ADAPTATION OF VISSIM, A DYNAMIC SIMULATION MODEL, TO THE TRAFFIC BEHAVIOR AT INTERSECTIONS IN MAYAGÜEZ, PUERTO RICO

by

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Abstract

The rapid evolution in the sophistication of microsimulation models has encouraged their use in transportation engineering and planning. Traffic In Towns SIMulation (VISSIM as its acronyms in German) is a microsimulation model used for the design of traffic actuated control systems. The main objective of this research is to validate the VISSIM program for Puerto Rican driving-behavior environment due to the fact that this program was developed and validated for Germany’s traffic behavior. The environment and traffic rules in Germany are different with respect to Puerto Rico’s. Part of this research is to adapt the microsimulation commercial software, “VISSIM” to these differences, and to determine its ability to represent the traffic behavior at major arterial street intersection conditions in Puerto Rico.

The test bed is a thirteen (13)-kilometer (8.1 miles) corridor located on highway PR-2 between the municipalities of Mayagüez and Añasco. The arterial network was divided in two different segments taking into consideration the geometric characteristics of each segment. Data were collected in the selected intersections for both, providing the necessary input to the simulation and comparing the results obtained. After performing the simulation, statistical analysis was performed to study how this microsimulation tool represents Puerto Rico’s traffic conditions. The results obtained using statistical analysis show that there is no significant difference between the output obtained in the simulation with VISSIM and the field studies at the 95% confidence level.

Resumen

La rápida evolución en la sofisticación de los modelos de microsimulación ha motivado su uso en la ingeniería y en la planificación de la transportación. El Programa de Simulación de Tráfico en Ciudades (VISSIM por sus siglas en alemán) es un modelo de microsimulación utilizado para el diseño de sistemas de control de tráfico actuado. El objetivo principal de esta investigación es validar el programa VISSIM para el ambiente del usuario Puertorriqueño dado que este programa fue desarrollado y validado para el comportamiento de tráfico en Alemania. El ambiente y reglas de tráfico en Alemania son diferentes con respecto a las de Puerto Rico. Parte de esta investigación es el adaptar el programa de microsimulación comercial “VISSIM” a estas diferencias, y determinar su habilidad para representar las condiciones de tráfico en intersecciones de una vía arteria principal en Puerto Rico.

El tramo de prueba es un segmento de trece (13) kilómetros (8.1 millas) situado en la carretera PR-2 entre los municipios de Añasco y Mayagüez. La red arterial fue dividida en dos segmentos distintos tomando en consideración las características geométricas a lo largo de la alineación. Los datos recopilados en la intersección seleccionada dentro de cada tramo, se utilizaron para la simulación y luego se procedió a comparar los resultados obtenidos con los recopilados en el campo. Después de realizar la simulación, se realizó un análisis estadístico para estudiar cómo esta herramienta de microsimulación representa las condiciones del tráfico en Puerto Rico. Los resultados obtenidos utilizando análisis estadístico demostraron que no existe diferencia estadística significativa entre los datos obtenidos en la simulación de VISSIM y los obtenidos en los estudios de campo para un nivel de confiabilidad de 95%.

Dedication

The efforts I have made through these years are dedicated to my loving wife, Michelle and my two children, Fabián and Diego; they are my inspiration to continue graduate studies. I also give thanks to my parents, Enrique González and María del C. Vélez for their guidance and support to continue my studies in Civil Engineering. Finally, and very important to me, I thank God, for giving me the strength I needed to continue working.

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Table of Contents

Page

Page

List of Figures

Page

Page

Page

List of Tables

Page

Page

Chapter 1

1.1. Introduction

Traffic simulation software has become very popular as a traffic analysis tool used in transportation analyses. One reason for the enhanced use of simulation is the need to model and analyze the operation of complex transportation systems under congested conditions. Simulation is used when some analytical techniques or conditions are not represented by using mathematical equations. Simulation models are typically classified according to the level of detail at which they represent the traffic stream. These include: Microscopic, Mesoscopic and Macroscopic Models.

Microscopic Models simulate the characteristics and interactions of individual vehicles. They essentially produce trajectories of vehicles as they move through the network. The processing logic includes algorithms and rules describing how vehicles move and interact, including acceleration, deceleration, lane changing, and passing maneuvers.

Mesoscopic Models simulate individual vehicles, and describe their activities and interactions based on aggregate (macroscopic) relationships. Typical applications of mesoscopic models are evaluations of traveler information systems. For example, they can simulate the routing of individual vehicles equipped with in-vehicle, real-time travel information systems. The travel times are determined from the simulated average speeds on the network links.

Macroscopic Models simulate traffic flow, taking into consideration aggregate traffic stream characteristics (speed, flow, and density) and their relationships. Typically, macroscopic models use equations of flow conservation and traffic disturbances (shockwaves propagation). They can be used to predict the spatial and temporal extent of congestion caused by traffic demand or incidents in a network; however, they cannot model the interactions of vehicles on alternative design configurations. Microscopic models are potentially more accurate than macroscopic simulation models.

A microsimulation model is a software tool that is used in a simulation process incorporating in detail the Microscopic model. It employs several submodels, analytical relationships, and logic to model traffic flow. Simulation models include algorithms and logic to:

- Generate vehicles into the system to be simulated.
- Move vehicles into the system.
- Model vehicle interactions.

Some of the microsimulation tools that have been used to model a road networks are AIMSUN, DRACULA, Paramics, SISTM, MITSIM, CORSIM, and VISSIM among others (Dowling et. al., 2004).

The area selected in which our study was performed is located in the western coast of Puerto Rico in the municipality of Mayagüez. Mayagüez, called "*La Sultana del Oeste*", has a population of 95,280 (Annual Estimates of the Population 2005 Census Bureau) and an area of 200 km^2. Is the third-largest city in Puerto Rico, and is considered one of the most important cities in the island. Figure 1.1, presents a map of Mayagüez and its surrounding municipalities. Mayagüez limits to the north (N) with the municipality of Añasco, to the south (S) with San Germán, Hormigueros and Cabo Rojo, to the east (E) with Las Marías and Maricao and to the west (W) with the Atlantic Ocean.

Figure 1.1 Map of Mayagüez and surrounding municipalities

Demand for highway lanes continues to grow as population increases, particularly in this metropolitan area where congestion has become one of the main transportation problems. Congestion is largely thought of as a big city problem, but delays are becoming increasingly common in small cities and some rural areas as well.

In essence, highway congestion results when traffic demand approaches or exceeds the available capacity of the highway system. Traffic demands vary significantly depending on the season of the year, the day of the week, and even the time of day. On the other hand, the capacity, often mistaken as constant, can change because of weather, work zones, traffic incidents, or other non-recurring events. All of the characteristics mentioned above are conditions that have being seen in the arterial network of PR-2 at the Mayagüez Metropolitan Area, the major system used by the community to travel every day.

Arterial systems serve major metropolitan centers, corridors with the highest traffic volume, and those with the longest trip lengths. The selected arterial network has problems with congestion, delays and queues. VISSIM was used to simulate and analyze the conditions of this arterial system. VISSIM was developed in Germany employing the environment and the driver behavior existing in that area. In Germany the drivers respect the traffic laws and the right-of-way of the vehicles. It can be assumed that the straight movements are the ones that have the right-of-way. Meanwhile in Puerto Rico, driver's tendency is to make left turns as a priority over the straight movements in intersections. In Germany, when two public roads cross at an uncontrolled intersection, the right-of-way is always given to traffic approaching from the right. This includes "T" intersections. In Puerto Rico, traffic on the through street of a "T" has the right-of-way. These factors increase the importance of adapting the use of this program to the Puerto Rico environment. At the same time the aaSIDRA program, which is mainly used by engineers in the field, was used to compare the behavior of the results obtained.

1.2. Justification

The modeling of individual vehicle movements on a second or sub-second basis for the purpose of assessing the traffic performance of highway and street systems, transit, and pedestrians is called Microsimulation. The rapid evolutions in the sophistication of microsimulation models have expanded their use in transportation engineering and planning practice (Dowling, 2003.).

VISSIM (Traffic In Towns: SIMulation) is used for the design of traffic actuated control systems (Fellendorf, 1994). A microscopic, behavior-based multi-purpose traffic simulation program, VISSIM, used on many engineering disciplines, has become an indispensable instrument for the analysis of complex technical systems. It is an invaluable cost-reducing tool. It offers a wide variety of urban and highway applications, integrating public, and private transportation. Even complex traffic conditions are visualized in great detail providing realistic traffic models. Traffic engineering expertise combined with 3D animations warranties realistic presentation for both technical experts and decision makers (PTV AG, 2004.).

VISSIM is a microsimulation software that is being used by different regions to analyze multi interaction transportation systems. VISSIM has not been used in Puerto Rico, and there is no research on how well it represents the traffic conditions in our environment. This research project intent to adapt and analyze the microsimulation commercial software VISSIM, and determine its ability to represent arterial network conditions in Puerto Rico, specifically in a test bed located in Mayagüez. Using VISSIM, we can compare how well this microsimulation tool represents the actual conditions in Puerto Rico.

VISSIM consists of two different programs: the traffic simulator, and the signal state generator. The traffic simulator is a microscopic simulation model comprising car-following logic and lane changing logic. The signal state generator is a signal control software that polls detector information from the traffic simulator on a discrete time step basis (ATAcenter, 2004.). A more detailed description of VISSIM is presented in Chapter 3.

1.3. Objectives

The main objective of this research is to validate the VISSIM program for the Puerto Rican driving-behavior environment due to the fact that this program was developed and validated for Germany’s traffic behavior. The environment and traffic rules in Germany are different with respect to Puerto Rico’s. Part of this research is to adapt the microsimulation commercial software, “VISSIM” to these differences, and to determine its ability to represent the traffic behavior at major arterial street intersection conditions in Puerto Rico, specifically in a test bed located on roadway PR-2 at Mayagüez. The above was achieved through:

- Identifying and selecting two different segments on the test bed located on roadway PR-2 at Mayagüez.
- Selecting a intersection for each segment, having in consideration its geometric characteristics and its complexity.
- Performing simulations on each of the segments separately, and obtain the output needed.
- Evaluating the output of VISSIM using statistical analysis on the two segments selected.

This chapter provides a brief description of the research areas that would be covered providing some characteristics and explaining the interactions of individual vehicles in typical classified simulation models that represent the traffic stream conditions.

1.4. Thesis Outline

The subsequent thesis chapters are organized as follows: Chapter 2 presents a literature review of existing microsimulation models and describes various car following models that are mainly used by microsimulation programs. Chapter 3 gives a description of the programs used in this research. Chapter 4 presents a description of the test bed in where VISSIM adaptation was performed, and discusses the Average Daily Traffic study for the intersections selected. Chapter 5 presents the intersection delay study. Chapter 6 presents the statistical analysis between the field data and the VISSIM output, and between the field data and the aaSIDRA output. Chapter 7 discusses the overall conclusions from this research, identifying the contributions of this research for the adaptation of the VISSIM program for Puerto Rico’s traffic environment. Chapter 8 presents the recommendations for future research as well as research needs and possible research directions.

Chapter 2 Literature Review

2.1. Microsimulation

Road traffic microsimulation models are computer models where the movements of individual vehicles traveling around road networks are determined by using car-following, lane changing and gap acceptance rules. The use of software modeling is becoming increasingly popular for the evaluation and development of road traffic management and control systems. Traditional models provide an aggregated representation of traffic, typically expressed in terms of total flows per hour. In such models, all vehicles of a particular group obey the same rules of behavior.

Microsimulation models provide a better and genuine representation of actual driver behavior and network performance. They are the only modeling tools available with the capability to examine complex traffic problems such as: complex junctions, shockwaves, urban network incidents effects and the implementation of intelligent transportation systems. In addition, there is the appeal to users of the powerful graphics offered by most software packages that show individual vehicles traversing across networks that include a variety of road categories and junction types. This visual representation of problem and solution in a format understandable to laymen and professionals alike can be a powerful way to gain more widespread acceptance of complex strategies.

Microsimulation can be used to develop new systems and optimize their effectiveness. They can easily estimate the impact of a new scheme by producing outputs on a wide range of measures of effectiveness. Many of these impacts, such as the amount of pollution emissions, are often difficult to measure in the field.

Microsimulation is suitable to the development, testing, and evaluation of Intelligent Transportation Systems (ITS). Many such systems interact with individual vehicles. Responsive signal control, public transport priority, and ramp metering systems react to vehicles approaching junctions. Dynamic Route Guidance systems provide specific information to individually equipped vehicles. Intelligent Cruise Control systems adjust the speeds of equipped vehicles. Microsimulation is used to assess the potential benefits of using ITS. As an assessment tool, microsimulation progresses are capable of modeling interactions at the level of individual vehicles. Microsimulation models, which can reproduce individual driver behavior, should therefore be an important part of any such assessment process. Moreover, as individual vehicles are being modeled it is often possible to use the microsimulation as an alternative for the real world and connect it directly to the actual systems. This approach would eliminate the need to produce a model to present the system being assessed.

Microsimulation has the potential to be used for short-term forecasting. As microsimulation models behave much faster than real-time, they can be used to make predictions about the future state of a road network before critical conditions unfold. This can be useful for applications such as incident managements or setting variable speed limits.

Microsimulation tools are also capable of providing realistic training for system operators and users prior to operation in the real world (Fox, 2005).

2.2. Microsimulation Tools

2.2.1. AIMSUN

Advanced **I**nteractive **M**icroscopic **S**imulator for **U**rban and **N**on-urban Networks (AIMSUN) is a microsimulation program developed by the Polytechnic University of Catalunya (Barcelona, Spain) (TSS, 2006). It is a software tool capable of reproducing real traffic conditions in urban and non-urban networks. It is based on a microscopic simulation approach. The behavior of every single vehicle in the network is continuously modeled throughout the simulation time period, according to several driver behavior models such as: car-following, lane changing, and gap acceptance. AIMSUN is a combined discrete-continuous simulator: there are some elements of the transportation system (vehicles, detectors), whose state changes continuously over the simulated time period, while there are other elements (traffic lights, entrance points), whose state changes discretely at specific points during the simulation time. It distinguishes between different types of vehicles and drivers; deals with a wide range of network geometries; models incidents, and conflicting maneuvers.

AIMSUN needs three types of input data: network description, traffic signal control plans and traffic conditions. The network description contains information about the geometry of the network, turning movements, layout of links and junctions and location of detectors. The traffic control plans define the signal stages, and their duration for signal controlled junctions, the priority definition for unsignalized junctions, and any required ramp-metering information. The essential inputs for the simulator are the traffic flows for the input links, the turning proportions at junctions and the initial state of the network.

The outputs provided by AIMSUN include a continuously animated graphical representation of the traffic network, a printout of statistical data, and data gathered by the simulated detectors. AIMSUN is integrated into the GETRAM simulation environment (Generic Environment for Traffic Analysis and Modeling), which consists of a traffic network graphical editor, a network database, static assignment models, temporal simulation models and a module for storing and presenting results.

2.2.2. CORSIM

Corridor **Sim**ulation (CORSIM) is a microsimulation program developed by the FHWA (FHWA, 2005). It is a program that has evolved over time from two separate traffic simulation programs. The first program, NETSIM or TRAF-NETSIM, is an arterial analysis program that models arterials with at grade intersections. The second program, FRESIM, is a freeway model that models uninterrupted facilities including grade separated expressways and interstate freeways. CORSIM combined these two programs in order to have the ability to analyze complete systems. The effects of traffic operations between freeways and signalized ramp terminal intersections can be analyzed directly as opposed to analyzing the two facility types and "guessing" the potential impacts one type of facility has on the other.

One advantage of the CORSIM software is that it has been refined based on input from a number of different users from around the country. As a result of all the inputs various problems have been identified and corrected (Advance CORSIM Training Manual, 2005).

CORSIM has expanded the capabilities of NETSIM and FRESIM with the following major enhancements:

- HOV Lanes in FRESIM
  - HOV lane bypass at ramp meters is allowed.
  - Incidents can occur on HOV lanes.
  - An HOV lane can be dropped and added.
  - Full-length auxiliary lanes can be specified as HOV lanes.
- Freeway Ramp Metering
  - A multiple occupancy threshold algorithm and an ALINEA algorithm are introduced. The ALINEA algorithm is a local feedback ramp metering policy.

The algorithm attempts to maximize the mainline throughput through maintaining a desired or optimal occupancy on the downstream mainline freeway. In addition, it implements logic for allowing two vehicles per green when fixed-time ramp metering is implemented.

- Vehicle-Type-Specific Turn Percentages
    - Surface street turn movement percentages and freeway exit percentages can be manipulated by vehicle type. This is useful for modeling facilities such as weight stations, toll booths, airport loading/unloading zones or anywhere that control of specific vehicle types is desired.
- Support Large Networks:
    - Increased maximum network size to the maximum allowed using the CORSIM node numbering scheme. Node numbers 1 through 6999 can be used for internal nodes. Node numbers 7000 through 7999 can be used for interface nodes and node numbers 8000 through 8999 can be used for entry or exit nodes. There is no limit to the number of links, segments or vehicles, other than the limitations imposed by the amount of available memory on the computer that is running CORSIM.
- Path Following Capability:
    - Vehicles normally follow paths that are determined randomly based on turn percentages, but CORSIM allows the user to define specific paths and force vehicles to follow those paths (FHWA, 2005).

2.2.3. DRACULA

Dynamic **R**oute **A**ssignment **C**ombining **U**ser **L**earning and Microsimul**A**tion (DRACULA) is a microscopic traffic network modeling suite, conceived and developed at the Institute for Transport Studies, University of Leeds (UK) over a five year period. It is part of the SATURN suite of programs developed at Institute for Transportation Studies (ITS, 2000). The development, testing, and validation of the model have been primarily funded by a large grant from the UK Engineering and Physical Sciences Research Council. Applications of this model in progress include the study of congestion based road pricing, real time traffic signal control, dynamic route guidance, segregated busway design, emergency evacuation procedures, and strategic inter-urban modeling. DRACULA is able to model the effect of policy, demand, and network changes on route and departure time choice.

DRACULA incorporates a range of possible assumptions and levels of detail, which may be selected by the transport planner depending on the objectives of the study. As an example, driver choices may be modeled at the level of the individual drivers or at an aggregate level; one second increment discrete microsimulation may be used to move drivers along their chosen routes, or macroscopic traffic models may be used; route choice may be assumed to be the only choice open to drivers. The transport planner may model departure time choice, in route diversion in response to unexpected conditions, or the details of lane choice switching to avoid blocked or heavily queued lanes. DRACULA differs from "traditional" equilibrium approaches in that it explicitly models the day-to-day dynamic evolution of driver behavior and traffic conditions, as a discrete time stochastic process (not fully determined). At its most detailed and comprehensive level, DRACULA has the following structure:

- Initialization
    - For each potential traveler in the network, assume initial perceived travel costs for each link in the network.
- OD demand
    - Generate the set of travelers who will actually make a car journey on a day.
- Travel choice
    - Each individual traveling on a day selects a departure time and route based on their currently perceived travel costs.
- Supply variability
    - Simulate day-to-day variability in characteristics of the traffic model, to represent rain/snow, accidents, parked vehicles, breakdowns, etc.
- Traffic model
    - Load the travel choices in the network using a one-second increment microsimulation model, recording individual travel experiences. During this stage, in route diversion from the originally selected route may occur.
- Learning
    - Via some kind of learning mechanism, each individual forms an updated perceived (day-averaged) travel cost for each link/turn and arrival time interval. This information is used as a learning process to simulate the next day.

This stochastic process approach possesses a sound theoretical basis, and indeed has a number of advantages over its equilibrium counterpart. This theory establishes that under mild conditions after an initial transient period it represents the real day-to-day variability in road conditions that we all know exists. The separation of traveler behavior and traffic flow/congestion in the day-to-day approach is the key to the flexibility and range of assumptions that DRACULA may incorporate.

DRACULA is deal to model breakdowns or weather conditions having a severe effect on road capacity. It is able to model how drivers respond in terms of *en route* diversions, taking into account how the users weight their typical experience compared to extreme conditions. On the traffic flow side, second-by-second microsimulation using lane changing and gap acceptance models is the only feasible technique in existence for modeling severe queue spillback, the effect on the details of driver behavior, and the dynamic propagation of congestion backwards in the system.

2.2.4. MITSIM

Microscopic **T**raffic **Sim**ulator (MITSIM) is the microsimulator in the simulation package MITSIMLab, (MIT, 2006). MITSIMLab also includes a traffic management simulator used for simulation of traffic control and route guidance systems. MITSIMLab is developed at the ITS program at Massachusetts Institute of Technology, MIT (USA). MITSIM models the network on a microscopic level. Input data to MITSIM include OD matrices. A probabilistic route choice model is used to determine each individual vehicle’s path at each intersection. An alternative route choice model is also available; vehicles are assigned specified paths prior to the simulation. These two route choice models can be used separately or simultaneously during one simulation. MITSIM is designed to be used in the evaluation of traffic management systems.

MITSMLab is a synthesis of a number of different models and has the following characteristics:

- represents a wide range of traffic management system designs;
- models the response of drivers to real-time traffic information and controls; and

- incorporates the dynamic interaction between the traffic management system and the drivers on the network.

The various components of MITSIMLab are organized in three modules:

- Microscopic Traffic Simulator (MITSIM),
- Traffic Management Simulator (TMS), and
- Graphical User Interface (GUI).

A microscopic simulation approach, in which movements of individual vehicles are represented, is adopted for modeling traffic flow in the traffic flow simulator (MITSIM). This level of detail is necessary for an evaluation at the operational level. The Traffic Management Simulator (TMS) represents the candidate traffic control and routing logic under evaluation. The control and routing strategies generated by the traffic management module determine the status of the traffic control and route guidance devices. Drivers respond to the various traffic controls and guidance while interacting with each other.

2.2.5. Quadstone Paramics

PARAllel MICroscopic Simulation (Quadstone Paramics) is a microsimulation program developed by the Edinburgh Parallel Computing Center and Quadstone Ltd (UK) (Quadstone, 2004). It is a suite of software tools for microscopic traffic simulation where individual vehicles are modeled. The package includes the following different modules:

- Modeler- which develops the network;
- Analyzer- which outputs data and provides analysis; and
- Processor- which can be used to run simulations.

The Windows based package can handle up to 4 million links, 1 million nodes 32,000 zones and 1 million control points, and in reality there is no real limit to what can be modeled within the software depending on the hardware. The program works using a default 0.5 second time step; a random release of vehicles onto the network, and if the same random seed is set the results are repeatable. The random seed is used to determine the aggressiveness, awareness and variability of headways.

The Paramics software is portable and scaleable, allowing a unified approach to traffic modeling across the whole spectrum of network sizes, from single junctions up to national networks. Paramics claims to simulate the traffic impact of signals, ramp meters, loop detectors linked to variable speed signs, VMS and CMS signing strategies, in-vehicle network state display devices, and in-vehicle messages advising of network problems and re-routing suggestions. Vehicle re-routing in the face of ITS, is controlled through a user-definable behavioral rule language for maximum flexibility and adaptability.

Currently, development is underway in the following areas: detailed modeling of noise and exhaust pollution, multi-modal transportation simulation, traffic state determination from on-line vehicle counts, and provision of predictive traffic information for in-vehicle services.

2.2.6. SISTM

SImulation of **S**trategies for **T**raffic on **M**otorways (SISTM) has been designed to study motorway traffic in congested conditions with the aim of developing and evaluating different strategies for reducing congestion (Fox, 2005). The program is available from Transport Research Laboratory (TRL) in UK, or the Highway Agency, and current version of the program is version 5.

SISTM can assess:

- different motorway layouts (i.e., junction designs)
- variable speed limit systems

- ramp metering systems
- modified vehicle characteristics
- modified driver behavior

It has been developed for the UK Highways Agencies, but is available to anyone requiring the modeling of motorways. It is a microscopic motorway simulation with a car-following algorithm that uses a modified Gipps' equation. Driver behavior is described by two parameters; aggressiveness and awareness; these are used to produce distributions of desired speed and indirectly desired headway. The time increment used is 5/8th second. Lane changing is controlled through a lane changing stimulus with the user specifying the desire to change lanes. When making a lane changing maneuver, a driver is allowed to accept an "unsafe" headway temporarily. This is to allow smooth merging to take place when a driver has to move into a particular lane.

Useful technical features:

- Network size
    - 99 km of unidirectional motorway with 9 entry and 9 exit slip roads. Four thousand (4,000) vehicles being modeled at any instant.
- Network details
    - Motorway geometry to an accuracy of 1 meter, and ghost islands at merges can be modeled. Gradients can be modeled, but bends cannot. Narrow lanes cannot be modeled. Up to 6 main carriageway lanes and 3 slip road lanes.
- Vehicle representation
    - Up to 8 vehicle types, with different lengths, desired speed, distributions for drivers' acceleration and braking rates.

- Vehicle assignment
    - User must supply an O/D matrix which specifies the flows from each entry slip road to each exit slip road.
- Control strategies and algorithms
    - VMS, Variable speed limits and ramp metering are all internal to the model.
- User interface
    - The user can choose to edit text files or use specially written data entry programs. Graphical representation of vehicles as they are being modeled.

2.2.7. VISSIM

German for Traffic in Towns – Simulation (VISSIM) has the ability of model transit and traffic flow in urban areas as well as interurban motorways on a microscopic level. It is a product with continuous add-ons provided by research institutions. VISSIM is a microsimulation program developed at the University of Karlsruhe, Germany during the early 1970s (Bloomberg and Dale, 2000).

VISSIM results are used to define optimal vehicle actuated signal control strategies, test various layouts and lane allocations of complex intersections, test the location of bus bays, test the feasibility of complex transit stops, test the feasibility of toll plazas, and find appropriate lane allocations of weaving sections on motorways. VISSIM is coupled with micro-scale decentralized controllers of various signal control manufacturers to test their control strategies in detail before they are implemented. VISSIM is a multipurpose simulator aimed for technical staff at cities responsible for signal control, transit operators, city planners and researchers to evaluate the influence of new control and vehicle technologies.

The traffic flow model of VISSIM is a discrete, stochastic, time step based microscopic model, with driver-vehicle-units as single entities. The model contains a psycho-physical car-following model for longitudinal vehicle movement, and a rule-based algorithm for lane changing (lateral movements). The model is based on the continuous work of Wiedemann at the University of Karlsruhe, and further calibrated and validated by PTV AG (Planung Transport Verkehr AG). Vehicles follow each other in an oscillating process. As faster a vehicle approaches a slower vehicle on a single lane, it has to decelerate. The action point of conscious reaction depends on the speed difference, distance and driver dependent behavior. On multi-lane links, vehicles check whether they improve their speed by changing lanes. If so, they seek acceptable gaps on neighboring lanes. Car-following and lane changing together form the traffic flow model, being the kernel of VISSIM.

Technical features:

- Network size
  - The network size is not limited by the software but for practical reasons of current hardware the usual applications run to about 4 to 30 intersections simulated in one model. The computation time corresponds closely with the number of vehicles in the network at the same time. When increasing traffic flow the computation time can exceed real-time. The number of links is of no meaning to VISSIM since, it depends mainly on the level of detail complex junctions with varying lanes can be modeled.
- Network details
  - VISSIM models intersections, motorway interchanges, transit stops etc. in every detail.

- Vehicle representation
  - Default values for acceleration, maximum speed and desired speed distributions are given but can be changed by the user to reflect local traffic conditions. Various car types, truck types, trams, buses and pedestrians can be defined.
- Vehicle assignment
  - VISSIM uses the paths generated by assignment models. A route choice model will be included in the near future.
- Control strategies and algorithms
  - VISSIM itself includes first the traffic flow model and secondly the signal control model. The traffic flow model is the master program which sends second by second detector values to the signal control program (slave). The signal control uses the detector values to decide on the current signal aspects. An open interface allows VISSIM to couple with research type control strategies and various fuzzy based algorithms were tested using VISSIM.
- User Interface
  - Data such as network definition of roads and tracks, technical vehicle and behavioral driver specifications, car volumes and paths, transit routes and schedule are entered graphically and through dialogue boxes under Windows. Signal control depends on the strategy and controller type used. VISSIM includes a flow charter under Windows to describe own local controller logics (Fox, 2005). A more detailed description is presented in the next Chapter.

2.3. Car-following Behavior

A traffic microsimulation model consists of sub-models that describe human driver behavior. Important behavior models include; gap-acceptance, speed adaptation, lane-changing, and car-following.

The gap-acceptance model determines minimum acceptable distances to surrounding vehicles in the context of intersections and merging situations. The Speed adaptation model refers to the adaptation to the road design speed in the network for a vehicle’s current position. The Lane-changing models describe drivers’ behavior when deciding whether to change lanes or not on a multi-lane road link, e.g. when traveling on a motorway. The car-following model describes the interactions with preceding vehicles in the same lane. In this section fully detailed description of the car-following model and commonly classifications are mentioned.

A car-following model controls driver’s behavior with respect to the preceding vehicle in the same lane. A vehicle is classified as a follower when it is constrained by a preceding vehicle, such that if driven at the desired speed will lead to a collision. When a vehicle is not constrained by another vehicle it is considered free and travels, in general, at its desired speed. The follower’s actions are commonly specified through the follower’s acceleration, although some models, for example the car-following model developed by Gipps (1981), specify the follower’s actions through the follower’s speed. Some car-following models only describe drivers’ behavior when actually following another vehicle, whereas other models are more complete and determine the behavior in all situations.

A car-following model should represent both in which regime or state a vehicle is in and what actions it applies in each state. Most car-following models use several regimes to describe the follower's behavior. A common setup is to use three regimes: one for free driving, one for normal following, and one for emergency deceleration.

Vehicles in the free regime are unconstrained and try to achieve their desired speed; vehicles in the following regime adjust their speed with respect to vehicle in front of it (leader); vehicles in the emergency deceleration regime decelerate to avoid a collision.

