Finding Ways out of Congestion for the Chicago Loop

- - A Micro-simulation Approach

By

Shan Jiang[*]

Master of Science in Transportation and Master in City Planning Candidate

Massachusetts Institute of Technology

ABSTRACT

Over the past two decades, the City of Chicago has experienced a great increase in traffic congestion, which limits regional mobility and impedes economic development. Due to the congestion, bus reliability and travel speed has decreased significantly. Since the demand for the rail system in the Loop has almost met its ceiling capacity during peak hours, and the Loop area concentrates a high percentage of total bus passenger boardings, improving bus Level-of-Service (LOS) in the Loop area is crucial to enhancing passenger mobility in the City of Chicago.

As a promising alternative, bus rapid transit (BRT) may reduce negative effects of traffic congestion; but how to evaluate the impacts of such policies on different stakeholders (i.e., auto-drivers and bus-riders) before their implementation and how to assist policy-makers to make sound decisions is complicated.

In order to solve the aforementioned problems, this study builds up a VISSIM micro-simulation model for the Chicago Loop area and uses traffic count, traffic signal and the CTA bus service data as input. This study proposes four sets of indicators, including: 1) bus reliability, 2) travel time, 3) travel speed, and 4) delay time by mode, to evaluate the current base case and bus improvement (e.g. BRT) scenarios. Based on the evaluation of the scenarios, this study makes recommendations on how to alleviate traffic congestion and improve bus LOS in the Chicago Loop area.

[*] **Address:** 350 Memorial Drive, Room 201, Cambridge, MA 02139

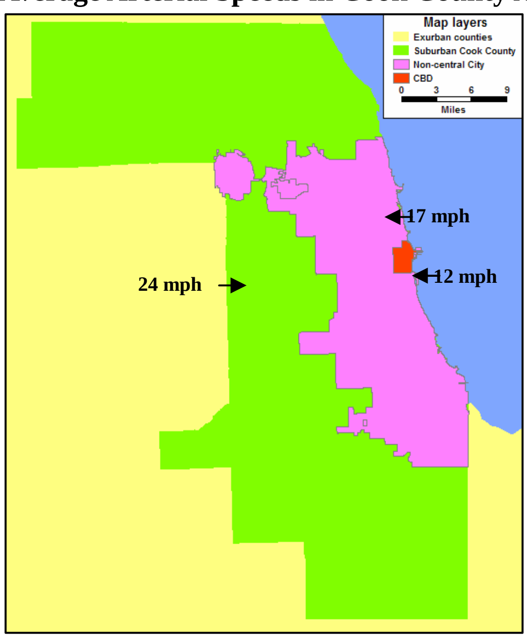
Tel: 857-654-5066 **Email:** shanjang@mit.edu

INTRUDUCTION

Traffic Congestion in Downtown Chicago

Over the past two decades, the City of Chicago has experienced a great increase in traffic congestion. According to *The 2007 Mobility Report* (Texas Transportation Institute, 2007), from the year 1982 to 2005, annual hours of delay per traveler in the Chicago urban area has increased from 15 hours to 46 hours (TTI, 2007). The same mobility report stated that in the peak period 82% of travel is congested and for daily travel, 41% is congested in the Chicago metropolitan area. For an important trip, an average Chicago traveler should plan 2.07 times of free-flow travel time to reach his/her destination, which ranked number one among nineteen U.S. urban areas for the year of 2007. In 2005, the Chicago area experienced 202.835 million hours of travel delay, and wasted 141.612 million gallons fuel, which equaled to 3,968 million dollar cost and ranked number three among the 437 American urban areas. The Chicago Area Transportation Study (CAT, now reorganized as the Chicago Metropolitan Agency for Planning -- CMAP) estimated that in the year 2005, the average arterial speeds for the Chicago's central business district (CBD) was as slow as 12 mile per hour (mph), 17 mph for the non-central city, 24 mph for the suburban Cook County, and 25-37 mph for the five suburban and exurban collar counties (Figure 1).

