Development of a Large Scale Traffic Simulation Model to Improve the Flow of Commercial Vehicles from Maquiladora Industry to International Border-Crossings

Jose Osiris Vidaña-Bencomo
Doctoral Candidate and Graduate Assistant Research
University of Texas at El Paso

Rajat Rajbhandari, Ph.D., P.E.
Associate Research Engineer
Texas Transportation Institute

Abstract

The maquiladora industry (twin plants owned by U.S. multinationals) in Mexico plays an important role in the economy of both U.S. and Mexico but also border cities of El Paso and Ciudad Juarez. Ciudad Juarez has 29 industrial parks where 350 maquiladoras are located. Maquiladoras ship goods produced in Mexico to warehouses in El Paso, Texas, from where they are transported to retail houses and consumers in other parts of the U.S. The rapid expansion of Ciudad Juarez as a result of the exploding maquiladora industry could not be supported by plans to manage urban mobility (specially the trucks) within the city. Hence, lack of timely transportation planning resulted in overloaded traffic network. This was exacerbated by the fact that industrial parks were constructed so as to strategically locate close to international border-crossings, which happened to be close to high density urban areas. This has resulted in trucks having to use local and often congested inner city streets. With this in perspective, the researchers developed a large scale traffic simulation model in Paramics for Ciudad Juarez and analyzed the mobility of commercial vehicles within the city especially between the industrial parks and international border-crossings. The simulation model can be utilized to improve the mobility of commercial vehicles within the city. Using the simulation model, planners and decision makers can improve the flow of trucks by identifying congested roadway segments and develop infrastructure improvement plans.

Background

The City of El Paso, Texas, together with Ciudad Juarez, Chihuahua, comprises one of the largest binational metropolitan areas on the world. The estimated population of these two cities is around 2 million (1) (2). The El Paso and Ciudad Juarez is considered as a borderplex due to its economy is independent and interlocked. This economy depends highly on the trade between both cities. During 2010 the amount of $71 Billion in trade crossed the border between El Paso and Ciudad Juarez (Import: $41.9 Billion, Export: $29.2 Billion) representing 18% of all trade between U.S. and Mexico (3).

The maquiladora industry has an important role in the economy of the Ciudad Juarez/El Paso borderplex. The maquiladora concept is referred as “Twin plants” or “in-bond” industry. The operation involves a manufacturing factory that import materials and equipment temporally except of fees. The final products or components once assembled in Mexico are then sending back to the country of origin (in this case U.S.).

Ciudad Juarez has 29 industrial parks where 350 maquiladoras are located. Types of production include automotive (36%), appliance (14%), electronics and telecommunications (14%), biotechnology (4%), information technology (6%), forestry and furniture (8%), clothing (2%), and others (16%). (4). The industrial parks are located in three main industrial zones in the city: Poniente (Western) with 11 industrial parks, Centro (Downtown) with 6 industrial parks, and Sur-Oriente (southeastern) with 12 industrial parks. Some maquiladoras are located outside of the industrial parks. Figure 1 shows the location of different industrial parks in Ciudad Juarez.

