hu 2010).

The third service factor “Station Amenities” can encompass attributes that effect the physical comfort experienced while transferring or waiting for buses. These include ‘availability of shelter’ from the wind, rain or sun at bus stops, and the “availability of seating”; a suitable number of seats at stations or stops to wait for a connecting vehicle. Shelter was found significant in four studies (Ewing 2001, Loukaitou-Sideris 2001, Eboli and Mazzulla 2008 and Tyrinopolis and Antoniou 2008) while seating was found to be significant in two (Ewing 2000 and Tyrinopolis and Antoniou 2008)

The fourth service factor ‘Safety and Security’ encompasses attributes that contribute to passengers perceptions of safety from crime and moving vehicles. Pedestrian safety has been found significant in one study (Iseki and Taylor 2010). Attributes used in the survey to describe safety and security are “safe street crossings”. The author is unaware of any study which has statistically linked service quality to safe and convenient crossings, however safe cross walks MRT exits either do not exist or require pedestrians to climb up and down stairs to cross bridges, often at an inconvenient distance from exits. “Safety from crime”; refers to the customer’s perception of their own safety from being a victim of crime, found to be significant in two studies (Loukaitou-Sederis et al 2001 and Iseki and Taylor 2010)

The survey was fielded following extensive pre-testing in both English and Thai in December and January 2011 by hired graduate students at Chulalongkorn University (native Thai speakers). The survey was fielded for data collection in late January to mid-February 2011. Respondents were approached at random while exiting MRT exits at all times of the day and week, but not after dark. Respondents were informed that the present research aimed to determine which service attributes around the MRT exit where they were intercepted would most improve their experience when transferring to a bus. Respondents were informed participation was voluntary, told their identity would remain anonymous and that they would receive no compensation for participating. The first set questions asked their age, sex, income and some of the characteristics of the journey they were presently on. Respondents were then asked to rate each of the following statements in the list below on a scale from 1-4, first on how satisfied they are with the present state of that service - 1 being very unsatisfied and 4 being very satisfied - and then to indicate on the same scale how important they consider that service attribute to be when making a transfer. The nine statements that relate to the 9 service attribute are listed below;

1. There are places for me to sit and wait (Availability of Seating).
2. There are bus shelters to protect from rain and sun (Availability of Shelter).
3. There are signs here that help find where I need to go (Appropriate Signage).
4. The bus stop is close by and easy to find (Bus Stop Location).
5. It will be a short wait time to catch a bus (Waiting Time)
6. The buses here will take me close to where I need to go (Bus Route Adequacy)
7. There is enough good quality sidewalk space (Sidewalk Quality)
8. There is a safe and convenient spot to cross the street (Safe Street Crossings)
9. This station is safe and free from crime (Safety from Crime)

A final statement, ‘This is a good place to transfer to a bus’ prompted individuals to rate the exit in terms of overall transfer experience. It is used in the ordered logistical regression analysis as the dependant variable. The final survey contained a total of 19 questions. The appendices contain both the Thai version of the questionnaire used to survey respondents and an English translation.

4.2 Station Selection

The survey was carried out at three MRT stations (Lat Phrao, Lumphini & Petchaburi) each located in measurably distinct urban settings and were also the focus of a pedestrian accessibility study carried out by Townsend and Zacharias (2010) in 2006 who recorded the Floor to Area ratios(FAR) within 400 M .The location of each MRT station is shown on the map in Figure 3. At Lat Phrao and Petchaburi stations 2 out of the 4 exits were canvassed; while at Lumphini respondents were surveyed at 1 out of the 3 exits. The particular exits chosen to recruit participants contain a wide range of overall service quality for transferring passengers. The study was conducted at a heterogeneous sample of stations in order to capture a range in quality of MRT-bus transfers.

At the station level, population densities and the built environment surrounding each of the stations are reflective of the unique urban environments that each station is situated in, while the quality of intermodal connections varies at each of the particular exits selected for this research. Service attributes that support bus transfers (Distance to bus stops, wait times bus stop amenities and qualitative attributes that characterize the pedestrian environment) were recorded by the author at each of the 5 station exits. Also, with the use of a handheld GPS (global positioning system) unit, some individuals were discreetly followed from the MRT exits and onto buses where bus trip lengths and average speeds were recorded. Over 300 observations were made, mostly during peak travel periods when most transfers from MRT stations to buses take place.

Individual exits were selected on the basis passenger volume and the presence of intersecting bus routes. Each exit selected to recruit respondents from was observed to have a high volume of transit passengers leaving station exits at many times during the day, as well as significantly higher amounts of activity during peak travel times. Also each exit had connecting BMTA bus services, some with reasonable quality connection, others with very poor transfer environments.

4.2.2 Lat Phrao Station

Lat Phrao's surroundings are the most suburban of the three stations reflecting its position at a high traffic location adjacent to predominantly residential neighbourhoods. Like all of Bangkok's rapid transit stations, Lat Phrao is in the middle of a major arterial roadway with 2 to 4 lanes of traffic travelling in both directions. The station is at the northern extent of MRT service coverage and is adjacent to some of Bangkok's largest superblock neighbourhoods comprised of tightly packed low-rise attached housing bounded by major arterial roadways. The maze like structure of *sois* and alleys with many dead ends prevents bus services from accessing large parts these neighbourhoods. Newer high rise condos occupied by mid income earners are within 400 meters of the station exits alongside the pre-existing commercial establishments on the first floor of many of the street side buildings. The station is located in a district with a population density of 5300 people per sq/km and has a built floor area to land area ratio of .7, the lowest of the three stations (Townsend and Zacharias 2010).

Individuals accessing buses from the two exits at Lat Phrao spent the smallest amount of time waiting, an average of only 2 minutes at rush periods, but travelled further than passengers boarding buses at Petchaburi or Lumphini, travelling an average distance of over 5 km at speeds of about 12 km per hour. In general, MRT users accessing buses travelled further and for longer amounts of time than riders taking buses at Petchaburi or Lumphini.

Lat Phrao Station Exit 4 is abutted to a mutli-story 1,600 space parking structure that is connected to busy surrounding streets by an elevated road link. MRT passengers alighting from Exit 4 (emerging from the corner of the building in Figure 7) can access BMTA bus services at an unmarked area approximately 25 meters from the station entrance. There is an elevated walkway, shown in Figure 8, where pedestrians can safely, albeit laboriously, cross the busy adjacent street approximately 50 meters from the exit. From a security standpoint Exit 4 is well protected by surveillance cameras, security guards and periodic patrols by armed MRTA police.

Figure 7: Lat Phrao Station Exit 4

Figure 8: Lat Phrao Station Exit 4 pedestrian bridge

Exit 3 at Lat Phrao is next to a commercial building with a bus stop approximately 25 meters from the station exit on sidewalks that are wide and of good quality. There is a small waiting area with seats for up to 6 passengers, without any shelter or overhead protection. MRTA police intermittently patrol outside this station exit. Lat Phrao exit 2 is directly across the street, and passengers can safely cross by an underground platform link and exit through the station. Lat Phrao exit 4 can be seen in Figure 9.

Figure 9: Lat Phrao Station Exit 3

4.2.3 Petchaburi Station

Petchaburi station is located under a noisy and polluted elevated intersection but just 200 m to the south a 1 km stretch of densely packed office buildings begin. The principal terminal for a new airport heavy rail link is located a short distance from Exit 1 and opened in 2010, but as of February 2011, no continuous pedestrian infrastructure connected the two facilities. Within 400 meters of the center of the station, the FAR is .09 (Townsend and Zacharias 2010). Petchaburi station is located in a district with a population density of about 7500 people per sq/km (Thai Ministry of the Interior 2008).

Passengers accessing buses from Petchaburi station waited on average 5 minutes, the longest wait times of the three stations, with a standard deviation of nearly 10 minutes, highly skewed to the right. Bus trips originating from Petchaburi were just over 4 km, lasting an average 16 minutes at speeds of about 13 km p/hr.

Survey participants were recruited from Exit 2 and 3. Exit 2, shown in Figure 10 located along a canal with regular boat service to the outskirts of Bangkok. It is within walking distance to a small university and some large office buildings. The bus stop is located 225 m from the exit with one connecting bus route that travels west down the busy Petchaburi road to dense inner parts of Bangkok. Surrounding sidewalk quality, shown in Figure 11 is generally poor, narrow, with many high curbs and with steep sidewalk grades which are an impediment to older or disabled pedestrians and transit users. There are no pedestrian street crossings. Seats or bus shelters for waiting passengers have not been installed, and there is no regular transit security presence.

Figure 10: Petchaburi Station Exit 2

Figure 11: Sidewalk linking to the bus stop at Petchaburi Station Exit 2

Petchaburi station Exit 1, shown in Figure 12 is beside a small 50 space parking lot and is located along the east bound side of Petchaburi road, with many riders transferring to buses that travel to Bangkok's inner suburbs. There are no major office buildings within a short walk, but there are many convenience shops, restaurants and street stalls occupying the first floor of street front buildings. The closest bus stop, shown in Figure 13 has a large shelter with 12 seats for waiting passengers. It is located 345 meters from the station exit, with 8 connecting routes, along a wide sidewalk that is of relatively good quality. A pedestrian bridge provides a means of crossing the busy Petchaburi Road.

Figure 12: Petchaburi Station Exit 1

Figure 13: Bus stop at Petchaburi Exit 1

4.2.4 Lumphini Station

Lumphini station is located close to a dense commercial corridor on Wireless road where many major foreign embassies as well some of the largest and most expensive hotels in the city are located. Within 400 meter radius of the center of the underground MRT platform, there are 5 large office buildings, a boxing stadium, a large city park, a number of newer high-rise residential towers, many restaurants and convenience shops and other small businesses that occupy street frontage. Lumphini station has the highest ratio of built floor space to land area with a FAR of 1.2 (Townsend and Zacharias 2010), and the surrounding district has a population density of 9036 people per sq/km(Thai Ministry of the Interior, 2008).

Wait times for buses at Lumphini were on average about 4 minutes in length, with a standard deviation of almost 5 minutes. Bus trips that originated from Lumphini were shorter than trips from the other two stations, on average only 2 ½ kilometres, with a high standard deviation of distance skewed to the left. Bus journeys from Lumphini tended to be shorter, accessing more central and denser locations in inner Bangkok. Many riders connecting to buses from Lumphini made trips less than 1 km in total distance, suggesting there is a reluctance to walk even short distances on sidewalks around the station.

Surveys were carried out at Lumphini Station at Exit 2 directly adjacent to the 40 storey Q. House Lumphini office building. The bus stop is located 290 meters from the exit. Figure 14 shows the narrow and obstructed sidewalk between the MRT exit and the closest bus stop. The high gray wall to the left of the sidewalk partitions the public space from adjacent hotels and offices and contributes to an isolated pedestrian environment.

Construction debris on sidewalks around Exit 2 is shown in Figure 15. The bus shelter, shown in Figure 16 is a simple awning, with no lighting or security presence, and has space for approximately eight waiting passengers. Pedestrians wishing to cross Wireless road must do so at considerable personal risk on a crosswalk without adequate signalling. Figure 17 shows the confusing and dangerous street crossing near Exit 2, where one pedestrian is seen running for his life across the street, while another waits for a greater traffic interruption before making an attempt to cross.

Figure 14: Sidewalks around Lumphini Exit 2

Figure 15: Obstructions and construction debris at Lumphini Exit 2

Figure 16: Bus Shelter at Lumphini Exit 2

Figure 17: Dangerous and unsignalled cross walk at Lumphini Exit 2

Table 4 is a summary of the population densities and FAR at each station as well as the available attributes that support intermodal connections at each station exit. Table 5 is a summary of bus journeys that individuals make on their egress trips away from each station and Table 6 summarizes the average wait times of passengers waiting for buses at each station.

Table 4: Service Attributes at 3 MRT Stations

Station	Bus Stop Number	District Pop Density (p/km2)	FAR	Distance to bus stop	Shelter	Seats	Routes	Street Crossing	Sidewalk	Security
Lumphini	Exit 2	9036	1.2	290 M	Yes	8	7	Inadequate	Poor	None
Petchuburi	Exit 1	7551	0.9	345 M	Yes	12	8	Pedestrian Bridge	Adequate	None
	Exit 2	7551	0.9	225M	No	0	1	None	Poor	None
Lat Phrao	Bus Stop 1	5386	0.7	15 M	No	6	10	N/A	Good	None
	Bus Stop 2	5386	0.7	25 M	No	0	10	Pedestrian Bridge	Good	Guards and cameras

Table 5: Bus Journey Characteristics

Station	Characteristics Bus Journeys from 3 MRT Stations				
	Number of obs	Meters (avg)	Std. Dev (m)	Minutes (avg)	Avg Speed (km/ph)
Lat Pharo	132	5221	2803	31	12
Phtechuburi	106	4024	2506	16	13
Lumphini	103	2659	1618	12	12

Table 6: Wait Times for Busses

Station	Wait Times		
	# of Obs	Average (min)	Std Dev (min)
Lat Phrao	107	1.7	2.49
Petchaburi	40	5	9.4
Lumphini	34	4.02	4.7

4.3 Analysis Methods

The aim of this research is to establish which service attributes at transfers are important to MRT users and which of these attribute could be used to improve customer satisfaction with connections to buses. The expectation is that simple improvements at MRT stops could be made to improve passenger experiences to encourage the use of public transit.

The analysis of the survey data is influenced by previous research by Iseki and Taylor (2010) who used both mathematical models and descriptive statistical techniques to analyze an importance and satisfaction survey. In this research, both importance and satisfaction ratings are used in importance/satisfaction analysis (I/S) to show the overall priority that changes to service attributes should take. Next, satisfaction scores are then used to model how individual responses to each of the questions influenced a customer's overall experience of making a transfer.

4.3.1 Importance/satisfaction (I/S)

Using customer-derived importance scores to drive product and service improvements has long history in marketing and advertising with smaller applications in transit research (Foote 2004, Iseki and Taylor 2010, Gabriloa and Mazulla, 2010). I/S analysis allow researchers to treat overall customer satisfaction as a function of the ratio between stated importance and stated satisfaction. In this way individual scores for customer satisfaction are weighted according to the relative perceived importance. Because all service attributes are not equally important, correcting satisfaction scores according to some measure of importance allows satisfaction scores to be more reflective of customer needs. This approach to measuring customer satisfaction has several advantages. Firstly, for data collection purposes, asking respondents to rank attributes according to importance and satisfaction is straightforward and requires minimal explanation allowing a greater number of surveys in less time. Second, analysis is straightforward and simple interpret. Third, the satisfaction component of the survey can be used for separate statistical procedures and modeling (Tyrinopoulos and Antoniou 2009). The I/S index is derived by calculating the number of respondents who were satisfied with a question by indicating a three or four on the questionnaire, which is then multiplied by one minus the proportion of respondents who thought the attribute to be very important to overall service. I/S scores are calculated by Equation 2

Equation 2: Importance Satisfaction(I/S) $\boldsymbol{IS = Importance \times [1 - Satisfaction]}$

$$IS = \textbf{Importance} \times [\mathbf{1} - \textbf{Satisfaction}]$$

A maximum I/S value of 1.0 result when all respondents consider an attribute to be very important and all respondents are either unsatisfied or very unsatisfied with the present condition of that attribute. A minimum value of 0 would be calculated if no respondents considered the attribute to be important or all respondents were at least somewhat satisfied with the attribute.