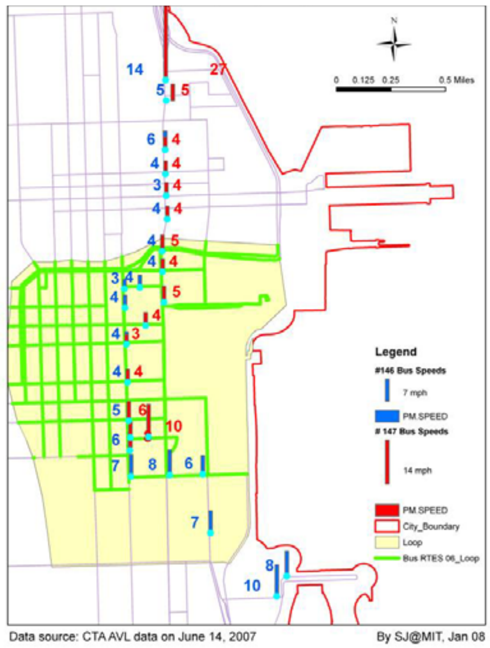
Figure 1. Average Arterial Speeds in Cook County Area, 2005



Data Source: Chicago Area Transportation Study, 2005

Due to traffic congestion, bus reliability and travel speed has decreased significantly. For example, the average speed of the CTA routes 146 and 147 during peak hour (in the year 2007) was four to five mph in downtown Chicago (Figure 2). The differences of level-of-service between bus and auto become more pronounced. As a consequence, the loss in bus ridership accelerates; mode share for car increases; and traffic congestion becomes even worse, which forms a vicious circle that leads to unsustainable development.

Figure 2. Average Arterial Speeds in Cook County Area, 2005



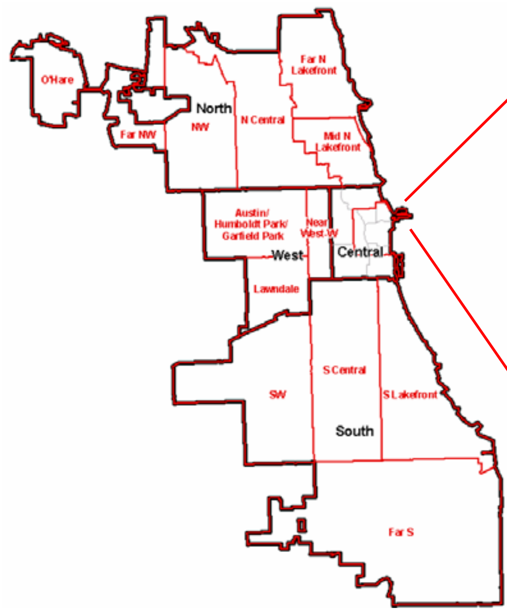
Benefits of Improving Bus Level-Of-Service

In order to mitigate traffic congestion in Chicago downtown area, improving the CTA bus level-of-service is very important, because

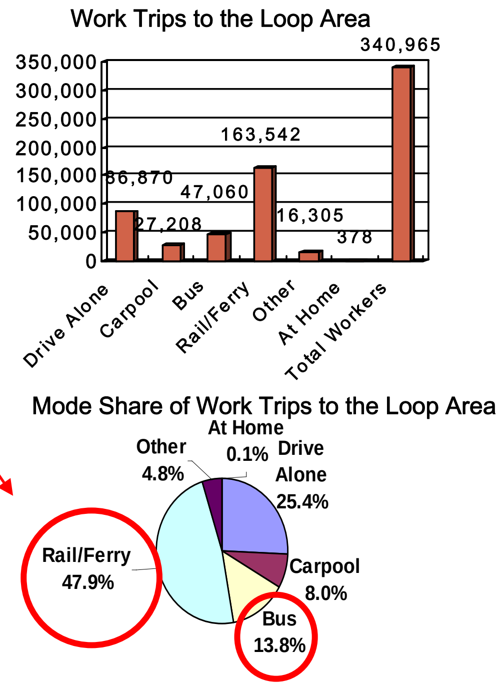
1) The demand for the rail system in the Loop area has almost met its ceiling capacity during peak hours. According to the CTPP 2000 survey data, among the 340,965 workers who worked in the Loop area, 47.9% of them commuted by rail, 13.8% by bus, and 25.4% drove alone (Figure 3). As the Loop area concentrates a high percentage of total bus passenger boardings, improving bus Level-of-Service (LOS) in the Loop is crucial to improving the capacity of the CTA transit system and enhancing passenger mobility in the City of Chicago.

2) To retain and attract more jobs is vital for Chicago to compete in the Global Economy. Reliable and comfortable mass transit service will facilitate job agglomeration. Improving bus LOS will encourage more people to use public transit and will promote sustainable development, including reducing CO_2 emission and global warming, reducing air pollution and negative effects on public health, and most importantly, encouraging economic development.