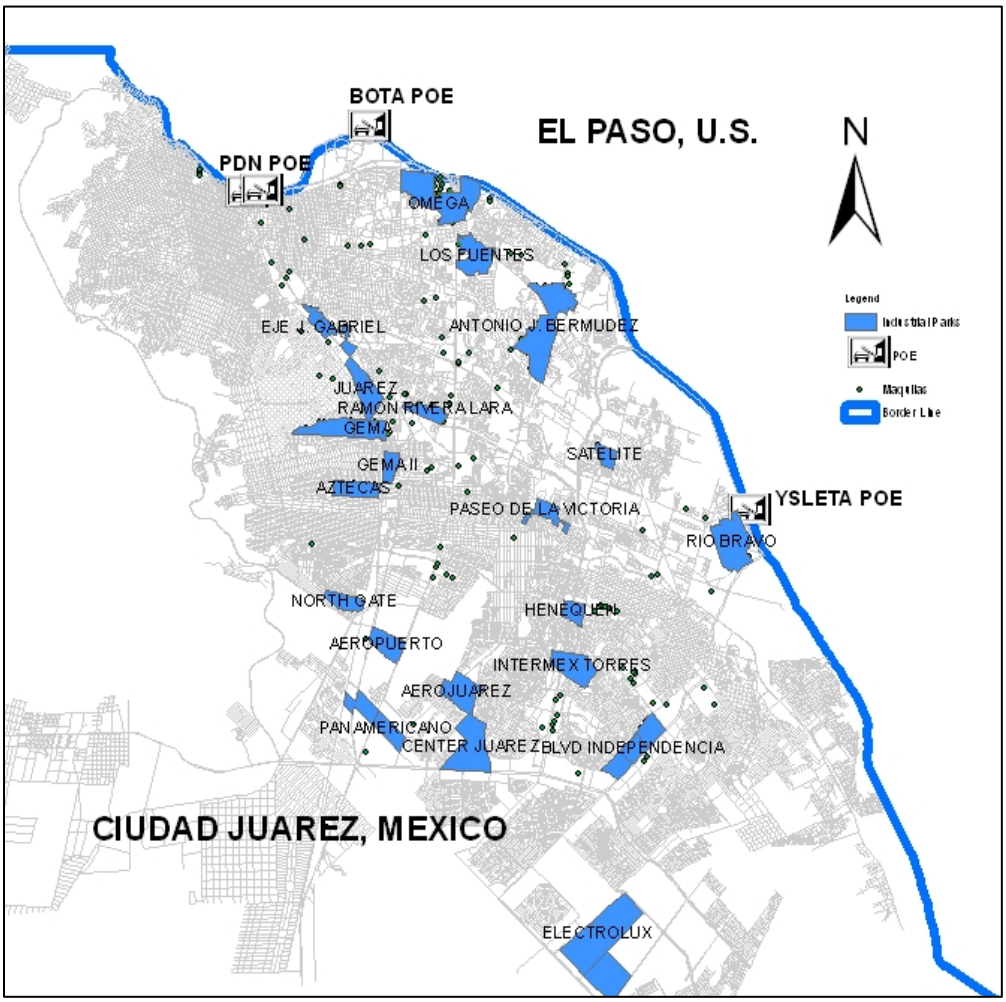

Figure 1. Location of Industrial Parks in Ciudad Juarez.

Maquiladoras transport produced goods to warehouses in El Paso through two land ports of entry: Bridge of the Americas (BOTA) and Ysleta Bridge (Ysleta). Maquiladora industry has an important impact in El Paso. The payroll of U.S. citizens that live in El Paso and commute to

work in Ciudad Juarez Maquilas was $247.8 million in 2005. The other benefit is the attraction of industries to El Paso as consequence of the "production/share" practice with companies in Ciudad Juarez. This industry attraction has contributed with direct and indirect jobs, retail sales, companies' providers of services, transportation, warehouses, etc. (5).

The maquiladoras industry started in the middle of the 60's. The implementation of this concept was a success due the different advantages that Ciudad Juarez offered as low labor costs, trainable workforce and the geographical proximity with distribution centers in United States. As a result Ciudad Juarez experienced tremendous growth in maquiladoras along with the overall growth of the city. However, Ciudad Juarez could not keep up with the urban planning process necessary to accommodate this rapid growth. The lack of planning resulted in an overloaded traffic network with considerable decrease in mobility. More specifically, decrease in mobility has been mainly due to inadequate capacity, frequent accidents, etc. In spite of the growing security issues, new companies continue to set up factories in Ciudad Juarez and more people migrate to Ciudad Juarez for jobs. Most likely, the population growth will result in more congestion. Hence, the city needs to evaluate the current traffic network and evaluate how it affects the accessibility of personal and commercial vehicles, especially to industrial parks and to the ports of entry.