Put simply, the higher the score, the greater overall need for improving that service attribute. I/S analysis can be performed to either make recommendations at the individual station level, or at a disaggregate system wide level. This research followed the methods of Iseki and Taylor (2010) who selected a range of bus stop/transfer points in the Los Angeles are to produce a generalized list of improvements to service attributes at all stops and stations.

4.3.2 Ordered Logistical Regression

Regression models are a useful tool that can capture the effects of individual or a set of predictor variables on a treatment variable. The challenge in this research was building suitable models that illustrate how available service attribute can influence customer satisfaction either in a standalone fashion or in combinations through the use of ordinal categorical predictors –or factors- as well as an ordinal treatment variable.

The survey instrument asked respondents to rate different aspects of service, performance and transfer quality according to a scale from 1 to 4, where 1 indicated complete dissatisfaction and 4 indicated complete satisfaction. Selecting an appropriate procedure to model the effects of the independent variables on a dependent variable a matter of deciding what assumptions must be satisfied prior to testing, given the scale of measurement the data is recorded in. Several statistical procedures were considered candidates for data analysis including OLS (ordinary least squares) regression and Pearson Bivariate analysis, multinomial logit modeling and ordinal regression. There are strengths and weaknesses to each approach.

OLS regression and Pearson Bivariate analysis are straightforward and make it possible to test the relationship between varieties of independent variables on a continuous response variable. Although categorical variables can be used in OLS regression and Pearson Bivariate, a problem arises when the independent variables must be tested for their effects on an ordinal, categorical dependent variable. In this research, it is assumed there is an inherent ordering to the levels of responses, but the difference between each level is subjective and therefore unknown. Research has been carried out in the past that using both OLS regression and Pearson Bivariate analysis on ordinal treatment and response variables collected from transit customer satisfaction surveys (Weinstein, 2000). However the lack of meaningful scale data can produce results that can only be considered 'loose' guides to predicting customer satisfaction.

Multinomial logit models are another common tool used to assess choices in transportation research (Park et al 2010). Logit models can test the effects of predictor variables on multiple binary or dichotomous outcomes. Although technically feasible, the use of multinomial logit techniques in this research would eliminate any ordering among the response variables, as all outcomes of the 1-4 scale would become binary values without differentiation. Each level or response for overall satisfaction would therefore be modelled according to the odds of someone choosing a particular level capturing the differences between all possible pairs of responses without making the assumption that larger coefficients indicate a an association with larger scores (Norûsis 2008). Although a great number researchers have made use of logit and OLS regression techniques providing a larger pool of cumulative research to draw from for help in performing analysis, both methods are unsuitable in this analysis.

To overcome the procedural obstacles with other forms of regression, this research makes use of ordinal regression as implemented in the SPSS Ordinal Regression Procedure, or PLUM (Polytomous Universal Model). Ordinal regression techniques allow continuous, categorical and ordinal level dependent variables to be tested against an ordinal outcome. In ordered logit models, the ordering of dependent outcome is important while the difference between consecutive values of the dependant variable is unknown.

Before the model results are presented, it is useful here to illustrate the similarities and differences between logistic regression and ordinal logistic regression. Consider the linear logistic expression in Equation 3 where we are interested in modeling what effect X has on Y, where Y has only two values; yes or no (1 or 0) and tests the likelihood of event $\pi(x) = P(Y = 1|X = x)$ given a set of k independent variables occurring in Equation 3,

Equation 3: Linear Logistic Regression Model

$$f[\pi(x)] = \alpha + \beta_1 X_1 + \dots + \beta_k X_k$$

Where α is the intercept and β is the coefficient for X. The portion of the formula written on the right side of the equals sign defines the random portion of the equation. f is the appropriate function or link which here is defined as the logit or the log of the odds that an event will occur over the odds of an event not occurring minus one, $\ln\left(\frac{\mathrm{prob(event)}}{1-\mathrm{prob(event)}}\right)$ $\ln(\frac{prob(event)}{1-prob(event)})$which is equal to the coefficients on the right side of the equation which explain how much the odds of the event of occurring changes based on the value of the independent variables (Norûsis 2008). The logit link does not predict Y directly, it instead predicts the log of the odds of Y=1. The log transformation of the odds produces a model linear in parameters, making the use and interpretation of these models relatively straightforward (O'Connell 2006). Using the logit link, solving for $\pi(x)$ the following logistic regression formula determines the odds of success as demonstrated in Equation 4;

Equation 4: Logistic Regression

$$1 + \exp[-(\alpha + \beta_1 \ldots . \beta_k X_k)))$$

This works well for modeling the outcome or 'yes or no; or '*success or failure'* type questions where success is defined as predicting an outcome of interest among two possibilities. However, when researchers are confronted with multiple outcomes ordered according to an 'unknown' scale, the term success must be reconsidered (O'Connell 2006).

Ordinal regression differs from logit regression in one important way; to take into account the ordered nature of the independent variable; ordinal logistic regression calculates the probability of an event and all events that are ordered before it occurring. The dependent variable is broken down into an ordered number of cumulative splits. '*Success*' therefore becomes defined as being at or below the numbered category (O'Connell). In the case of overall satisfaction with a particular transit station, where there are four categories of responses, the term 'success' in an ascending model takes on the meaning of being at or below the final category. Thus predicting overall satisfaction at a given transfer point, an ordinal regression would model the following odds (Norûsis 2008),

Θ_1 = probability(score of 1) / probability (score greater than 1)
Θ_2 = probability (score of 1 or 2) / probability (score greater than 2)
Θ_3 = probability (score of 1, 2 or 3) / probability (score greater than 3)

Modeling the odds of the final category of 4 being selected would be redundant here since the odds of selecting all possible outcomes before 4 have been calculated. The final probability of falling into the 4th category must therefore be equal to 1 or 100% of all choices. Figure 18 illustrates this concept. For simplicity all respondents to the survey in Figure 18 were grouped according to being satisfied (choosing 3 or 4) or unsatisfied (choosing 1 or 2) with their satisfaction of being able to locate bus stops at MRT stations. The graph displays the cumulative frequency at which those who were either satisfied or unsatisfied with bus stop location indicated a particular overall satisfaction score. It can be seen that among those who were unsatisfied with bus stop location, the cumulative probability of selecting ***3 or lower*** (somewhat satisfied) with overall satisfaction with the transfer was about 90%, while among those who were satisfied with the location of stops, the cumulative probability of selecting 3 or lower on overall satisfaction with the transfer was about 77%. In other words, about 13% more of respondents who were satisfied with bus stop locations around an MRT station were very satisfied with their overall ability to make a transfer than those who were not satisfied with the bus stop location. It is only at the 4th level of response (very satisfied) that the lines converge as all respondents have been counted and the accumulation of their responses must be equal to 1 or 100%.

Figure 18: Plot of observed cumulative percentages

Using the cumulative approach described above, one model instead of several can be used to estimate the probabilities of being at or below a given category across all the cumulative splits of the dependent variable. This is an attractive feature of cumulative logit method because it allows the model to be far more parsimonious than one where four different logistic regressions must be calculated according to the sequential partitioning of the data (O'Connell 2006).

Thus a ordnial logistic regression model in SPSS PLUM procedure with multiple independent variables takes the form of Equation 5;

Equation 5: Ordinal Logistic Model $f(\theta_j) = \alpha_j - \beta_1 X_1 + \cdots + \beta_k X_k$

$$f(\Theta_j) = \alpha_j - \beta_1 X_1 + \cdots + \beta_k X_k$$

Where *j* goes from 1 to the number of categories in the dependant variable minus 1, *f* is the appropriate link function, α_j is the intercept and β is the regression coefficient for the *k* variable. The minus sign before the coefficients is there so larger coefficients are associated with larger scores. Each cumulative logit (three cumulative logits for four levels of responses, one for each combination of probabilities of picking a particular score or less) has a unique intercept, but an assumption with ordinal logistic regression models is that each logit is has the same coefficient β. In effect and with respect to the logit link function *f,* all corresponding coefficients are equal. While logistic regression requires the assumption of constant variance, ordinal logistic regression is validated by checking if the relationship between the independent variables and all logits are the same. The PLUM procedure simultaneously estimates equations for the number categories in the dependent minus 1. Table 7 depicts how the cumulative odds would be modelled in ascending order according to a 4 category outcome.

Table 7: Ascending order of cumulative odds in ordinal regression

	Pooled Categories		Pooled Categories
Equation 1	1	compared to	2, 3 , 4
Equation 2	1,2		3,4
Equation 3	1,2,3		4

Ordinal logistic regression provides one coefficient for each of the independent variables, meaning that if each category for the dependent variable were modelled separately, the coefficients would not significantly vary. This is why ordinal logistic regression is often called the ‘proportional odds model’ (Chen and Hughes 2004). Testing whether this assumption is satisfied is called testing for Parallel Lines and will be discussed further in a later paragraph.

Ordinal logistic regression is one of many models within the realm of generalized linear models for ordinal data (Norûsis 2008). The model is based on the assumption there is a ``discretized variable of an underlying latent continuous trait” that defines the cut off points between the different levels of the dependent variable (Bender and Benner 2000) with thresholds that estimate the cut off values between the different levels of responses. Thus the basic form for a general linear model substitutes θ_j for Y_j, the cumulative probability of all categories, Equation 6 is the general linear model;

Equation 6: General Linear Model

$$f(\gamma_j) = \frac{\theta_j - [\beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k]}{\exp(\tau_1 z_1 + \tau_1 z_1 \ldots \tau_m z_m)}$$

Where γ_j is the cumulative probability for the *j*th factor, given the appropriate link function $f(\gamma_j)$, θ_j is the threshold or cutoff point for category *j* of the dependent variable, $\beta_1 \ldots \beta_k$ are regression coefficients and $X_1 \ldots X_k$ are the predictor variables. The numerator describes the location of the independent variables in the model and the denominator specifies the scale which accounts for the different amount of variability among the independent variables. Accounting for the differing quantities of variability can greatly influence the predictive power of a model (Norûsis 2008). Different functions or *links* have been developed that better represent the distribution of a given dataset to produce a model with linear parameters (hence *general linear model)* where assumptions of equal variance and normality are relaxed. The two most common link functions used when fitting an ordinal regression models are (Bender and Benner, 2000);

1) The logit link function or proportional odds model : $\ln\left(\frac{\gamma}{\gamma-1}\right)$

2) The complimentary log-log, cloglog or partial hazards model: $\ln(-\ln(1-\gamma))$

Where γ represents the cumulative probability of an event occurring.

The ordinal analysis in this research made use of both these links. The logit link may be applied to data where responses to the outcome variable are assumed to be equal across all categories of response, hence being known as the proportional odds model. The cloglog link is more appropriate when testing variables that are thought to influence respondents to pick higher categories of the dependent variable. The cloglog link relaxes some of the strict assumptions of parallel lines allowing one or more of the explanatory variables to deviate from the equal slopes assumption (Bender and Benner 2000) Using charts - such as the one displayed in Figure 18 used to illustrate the cumulative frequencies of responses is one method of pre-analysis that can be used to help decide what link function will produce the best model estimates. Each of the 9 variables was visually analyzed in this manner to determine the overall shape and form of the data and can be reviewed in the appendices.

Whatever link function is selected to best estimate model parameters, the assumption that the corresponding regressions in the link function are equal according to each cumulative partition or cut off points in the dependent variable is used to assess the adequacy of both models (Chen and Hughes 2004). SPSS refers to the model fitting estimate as the ‘test of parallel lines’ meaning that the results are a set of parallel lines or planes – one for each outcome of the dependent variable. Parallelism can be assessed by comparing -2 Log Likelihood estimates for the constrained and general models, both of which can be calculated in SPSS’s PLUM procedure. If the lines between each cumulative logit are parallel, the general model should not result a sizable improvement over the constrained model that assumes the null hypothesis that the lines are parallel.

4.3.3 Constructing Ordered Logistical Regression Models

One of the purposes of this study is to identify which measured satisfaction variables most influence users’ overall satisfaction with transfer points at three MRT stations in Bangkok, Thailand. Ordinal logistic regression will be used to identify which independent variables have the most effect on overall satisfaction either by themselves, or in combination with others and to describe what relationship and magnitude the variables have on overall satisfaction. Two different series of models were specified. The first series involved conducting ordinal regressions one variable at a time to determine which individual components of the transfers most influenced overall satisfaction. The second series of models were estimated to determine which attributes most influenced overall satisfaction while controlling for other significant variables.

The first task is to establish which improvements to service quality attributes can have the most impact on overall satisfaction in a ‘standalone’ format. In other words, which improvements without controlling for the influence of other variables increase the likelihood of an MRT user being more satisfied with the overall transfer experience. To determine which variables are most significant each question related a service attribute on the survey was transformed into a binary value. Although independent variables could be inputted as ordinal variables (i.e. each of the nine variables are left untransformed in their original 1 to 4 scale),it was found that the four variables related to seating, signage, shelter and cross walk availability produced models that failed to converge. The reasons for non-convergence are technical in nature and are beyond the scope of this paper to explain. Allison (2008) contains an advanced discussion of non-convergence in logistical regression analysis and also offers some solutions to mitigate some of the more common issues. Thankfully, in spite of the relative complexity of the problem, there are several simple solutions that can be experimented with on problematic variables to produce models that can converge. As a first step Allison (2008) recommends breaking categorical (ordinal) variables into groups of dummy variables. Dummy variables can be used to combine levels of responses or eliminate the categorical levels determined to be problematic. This procedure allowed each level of response to be tested both individually and in groups. Through this process of stepwise experimentation of the transformed variables, it was possible to eliminate categories that were insignificant or that created instability in the modeling procedure.

Beyond this, the major steps in the modeling procedure were to determine which variables to include in the multivariate model, and to decide which link function produced linear estimates of the coefficients. The appendices contain charts that illustrate the observed cumulative percentages of responses for each variable. By examining the proportion of respondents who were satisfied or unsatisfied with each variable and their overall satisfaction with the transfer, it was possible to come to preliminary conclusions about which link function might best fit the data set. For example if the cumulative curves suggest that an approximately equal number of respondents could be fit into each categorical outcome, a logit link might be the best choice. If however, more people could be grouped into higher categories, or if the curves intersected (violating the assumption of parallel lines), then the clog-log link might be more appropriate. In most cases, it was not entirely clear how the data was categorically spread, particularly when constructing the final multivariate model, it was therefore necessary in some cases to experiment with both links to determine which fit the data more appropriately (Chen and Huges 2004).