Figure 3. Basic Work Trips and Mode Share Facts in the Loop Area, 2005



Source:http://www.rtams.org/



Data Source: CTPP 2000

Bus Rapid Transit (BRT) is an alternative to fulfill the aforementioned goals. There have been many successful experiences of BRT and bus improvements around the world, including Paris BRT, Mobillien, BRT in Curitiba, Brazil, Bogotá BRT TransMilenio in Santiago, and bus improvement in London (Figure 4). Elements of BRT include dedicated bus lane, far side stops, queue-jumping lanes,

Figure 4. Bus Improvements and BRT Examples around the World

Paris BRT, Mobilien

Source: http://connectedcities.eu /guide/mobilien.html

BRT in Curitiba, Brazil

Source: BRT Planning Guide, ITDP 2007

Bus improvement in London

Sources: London Bus Routes by Ian Armstrong, http://www.btinternet.com/~tony.papard/Routemaster.htm

Bogotá BRT, TransMilenio SA

Source: BRT Planning Guide, ITDP 2007

In April, 2008 the U.S. Department of Transportation announced its designation of Chicago, as a Congestion Reduction Demonstration ("CRD") Partner[1] … under the terms of the CRD Agreement, *the City of Chicago and CTA* have committed to implementing an integrated and aggressive program to reduce traffic congestion with substantial Federal funding to support four sets of projects, including 1) Bus Rapid Transit (BRT), 2) loading zone fees, 3) variable parking pricing, and 4) parking concession agreement. CTA will establish dedicated BRT service along four corridors, serving as the first phase of a proposed city-wide arterial BRT network, including 1) 79th St. (State St.->Ashland Ave.); 2) Chicago Ave. (California Ave.-> Fairbanks Ct.); 3) Halsted St. (Lake St.-> North Ave.); and 4) Jeffrey Blvd. (87th St.->67th St.).

Although bus rapid transit (BRT) may reduce negative effects of traffic congestion, yet how to evaluate the impacts of such policies on different stakeholders (i.e., auto-drivers and bus-riders) before their implementation and how to assist policy-makers to make sound decisions is complicated. The purpose of this study is to develop a micro-simulation model as a planning/decision-making tool to 1) explore the potential for bus service improvements, and 2) examine the impacts that different scenarios of BRT corridors may bring in the effort to relieve traffic congestion in the Chicago area. Proposed indicators to evaluate the alternatives include: 1) bus reliability, 2) total/average travel time by bus/car, 3) average travel speed by bus/car; and 4) delay time: total passenger-hours delay by bus, and person hours by car.