Problem Statement

As the city of Ciudad Juarez grows, ports of entry are now located farther from the newly developed urban areas. The housing developments located around the ports of entry have avenues and streets that have a limited capacity for connecting traffic from the new housing areas to the ports of entry and the industrial parks that were once outside the city are now inside the city core. Trucks have to use congested inner city streets to transport products and supplies from/to the maquiladoras causing delays that have been exacerbated by the increasing number of accidents, limited roadway capacity, and other traffic controls. Planning agencies in the city desperately needs tools to evaluate the current traffic conditions and develop infrastructure to accommodate future demand and relieve already congested roadways.

Objective of the Project

The objective of this particular project is to develop a microscopic traffic simulation model (MTS) for the Ciudad Juarez to highlight the importance of using a large scale microscopic traffic simulation model to analyze the mobility of commercial vehicles within the city, especially between the industrial parks in Ciudad Juarez and both freight Ports of Entry (POEs)

Literature Review

The use of microscopic traffic simulation in large scale projects has been used to evaluate freeway corridors where the critical element—traffic demand—is easily obtained through counts located in ramps. The results obtained in this scenario have been accurate where a different calibration process has been developed successfully (6). However, the use of microscopic traffic simulation in urban networks has been difficult. A compilation of large-scale microscopic traffic simulation projects in urban areas is included in a report by John Hourdos et al., (7). The main objective of these large scale simulations has been to support the traffic management systems

and conduct feasibility studies for public transportation. Difficulties in performing large-scale microscopic simulation are the following:

- Data collection is laborious and time consuming.
- Modeling the geometric and signaled intersections is time consuming.
- Lack of origin-destination (O-D) matrices to be used directly in the models.
- Dependency upon using travel demand planning O-D matrices to convert into microscopic traffic simulation model O-D matrices.
  Large number of traffic count data and point traffic counts are needed to achieve precise and realistic results.
- Feeding traffic between microscopic traffic simulation models and travel demand models. mismatch
- Travel paths generated by the O-D do not match with the real traffic pattern.

Methodology

In this research project, Paramics was used to create a large-scale simulation model of Ciudad Juarez because the software creates an origin-destination matrix from screen line counts and intersections counts since Ciudad Juarez does not have a travel demand model; and because it uses a customized application within Paramics to input large number of variables and parameter data for sensitivity analysis.

The methodology used to develop the MTS model of Ciudad Juarez using Paramics consists of different stages: data collection, modeling, and calibration/validation. The methodology consisted of data collection from different agencies in Ciudad Juarez, coding the network and inputting traffic characteristics, generating the morning peak-hour O-D_m based on traffic intersection turn movements and traffic link flows, and finally, evaluating and calibrating the network comparing observed and simulated traffic counts data.

The street network along with the proper configuration was drawn over an aerial mosaic. Figure 2 shows a snapshot of the street network in Paramics. The number of lanes, width, directionality, and horizontal curvature of the streets were based on online maps (e.g., Google Maps) and field studies. Turning movements were obtained from online maps as well as field data collection. The network contains 5,513 links with a total distance of 560 miles (902 km).

Signal timings of 204 pre-timed traffic lights and right of way information was added. During this process, turning movement of each lane of intersections was defined. Roundabouts were also added to the network. Finally, as part of the street network configuration, traffic restrictions on certain vehicle types were added.

The traffic demand in the network was obtained as a function of an estimated O-D_m. In order to create the O-D_m estimation, these data were used: the 126 traffic counts obtained from the intersection movement field data collection, ports of entry traffic counts, and the database provided by IMIP. The task involved a visual and traffic flow calibration process. Two O-D_m s were obtained to provide a simulation of the traffic flow of vehicles and trucks in the network.

Figure 2. Snapshot of Ciudad Juarez Roadway Network in Paramics.

Results

Using Paramics and the large scale microscopic traffic simulation model, the movement of commercial freight between various industrial parks in Ciudad Juarez and the two land ports of entry were evaluated. The evaluation was based on measures of effectiveness (MOEs) representing traffic delay and congestion incurred to trucks on pre-defined routes connecting different origins and destinations were obtained and evaluated. The pre-defined routes represent the shortest path available as result of assignment network process (dynamic feedback).

In the simulation model, origins were represented by traffic zones, which included the industrial parks while destinations were represented by traffic zones located at the entrance of the

Mexican customs facilities at the ports of entry. The truck traffic from Chihuahua and Casas Grandes highways entering Ciudad Juarez with destination to both ports of entry also were evaluated.