Car-following model notation:

a_n : Acceleration, vehicle *n*, [m/s^2]

x_n : Position, vehicle *n*, [m]

v_n : Speed, vehicle *n*, [m/s]

Δ_x : $x_{n-1} - x_n$, space headway, [m]

Δ_v : $v_n - v_{n-1}$, difference in speed, [m/s]

$v_n^{desired}$: Desired speed, vehicle *n*, [m/s]

L_{n-1} : Length, vehicle *n-1*, [m]

s_{n-1} : Effective length (L_{n-1} + minimum clearance between stationary vehicles), vehicle *n-1*, [m]

T : Reaction time, [s]

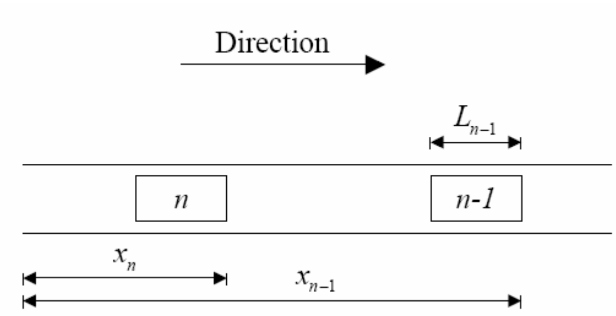

Figure 2.1 Car-following notation.

Car-following models are commonly classified into classes depending on the logic used. Such model classes include:

- Gazis-Herman-Rothery models (GHR): states that the following vehicle's acceleration is proportional to the speed of the follower, the speed difference between follower and leader and the space headway.
- Safety-distance models: are based on the assumption that the follower always keeps a safe distance to the vehicle in front.
- Psycho-physical car-following models: uses thresholds for example, the minimum speed difference between follower and leader perceived by the follower.

The car-following model of AIMSUN is a safety distance model. MITSIM's car-following model uses GHR logic and the Fritzsche (Paramics) model. The model incorporated in VISSIM can be classified as a psycho-physical model. The most important property of the car-following models used in such applications is their ability to produce representative macroscopic traffic measures (Janson and Tapani, 2004).

2.3.1. AIMSUN

The AIMSUN car-following model is a safety distance model based on the Gipps's model (1981). Vehicles are classified as free or constrained by the vehicle in front in Gipps car-following model. The follower tries to adjust its speed to obtain a safe space headway with respect to its leader when the vehicle is constrained in front. If it is possible, a specific headway is safe to perform, a follower response to any reasonable leader action without colliding with the leader. The vehicle's speed is constrained by its free desired speed and its maximum acceleration. The AIMSUN's notations used in the description of acceleration model are:

a_n^{max} Maximum desired acceleration, vehicle n, [2.5 m/s^2]

$d_n^{\max}$ Maximum desired deceleration, vehicle *n*, [2 m/s^2]

$\hat{d}_{n-1}$ Estimation of maximum deceleration desired by vehicle *n-1*, [m/s^2]

T Reaction time step, [0.7 s]

v_n^a Maximum speed a vehicle can accelerate to, vehicle *n*, [m/s]

v_n^b Vehicle maximum safe speed, vehicle *n*, [m/s]

The speed during the time interval [*t*, *t*+*T*], is chosen as:

$$V(t+T) = \min\{v_n^a(t+T), v_n^b(t+T)\} \quad \textbf{Equation 2-1}$$

The maximum speed a vehicle can accelerate to during one time step is given by:

$$v_n^a(t+T) = v_n(t) + 2.5.a_n^{\max}.T.\left(1 - \frac{v_n(t)}{v_n^{desired}}\right)\sqrt{0.025 + \frac{v_n(t)}{v_n^{desired}}} \quad \textbf{Equation 2-2}$$

The vehicle *n* maximum safe speed with respect to the vehicle in front at time *t* is calculated as:

$$v_n^b(t+T) = d_n^{\max} \cdot T + \sqrt{\left(d_n^{\max} \cdot T\right)^2 - d_n^{\max}\left[2\{x_{n-1}(t) - s_{n-1} - x_n(t)\} - v_n(t) \cdot T - \frac{v_{n-1}(t)^2}{\hat{d}_{n-1}}\right]} \quad \textbf{Equation 2-3}$$

The vehicle effective length, s_{n-1}, consists of the vehicles length and the user specified parameter min distance between vehicles. There are two ways for the follower to guess the leader's desired deceleration. The first way assumes the driver can estimate the leader's deceleration, as a result, the estimation will be equal to the leader's desired deceleration, d_{n-1}, that is:

$$\hat{d}_{n-1} = d_{n-1}. \quad \textbf{Equation 2-4}$$

The second way is to calculate the leader's desired deceleration as the average of the leader's and the follower's desired decelerations:

$$\hat{d}_{n-1} = \frac{d_n + d_{n-1}}{2}.$$ **Equation 2-5**

2.3.2. MITSIM

The MITSIM car-following model incorporates three regimes with different follower behavior; free driving, following and emergency deceleration. The behavior in the following regime is based on an unsymmetrical GHR model. The follower's time headway to the vehicle in front determines which regime the follower belongs to.

In addition, the vehicle is not constrained by the vehicle in front, if the time headway is larger than a threshold h_{upper}. The vehicle free driving regime accelerates to obtain its desired speed. The vehicle is in the car-following mode, if the time headway is between h_{upper} and another threshold h_{lower}. The difference in speed determines the acceleration rate, and the front to rear distance of the vehicle and the vehicle in front. The time headway should be smaller than h_{lower} then the vehicle is too close to the vehicle in front, and emergency decelerates to extend the headway. The MITSIM notations used in the model description are:

h_{upper} Maximum following time headway, [1.36 s]

h_{lower} Minimum following time headway, [0.5 s]

α^{+} Car-following parameters acceleration, [2.15]

β^{+} Car-following parameters acceleration, [-1.67]

γ^{+} Car-following parameters acceleration, [-0.89]

α^{-} Car-following parameters deceleration, [1.55]

β^{-} Car-following parameters deceleration, [1.08]

γ^{-} Car-following parameters deceleration, [1.65]

a_n^+ Maximum acceleration rate, vehicle n [m/s^2]

a_n^- Normal deceleration rate, vehicle n [m/s^2]

The vehicle's behavior in the different regimes is as follows:

Free driving:

In this regime the vehicles intention is to achieve its current desired speed. The vehicle uses the normal deceleration rate to slow down to the desired speed, if the current speed is higher than the desired speed. In other hand, if the speed is lower than the desired speed, the vehicle uses its maximum acceleration rate to reach the desired speed faster. The normal deceleration and maximum acceleration rates are parameters, which are functions of vehicle type and the current speed. The acceleration rate of vehicle may be expressed as:

$$a_n = \begin{cases} a_n^+ & v_n < v_n^{desired} \\ 0 & v_n = v_n^{desired} \\ a_n^- & v_n > v_n^{desired} \end{cases}, \qquad \textbf{Equation 2-6}$$

where a_n^+ is the maximum acceleration rate, and a_n^- is the normal deceleration rate, both measured in m/s^2.

Car-following:

The acceleration rate of vehicle n in the car-following regime, a_n, is given by an unsymmetrical Gazis-Herman-Rothery (GHR) model. The acceleration is calculated as:

$$a_n = \alpha^{\pm} \frac{v_n^{\beta^{\pm}}}{\left(x_{n-1} - l_{n-1} - x_n\right)^{\gamma^{\pm}}} \left(v_{n-1} - v_n\right), \qquad \textbf{Equation 2-7}$$

where $\alpha^{\pm}$, $\beta^{\pm}$ and $\gamma^{\pm}$ are model parameters. The parameters α^+, β^+ and γ^+ are used if $v_n \leq v_{n-1}$ and α^-, β^- and γ^- if $v_n > v_{n-1}$.

Emergency:

In this regime the vehicle uses a deceleration rate to prevent collision and extend the headway. This deceleration rate is given by

$$a_n = \begin{cases} \min\left\{a_n^-, a_{n-1} - 0.5\left(v_n - v_{n-1}\right)^2 / \left(x_{n-1} - L_{n-1} - x_n\right)\right\} & v_n > v_{n-1} \\ \min\left\{a_n^-, a_{n-1} + 0.25 a_n^-\right\} & v_n \le v_{n-1} \end{cases}. \qquad \textbf{Equation 2-8}$$

2.3.3. Fritzsche (Paramics)

The Paramics's acceleration model is based on the psycho-physical model developed by Fritzsche (1994). The Fritzsche model accounts for human perception in the definitions of the model regimes. For example, speed differences have to be of certain magnitude to be perceived by the driver. The Fritzsche notations used in its thresholds are:

k_{PTN}	Calibration parameter, [0.002]
k_{PTP}	Calibration parameter, [0.001]
f_x	Calibration parameter, [0.5]
T_D	Desired time gap, [1.8 s]
T_r	Risky time gap, [0.5 s]
T_s	Safe time gap, [1 s]
Δb_m	Deceleration parameter, [0.4 m/s^2]
b_{null}	Acceleration parameter, [0.2 m/s^2]
s_{n-1}	Effective length, vehicle *n*-1, [6 m]
a_n^+	Normal acceleration rate, [2 m/s^2]

Thresholds for perception of, negative (*PTN*) and positive (*PTP*), speed differences are defined as:

$$PTN = -k_{PTN}\left(\Delta x - s_{n-1}\right)^2 - f_x \quad and \\ PTP = k_{PTP}\left(\Delta x - s_{n-1}\right)^2 - f_x ,$$ **Equation 2-9**

where k_{PTN}, k_{PTP} and f_x are model parameters. The differences in speed below the thresholds *PTN* and *PTP* is not perceive by the follower. Drivers observe smaller negative speed differences than positive, thus *PTN* is smaller than *PTP*.

Fritzsche model incorporates four thresholds for the follower's space headway to its leader:

- Desired distance, *AD:* expresses the gap drivers' wish to maintain to the vehicle in front and is defined as:

  $$AD = s_{n-1} + T_D \cdot v_n ,$$ **Equation 2-10**

  where T_D is a parameter representing the desired time gap.

- Risky distance, *AR*: the distance keeping behavior gives rise to another distance threshold defined as:

  $$AR = s_{n-1} + T_r \cdot v_{n-1},$$ **Equation 2-11**

  where T_r is the risky time gap. For gaps smaller than or equal to the risky distance drivers decelerate heavily to avoid collisions.

- Safe distance, *AS*: defines the smallest headway where positive acceleration is accepted as the distance increment between follower and leader. The safe distance is calculated as:

  $$AS = s_{n-1} + T_s \cdot v_n ,$$ **Equation 2-12**

  where T_s is a model parameter.

- Braking distance, *AB*: the vehicle's maximum deceleration is possible when a collision occurs if the initial speed difference between two vehicles is large. To prevent such collisions, the braking distance is defined as:

$$AB = AR + \frac{\Delta v^2}{\Delta b_m}, \qquad \textbf{Equation 2-13}$$

where Δb_m is given by:

$$\Delta b_m = |b_{\min}| + a_{n-1}^{-}. \qquad \textbf{Equation 2-14}$$

The equation, $b_{\min}$ and a_{n-1}^{-} are model parameters controlling maximum deceleration.

Finally, the time gap parameters, T_D , T_r and T_s satisfy:

$$T_D > T_s > T_r \qquad \textbf{Equation 2-15}$$

The thresholds given above define the following regimes in the phase-space relative speed – relative position for a car-following pair (see Figure 2.2):

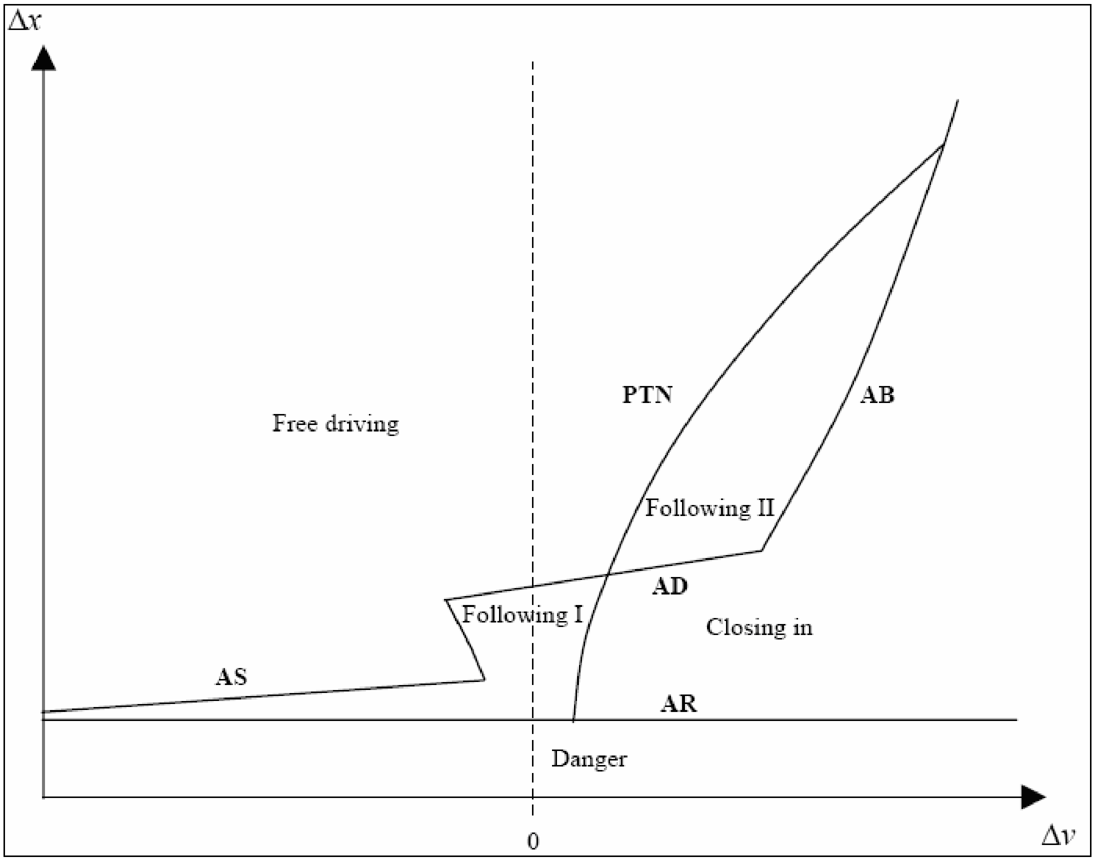

Figure 2.2 Different thresholds and regimes in the Fritzsche car-following model.

The vehicle's behavior in the different regimes is described below:

- Danger: the distance to the leading vehicle is smaller than the risky distance *AR*. The follower uses its maximum deceleration, *b* to extend the headway.
- Closing in: the speed difference is larger than *PTN* and the space headway is between *AB* or *AD* and *AR*. The follower decelerates to obtain the vehicle's speed in front. The deceleration rate is taken so that the leader's speed will be obtained when the space headway equals the risky distance (*AR*). The following expression is used for the acceleration of vehicle *n* (Saldaña and Tabares, 2000):

$$a_n = \frac{\left(v_{n-1}^2 - v_n^2\right)}{2d_c}, \qquad \textbf{Equation 2-16}$$

where d_c is the constraint distance given by:

$$d_c = x_{n-1} - x_n - AR + v_{n-1}\Delta t, \quad \textbf{Equation 2-17}$$

where Δt is the simulation time step.

- Following: if the speed difference is between *PTN* and *PTP*, the follower takes no conscious action, or there is a space headway between *AR* and *AD* or speed difference larger than *PTP*, and space headway between *AS* and *AR*. A parameter b_{null} is used to model driver's inability to maintain constant speed. When a vehicle passes into the following regime, passing the *PTN* threshold it is assigned the acceleration rate $-b_{null}$, and when passing the thresholds *PTP* or *AD* it is assigned the acceleration b_{null}.
- Following II: speed difference is larger than *PTN* or there is space headway larger than *AB* or *AD*. The driver has noticed that is closing in on the vehicle in front, and the space headway is too large for any action to be necessary.
- Free driving: speed difference is smaller than *PTN* and space headway is larger than *AD* or positive speed difference is larger than *PT*, and space headway larger than *AS*. The follower accelerates in order to achieve the desired speed with a normal acceleration rate. When driving at the desired speed, a parameter b_{null} is used to model driver's inability to maintain constant speed.

2.3.4. VISSIM

VISSIM incorporate a car-following model based on the psycho-physical model suggested by Wiedemann. (Planung Transport Verkehr AG, 2003) The model was first presented in 1974 (Wiedemann, 1974) and has been continuously enhanced since then.

The model is of similar fashion as the Fritzsche model constituted by thresholds that form regimes. Figure 2.3 displays the thresholds and regimes in the relative speed relative position space. The threshold definitions presented are taken from Wiedemann and Reiter (1992). The developer of VISSIM, PTV, refers to Wiedemann and Reiter (1992) for a complete listening of the random numbers used in the model. The exact difference between the car-following models used in VISSIM and Wiedemann and Reiter (1992) is not publicly known.

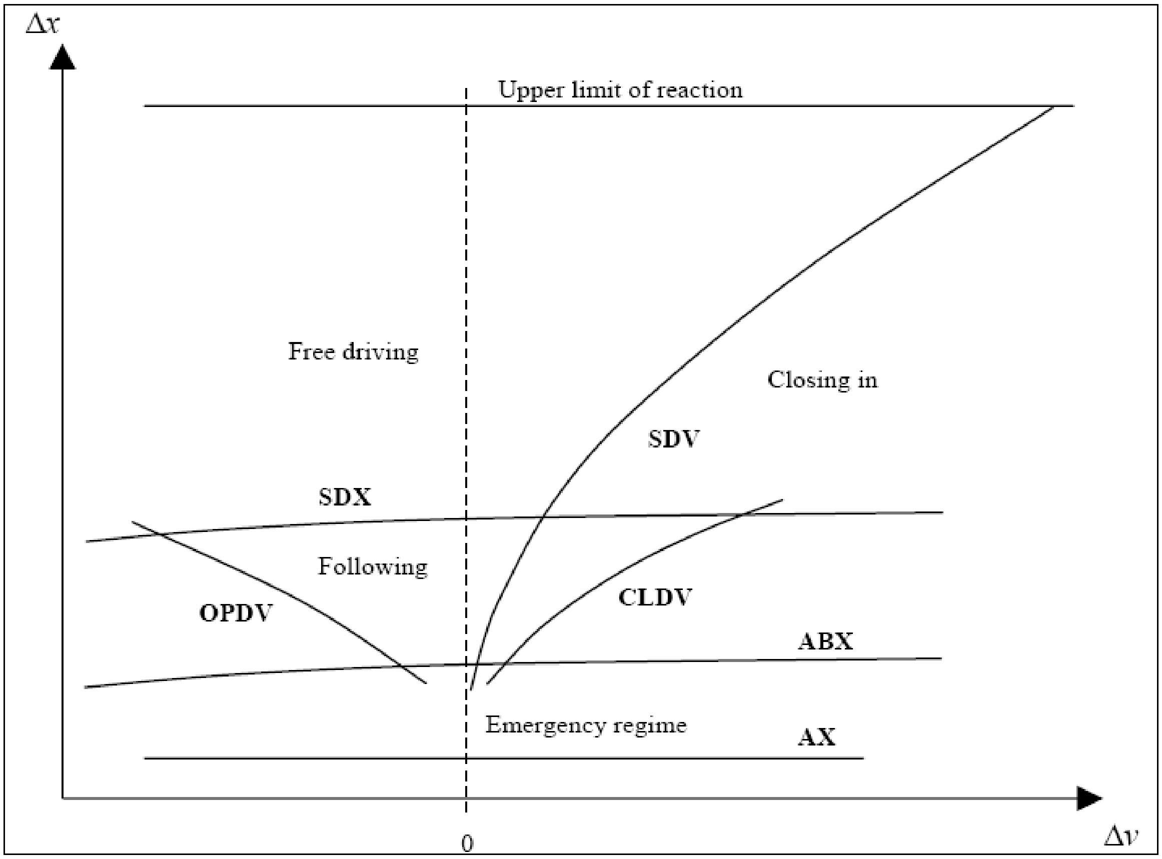

Figure 2.3 Different thresholds and regimes in the Wiedemann car-following model.

- The desired distance between stationary vehicles, AX
  - This threshold consists of the length of the front vehicle and the desired front-to-rear distance and is defined as:

$$AX = L_{n-1} + AXadd + RND1_n \cdot AXmult, \qquad \textbf{Equation 2-18}$$

where *AXadd* and *AXmult* are calibration parameters. $RND1_n$ is a normally distributed driver dependent parameter.

- The desired minimum following distance at low speed differences, ABX.
  - It is calculated as:

$$ABX = AX + BX \text{ with } BX = \left(BXadd + BXmult \cdot RDN1_n\right) \cdot \sqrt{v}, \qquad \textbf{Equation 2-19}$$

    where *BXadd* and *BXmult* are calibration parameters. The speed v is defined as:

$$v = \begin{cases} v_{n-1} & for \quad v_n > v_{n-1} \\ v_n & for \quad v_n \le v_{n-1} \end{cases}. \qquad \textbf{Equation 2-20}$$

- The acceleration or deceleration rate, b_{null},
  - It is defined as:

$$b_{null} = BNULLmult \cdot \left(RND4_n + NRND\right) \qquad \textbf{Equation 2-21}$$

    where *BNULLmult* is a calibration parameter. $RND4_n$ is a normally distributed driver parameter, and *NRND* is a normally distributed random number.

- The maximum following distance, *SDX*.
  - This distance varies between 1.5 and 2.5 times the minimum following distance, *ABX*, (PTV). SDX is defined as:

$$SDX = AX + EX \cdot BX \text{ with } EX = EXadd + EXmult \cdot \left(NRND - RND2_n\right), \qquad \textbf{Equation 2-22}$$

    where *EXadd* and *EXmult* are calibration parameters. *NRND* is a normally distributed random number, and $RND2_n$ is a normally distributed driver dependent parameter.

- Approaching point, SDV
  - This is used to describe the point where the driver notices that he or she approaches a slower vehicle. *SDV* is defined as:

$$SDV = \left(\frac{\Delta x - L_{n-1} - AX}{CX} \right)^2 \text{ with} \qquad \textbf{Equation 2-23}$$

$$CX = CXconst \cdot \left(CXadd + CXmult \cdot \left(RND1_n + RND2_n \right) \right) \qquad \textbf{Equation 2-24}$$

where *CXconst*, *CXadd* and *CXmult* are calibration parameters.

- Decreasing speed difference, *CLDV*. Wiedemann and Reiter (1992) includes another threshold similar to *SDV*, to model perception of small speed differences at short, decreasing distances. In VISSIM this threshold is ignored, and *CLDV* is simply assumed to be equal to SDV, (PTV).
- Increasing speed difference, OPDV. This threshold describes the point where the driver observes that he or she is traveling at a lower speed than the leader. This threshold is defined as:

$$OPDV = CLDV \cdot \left(-OPDVadd - OPDmult \cdot NRND \right) \qquad \textbf{Equation 2-25}$$

where *OPDVadd* and *OPDVmult* are calibration parameters. *NRND* is a normally distributed random number.

The thresholds above give rise to the following car-following regimes:

- Following
    - The thresholds *SDV*, *SDX*, *OPDV* and *ABX* constitute the following regime. In order to account for inexact handling of the throttle, vehicles acceleration rate is assumed to always be separated from zero at all times. When a vehicle passes into the following regime, passing either the *SDV* or the *ABX* threshold; it is assigned the acceleration rate $-b_{null}$ and when passing the thresholds *OPDV* or *SDX*, it is assigned the acceleration b_{null}.

      The acceleration or deceleration rate, b_{null}, is defined as:

$$b_{null} = BNULLmult \cdot \left(RND4_n + NRND \right) \qquad \textbf{Equation 2-26}$$

where *BNULLmult* is a calibration parameter. $RND4_n$ is a normally distributed driver parameter, and *NRND* is a normally distributed random number.

- Free driving
  - The vehicle is located above all thresholds in the phase diagram, shown in Figure 2.3, and travels uninfluenced of the surrounding traffic. The vehicle uses its maximum acceleration to reach its desired speed; inexact handling of the throttle is modeled by assigning an acceleration of $-b_{null}$ or b_{null} to the vehicle. The maximum acceleration, b_{max} , for passenger cars is defined as:

$$b_{\max} = BMAXmult \cdot \left(v_{\max} - v \cdot FaktorV \right) \text{ with} \qquad \textbf{Equation 2-27}$$

$$FaktorV = \frac{v_{\max}}{v_{des} + FAKTORVmult \cdot \left(v_{\max} - v_{des} \right)} \qquad \textbf{Equation 2-28}$$

where $v_{\max}$ is the vehicles maximum speed. *FAKTORVmult* is a calibration parameter.

- Closing in
  - When passing the *SDV* threshold, the driver notices that he or she is approaching a slower vehicle. The driver decelerates in order to avoid collisions. The following deceleration rate is used:

$$b_n = \frac{1}{2} \cdot \frac{\left(\Delta v \right)^2}{ABX - \left(\Delta x - L_{n-1} \right)} + b_{n-1}, \qquad \textbf{Equation 2-29}$$

where is the deceleration of the leader.

- Emergency regime

- When the front to rear distance is smaller than *ABX* the follower adopt, if necessary, the following deceleration to avoid collision with the vehicle in front:

  $$b_n = \frac{1}{2} \cdot \frac{(\Delta v)^2}{ABX - (\Delta x - L_{n-1})} + b_{n-1} + b_{\min} \cdot \frac{ABX - (\Delta x - L_{n-1})}{BX}, \quad \textbf{Equation 2-30}$$

  The vehicle's maximum deceleration rate, $b_{\min}$, is calculated as:

  $$b_{\min} = -BMINadd - BMINmult \cdot RND3_n + BMINmult \cdot v_n, \quad \textbf{Equation 2-31}$$

  where *BMINadd* and *BMINmult* are calibration parameters. $RND3_n$ is a normally distributed driver parameter.

This chapter provided a detailed explanation of microsimulation models available in the market. It explained some of the existing models, and discussed the car following behaviors that they use. The next Chapter gives a description of the programs been used in this research: VISSIM and aaSIDRA.

Chapter 3 Program Description

This Chapter presents a detailed description of the microsimulation model VISSIM and at the same time a description of the model aaSIDRA which is mainly used by engineers for evaluating and designing various types of intersections.

3.1. VISSIM

The VISSIM simulation model was developed at the University of Karlsruhe in Germany during the 1970s. VISSIM is a stochastic microscopic simulation model capable of simulating traffic operations in urban areas with emphasis on public transportation and/or multi-modal transportation; represents the network characteristics in 3D animation including pedestrian and public transportation. Users can construct networks using background images in BMP format, which can be easily generated from CAD programs and aerial photographs.

VISSIM is different from the typical microscopic simulation models. The main difference of VISSIM from those models is the independence from a node-link structure; VISSIM networks are based on links and connectors. The models based on a node-link structure are the ones where vehicles arrive to a node, need an upstream or downstream node above or below to continue its trajectory. In VISSIM, the vehicles arrive to the end of the links, and in the end of the link each vehicle decides to take a connector that allows it to arrive to its final destination. It is able to construct complex intersections representing the actual network conditions as a replacement for computer generated connections.

The VISSIM's abilities include:

- realistic representation of traffic flow of cars, trucks, buses, and light rail systems,
- implementation of a psycho-physical car-following model, and thus, provides a very realistic driving behavior,

- integrated operation of surface street system and freeway system,
- an opportunity to simulate, visualize, and analyze access management issues and strategies,
- assessment of traffic operations along many different types of roadway network parameters,
- excellent graphical capabilities and its ability to model roundabouts,
- the development and analysis of operational strategies for a single-guideway alignment, and
- visualizes safety and operational issues and strategies related to the lack of access management.

The simulation system VISSIM consists of two separate programs. The first program is the traffic flow model, the second the signal control model. VISSIM is the master program which sends second by second detector values to the signal control program to decide the current signal aspects. VISSIM receives the signal aspects and the next iteration of traffic-flow starts. The simulation is microscopic (vehicle by vehicle, and second to second analyses) and stochastic (non-deterministic state behavior of an environment where is not fully determined by the previous state). The result of the simulation is an online animation of the traffic flow and offline reports of travel time, and waiting time distributions. Figure 3.1 presents the system architecture of VISSIM.

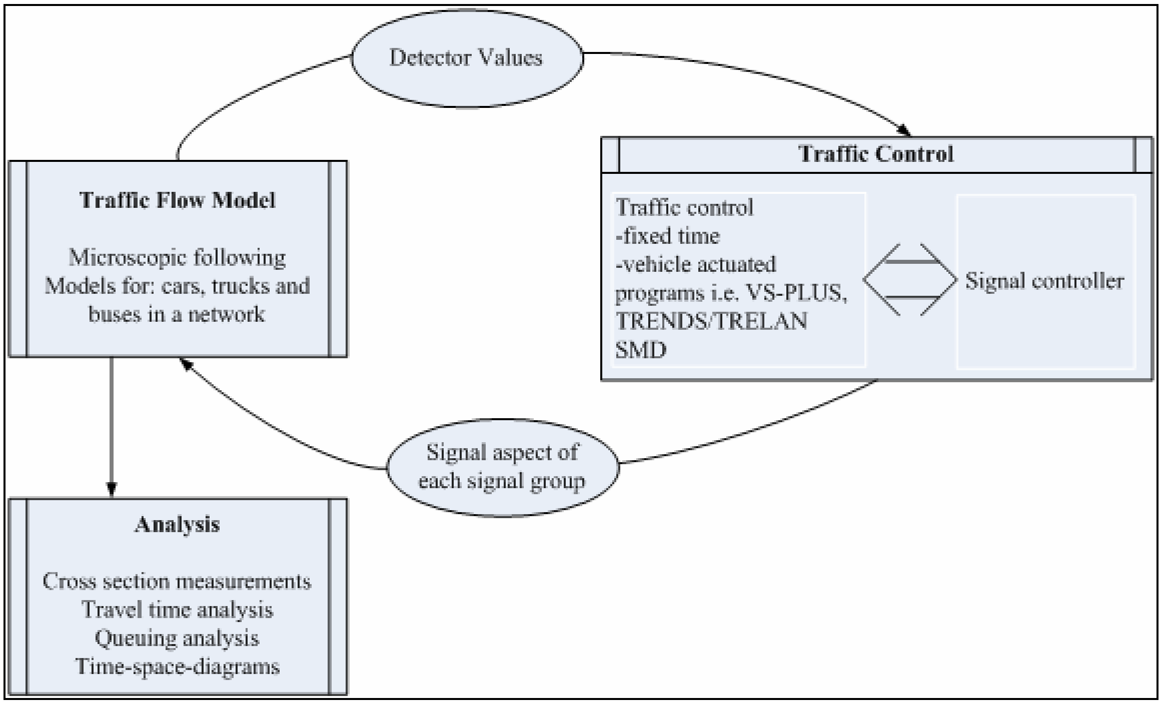

Figure 3.1 Communication between traffic simulator and signal state generator

The car-following and the lane-changing models are part of this software. The car-following model (also called spacing-model) describes the movement of a vehicle whose driver wants to drive faster than the present speed of the preceding vehicle. If more than one lane is available vehicles tends to overtake which is modeled in the lane-changing algorithm; instead of a deterministic car-following model VISSIM uses the psycho-physical model that is presented in Figure 3.2. A faster moving vehicle starts to decelerate as it reaches its individual perception threshold to a slower moving vehicle. It cannot exactly determine the speed of that vehicle; its speed will fall below that vehicle's speed until it starts to slightly accelerate again after reaching another perception threshold. The action point of conscious reaction depends on the speed difference, distance and driver behavior. This results in an iterative process of acceleration and deceleration (VISSIM User Manual).