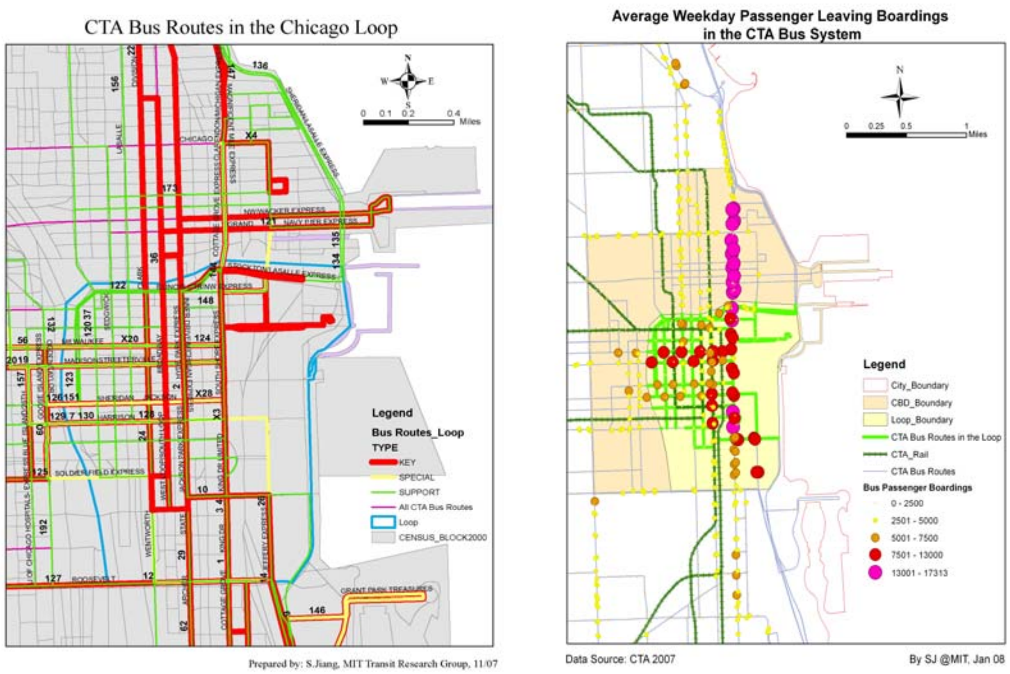
STUDY AREA: THE LOOP

This study mainly focuses on the Chicago Loop area. Besides the abovementioned reasons of serious congestion in downtown area and slow traffic speeds, heavy concentration of the supply of and demand for the CTA bus service is another important reason (Figure 5). There are 47 CTA bus routes traveling through the Loop area,

[1] *http://www.crd.dot.gov/agreements/chicago.htm*

and the bus stops with more than 7500 average weekday passenger leaving boardings mainly concentrate in three corridors in the Loop area (including Michigan Ave, Washington Street, and Madison Street)

Figure 5. Heavy Concentration of the Supply of and Demand for the CTA Bus Service in the Loop



METHODOLOGY AND MODEL DELVEOPMENT

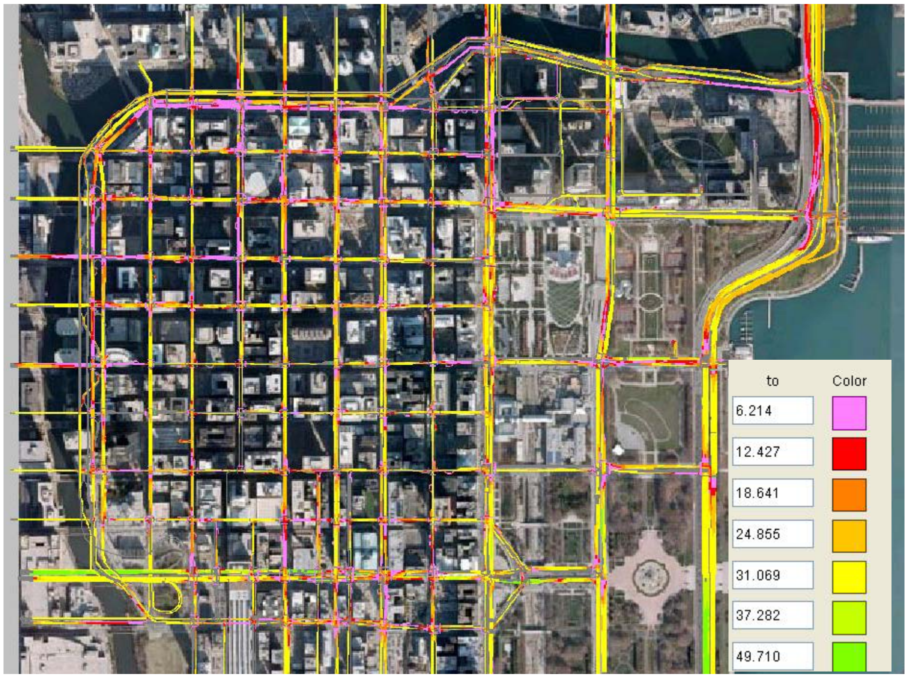
Advantages of a micro-simulation approach

In order to develop BRT's full potential, a micro-simulation approach has been employed. Micro-simulation is very powerful, because:

- it can describe all the factors of the traffic system, including double parking, random traffic effects, and the non-linearity of traffic congestion;
- it allows us to analyze a network rather than a corridor so that we can re-assign automobile traffic to give priority to buses;
- it allows us to explore different scenarios of BRT and do sensitivity analysis for each scenario; and
- it can assist decision makers/transportation planners/traffic engineers to make sound decisions.

A microscopic, behavior-based multi-purpose traffic simulation package VISSIM has been used for this study. Figure 6 is a snapshot of the VISSIM Loop Model.

Figure 6. Aggregated Travel Speed of the VISSIM Chicago Loop Simulation Model



Model Development

Figure 7 shows a complete process of the model development. I will illustrate how to build the VISSIM simulation model in the following paragraphs.