The MOEs selected to evaluate the truck movement were simulated travel time and delay. Modeled travel time represents the total truck average travel time from origin to the destination. Delay represents the difference between the modeled travel time and free-flow travel time. Delay includes the average delay due to traffic congestion and traffic control devices.

Analysis

The analysis of MOEs between different industrial parks and highway entrances from Ciudad Juarez to both ports of entry indicates that the longer the travel distance connecting them, the longer the travel time is as shown in Figure 3. However, from the delay MOE it is possible to detect that the delay for commercial vehicle traffic is not correlated with the travel distance as illustrated in Figure 4.

The delay is caused by the traffic of the network particularly in minor streets. Some trucks with longer trips use freeway corridors where the delay is lower than for shorter trips because trucks travel through urban streets that are usually congested.

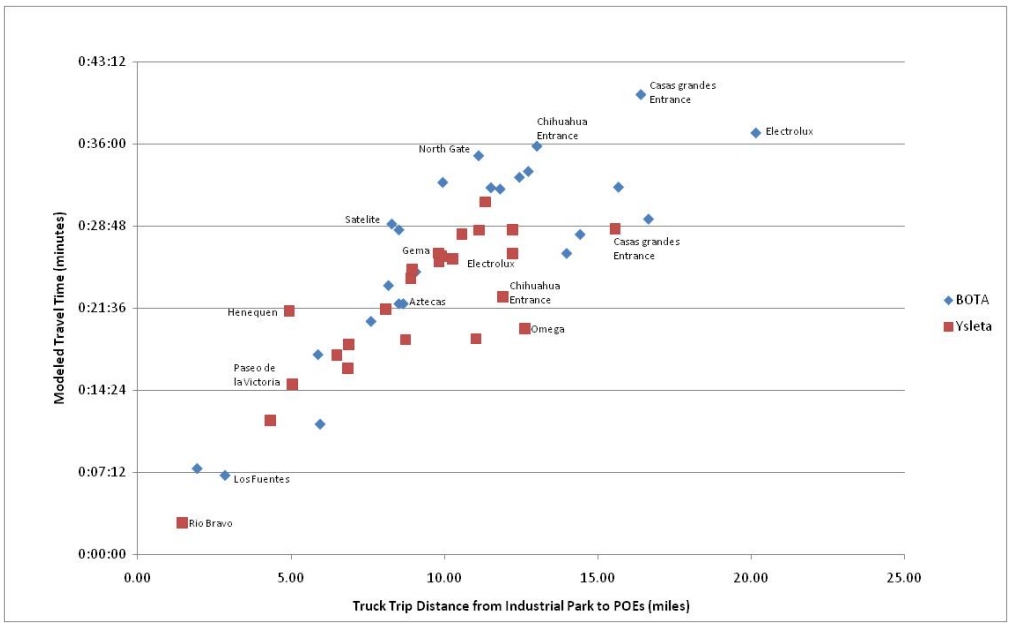

Figure 3. Comparison of Simulated Travel of Commercial Vehicles between Individual Industrial Parks and Both Ports of Entry.