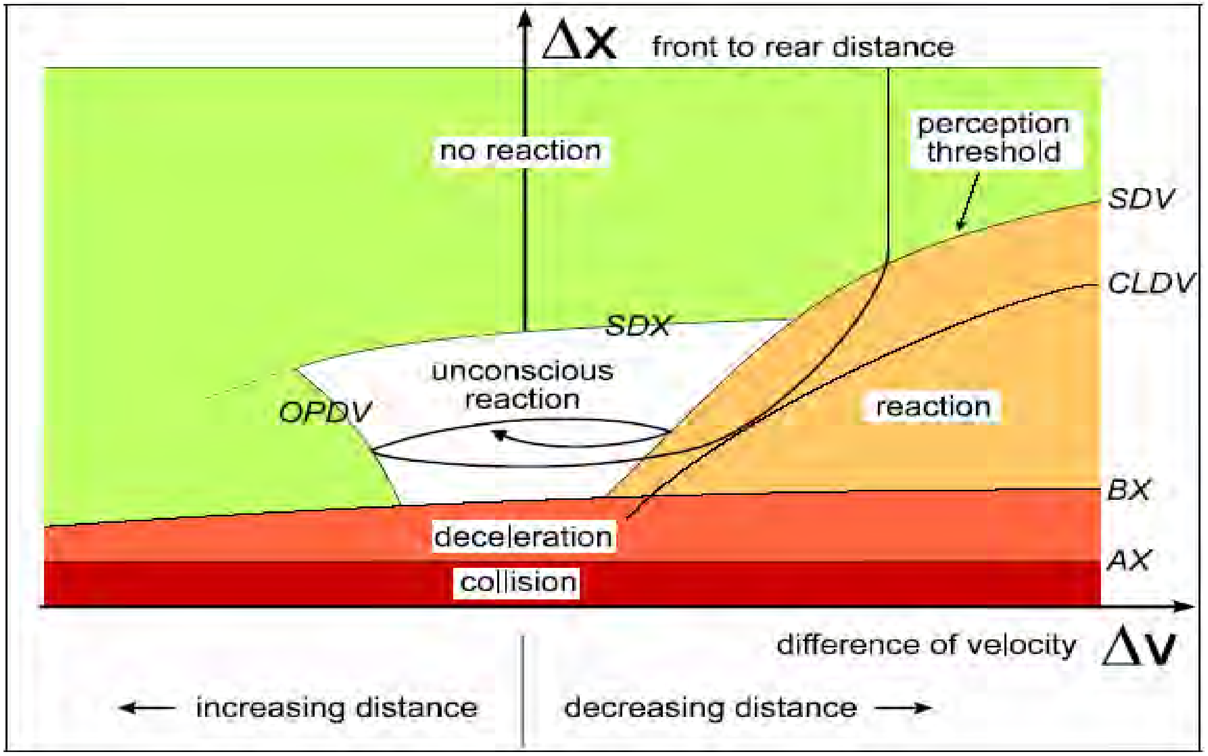

Figure 3.2 Car-following logic (Wiedemann 1974)
Source: VISSIM User Manual – Version 4

Figure 3.2 presents the oscillating process of this approach. Driver specific perception abilities and individual risk behavior is modeled by adding random values to each of the parameters as shown for AX. The thresholds shown in abbreviated form in Figure 3.2 are explained below.

AX: Desired distance between the fronts of two successive vehicles in a standing queue.

BX: Desired minimum following distance at low speed difference.

SDV: Action point where a driver consciously observes that she approaches a slower car in front. SDV increases with increasing speed differences (Δv).

OPDV: Action point where the following driver notices that she is slower than the leading vehicle and starts to accelerate again.

SDX: Perception threshold to model the maximum following distance which is about 1.5 - 2.5 times BX.

CLDV: Decreasing speed difference.

The model includes a rule for exceeding the maximum deceleration rate in case of emergency. This happens if BX is exceeded. The values of the thresholds depend on the present speed of the vehicle (Fellendorf and Hoyer, 1997).

3.2. aaSIDRA

The aaSIDRA, or aaTraffic SIDRA (Signalized & unsignalized Intersection Design and Research Aid) software is for use as an aid for design and evaluation of the following intersection types:

- signalized intersections (fixed-time / pre-timed and actuated),
- roundabouts,
- two-way stop sign control,
- all-way stop sign control, and
- give-way (yield) sign-control.

aaSIDRA uses detailed analytical traffic models coupled with an iterative approximation method to provide estimates of capacity and performance statistics (delay, queue length, stop rate, etc). Although, aaSIDRA is a single intersection analysis package, the analyst performs traffic signal analysis as an isolated intersection (default) or as a coordinated intersection by specifying platoon arrival data.

aaSIDRA is compatible with the US Highway Capacity Manual (HCM) and can be calibrated for local conditions. The HCM version of aaSIDRA does not claim to be a simple replication of the HCM procedures. This means that generally (for all types of intersection), aaSIDRA uses more advanced models and methods, including lane by lane analysis rather than analysis by lane groups, modeling of short lanes, among others.

aaSIDRA can be used to:

- obtain estimates of capacity and performance characteristics such as delay, queue length, stop rate, as well as, operating cost, fuel consumption, and pollutant emissions for all intersection types
- analyze many design alternatives to optimize the intersection geometry, signal phasing and timings specifying different strategies for optimization
- handle intersections with up to eight (8) legs, each with one-way or two-way traffic, one-lane or multi- lane approaches, and short lanes, slip lanes, continuous lanes, and prohibit turns as relevant
- determine signal timings (fixed-time / pretimed and actuated) for any intersection geometry allowing for simple, as well as complex phasing arrangements
- carry out a design life analysis to assess impact of traffic growth
- carry out a parameter sensitivity analysis for optimization, evaluation, and geometric design purposes
- design intersection geometry including lane use arrangements taking advantage of the unique lane-by-lane analysis method of aaSIDRA
- design short lane lengths (turn bays, lanes with parking upstream, and loss of a lane at the exit side)
- analyze effects of heavy vehicles on intersection performance
- analyze complicated cases of shared lanes, and opposed turns (e.g. permissive and protected phases, slip lanes, turns on red)

- analyze oversaturated conditions making use of aaSIDRA's time-dependent delay, queue length, and stop rate formulae.

In using aaSIDRA, the analyst is able to:

- prepare data, and inspect output with ease due to the graphical nature of aaSIDRA input and output
- obtain output including capacity, timing and performance results reported for individual lanes, individual movements (or lane groups), movement groupings (such as vehicles and pedestrians), and for the intersection as a whole
- control the amount of output by selecting individual output tables, with options for summary and full output
- reports, data, and results in picture and graphs form
- carry out sensitivity analyses to evaluate the impact of changes on parameters representing intersection geometry and driver behavior
- calculate annual sums of statistics such as operating cost, fuel consumption, emissions, total person delay, stops and so on, and present demonstrate benefits of alternative intersection treatments in a more powerful way
- compare alternative (gap-acceptance and "empirical") capacity estimation methods for roundabouts
- calibrate the parameters of the operating cost model for your local conditions allowing for factors such as the value of time and resource cost of fuel.

aaSIDRA is mainly a macroscopic model Windows program having data processing, computational and graphical display routines, and input module RIDES. The operation of the aaSIDRA system is shown in Figure 3.3 (Akcelik et. al., 2002).

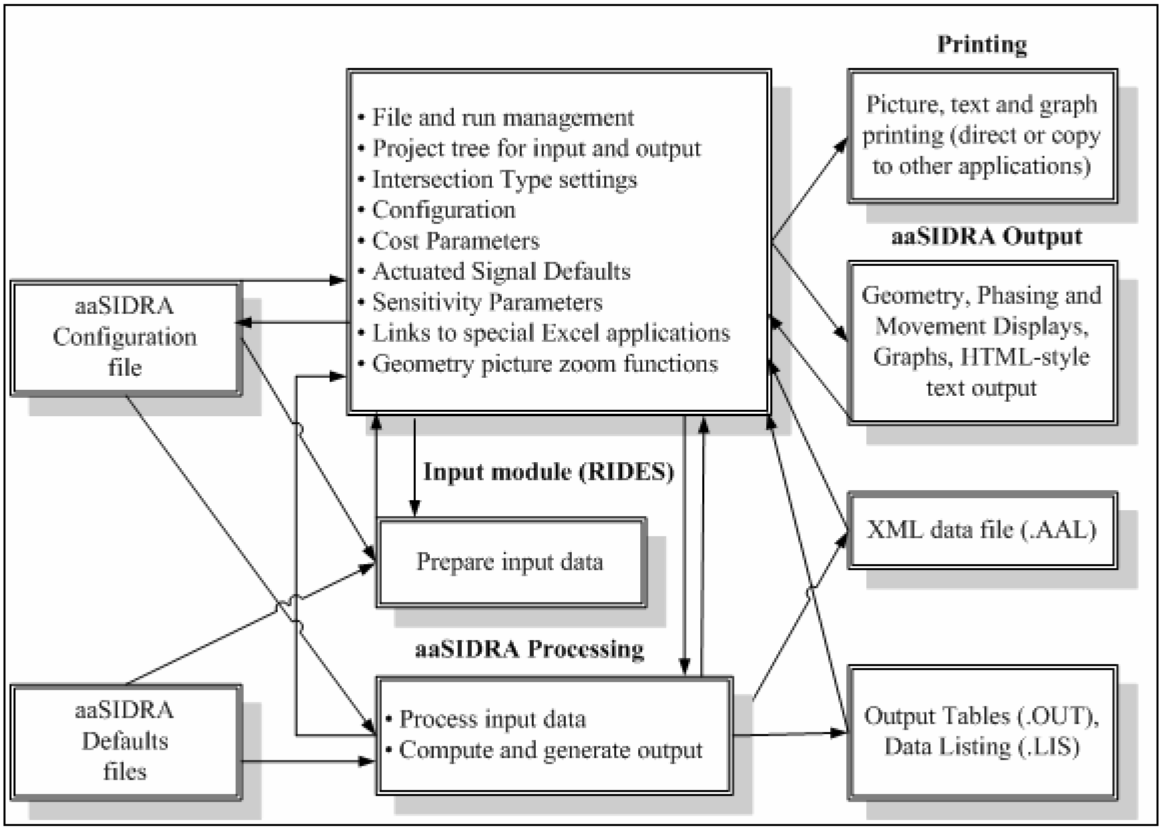

Figure 3.3 Operation of the aaSIDRA system

In this Chapter a detailed description of the microsimulation models VISSIM and aaSIDRA was presented. The next Chapter describes in detail the test bed used for this research and presents a description of the traffic study for each of the hourly peak periods at each intersection selected.

Chapter 4 Network Description

4.1. Mayagüez Network

The selected Test bed network along the PR-2 arterial street started at the “Corazones” Avenue (PR-114) and ended at the PR-2 intersection with the PR-109 and PR-115 of the Añasco and Rincon municipality respectively, (see Figure 4.1). The length of the project was about thirteen (13) kilometers and consisted on twenty (20) principal signalized intersections.

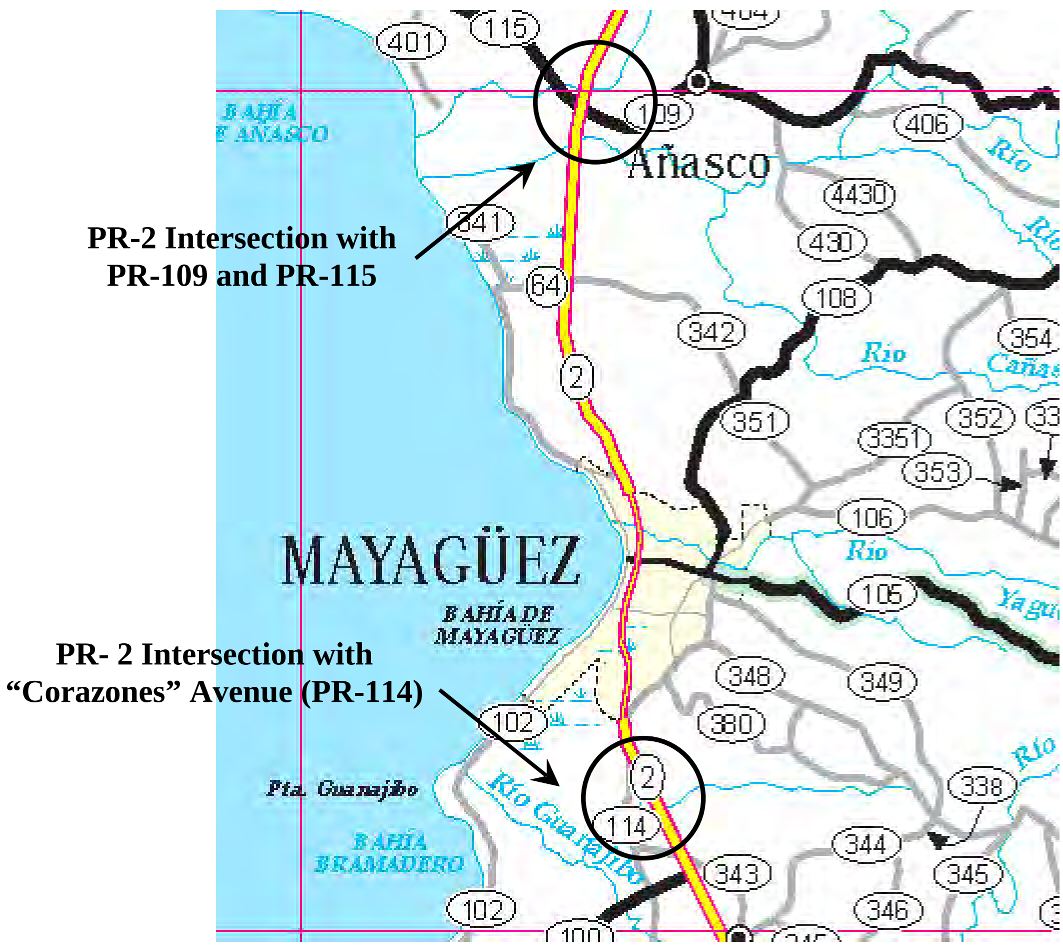

Figure 4.1 Mayagüez road map area

This network was divided in two principal segments, taking into consideration that each segment has homogeneous geometric characteristics in terms of number of lanes in both directions through its entire length.

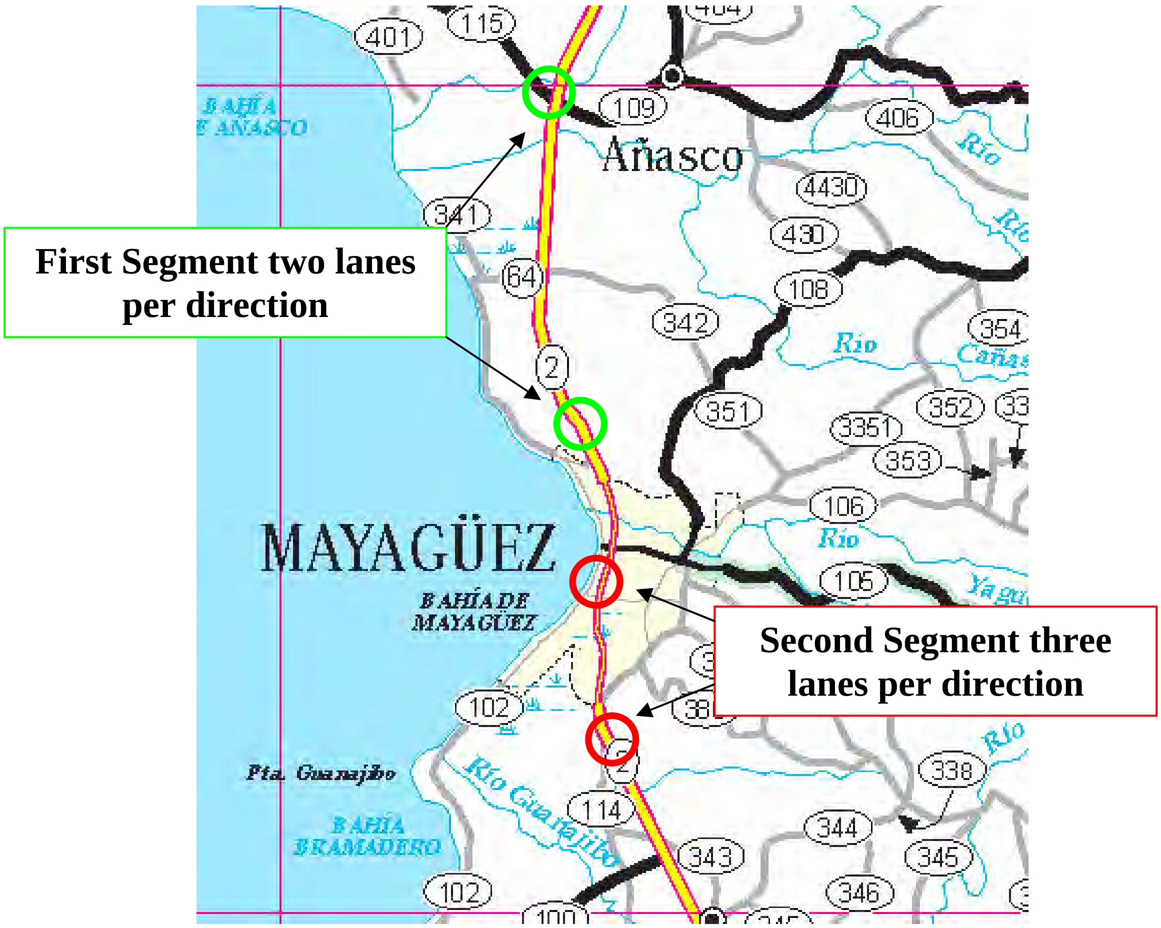

Figure 4.2 Two principal segments in which the network was divided

The first segment has two lanes for each direction, and the other segment has three lanes for each direction. The three lanes segment starts at the intersection of PR-2 (see Figure 4.3) with "Corazones" Avenue (PR-114) and ends at the intersection of PR 2 with Nenadich Street (see Figure 4.4).

Figure 4.3 PR-2 Intersection with the "Corazones" Avenue and PR-114

Figure 4.4 PR-2 Intersection with the Nenadich Street

The segment of three lanes per direction, started at the intersection of PR-2 with University Plaza (see Figure 4.5), and ended at the intersection of PR-2 with PR-109 of the Añasco municipality and PR-115 of the Rincon municipality (see Figure 4.6).

Figure 4.5 PR-2 Intersection with the University Plaza

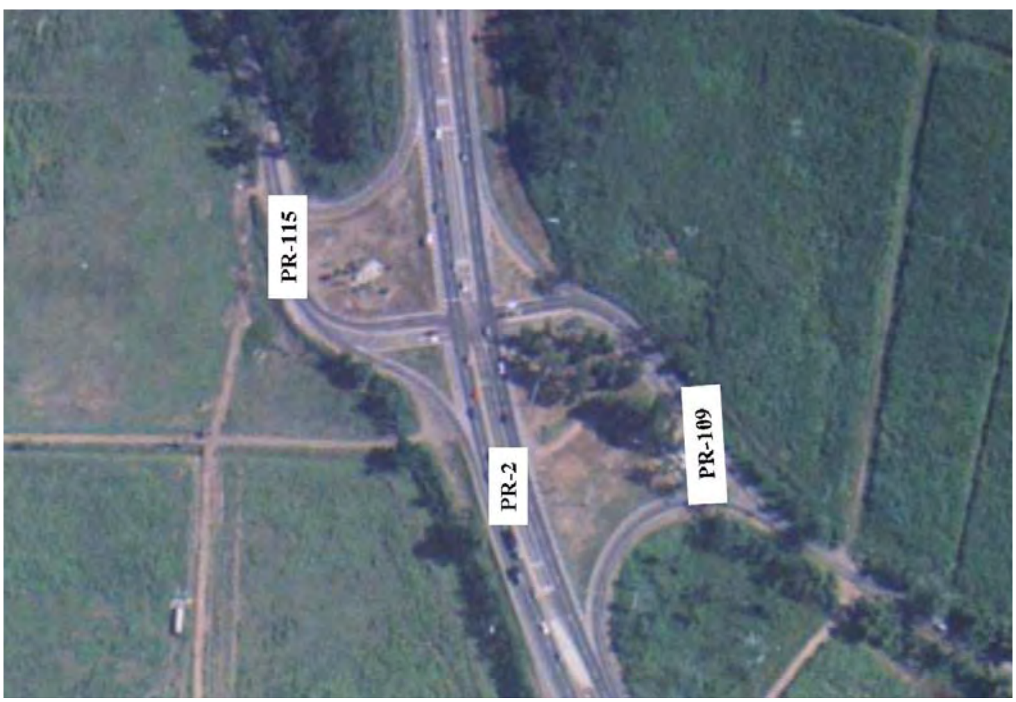

Figure 4.6 PR-2 Intersection with the PR-109 and PR-115 (Añasco and Rincon Municipalities)

The section between these two segments was not selected for this research because this is a transition segment that makes the geometric adjustments from two lanes per direction to three lanes per directions. Moreover it has a complex junction (see Figure 4.7) where a minor street converges with the major street PR-2 in front of the main entrance of the University of Puerto Rico at Mayagüez.

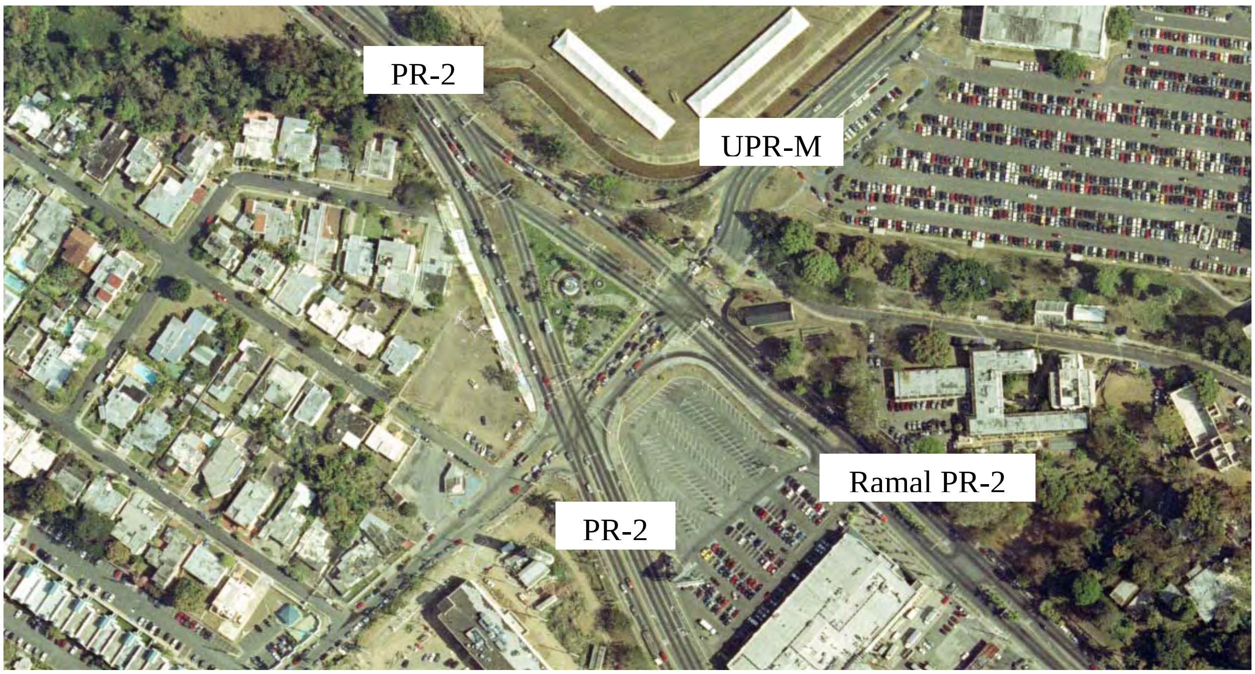

Figure 4.7 Intersection of PR-2 with Ramal of PR-2

4.2. Example of Network modeling using VISSIM: Conversion of arterial street PR-2 to expressway PR-2

As a part of a study for the Highway and Transportation Authority, the University of Puerto Rico conducted a research for the conversion of the arterial street into an expressway in a stretch located on the municipalities of Mayagüez and Añasco. The length of the project was about thirteen (13) kilometers and consisted on twenty (20) signalized intersections: the first located at the intersection of PR-2 with “Corazones” Avenue and PR-114 and the second located at the intersection of PR-2 with PR-109 and PR-115 (Añasco and Rincón Municipalities). For this example, volumes studies were performed at each one of the intersections. Also, phase and traffic signal times were recorded along the entire network. This information was the starting point of the simulation process of the PR-2 network (see Figure 4.8).

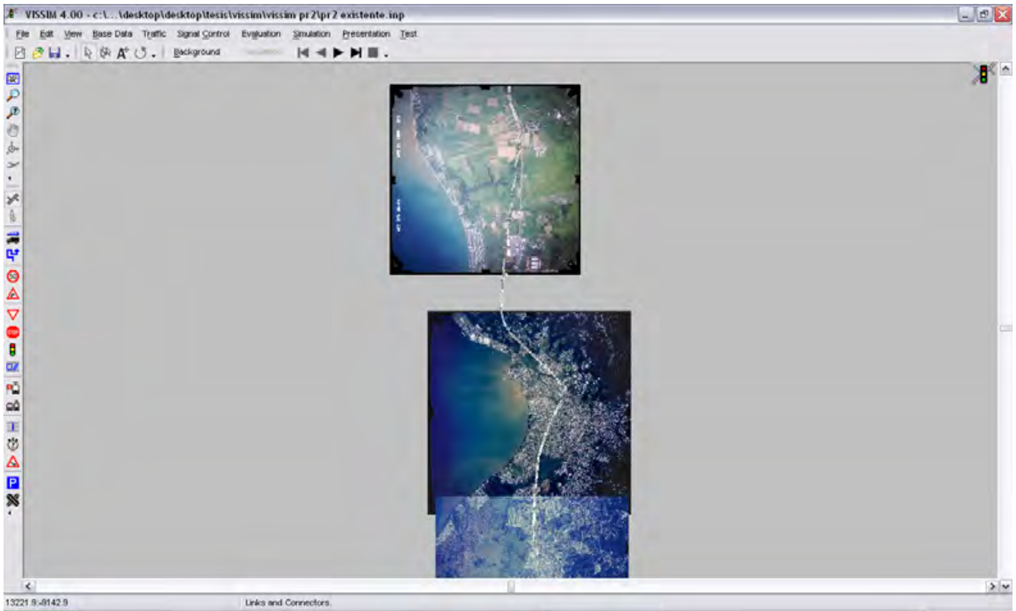

Figure 4.8 VISSIM simulation of the entire PR-2 network

Information was gathered from VISSIM simulation for the morning peak period in order to validate the recommendations to eliminate the signalized intersection. The alternative was to add elevated U-turn intersections, and other types of elevated intersections to eliminate the traffic congestion along the arterial network.

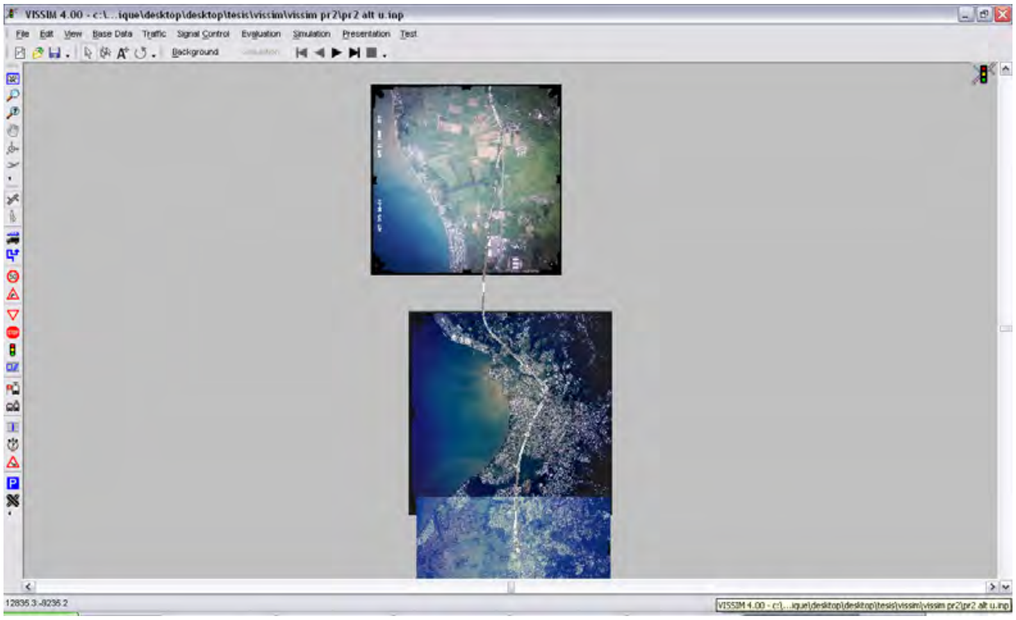

Figure 4.9 VISSIM simulation of the U-Turn alternative for the PR-2 arterial network street

Figure 4.9 presents the VISSIM simulation alternative of the arterial street PR-2 network for the conversion of this highway into an expressway. The software allowed us to open more than one background picture to understand better the simulation process. This is one of the features of the VISSIM version 4.0 compared to previous versions.