The first step is to develop a base VISSIM Loop Simulation model, involving building, updating and/or validating 1) the geometry of the road network, 2) network connectivity, 3) bus network, 4) locations of origins and destinations of traffic flows, 5) traffic signals and 5) auto OD matrix. The first two elements are based on real road geometry, Google Maps, and Microsoft Live Maps. The third element is based on the CTA bus maps, and the fourth and fifth elements are based on the data from the City of Chicago, and the last one is an output of another planning package – TransCAD, estimated from the traffic counts data coming from the City of Chicago (2004).

In order to estimate accurate OD matrix by TransCAD, a TransCAD GIS-planning model has been developed (Figure 8). Elements of the TransCAD model include the same Loop network (links, nodes, and origins and destinations). The characteristics of the network essential to estimate the OD matrix are travel time, link capacity, and traffic counts. The first elements are estimated from the VISSIM simulation model (as shown in Figure 6), and the other two factors come from observations and data recordings in the City of Chicago.

Figure 7. Model Framework

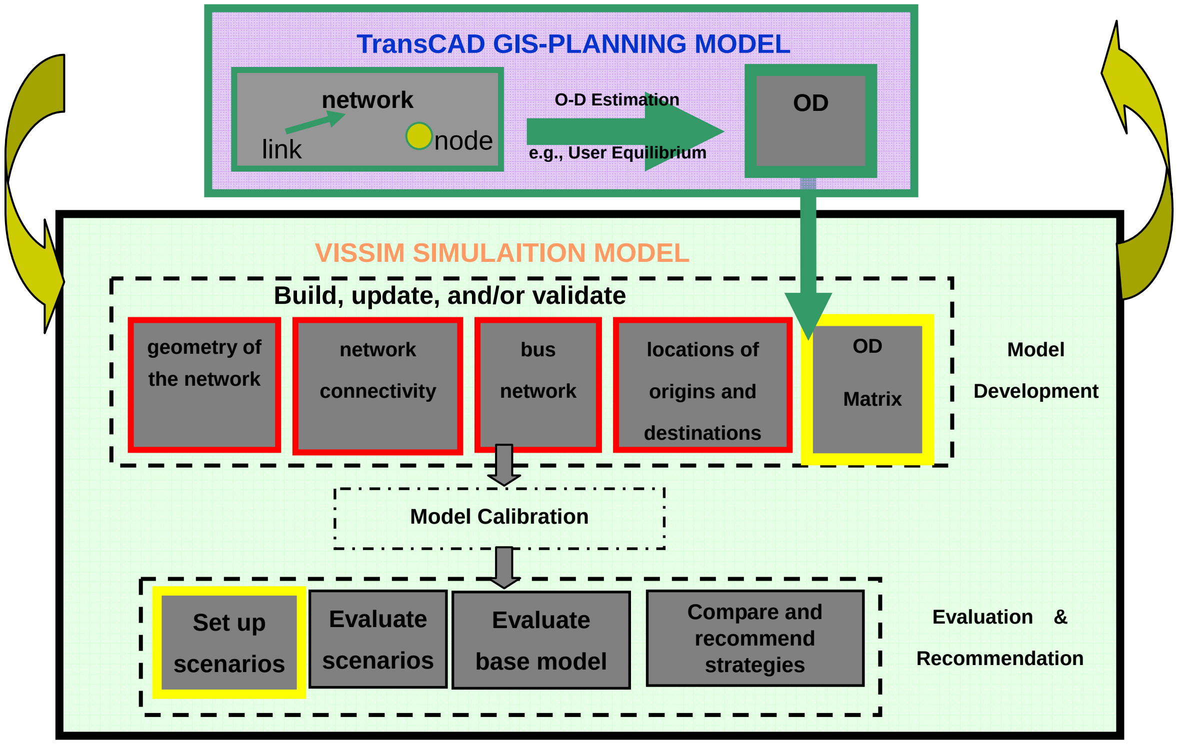
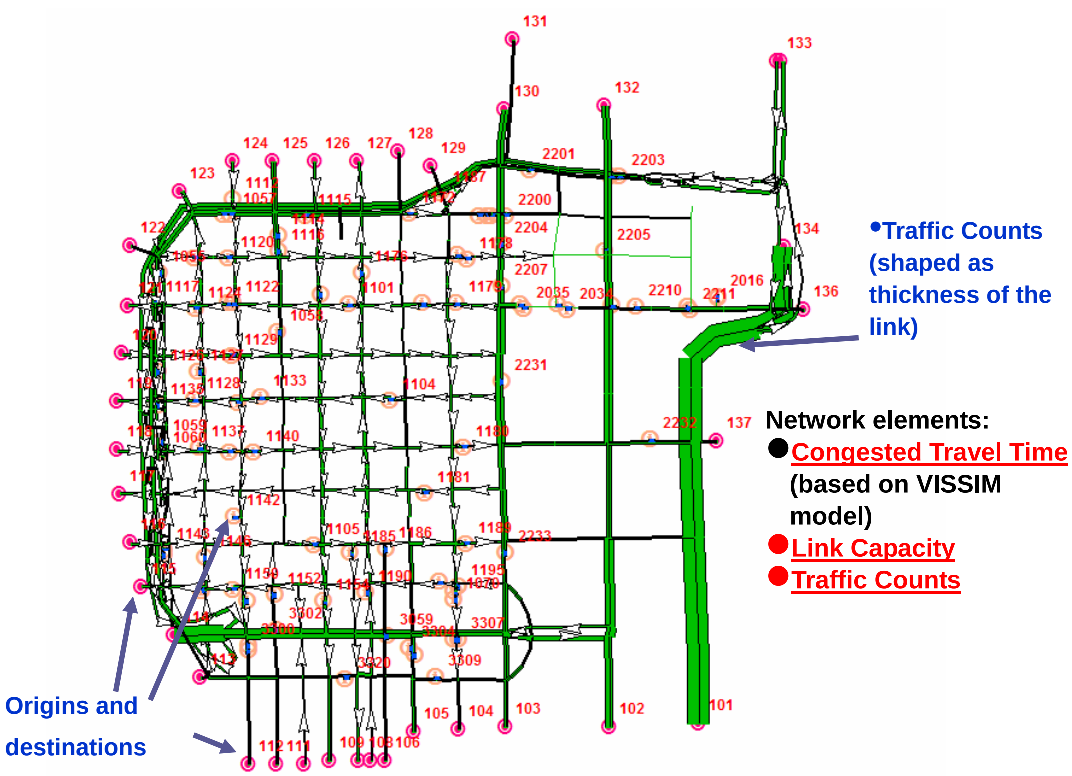