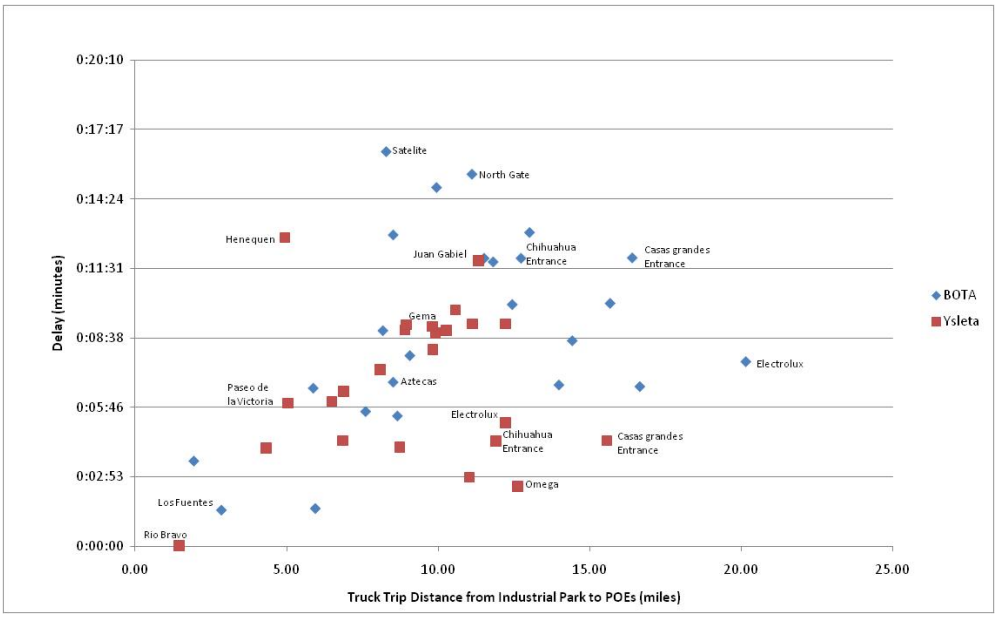

Figure 4. Comparison of Delay of Commercial Vehicles between Individual Industrial Parks and Both Ports of Entry.

Figure 5 shows that the average percentage of delay incurred to trucks traversing between industrial parks and the Ysleta port of entry is approximately 32% of the total travel time. In the case of the BOTA port of entry, delays represent a 35% of the total travel time. Figure 6 shows the proportion of delay for trucks from each industrial park to the BOTA port of entry.

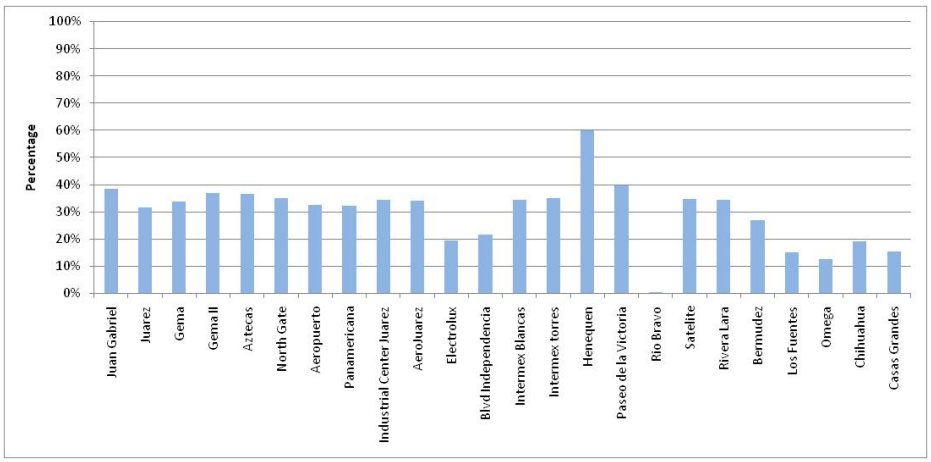

Figure 5. Percentage of Delay Incurred to Trucks Originating from Different Industrial Parks and Both Highway Entrances to Ysleta (Zaragoza Bridge) Port of Entry.

The simulation model also provides delay incurred by trucks on different segments that form a path of trucks traveling from the industrial parks and highway entrances to both ports of entry. Using the simulation results, segments of the route with higher delays were identified to target the segment for possible traffic improvements in order to reduce delay over the entire route (path) between industrial parks and the ports of entry.