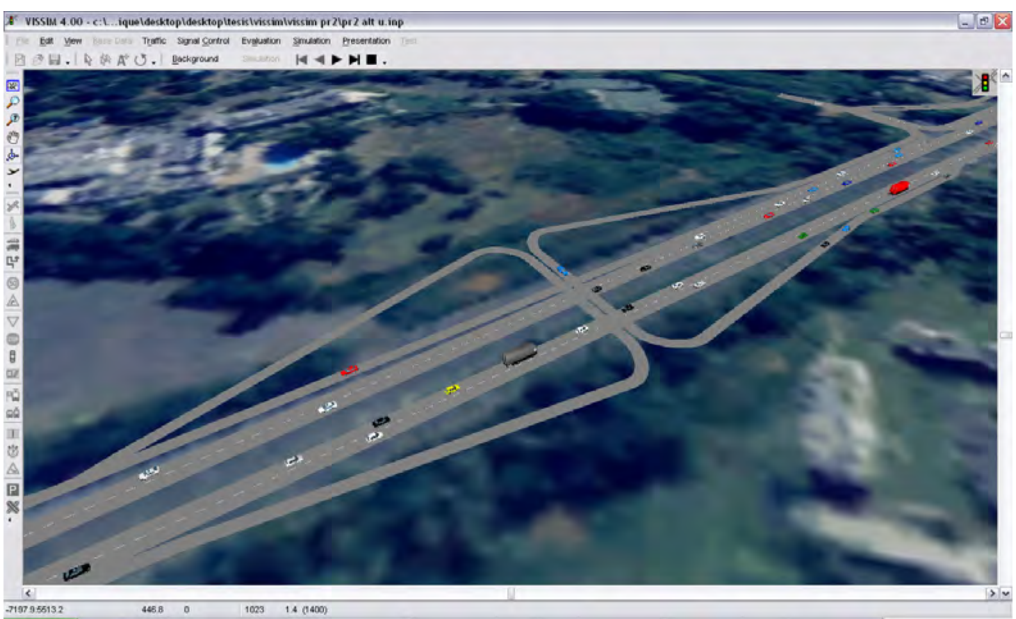

Figure 4.10 Example of a U Turn for the PR-2 network

Figure 4.10 shows the simulation of one of the elevated intersections proposed by Dr. Felipe Luyanda[1] for this study; where a driver could make a U turn movement that allows them to get the final destination without the use of a signalized intersection.

Figure 4.11 Example of a clover leaf intersection for the PR-2 network at the PR-109 and PR-115

Figure 4.11 presents the selected alternative for the intersection of the PR-2 with the PR-109 and PR-115. The elevated alignment of PR-2 and clover leaf form ramps provides the drivers access to PR-109 and PR-115.

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[1] Dr. Felipe Luyanda, professor of the University of Puerto Rico at Mayagüez at the Department of Civil Engineering and Surveying.

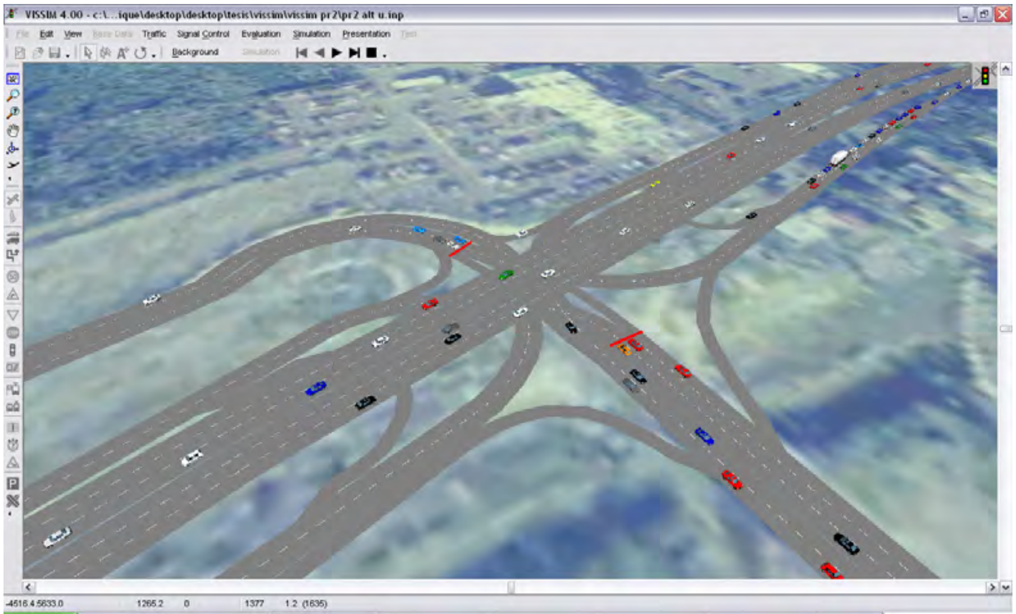

Figure 4.12 Example of an elevation section for the PR-2 network at the "Corazones" Avenue intersection

Figure 4.12 presents the alternative selected for the intersection of PR-2 arterial street with "Corazones" Avenue and PR-114. This is an intersection where PR-2 is elevated above a single-point signal intersection that controls the movements between PR-2 and PR-114, between PR-2 and "Corazones" Avenue, and between "Corazones" Avenue and PR-114.

Figure 4.13 Example of an elevation intersection for the PR-2 network with Luis Llorens Torres Avenue

Figure 4.13 presents the alternative selected for the intersection of the PR-2 arterial street with the Luis Llorens Torres Avenue. The PR-2 is elevated above a signalized intersection by which other transit movements are controlled.

As part of this project for the Highway and Transportation Authority volumes studies were performed at each one of the intersections for the analysis of conversion of this highway from arterial street to expressway. For that study, traffic counts were performed during typical weekdays (Tuesday, Wednesday, and Thursday) in the morning and evening periods. The analysis of the data gathered showed similar results for anyone of these days, clearly indicating that it is necessary to consider only one typical weekday to obtain the relevant data corresponding to peak periods and general trends in traffic volumes.

This concludes the extent of the Highway and Transportation Authority study used as an example of network modeling (VISSIM) for the conversion of arterial street PR-2 to expressway PR-2.

4.3. PR-2 Intersections with the “Centro Médico” Hospital

The PR-2 intersection with the “Centro Médico” hospital was the intersection selected in the segment of three lanes per direction along the PR-2 alignment. This intersection was selected because it is the only one along the segment that was not a “T” intersection but a four-leg intersection. The “Centro Médico” west approach has three (3) lanes to exit and 2 entrance lanes (see Figure 4.14). The east approach consisted of 2 entrance lanes and 2 exit lanes with a right turn with a non-stop restriction.

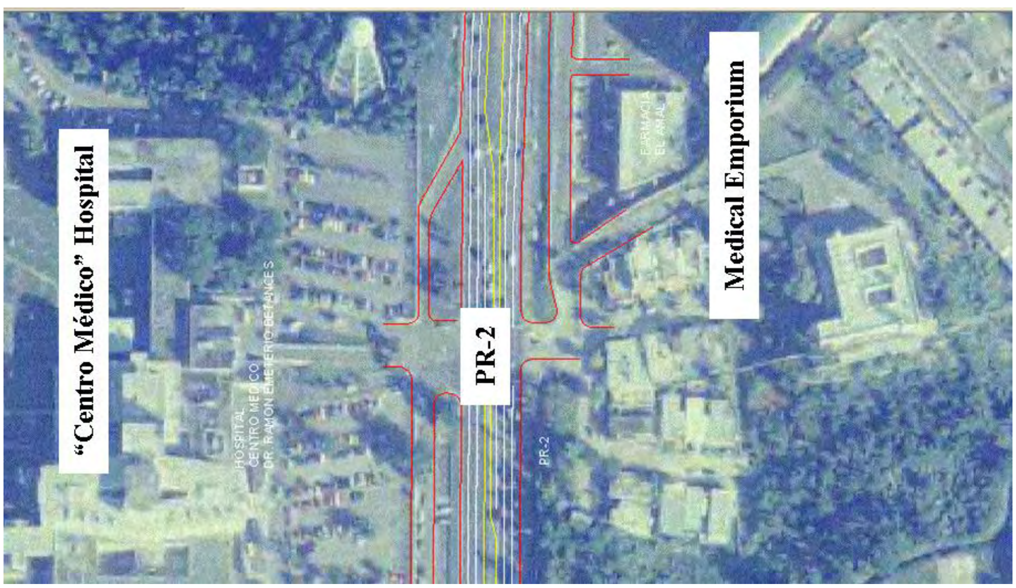

Figure 4.14 PR-2 Intersection with the “Centro Médico” Hospital geometry

The east approach provides access to commercial buildings (Medical Emporium) where restaurants, fast-food facilities, government offices, medical offices, clinical laboratories, a video rental, a drugstore, and the Veteran’s Hospital are located (see Figure 4.15). On the west approach “Centro Médico” Hospital can be found; it is the most important trauma and cardiovascular center in the western area of Puerto Rico.

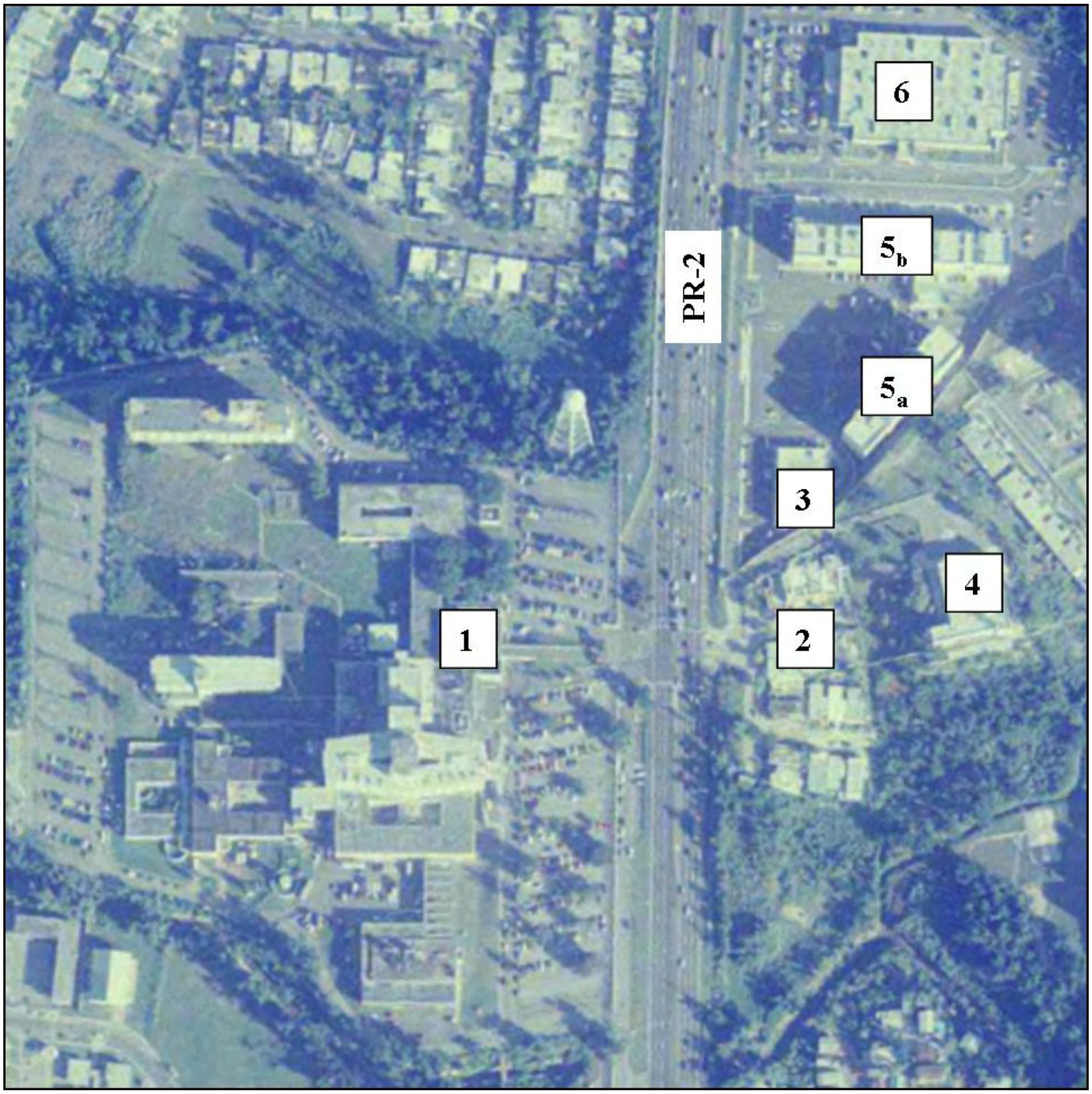

Figure 4.15 PR-2 Intersection with the "Centro Médico" Hospital description

Legend

1. "Centro Médico"
2. Houses
3. Drug Store
4. Church
5. Medical Emporium:
    a. Medical Offices
    b. Other Offices
6. Veterans Hospital

This intersection has some particular features that make it different from other intersections along the arterial network. Its volume was extremely high during the periods analyzed. In the morning period, a police officer controlled traffic conditions at this intersection. The longest uninterrupted flow period was observed on the north bound traffic in the intersection of the PR-2 and "Centro Médico" during the officer's intervention. On the second day, a volume count was performed. This study was performed during the morning and evening periods to determine the intensity during peak periods. The volume data for this study was collected manually. In this case, one observer was required for each intersection approach studied. The following sections explain in more detail the intersection analysis.

4.3.1. "Centro Médico" Typical Weekday Morning Period Maneuvers and Hourly Peak Volumes

The morning period analysis was performed between 6:00 A.M. and 9:00 A.M. on Wednesday January 26, 2005. The total maximum hourly volume was 6,559 vehicles between 7:25 A.M. and 8:25 A.M. with a Peak Hour Factor (PHF) based on fifteen (15) minutes interval of 0.98. This value was used for the analysis using the aaSIDRA program. To obtain the PHF, the hourly volume was divided by the maximum rate of flow (see Equation 4-1).

$$PHF = \frac{Hourly \quad Volume}{Maximum \quad rate \quad of \quad flow}$$ **Equation 4-1**

$$PHF_{am} = \frac{6559}{1674 * 4} = \frac{6559}{6696} = 0.98$$

Table 4-1 Traffic counts classified by movement for the morning period at the PR-2 with the “Centro Médico” intersection

	Morning Peak Period at 8:25 A.M.		
From	Left	Straight	Right
PR-2 North	290	2353	5
PR-2 South	303	3063	345
CM	68	13	66
Amal (MP)	42	9	2
		Total Volume:	6559

The Table 4-1 presents the traffic counts classified by movement for the peak morning period. The movements from the PR-2 north bound had the greatest demand, and required the longest time intervals for the green time at the signal phases. The peak hour volumes are illustrated by maneuvers in Figure 4.16.

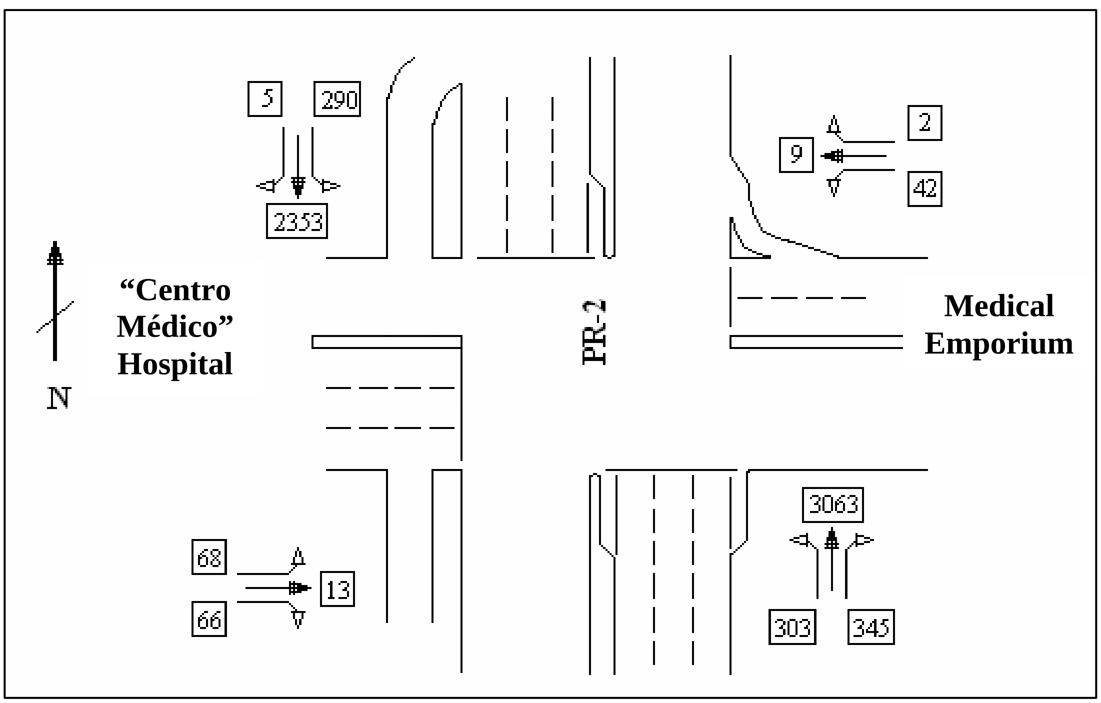

Figure 4.16 Volumes classified by movements of the PR-2 with the “Centro Médico” intersection in the morning period

Table 4-2 Description of the PR-2 with the "Centro Médico" intersection phases time for the morning period

Morning Period Movements	Times in seconds used in the signals phases				
	All Red	Amber	Green Min	Green Max	Green
To "Centro Médico" Hospital	1.0	3.0	10.0	50.0	50.0
PR-2 from South	1.0	4.0	30.0	150.0	150.0
PR-2 from North	0.0	3.0	30.0	140.0	120.0
To Medical Emporium	0.0	3.0	12.0	50.0	20.0
Out of Medical Emporium and "Centro Médico"	1.0	3.0	6.0	15.0	8.0

The Table 4-2 presents the average phase times used to model traffic signals in VISSIM. These values were obtained while the police officer was controlling traffic conditions in the intersection, and were not measured directly from signal lights.

4.3.2. "Centro Médico" Typical Weekday Evening Period Maneuvers Hourly Peak Volumes

The analysis of the evening period was performed between 3:00 P.M. and 6:00 P.M. on Wednesday January 26, 2005. Total volume was 6,498 vehicles between 3:05 P.M. and 4:05 P.M. with a Peak Hour Factor (PHF) of 0.95. To obtain the PHF, the hourly volume was divided by the maximum rate of flow.

$$PHF_{pm} = \frac{6498}{1715 * 4} = \frac{6498}{6860} = 0.95$$

Table 4-3 Traffic counts classified by movements for the evening period at the PR-2 with the "Centro Médico" Intersection

	Evening Peak Period at 4:05 P.M.		
From	Left	Straight	Right
PR-2 North	79	2735	3
PR-2 South	126	2880	164
CM	141	6	152
Amal (MP)	190	10	12
		Total Volume:	6498

The Table 4-3 presents the amount of vehicles that make each of the permitted movements in the intersection during the peak evening period. The movements from the PR-2 south direction produce the greatest congestions. The resulting volumes for the peak period are shown by maneuvers in Figure 4.17.

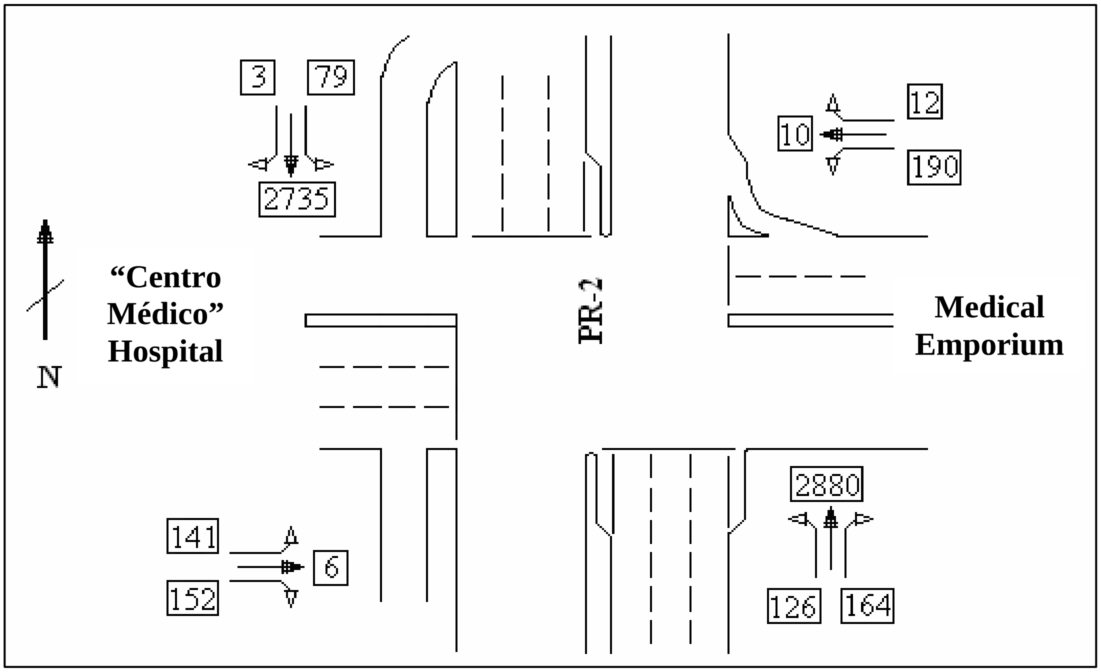

Figure 4.17 Volumes classified by movements of the PR-2 with the "Centro Médico" intersection in the evening period

Table 4-4 Description of the PR-2 with the "Centro Médico" intersection phases time for the morning period

Evening Period Movements	Times in seconds used in the signals phases				
	All Red	Amber	Green Min	Green Max	Green
To "Centro Médico" Hospital	0.0	3.0	12.0	25.0	13.0
PR-2 from South	1.0	4.0	30.0	80.0	80.0
PR-2 from North	1.0	4.0	30.0	80.0	80.0
To Medical Emporium	0.0	3.0	12.0	25.0	14.0
Out of Medical Emporium and "Centro Médico"	2.0	4.0	8.0	20.0	13.0

The Table 4-4 presents the times measured directed from the signals lights.

4.4. PR-2 Intersection with Western Plaza

The PR-2 intersection with Western Plaza was the intersection selected in the segment of two lanes per direction along the PR-2 alignment. This intersection was selected because it is the only one in this segment with high geometric complexity that includes a frontage road along the PR-2. The study of this complex intersection allows us to explore how difficult would be its simulation with both programs (VISSIM and aaSIDRA).

The Western Plaza intersection gives access to a commercial center area with uncommon geometric characteristics (see Figure 4.18). It consists of a frontage road that gives access to vehicle dealers, fast foods and other commercial buildings. The movie theater, SAM'S, K-mart, Home Depot and other fast foods are located on the other side of the intersection at the Western Plaza commercial center (see Figure 4.19).

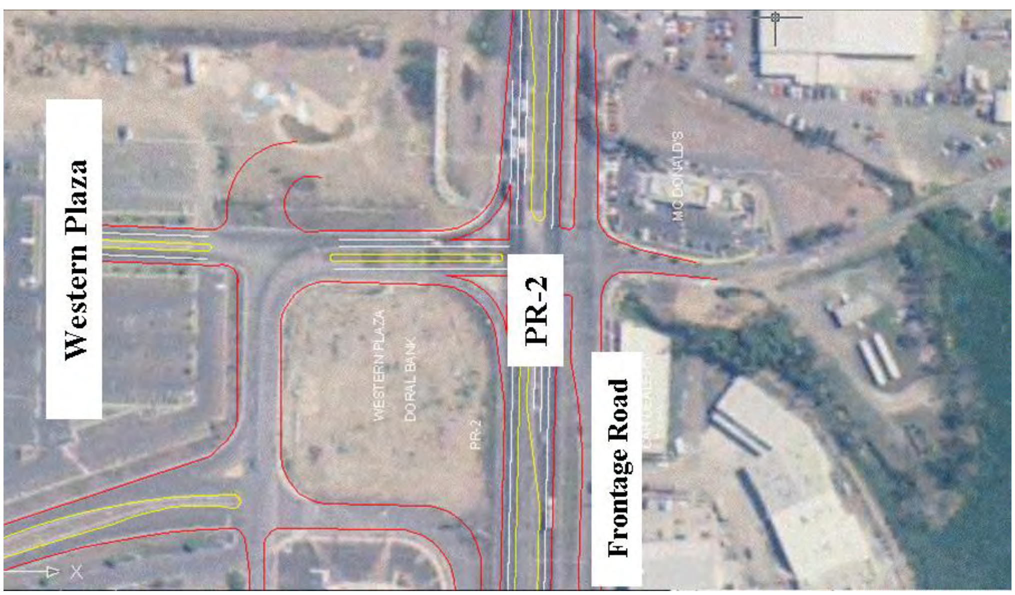

Figure 4.18 PR-2 Intersection with the Western Plaza geometry

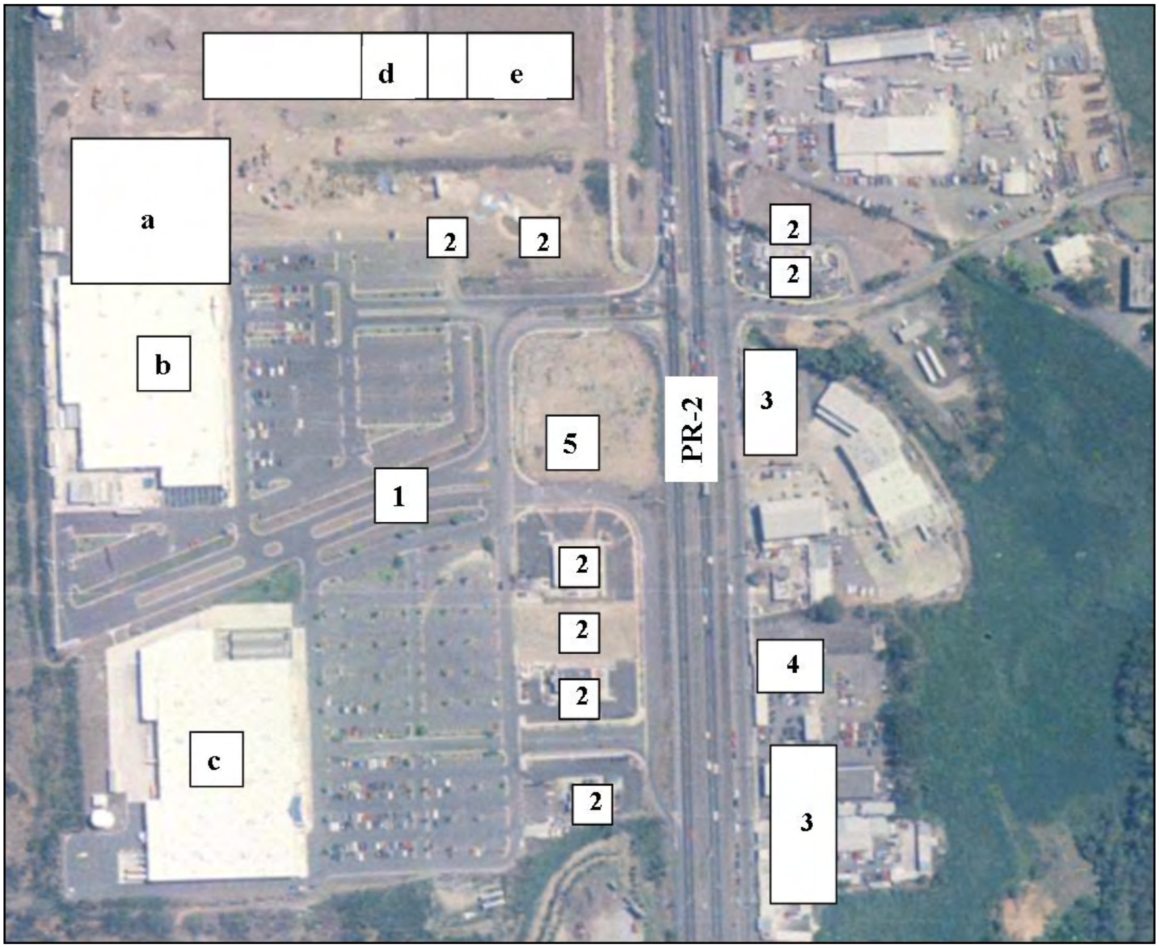

Figure 4.19 PR-2 Intersection with the Western Plaza description

Legend

1. Western Plaza
    a. SAM'S
    b. K-Mart
    c. Home Depot
    d. Caribbean Cinemas
    e. Pep boys
2. Fast Food
3. Dealers
4. Gas Station
5. Bank

Manual volume counts ware performed at this intersection in order to determine the traffic characteristics of peak and off-peak periods. The Western Plaza intersection showed a particular feature due to the fact that it gives access to a commercial area: the traffic pattern was different on weekdays and weekends. Therefore, in this case traffic studies were performed during the weekend (Saturday) and also on a typical weekday morning and evening peak hours.

From the 2001 Puerto Rico Continuous Traffic Volumes Counts, Planning Area Data Collection, and Traffic Analysis Office of the Department of Transportation and Public Works (DTOP), and Highway and Transportation Authority (ACT) data was obtained in order to specify the hours were the volume counts should be taken. The station number PM-3 located in the PR-102 at the km 5 southwest of Mayagüez was selected to determine the differences in traffic patterns. Table 4-5, 4-6, and 4-7 show the complete information for this station.