Before coefficients can be analyzed and interpreted, the validity of the model must be confirmed. There are several ways to judge the overall fit and adequacy of each model. Firstly a Pearson chi-square statistic can be estimated to assess the discrepancy between observed and expected counts of responses to overall satisfaction according to how each independent variable was rated. Table 8 shows a two way cross tabulation of the overall rating of the transfer and a binary satisfaction measure with ease of locating a bus stop. The row called *Observed* is the actual count of respondent's ratings of overall satisfaction from the survey. The row titled *Expected* contains the estimated cumulative probabilities of choosing a particular level satisfaction which is calculated by Equation 7;

Equation 7: Cumulative Predicted Probabilities

$$\mathbf{prob}(\mathbf{event}\ j) = \frac{1}{1 + e^{-(\alpha_j - \beta_x)}} * \bar{n}$$

where α_j is the intercept term for the cumulative probability of being at or below the j^{th} category, β_X is the coefficient and $\bar{n}$ is the number of respondents who were either satisfied or unsatisfied for a particular variable (Norûsis, 2008). Observed and expected counts can then be used to conduct Pearson Chi-square test to check the null hypothesis that the distribution of responses conforms to a theoretical chi square distribution. Failing to reject the null hypothesis indicates that the model fits the observed data (Triola 2008) and is therefore a reasonable estimation.

Table 8: Cross tabulation of observed and expected response frequencies

It's easy to find a bus stop at this station…		**Transfer Experience**			
		Unsatisfied	s.w unsat	s.w satis	Satisfied
Disagree (≤3)	Observed	52	82	84	24
	Expected	52.605	81.987	81.746	25.662
Strongly Agree (4)	Observed	4	10	26	28
	Expected	3.264	9.337	28.524	26.876

Pearson chi-square tests are acceptable to validate the goodness of fit for models where each cell – as seen in Table 8 - has reasonably large observed and expected frequencies (≥3). However, the dimensions of the model quickly grow as additional variables are added. Table 8 contains 8 cells representing the different combinations of one predictor (binary) and four response variables. However, in larger tests involving multiple treatments - for example, when 4 independent variables with 4 levels are tested according to 4 categories of responses - the number of cells total 418. In this case many cells contain 0 or very low frequencies, limiting the robustness of Pearson chi square goodness of fit tests. This presented a problem when estimating multivariate models in this research. In cases where cross tabulation reported many empty cells, an alternative overall model test is reported. SPSS provides -2 maximum log-likelihoods (-2 ML) of a model that contains no treatments (a *constrained* model) and one that contains all treatments of interest (a *saturated model)*. -2 MLs are arrived at through an iterative process that maximizes the models ability to return the original data (O'Connell, 2006). In cases where Pearson chi-square statistics could not be reported, the difference between the two -2 MLs are analyzed to test the null hypothesis that the model without treatments is as good as the one with all treatments of interest included. This is distributed as a chi-square with degrees of freedom equal to the number of variables in the model. Failing to reject the null hypothesis indicated the model was deficient and must be discarded.

Once all assumptions were checked, and goodness of fit tests performed and validated, a model was considered a candidate for final results. Each coefficient was then analyzed for appropriate effects on the outcome (+/- sign) and its overall p-value (<.05) in the model. PLUM lacks an automated stepwise procedure for including and eliminating variables, therefore each level of each independent variable was included through a trial by error process, and removed if it was demonstrated to cause instability in the overall model or was insignificant in influencing the log odds of an individual choosing a category of response. In cases where two multivariate models both demonstrated convincing results and all assumptions and goodness of fit checks had been validated, overall model accuracy was used as a tiebreaker to choose one model over another. By classifying the predicted probability to each level of response across all cells, classification tables in SPSS can be produced to display the number of times a model predicted a particular response to the outcome variable compared to how many times it was observed in the sample data. Table 9 displays a confusion matrix of the predicted probabilities of each response category in a model that estimated the probabilities of respondents who were very satisfied with their ability to locate bus stops of choosing a particular category of overall satisfaction. As can be seen in the columns beneath

Predicted Response Category, the model did not correctly assign any individual who choose either 1 or 2 in overall satisfaction. Of the 110 individuals who selected 3 or satisfied in overall satisfaction, 84 are correctly assigned in this model. Of the 52 individuals very satisfied with the transfer facility, 28 were correctly assigned. The overall model accuracy is %36. These results are only slightly better than the one in four odds of random selection. Poor overall classification does not necessarily mean the model does not fit or is not useful and informative. It should be noted that the majority of studies employing either logistical or ordinal logistic regression do not report overall model accuracy as it is not a decisive factor in determining overall goodness of fit. While a confusion matrix does provide interesting information, it does not explain how well a model fits observed data (Norûsis, 2008).

Table 9: Confusion matrix of correctly assigned cases

		Predicted Response Category		**Total**	
		3	**4**		
Good Transfer	**1**	52	4	56	**0%**
	2	82	10	92	**0%**
	3	**84**	26	**110**	**76%**
	4	24	**28**	**52**	**54%**
Total		242	68	310	**36%**

In summation, models were constructed and validated using the following process. First individual and multiple variables - inputted as binary values - were intuitively inserted for modeling. According to a qualitative visual examination of each variable, an appropriate link function - either logit link or clog-log link - was selected to best account for the levels of variability in overall response. Second each model was then evaluated for overall goodness of fit using the Pearson chi-square test of observed and expected values. If the dimensions of the model were such that many cells in a cross tabulation of every combination of two variables was either very low or zero, Pearson Chi-Square tests were considered inappropriate for overall model fitting checks. In these cases, the differences in calculated -2 ML between a constrained and unconstrained model was evaluated. If the unconstrained model is an improvement upon the constrained parameters, it was considered valid. Third, each model was then examined for overall parallelism, or testing weather the null hypothesis that each coefficient does not significantly differ can be retained. Failing to reject the null hypothesis meant the model was sound and the coefficients could be considered a reasonable model for basing conclusions upon.

Before the results are presented a key limitation of the survey data should be discussed; the results of the data cannot be disaggregated to the individual station level because of small samples from each exit. About 60 surveys were completed per exit, an insufficient sample to model the results at each exit and apply the findings to specific circumstances. Exits were selected at stations that had a variety of service attribute characteristics to capture a range of levels of service attributes. Results should therefore be considered as general findings that represent the broad opinion of MRT user's about bus transfers and better integration of buses and heavy rail. Therefore, the models presented will contain attributes that refer to the condition of service attributes in general, not at specific station or exit.

5 RESULTS

This chapter begins with a brief portrait of the surveyed individuals presenting their reported socio-demographic characteristics (sex, income, car access) and their other reported modes of transport on the they were making. Then respondents rating of the place where they were intercepted as a place to transfer to a bus is summarized. The chapter then presents the I/S analysis before the results of the ordinal regression models are explained.

5.1 Basic Demographics and Trip Characteristics

Table 10 shows the number of surveys completed and the rates of response at each of the 5 exits. The overall response rate is low compared with Iseki and Taylor (2010), who reported a rate of response greater than 70% in Los Angeles.

Table 10: Survey Response Rates from Each Exit

Station	Exit	Respondents	Response Rate
Petchuburi	Exit 2 Asoke	55	0.39
	Exit 1	63	0.47
Lat Phrao	Exit 3 Park and Ride	62	0.46
	Exit 4 Soi 9	71	0.49
Lumhini	Exit 2 L.H. Bank Tower	59	0.40
		310 Total	**44% Response**

55% of respondents were female; reflective of actual ridership, as a greater proportion of females have been observed using mass transport of all forms than men in Bangkok. This is consistent with other mass transit studies where females make a greater proportion of transit ridership in general (Beimborn 2004).

Figure 19 shows the reported monthly income of respondents. The vast majority of riders earn under $750 per month, and 38% earn less than $450 per month. Riders earning $450 (CAD) per month earn approximately $18.75 CAD per day. The majority of riders earn between $165 (CAD) and $1100 (CAD) corresponding to middle to low-middle incomes of the type paid to lower administrative staff or civil servants. Virtually no riders reported incomes below $150 (CAD) and very few reported wages of over $2000 (CAD) per month indicating the poor and rich alike are not large users of rapid transit. According to official estimates, roughly one third of the BMA population work in the informal sector, likely earning close to or below the official minimum wage of $7.00 (CAD) per day. Given the separate cost of MRT and bus fares (see Table 1), a significant portion of rider's daily income is directed towards day to day transportation costs. Monthly passes for the MRT are approximately $30 CAD and individual tickets, priced according to distance, can vary between $.50 and $1.75 per trip. Paying fares regularly may be prohibitively expensive for people earning at or below minimum wage.

Figure 19: Monthly Income Ranges

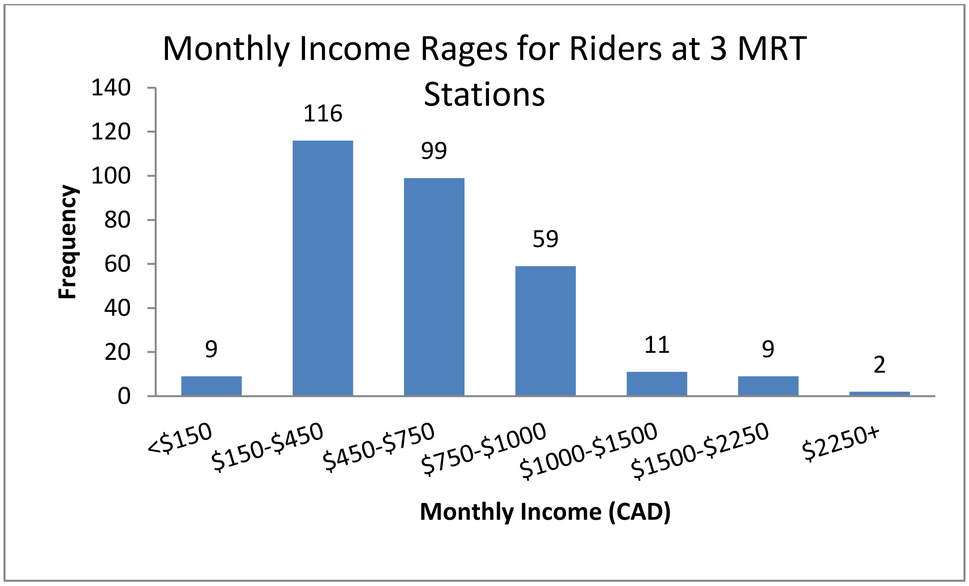
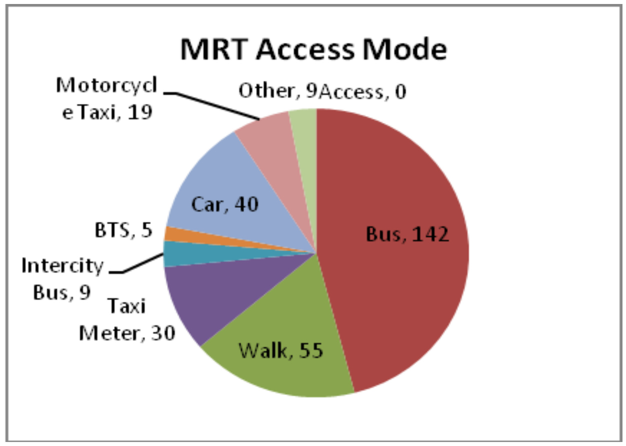
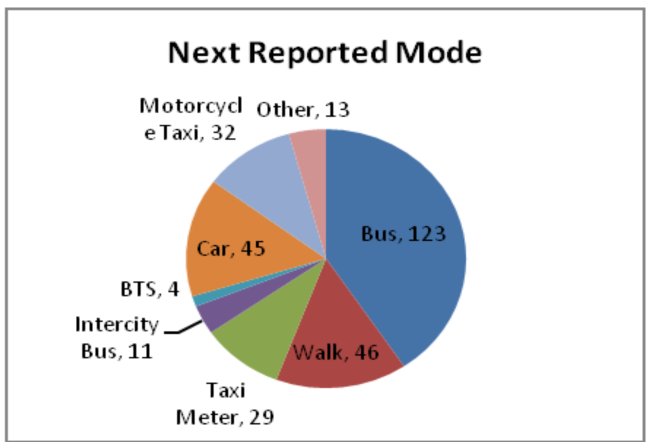


Figure 20 shows the mode of transport passengers used to access and egress the MRT. Nearly half of all respondents accessed MRT services using a BMTA bus, and over one third of respondents intended to use a BMTA bus immediately after leaving the MRT. Overall, the proportion of passengers transferring to a bus was higher than anticipated and reinforced the value of research investigating MRT bus transfers. Combined use of licensed metered taxis, informal para transit (motorcycle taxis) and private vehicles also make up a considerable portion of reported access and egress modes.

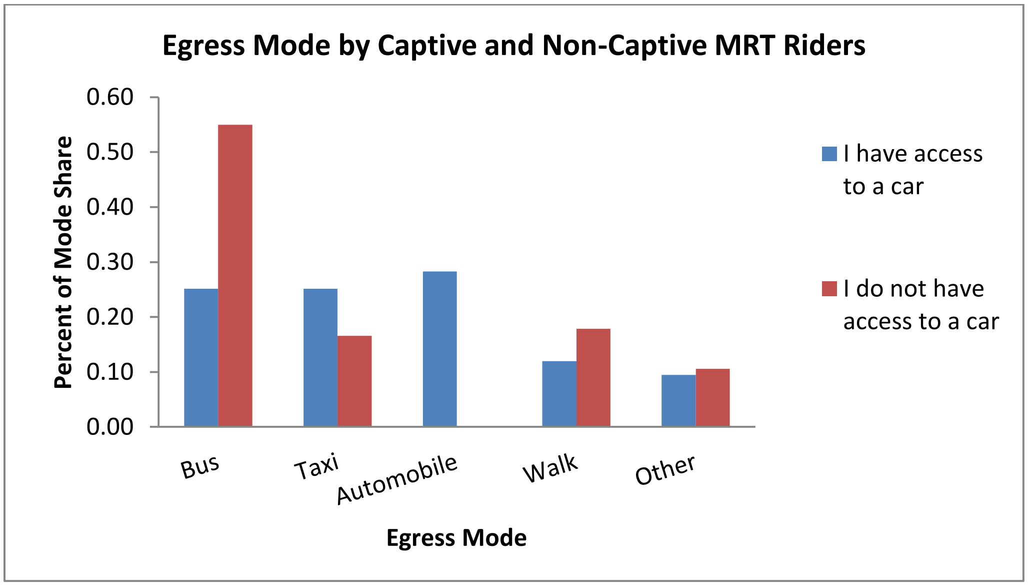
Figure 20: MRT access and egress modes





About half of respondents (159) reported they had access to a car to make the trip they were on. Figure 21 shows the egress modes of MRT riders who indicated they had access to a car and MRT riders who indicated they did not have access to a car. Of the 159 who indicated they could access a car, only 40 individuals (24%) reported they would be using a bus on the next leg of their journey, and a similar number (41) indicated they would be using a taxi (either a licensed metered taxi or motorcycle taxi) as their next mode. On the other hand, 55% (89) of MRT passengers who stated they could not access a car intended to use a BMTA bus immediately after leaving the MRT. This suggests the majority of MRT users who transfer to buses are captive riders who lack other options. Non-captive riders will only use buses if the perceived costs in time, relative comfort or money are less than the competing alternatives (Kittelson and Associates 2003). Some focus of customer recruitment should be directed at those individuals who are not transferring to buses, as they are much more likely to be choice riders who may be persuaded to adopt bus transport through service improvements. Establishing levels of customer satisfaction so services may be designed to meet or exceed existing user's expectations and are of sufficient quality to draw choice users over the long term are important operational aspects of any transit service. Differences in how service quality is perceived by the two groups –if they exist- should be identified so appropriate recommendations can be made.

