



Feasibility of Implementing a PR-181 Busway  
in the Trujillo Alto Area

An Interactive Qualifying Project  
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## **Executive Summary**

The metropolitan region of San Juan, Puerto Rico is struggling with the integration of the mass transportation system and the surrounding municipalities. The problem facing San Juan is very complex, ranging from unsafe and inadequate pedestrian ways, to an under-developed mass transit system. These conditions lower the quality of life throughout the region, making it difficult for people to enjoy the area. The municipality of Trujillo Alto is one such area that is facing these problems. The implementation of a dedicated bus lane, or Busway, along the PR-181 corridor of Trujillo Alto is a possible starting point for an overall solution. The goal of this study is to identify issues relevant to the implementation of a Busway along the PR-181 corridor of Trujillo Alto and develop preliminary concepts for its design. Understanding potential issues that could arise with the construction of a Busway, is critical in the planning and design process. These issues impact the physical design of the system, modifications and/or reconstruction of roadways, price of the project, potential ridership, and overall time for completion of project. We hope the development of preliminary concept ideas will act as a catalyst for city planners, providing initial ideas that can be further developed or inspire completely new ideas for developing the PR-181 corridor.

A basic understanding of the demographics of Trujillo Alto is an important first step in attempting to address the transportation problem facing the community. The municipality of Trujillo Alto is southeast of the municipality of San Juan. It is currently home to approximately 76,000 residents (ACT, 2004) with a projected population of roughly 86,000 by 2010. Trujillo Alto is divided into eight barrios, or wards. The most densely populated barrios are in the northern section, adjacent to the San Juan border. These barrios are named Cuevas and Saint Just. The central area of the city is in the Pueblo barrio, directly in between Dos Bocas, Carraízo, and La Gloria. The barrios named Quebrada Grande and Quebrada Negrito are in the southern section of the city, and are very rural areas.

The barrio that has seen the most increase in population is the Dos Bocas barrio. The reason why Dos Bocas has thrived is mainly because of the newly developed La

Encantada neighborhood, which houses approximately 7,000 people in 2,800 units (Oficina de Planificacion y Ordenacion Territorial, 2005). The rapidly increasing population of Trujillo Alto is compounding the traffic problems along PR-181. PR-181 is the major roadway that connects Trujillo Alto with San Juan and serves the heavily northern barrios of San Just, Cuevas, and Dos Bocas. Not only does the corridor directly serve those areas but it also has many junctions with other smaller corridors, which bring traffic from other regions of Trujillo Alto and even other municipalities.

The growing population of Trujillo Alto is only one aspect in the overall transportation problem that is affecting the municipality. Trujillo Alto also is confronted with inadequate roadways, unreliable public transportation, and dependence upon the automobile. The PR-181 corridor suffers from all these factors, but most of all suffers from having no alternative mode of transportation available for commuters to use. A Busway along the PR-181 corridor would provide an attractive alternative for commuters to use.

Implementing a Busway is a very complicated task to accomplish. As with any major construction project, many considerations need to be taken into account, including terminal location and design, current conditions of proposed land for development, identifying potential obstacles, identifying pedestrian needs, identifying major traffic generators, and developing creative concepts for design. This paper will assess these aspects and provide necessary information needed for future development.

The first step taken was to research transportation around the world. This research is important because it provides a basic understanding of causes and effects due to transportation. Examples and case studies of how cities around the world manage their transportation issues were also discovered during this initial research phase. From these case studies, basic strategies were deduced and examined. Though these basic strategies are not utilized to solve our specific problem, the information is important in understanding the field of study and may be applied to future developments.

Determining issues that are potential problems for proposed locations of terminals was the first area analyzed. We determined these issues by analyzing GIS maps and by meeting with city planners. The second step our group took was to identify issues

dealing with the current conditions of the PR-181 corridor. Again, we utilized GIS maps to analyze the section of roadway we are proposing for the development of the Busway. We also visited PR-181 in order to collect data using data collection sheets that we developed. These data collection sheets were completed and compiled along with pictures of the area to form a small database of information relevant to the corridor. This intersection database is a quick and easy source of information, providing a clear description of the selected intersections. We also rated the roadway and intersections for pedestrian safety and accessibility. These ratings took in account the presence of sidewalks, crosswalks, and pedestrian traffic lights. We used these ratings to make recommendations on how PR-181 can be improved for pedestrians and cyclists.

The first step taken in developing concepts for a PR-181 Busway was to talk with experts. The physical layout of median Busway design concept along PR-181 was our main focus. We developed numerous methods for a median Busway to integrate with PR-181 and its major intersections. Understanding that a median Busway may not be the most feasible option, we also explored alternatives involving a shoulder configuration for a Busway. These alternatives are not developed as thoroughly as the median Busway concept, yet they provide creative options that have the potential of being further developed.

We provide a list of recommendations that could immediately address what would improve PR-181. These recommendations include road maintenance and ways to improve the overall area along PR-181. Improving the overall area is an important aspect that should be addressed in any developments to the area. These improvements will enhance the quality of life for commuters and residents of the area.

Figure 1 is an image of the proposed PR-181 Busway route. The image includes major intersection locations, recommended bus stop locations, proposed Northern and Southern Terminal locations, and key traffic generators (i.e. Shopping Plaza, School, & Hospital) along PR-181. It is our hope that the issues we identify and the preliminary concept ideas for a Busway along PR-181 will supply city planners with valuable information that will aid in developing the area for commuters and residents of Trujillo Alto.