Table 4-5 2001 Continuous Traffic Volumes Station Description

Station Number	Route Number	Location (Km)	Description	Area	Functional Classification
PM-3	PR-102	5.0	South of PR-340 (Southwest of Mayagüez)	Mayagüez	Collector

Table 4-6 Traffic Data Statistics

Station Number	AAWT	AADT	Peak Hour				
			Date	Hour	Volume	% of AADT	% D
PM-3	9,450	9,270	Friday-January 26, 2001	5:00 PM-6:00 PM	1,155	12.00	50

Table 4-7 Monthly Average Traffic Volume

Month	MAWT	MADT
January	9,420	9,084
February	9,754	9,505
March	9,748	9,627
April	9,708	9,379
May	9,713	9,686
June	9,635	9,820
July	9,305	9,379
August	9,330	9,225
September	9,576	9,294
October	8,897	8,768
November	9,280	8,706
December	9,198	8,820
Annual Average	9,450	9,270

Table 4-8 Annual Average Hourly Volumes

Hour		Weekday AAHV	Saturday AAHV
12:00-1:00	am	71	218
1:00-2:00	am	38	159
2:00-3:00	am	27	82
3:00-4:00	am	23	54
4:00-5:00	am	43	49
5:00-6:00	am	121	83
6:00-7:00	am	457	140
7:00-8:00	am	882	240
8:00-9:00	am	549	345
9:00-10:00	am	428	426
10:00-11:00	am	433	478
11:00-12:00	am	484	530
12:00-1:00	pm	570	583
1:00-2:00	pm	586	599
2:00-3:00	pm	625	611
3:00-4:00	pm	686	615
4:00-5:00	pm	738	600
5:00-6:00	pm	739	594
6:00-7:00	pm	516	574
7:00-8:00	pm	405	523
8:00-9:00	pm	342	465
9:00-10:00	pm	300	425
10:00-11:00	pm	243	361
11:00-12:00	pm	156	291
Total		9,462	9,045

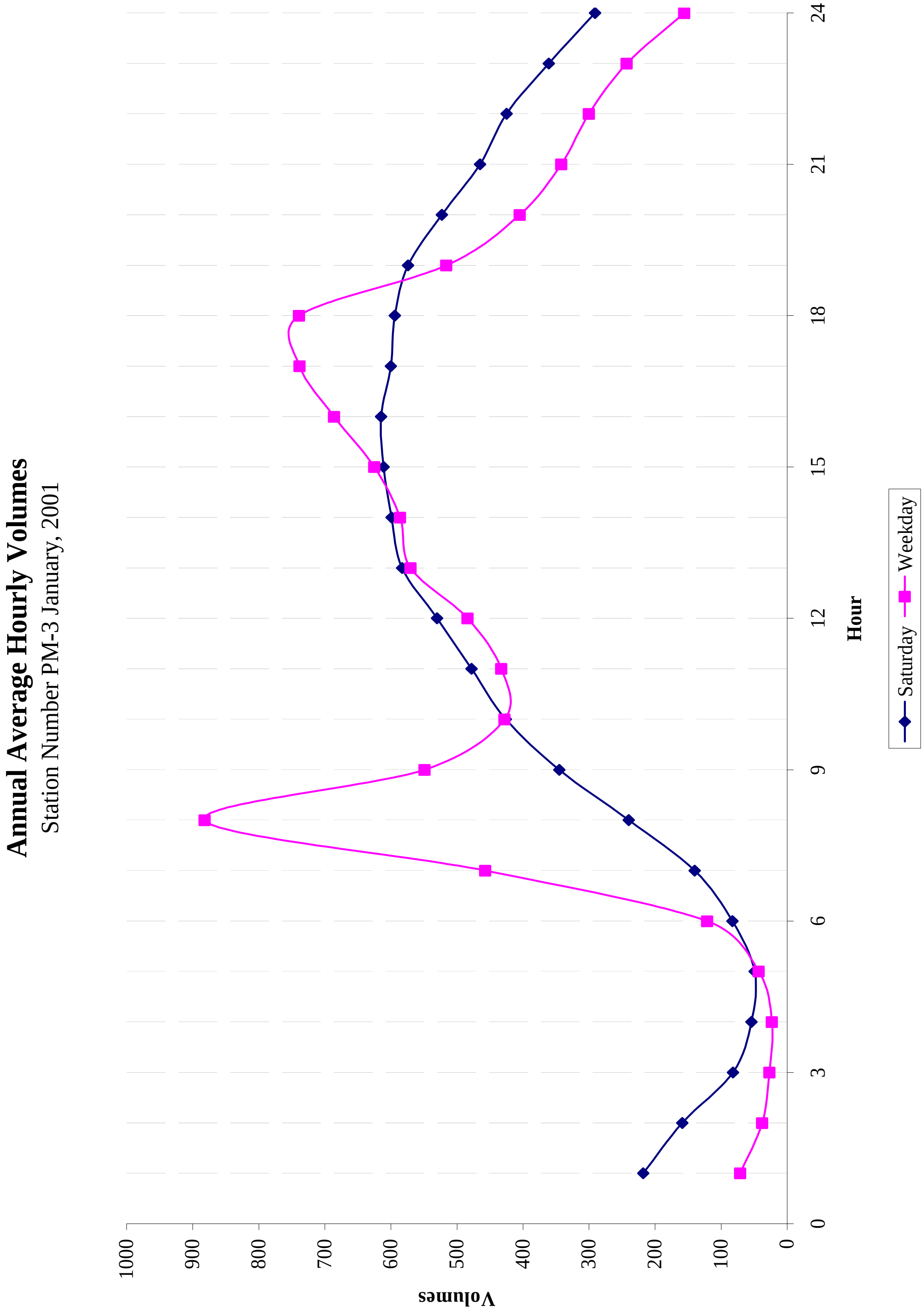

Figure 4.20 Data gathered from the Continuous Traffic Volumes Counts by the DTOP

Figure 4.20 shows the data gathered. This data was plotted for the Saturday and weekdays. The graph on Figure 4.20 shows two peak hours on weekdays: during the morning period (between 6:00-9:00 A. M.), and during the evening period (between 3:00-6:00 P.M.). However, in the case of the Saturday plot, there is only one peak period between 9:00 a.m. through 4:00 p.m. The volume studies in the Western Plaza intersection were performed using this information.

Table 4-8 demonstrates that the annual average hourly volumes had a highest peak hour vehicle volume of 882 at 7:00-8:00 A.M on a weekday and 739 for the evening period at 5:00-6:00 P.M. On Saturday, the peak hour period was between 3:00-4:00 P.M. with 615 vehicles. On Table 4-7 the weekly and daily averages for the traffic volumes showed for the station PM-3 where 9,754 (February) and 9,820 (June) respectively.

4.4.1. Western Plaza Typical Weekday Morning Period Maneuvers Hourly Peak Volumes

The analysis of the morning period was performed between the 6:00 – 9:00 A.M. on Thursday February 24, 2005. Total volume was 4,215 vehicles between 7:25 A.M. and 8:25 A.M. with a Peak Hour Factor (PHF) based on fifteen (15) minutes interval of 0.96. To obtain the PHF the Equation 4-1 was used.

$$PHF_{am} = \frac{4215}{1098 * 4} = \frac{4215}{4392} = 0.96$$

Table 4-9 Traffic counts classified by movements for the morning period at the PR-2 with the Western Plaza intersection

	Morning Peak Period at 8:25 A.M.			
From	Left	Straight	Right	U Turns
PR-2 North	226	1782	92	
PR-2 South	224	1155		
WP	82	133	67	41
McD	117	55	20	
Frontage	12	22	169	18
			Total Volume:	4215

Table 4-9 presents the amount of vehicles that makes each of the permitted movements in the intersection during the peak evening period. The greatest demand of vehicle movements was observed from the PR-2 North direction. The resulting volumes for the peak period are shown by maneuvers in Figure 4.21.

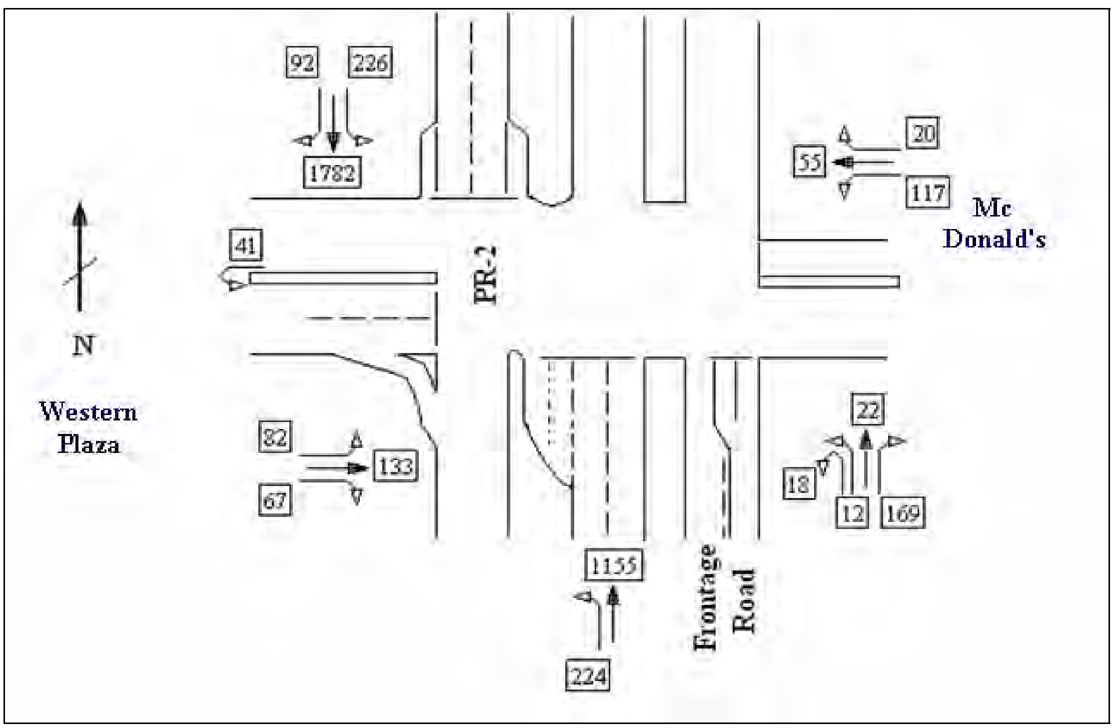

Figure 4.21 Volumes classified by movements of the PR-2 with the Western Plaza intersection in the morning period

Table 4-10 Description of the PR-2 with the Western Plaza intersection phases time for the morning period

Morning Period Movements	Times in seconds used in the signals phases				
	All Red	Amber	Green Min	Green Max	Green
To Western Plaza	1.0	3.0	14.0	25.0	14.0
PR-2 from South	2.0	4.0	25.0	125.0	120.0
PR-2 from North	2.0	4.0	25.0	125.0	120.0
To Mc Donald's	1.0	3.0	15.0	25.0	20.0
Out of Frontage	1.0	2.0	10.0	10.0	10.0
Out of Mc Donald's & Western Plaza	1.0	3.0	15.0	25.0	25.0

The Table 4-10 presents the measurements directly from the signals lights.

4.4.2. Western Plaza Typical Weekday Evening Period Maneuvers Hourly Peak Volumes

The analysis of the evening period was performed between the 3:00 – 6:00 P.M. on Thursday February 24, 2005. Total volume was 4,517 vehicles between 3:15 P.M. and 4:15 P.M. with a Peak Hour Factor (PHF) of 0.94. To obtain the PHF, the hourly volume was divided by the maximum rate of flow.

$$PHF_{pm} = \frac{4517}{1199 * 4} = \frac{4517}{4796} = 0.94$$

Table 4-11 Traffic counts classified by movements for the evening period at the PR-2 with the Western Plaza intersection

	Evening Peak Period at 4:15 P.M.			
From	Left	Straight	Right	U Turns
PR-2 North	103	1223	70	
PR-2 South	445	1551		
WP	390	68	182	
McD	99	64	17	
Frontage	38	73	140	54
			Total Volume:	4517

Table 4-11 presents the amount of vehicles that makes each of the permitted movements in the intersection during the peak evening period. The movements from the PR-2 South direction had the greatest amounts. In the morning period the greatest traffic flows came from the North. The resulting volumes for the peak period are shown by maneuvers in Figure 4.22.

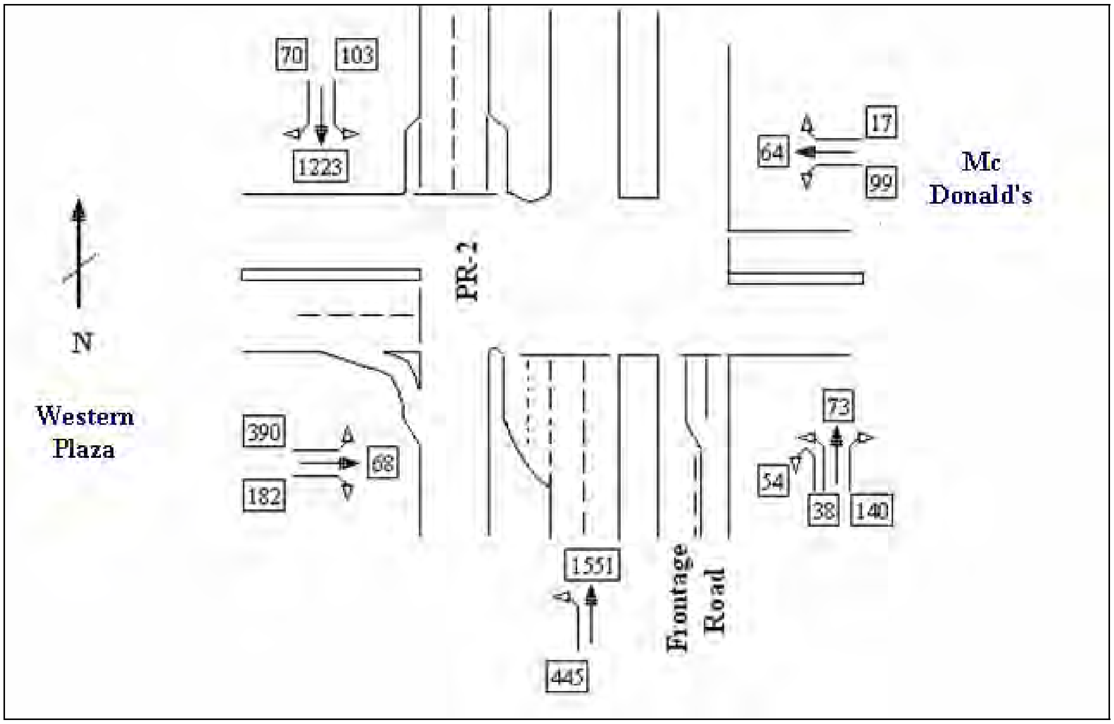

Figure 4.22 Volume classified by movements of the PR-2 with the Western Plaza intersection in the evening period

Table 4-12 Description of the PR-2 with the Western Plaza intersection phases time for the evening period

Evening Period Movements	Times in seconds used in the signals phases				
	All Red	Amber	Green Min	Green Max	Green
To Western Plaza	1.0	3.0	15.0	25.0	22.0
PR-2 from South	2.0	4.0	60.0	125.0	125.0
PR-2 from North	2.0	4.0	60.0	125.0	125.0
To Mc Donald’s	1.0	3.0	15.0	25.0	16.0
Out of Frontage	1.0	2.0	9.0	15.0	15.0
Out of Mc Donald’s & Western Plaza	1.0	3.0	15.0	30.0	30.0

Table 4-12 present the measured times directly from the signals lights.

4.4.3. Western Plaza Typical Saturday Period Maneuvers Hourly Peak Volumes

The analysis of a typical Saturday was performed between 9:00 A.M. to 4:00 P.M. on March 5, 2005. Total volume was 4,555 vehicles between 1:20 P.M. and 2:20 P.M. with a Peak Hour Factor (PHF) of 0.96. To obtain the PHF, the hourly volume was divided by the maximum rate of flow.

$$PHF_{saturday} = \frac{4555}{1185*4} = \frac{4555}{4740} = 0.96$$

Table 4-13 Traffic counts classified by movements for the Saturday period at the PR-2 with the Western Plaza intersection

	Saturday Peak Period at 2:20 P.M.			
From	Left	Straight	Right	U Turns
PR-2 North	61	1320	199	
PR-2 South	526	1214		
WP	522	53	301	
McD	9	44	10	
Frontage	68	83	90	55
			Total Volume:	4555

The volumes of vehicles of Table 4-13 represent each of the movements allowed in the intersection during the peak period for a typical Saturday. The movements from the PR-2 South direction had the greatest volumes. The volumes included maneuvers that allow the drivers to access from the PR-2 to the Western Plaza. The resulting volumes for the peak period are shown by each maneuver in Figure 4.23.

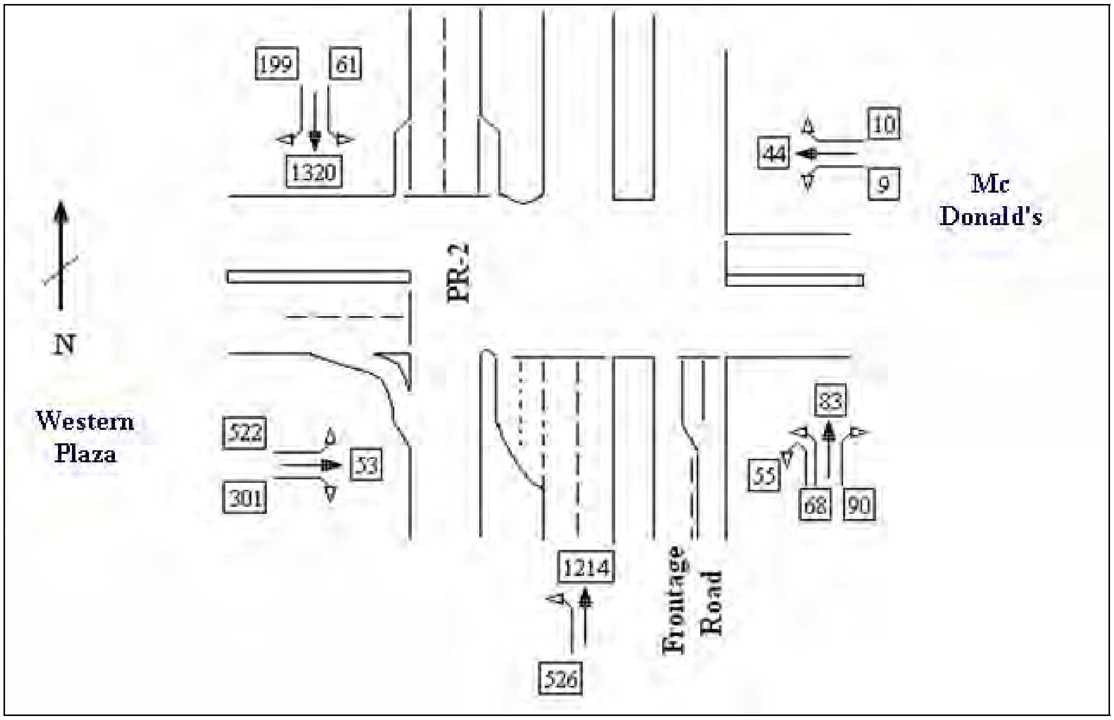

Figure 4.23 Volumes classified by movements of the PR-2 with the Western Plaza intersection in the Saturday period

Table 4-14 Description of the PR-2 with the Western Plaza intersection phases time for the Saturday typical day

Saturday Period Movements	Times in seconds used in the signals phases				
	All Red	Amber	Green Min	Green Max	Green
To Western Plaza	1.0	3.0	3.0	25.0	21.0
PR-2 from South	2.0	4.0	25.0	75.0	75.0
PR-2 from North	2.0	4.0	25.0	75.0	75.0
To Mc Donald's	1.0	3.0	3.0	15.0	6.0
Out of Frontage	1.0	3.0	10.0	15.0	10.0
Out of Mc Donald's & Western Plaza	1.0	3.0	15.0	30.0	26.0

The Table 4-14 is measured directly from the signals lights during the volume study.

This Chapter presented a description of the test bed in where the adaptation of VISSIM was performed, and explained the reason for selecting the "Centro Medico" Hospital intersection and the Western Plaza intersection. It also provides a comprehensive discussion of the traffic study performed at the selected intersections. With this study the time where the peak hour occurs and the vehicles volumes corresponding for each intersection was found. The next Chapter presents a complete description of the delay study.

Chapter 5 **Intersection Delay Study**

5.1. Purpose

The Intersection Delay Study is used to evaluate the transit performance of intersections. This study will effectively provide a detailed evaluation of stopped time delay conditions at the intersection. This study can be equally applicable in the evaluation of pedestrian delays at an intersection by substituting “vehicle” for “pedestrian” counts.

5.2. Intersection Delay Study

The intersection delay study was performed during periods of congestion. Typically, the peak delay occurs during the peak hour, which could be identified from the traffic counts. The peak delay may occur during the major or minor street's peak hours. Care had to be taken when determining the study time period.

The intersection delay data was collected manually, unless the agency soliciting the study requires the use of a delay meter. In most cases, one observer is required for each intersection being evaluated. In some cases, traffic volumes are too heavy for one person to handle then alone, and a second observer was used (Traffic Signals Manual, 1999).

The study involves counting the vehicles that came to a complete stop in the intersection at successive intervals. A typical duration for these intervals is 15-seconds, although other interval lengths can be selected. However, if a larger interval is selected, the overestimation amount of delay increases. Conversely, if a smaller interval is selected, the overestimation amount of delay is lower, but the amount of data collected increases. Therefore, the 15 seconds intervals used for the study represent an adequate measure.

5.2.1. Field Observation

To perform the study, the observer counts and records the number the vehicles that came to a complete stop in the intersection at successive intervals. A stop watch was used to verify the time intervals for counting the halted vehicles. A vehicle is accounted for more than once in this study if it is still located in the intersection for more than one interval (more than 15 seconds).

The observer performed a separated tabulation of the approach volume for each time period that would represent the total amount of vehicles departing from the intersection where the study was performed for each approach in where the study was performed (Manual on Uniform Traffic Studies, 2000).

5.3. Delay Study for the PR-2 Intersection with the "Centro Médico" Hospital

An analysis was performed to measure how well the VISSIM software represented the conditions of an extremely saturated intersection controlled by a police officer for the morning week day peak period. As was mentioned before, to perform the study the observer counts and records the number of vehicles that came to a complete stop in the intersection at successive intervals. In this intersection, the volumes in the major street PR-2 were overflowing at the point that the observer can not have the opportunity to measure where the end of the complete stopped vehicles is. The maneuvers showed on Figure 5.1 had this characteristic, where the observer can count the amount of completely stopped vehicles at the intersections. This explains why only the maneuvers presented were selected at each intersection. The maneuvers analyzed in this section corresponding to the intersection of the PR-2 with the "Centro Medico" are shown in Figure 5.1.

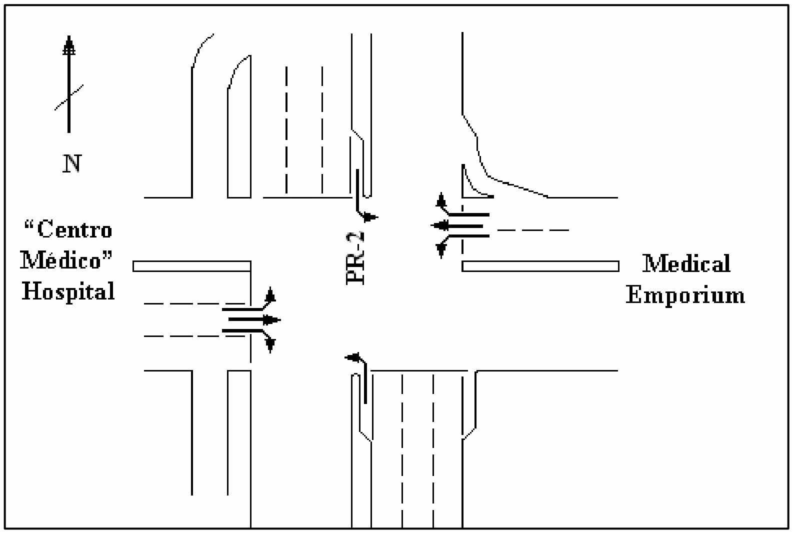

Figure 5.1 Schematic representation for the Delay Study

The data gathered and corresponding calculations are the following:

Three hundred (300) vehicles for the accumulative queue count were obtained for the movements that depart from the Medical Emporium approach. The value was multiplied with the measurement interval giving 300 vehicles. This value was multiplied per 15 seconds and equals four thousand and five hundred (4,500) vehicles per second in queue during the hour. Therefore, the total of departing vehicles during the analysis period measured was fifty six (56) vehicles that departed from this approach. The average stopped delay per vehicle was calculated giving 4,500 vehicle-second. This value was divided by 56 vehicles, obtaining eighteen point thirty six (80.36) seconds. This result is the average stopped delay per vehicle for the movements departing from the Medical Emporium in the study performed on Tuesday, September 20, 2005.

Table 5-1 Results for the Delay Study

Morning Period	Approach	Accumulative Queue Vehicles	Vehicles second	Total of exiting vehicle	Average Stopped delay per vehicle (sec)
Movements to:	"Centro Médico" Hospital	1,256	18,840	328	57.44
	Medical Emporium	1,333	19,995	252	79.35
Movements out:	"Centro Médico" Hospital	744	11,160	148	75.41
	Medical Emporium	300	4,500	56	80.36

The maneuvers departing “Centro Médico” Hospital include seven hundred with forty four (744) the vehicles were in the accumulative queue, and one hundred forty eight (148) vehicles departed this approach. The vehicles amounts per second in queue were eleventh thousand and one hundred sixteen (11,160) vehicles per second. The average stopped delay per vehicle was seventy five point forty one (75.41) seconds.

The maneuvers towards “Centro Médico” Hospital include one thousand and two hundred with fifty six (1,256) vehicles were in the accumulative queue, and three hundred twenty eight (328) vehicles departed from this approach. The amounts of vehicles per second in queue were eighteen thousand and eight hundred forty (18,840) vehicles per second. The average stopped delay per vehicle is fifty seven point forty four (57.44) seconds.

The maneuvers towards Medical Emporium include one thousand and three hundred with thirty three (1,333) vehicles were in the accumulative queue, and two hundred fifty two (252) vehicles departed from this approach. The vehicles amounts per second in queue were nineteen thousand and nine hundred ninety five (19,995) vehicles per second. The average stopped delay per vehicle is seventy nine point thirty five (79.35) seconds.

5.4. Delay Data Study for the PR-2 Intersection with the Western Plaza

5.4.1. Morning Week Day Period

For the morning and evening peak period, to measure how well the VISSIM software represented the conditions of a non-normal geometric intersection in a commercial area. The maneuvers analyzed corresponding for the intersection of the PR-2 with the Western Plaza are shown in Figure 5.2.

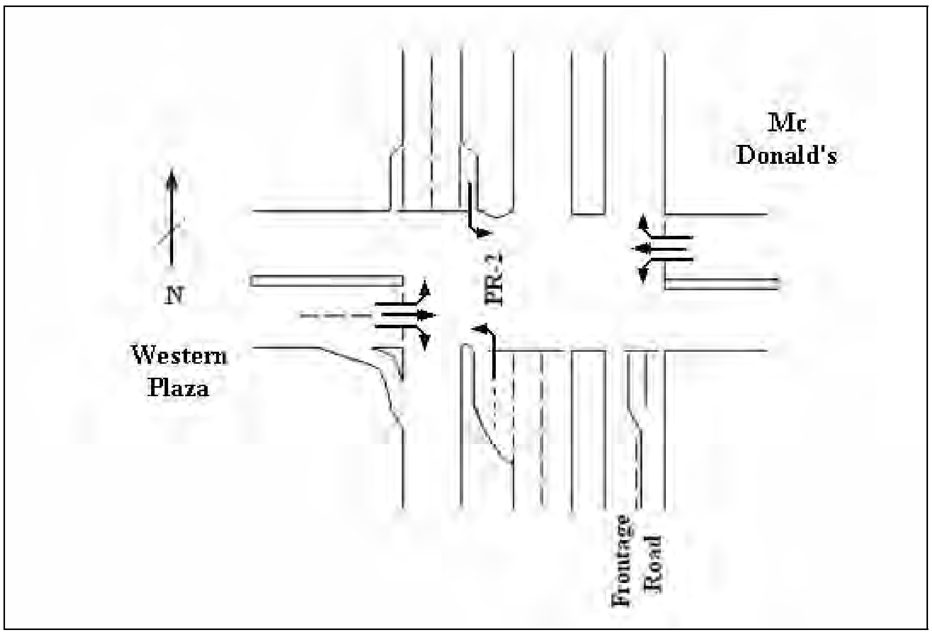

Figure 5.2 Schematic representation for the Delay Study

The data gathered and corresponding calculations are the following:

In the morning period, the counts were performed in fifteen (15) seconds intervals for each of the approaches obtaining two thousand and two hundred sixty two (2262) vehicles for the accumulative queue count. This value was multiplied with the measurement's interval of 2262 vehicles and multiplied per 15 seconds. This resulted in thirty three thousand and nine hundred thirty (33,930) vehicles per second in queue during the hour. Therefore, the total of vehicles that departed from this approach during the analysis period was two hundred three (203). The average stopped delay per vehicle was 33,930 vehicle per second divided by 203 vehicles and equals one hundred and sixty seven point fourteen (167.14) seconds. The average stopped delay per vehicle for the maneuvers towards the Mc Donald’s in the study performed on October 27, 2005.

Table 5-2 Results for the Delay Study for the morning period at the PR-2 intersection with the Western Plaza

Morning Period	Approach	Accumulative Queue Vehicles	Vehicles second	Total of exiting vehicle	Average Stopped delay per vehicle (sec)
Movements to:	Mc Donald's	2,262	33,930	203	167.14
	Western Plaza	1,041	15,615	197	79.26
Movements out:	Mc Donald's	1,387	20,805	211	98.60
	Western Plaza	1,131	16,965	277	61.25

The maneuvers towards the Western Plaza include one thousand and forty one (1041) vehicles were in the accumulative queue and one hundred ninety seven (197) vehicles departed this approach. The amounts of vehicles per second in queue gave us fifteen thousand and six hundred fifteen (15,615) vehicles per second. The average stopped delay per vehicle in the approach was seventy nine point twenty six (79.26) seconds.