Figure 21: Egress modes by captive and Non-Captive MRT riders



Error! Reference source not found. Figure 22 shows the proportion of passengers at each of the stations who reported they are satisfied with making a transfer. Overall 63% of respondents were satisfied; a very low rate compared with similar studies that asked transit users in the United States and Europe to rate their perceptions of service. Chicago residents were 82% satisfied by bus services (Foote 2004), while 88% of respondents were satisfied with bus transfers in Los Angeles (Iseki and Taylor 2010), and bus users in Cosenza, Italy were over 80% satisfied with available service attributes (Eboli and Mazzulla 2007). In Bangkok the level of overall satisfaction varied between stations and exits. Respondents were the least satisfied with service attributes at Lumphini, while passengers at Lat Phrao were overall most satisfied with services. These results are largely consistent with the first hand observations of the researcher and reflective of the overall service quality available at the station exits.

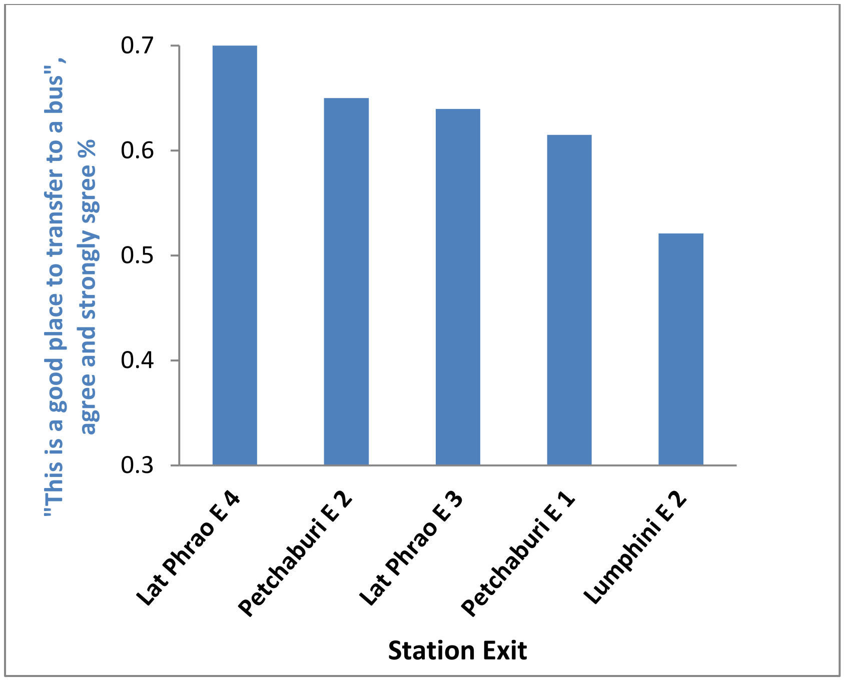


Figure 22: Overall % satisfaction with transfers by exit

5.2 Importance Rates and Satisfaction Rates

Importance and satisfaction scores in this section are calculated in three ways; for all MRT passengers and also for a segmented analysis of passengers not transferring to a bus and of passengers who indicated they were transferring to a bus.

It is useful to determine the relative priority of improvements for riders transferring to bus and riders not transferring to buses for two reasons; first, non bus transferring passengers may perceive the importance of certain attributes differently from those who are transferring. Making future adjustments to improve transfer experiences should only be undertaken after considering the perceptions of those who are not currently using buses. Second, preliminary analysis of the survey data showed the majority of riders who were transferring to a bus did not have access to a private vehicle, while those who could access to a car preferred other modes such as motorcycles, metered taxis, passengers vans, and in many cases, private autos. Improving service for this segment to a level that could persuade them to abandon cars may require separate considerations, different from captive riders or existing customers. Attracting new customers– not just retaining existing ones – should be the aim of any systematic improvements to service attributes. It is therefore necessary to analyze the perceptions of each group to determine if some priorities should be balanced between the needs of passengers transferring to buses and the needs of passengers who are not transferring to buses.

Table 11 shows summary statistics aggregated for all respondents. The mean and overall variance of each attribute for both importance and satisfaction scores are reported. Although variables are recorded from 1 to 4, scored recoded to be scaled out of 100, hence all calculations are reported as percentages. The rate that MRT users expressed an attribute to be either very important or that they were very satisfied is also reported. Average satisfaction, importance and variance for each service factor are shown within the cells highlighted in grey. All respondents evaluated service characteristics fairly homogeneously across all attributes. Average rates of importance have a maximum spread of 11%. On average, seating was judged by users as the least important attribute to service quality, while safety from crime was evaluated as the most important. Average rates of satisfaction with individual attributes were also homogeneously evaluated by respondents and possessed an even smaller difference of values by measure of highest and lowest scores; average satisfaction with shelters was lowest at 63% and satisfaction was highest with the safety from crime at 69%.

Levels of variance remain almost constant across all attributes in both the importance and satisfaction scores. Across importance scores, variance remained within 5% of the mean, similar to satisfaction scores. Previous research in service quality indices have found that levels of variance within customer rated attributes should be accounted for when calculating weighted importance and satisfaction scores. Eboli and Mazualla (2009) proposed a methodology that accounts for high levels of variance in importance and satisfaction surveys. The method discounts variance from total scores which prioritizes attributes judged more homogenously by respondents. In this case, such an approach was deemed unnecessary. The maximum amount of variance is only +/- 1.5% of the mean, and a great deal less than the amount of variance Eboli and Mazualla (2008) documented in a study of bus passengers in Southern Italy.

Table 11: Summary of Importance and Satisfaction for All Users (n=310)

		Importance			Satisfaction		
Service Attribute	Service Factor	Mean %	Variance	Imp Rate	Mean	Variance	Sat Rate
Places to Sit	Amenities	0.782	0.053	0.390	0.635	0.050	0.580
Bus Shelter		0.806	0.046	0.430	0.633	0.055	0.510
AVERAGE		0.794	0.050	0.410	0.634	0.052	0.545
Side Walk Quality	Accessibility	0.802	0.045	0.420	0.659	0.049	0.570
Bus Stop Location		0.830	0.042	0.590	0.664	0.060	0.570
Signs		0.785	0.051	0.400	0.679	0.052	0.650
AVERAGE		0.805	0.046	0.470	0.667	0.054	0.597
Wait Time	Reliability & Performance	0.830	0.048	0.520	0.614	0.060	0.470
Bus Routes		0.834	0.047	0.520	0.661	0.059	0.580
AVERAGE		0.832	0.047	0.520	0.637	0.060	0.525
Safe Street Crossing	Safety & Security	0.816	0.048	0.480	0.663	0.053	0.570
Safety from crime		0.896	0.046	0.650	0.689	0.056	0.620
AVERAGE		0.856	0.047	0.565	0.676	0.054	0.595
Good Transfer	Overall	0.832	0.049	0.550	0.630	0.060	0.527

Table 12 shows the summary statistics of the importance and satisfaction data for respondents who indicated they would be immediately transferring to a bus (123). Almost across all attributes and service dimensions, bus users found all service attributes to be somewhat more important than all passengers as a whole. As well, average importance scores have a considerably larger range of values then were found with all respondents likely reflecting the experience these individuals have with using and accessing busses at each of the station exits. Overall average scores indicate that places to sit are considered the least important aspect of service (80), closely followed by the presence of clear signage (81) and the availability of safe places to cross the street (83). Attributes ranked most important were safety from crime (94), wait times (89) and the location of bus stops relative to station exits (89). Variance is higher, +/- 3% from the mean. However, attributes considered most important possessed less overall variance, indicating that the most important attributes that facilitate transfers are widely agreed upon by this sample of bus users. Rates of importance - the proportion of respondents who selected the highest level of importance - tell a similar story. Nearly 7/10 bus users indicated safety from crime to be the most important issue affecting the quality of transfers, closely followed by the proximity of bus stops to exits at 60%.

Satisfaction rates were lower than users as a whole. Average scores indicate that respondents transferring to a bus were equally dissatisfied with the seating at waiting areas, the quality of shelter at stops, the location of bus stops and waits times which with average scores of approximately 60% . Users were most satisfied with the presence of signage, the available bus routes, and the presence of safe places to cross the street. Levels of variance are relatively constant between most attributes ranging approximately +/- 2% from average overall variance. Satisfaction rates show a larger dispersion of values, with less than half of people being at least somewhat satisfied with wait times buses (47) with similar rates of dissatisfaction with provision of shelters at waiting areas (50) and available seating (53). Overall satisfaction with user's experience with making transfers as whole was exceedingly low at 51% suggesting a great deal could be done to improve the inter modality of stations and bus stops.

Table 12: Summary of Importance and Satisfaction Scores for Bus Users (n=142)

		Importance			Satisfaction		
Service Attribute	**Service Factor**	**Mean**	**Variance**	**Imp Rate**	**Mean**	**Variance**	**Sat Rate**
Places to Sit	Amenities	0.800	0.055	0.490	0.603	0.047	0.530
Bus Shelter		0.840	0.042	0.510	0.609	0.061	0.500
AVERAGE		0.820	0.049	0.500	0.606	0.054	0.515
Side Walk Quality	Accesibility	0.830	0.042	0.500	0.640	0.051	0.660
Bus Stop Location		0.890	0.024	0.650	0.600	0.067	0.560
Signs		0.810	0.046	0.500	0.673	0.055	0.660
AVERAGE		0.843	0.037	0.550	0.638	0.058	0.627
Wait Time	Reliability & Performance	0.890	0.031	0.660	0.609	0.068	0.470
Bus Routes		0.880	0.035	0.640	0.683	0.057	0.620
AVERAGE		0.885	0.033	0.650	0.646	0.063	0.545
Safe Street Crossing	Safety & Security	0.830	0.031	0.580	0.685	0.052	0.570
Safety from crime		0.940	0.053	0.760	0.660	0.066	0.540
AVERAGE		0.885	0.042	0.670	0.673	0.059	0.555
Good Transfer	Overall	0.910	0.027	0.790	0.630	0.060	0.510

Table 13 reports the summary statistics for respondents who indicated they ***would not*** be to transferring to a bus. Overall this segment considered transfer services to be less important than the transferring segment, but nonetheless still considered most services to be important components to quality of service with average importance rankings for all attributes equal to or greater than 75%. Variance for 8 out of 9 attributes is close to 5%, a greater amount then in the transferring segment. Safety from crime had the least overall variance at +/- 3.4% from the average. Average importance scores indicate that signs (75%), seats (76%) and crosswalks were judged to be least important to overall service. Safety from crime was evaluated to be considerably more important than all other attributes at 87%, trailed by available bus routes (80%) and wait times (79%) and sidewalk quality (79%). Rates of importance are considerably lower than rates reported by bus users, reflecting the lower proportion of captive transit users in this segment.

Table 13: Summary of Importance and Satisfaction for non-bus users (n=167)

Service Attribute	Service Factor	Importance Mean	Importance Variance	Importance Imp Rate	Satisfaction Mean	Satisfaction Variance	Satisfaction Sat Rate
Places to Sit	Amenities	0.761	0.048	0.327	0.652	0.049	0.610
Bus Shelter		0.786	0.049	0.400	0.644	0.048	0.530
AVERAGE		0.774	0.049	0.364	0.648	0.049	0.570
Side Walk Quality	Accessibility	0.793	0.041	0.382	0.661	0.045	0.587
Bus Stop Location		0.781	0.040	0.410	0.652	0.052	0.581
Signs		0.750	0.048	0.338	0.680	0.048	0.630
AVERAGE		0.775	0.043	0.377	0.664	0.048	0.599
Wait Time	Reliability & Performance	0.794	0.050	0.450	0.618	0.053	0.490
Bus Routes		0.802	0.053	0.473	0.648	0.057	0.581
AVERAGE		0.798	0.052	0.462	0.633	0.055	0.536
Safe Street Crossing	Safety & Security	0.780	0.053	0.430	0.600	0.052	0.570
Safety from crime		0.876	0.034	0.610	0.704	0.050	0.672
AVERAGE		0.828	0.044	0.520	0.652	0.051	0.621
Good Transfer	Overall	0.773	0.055	0.415	0.620	0.057	0.519

Average satisfaction values were somewhat higher than average ratings indicated by bus users, but still low exceptionally low compared to other transit studies. Average satisfaction rates for all attributes are approximately 63%. Rates of satisfaction, the proportion of MRT riders who chose somewhat satisfied and very satisfied, are even lower at about 58%. Non transferring passengers on average were most satisfied with their safety from crime (70%), signage (68%) and the availability of safe and convenient street crossings (66%). Levels of variance also remain somewhat constant, not deviating more than 1.2% across all variables.

Table 14 shows the ranked service quality attributes according to relative importance for both bus users and non-bus users. Safety from crime in both groups ranks as the most important aspect to be controlled for at stations. This should come as no surprise to anyone familiar with previous research that has evaluated the relative importance of transit service attributes, and should reinforce the need to provide safety and security at busy transfer points. Station amenities such as places to sit and bus shelters are less important while attributes from service planning and reliability rank prominently among both groups.