Figure 8. Auto OD Matrix Estimation: TransCAD Model



After the first round OD estimation by TransCAD, and traffic simulation by VISSIM, it is necessary to evaluate, and re-estimate the OD matrix by comparing and updating the network capacity, traffic signals and road counts, and traffic flows. Using the updated OD matrix as an input, the fourth step is to calibrate the base VISSIM simulation model.

The fifth step is to set up scenarios for BRT, including changing geometry of the road network, network connectivity, bus network, locations of origins and destinations and updating a new auto OD matrix, which is significantly determined by accurate traffic count data.

SCENARIOS AND RECOMMENDATIONS

Selecting BRT Corridors in the Loop Area

Based on the TransCAD model, we are able to estimate the number of buses per hour on each road during peak hours in the Loop area. We found that during peak hours, 35 to 60 buses per hour run on Michigan Avenue; 30 to 45 on State Street; around 25 to 40 on both Washington and Madison Streets, and around 30 to 80 on both Adams and Jackson Streets. Based on the average daily passenger (leaving) boardings in the CTA system, four corridors are recommended as scenarios to run BRT (Figure 9). They are Michigan Ave, State Street, Washington Street and Madison Street.

Figure 9. Scenarios of BRT in the Loop Area

Evaluating Local Traffic Details

Since the latest traffic count data has not been released to the public yet, the OD matrix may not yet reflect recent traffic flows. An accurate VISSIM model needs an updated OD matrix to estimate the previously mentioned indicators to evaluate the base case and the scenarios. Among those indicators, bus reliability will increase significantly after the BRT implementation, average bus travel speed will increase, and average bus travel time and total passenger-hours delay by bus will decrease. For auto travel, the situation is complicated, and it needs updated traffic counts data to support finer analysis.

FUTURE RESEARCH

The VISSIM model can help planners/decision makers understand potential benefits of bus priority in the Chicago Loop, including: accessibility improvements, mode share changes in the Loop, (auto and/or bus) CO_2 emission and energy consumption change in the Loop area. It can also be used as an analysis tool for other planning or policy changes in the future.

As an infrastructure, the VISSIM micro-simulation model provides planners and decision makers a great opportunity to test their ideas without large capital investment. Furthermore, the VISSIM simulation model will help communities and neighborhoods understand various impacts of proposed plans on different stakeholders vividly, and will enable the general public to participate in discussing about advantages and disadvantages of each plan.