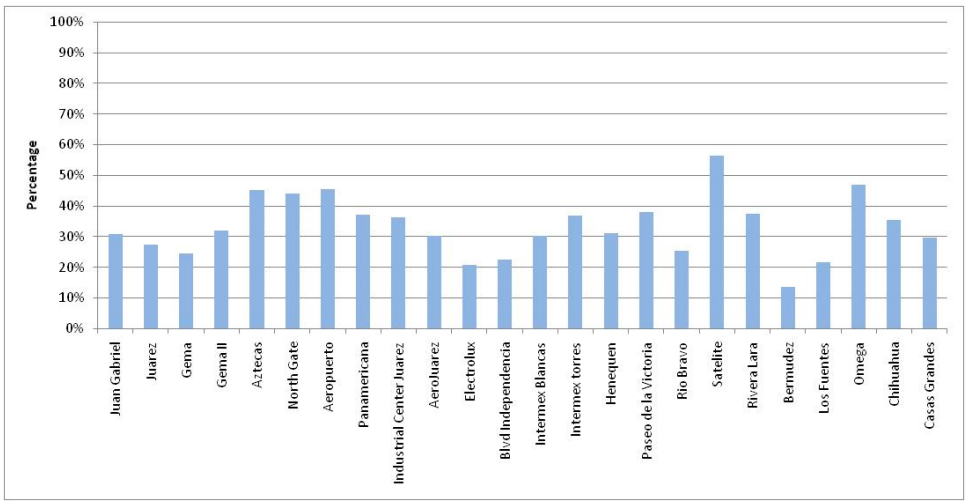

Figure 6. Percentage Delay Incurred to Trucks Originating from Different Industrial Parks and Both Highway Entrances to BOTA (Americas) Port of Entry.

A comparison of two route paths between two different industrial parks connecting with the BOTA is show next. Figure 7 shows the path of the trucks traveling from two different industrial parks to the BOTA port of entry. The left image show a path through a freeway. Delays on this path occur on freeway segments and at the intersection of Bermudez Avenue, as illustrated in figure 8. The right image on figure 7 shows a path through local streets. This second path has a shorter distance but it has higher delay than the first one, which is mostly due to traffic congestion in the inner core of the city as depicted in Figure 9.

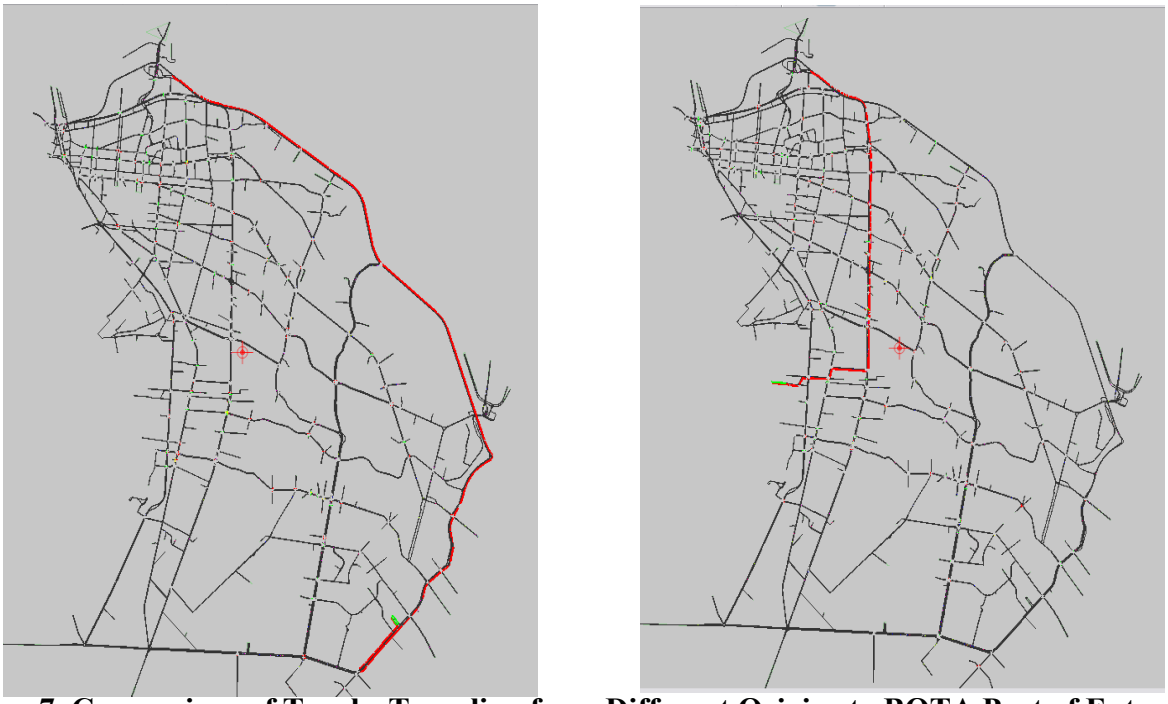

Figure 7. Comparison of Trucks Traveling from Different Origins to BOTA Port of Entry.