Table 14: Ranked Importance of Attributes for Bus Users and Non Bus Users

	Bus Users (n=142)	Non Bus Users (167)
More Important	Safety From Crime	Safety From Crime
	Wait Times	Bus Routes
	Bus Stop Location	Wait Times
	Bus Routes	Safe Street Crossing
	Safe Street Crossing	Bus Stop Location
	Bus Shelters	Bus Shelters
	Sidewalk Quality	Side Walk Quality
	Signage	Signage
Less Important	Places to Sit	Places to Sit

Table 15 shows how satisfied each segment of MRT riders are with the nine stations and stop attributes. Both groups are very satisfied with clear signage, and least satisfied with the perceived or actual wait times at bus stops. Individuals not transferring to a bus are most satisfied with their safety from crime, while those immediately switching to a bus are somewhat unsatisfied with crime at stops. Non bus users also tended to be fairly satisfied with seating at stops, reflecting a probable perception of services rather than an opinion formed out of experience. Bus users tended to be fairly unsatisfied with seating, as seats beneath shelters tend to be completely occupied at rush periods. Overall, *non bus users* accessing services tended to be satisfied with different service attributes than *users*.

Table 15: Ranked Satisfaction with Attributes for Bus Users and Non Bus Users

	Bus Users (n=142)	Non Bus Users (n=167)
More Satisfied	Signage	Safety from Crime
	Side Walk Quality	Signage
	Bus Routes	Places to Sit
	Safe Street Crossing	Side Walk Quality
	Bus Stop Location	Bus Routes
	Safety From Crime	Bus Stop Location
	Places to Sit	Safe Street Crossing
	Bus Shelters	Bus Shelters
Less Satisfied	Wait Times	Wait Times

5.3 I/S Analysis

Customer satisfaction and importance indices are used as the basis for proposing a list of prioritized attributes that are considered to be both important and deficient at the five station exits. I/S calculations are reported for all respondents in Table 16. The order of attributes is ranked from most in need of improvement to least. According to I/S calculations for all respondents, wait times at bus stops require the most immediate attention to ensure overall quality of service (27), followed by safety from crime (26). Bus stop locations were similarly ranked as an aspect of service quality that needs attention (25). Routes (21.8), shelters at stops (21) and street crossings (20) were in the middle, while sidewalks(18), places to sit (16) and signage at stations (14) should be the least concern for immediate improvement. It should be noted that although sidewalks were rated as relatively unimportant compared to safety and wait times, the reported variance for both satisfaction and importance scores as shown in **Error! Reference source**

ot found. was very low, indicating users did not overwhelmingly indicate that sidewalks were very important, but did nevertheless ranked this attribute homogeneously as a somewhat important feature of service quality. This indicates that although sidewalk quality is not the top priority among MRT users, it is however considered by most people to be an important component of service.

Table 16: Ranked I/S Scores for All Respondents (n=310)

	Importance	Satisfaction	I/S
Wait Time	0.52	0.47	0.2756
Safety from crime	0.65	0.6	0.26
Bus Stop Location	0.59	0.57	0.2537
Bus Routes	0.52	0.58	0.2184
Bus Shelter	0.43	0.51	0.2107
Safe Street Crossing	0.48	0.57	0.2064
Side Walk Quality	0.42	0.57	0.1806
Places to Sit	0.39	0.58	0.1638
Signs	0.4	0.64	0.144

Table 17 and Table 18 show the ranked list of improvements for the two MRT rider segments of those who indicated they were transferring to a bus and those who indicated they would be making their egress trip by another mode**.** When weighted for importance, the relative priority for improvements more or less converges for both segments of MRT riders. Attributes that relate to safety and security as well as performance and reliability are overall in most need of improvement, while seating unsurprisingly is the least in need of improvement. Shelter was ranked as fairly important to service reflecting Thailand's hot and monsoonal climate. Brief but heavy rainfall in the late afternoon - roughly coinciding with the evening commute - is a daily occurrence for a large portion of the year. Most importantly, the findings of the I/S analysis indicate that individuals are most concerned with their own safety and security while making transfers, and that improvements to the security between exits and bus stops would likely yield the greatest improvements to overall customer satisfaction. Previous research has indicated that individuals in the United States will simply not use transit if they feel their physical safety may be at risk, or change their long term travel patterns (Iseki and Taylor 2010, Loukaitou-Sideris 2001).

Table 17: Ranked I/S Scores for Bus Users (n=142)

	Satisfaction	Importance	I/S
Wait Time	0.47	0.66	0.3498
Safety from crime	0.54	0.76	0.3496
Bus Stop Location	0.56	0.65	0.286
Bus Shelter	0.5	0.51	0.255
Bus Routes	0.62	0.64	0.2432
Safe Street Crossing	0.59	0.58	0.2378
Places to Sit	0.53	0.49	0.2303
Side Walk Quality	0.54	0.5	0.23
Signs	0.65	0.5	0.175

Table 18: Ranked I/S for Non Bus Users (n=142)

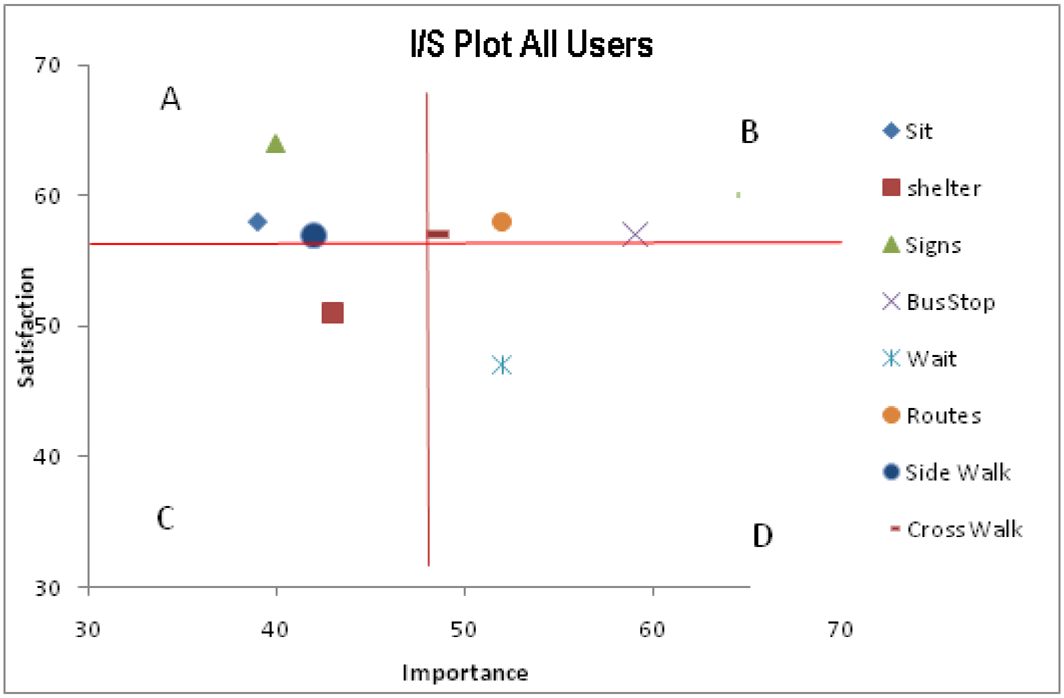
	Satisfaction	Importance	I/S
Wait Time	0.49	0.45	0.2295
Safety from crime	0.67	0.61	0.2013
Bus Routes	0.58	0.47	0.1974
Bus Shelter	0.53	0.4	0.188
Safe Street Crossing	0.57	0.43	0.1849
Bus Stop Location	0.58	0.41	0.1722
Side Walk Quality	0.58	0.38	0.1596
Places to Sit	0.61	0.32	0.1248
Signs	0.63	0.33	0.1221

I/S analysis are often presented in a chart format to graphically illustrate the stated importance and satisfaction of each stop and station attribute.

Figure 23 is a quadrant analysis chart that shows the relative satisfaction and importance rates that all respondents have placed on each service quality attribute. Table 17 and Table 18 show that when satisfaction rates are weighted on importance rates, the prioritization of improvements for both segments of MRT riders converge, the major exception being bus stop location, ranked considerably lower by MRT riders not transferring to a bus. Although there are some small differences in the I/S between the two segments, one chart representing all respondents is presented here

On the X axis is the percent of respondents who indicated the service attribute to be very important and on the Y axis is the proportion of respondents who reported they were at least satisfied with the current state of service. The overall average rates of satisfaction and importance are demarcated by the red lines.

Figure 23: I/S Quadrant Analysis Chart



The quadrant marked A indicates areas of service that users are more satisfied with, but consider to be less important to their needs. Respondents in this survey considered seating, signage and sidewalk quality to be attributes that were well serviced, but below average importance. Service attributes that fall into this quadrant for planning purposes can be considered adequately provisioned.

The quadrant marked B indicates areas that are above average importance and satisfaction. This represents areas of service that are being well provided, but need constant consideration because the relative importance customer's perceive these attributes as having. It is worth noting all four service attributes in this quadrant - crime, bus routes, crosswalks and bus stop location- are very close to the average of satisfaction and measurably higher in stated importance. As well, average satisfaction in this survey across all service attributes is 49%, a very low level compared to similar studies.

The quadrant marked C contains attributes are both below average importance and satisfaction. Shelter – curiously - was the only attribute fond in this category. For planning purposes, attributes that fall into this category should be considered relative to other services a low priority.

Attributes that fall into quadrant D are in need of immediate attention and should be considered a top priority for improvement. Wait times for buses, though not considered to be as important to overall service as bus stop locations, is well below the average rate of satisfaction and is expressed by weighted satisfaction scores as the service attribute in greatest need of improvement.

5.4 Ordered Logistic Regression

The previous I/S analysis determined the order which attributes and stops should ideally take according to stated levels of satisfaction and importance. However, a central question of this research asks which improvements to service can be expected to improve out of vehicle travel experience at MRT station exits. The happier or more satisfied individuals are with the out of vehicle travel components of a trip, the likelier they are to continue using transit in the future. Similarly, by providing the correct upgrades to transfer points, transit system operators may expect to attract new or choice riders. To help determine which service attributes would most improve overall MRT customer satisfaction, two series of ordinal regression models were calculated. The first series of models tested each variable at all levels, one at a time. The findings determine a relative order among all attributes and how each variable influences the overall odds of choosing a particular level of overall satisfaction.

The series of individually modeled variables show the influence specific levels of satisfaction have on the odds of selecting a particular level of satisfaction or higher without controlling for other variables. Modelling individual variables - one at a time - was necessary in this case to determine the relative magnitude each variable has on influencing overall transfer experience because a multivariate model with all attributes failed to converge. Modeling each variable separately allowed the SPSS PLUM procedure to evaluate how each service attribute individually contributes to improving a model fit. To do so, each variable thought to influence satisfaction was broken into three dummy variables which represented all categories of satisfaction minus one. Because in ordinal regression the probability of an event occurring is redefined in terms of cumulative probabilities, it is redundant to test for all levels of responses. All attributes were tested across all categories of stated satisfaction except for level 4 or very satisfied.

Variable	n	Levels	Psuedo R2 (Neg)	Coefficient	Parallel p-value
Seats	310	3	0.02	0.466	0.234
Shelter	310	3	0.03	0.846	0.567
Signs	310	3	0.04	0.911	0.331
Stop Location		2		0.94	
	310	3	0.18	2.21	0.386
Wait	310	3	0.15	2.108	0.216
Routes		1		-0.315	
	310	3	0.15	1.026	0.082
Sidewalks		1		-0.658	
		2		0.605	
	310	3	0.04	0.911	0.318
Crosswalk	310	3	0.05	0.642	0.93
Crime	310	3	0.11	0.923	0.123

Table 19: Ordered Logistical Regression Models

Table 19 presents the results for the series' of individually modelled variables. For each model all 310 valid responses were tested. The third column labelled *'Levels'* indicates the individual dummy categories of the independent variables which were observed to significantly influence the log odds of choosing a particular level of overall satisfaction. A conservative interpretation of parsimony for statistical model building was applied in this research. It is common in some research models to include all variables of interest regardless of statistical significance (Chen and Hughes 2003, Tyrinopoulos and Antoniou 2008). Including variables or levels of variables that are insignificant can influence model fitting statistics, pseudo R^2 values - or both - producing potentially misleading results. Only variables that were shown to significantly influence the outcome variable were included in any model. In most cases only one level of the independent variable significantly altered the log odds of choosing a particular outcome level or lower.

The fourth column labelled Psuedo R^2 reports the Negelkerke method for obtaining the pseudo R Squared Statistic. These are corrected ratios between fitted and intercept models. That is, the pseudo R Squared statistic reports back the degree to which the added variable improves the predictive capabilities of the model. These cannot be interpreted in the same manner as OLS regression. An R^2 value represents the "proportion of variability of the outcome that is accounted for by the model", a different interpretation than what made is made with most variations of Pseudo R^2. Interpretation of Psuedo R^2 to evaluate one model against another can be deceptive, and should be used here only as a loose indicator of the model's overall performance. The limitations of Pseudo R^2 are technical and debated. For a more complete discussion of interpretation and precautions when using Pseudo R Square see Statistical Consulting Group (2010).

The fifth column labelled coefficient is the ordered logit coefficients for the predictor variables. For every change in a given predictor variable (for example, from satisfied to very satisfied or from 3 to 2) the ordered log-odds of the level of the response variable is expected to change by the respective coefficient.

The assumption of proportional odds is verified in the next column labelled Parallel sig. In this column p-values that assess the differences between the constrained and saturated model estimates are reported. In each case we fail to reject the null hypothesis that the model does not deviate from the assumption of proportional odds. Although not displayed in Table 18 all model estimates were validated by examining the overall goodness of fit (Pearson Chi-square test) and by comparisons of the differences between -2 Log Likelihoods of both the constrained (intercept only model) and the saturated (all variables included) model.

The results of the simple ordered logistical regression can help determine the overall magnitude each area of service has on influencing customer perceptions.

It should be noted that adding the Pseudo R^2 values does not describe the collective ability of all attributes to explain overall variance. Table 19 shows the results of individually modeled attributes that do not control for the presence of other attributes. The results could inform strategies that modifying station interconnectivity to support bus and heavy rail integration.

Overall, the final ordered list of attributes is supportive of the prioritized improvements calculated through stated rates of importance and satisfaction. The most important service aspects that influence overall satisfaction are:

1) Bus stop locations (Pseudo R^2 18)

2) Available Routes (Pseudo R^2 15, significant at two levels)

3) Waiting Time (Pseudo R^2 15)

4 Safety from crime (Pseudo R^2 11)

It was found that only the highest category of the independent variables measuring overall satisfaction significantly influenced the ordered log-odds across all treatments as respondents moved to a lower response category. This may indicate that individual expectations are low and very little is expected of interconnectivity between modes. It is only when services are obviously provisioned and well provided that overall satisfaction is influenced. The findings from this model clearly indicate that the location and the ability of passengers to reliably locate bus stops strongly affect overall satisfaction with making transfers to buses.