The maneuvers towards Mc Donald’s include one thousand and three hundred eighty seven (1,387) vehicles in the accumulative queue, and two hundred eleventh (211) vehicles departed from this approach. The vehicle amounts per second in queue equals twenty thousand

and eight hundred five (20,805) vehicles per second. The approach finding that the average stopped delay per vehicle was ninety eight point sixty (98.60) seconds.

The maneuvers departing from the Western Plaza include one thousand and one hundred thirty one (1,131) vehicles in the accumulative queue and two hundred seventy seven (277) vehicles went out of this approach. The vehicle amounts per second in queue equal sixteen thousand and nine hundred sixty five (16,965) vehicles per second. The average stopped delay per vehicle is sixty one point twenty five (61.25) seconds.

5.4.2. Evening Week Day Period

For the evening peak period, the vehicle counts were done for fifteen (15) seconds intervals for the approach that allowed movements to Mc Donald's obtaining five hundred twenty nine (529) vehicles for the accumulative queue count. Seven thousand and nine hundred thirty five (7,935) vehicles per second in queue during the hour were obtained. Ninety seven (97) vehicles departed from this approach. On the study realized on November 17, 2005 for these maneuvers, the average stopped delay per vehicle obtained was eighty one point eighty (81.80) seconds.

Table 5-3 Results for the Delay Study for the evening period at the PR-2 intersection with the Western Plaza

Evening Period	Approach	Accumulative Queue Vehicles	Vehicles second	Total of exiting vehicle	Average Stopped delay per vehicle (sec)
Movements to:	Mc Donald's	529	7,935	97	81.80
	Western Plaza	4,506	67,590	459	147.25
Movements out:	Mc Donald's	972	14,580	178	81.91
	Western Plaza	2,985	44,775	454	98.62

The maneuvers towards the Western Plaza include four thousand and five hundred six (4,506) vehicles that were in the accumulative queue and four hundred fifty nine (459) vehicles from this approach. The amounts of vehicles per second in queue was sixty seven thousand and five hundred ninety (67,590) vehicles per second. The average stopped delay per vehicle was one hundred forty seven point twenty five (147.25) seconds.

The maneuvers departing from Mc Donald's include nine hundred seventy two (972) vehicles that were in the accumulative queue and one hundred seventy eight (178) vehicles departing from this approach. The amount of vehicles per second in queue giving was fourteen thousand and five hundred eighty (14,580) vehicles per second. The average stopped delay per vehicle was eighty one point ninety one (81.91) seconds.

The maneuvers departing from Western Plaza include two thousand and nine hundred eighty five (2,985) vehicles that were in the accumulative queue and four hundred fifty four (454) vehicles got out of this approach. The amount of vehicles per second in queue was forty four thousand and seven hundred seventy five (44,775) vehicles per second. The average stopped delay per vehicle is ninety eight point sixty two (98.62) seconds.

This chapter provided a detailed explanation of the delay study for the intersections that were selected. The following results are major highlights of this study: in the "Centro Medico" intersection, the maneuver with the greatest delay was departing from the Medical Emporium access with a value of 80.36 seconds for the morning period; in the Western Plaza intersection the movements trying to get to the Mc Donald's approach from the PR-2 North (left turn) had the greatest delay with a value of 167.14 second for the morning period. The next Chapter presents the statistical analysis between the field data and the VISSIM output, and between the field data and the aaSIDRA output.

Chapter 6 **Analysis**

6.1. Statistics General Information

Descriptive statistics are used to describe the basic features of the study data. They provide simple summaries about the sample and the measures. With descriptive statistics you are simply describing what is or what the data shows. Descriptive statistics are typically distinguished from inferential statistics.

Inferential statistics test hypotheses about differences or relationships in populations on the basis of measurements made on samples, and can help us decide if a difference or relationship could be considered real or just a chance fluctuation (Price, 2000). With inferential statistics, you are trying to reach conclusions that extend beyond the immediate data alone. For instance, the use of inferential statistics to try to infer from the sample data what the population might think (Trochim, 2002). This chapter presents the analysis performed using inferential statistics to test if a significant difference exists between the field data and the VISSIM output. Another comparison was done to test the aaSIDRA software.

6.2. VISSIM Statistical Analysis

After performing the VISSIM intersections simulation during the peak period and with the delay study data gathered, a T-Test Statistical Analysis was performed. In this section, a comparison between the field measurement and the VISSIM output delay was performed. The Table 6-1 shows the data used to make the statistical analysis.

Table 6-1 Data used for the Paired *t*-test Statistical Analysis

Movements	Average Stopped delay per vehicle in seconds		
	VISSIM output	Field Data	Difference
Towards			
Medical Emporium	75	79.35	-4.35
“Centro Medico” Hospital	58.1	57.44	0.66
Departing			
Medical Emporium	87.2	80.36	6.84
“Centro Medico” Hospital	42.9	75.41	-32.51
Towards			
Medical Emporium	71.5	79.35	-7.85
“Centro Medico” Hospital	67.1	57.44	9.66
Departing			
Medical Emporium	85.1	80.36	4.74
“Centro Medico” Hospital	44.7	75.41	-30.71
Towards			
Medical Emporium	82.2	79.35	2.85
“Centro Medico” Hospital	67.6	57.44	10.16
Departing			
Medical Emporium	102.8	80.36	22.44
“Centro Medico” Hospital	42.7	75.41	-32.71
Towards			
Medical Emporium	79.4	79.35	0.05
“Centro Medico” Hospital	70.1	57.44	12.66
Departing			
Medical Emporium	91.7	80.36	11.34
“Centro Medico” Hospital	42.5	75.41	-32.91
Towards			
Medical Emporium	80.2	79.35	0.85
“Centro Medico” Hospital	71.4	57.44	13.96
Departing			
Medical Emporium	94.5	81.8	11.94
“Centro Medico” Hospital	54	75.41	-21.41

Movements	Average Stopped delay per vehicle in seconds		
	VISSIM output	Field Data	Difference
Towards			
Mc Donald’s	137.4	167.14	-29.74
Western Plaza	78	79.26	-1.26
Departing			
Mc Donald’s	99	98.6	0.4
Western Plaza	71.4	61.25	10.15
Towards			
Mc Donald’s	131	167.14	-36.14
Western Plaza	73.9	79.26	-5.36
Departing			
Mc Donald’s	84	98.6	-14.6
Western Plaza	71.8	61.25	10.55
Towards			
Mc Donald’s	217.8	167.14	50.66
Western Plaza	73.8	79.26	-5.46
Departing			
Mc Donald’s	230.2	98.6	131.6
Western Plaza	74	61.25	12.75
Towards			
Mc Donald’s	123.3	167.14	-43.84
Western Plaza	83.1	79.26	3.84
Departing			
Mc Donald’s	149.8	98.6	51.2
Western Plaza	74.1	61.25	12.85
Towards			
Mc Donald’s	125.2	167.14	-41.94
Western Plaza	78.9	79.26	-0.36
Departing			
Mc Donald’s	109.3	98.6	10.7
Western Plaza	76.8	61.25	15.55

Movements	Average Stopped delay per vehicle in seconds		
	VISSIM output	Field Data	Difference
Towards			
Mc Donald’s	94.5	81.8	12.7
Western Plaza	174.3	147.25	27.05
Departing			
Mc Donald’s	82.1	81.91	0.19
Western Plaza	86.8	98.62	-11.82
Towards			
Mc Donald’s	104	81.8	22.2
Western Plaza	188.8	147.25	41.55
Departing			
Mc Donald’s	77.2	81.91	-4.71
Western Plaza	98.7	98.62	0.08
Towards			
Mc Donald’s	90	81.8	8.2
Western Plaza	108.2	147.25	-39.05
Departing			
Mc Donald’s	119.4	81.91	37.49
Western Plaza	133.4	98.62	34.78
Towards			
Mc Donald’s	100	81.8	18.2
Western Plaza	165.8	147.25	18.55
Departing			
Mc Donald’s	105.6	81.91	23.69
Western Plaza	83.5	98.62	-15.12
Towards			
Mc Donald’s	101.7	81.8	19.9
Western Plaza	144.8	147.25	-2.45
Departing			
Mc Donald’s	111.8	81.91	29.89
Western Plaza	85.6	98.62	-13.02

Table 6-1 presents the data used for the ***t***-test: Paired Two Samples for means analysis. Figure 6.1 (from MINITAB 14) shows a comparative box plots for the Field data and the VISSIM output. These comparative box plots give an excellent visual summary of the distribution, its central value, and variability between VISSIM output and Field data. The ***t***-test: Paired Two Samples for means analyses gave an exact comparison between these two samples.

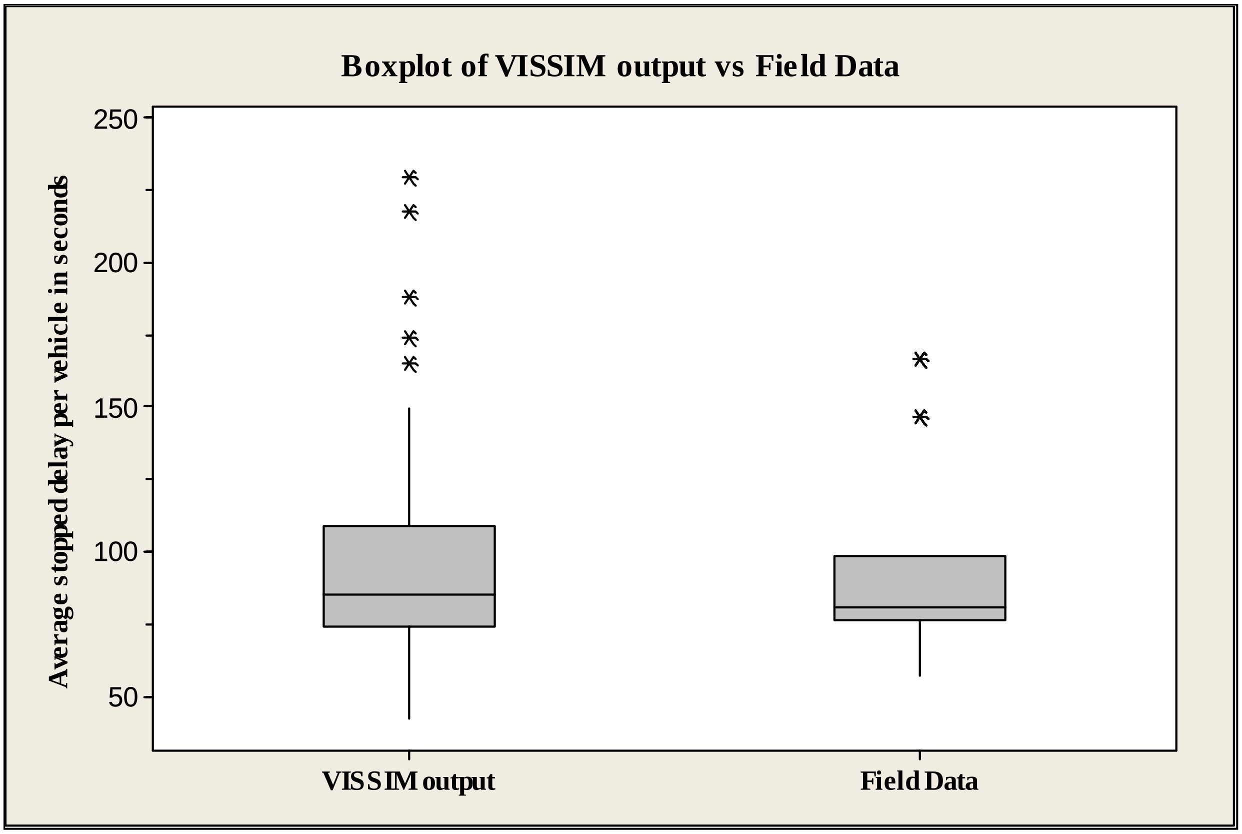

Figure 6.1 Comparative box plot for the Field data and VISSIM output

After the difference for each of the approach were calculated, the mean difference, $\overline{d}$, was calculated, which is the sum of all the scores divided by the number of scores. The formula in summation notation is:

$$\mu = \overline{d} = \frac{1}{n}\sum_{i=1}^{n}(d_i) \qquad \textbf{Equation 6-1}$$

where μ / $\overline{d}$ is the mean (population or sample respectively) and n is the number of scores. The mean for the difference corresponding to the PR-2 was 4.76. This value is used later on to calculate the ***t*** statistic, with $n-1$ degrees of freedom fifty-nine (59) and a confidence interval of ninety five percent (95%). To perform the Hypothesis test, first it is needed to find other values used in the formula of the ***t*** statistic which are the standard deviation and the standard error of the mean difference.

The standard deviation of the differences, s_d , need to be calculated but first, the variance was calculated. The variance is a measure of how spread out a distribution is. It was computed as the average squared deviation of each number from its mean. The formula for the variance is:

$$\sigma^2 = s_d^2 = \frac{1}{N}\sum_{i=1}^{n}\left(d_i - \bar{d}\right)^2 \qquad \textbf{Equation 6-2}$$

where σ^2 / s^2 is the variance (population or sample respectively). The variance for the difference corresponding to the PR-2 was 757.87. Then the standard deviation was calculated. The formula for the standard deviation is very simple: it is the square root of the variance.

$$\sigma = s = \sqrt{\sigma_d^2} = \sqrt{s_d^2} = \sqrt{\frac{1}{N}\sum_{i=1}^{n}\left(d_i - \bar{d}\right)^2} \qquad \textbf{Equation 6-3}$$

The standard deviation for the difference corresponding to the PR-2 was 27.53. Then, the standard error of the mean difference ($SE(\bar{d})$) was calculated. The $SE(\bar{d})$ of a random variable is a measure of how far it is likely to be from its expected value; that is, its scatter in repeated experiments. The $SE(\bar{d})$ is defined as:

$$SE(\bar{d}) = \frac{s_d}{\sqrt{n}} \qquad \textbf{Equation 6-4}$$

The standard error for the difference corresponding to the PR-2 was 3.55. Finally, calculate the *t*-statistic, which is given by:

$$t = \frac{\bar{d}}{SE(d)}. \qquad \textbf{Equation 6-5}$$

The ***t***-statistic value for the difference corresponding to the PR-2 was 1.34, and using the tables of the *t*-distribution we found a *t*-theoretical of 2.00 for the paired t-test. The statistical results are shown in detail at the Table 6-2, and 6-3.

Table 6-2 Statistical Results for the differences between the Field Data and the VISSIM Output at the Intersections in the PR-2

	VISSIM output	Field data	Difference	
Mean	97.13	92.37	4.76	$\bar{d}$
Variance	1518.79	1005.36	757.87	s_d^2
Standard Deviation	38.97	31.71	27.53	$\sqrt{s_d^2}$
Standard Error	5.03	4.09	3.55	$SE(\bar{d})$
t-statistic	***t*** = 1.34			

Table 6-3 T-Test: Paired Two Samples for Means difference between the Field data and VISSIM output

	VISSIM output	*Field Data*
Mean	97.13	92.37
Variance	1518.79	1005.36
Observations	60	60
Pearson Correlation	0.71	
Hypothesized Mean Difference	0	
Df	59	
t Stat	1.34	
P(T<=t) one-tail	0.09	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.19	
t Critical two-tail	2.00	

Data obtained from Excel

Since α=0.025, H_0 could be rejected if $t_0 > t_{0.025,\ 59}$=2.00 or if $t_0 < -t_{0.025,\ 59}$= -2.00. After performing the statistical analysis for the ***t***-Test, the null hypothesis analysis (H_0: $\mu_d = 0$) was performed; the result demonstrated that there is not enough information to say that exist difference between the Field data and VISSIM output, since 1.34 is less than 2.00, the null hypothesis cannot be rejected (the ***t*** statistic was between the ***t*** theoretical -2.00 to 2.00). This evidenced that there are not significant difference (at the 95% confidence level) between the Field data and VISSIM output.

6.3. aaSIDRA Statistical Analysis

After performing the aaSIDRA intersections simulation (see Figure 6.2) during the peak period and with the delay study data gathered, a Paired *T*-Test Statistical Analysis was performed. In this section a comparison between the field measurement and the aaSIDRA output delay was performed.

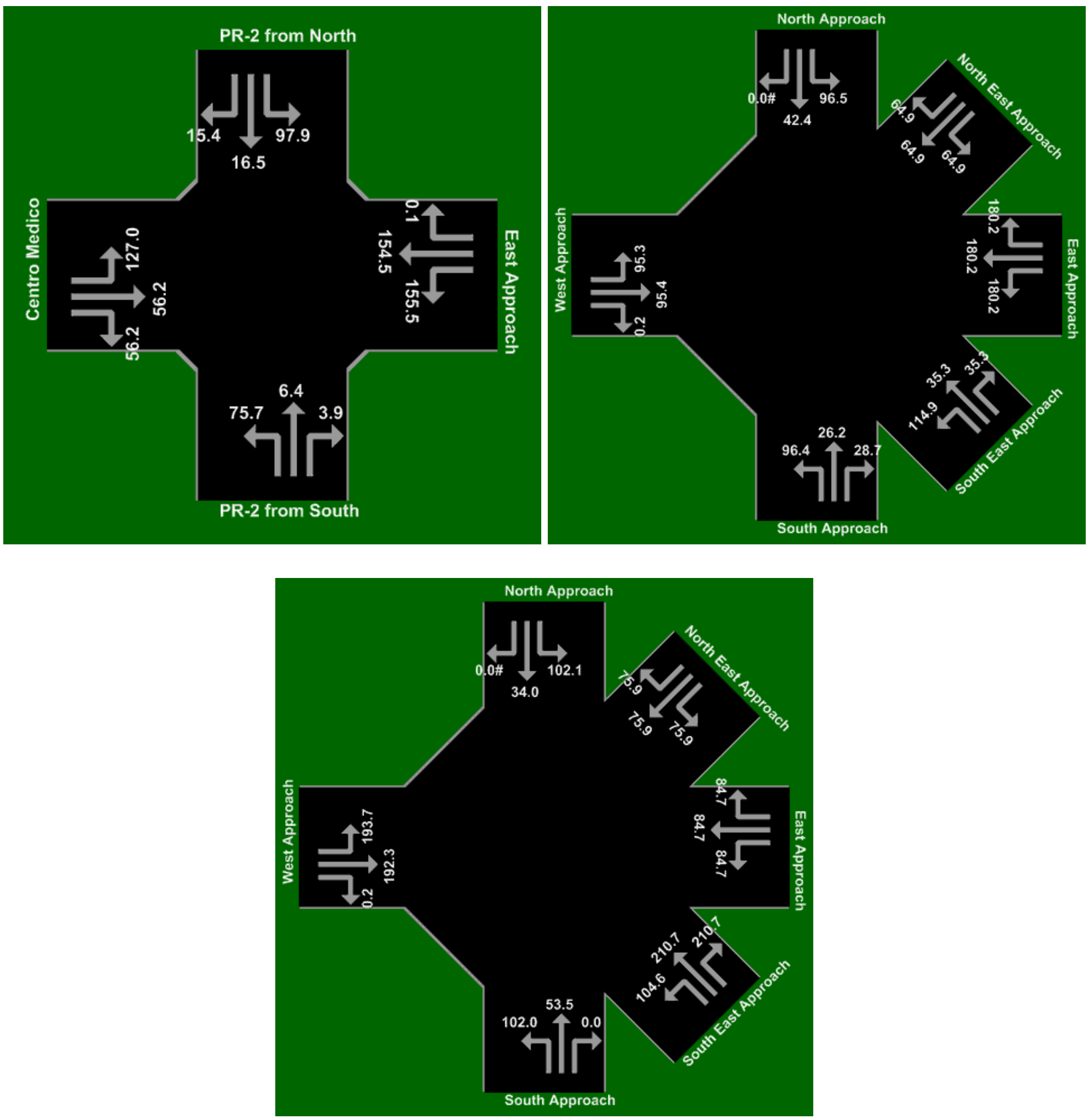

Figure 6.2 aaSIDRA Average stop-line delay per vehicle output for the PR-2 Intersections selected

With the calculated difference between the two observations (d = Field - aaSIDRA) showed on Table 6-4, the procedure to test the null hypothesis that the true mean difference is zero begins.

Table 6-4 Average Stopped delay per vehicle in seconds

Approach	Average Stopped delay per vehicle in seconds		
	Field Data	aaSIDRA output	Difference
Towards			
Medical Emporium	79.35	97.90	-18.55
"Centro Medico" Hospital	57.44	75.70	-18.26
Departing			
Medical Emporium	80.36	155.00	-74.64
"Centro Medico" Hospital	75.41	79.80	-4.39
Towards			
Mc Donald's	167.14	96.50	70.64
Western Plaza	79.26	96.40	-17.14
Departing			
Mc Donald's	98.60	180.20	-81.60
Western Plaza	61.25	95.35	-34.10
Towards			
Mc Donald's	81.80	102.10	-20.30
Western Plaza	147.25	102.00	45.25
Departing			
Mc Donald's	81.91	84.70	-2.79
Western Plaza	98.62	193.00	-94.38

Table 6-4 presents the data used for the ***t***-test: Paired Two Samples for means analysis. Figure 6.3 (from MINITAB 14) shows a comparative box plots for the field data and the aaSIDRA output. These comparative box plots give an excellent visual summary of the distribution, its central value, and variability between Field data and aaSIDRA output. The ***t***-test: Paired Two Samples for means analyses gave an exact comparison between these two samples.

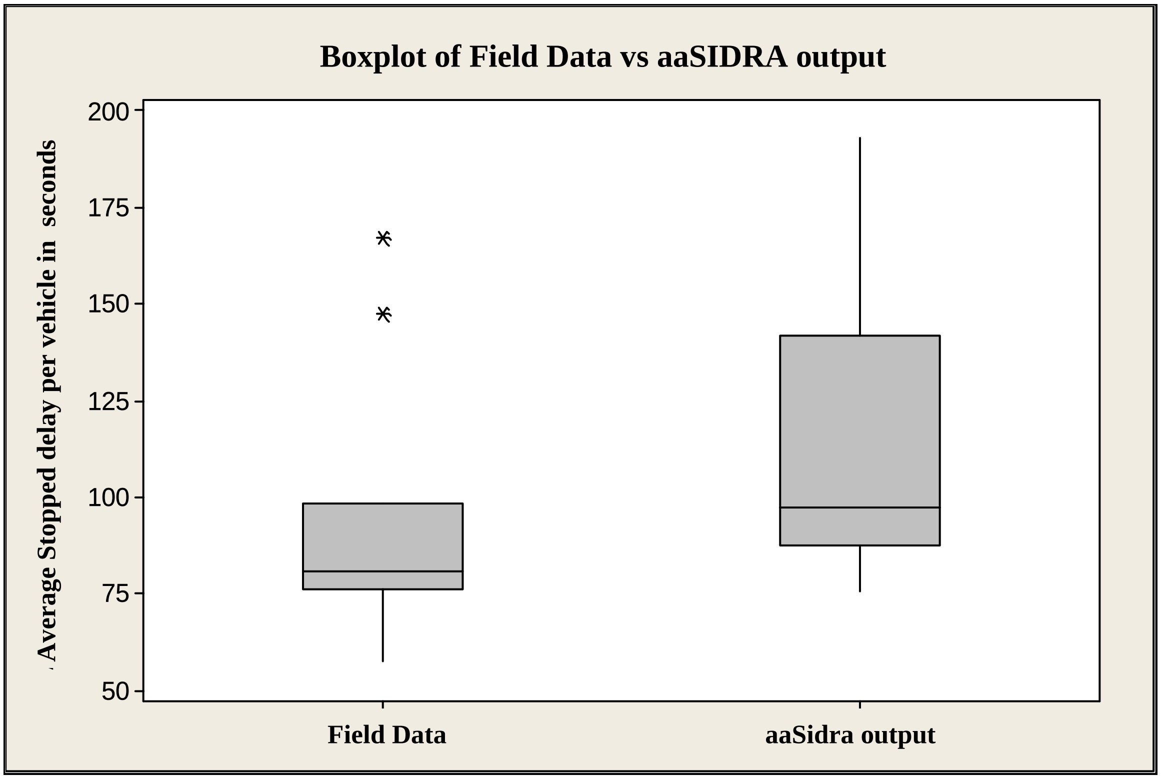

Figure 6.3 Comparative box plot for the Field data and aaSIDRA output

After the approach differences were calculated, the mean difference, $\bar{d}$, was calculated. The mean difference between the Field data and the aaSIDRA output was -20.86. This value is used later on to calculate the ***t*** statistic, with $n-1$ degrees of freedom (11) and a confidence interval of ninety five percent (95%). Then standard deviation result of 48.17 was found. Furthermore, the variance difference between the Field data and the aaSIDRA output was calculated, this resulted in a value of 2320.81.

Then the standard error of the mean difference ($SE(\bar{d})$) result was 13.91. Finally, the ***t***-statistic, differences between the Field data and the aaSIDRA output was calculated giving a value of -1.50. The statistical results are shown in detail at the Table 6-5, and 6-6.

Table 6-5 Statistical Results for the differences between the Field Data and the aaSIDRA Output at the Intersections in the PR-2

	Field data	aaSIDRA output	Difference	
Mean	92.37	113.22	-20.86	$\bar{d}$
Variance	1078.47	1572.80	2320.81	s_d^2
Standard Deviation	32.84	39.66	48.17	$\sqrt{s_d^2}$
Standard Error	9.48	11.45	13.91	$SE(\bar{d})$
***t*-statistic**	***t*** = -1.50			

Table 6-6 T-Test: Paired Two Samples for Means difference between the Field data and aaSIDRA output

	Field Data	*aaSIDRA output*
Mean	92.37	113.22
Variance	1078.47	1572.80
Observations	12	12
Pearson Correlation	0.13	
Hypothesized Mean Difference	0	
Df	11	
t Stat	-1.50	
P(T<=t) one-tail	0.08	
t Critical one-tail	1.80	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.20	

Data obtained from Excel

Since α=0.025, H_0 could be rejected if $t_0 > t_{0.025,\ 11}$=2.20 or if $t_0 < -t_{0.025,\ 11}$= -2.20. After performing the statistical analysis for the ***t***-Test, the null hypothesis analysis (H_0: $\mu_d = 0$) was performed, the result demonstrate that there was no difference between the field data and the aaSIDRA output (-2.20 < -1.50 < 2.20). This evidenced that there is not enough information to say that exist difference between the field data and aaSIDRA output, since -1.50 is less than 2.20, the null hypothesis cannot be rejected (the ***t*** statistic was between the ***t*** theoretical -2.20 to 2.20). This evidenced that there are not significant difference (at the 95% confidence level) between the Field data and aaSIDRA output.

To conclude with the statistic analysis of this section, the results for a Paired T-test was seen for both programs showing evidence that there was not enough information to say that exist difference between the field data and output. For this reason the null hypothesis cannot be rejected. This evidenced that there are not significant difference (at the 95% confidence level) between the field data and the programs output.

6.4. Analysis during Simulation process

The person performing the simulation has to be acquainted with intersection maneuvers and geometry in order to represent an accurate simulation. The entire network is constructed in VISSIM, the links have to be defined first, followed by the connectors. Connectors are used to define vehicle maneuvers.

During the simulation process maneuvers are simulated similar to those conditions observed in the field during the study period, the program user can say that the simulation correctly represents the field reality. For example, during the simulation process in 3D graphics a queue on the left turn lane and the blocking effect caused can be seen (see Figure 6.4). The queue occurs on the PR-2 “Centro Médico” Hospital intersection where the vehicles filled the left turn lane and blocked part of the lane that gives access to it.

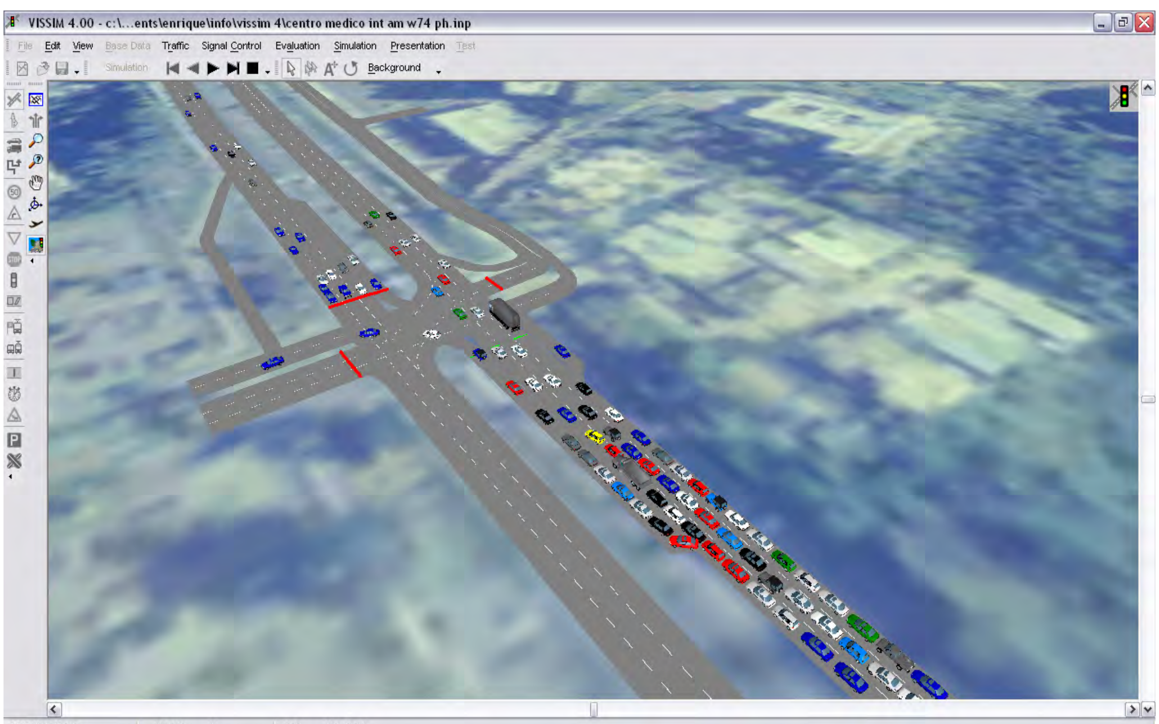

Figure 6.4 PR-2 with “Centro Médico” intersection turn lane to “Centro Médico” Hospital filled.