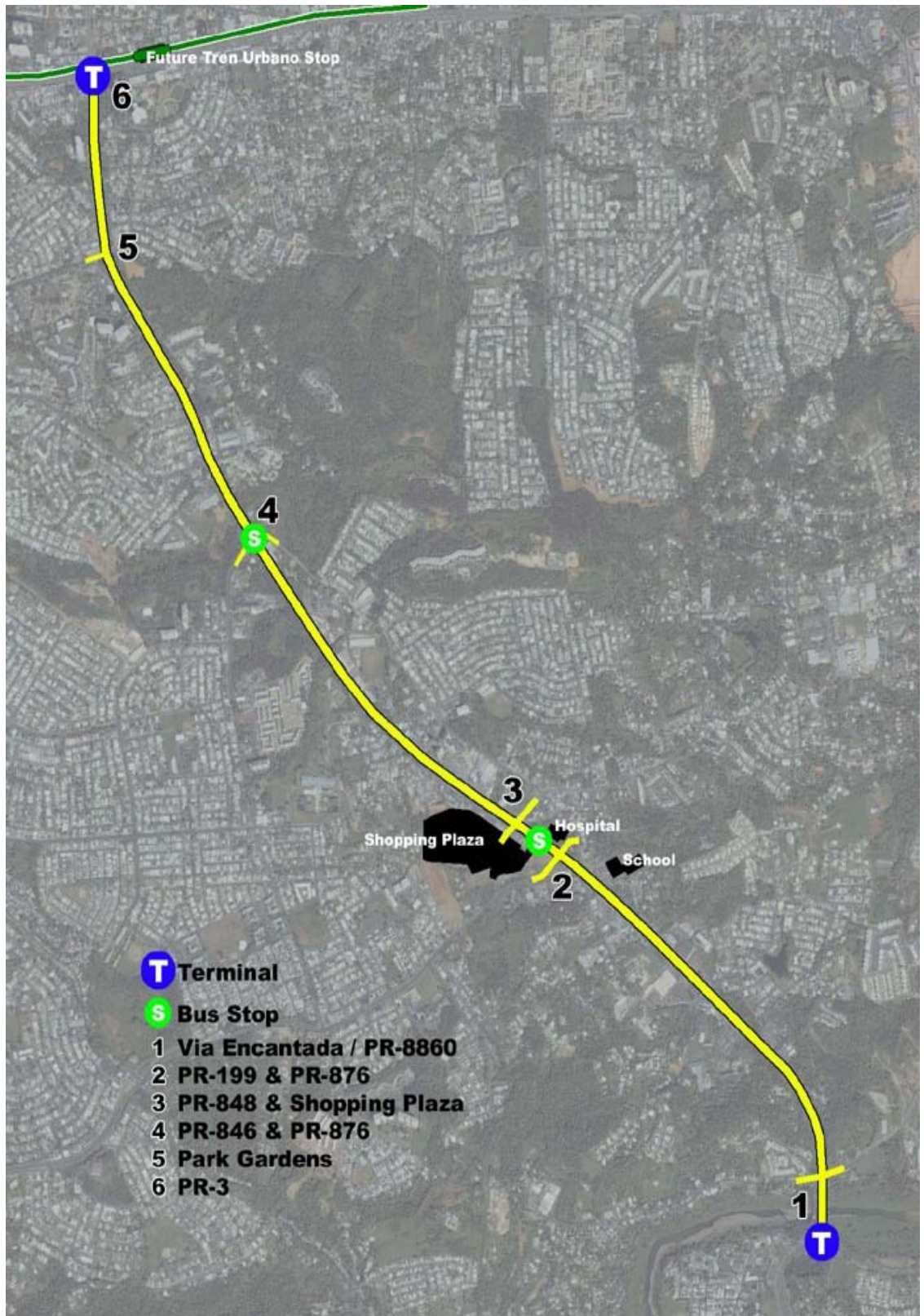


Figure 1: Proposed PR-181 Busway Route

## **Abstract**

This project, prepared for the Autoridad de Carreteras y Transportacion of San Juan, Puerto Rico, provides an analysis of the PR-181 corridor in Trujillo Alto along with recommendations to install a Busway. This project focuses on three main areas: assessing terminal location and design, identifying intermediate bus stop locations and design, and evaluating the road conditions. Issues were identified at each of the major intersections that will pose a problem for the integration of the Busway and PR-181. These issues lead into formulating ideas and recommendations on how to better manage the traffic and improve the quality of life in Trujillo Alto.

## Authorship Page

We, the undersigned, have put equal efforts forward towards the purpose of completing this report, and all material contained within is original unless cited as otherwise.

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## **1.0 Introduction**

Populations in major cities all over the world are increasing, and still more people are commuting to and from these cities everyday from suburbs nearby. In many of these cities, the primary means of transportation for commuters is the automobile. In the United States alone, a survey conducted in 1990 revealed that 91 percent of all commutes in and out of work were completed using a personal vehicle (Shoup & Breinholt, 1995). The increasing number of cars on the road results in traffic congestion on major roadways. In some cities, this has become a major problem that is in critical need of a solution.

San Juan, Puerto Rico is one city where traffic congestion has become a major problem. The city of San Juan has expanded in recent years, engulfing nearby towns which have become the various sub-sections of the city. Many people from these surrounding regions commute into the downtown area for work, and their primary means of transportation is their cars. The new heavy-rail system, the Tren Urbano, provides an attractive alternative to driving for the people that live close to one of its 16 stations, but there are still many areas that do not have easy access to this new train system.

One of the areas that are not currently served by the Tren Urbano is Trujillo Alto. People from this area still commute to San Juan via PR-181, which goes directly from the Trujillo Alto area to downtown San Juan. The high volume of commuting traffic results in lengthy delays and frustration for commuters. Local officials have deemed this to be one of the major problems that affect its citizens and they are actively seeking methods to alleviate this congestion (Carmona, 2004).

The idea of a Busway along the PR-181 corridor has been mentioned among city planners as a means to better integrate Trujillo Alto with the Tren Urbano system but the concept has not been investigated. The goal of this project is to analyze the current conditions of the PR-181 corridor and identify the major obstacles that would impede the realization of a PR-181 Busway. After identifying these major issues, we will develop preliminary concepts for the configuration of a Busway. The information provided in this study is intended to be of use to city planners in San Juan and Trujillo Alto and to the future development of a Busway along the PR-181 corridor.

## **2.0 Background Research**

### ***2.1 Introduction***

Major cities all over the world are faced with various challenging transportation issues. Each city faces its own problems and discovers its own solutions, but there are many similar themes among all of the solutions to these problems that can be considered universally. In this section, we will present the specific transportation issues faced by San Juan, Puerto Rico and its surrounding municipalities, and analyze the role that the Municipality of Trujillo Alto, Alternativa de Transporte Integrado and Tren Urbano might play in alleviating congestion along Road 181 in the Trujillo Alto area. We will then study general causes of major transportation issues and their solutions, and show how these solutions can be applied to problems in San Juan. Specific examples of mass transit systems in major cities throughout the world are then discussed, along with reasons for their relative success or failure and their possible implications for use in San Juan. We hope to show that there are many examples in the world of the transportation problems that San Juan is facing, and that there are many different approaches to solving these problems. When these different methods are utilized and integrated creatively, they can have a large and positive impact.