5.4 Multivariate Ordinal Regression Model

One of the main questions driving this research asks which combinations of improvements could be expected to increase MRT rider's overall experience with making transfers to buses. Transit plans and official transit agency documents often contain recommendations on how service at stations could be improved only to list station amenities and service quality measures which are assumed to improve overall transit experience (Taylor et al 2008). Station improvements are rarely statistically modelled with actual satisfaction data to determine the true drivers of quality service (Metropolitan Transit Commission, 2006). By building multivariate mathematical models, targeted recommendations can be made about which improvements and in what combinations would most influence customer satisfaction.

After multiple iterations of all different combinations of predictors, a final list of variables that most influence overall satisfaction, while controlling for the other service measures, was arrived at. In constructing the final list, many additional predictors were added to candidate models to test for significance such as respondent's sex, income, whether they intended to use a bus as their next mode, as well as if they had access to a car. According to the results of this research, none of these contextual variables influenced in a statistically meaningful way a respondent's overall satisfaction with the quality of bus connections. Segmenting the data set according to sex or next reported mode also yielded insignificant results. This lack of correlation, while disappointing, does not detract from the overall findings of this research.

The final stage of analysis determined which service attributes can increase overall satisfaction with a stop while holding other relevant attributes constant. A final list of service attributes that most influence overall satisfaction with bus transfers while controlling for the other significant service attributes is presented in Table 20. The final model that tested all 310 observations used a logit link function and is parsimonious in that it contains only service attributes at levels that statistically influence overall satisfaction in a significant way. Modeling was conducted in descending order meaning all levels of the overall response were included except for the highest level (4) of satisfaction. The model verifies the statistical tests that judge goodness of fit with a Pearson test statistic (χ^2) likelihood ratio of .79 at 41 degrees of freedom. The assumption of parallel lines is retained (p-value .06). The pseudo R^2 value of .242 is an improvement on previous models that used similar predictors and the complimentary log link function where some of the assumptions of parallelism are relaxed (Bender and Benner, 2000). At the bottom of Table 21 %Right indicates the model successfully classified 40/100 overall satisfaction scores; only somewhat better than the .25 probability of correctly classifying cases according to chance. Table 21 is a confusion matrix displaying the correctly classified cases according to the overall level of satisfaction. At bottom right of Table 20 are the ancillary parameters of the model. An assumption of ordinal logistic regression is that a "discretized variable of an underlying latent continuous trait" defines the cut off points between the different levels of the dependent variable (Bender and Benner 2000) with thresholds that estimate the cut off values between the different levels of responses. These thresholds are reported in Table 20.

Table 20: Final Multivariate Ordered Logistical Regression Model

Variable	#	Levels	Coefficient	expB	P-value
Stop Location	310	3	-1.04	0.353455	0.000
Wait	310	3	-0.856	0.424858	0.001
Routes	310	3	-1.012	0.363491	0.019
Crime	310	3	-0.633	0.530996	0.018
2 Log Liklihood constrained			207.58	Ancillary Parameters	
2 Log Liklihood saturated			128.34	4 > 3	-0.913
Liklihood Ratio X^2			79.243	3 > 2	-3.055
Psuedo R			0.25	2 > 1	-4.617
% Right			40		

The final multivariate model determined four of the nine service variables significant, and all of them at the highest tested level of satisfaction. Table 20 shows the final four attributes that together significantly influence overall satisfaction with transfers. Estimation was conducted in a descending order. Coefficients represent the how dissatisfied MRT users becomes with transfers as they go from a higher score on a particular attribute to a lower score. Because the final model used the logit-link function and tests for users overall satisfaction at all categories, coefficients in this case can be reliably compared. A larger coefficient indicates a greater overall magnitude the attribute has in influencing the odds an individual will be choose a lower category of satisfaction. Controlling for other significant attributes, the location of bus stops relative to station exits and the available routes that buses take, were the most determinant service characteristics for overall satisfaction with transfers. In other words, MRT customers who are happy with bus stops that are close and convenient to exits with routes that travel to where they need to go are significantly more likely to positively evaluate transfer experiences. Wait time and perceived safety from crime were also determined significant in reducing the chances individuals were unsatisfied with transfers. All other attributes, when considered in the multivariate model, do not significantly increase or decrease the odds of satisfaction with making transfers.

Just as in binary logit models, coefficients in ordinal regression can be exponentiated and reported as proportional odds ratios. In this way, all exponentiated coefficients are interpreted as the odds that the outcome will change given the predictor variable while the other variables constant. An odds ratio of 1 indicates that the variable at a given level of satisfaction does not influence in either direction the probability of selecting a particular level of overall satisfaction or higher, while an odds ratio of .50 indicates that the variable at a given level of satisfaction reduce the odds by 50% that an individual will select a higher level of overall satisfaction. Located in Table 20 under the column exp^B is the calculated odds ratio of each coefficient. All independent variables are binary (1,0) of whether or not an individual selected 3 (satisfied). Individuals who indicated they were only satisfied with bus stop locations were 65% more likely to be in a lower category of satisfaction than individuals who were very satisfied with the location of stops. The other odds ratios can be interpreted the same way. Bus routes and wait times had similarly positive results on transfer experience, with safety from crime being a less but still significant determinant factor in overall transfer experience.

Table 21 is a confusion matrix for the final multivariate model. The model did not correctly assign any cases the first level of response, but did correctly assign some cases to levels 2, 3 and 4. Overall the model correctly assigned 39.80% of cases; better than the odds of random prediction (1:4), but not exceptional.

Table 21: Confusion Matrix for the Final Multivariate Model

		Predicted Response			Total
		2	3	4	
Good Transfer	1	38	18	0	**56**
	2	67	24	1	**92**
	3	62	34	14	**110**
	4	4	26	22	**52**
Total		**171**	**102**	**37**	**310**
			Model Accuracy		39.80%

6) DISCUSSION & CONCLUSIONS

This research used multiple techniques to evaluate a handful of service attributes that could improve the out of vehicle experience transit customers have at a selection MRT/Bus interchanges in Bangkok Thailand. Table 22 shows how each of the service attributes were evaluated by the different forms of analysis employed by this research. In general, the robustness of analysis increases from left to right, with multivariate ordered logit regression having the highest amount of explanatory value. The top rated attributes are highlighted in green.

Two of the main questions motivating this research asked which out of vehicle service attributes are most important for MRT/Bus transfers. This research also asked if there are combinations of attributes which could be used to improve customer satisfaction with transfers at a selection of MRT exits. Bus stop location was estimated in both ordered logit methodologies as the most influential attribute affecting customers overall satisfaction with their transfer experience, while ranking third in importance satisfaction. The ordered logit regression and multivariate ordered regression agreed on the top attributes if service, lending credibility to the appropriateness for this method of analysis. The multivariate ordered logit analysis also found that bus stop locations wait times, better bus routes and safety from crime when put together have the greatest potential at improving customer experience. The multivariate model also found that smaller improvements to amenities such as seating and shelters were insignificant when controlled for the safety, service and reliability attributes. This partially answers if smaller or larger improvements to service are necessary to improve customer's perceptions of transfers. From this analysis, increased headways, closer bus stops in a safer seeming pedestrian environment are necessary to significantly improve customer experience. These service attributes are likely to more expensive to implement than the attributes that tended to be less important.

Table 22: Rank of service attributes according to applied analysis

	Rank of Importance of Attributes for Each Analysis		
	Importance/Satisfaction	Ordered Logit Regression	Multivariate Ordered Logit
Wait Time	1	2	2
Safety from crime	2	4	4
Bus Stop Location	3	1	1
Bus Routes	4	3	3
Bus Shelter	5	8	Insignificant
Safe Street Crossing	6	5	Insignificant
Side Walk Quality	7	6	Insignificant
Places to Sit	8	9	Insignificant
Signs	9	7	Insignificant

6.1 Policy Implications

The analysis of the survey data has made a number of important findings relevant to any organization or body that may attempt to improve integration of Bangkok's MRT and bus systems. First and foremost, the quality of connections between buses and heavy rail matter in Bangkok. Although the existing quality of services between heavy rail and bus modes is highly mismatched, prompting this researcher to initially suspect that many, perhaps even a majority, of MRT riders would find service improvements to enhance transferability to be unimportant. The results of the research are supportive of improving interconnections by focusing on a selection of service quality aspects for all users, not just current users. Not only do significant portions of metro riders regularly use buses, but 48% are unsatisfied with the present interconnectivity and over 80% believe transfers to be an important aspect to service at station exits. These findings illustrate that customers are cognizant of the lack of overall service quality and aware of what could be done to improve it. Introducing better service quality at stops and stations could therefore be a viable strategy to improve the out of vehicle travel experiences of transferring passengers, and perhaps to attract additional riders onto buses over the short or medium term.

Analysis was also carried out to determine if different segments of MRT passengers were more or less satisfied with different service aspects. It was found that once satisfaction scores were weighted by importance scores, individuals leaving MRT stations who were not transferring to a bus had similar needs as transit customers. It was found that wait times and safety from crime were the two service attribute that all customers could agree were most lacking. Passengers who were transferring to buses unsurprisingly found the location of bus stops to be the third most important attribute influencing overall satisfaction, while those not transferring considered the available bus routes a the bus stops to third most important service and bus stop location to be near the bottom of importance.

The results from both weighted satisfaction procedures and the ordinal regression clearly indicate that the position of bus stops are the most important service aspect that determines overall customer satisfaction, as well as being considered a high a priority among all users for improvement. I/S analysis prioritized the location of stops relative to station exits as the service attribute in the third most need for improvement, while the multivariate ordinal regression model determined users who indicated they were only somewhat satisfied with bus stop locations were 65% more likely to select a lower category of overall satisfaction than someone who indicated they were very satisfied with the location of stops. In similar research, bus stop accessibility and ability to locate stops was also found to be a decisive factor in shaping overall satisfaction as other service measures such as wait time and scheduling (Iseki and Taylor 2010).

At three of the five exits where surveys were carried out, the position of bus stops are at a considerable distance from where passengers leave the MRT. This research cannot make specific recommendations on ideal distances, or provide coefficients that describe how personal utility improves as distance decreases. However, long walks along unpleasant roadways on poorly maintained sidewalks undoubtedly contribute to increasing the perceived penalties with switching from MRT to bus. This may prompt some to forgo using buses in favour of more immediately convenient – and expensive - transportation options such as motorcycles or metered taxis.

The research also sought to understand the scale of improvements that would necessary to enhance customer satisfaction with transfers at a sample of busy MRT exits. The primary findings from this research which could be acted immediately on are likely changes to the stations which require a larger financial than other upgrades. Reorganizing station areas to reduce the distance to stops would require significant changes to the existing configurations of vehicle lanes on the roads that are adjacent to MRT stations. Both Petchaburi and Lumphini stations are located on the corners of arterial streets that have fly-over roadways –elevated road structures that allow vehicles to bypass traffic signals - spanning the median of adjacent intersections. The available space on the streets for buses to load passengers at MRT exits is restricted to curb side lanes, located immediately before single lane left-turn cutaways. These road spaces are unsuitable for bus stops. Repositioning bus stops closer to exits would require additional lane space, or for a balance to be made that compromises between the present vehicle capacity on adjacent streets and transit prioritization that allows passengers to board bussed at a more reasonable distance to MRT exits.

Personal safety from crime was also determined to be a significant attribute that influences the satisfaction customers feel with transfers and was also found to be something that was in need of improvement across those transferring and not transferring to buses. Personal safety was considered to be by both segments of MRT riders as the most important attribute to improve the experience of transfers between bus stops and station exits. The ordered logistical regressions determined safety from crime at the highest level of satisfaction improved the model fit by 11% (Pseudo R^2 .11) compared to a model with no treatments and the final multivariate model determined that individuals who indicated they were only somewhat satisfied with safety from crime were %47 less likely to be in a higher overall category of satisfaction.

Loukaitou-Sideris et al (2002) found a positive correlation between attributes of the built environment and the incidence of crimes such as assault, robbery and sexual harassment. Their findings indicated characteristics at bus stops and transit waiting areas can have significant impacts on the incidence of crime against transit customers. The presence of bus shelters, the volume of pedestrian activity and visibility to surrounding buildings all significantly influenced the incidence of crime. Much could be done at Bangkok MRT stations to improve all three of these categories. Expanding and improving sidewalk quality, reducing curb heights, removing obstructions such as telephone booths, poorly positioned utility poles and construction debris would improve the quality of the pedestrian environment. Eliminating concrete walls that partition sidewalks from many adjacent buildings would improve the aesthetics of the sidewalk environment, and also increase an ‘eyes on the street’ effect which has been demonstrated to increase both an individuals’ perception of safety from crime and also reduce the occurrence of crimes against property and people. Property around MRT exits should be considered conduits of public space with the necessary physical attributes to minimize the negative perceptions of personal safety. Undertaking the relative simple improvements to public space could increase the number of pedestrians which could produce a safer feeling waiting environment.

Bus routing and wait times, both in the performance category, were considered in all aspects of this research to be important quality of service attributes. In most research, wait times are nearly always a top concern among transit customers (Eboli and Mazzualla 2007 and 2008, Weinstein 2001, Hensher and Prioni 2001, Iseki and Taylor 2010), and bus riders and MRT patrons in Bangkok are no exception. Most riders would walk and wait in sterile, even depressing transfer facilities, so long as transfers are convenient and fast (Iseki and Taylor, 2010). According to the I/S survey, wait times and bus routes were ranked as the second and fourth most important service attributes. The multivariate ordinal regression model determined that a MRT riders who felt ‘satisfied’ with wait times rather than ‘very satisfied’ were 58% less likely to be in a higher category of overall satisfaction. Similarly, dissatisfaction with available routes detracted heavily from overall satisfaction. An individual who was only satisfied with where the bus route go were 64% less likely to be in a higher category of overall satisfaction then someone who was very satisfied with where the bus routes travel.

Providing reliable bus scheduling and time tables would improve customer service, reduce the anxiety involved with waiting and allow riders to plan trips in advance. Currently, there is no publically available system of scheduling in place at BMTA bus stops and likely no plans in the immediate future to predict or better schedule the irregular bus arrivals. Street network saturation, particular during rush periods make scheduling and regular arrivals difficult to predict; however transit agencies around the world are capable of predicting bus arrivals and producing schedules; there is no reason why the BMTA cannot do the same.

Simpler to remedy, but also widely considered a barrier to transfers, is the current available routes from stations. It has been recognized that service redundancies along arterial roads that intersect with stations could be eliminated, and better routing integration that serves areas surrounding stations could be planned (World Bank 2007). At all three stations many bus routes track the MRTs route above ground, while bus services that carry the majority of passengers tend to travel the same stretches of road way for long distances with little variation. To solve this, origin/destination surveys should be conducted to determine an ideal network of routes that better serves customer needs. Current routes are either redundant, or do not penetrate into some of the larger neighbourhood blocks that surround stations such as Lat Phrao.