On the Western Plaza intersection a particular event during the week morning peak hours occurred. Drivers coming from the north access of the PR-2 and heading eastbound noticed that the left turn lane was congested. Taking into consideration that the green time was short, the drivers opted to enter Western Plaza, make a U-turn (see Figure 6.5) and avoid the congestion on the PR-2 left turn lane making a semi-direct turn. This maneuver is not usual; only drivers that travel daily using this route make this maneuver to reduce the travel time and delay. This maneuver was modeled using the connector interaction that exclusively allows some drivers to make those movements and using direction decisions rules.

Figure 6.5 Western Plaza U-turn Movement inside Western Plaza Approach

Figure 6.6 Left turn movements priority from straight movements

Using priority rules in VISSIM, the right of way to maneuvers that are secondary movements could be represented. For example, in the Western Plaza intersection the vehicle getting out from the Western Plaza approach make a left turn instead of giving the right of way corresponding to the vehicles that are getting out from the Mc Donald’s approach going straight to the Western Plaza (see Figure 6.6). An additional advantage of this program is that it provides for representation of pedestrians as well as busses, and light rail systems (see Figure 6.7).

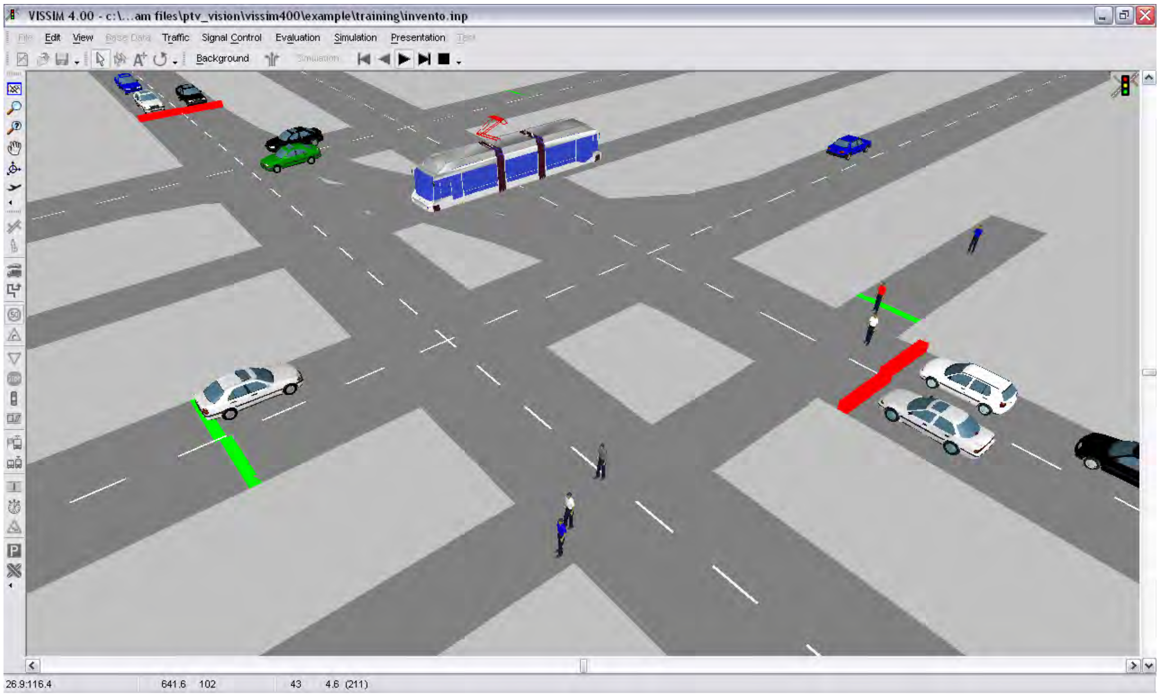

Figure 6.7 Other applications of VISSIM: modeling Transit and pedestrians

Figure 6.8 Spill back simulation at intersections

Other advantage of this program is that it allows modeling the effect of spill back at intersections (see Figure 6.8).

VISSIM is designed to provide several runs for the same model by changing the random generator seed to perform better analysis, meanwhile aaSIDRA only produces one result per condition. This situation is part of the nature of each program aaSIDRA is macroscopic with no variability meanwhile VISSIM is microscopic where each vehicle is represented independently. During the analysis of the Western Plaza intersection aaSIDRA presented various problems due to the complex geometrics characteristics of this intersection. The intersection has a frontage road difficult to represent using the aaSIDRA since the program represents it as additional legs converging at the intersection. This representation forces the use of some traffic flows that are not allowed in the intersection. If in the modeling process such flows are not provided, the program will not run. For this reason some delay results do not represent what was really happening at the intersection. In that sense, this research project also establishes a precedent for future works in the validation or calibration of aaSIDRA to the Puerto Rico's environment. No evidence was found of this type of work in the past.

This chapter provides a detailed statistic analysis for a Paired ***t***-test for the evaluation of both programs. The results demonstrated that there is not enough information to say that exist difference between the field data and VISSIM output, and between the field data and aaSIDRA output. For this reason the null hypothesis cannot be rejected.

The next Chapters discuss the overall conclusions, and identify the contributions of this research for the adaptation of the VISSIM program for Puerto Rico's traffic environment. Therefore, it presents the recommendations for future researches as well as identifies research needs and possible research directions.

Chapter 7 **Conclusions**

The research's main objectives were achieved. VISSIM program was validated for the Puerto Rican driving-behavior environment at intersections. As part of this research the adaptation of "VISSIM" considering the differences between the behavior and traffic rules in Puerto Rico vs. Germany were done. The ability of VISSIM to represent the traffic behavior at major arterial street intersection conditions in Puerto Rico was determined.

The test bed site located on roadway PR-2, a major arterial street at Mayagüez, was differentiated in two segments by its geometric characteristics. In the first segment the PR-2 - "Centro Médico" Hospital intersection was first tested and analyzed with VISSIM and then tested with aaSIDRA. As mention before this intersection was selected because it was the only one along the segment that was not a "T" intersection but a four-leg intersection. The second segment corresponds to the analysis of the PR-2 - Western Plaza intersection. This intersection, like the first one, was tested and analyzed with VISSIM and then tested with Akçelik's aaSIDRA program. This intersection was selected because it is the only one in this segment with high geometric complexity that includes a frontage road along the PR-2. The study of this complex intersection allows us to explore how difficult would be its simulation with both programs (VISSIM and aaSIDRA). During the analysis of the Western Plaza intersection using aaSIDRA, the program presented many problems due to the intersection complexity. When frontage road intersection is trying to be represented using aaSIDRA, the program forces to use some traffic flows that were never observed in the intersections. If in this process the person trying to do the simulation does not enter those flows, the program does not run and it would not give any outputs.

The null hypothesis used for the analysis (H_0: μ_d=0) said that there was no difference between the field data and the VISSIM output, and also between the Field data and aaSIDRA outputs. The result for the paired ***t***-test result demonstrated that there was no difference between the Field data and the VISSIM output ($-2.00 < 1.34 < 2.00$).

For the analysis performed using aaSIDRA, the values for the paired ***t***-test result analysis demonstrated that there was no difference between the Field data and the aaSIDRA output ($-2.20 < -1.50 < 2.20$). Comparing the results of aaSIDRA and VISSIM against the field data, the results from VISSIM present less variability.

According to the results obtained, the null hypothesis cannot be rejected. Therefore, there is evidence that there was not enough information to indicate significant difference (at the 95% confidence level) between the field data and the output obtained in both programs.

An advantage of VISSIM during the simulation process is the use of priority rules signs located in the intersections. Other advantage of VISSIM was its ability for three dimensional representations (3D view) because the intersection surroundings are clearly seen.

Chapter 8 **Recommendations**

After the research analysis was performed, the use of the VISSIM software could be recommended. The VISSIM simulation can be performed due to its well represented 3D visual graphics simulation for the actual conditions of any network. Other simulations can be performed for the entire arterial network or in the entire segments where the arterial was divided. Future research should be performed, taking into account the potential impact of downstream congestion in both directions of the intersection operation. Furthermore, a comparison can be made using other of the mentioned microsimulation programs versus VISSIM.

Other simulations can be performed for future work in networks, highways, and arterial systems incorporating the use of urban transit and pedestrians to evaluate how the VISSIM program represents them. A recommendation for the Puerto Rico Highway and Transportation Authority (PRHTA) traffic simulation analyst is that the analyst has to go first to the field to observe and analyze all the maneuvers that are done by the drivers to be familiarized with the environment. Then, make the simulation using VISSIM and in the running process of the simulation perform a visual evaluation comparing what was seen at the field vs. the program visual representation (3D). This procedure simplifies the verification process visually indicating if the simulation is performed correctly.

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Appendix

Delay Study Data

Intersection: **PR-2 and the"Centro Médico" Hospital**

Movements to: "Centro Médico" Hospital

Date: September 20, 2005

Delay Data

Minutes	**Seconds into Minutes**				
	15	**30**	**45**	**60**	SUM
7:25	0	0	0	0	0
7:26	0	0	0	1	1
7:27	3	8	10	12	33
7:28	14	16	17	17	64
7:29	9	6	0	8	23
7:30	12	14	0	0	26
7:31	0	3	6	6	15
7:32	9	9	0	0	18
7:33	0	0	0	1	1
7:34	7	0	0	0	7
7:35	3	6	0	0	9
7:36	0	0	0	2	2
7:37	5	6	0	1	12
7:38	0	1	1	1	3
7:39	2	7	9	13	31
7:40	15	18	19	22	74
7:41	27	0	0	0	27
7:42	0	0	6	8	14
7:43	0	6	8	10	24
7:44	16	20	21	0	57
7:45	0	3	0	0	3
7:46	0	0	0	2	2
7:47	6	10	11	15	42
7:48	18	22	22	0	62
7:49	0	0	0	0	0
7:50	4	0	0	0	4
7:51	4	7	11	13	35
7:52	14	14	16	19	63
7:53	19	0	0	0	19
7:54	0	0	2	0	2
7:55	0	0	1	2	3
7:56	0	0	0	0	0
7:57	0	0	0	1	1
7:58	6	10	13	16	45
7:59	17	18	18	0	53

8:00	0	0	0	0	0
8:01	0	0	0	0	0
8:02	0	3	8	0	11
8:03	0	0	0	0	0
8:04	0	3	4	6	13
8:05	10	14	14	20	58
8:06	23	0	0	0	23
8:07	4	9	14	20	47
8:08	24	24	0	0	48
8:09	0	4	6	0	10
8:10	0	0	3	5	8
8:11	8	9	10	10	37
8:12	11	12	12	16	51
8:13	17	19	0	0	36
8:14	0	3	0	0	3
8:15	0	0	0	0	0
8:16	0	1	3	4	8
8:17	6	8	8	10	32
8:18	12	15	0	0	27
8:19	0	0	0	0	0
8:20	0	0	0	2	2
8:21	3	6	7	10	26
8:22	13	13	15	0	41
8:23	0	0	0	0	0
8:24	0	0	0	0	0

1256 Vehicles

1256 x 15 sec

18840 Vehicle-second

Total of exiting vehicle was **328** Vehicles

19155 / 328

Average Stopped delay per vehicle is **57.44** sec

Intersection: **PR-2 and the"Centro Médico" Hospital**
Movements to: Medical Emporium
Date: September 20, 2005

Delay Data

Minutes	Seconds into Minutes				
	15	30	45	60	SUM
7:25	0	1	0	0	1
7:26	0	0	1	2	3
7:27	3	3	3	3	12
7:28	5	8	11	12	36
7:29	8	4	0	1	13
7:30	1	1	1	1	4
7:31	1	1	4	8	14
7:32	8	0	0	0	8
7:33	0	0	2	4	6
7:34	6	6	6	6	24
7:35	6	0	0	1	7
7:36	3	3	3	3	12
7:37	7	7	7	0	21
7:38	0	0	1	1	2
7:39	4	4	6	6	20
7:40	7	9	9	10	35
7:41	13	13	13	0	39
7:42	0	0	0	0	0
7:43	0	0	0	1	1
7:44	2	5	0	0	7
7:45	1	2	0	1	4
7:46	1	2	4	8	15
7:47	9	12	12	14	47
7:48	15	16	16	17	64
7:49	21	0	0	0	21
7:50	0	0	0	0	0
7:51	0	1	3	6	10
7:52	10	11	15	19	55
7:53	22	14	0	0	36
7:54	0	0	0	0	0
7:55	0	2	5	0	7
7:56	0	0	0	0	0
7:57	0	0	1	3	4
7:58	9	10	10	11	40
7:59	18	18	18	19	73

8:00	20	22	5	0	47
8:01	0	1	0	1	2
8:02	3	8	11	14	36
8:03	0	0	0	0	0
8:04	0	0	4	7	11
8:05	7	11	11	12	41
8:06	13	16	7	0	36
8:07	0	0	0	0	0
8:08	4	7	0	0	11
8:09	0	0	0	0	0
8:10	0	0	1	2	3
8:11	5	8	11	14	38
8:12	20	24	26	28	98
8:13	29	0	0	0	29
8:14	0	0	0	0	0
8:15	0	0	0	0	0
8:16	2	5	10	15	32
8:17	18	21	21	21	81
8:18	21	0	0	0	21
8:19	0	0	0	0	0
8:20	0	0	3	8	11
8:21	10	17	17	17	61
8:22	17	17	18	19	71
8:23	23	0	0	0	23
8:24	8	9	11	12	40

1333 Vehicles

1360 x 15 sec

19995 Vehicle-second

Total of exiting vehicle was **252** Vehicles

20400 / 252

Average Stopped delay per vehicle is **79.35** sec

Intersection: **PR-2 and the"Centro Médico" Hospital**

Date: September 20, 2005

Time	Movements to MP	
7:20		
7:25	16	16
7:30	31	**15**
7:35	48	**17**
7:40	59	**11**
7:45	82	**23**
7:50	103	**21**
7:55	124	**21**
8:00	144	**20**
8:05	176	**32**
8:10	202	**26**
8:15	230	**28**
8:20	252	**22**
8:25	273	**21**
8:30	300	27

252 Volume

MP- Medical Emporium

Time	Movements to CM	
7:20		
7:25	29	29
7:30	53	**24**
7:35	84	**31**
7:40	99	**15**
7:45	144	**45**
7:50	176	**32**
7:55	208	**32**
8:00	232	**24**
8:05	257	**25**
8:10	291	**34**
8:15	312	**21**
8:20	328	**16**
8:25	344	**16**
8:30	365	21

328 Volume

CM - "Centro Médico" Hospital

Intersection: **PR-2 and the"Centro Médico" Hospital**
Movements out: Medical Emporium
Date: September 20, 2005

Delay Data

Minutes	Seconds into Minutes				
	15	30	45	60	SUM
7:25	0	0	0	0	0
7:26	1	1	1	2	5
7:27	2	3	3	3	11
7:28	3	3	3	3	12
7:29	3	3	4	5	15
7:30	0	0	0	0	0
7:31	0	0	0	0	0
7:32	0	0	0	1	1
7:33	0	0	0	0	0
7:34	2	2	2	2	8
7:35	2	2	3	3	10
7:36	0	0	0	0	0
7:37	0	1	1	1	3
7:38	2	0	0	0	2
7:39	0	0	0	1	1
7:40	3	3	3	3	12
7:41	3	3	4	4	14
7:42	4	4	0	1	9
7:43	1	1	1	1	4
7:44	1	2	2	2	7
7:45	2	0	0	0	2
7:46	0	0	0	0	0
7:47	0	0	0	0	0
7:48	0	0	0	0	0
7:49	0	0	0	1	1
7:50	0	0	0	1	1
7:51	1	1	1	1	4
7:52	1	1	1	1	4
7:53	1	1	1	1	4
7:54	2	0	0	0	2
7:55	0	0	0	1	1
7:56	2	3	3	0	8
7:57	0	0	0	0	0
7:58	0	0	0	0	0
7:59	0	0	0	0	0

8:00	0	0	0	0	0
8:01	0	0	0	0	0
8:02	0	1	1	1	3
8:03	1	2	2	0	5
8:04	0	0	1	1	2
8:05	1	1	1	1	4
8:06	1	2	2	2	7
8:07	0	0	1	1	2
8:08	2	2	2	2	8
8:09	2	2	0	1	5
8:10	1	1	1	1	4
8:11	2	2	2	2	8
8:12	3	3	3	3	12
8:13	3	3	3	3	12
8:14	3	3	3	0	9
8:15	0	0	0	1	1
8:16	1	1	1	1	4
8:17	1	1	2	2	6
8:18	2	2	2	2	8
8:19	2	2	2	0	6
8:20	0	0	1	1	2
8:21	1	2	3	3	9
8:22	3	4	4	5	16
8:23	6	6	6	7	25
8:24	0	0	0	1	1

300 Vehicles

300 x 15 sec

4500 Vehicle-second

Total of exiting vehicle was **56** Vehicles

4500 / 56

Average Stopped delay per vehicle is **80.36** sec

Intersection: **PR-2 and the"Centro Médico" Hospital**

Movements out: "Centro Médico"

Date: September 20, 2005

Delay Data					
Minutes	**Seconds into Minutes**				
	15	**30**	**45**	**60**	SUM
7:25	1	1	2	0	4
7:26	0	1	2	3	6
7:27	4	4	4	5	17
7:28	5	5	6	7	23
7:29	6	5	5	5	21
7:30	5	0	0	0	5
7:31	0	0	1	1	2
7:32	2	2	4	2	10
7:33	0	0	2	2	4
7:34	2	3	3	4	12
7:35	5	6	4	0	15
7:36	0	0	0	0	0
7:37	0	0	2	3	5
7:38	3	1	1	2	7
7:39	4	5	6	6	21
7:40	6	7	7	7	27
7:41	7	7	8	9	31
7:42	9	9	9	0	27
7:43	1	1	2	2	6
7:44	2	1	2	3	8
7:45	3	0	0	0	3
7:46	0	1	1	1	3
7:47	2	2	3	3	10
7:48	3	3	3	3	12
7:49	3	3	3	3	12
7:50	0	0	1	1	2
7:51	2	2	2	3	9
7:52	3	3	3	4	13
7:53	4	4	4	4	16
7:54	5	6	0	0	11
7:55	1	1	1	2	5
7:56	2	3	0	0	5
7:57	0	1	1	2	4
7:58	2	3	3	3	11
7:59	3	3	3	1	10

8:00	3	5	5	6	19
8:01	6	0	0	2	8
8:02	3	5	5	3	16
8:03	3	4	4	0	11
8:04	1	2	3	5	11
8:05	5	6	6	6	23
8:06	6	4	4	4	18
8:07	4	0	0	0	4
8:08	2	4	4	4	14
8:09	4	5	0	1	10
8:10	2	3	3	4	12
8:11	5	5	6	6	22
8:12	6	6	6	6	24
8:13	7	7	5	4	23
8:14	5	6	6	6	23
8:15	6	0	0	0	6
8:16	1	1	2	2	6
8:17	2	3	4	4	13
8:18	6	8	8	8	30
8:19	5	6	0	1	12
8:20	1	1	2	2	6
8:21	3	3	4	4	14
8:22	5	5	5	5	20
8:23	6	7	5	4	22
8:24	0	0	0	0	0

744 Vehicles

744 x 15 sec

11160 Vehicle-second

Total of exiting vehicle was **148** Vehicles

11160 / 148

Average Stopped delay per vehicle is **75.41** sec

Intersection: **PR-2 and the"Centro Médico" Hospital**

Date: September 20, 2005

Minutes	**Out MP**
7:25	0
7:26	0
7:27	0
7:28	0
7:29	0
7:30	5
7:31	0
7:32	0
7:33	1
7:34	0
7:35	0
7:36	0
7:37	0
7:38	2
7:39	0
7:40	0
7:41	0
7:42	4
7:43	0
7:44	0
7:45	3
7:46	0
7:47	0
7:48	0
7:49	0
7:50	1
7:51	0
7:52	0
7:53	0
7:54	3
7:55	0
7:56	4
7:57	0
7:58	0

Minutes	**Out MP**	
7:59	0	
8:00	0	
8:01	1	
8:02	0	
8:03	2	
8:04	0	
8:05	0	
8:06	0	
8:07	3	
8:08	0	
8:09	3	
8:10	0	
8:11	0	
8:12	0	
8:13	0	
8:14	2	
8:15	8	
8:16	0	
8:17	0	
8:18	0	
8:19	4	
8:20	2	
8:21	0	
8:22	0	
8:23	0	
8:24	8	
8:25	0	**23**

MP- Medical Emporium

Intersection: **PR-2 and the"Centro Médico" Hospital**

Date: September 20, 2005

Minutes	Out CM
7:25	3
7:26	1
7:27	0
7:28	0
7:29	5
7:30	7
7:31	0
7:32	2
7:33	2
7:34	1
7:35	8
7:36	0
7:37	1
7:38	4
7:39	0
7:40	0
7:41	0
7:42	11
7:43	3
7:44	2
7:45	4
7:46	1
7:47	0
7:48	1
7:49	0
7:50	4
7:51	1
7:52	0
7:53	0
7:54	7
7:55	0
7:56	5
7:57	0
7:58	0

Minutes	Out CM	
7:59	2	
8:00	1	
8:01	8	
8:02	2	
8:03	4	
8:04	0	
8:05	0	
8:06	2	
8:07	12	
8:08	0	
8:09	6	
8:10	0	
8:11	0	
8:12	0	
8:13	3	
8:14	1	
8:15	14	
8:16	0	
8:17	0	
8:18	0	
8:19	13	
8:20	0	
8:21	0	
8:22	0	
8:23	3	
8:24	4	
8:25	0	**73**

CM - "Centro Médico" Hospital

Intersection: **PR-2 and the Western Plaza**
Movements to: Mc Donald's
Date: Thursday, October 27, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	**30**	**45**	**60**	SUM
7:25	0	0	6	12	18
7:26	13	15	15	16	59
7:27	16	16	17	17	66
7:28	17	0	0	3	20
7:29	3	7	8	11	29
7:30	13	16	20	20	69
7:31	23	23	0	14	60
7:32	14	18	18	18	68
7:33	18	18	21	23	80
7:34	23	23	0	0	46
7:35	10	13	14	14	51
7:36	14	14	14	15	57
7:37	15	16	17	22	70
7:38	0	0	10	13	23
7:39	17	17	17	17	68
7:40	18	18	19	20	75
7:41	21	0	0	4	25
7:42	9	10	11	15	45
7:43	15	17	17	19	68
7:44	19	19	0	0	38
7:45	3	8	10	13	34
7:46	13	15	20	22	70
7:47	23	23	23	23	92
7:48	0	0	13	21	34
7:49	21	22	22	22	87
7:50	22	22	22	23	89
7:51	23	23	0	6	52
7:52	13	16	18	20	67
7:53	20	20	21	22	83
7:54	23	23	26	0	72
7:55	0	11	18	17	46
7:56	18	18	21	24	81
7:57	24	24	22	22	92
7:58	0	0	5	5	10

7:59	8	8	10	12	38
8:00	13	13	14	14	54
8:01	15	19	0	0	34
8:02	1	1	1	3	6
8:03	4	5	5	0	14
8:04	0	0	0	0	0
8:05	0	1	2	3	6
8:06	3	5	5	6	19
8:07	0	0	0	0	0
8:08	0	1	2	2	5
8:09	2	4	8	9	23
8:10	9	9	0	0	18
8:11	4	5	5	5	19
8:12	5	5	8	0	18
8:13	0	0	0	1	1
8:14	1	1	4	6	12
8:15	6	6	6	0	18
8:16	0	0	0	0	0
8:17	1	2	2	2	7
8:18	0	0	1	1	2
8:19	1	1	2	2	6
8:20	2	2	3	4	11
8:21	0	0	0	0	0
8:22	0	0	0	0	0
8:23	0	1	1	1	3
8:24	4	0	0	0	4
					2262

2262

2262 x 15 sec

33930 Vehicle-second

Total of exiting vehicle was **203** Vehicles

33930 / 203

Average Stopped delay per vehicle is **167.14** sec

Intersection: **PR-2 and the Western Plaza**
Movements to: Western Plaza
Date: Thursday, October 27, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	30	45	60	SUM
7:25	0	0	0	0	0
7:26	0	1	2	2	5
7:27	2	2	2	3	9
7:28	3	0	0	0	3
7:29	0	0	0	1	1
7:30	1	2	2	3	8
7:31	4	5	0	0	9
7:32	0	2	5	5	12
7:33	5	6	6	7	24
7:34	7	9	0	0	16
7:35	0	0	0	0	0
7:36	1	2	3	3	9
7:37	5	6	6	7	24
7:38	0	1	3	4	8
7:39	4	5	5	5	19
7:40	7	7	7	7	28
7:41	8	0	0	0	8
7:42	0	3	4	6	13
7:43	9	10	10	11	40
7:44	12	14	0	0	26
7:45	0	3	3	3	9
7:46	3	3	4	6	16
7:47	6	7	7	8	28
7:48	0	0	0	0	0
7:49	1	2	5	7	15
7:50	9	10	11	12	42
7:51	14	0	0	1	15
7:52	1	4	8	10	23
7:53	10	12	12	12	46
7:54	12	12	15	0	39
7:55	0	1	1	2	4
7:56	2	2	3	7	14
7:57	8	8	8	0	24
7:58	0	0	0	0	0

7:59	6	7	8	8	29
8:00	8	8	8	9	33
8:01	10	0	0	0	10
8:02	1	2	5	5	13
8:03	5	5	6	0	16
8:04	0	2	3	5	10
8:05	6	7	7	8	28
8:06	8	9	11	14	42
8:07	0	0	0	0	0
8:08	0	3	3	4	10
8:09	4	5	6	7	22
8:10	7	8	0	3	18
8:11	4	5	6	6	21
8:12	7	7	8	0	22
8:13	1	1	1	1	4
8:14	6	8	8	9	31
8:15	11	13	0	0	24
8:16	0	1	1	4	6
8:17	4	4	4	5	17
8:18	1	4	6	9	20
8:19	9	9	9	9	36
8:20	10	10	11	12	43
8:21	0	0	1	1	2
8:22	3	3	3	3	12
8:23	3	4	8	9	24
8:24	11	0	0	0	11
					1041

1041

1041 x 15 sec

15615 Vehicle-second

Total of exiting vehicle was **197** Vehicles

15615 / 197

Average Stopped delay per vehicle is **79.26** sec

Intersection: **PR-2 and the Western Plaza**

Date: Thursday, October 27, 2005

Time	**Movements to WP**	
7:25	/	/
7:30	9	**9**
7:35	23	**14**
7:40	30	**7**
7:45	56	**26**
7:50	64	**8**
7:55	90	**26**
8:00	110	**20**
8:05	132	**22**
8:10	148	**16**
8:15	167	**19**
8:20	172	**5**
8:25	197	**25**

197 Volume

Time	**Movements to McD**	
7:25	/	/
7:30	29	**29**
7:35	48	**19**
7:40	66	**18**
7:45	92	**26**
7:50	101	**9**
7:55	121	**20**
8:00	145	**24**
8:05	165	**20**
8:10	172	**7**
8:15	192	**20**
8:20	194	**2**
8:25	203	**9**

203 Volume

Intersection: **PR-2 and the Western Plaza**
Movements out: Mc Donald's
Date: Thursday, October 27, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	30	45	60	SUM
7:25	1	3	3	4	11
7:26	5	5	5	5	20
7:27	5	5	0	0	10
7:28	1	1	2	3	7
7:29	3	4	6	6	19
7:30	6	7	9	0	22
7:31	0	0	0	1	1
7:32	2	2	3	5	12
7:33	7	7	7	7	28
7:34	0	0	4	5	9
7:35	7	6	6	7	26
7:36	9	9	9	9	36
7:37	0	0	2	3	5
7:38	3	3	5	6	17
7:39	6	10	10	10	36
7:40	10	10	0	0	20
7:41	1	1	2	2	6
7:42	4	4	4	5	17
7:43	7	7	9	0	23
7:44	0	0	3	4	7
7:45	4	4	6	7	21
7:46	9	9	9	9	36
7:47	0	0	1	1	2
7:48	1	5	7	8	21
7:49	8	9	9	9	35
7:50	9	9	0	0	18
7:51	7	7	8	8	30
7:52	9	9	9	9	36
7:53	9	9	10	0	28
7:54	0	1	6	7	14
7:55	7	8	9	10	34
7:56	10	10	10	10	40
7:57	10	0	0	3	13
7:58	7	9	10	10	36

7:59	10	10	10	12	42
8:00	10	10	0	0	20
8:01	6	7	9	9	31
8:02	8	10	10	10	38
8:03	0	0	1	2	3
8:04	7	7	8	8	30
8:05	8	8	8	8	32
8:06	8	0	0	1	9
8:07	5	9	9	9	32
8:08	9	9	9	9	36
8:09	9	9	0	0	18
8:10	0	1	6	9	16
8:11	9	9	9	10	37
8:12	0	0	5	8	13
8:13	10	10	10	10	40
8:14	10	10	10	10	40
8:15	10	0	7	8	25
8:16	10	10	10	10	40
8:17	10	0	0	3	13
8:18	8	8	9	10	35
8:19	10	10	10	10	40
8:20	10	0	4	4	18
8:21	7	7	7	7	28
8:22	8	9	9	9	35
8:23	9	9	0	0	18
8:24	0	0	0	2	2
					1387