The background research has been performed in a broad context. It includes information that may or may not be specific to the implementation of a PR-181 Busway, yet we believe that this information is useful in comprehending other aspects that deal with the varying transportation issues. These aspects could trigger further exploration for future transportation projects.

### ***2.2 World Problem***

Traffic congestion is an issue that exists in many parts of the world. Due to traffic congestion posing such a concern for society, changes are being developed and implemented constantly. The Texas Transportation Institute's Urban Mobility Study, an independent analysis of traffic, has been conducted annually since 1982. Swift (2004) states in the Urban Mobility Report from the Texas Transportation Institute of 2004 that traffic congestion problems are apparent all over the world and that these complications

are growing in all areas and in catastrophic amounts. We will now begin to investigate these problems in diverse locations.

In metropolitan Manila, Philippines, there is a matter at hand for the citizens. “With there being over 10 million residents that are affected, vehicles are traveling on the average of no faster than 15 kph on a weekday along Epifanio de los Santos Avenue” (The World Bank 2004). Due to this grave conflict, the new World Bank Country Director for the Philippines, felt it necessary to implement a light-rail transport in order to better manage traffic as well as accessing road improvements (The World Bank 2004).

In Britain, traffic congestion is a hot topic. In fact, Britain’s roads are the most congested in Europe. There are nearly half a million traffic jams in Britain every year, which averages to almost 10,000 a week. Also, there are between 200 and 300 incidents of severe traffic congestion a day and a quarter of Britain’s most traveled roads are jammed for at least an hour a day (BBC News 2002).

The United States is also an area of the world where this issue is prevalent. The Texas Transportation Institute study found that the average annual delay time per peak period traveler climbed from 16 hours in 1982 to 46 hours in 2002. Among the worst cities in the nation regarding traffic problems is Los Angeles, California where each driver averaged 136 hours in rush hour traffic in 2002. Table 1 lists the top 10 cities in the United States with the annual delay each person encounters. As shown, traffic delays are in various cities around the nation.

**Table 1: Big City Delays (Schrank & Lomax, 2002)**

Rank	Urban area	Annual delay per person in hours
1.	Los Angeles, Calif.	136
2.	San Francisco-Oakland, Calif.	92
3.	Washington, DC-Md.-Va.	84
4.	Seattle-Everett, Wash.	82
5.	Houston, Tex.	75
6.	San Jose, Calif.	74
6.	Dallas-Fort Worth, Tex.	74
8.	New York, N.Y.-Northeastern N.J.	73
9.	Atlanta, Ga.	70
10.	Miami-Hialeah, Fla.	69

### **2.2.1 Central Causes & Effects of Traffic Congestion**

There are several important causes and effects that stem from the existence of traffic congestion. The Transit Cooperative Research Program (TCRP) serves as one of the main ways in which the transit industry can formulate logical solutions to the demands put upon it (Burchell et al. 2000).

In the *TCRP report 74* there is a study which informs us that there will be sizeable increases in many areas of society that potentially may contribute to more traffic woes. In the study, it is forecasted that the residential population will increase by 22 percent from the year 2000 to the year 2025. The residential population will reach 342.2 million which is a 60.7 million increase from 2000. With regards to the number of households over the same time period, it is predicted that the households will increase by 23.5 million, a 23 percent increase (Burchell et al. 2000). These figures show that in the near future there will be a greater number of people going to work and a greater number of people using a means of transportation. With immense increases in residential population



and number of households, the future has its hands full if the abolishment of traffic congestion is considered a worthy goal.

There is one common underlying theme dealing with causes for traffic congestion: too many vehicles crowding available road space combined with limited travel options (American Public Transportation Association 2003). There are some other key factors that contribute to this root problem. These include disproportionate increases in private vehicle use. From 1980 to 2000, the U.S. population grew 24 percent, while the number of registered motor vehicles increased 46 percent and the number of vehicle miles traveled grew 80 percent (Highway Statistics Series). Clearly, the United States is growing rapidly with regards to not only the population but the number of registered vehicles which in turn increase the amount of traveled miles. This poses a concern for the nation since business is heavily reliant on just-in-time strategies, designed to keep business competitive in the global economy requiring smaller but more frequent deliveries, resulting in more freight traffic on the roadways and more congestion (Card 2002).

Sprawl development patterns in America's urban and suburban areas often provide no choice but to use private vehicles for every travel need, continually increasing congestion and increasing pressure for more roads and available parking (American Public Transportation Association 2003). To clear up any confusion, "Sprawl is a pattern and pace of land development in which the rate of land consumed for urban purposes exceeds the rate of population growth and which results in an inefficient and consumptive use of land and its associated resources" (Towson University Study). Tiresome driving, frequent traffic jams, air pollution, and damaged communities are among the visible effects of urban sprawl. However, urban sprawl carries a "hidden price tag," placing a financial burden upon cities and towns when they are extending services and infrastructure (Benfield et al. 2001). Figure 2 shows the annual congestion costs from 1982 to 2001. The graph shows the varying sizes of the urban areas and how the annual congestion costs have risen over the past 20 years. With regards to medium and small urban areas, the annual costs of congestion have risen at a more feverish pace than the much larger urban areas.