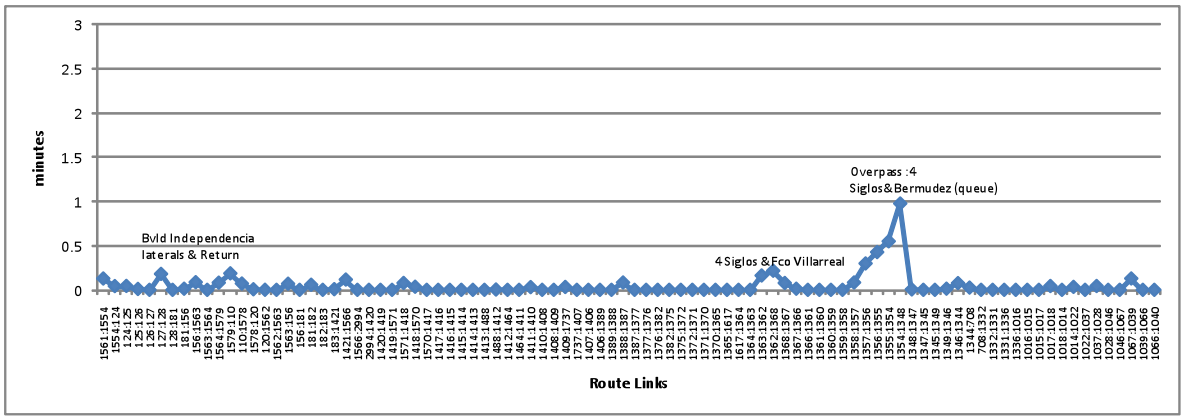

Figure 8. Delay on Segments of a Path from Independencia to the BOTA Port of Entry.

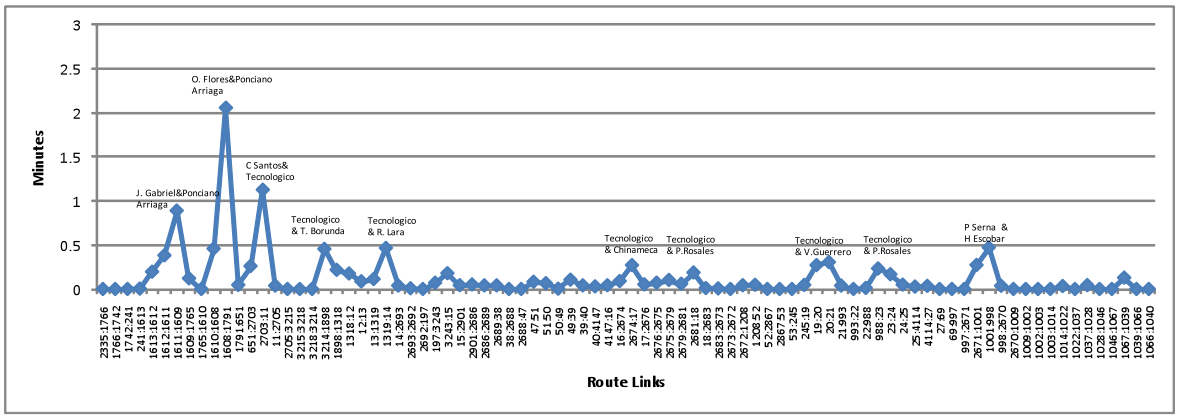

Figure 9. Link Delay of the Path of Trucks Traveling from I.P. Aztecas to BOTA Port of Entry.

Other results provided by the MOEs were the travel time comparison between each industrial park and both ports of entry. Figure 10 shows both options. Similarly, Figure 11 illustrates the comparison of delay between each industrial park and both ports of entry.