Smaller improvements to station areas did not influence customer satisfaction in the same way that other attributes such as bus stop locations and wait times were found to. Amenities such as seats and shelters were considered only minor service attributes to both MRT riders who were transferring to buses and those who stated they would be utilizing some other mode of transport. However, because wait times for buses were evaluated so poorly by most respondents, bus shelters in particular should be provided to diminish some of the environmental conditions that can add to the burden of transfers. Other attributes such as signage and cross walks ranked as fairly unimportant across all forms of analysis. The implications of these findings reinforce the need to improve bus services and stop locations before minor changes to amenities and accessibility are considered. The survey and accompanying analysis suggests that a well coordinated, safer and more secure transit environments would go a long way to improving customer satisfaction with some of the out of vehicle burdens of transfers. Transit riders in Bangkok do not have radically different preferences than transit users in North America and Europe. Simple, convenient and reliable service would go a great distance to improve customer perceptions of bus services and out of vehicle travel.

6.2 Limitations

This thesis could benefit with the addition of some administrative and methodological enhancements. Firstly, if this study was repeated, the sample should be expanded to 500-600 complete surveys. An increase in sample size may improve the robustness of the ordinal logistic regression models, and provide a better snap shot of the MRT user population. The final sample of 310 individuals is a small number when compared to the thousands who use the stations in this study every day. Increasing the sample size may have also contributed to models with more explanatory power. During the analysis steps, the model building process was complicated by non-convergence issues, necessitating several rounds of data recoding to arrive at a final model with more than one significant attribute. Non-convergence issues may have been a direct result of the small sample size.

Second, the study would also benefit by conducting interviews at additional stations. Although some effort was made to select three stations within characteristically different urban settings, the findings of the I/S survey and ordinal regression analysis may have suffered as a result of biases arising from a lack of geographic diversity. For example, the proportion of riders who said they had access to a car may be higher within the surveyed population than MRT riders in general because over 70 individuals were interviewed at Lat Phrao exit 4 which contains a major MRT park and ride facility. Increasing the number of stations and exits would mitigate these kinds of biases.

Last, more independent variables could be added to increase the richness and resolution of the findings. During the survey design process, independent variables were whittled down to a final nine attributes from an original eighteen. The nine variables included were thought to be the most important attributes that would affect the perception of bus transfers in the context of Bangkok, and also the most straightforward to communicate in the short period of time respondents would have to answer the survey. Fewer questions pertaining to station area cleanliness and safety and security were asked then in comparable studies for belief that they were too complicated to communicate or may be of less relevance to Thais. The small number of independent variables also ruled out procedures to collapse the variables into groups or factors for analysis, a common practice in other customer satisfaction research (Weinstein 2001).

6.3 Additional Research

This study makes an original contribution to transit research by applying a service quality evaluation to a middle income city where such studies are uncommon. However, the findings from this work could be expanded upon by additional research steps;

specifically by extending what has been learned about respondent preferences at MRT exits to inform more new studies which could make use of more refined analytical tools. Translating the findings from the survey into concrete recommendations is difficult to achieve by using I/S statements alone. Follow up work to expand on the findings could take many possible forms.

Focus groups could be convened to probe how individuals understand the I/S statements to draw conclusions about what specific actions could be taken at stations to increase satisfaction. For example, individuals who stated they were unsatisfied with 'This station is safe and free from crime' were found in the present study to be significantly less likely to be satisfied overall with making transfers at the station in general. However, improving MRT rider's perceptions of their own safety may have little to do with adding additional police patrols, better night time lighting or security cameras; all common recommendations for increased safety at transit stops and stations in North America (Taylor et al 2008). In Bangkok, citizens are just as likely to be wary of city police, terrorism, or military actions (the result of ongoing political tensions within the country) as they are afraid of being the victim of random street crime. Focus groups or in-depth interviews could be one way to collect the specifics of customer perceptions of service attributes and improvements.

The findings of this study could also inform the design of stated preference experiments to determine precise configurations of service upgrades that would yield maximum utility to customers. Stated preference (SP) methods are not often applied to global service quality studies because the number of variables required for testing makes designing these surveys overly complex (Eboli and Mazulla 2008). However, this study has narrowed the number of significant service attributes to a more manageable number that could be used to formulate SP experiments. For example, specific experiments could be designed to test for which amenities to waiting areas could be used to leverage the most satisfaction with over all service quality in the absence of moving bus stops closer to exits. SP experiments are methods commonly used in private consultation and regularly inform investment decisions for transit upgrades. SP experiments would be a suitable method to determine very precise recommendations about combinations of specific upgrades.

6.4 Conclusions

This research tests which particular service attributes at MRT-bus transfers could be improved. Although the scope and size of the study is modest, the overall importance of improving the convenience and perceptions of using transit has never been greater. Middle income developing cities such as Bangkok face major challenges to sustainability and economic growth as the demand for cars and roads continues outpace the capabilities of both private and public organizations to build and maintain capacity for vehicles. Despite decades long near exclusive commitment of resources to accommodate private vehicles, Bangkok has gained a well deserved reputation as a ‘traffic disaster’ (Poboon 1997). The ability of Bangkok to continue to absorb the phenomenal growth of private vehicles is made all the more unlikely as environmental changes and looming resource shortages threaten the ‘business as usual” approach to building and transportation infrastructure.

Bangkok’s three operational rapid transit systems are viewed by all city residents as an improvement to the overall transport system. A new elevated line which will serve a middle income suburb began construction in 2011 and almost 200 additional kilometres of rapid transit infrastructure are planned. Increased investment in transit would provide a more equitable and sustainable transportation future that in some ways the city is well suited to achieve (Poboon 1997). The overall low ratio of road space to urban land makes mass auto-mobility problematic (Cervero 2001), if not impossible. Furthermore, Bangkok has relatively high population densities and mixed land uses, all conducive to efficient and effective mass transport (Poboon 1997). However, prioritizing transit over cars is an approach that would run counter to nearly three decades of transportation infrastructure development and popular public sentiments towards private car ownership (Rujopakarn 2003) requiring a major shift in how the public perceives and interacts with the existing and fragmented mass transport organizations. Any successful outcome would likely require a reorganization of public bus services, well beyond the relatively simple re-arrangement transfer nodes. However, continuing in the opposite direction –building more roads, highways and bridges – has been a well documented failure, and against the interests of most Bangkok residents. Meanwhile the evidence that supports improving the comfort, convenience and accessibility of transit services continues to mount as one of the best and low cost ways to attract ridership.

Transfers cannot be eliminated and will always remain a necessary component to every major transit service (Taylor 2008). To mitigate, a growing volume of literature supports improving the connectivity of multiple modes to improve overall service quality to make transfers as straightforward and pleasant as possible (Currie and Loader, 2010, Taylor et al 2008, Guo and Wilson 2004). Such an approach to improving the out of vehicle aspects of service has been studied in the United States by Iseki and Taylor

(2010) and using similar methods, have been applied in Bangkok, Thailand where intermodal integration has been almost entirely neglected between new heavy rail service and the existing bus system.

Lack of integration between the MRT stations and BMTA bus services is thought to negatively affect the overall quality of service for transit passengers switching from subway to bus. The disutility associated with transfers likely contributes to the high proportion of MRT passengers who drive or take informal para transit services once they egress from MRT services. Understanding which aspects of out of vehicle travel can best diminish the out of vehicle travel burdens of transfers can be basis of improve any transit agency's services. This research sought to understand which attributes related to service at transfer nodes are in most need of improvement, and which of these attributes influences MRT customer's overall satisfaction with transfers in a standalone fashion and also while controlling for other significant service attributes. This research asked some straightforward questions to determine how transfer experiences could be improved at MRT stations to better facilitate heavyrail/bus transfers. Specifically, this research asked which improvements to service relating to transfers are most important to MRT users? Which are the least important? Could overall quality of service be ameliorated with smaller improvements to service? Or are additions on a larger scale necessary to satisfy customer's stated importance? This research also asked if different segments of MRT patrons consider different services to be more important than others. Part of this research is aimed at determining if there is a need among MRT users to improve the connectivity between buses and stations and to identify what those needs are. The research also asks what changes to the out of vehicle travel experience can be improved to make busses more attractive to MRT patrons who reported not using buses at the studied stations?

To these ends, 310 interviews were carried out at 5 metro exist at three stations in Bangkok, Thailand. Stations selected for use in the study were located in distinctly different urban settings, and the five exits displayed a range of available service quality attributes for transfers. Respondents were asked to rate 9 service aspects - considered important for transfers - according to how satisfied they were with the present level of that service and how important that service is when making a transfer.

Two forms of analysis were used to explore and draw findings from the survey data. The first method used stated importance and satisfaction scores to determine which service attributes MRT riders are most or least satisfied with and which they find most important. I/S analysis was then preformed which weighted satisfaction scores according to their relative importance. I/S analysis is applied in this case to determine the relative need for specific improvements according to stated customer perceptions. Next, ordinal regression models were calibrated using the stated satisfaction of each attribute as independent variables, and overall satisfaction as the dependant variable. The first series of models determined which variables and at what level of satisfaction best improved an overall model fit. A better fit meant the variable was more important to overall service. Next, a multivariate ordinal regression model was calibrated that determined a significant combination of service attributes that most influence overall satisfaction.

The principal finding of this study determined that the position of stops in relation to MRT exists was not only the service attribute in most need of improvement, but also influenced overall satisfaction of respondents more than any other attribute. This is an important finding, as currently little physical integration with buses has been attempted at 4 of the 5 exits where respondents were recruited. These findings are supportive of the assumptions that many choice riders may be dissuaded from using buses due to excessive distances between stops and stations. Furthermore, the relatively poor pedestrian environment between exits and stops likely contributes to customer's negative perceptions of walking to access buses. A key recommendation of this research is to reduce the distance between exits and bus stops, and to improve the pedestrian environment to minimize the negative aspects of out of vehicle travel. The overall thrust of the findings indicates that the larger improvements and service adjustments are needed to change the transfer environments for the better. Improvements such as repositioning bus stops and predictable scheduled headways are a combination of service that if improved would likely bring meaningfully change to customer satisfaction.

Performance and reliability attributes such as wait times and bus routes that intersect with the stop were also considered by MRT passengers to be very important to service quality. If the goal of the BMTA was to increase its ridership- or even just to stem losses of ridership it has experienced for almost a decade – services would have to be better integrated with the MRT, BTS and ARL. The findings also revealed that many MRT riders are concerned about their safety from crime during out of vehicle travel at the five station exits. MRT riders that were switching to buses tended to be less satisfied with measures to prevent crime at stations and felt safety to be a higher priority than individuals who were not transferring to a bus. This should be a powerful endorsement to carefully consider how the stations could be better organized to control for the negative perceptions of crime.

This research also determined that improvements to amenities, while still important, do not influence customer perceptions of service in the same ways as bus stop locations or safety from crime. While bus shelters, seating, better sidewalks and crosswalks may go some way to improving customer perceptions of transfers, most MRT riders would prefer services that are above all convenient and safe.

The findings of this research illustrate that a well coordinated and structured intermodal transportation environment should be the main priority to improve transfer nodes. There is a clear demand and a high level of expressed importance from all MRT users who think that buses are an integral component of a quality transportation network. The current mismatched and poorly integrated services are a barrier to intermodal transfers and significantly harm the image and operations of the publicly managed BMTA. Applying some of the recommendations made within this research would be a small first step in improving transfers between the two systems – a critical aspect of overall service.

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APPPENDICES

SURVEY: English

Hello, may I ask you some questions for a survey being carried out for university researchers seeking to understand how railway and bus systems work? It should take about 3 minutes to complete, and you may stop at any time. You will not be asked for your name, so there will be no way to identify you from the answers you give. Do you agree to participate?

Y/N

Good. First I will ask you some questions about the trip that you are now making. Second I will ask you some questions about the area surrounding the MRT station and how it could be improved for people using buses and trains.

ONE – QUESTIONS ABOUT THE TRIP

1. How many days a week do you usually ride a bus?
2. Which type of bus do you usually ride?

BMTA/Green mini/Minibus/Inter-city

3. How many days a week do you usually ride the BTS? ___
4. How many days a week do you usually ride the MRT? __
5. Do you or someone in your house own a car which you could have been used to make this trip today? Y/N
6. What is the purpose of your trip today?

Work/eating/shopping/school/recreation/visiting friends/family/other

7. How often do you make this trip?

Regularly/sometimes/not often/never before

8. Please provide information on the trip you are on now (map can be shown if required):
    a. What is the name of the khet/amphoe where you began this trip? ____________ _______
    b. What is the name of the khet/amphoe where you will finish this trip? _________ _______
    c. Which MRT station did you start at? ________________________
    d. Which type or types of transportation did you use to get to the MRT station?

Bus/BTS/car/walk/minibus/motorcycle taxi/ private motorcycle/taxi meter/boat/train/silor other ____ ________________________

e. Which type of types of transportation will you use next?

Bus/BTS/car/walk/minibus/motorcycle taxi/ private motorcycle/taxi meter/boat/train/silor other ____ ________________________

TWO – IMPORTANCE

I would like you to read the following list of possible services that could help to make catching a bus from here easier or more pleasant. Please indicate on a scale of 1 to 4 how satisfied you are with the current availability of each service and then indicate and the scale of 1 to 4 how important to you is that service when making a journey from this station.

Satisfaction Rating Scale	Importance Rating Scale
1= Very satisfied 2= Somewhat satisfied 3= Somewhat unsatisfied 4= Unsatisfied	1= Very important 2= Somewhat important 3= Somewhat unimportant 4= Unimportant

		How satisfied are you with these services at this station?	How important is this service to you when making a journey from this station?
1	Places for me to sit and wait		
2	Bus shelters to protect from rain and sun		
3	Signs here that me help find where I need to go		
4	The bus stops are close by and easy to find		
5	Short wait times to catch a bus		
6	The buses here will take me close to where I need to go		
7	Enough good quality sidewalk space		
8	A safe and convenient spot to cross the street		
9	This station is safe and free from crime		
10	This is an easy place to make a transfer to a bus		

THREE – PERSONAL QUESTIONS

1. Approximately how much is your monthly income (including job, investments, or payments from family supporting you)?
    a. Less than 5,000
    b. 5,000-15,000
    c. 15,000-25,000
    d. 25,000-35,000
    e. 35,000-50,000
    f. 50,000-70,000
    g. 75,000-100,000
    h. 100,000 or more
    i. Declined to answer
2. What is your age? _____
3. Are you Male / Female?

Thank you for your participation in this survey.