Figure 1  
Annual Cost of Congestion

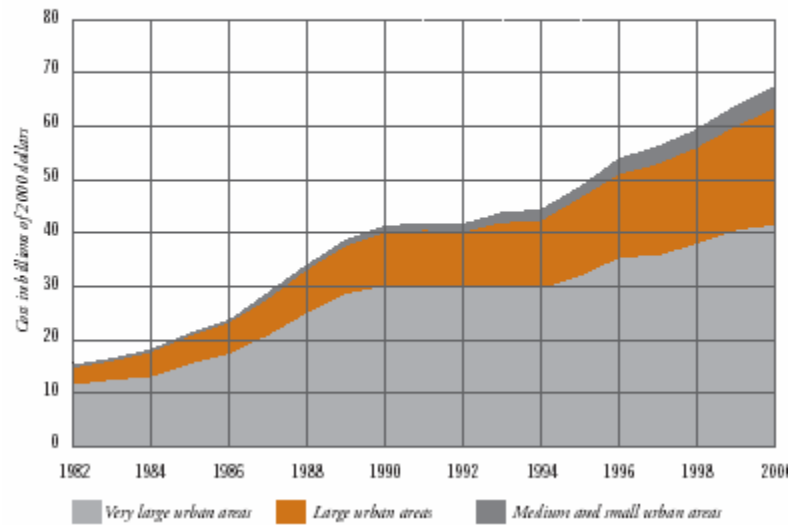


Figure 2: The Costs of Traffic Congestion (Texas Transportation Institute 2002)

Traffic congestion has many consequences. Large costs and wasted fuel are among the financial burdens cause by traffic. According to the TTI study in 2000, the total cost of congestion in terms of lost hours and wasted fuel was \$68 billion. Nationwide, the total annual cost may approach \$100 billion (Lomax 2002). Business costs increase drastically due to the economy of business relying on the “just-in-time” flow of materials. Due to trucks transporting goods to 75 percent of American communities, congestion delays increase business costs (Card 2002). In the US there is an ongoing dependence on foreign oil mainly because of the large amount of energy resource use. Nearly 43 percent of America’s energy resources are used for transportation, and a significant amount of which, is eaten up by traffic congestion (Shapiro et al 2002).

In addition to the previous financial and economic consequences that arise with traffic congestion, there is much concern regarding pollution due to urban sprawl as well as the congestion. Associate professor Tim Buckley from John Hopkins University expresses that traffic congestion presents society with a unique health threat that is very serious. He explains that this threat is growing at epidemic proportions and that it can no longer be ignored (Hulsey et al. 2004). A John Hopkins study reveals a correlation

between traffic and curbside concentration with cancer-causing pollutants. To add to the severity of the pollution threat is the realization that air pollution contributes to over 100,000 premature deaths each year in the United States (Hulse et al. 2004).

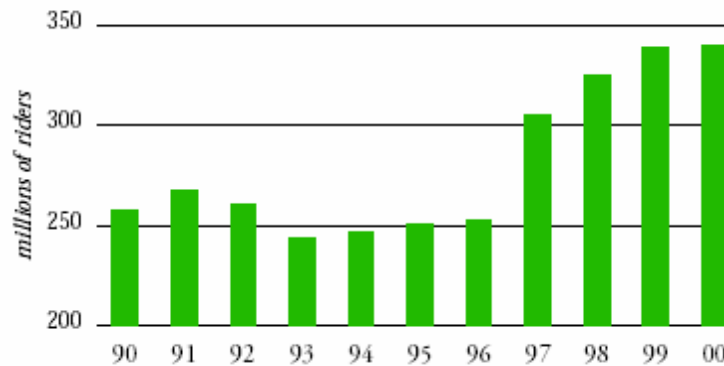
When dealing with city life, vehicle traffic provides a great impact on the quality of life. Traffic has its most severe effects on the safety of pedestrians, bicyclists, and children who play in the street. In American cities, more often than not a car accident involves the death of a pedestrian. "In Boston, New York City, and San Francisco, half the people killed in car crashes are pedestrians" (Conservation Law Foundation). Children and the elderly have the highest risk mainly due to their high dependency on walking or bicycles for transportation. More than one-third of children ages 12 years or younger in the United States killed in car crashes are killed while walking or riding bicycles. Also, more than 20 % of senior citizens killed in car crashes in 1995 were killed while walking or on a bicycle. This statistic was at a rate one-third higher than the general population, hence, revealing a substantial risk separation (Conservation Law Foundation 1998).

### **2.2.2 Urban Congestion Management**

There have been efforts to work towards improving the traffic problem all over the United States but there has been a common problem that keeps surfacing. The addition of highways has been the all too typical response to traffic issues. Gary Richards, who writes a column called "Mr. Roadshow" for the San Jose Mercury News in California, describes a great example of how this is relevant. After building Highway 85, a six lane highway in California, many in the surrounding communities were convinced that it was their salvation for traffic problems. Within two years, Interstate 280, a parallel freeway, was more congested than it was before 85 opened up (American Public Transportation Association 2003). This just backs up the truth that building more roads does not relieve traffic congestion. In theory, building more roads allows more cars to drive on them, in turn creating more congestion. Mass transportation has been referred to in many instances within this paper as a traffic alleviator, but when more and more roads are being built, this allows more and more people to use their own cars and stray away from utilizing mass transportation, giving in to traffic congestion.

The common incident to make additions to highways and road infrastructure contradicts its purpose. The purpose is to relieve traffic, yet that is clearly not always the outcome.

“Traffic congestion in the United States in small urban and rural areas is increasing 11 percent each year, while it is doubles that amount in urban areas.” (CTAA, Full Steam Ahead for Reauthorization) The graph below reveals the ridership issue that has been a problem in managing traffic congestion across the United States. Figure 3 exhibits the increase in millions of riders of mass transportation over a 10 year period in the United States. It is evident that people are opting to partake in mass transportation, whether it is their choice or not.



**Figure 3: Millions of Riders vs. Years (American Public Transportation Association, 2002)**

A new strategy for managing urban congestion is emerging. This new strategy is referred to as new urbanism (New Urbanism 2005). New urbanism is more than implementing mass transportation; it is a new perspective that focuses on how to plan the layout of cities. Designing the layout of housing, work places, shops, entertainment, schools, parks, and civic facilities using the principles of new urbanism will shape a city that is less automobile orientated (ICMA).