1387

1387 x 15 sec

20805 Vehicle-second

Total of exiting vehicle was **211** Vehicles

20805 / 211

Average Stopped delay per vehicle is **98.60** sec

Intersection: **PR-2 and the Western Plaza**
Movements out: Western Plaza
Date: Thursday, October 27, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	**30**	**45**	**60**	SUM
7:25	1	2	2	3	8
7:26	3	4	5	8	20
7:27	8	10	0	0	18
7:28	1	1	2	3	7
7:29	4	5	7	10	26
7:30	11	14	15	0	40
7:31	0	0	0	1	1
7:32	2	3	3	4	12
7:33	6	7	8	8	29
7:34	0	0	1	1	2
7:35	1	4	7	7	19
7:36	7	7	8	9	31
7:37	0	0	1	1	2
7:38	2	2	3	6	13
7:39	6	8	9	9	32
7:40	13	13	0	0	26
7:41	1	2	3	3	9
7:42	3	3	5	7	18
7:43	11	11	13	0	35
7:44	0	2	4	4	10
7:45	5	7	8	10	30
7:46	13	14	15	17	59
7:47	0	0	1	4	5
7:48	4	6	7	8	25
7:49	8	10	14	16	48
7:50	17	18	0	0	35
7:51	0	3	5	6	14
7:52	9	11	14	17	51
7:53	17	20	23	0	60
7:54	0	0	0	2	2
7:55	3	4	6	6	19
7:56	9	12	12	12	45
7:57	16	0	0	0	16
7:58	1	2	4	11	18

7:59	13	13	17	17	60
8:00	17	18	0	0	35
8:01	0	0	1	2	3
8:02	3	6	6	6	21
8:03	0	0	1	1	2
8:04	1	1	1	3	6
8:05	4	4	4	5	17
8:06	6	0	0	0	6
8:07	2	2	4	5	13
8:08	5	5	6	8	24
8:09	8	9	0	0	17
8:10	0	0	1	2	3
8:11	2	2	3	4	11
8:12	0	0	0	1	1
8:13	1	1	1	1	4
8:14	3	3	4	4	14
8:15	4	0	0	0	4
8:16	0	1	2	2	5
8:17	2	0	0	0	2
8:18	0	0	2	3	5
8:19	4	5	5	6	20
8:20	6	0	0	0	6
8:21	2	2	4	4	12
8:22	5	7	8	9	29
8:23	11	12	0	0	23
8:24	0	0	1	2	3
					1131

1131

1131 x 15 sec

16965 Vehicle-second

Total of exiting vehicle was **277** Vehicles

16965 / 277

Average Stopped delay per vehicle is **61.25** sec

Intersection: **PR-2 and the Western Plaza**

Date: Thursday, October 27, 2005

Time	**Movements out WP**	
7:25	/	/
7:30	32	**32**
7:35	58	**26**
7:40	74	**16**
7:45	100	**26**
7:50	122	**22**
7:55	168	**46**
8:00	184	**16**
8:05	210	**26**
8:10	227	**17**
8:15	234	**7**
8:20	255	**21**
8:25	277	**22**

277 Volume

Time	**Movements out McD**	
7:25	/	/
7:30	17	**17**
7:35	29	**12**
7:40	40	**11**
7:45	64	**24**
7:50	75	**11**
7:55	96	**21**
8:00	110	**14**
8:05	129	**19**
8:10	145	**16**
8:15	169	**24**
8:20	194	**25**
8:25	211	**17**

211 Volume

Intersection: **PR-2 and the Western Plaza**
Movements to: Mc Donald's
Date: Thursday, November 17, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	30	45	60	SUM
3:15	1	1	2	2	6
3:16	0	1	1	2	4
3:17	2	3	2	3	10
3:18	5	5	6	7	23
3:19	8	8	0	1	17
3:20	1	2	2	2	7
3:21	2	3	5	5	15
3:22	6	6	7	8	27
3:23	0	0	0	0	0
3:24	0	1	2	2	5
3:25	2	2	2	3	9
3:26	0	1	2	2	5
3:27	2	2	2	2	8
3:28	2	0	0	0	2
3:29	2	2	3	6	13
3:30	6	6	6	6	24
3:31	9	9	0	0	18
3:32	0	0	0	1	1
3:33	2	2	2	4	10
3:34	4	5	7	0	16
3:35	0	0	0	0	0
3:36	0	1	1	1	3
3:37	1	2	2	2	7
3:38	3	0	1	1	5
3:39	1	2	2	2	7
3:40	1	2	2	2	7
3:41	3	3	4	4	14
3:42	4	4	4	0	12
3:43	0	0	0	0	0
3:44	2	4	4	4	14
3:45	0	0	1	2	3
3:46	3	3	3	3	12
3:47	4	4	4	4	16
3:48	0	0	2	3	5
3:49	3	5	5	5	18

3:50	5	5	6	6	22
3:51	7	0	0	0	7
3:52	0	0	0	0	0
3:53	1	1	1	1	4
3:54	1	1	1	0	3
3:55	1	1	1	1	4
3:56	1	1	1	1	4
3:57	7	7	7	7	28
3:58	0	0	0	0	0
3:59	0	0	0	0	0
4:00	1	2	3	4	10
4:01	4	4	0	0	8
4:02	0	1	1	1	3
4:03	1	1	2	2	6
4:04	3	1	1	2	7
4:05	2	4	4	5	15
4:06	5	5	5	5	20
4:07	5	0	1	2	8
4:08	2	2	2	2	8
4:09	2	2	2	2	8
4:10	2	2	2	0	6
4:11	0	0	0	0	0
4:12	0	1	1	1	3
4:13	1	2	3	3	9
4:14	3	0	0	0	3
					529

529

529 x 15 sec

7935 Vehicle-second

Total of exiting vehicle was **97** Vehicles

7935 / 97

Average Stopped delay per vehicle is **81.80** sec

Intersection: **PR-2 and the Western Plaza**

Movements to: Western Plaza

Date: Thursday, November 17, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	**30**	**45**	**60**	SUM
3:15	25	26	28	29	108
3:16	30	0	6	10	46
3:17	14	18	23	29	84
3:18	30	30	30	30	120
3:19	32	34	0	14	80
3:20	17	21	26	26	90
3:21	27	27	27	27	108
3:22	27	30	35	0	92
3:23	0	8	13	15	36
3:24	21	23	24	24	92
3:25	25	28	30	33	116
3:26	0	10	13	15	38
3:27	20	20	22	23	85
3:28	25	27	0	7	59
3:29	10	15	18	21	64
3:30	21	22	24	26	93
3:31	27	27	0	0	54
3:32	2	2	2	2	8
3:33	3	3	8	10	24
3:34	15	16	19	0	50
3:35	0	4	5	7	16
3:36	8	10	14	18	50
3:37	21	23	24	27	95
3:38	31	0	8	8	47
3:39	8	8	10	14	40
3:40	0	0	0	6	6
3:41	7	11	13	15	46
3:42	15	20	23	0	58
3:43	0	1	1	9	11
3:44	10	10	11	11	42
3:45	0	0	0	3	3
3:46	7	8	11	11	37
3:47	11	16	19	23	69
3:48	0	0	4	4	8
3:49	5	11	16	18	50

3:50	18	21	22	26	87
3:51	27	0	0	2	29
3:52	2	3	8	11	24
3:53	17	20	23	24	84
3:54	30	33	37	0	100
3:55	10	12	18	20	60
3:56	24	28	32	33	117
3:57	37	43	43	43	166
3:58	0	0	21	25	46
3:59	25	28	29	29	111
4:00	32	37	42	42	153
4:01	45	45	0	0	90
4:02	16	20	26	30	92
4:03	30	32	33	34	129
4:04	37	0	7	12	56
4:05	17	20	27	29	93
4:06	31	32	37	39	139
4:07	42	0	9	14	65
4:08	18	20	23	28	89
4:09	34	38	40	41	153
4:10	43	47	50	0	140
4:11	0	7	16	24	47
4:12	30	31	36	40	137
4:13	46	48	50	53	197
4:14	56	0	6	15	77
					4506

4506

4506 x 15 sec

67590 Vehicle-second

Total of exiting vehicle was **459** Vehicles

67590 / 459

Average Stopped delay per vehicle is **147.25** sec

Intersection: **PR-2 and the Western Plaza**

Date: Thursday, October 27, 2005

Time	Movements to WP	
3:15	/	/
3:20	48	**48**
3:25	74	**26**
3:30	124	**50**
3:35	153	**29**
3:40	190	**37**
3:45	229	**39**
3:50	267	**38**
3:55	306	**39**
4:00	340	**34**
4:05	391	**51**
4:10	414	**23**
4:15	459	**45**

459 Volume

Time	Movements to McD	
3:15	/	/
3:20	10	**10**
3:25	20	**10**
3:30	27	**7**
3:35	37	**10**
3:40	48	**11**
3:45	54	**6**
3:50	61	**7**
3:55	70	**9**
4:00	80	**10**
4:05	87	**7**
4:10	92	**5**
4:15	97	**5**

97 Volume

Intersection: **R-2 and the Western Plaza**

Movements out: Mc Donald's

Date: Thursday, November 17, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	30	45	60	SUM
3:15	11	0	0	3	14
3:16	6	6	7	8	27
3:17	8	9	9	9	35
3:18	10	11	12	0	33
3:19	0	3	5	5	13
3:20	6	6	8	8	28
3:21	8	8	8	9	33
3:22	0	0	0	0	0
3:23	1	1	1	1	4
3:24	1	2	3	4	10
3:25	0	0	0	0	0
3:26	0	0	0	3	3
3:27	4	4	0	0	8
3:28	0	1	2	3	6
3:29	7	7	7	8	29
3:30	8	9	10	0	27
3:31	0	6	7	8	21
3:32	9	10	10	11	40
3:33	11	11	12	14	48
3:34	0	0	0	3	3
3:35	3	6	6	6	21
3:36	7	7	8	8	30
3:37	9	9	0	0	18
3:38	0	0	0	0	0
3:39	0	0	0	1	1
3:40	1	3	3	3	10
3:41	5	6	7	7	25
3:42	0	0	0	0	0
3:43	0	0	0	1	1
3:44	2	2	0	0	4
3:45	1	2	2	2	7
3:46	3	4	6	6	19
3:47	7	0	0	0	7
3:48	0	1	2	2	5
3:49	1	2	2	2	7

3:50	4	0	0	0	4
3:51	0	0	1	2	3
3:52	2	2	3	3	10
3:53	4	4	4	0	12
3:54	0	0	1	1	2
3:55	1	4	4	4	13
3:56	5	5	6	8	24
3:57	11	0	0	0	11
3:58	4	8	8	9	29
3:59	11	11	13	13	48
4:00	13	13	13	0	39
4:01	0	3	5	7	15
4:02	8	10	11	11	40
4:03	12	0	0	0	12
4:04	6	7	9	10	32
4:05	10	10	11	11	42
4:06	12	12	0	0	24
4:07	2	2	2	2	8
4:08	2	2	2	2	8
4:09	3	4	5	6	18
4:10	0	1	1	2	4
4:11	2	2	2	3	9
4:12	4	4	4	5	17
4:13	5	6	0	0	11
4:14	0	0	0	0	0
					972

972

972 x 15 sec

14580 Vehicle-second

Total of exiting vehicle was **178** Vehicles

14580 / 178

Average Stopped delay per vehicle is **81.91** sec

Intersection: <u>PR-2 and the Western Plaza</u>

Movements out: Western Plaza

Date: Thursday, November 17, 2005

Delay Data

Minutes	Seconds in a Minutes				
	15	**30**	**45**	**60**	SUM
3:15	17	0	0	0	17
3:16	1	2	7	10	20
3:17	11	14	14	14	53
3:18	18	19	21	0	58
3:19	0	4	5	5	14
3:20	5	5	9	9	28
3:21	9	13	16	18	56
3:22	0	0	3	3	6
3:23	4	6	11	12	33
3:24	14	19	22	25	80
3:25	0	0	0	9	9
3:26	11	12	17	19	59
3:27	22	23	0	0	45
3:28	0	0	5	6	11
3:29	7	11	17	20	55
3:30	24	25	25	0	74
3:31	0	2	5	6	13
3:32	8	12	16	17	53
3:33	19	21	22	25	87
3:34	0	0	0	10	10
3:35	12	13	17	22	64
3:36	25	27	28	28	108
3:37	29	35	0	0	64
3:38	12	20	20	20	72
3:39	21	0	0	7	28
3:40	9	9	10	14	42
3:41	15	15	18	21	69
3:42	0	0	0	8	8
3:43	9	10	10	12	41
3:44	12	13	0	1	26
3:45	4	6	8	10	28
3:46	11	13	16	17	57
3:47	18	0	0	2	20
3:48	5	9	11	12	37
3:49	14	14	19	20	67

3:50	22	0	0	0	22
3:51	8	12	13	16	49
3:52	20	20	22	23	85
3:53	23	24	26	0	73
3:54	0	0	5	8	13
3:55	8	8	8	8	32
3:56	11	15	18	20	64
3:57	20	0	0	0	20
3:58	3	4	5	7	19
3:59	9	11	13	17	50
4:00	19	20	21	0	60
4:01	0	6	8	9	23
4:02	13	17	22	26	78
4:03	28	0	0	0	28
4:04	16	19	19	20	74
4:05	25	28	30	32	115
4:06	33	36	0	0	69
4:07	12	14	14	18	58
4:08	20	23	25	26	94
4:09	28	29	32	0	89
4:10	0	0	13	16	29
4:11	19	20	22	24	85
4:12	27	28	31	33	119
4:13	37	0	0	0	37
4:14	17	22	24	25	88
					2985

2985

2985 x 15 sec

44775 Vehicle-second

Total of exiting vehicle was **454** Vehicles

44775 / 454

Average Stopped delay per vehicle is **98.62** sec

Intersection: **PR-2 and the Western Plaza**

Date: Thursday, October 27, 2005

Time	Movements out WP	
3:15	/	/
3:20	38	**38**
3:25	61	**23**
3:30	111	**50**
3:35	161	**50**
3:40	200	**39**
3:45	238	**38**
3:50	260	**22**
3:55	316	**56**
4:00	339	**23**
4:05	376	**37**
4:10	411	**35**
4:15	454	**43**

454 Volume

Time	Movements out McD	
3:15	/	/
3:20	37	**37**
3:25	50	**13**
3:30	59	**9**
3:35	83	**24**
3:40	94	**11**
3:45	105	**11**
3:50	111	**6**
3:55	122	**11**
4:00	132	**10**
4:05	158	**26**
4:10	168	**10**
4:15	178	**10**

178 Volume

VISSIM Presentation

Civil Engineering and Surveying Department
University of Puerto Rico-Mayagüez Campus
Mayagüez, Puerto Rico

VISSIM 4.0

by *Enrique González Vélez, MSCE*

Agenda

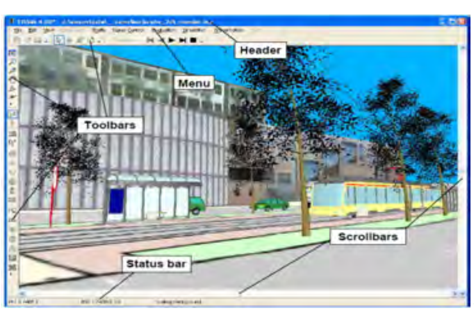
- Introduction
- VISSIM
  - *"Desktop"*
  - *"Toolbar"*
- Example

VISSIM
{Traffic In Towns SIMulation (as its acronyms in German)}

Introduction

- The simulation is microscopic
  - vehicle by vehicle, and second to second analyses
- Microsimulation model used for the design of traffic actuated control systems
- It offers a wide variety of urban and highway applications, integrating public and private transportation.
- 3D animations warranties realistic presentation

VISSIM 4.0



VISSIM Desktop

Header	Shows program title, version and input file name
Menu	Access by mouse click or hotkey Indicates following sub-menu " ▶ Indicates following dialog box
Tool bars	Control network editor and simulation functions (see separate section below)
Status bar	Shows editing instructions and simulation status
Scroll bars	Horizontal and vertical scrolling of network viewing area

Tool bars

- Dynamic zoom (left click), previous view (right click) (**shortcut** page up, page down)
- Zoom by factor
- Show entire network
- Rotate network (3D only)
- Move network (3D only, shortcuts also in 2D) (**shortcut** ↑,↓,←,→)
- Fly through network (3D only)

Simulation toolbar

- Continuous simulation, animation or test **(shortcut F5)**
- Single step simulation, animation or test **(shortcut F6)**
- Stop simulation, animation or test **(shortcut Esc)**
- Continuous backwards (animation only)
- Single step backwards (animation only)

Selection toolbar

- Standard selection mode
- Multi-select mode
- Label mode. Any labels of network elements can be relocated if at the same time the edit mode of that network element is active.
- If several links/connectors are located at the mouse click position this button can be used to browse through all these links/connectors. **(shortcut Tab)**

Network elements toolbar

Basic roadwork

- Links and connectors

Vehicle flow

- Vehicle inputs
- Direction decisions (mainly historical)
- Static routes (to direct traffic within the network)

Network elements toolbar (cont.)

Vehicle speeds

- Desired speed decisions
- Reduced speed areas

Priority control

- Priority rules (e.g. for non-signalized intersections)
- Stop signs

Network elements toolbar (cont.)

Priority control

- Signal heads
- Signal detectors

Public transport

- Public transport stops
- Public transport lines

Network elements toolbar (cont.)

Evaluations

- Cross section measurements
- Travel time and delay measurements
- Queue counters

Graphics

- Pavement Markers

Network elements toolbar (cont.)

Dynamic Assignment (optional module)

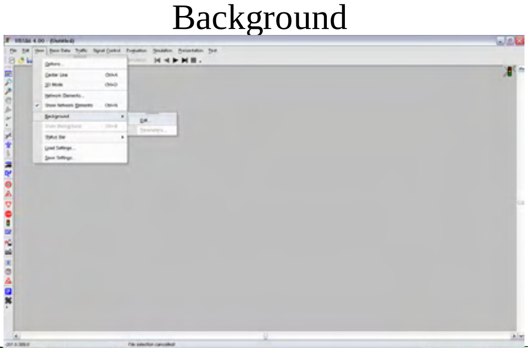
- Parking lots / zone connectors
- Nodes (some VISSIM licenses also allow for node evaluation independently of Dynamic Assignment)

VISSIM Quick Example

Background Types

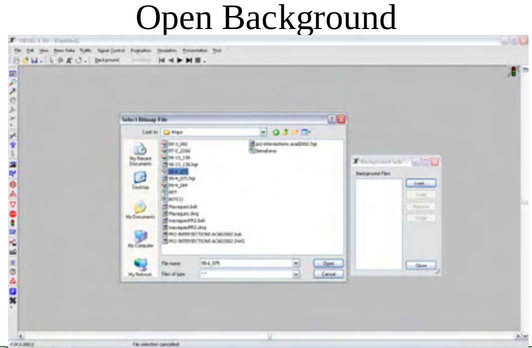
- Bitmap format
  - *.BMP
  - *.JPG
  - *.PNG
  - *.TGA
  - *. TIF
  - *.SID
- Vector format
  - *.DWG
  - *.DXF
  - *.EMF
  - *.WMF
  - *.SHP

Background



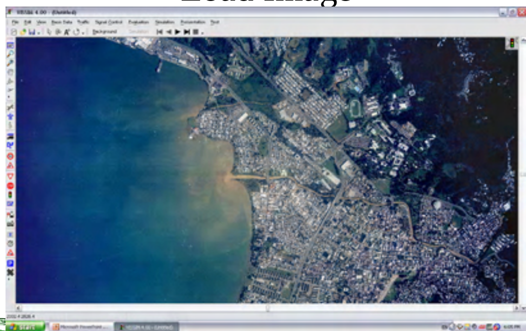
View / Background / Edit

Open Background



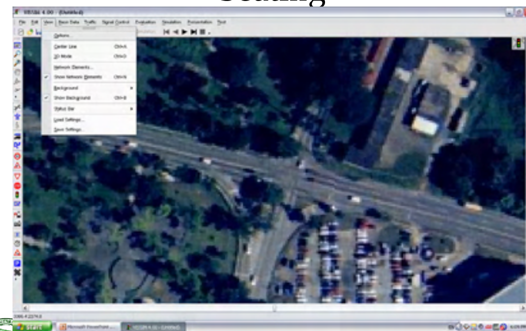
Load / Search / Select

Load Image



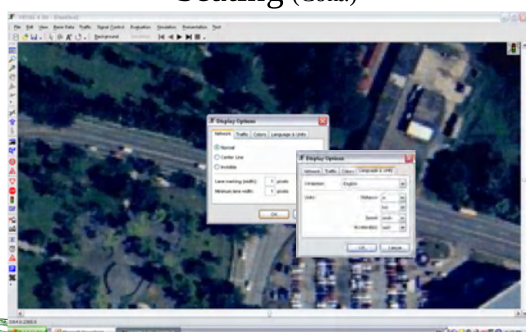
View / Background / Edit/ Scale

Seating



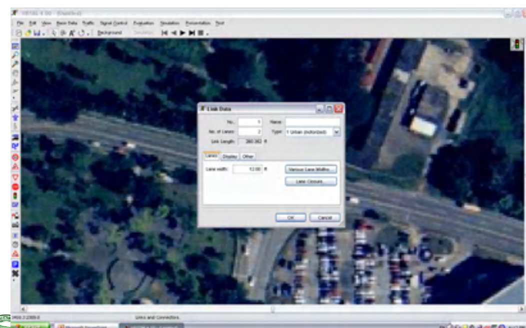
View / Options

Seating (Cont.)



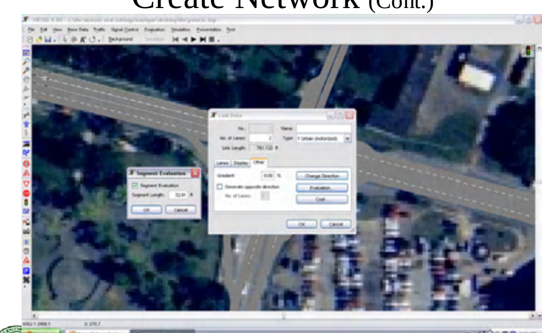
Display options / Network / Language & Units

Create Network



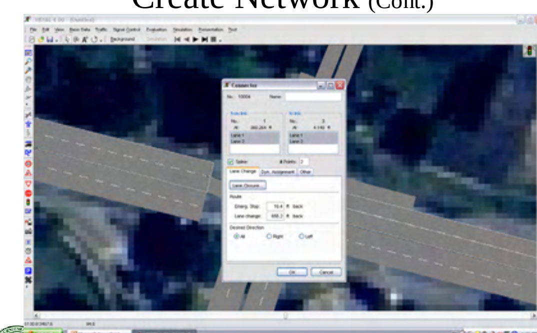
Link Data

Create Network (Cont.)



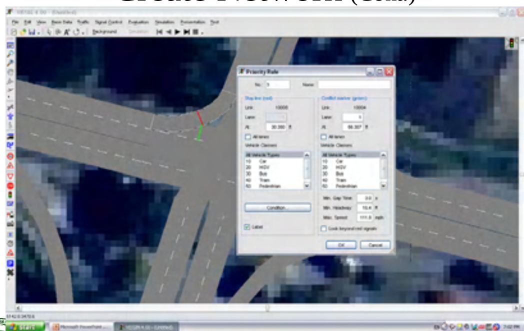
Link Data / Other / Evaluation / Segment Evaluation

Create Network (Cont.)



Connector

Create Network (Cont.)

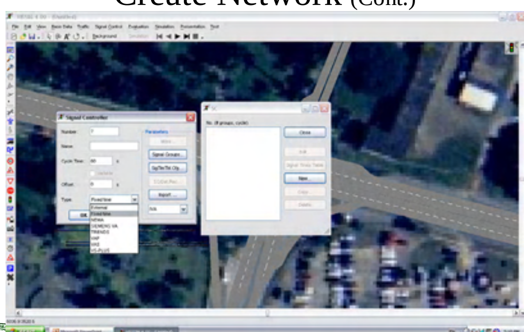


Priority Rule

Create Network (Cont.)

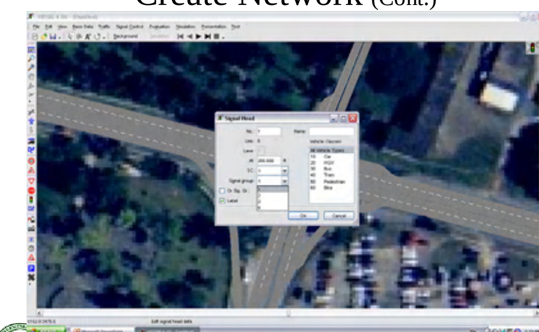
Signal Control / Edit Controllers

Create Network (Cont.)



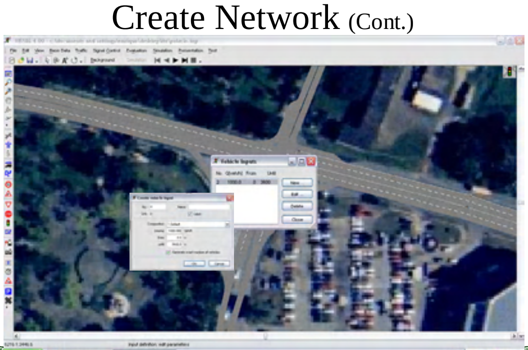
New / Type

Create Network (Cont.)



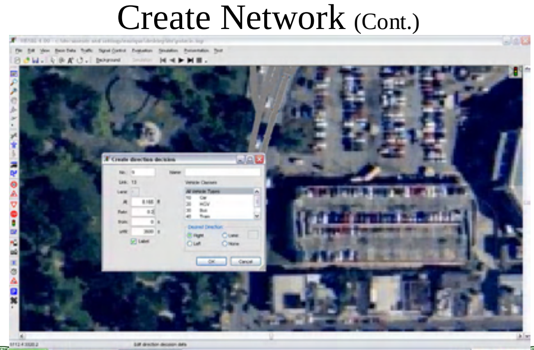
Signal Head

Create Network (Cont.)



Create vehicle input / Vehicle inputs

Create Network (Cont.)

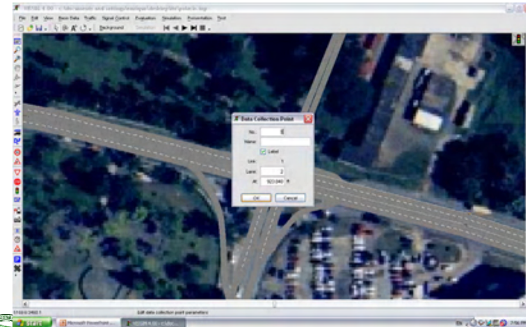


Create direction decision

Run Simulation

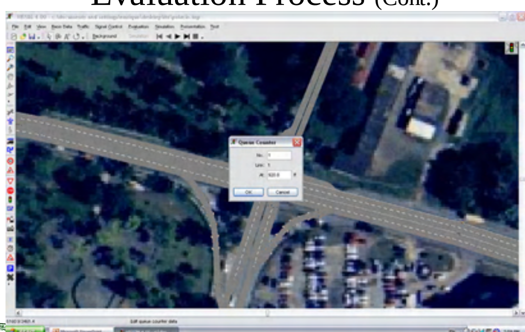
3D View

Evaluation Process



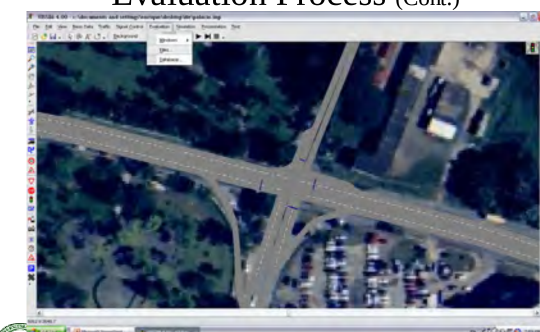
Data collection point

Evaluation Process (Cont.)



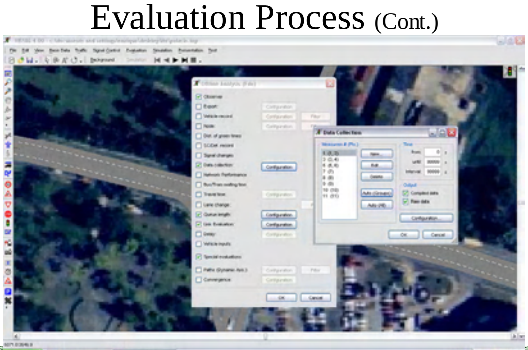
Queue counters

Evaluation Process (Cont.)



Evaluation / Files

Evaluation Process (Cont.)

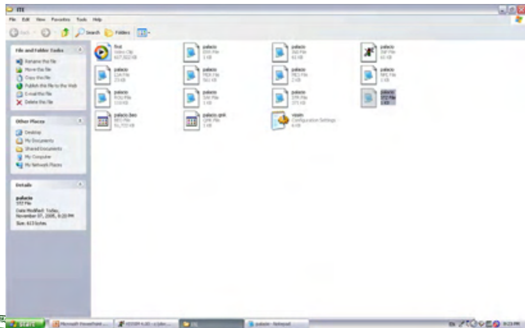


Offline analysis (file) / Data Collection

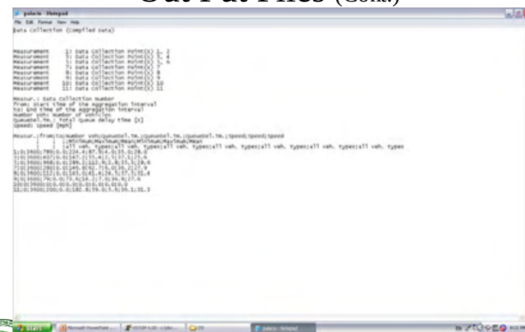
Run Simulation

Run Simulation / Out put

Out Put Files

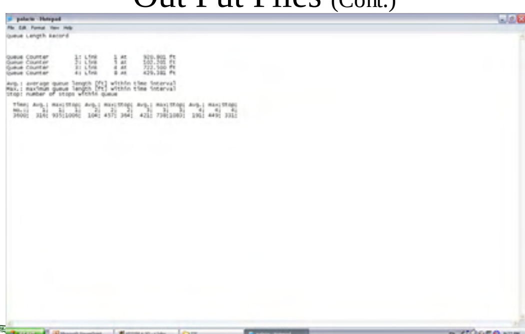


Out Put Files (Cont.)



Data collection (compiled data)

Out Put Files (Cont.)



Queue length record

Questions

Thanks for your attention

gonzalez.v.e@gmail.com

Reference:

- VISSIM 4.0 User Manual PTVAG June 2004.