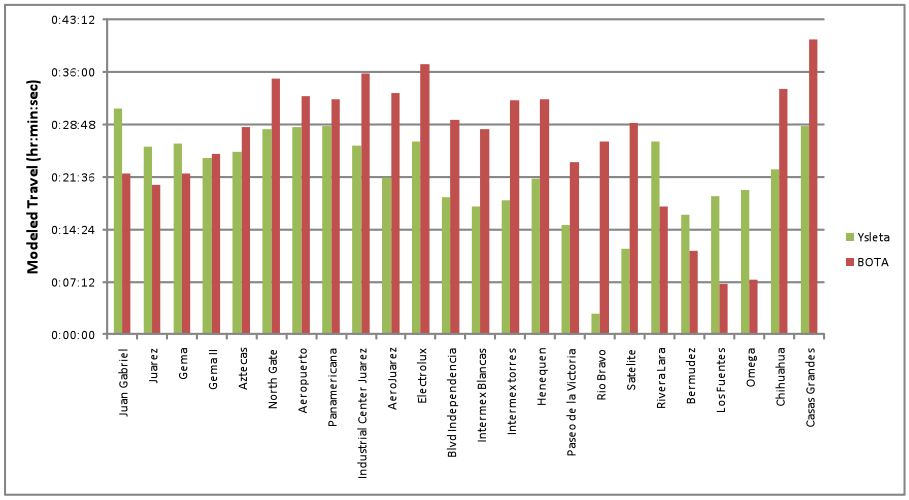

Figure 1. Modeled Travel Time Originating from Different Industrial Parks and Both Ports of Entry.

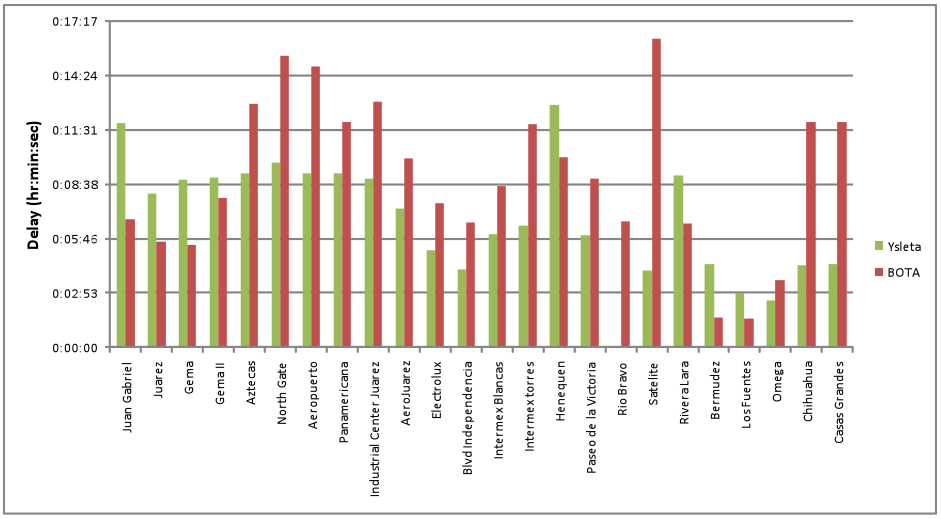

Figure 11. Delay Time Originating from Different Industrial Parks and Both Ports of Entry.

Concluding remarks

The simulation model developed in this research demonstrated various scenarios of truck paths connecting industrial parks to land ports of entry on the U.S.-Mexico border in the El Paso-Ciudad Juarez region.

The analysis showed that the delay on truck paths is attributed to congestion in the inner urban areas, while freeways surrounding the city provide reliable access to the ports of entry

The delay contributes to 20–60% of the total travel time of trucks moving between industrial parks and the ports of entry, which ultimately results in higher costs for shipping and moving goods.

The results derived from the model will relay a strong need for improved planning and operation of transportation infrastructure in Ciudad Juarez

It is hoped that the simulation model will provide planners and decision makers tools to improve the flow of trucks and develop infrastructure improvement plans benefiting the borderplex economy