New urbanism’s goal is to design diverse, walkable, compact, and vibrant cities. In order to create these types of cities, it is important to follow the key principles (New Urbanism 2005):

- Walkability
- Connectivity

- Mixed use and diversity
- Mixed housing
- Quality of architecture and urban design
- Traditional neighborhood structure
- Increased density
- Smart transportation
- Sustainability
- Quality of life

Designing a city that is more pedestrian friendly involves having destinations closer together, as well as giving pedestrians the right of way over vehicles, and even limiting the extent to which vehicles can travel in the city center. People will not be encouraged to leave their cars in the garage and either walk or ride a bike if their destination is not within a reasonable distance. Also, ensuring that sidewalks and/or bikeways are maintained in good order will encourage people to walk or bike to their destinations. This would include not allowing obstructions in pathways and also designing sidewalks with inviting architecture and protection from environment such as the sun or rain. Making these efforts will provide travelers with a realistic alternative to the automobile as well making that alternative attractive and pleasurable.

The design of roadways is also a major area that factors into whether or not a city is pedestrian friendly. The construction of highways and major roads has forced people into a situation where they have limited options for routes to travel in order to reach their destination. These major roads are not conducive to pedestrians or resident developments, therefore these roads are only suitable for automobile traffic (ICMA). Instead of having these major roads, installing a network of smaller roadways is a possibility that could be used to reduce traffic congestion and at the same time encourage pedestrians and cyclists. A network of smaller roads has the potential of moving a larger volume of vehicles, while reducing the speed that cars can travel due to the roads being narrower.

Designing sidewalks and roadways that encourage pedestrians and cyclists is fast becoming the new wave of urban planning management. Having the mindset of

designing cities around people rather than cars is a solution to the traffic congestion problem that could be applied to a large number of urban areas.

### **2.3 Traffic Congestion in San Juan, Puerto Rico**

San Juan, Puerto Rico is scarred by an overwhelming traffic congestion issue. Every day in San Juan, thousands of drivers suffer long delays and major jams in rush hour traffic. The traffic congestion present in San Juan not only produces delays and major jams on the interstate, but poses environmental concerns, along with economic strains (Carmona 2004). The Department of Transportation and Public Works has made great strides in the past 35 years but they are realizing that their focus should not mainly be on road development and highway additions, but rather on mass transportation (The End of Gridlock). Government administration in Puerto Rico has spent millions of dollars every year on developing their highways and roads. In 2004 alone, the Highway & Transportation Authority (HTA) had a \$698.4 million dollar budget for road construction and improvements (Carmona 2004). “With 2.5 million registered vehicles on the island traveling on 17,000 kilometers (10, 563 miles) of paved roads, however, no amount of money is ever going to be enough to solve the island’s traffic problems” (Carmona 2004). It is a clear-cut case that there are just too many cars along with too few roads. If they keep building more and more roads then the island will drown itself in pavement and cars. This is something that Puerto Rico has put great thought into and it has opened their eyes to the idea of mass transportation (Carmona 2004).



**Figure 4: Puerto Rico**

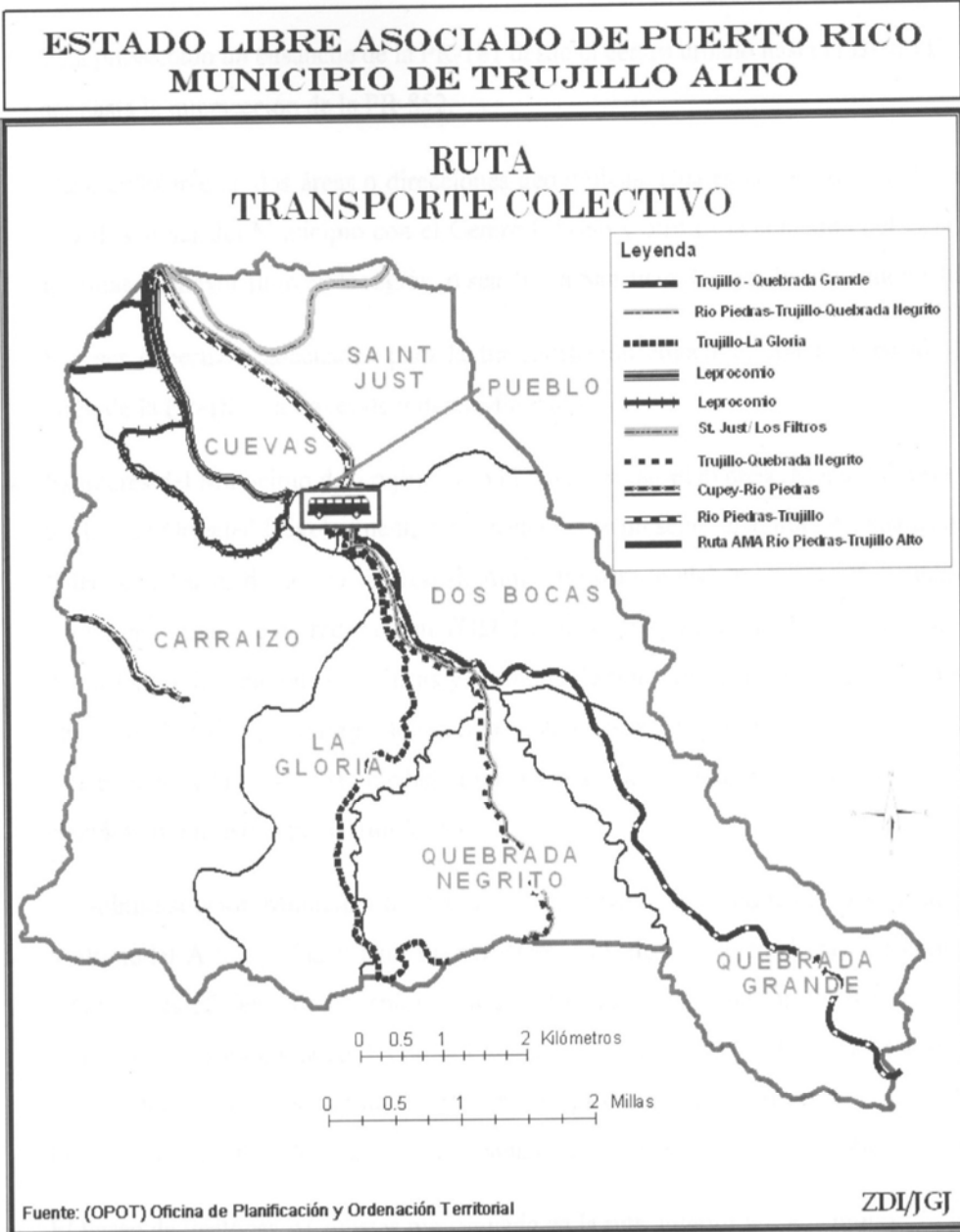
Trujillo Alto is located in the southeast area of the Metropolitan Region of San Juan as shown in Figure 4. The municipality is divided into eight barrios, or wards. The most densely populated barrios are in the northern section, adjacent to the San Juan border. These barrios are named Cuevas and Saint Just. The central area of the city is in the Pueblo barrio, directly in between Dos Bocas, Carraízo, and La Gloria. The barrios named Quebrada Grande and Quebrada Negrito are in the southern section of the city, and are very rural areas. Directly through the center of the city is the Rio Grande de Loiza, which is a fresh water river that leads to a water treatment plant outside of the city, and supplies the San Juan area with fresh water. For this reason, the river is very important to the entire Metropolitan Area, and cannot be overlooked when it comes to development or other potential environmental concerns. The barrio that has seen the most increase in population is the Dos Bocas barrio. The reason why Dos Bocas has thrived is mainly because of the newly developed Encantada neighborhood, which houses approximately 7,000 people in 2,800 units. As of 2000, the municipality has a population of 75,728. Compared to the rest of the Metropolitan Region, Trujillo Alto has seen a great increase in population between 1990 and 2000. The 23.9% increase is the second highest increase of any municipality in the San Juan Area (Oficina de Planificacion y Ordenacion Territorial, 2005).