SURVEY: Thai with English Captions

ผู้สำรวจ..........................สถานี..........................Exit #.....................

เวลาสำรวจ................ วันที่..............

แบบสำรวจนี้จะใช้เวลาประมาณ 7 นาทีในการตอบคำถามทั้งหมด
โปรดทราบว่าการทำแบบสอบถามนี้ขึ้นกับความสมัครใจของคุณ
ดังนั้นคุณสามารถหยุดตอบได้ทุกเมื่อ
และจะไม่มีการซักถามชื่อหรือบันทึกบุคลิกรูปพรรณใดๆ ของคุณ
ซึ่งทำให้สามารถระบุตัวตนได้

คุณอายุเท่าไหร่ (ถ้าคุณอายุต่ำกว่า 18 ปี ไม่ต้องตอบแบบสอบถามต่อไป)

a. อายุระหว่าง 19 – 35 ปี b. อายุระหว่าง 36 - 50 ปี
c. อายุระหว่าง 50 - 64 ปี d. อายุมากกว่า 65 ขึ้นไป

ตอนที่ 1 การเดินทาง

1. ภายในหนึ่งสัปดาห์ คุณใช้บริการรถโดยสารประจำทางกี่วัน.............. How many days a week do you usually ride a bus?

1. รถโดยสารประจำทางชนิดใดที่คุณใช้อยู่เสมอ Which type of bus do you usually ride?

a. รถโดยสารประจำทางปรับอากาศ A/C bus b. รถโดยสารประจำทางธรรมดา Non A/C bus

c. รถมินิบัสสีส้ม Orange mini-bus d. รถตู้โดยสารปรับอากาศ Inter-city van

e. อื่นๆ โปรดระบุ.. other – please identify

3. ภายในหนึ่งสัปดาห์
คุณใช้บริการรถไฟฟ้าบีทีเอสหรือรถไฟใต้ดินเอ็มอาร์ทีกี่วัน............... How many days a week do you usually ride the BTS or MRT?

4.
คุณหรือสมาชิกในครอบครัวมีรถยนต์ส่วนบุคคลที่คุณสามารถใช้ในการเดินทางครั้งนี้หรือไม่ Do you or someone in your house own a car which you could have been used to make this trip today?

a. มี have b. ไม่มี do not have

5. จุดประสงค์ในการเดินทางวันนี้ของคุณคือ What is the purpose of your trip today?

a. ทำงาน Work b. รับประทานอาหาร eating c. ช้อปปิ้ง/ซื้อของ shopping d. ไปโรงเรียน school e. สันทนาการ recreation f. พบปะเพื่อน visiting friends g. เยี่ยมครอบครัว visiting family h. อื่นๆ... other

6. กรุณาชี้แจงข้อมูลการเดินทางของคุณในครั้งนี้ (คุณสามารถขอดูแผนที่ประกอบได้) Please provide information on the trip you are on now

6.1 คุณเริ่มต้นการเดินทางนี้ที่เขตหรืออำเภอใด.. What is the name of the khet/amphoe where you began this trip?

6.2 การเดินทางนี้ของคุณจะสิ้นสุดลงที่เขตหรืออำเภอใด.. What is the name of the khet/amphoe where you will finish this trip?

6.3 คุณเริ่มต้นเดินทางด้วยรถไฟฟ้าใต้ดินเอ็มอาร์ทีที่สถานีใด... Which MRT station did you start at?

6.4 ยานพาหนะชนิดใดที่คุณใช้เดินทางมายังสถานีรถไฟฟ้าใต้ดินเอ็มอาร์ทีต้นทางของคุณ

Which type or types of transportation did you use to get to the MRT station?

a. รถโดยสารประจำทาง Bus b. รถไฟฟ้าบีทีเอส BTS c. รถยนต์ส่วนตัว personal vehicle d. เดิน walk e. มินิบัส minibus f. มอเตอร์ไซค์รับจ้าง motorcycle taxi g. แท็กซี่ taxi meter h. เรือ boat i. รถไฟฟ้าแอร์พอร์ตลิงค์ airport train j. รถตู้ inter-city van k. อื่นๆ โปรดระบุ ....other – please identify

6.5 การเดินทางวิธีใดหรือยานพาหนะใดที่คุณกำลังจะใช้เดินทางต่อจากนี้ .... Which type of transportation will you use next?

<u>ตอนที่ 2: ความสำคัญและความพึงพอใจ</u> QUESTIONS ABOUT THE STATION AREA

คะแนนระดับความพึงพอใจ rating of satisfaction	คะแนนระดับความสำคัญ rating of importance
4= พึงพอใจอย่างยิ่ง strongly agree 3= พึงพอใจ somewhat agree 2= ไม่พึงพอใจ somewhat disagree 1= ไม่พึงพอใจอย่างยิ่ง strongly disagree	4= สำคัญอย่างยิ่ง strongly agree 3= สำคัญ somewhat agree 2= ไม่สำคัญ somewhat disagree 1= ไม่สำคัญเลย strongly disagree

โปรดระบุความพึงพอใจของคุณต่อบริการต่างๆ ในการเดินทางต่อไปจากสถานีที่มีอยู่ ณ ปัจจุบันนี้ว่า<u>พึงพอใจ</u>มากน้อยเพียงใด ด้วยการให้คะแนน 1 ถึง 4 และ บริการต่างๆ เหล่านี้มีความ<u>สำคัญต่อคุณ</u>มากน้อยเพียงใดนี้ ด้วยการให้คะแนน 1 ถึง 4 เช่นกัน **I am going to ask you a series of questions that refer to the immediate area around this station you have just exited; I would like you to answer by indicating how much you agree or disagree to each question. By indicating 4 you strongly agree, by indicating 3 you agree somewhat, by indicating 2 you disagree somewhat and by indicating 1 you strongly disagree.**

		คุณ**พึงพอใจ**กับบริการต่างๆในสถานีนี้เพียงใด? satisfaction	บริการต่างๆมีความ**สำคัญต่อคุณ**ในการเดินทางต่อไปจากสถานีนี้เพียงใด importance
1	มีที่นั่งให้ฉันพักและรอ there are places for you to sit and wait		
2	ป้ายรถเมล์มีหลังคากันแดดและฝน there are bus shelters to protect you from rain and sun		
3	มีป้ายบอกทางนำฉันไปยังจุดหมายที่ต้องการ there are signs here that can help you find where you need to go		
4	สามารถหาป้ายรถเมล์ที่อยู่ใกล้ๆได้โดยง่าย The bus stops are close by and easy to find		
5	ใช้เวลารอต่อรถเมล์เพียงเล็กน้อย you will only have to wait a short time to catch a bus		
6	มีรถเมล์หลายสายจากที่นี่พาฉันไปใกล้ยังจุดหมายที่ต้องการได้ the buses that pass by this station will take you close to where I need to go		
7	พื้นที่ทางเท้ามีคุณภาพดีพอ There is enough food quality sidewalk space		
8	มีจุดข้ามถนนได้อย่างสะดวกและปลอดภัย There is a safe and convenient spot to cross the street		
9	สถานีนี้ปลอดภัย และปราศจากมิจฉาชีพ this station seems like it is safe and free from crime		
10	จากที่นี่ฉันสามารถไปต่อรถเมล์ได้อย่างง่ายดาย this is an easy place to make a transfer to a bus		

<u>ตอนที่ 3 ข้อมูลพื้นฐานของผู้ตอบแบบสำรวจ</u>

1. รายได้เฉลี่ยต่อเดือนของคุณ

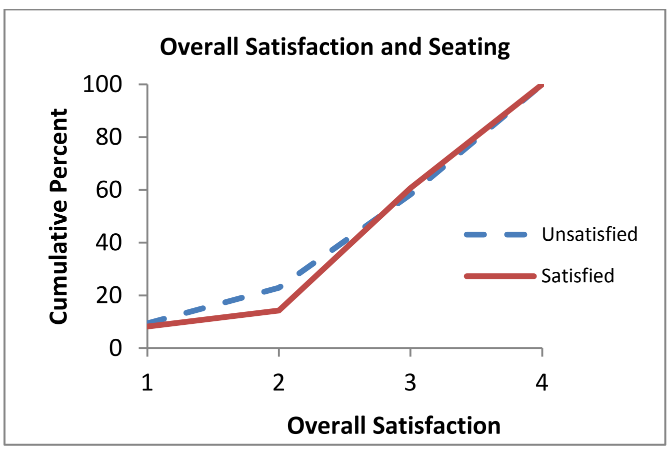
a. น้อยกว่า 5,000 บาท less than... b. 5,000 – 15,000 บาท

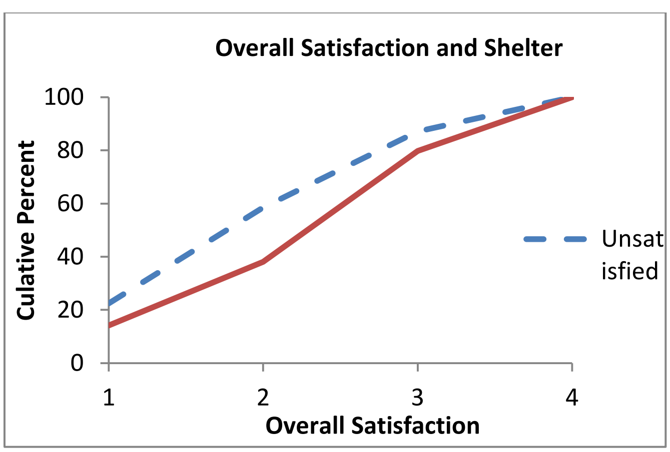
c. 15,000 – 25,000 บาท d. 25,000 – 35,000 บาท

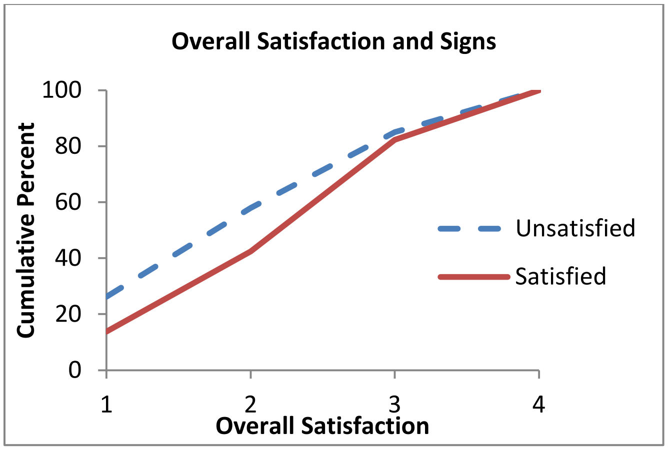
e. 35,000 – 50,000 บาท f. 50,000 – 75,000 บาท g. มากกว่า 75,000 บาทขึ้นไป more than...

2. เพศ ◯ ชาย M ◯ หญิง F

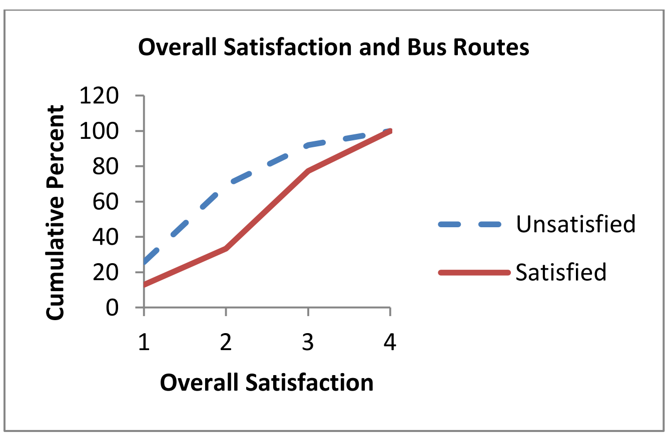
<u>CUMULATIVE PROBABILITIES FOR EACH ATTRIBUTE</u>

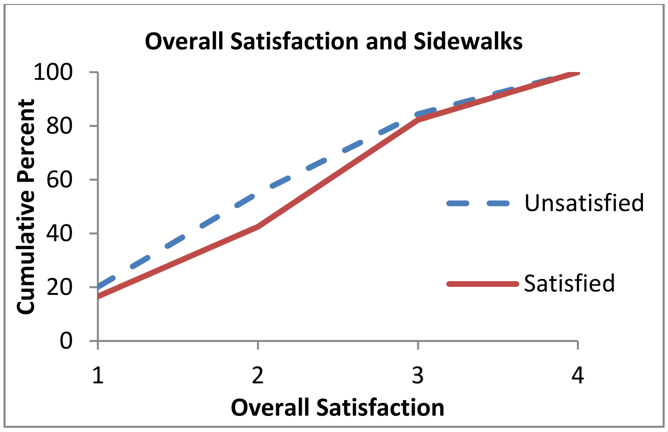





Overall Satisfaction and Signs
Cumulative Percent
100
80
60
40
20
0
1
2
3
4
Overall Satisfaction
Unsatisfied
Satisfied

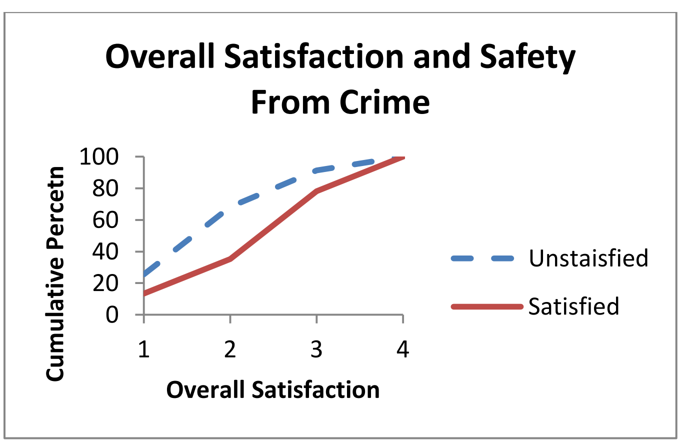

Overall Satisfaction and Bus Stop Location
Cumulative Percent
100
80
60
40
20
0
1
2
3
4
Overall Staisfaction
Series1
Series2


Overall Satisfaction and Bus Routes
Cumulative Percent
120
100
80
60
40
20
0
1
2
3
4
Overall Satisfaction
Unsatisfied
Satisfied



Overall Satisfaction and Sidewalks
Cumulative Percent
100
80
60
40
20
0
1
2
3
4
Overall Satisfaction
Unsatisfied
Satisfied

Overall Satisfaction and Street Crossing
Cumulative Percent
100
80
60
40
20
0
1
2
3
4
Overall Satisfaction
Unsatisfied
Satisfied



Overall Satisfaction and Safety From Crime
Cumulative Percetn
100
80
60
40
20
0
1
2
3
4
Overall Satisfaction
Unstaisfied
Satisfied