Similar to other cities around the world, Trujillo Alto has fallen victim to the effects of urban sprawl. Traffic and congestion are large problems within the city. The main street in Trujillo Alto is PR-181, also known as the Expresso Trujillo. This four-lane highway comes directly from the San Juan area and connects to the downtown area of the city. After PR-181 goes through the downtown area, it becomes a rural two lane road with dangerously sharp curves and steep grades. The road is not safely accessible to commercial traffic, which causes trucks and buses to seek alternate routes.

The main areas where traffic is an issue is along the corridor of PR-181 coming from San Juan and through the shopping centers, through Barrio Pueblo where PR-181 is no longer a four lane highway, and several intersections along PR-181 that junction routes from neighboring towns. To lessen some of the commuter traffic, publicos have routes existing in the city going to several different locations as shown in Figure 5.

Trujillo Alto publicos are a part of a privately owned van system in the metropolitan San Juan area. The publicos that originate in Trujillo Alto leave from the Trujillo Alto Terminal in Barrio Pueblo, and bring passengers to various neighboring towns. Most of the publico routes are currently traveling to Rio Piedras where there is a very large terminal that allows one to travel virtually anywhere in the San Juan Metropolitan Area. Other publico routes include destinations such as Quebrada Grande/ El Chorro, La Gloria, and Buenos Aires/Quebrada Negrito.





**PLAN  
ORDENAMIENTO TERRITORIAL  
TRUJILLO ALTO**

**Figure 5: Public Routes through Trujillo Alto**

Employment in Trujillo Alto is well above average compared to the rest of the island of Puerto Rico. As of 2003, approximately 31,000 persons living in the city are employed. The unemployment rate in Trujillo Alto is 7.2%, and the unemployment rate of Puerto Rico is 12.4%. The per capita income for Trujillo Alto is \$10,727 and for Puerto Rico it's \$10,120. The barrio that has the highest per capita is the Dos Bocas barrio with \$22,034. Most of this income comes from the Encantada community, which is known as an upper middle class neighborhood. Pueblo barrio has the lowest per capita income which is \$5,923. This is due to the aging of the community and citizens are moving to newer parts of the city (Trujillo Alto Presentation, 3/21/2005).

### **2.3.1 ACT, Municipality of Trujillo Alto, & ATI**

In order to gather more information on the traffic problem in San Juan and to make recommendations for improvements, we will be working with two major organizations involved with transportation. These two sponsors are the Municipality of Trujillo Alto and Autoridad de Carreteras Transportacion (ACT). ACT is focused on providing Puerto Rico, and more specifically San Juan, with alternative means of transportation to alleviate the congestion on major roadways. One of the alternate forms of transportation is a light rail system called the Tren Urbano, which currently runs from Bayamon Centro to the Sagrado Corazon area of Santurce and has an additional 14 stops in between. San Juan also has the Metropolitan Bus Authority which has not worked as effectively as officials would like in the recent past, partially due to poor public image. However, changes are being made to the system so that it will be able to integrate as seamlessly as possible into the Tren Urbano.

Our project focuses on alleviating the congestion on Road 181 that residents in the Trujillo Alto area use to commute to and from work in the downtown Santurce area. This congestion is one of the major problems that the citizens of Trujillo Alto have to face, which makes it one of the major problems for the Municipality of Trujillo Alto to solve. ATI and Tren Urbano are also involved, since the Municipality will likely be working with both of these organizations to devise a solution to the problem.

The ACT has many initiatives in the short and long term future. ACT maintains the Land Use and Transportation issues on the entire island. ACT is what is known as the

“umbrella” over several transportation organizations. Some of these organizations include Metrobus, AMA, and ATI. ACT is a government funded organization with several hundred employees located all over the island. In the land use planning department where we work, there are about 30 employees including a GIS department.

The first initiative for ACT is to create and promote an efficient and reliable collective transport. This initiative is directly involved with our project. The first objective of the initiative is to establish collective transport alternatives. There is a great need to educate people about alternatives to driving their car. When there are so many people dependent upon their car, congestion is naturally created. The second objective is to ensure easy intermodal access and connections. Mass transportation needs to be made easier to use in order to save people valuable time and effort. Otherwise, the mass transportation alternatives will not be as attractive, and could receive little support from the riders. The third objective in this initiative is to increase the disincentives to car use. By making it less convenient for people to drive their cars, this can in turn increase mass transportation use, and lessen traffic congestion.

The second initiative for ACT is to ensure that the land use plan reduces the need for transport. It is necessary to ensure that non-car options are built into all aspects of the new land use plans. The first objective is the revitalization of dense inner city areas. This is referred to as new urbanism. From these densely populated areas, services need to be accessible for people within walking distance. By making a traffic situation better, it may not solve the entire problem. What could happen is that the urban area will sprawl and in the short future, these traffic problems will occur once again. Sidewalks need to be made more accessible, and attractive for people to use. There is a need for lighting, bike lanes, greenways, and parks.

The third initiative is to complete the road and highway network. The main area of focus here is the Transportation Plan of 2030. This plan includes all transportation projects that are scheduled to be completed by 2030. In the near future, the initiative is to continue completing existing projects on the road and highway network, define operations and technical requirements, and complete design and environmental studies. It

is a lot of work to be done by 2030, but much of it is underway. Little by little, more and more is completed to eventually produce a revitalization of the entire system.

ATI, which stands for Alternativa de Transporte Integrado is a transportation agency that was formed two years ago to be in charge of all of the different modes of transportation. Before ATI was formed, there was only the Autoridad de Carreteras y Transporte (ACT), which has authority over all of the roadways on the island. Two years ago, when the Tren Urbano was being constructed, ACT designed ATI with the intention of having it control of all of forms of transportation on the island. It was originally just an extension of ACT, but in the summer of 2004 it was granted its own budget independent from ACT and it started to become its own agency. As ATI grows, it will eventually become an independent, fully functioning transportation agency that will integrate all of the different modes of transportation to work efficiently as one large system.

ATI is divided into four sections consisting of Operations, Facilities and Maintainers, Community Relations and Intermodal. The Operations Division is solely in charge of the Tren Urbano, which is currently the major form of transportation that ATI oversees. The Facilities and Maintainers Division is in charge of maintaining the Tren and ensuring its smooth operation. Community Relations deals with the public in regards to transportation, and the Intermodal division is in charge of the integration of all of the different modes of transportation.

The different modes of transportation currently operating in Puerto Rico that ATI has charge over are the Tren Urbano, the Metropolitan Bus Authority (AMA), Metrobus, and to a small extent, the Publicos. The major goal of ATI is to integrate these different modes of transportation so that they work seamlessly together to take people where they need to go in a timely fashion. The problem that ATI is facing with this objective is that AMA, Metrobus and the Publicos have their own managers and corporations and they work independently for their own interests. It will take some time to overcome this problem, but a project such as our proposed Busway in Trujillo Alto will help speed along the integration process.

## **2.3.2 Completed or Ongoing Transportation Projects in Puerto Rico**

### **2.3.2-1 Road Work**

From 1993 to 2000, traffic across metropolitan roadways increased by 50%. Despite this increase in traffic, the Department of Transportation and Public Works in Puerto Rico has managed to reduce travel time by 40%. They did this with a \$5.5 billion investment spread from 1993 to 2001 which involved improving existing roadways and adding new ones. The PR-9 expressway was opened in 2000 in Ponce as well as PR-10, which runs between Ponce and Adjuntas, cutting the normally hour-long distance into 15 minutes. Other major projects completed in 2000 include improvements to Highways 2, 3, 22, 26, 30, and 52. Highway 53, between Fajardo and Yabucoa was finished in 2000 as well as the Ponce bypass, which circumvents the town center to avoid congestion, and Highway 10 which cuts the travel time down 50% between Arecibo and Utuado. Kennedy Avenue, which runs toward San Juan, was converted into an expressway, and as a result, travel time on this road decreased by about 62% despite an increase of traffic of 82%. Highways such as the De Diego Expressway incorporate reversible lanes to accommodate the shift of traffic from the morning commute to the evening commute.

Although Puerto Rican officials understand the need for emphasis on mass transportation, highways and major roads will still be used heavily by motorists, so efforts must be made to ensure their smooth operation. (Garcia, 2000)

### **2.3.2-2 Metropolitan Bus Authority**

The Metropolitan Bus Administration (AMA by its Spanish acronym) planned to have various improvements to their current system completed by the time the first stage of the Tren Urbano was completed. Adaline Torres Santiago, president of AMA, said in 2001 that they have 271 vehicles along with 18 other buses, and 80% of this fleet is fully operational, meaning that the agency can apply for federal funding to buy new buses. AMA already transports close to 113,000 passengers daily, but there is potential for much more. Santiago asserts that new buses need to be bought in order to comply with their

itineraries and improve their image to the public, who currently view mass transportation as something for the underprivileged (Guadalupe-Fajardo, 2001).

Along with buying more buses for the opening of the Tren Urbano, AMA will be implementing a Global Positioning System (GPS) to modernize the outdated control center which was established in 1983. This system will allow operators to closely monitor all of the buses on each of the 30 routes in the itinerary, and to determine if buses are on-time or off schedule. Since the first phase of the Tren Urbano has been opened recently, hopefully the AMA has been successful in implementing its changes. Puerto Rico's goal is to have a multimodal transportation system which utilizes all of the different means of travel in an efficient, systemic way in order to reduce congestion in all of the metropolitan areas of Puerto Rico. For this vision to be realized, each mode of transportation in the multimodal system must be working effectively, including the AMA (Guadalupe-Fajardo, 2001).

### **2.3.2-3 Tren Urbano**

The first leg of the Tren Urbano, pictured in Figure 6, which runs from Bayamon Centro to the Sagrado Corazon area of Santurce has just opened. It is a 10.7 mile rapid rail line with 16 stations, and it is expected to carry 113,300 riders per day by 2010 (<http://www.fta.dot.gov/library/policy/ns/ns2003/ns7existingffc.html>, 2002).



Figure 6: Map of Current Tren Urbano Route (<http://www.ati.gobierno.pr>)

The 16 stations currently open are Bayamón, Deportivo, Jardines, Torrimar, Martínez Nadal, Las Lomas, San Francisco, Centro Médico, Cupey, Río Piedras, Universidad, Piñero, Domenech, Roosevelt, Hato Rey and Sagrado Corazón. During peak hours trains run every 5 minutes, and during off-peak hours they run every 12 minutes. Fare is \$1.50 for adults, which includes a connecting bus ride, \$0.75 for students and persons aged 60-74 years, and the train is free for children under 6 and seniors 75 and older. A one day pass can be bought for \$5.00, as well as a seven day pass for \$15.00, a 30 day pass for \$50.00, and a three month pass for \$90.00. One-use tickets are bought outside of the gate to the station, and then these, along with the multiple-use passes, can be swiped into the turnstiles to gain entry. This is similar to the system used in the New York City subway, and it is very efficient. The Tren Urbano also has a program called Bici-Tren, which allows riders to obtain a permit for bringing a bicycle onto the train so that they may ride to and from the train stations to wherever they are going.

The Tren Urbano is the major push by the FTA and the government of Puerto Rico to reduce traffic congestion and dependence on personal transportation. It cannot, however alleviate the traffic congestion on its own; it needs help from other modes of transportation, including the AMA.

## **2.4 World Studies - Unique Strategies**

The next step of our project is to look into how other areas have dealt with the overwhelming problem of traffic. In the following section we discuss several examples of ideas from around the world. Each subsection touches upon the measures taken to alleviate traffic problems in their respective area. The examples stress unique strategies that were used to solve challenges facing their public transportation system. We believe that these unique strategies could be possibilities that ATI could look into or spark creative thinking to develop unique ways of their own to solve the transportation problems in Trujillo Alto.

### **2.4.1 BART - Ways to attract passengers**

Urban planners in the city of San Francisco, California realized early that traffic would be a potentially crippling problem if they did not develop plans to help prevent it. In 1957 the Bay Area Rapid Transit (BART) was established to develop plans and implement a regional rapid transit system (Stokes, 1973). The Bay Area Rapid Transit's initial concern was to construct a 75-mile network of transit rails.

A major problem that BART faced was how to get people out of their cars and on to the transit system. This problem is one that many mass transit developments face. One reason that the BART was and still is a success is that the system is attractive to the commuters in the San Francisco Bay Area. One of the first measures taken to finance and attract people to the transit system was by increasing the gas tax. Other ways they were able to accomplish this was by raising parking taxes and raising peak hour bridge tolls. Such local measures are extremely effective in that they discourage unnecessary automobile use while at the same time provide for realistic alternatives to the automobile (Stokes, 1973). BART was successful in making an expansive transit system due to good



planning and strategic measures to ensure use and revenues needed to maintain and expand the system.

#### **2.4.2 Europe's Tram-Train System - Quality of Service**

The concept of developing a tram-train system was developed in Germany in the 1950's. The tram-train system consists of trains that not only can go about the countryside, but also to the inner-city. These trains are deemed special because they have converters that are able to use 15,000 volts (heavy rails) or 750 volts (light rails). The idea was to have trams that were able to run on the same rails that regional passenger trains ran along. By the 1990's the use of the Tram-Train system for transportation was widely spread all over Europe.

In Karlsruhe, Germany the tram-train system was a great success, though the system did face a number of problems. One major problem that opposed initial success in Karlsruhe was that the main railway station was "2 km south of the centre" (Novales, 2002). Passengers who traveled to Karlsruhe had to transfer to either another tram or to a bus system in order to reach the center of the city. Research showed that due to the need of passengers often transferring in their travels "lowered rail user's perception of the quality of the service" (Novales, 2002). Much of this statement applies in Puerto Rico. This problem is something that needs to be solved in order to promote the new system and make passengers feel that traveling on mass transportation is very worthwhile. The department of transportation in Karlsruhe made the decision to use trams that ran along the existing rails that would provide a direct route to center of the city for travelers. This decision resulted in an increase of usage of the tram-train system in Karlsruhe.

Overall it appears that the Tram-Train systems used in Europe are an excellent answer to the problems of public transportation and traffic. The systems also provide a good rubric that other systems could use to help promote their system to travelers. The following is taken from Novales and Bugarin's (2002) study of the Tram-Train systems of Europe:

##### **6.2 Advantages for passengers**

1. Public transport users save time, as the tram-train can reach speeds double those of buses. Door to door traveling time is comparable with that of the private car, as running times between stations are reduced

thanks to the braking and acceleration values of light rail vehicles in comparison with traditional trains. Stopping times at stations are also shorter, thanks to improved passenger access due to the number of side access doors. Finally, waiting times between different modes of transport are reduced.

2. Direct access from the region to the main business and shopping centres can be provided, without the need to change to another mode of transport, as occurred before the introduction of these services.

3. Punctuality rates are improved appreciably because the length of tracks with shared rights of way is smaller.

4. Greater comfort, due to an increased number of larger seats in each car and their improved dynamic features, which make for a smoother journey.

5. The system is easy to use, as its introduction is usually accompanied by improved passenger information systems, with electronic information devices at stops, normally operated from the control centre, specifying the arrival time of the next vehicle, as well as the stops along the route and waiting times.

6. Integrated pricing, due to the fact that an operating company is normally set up to take charge of planning and coordinating the timetables and prices of both urban and regional public transport in order to make it user-friendly.

7. An increase in the number of stops on the routes previously covered exclusively by trains means that stations are now closer to potential users, which makes the system more accessible.

8. Light rail services are more frequent than traditional rail services, thereby reducing waiting times at stops.

### **6.3 Non-user benefits**

1. There is reduced congestion on motorways and local roads.

2. There is a reduction in the need for investment in road building and maintenance.

3. Environmental impact is lower.

4. There are savings on parking costs.

5. There are savings on costs arising from accidents.

Even though the advantages listed above are specific to how the Tram-Train system is a good idea, the same principles of what is important to users can be applied to any system of public transportation. If developing public transportation systems are able to make sure that they provide users with some of these advantages, and, also make it known that the system does provide benefits to its users, the result will be in an increase usage of the system.

### **2.4.3 Seattle Metro - Corporate Participation/Carpooling**

King County, WA, which includes the city of Seattle, has about 1.7 million people living in the area. Considering that it is not as densely populated as some larger cities, King County is proud to boast that they operate a top ten bus system in the U.S., based on bus ridership. Twice, the Seattle Metro, has been honored as the best public transportation system in North America. The Metro has a total of 1,300 vehicles, with a 100 million passenger annual ridership. The Metro also has the largest VanPool program in the country. It consists of 600 vans which about 5,000 people use everyday, eliminating approximately 4,500 vehicles on the city's streets. Figure 7 shows one of these carpool vans. Groups meet at one of 122 lots around the area and all travel in a provided van. A Regional Ridematch system, which is a computer system that forms carpools through matching people on a database, is provided for commuters. This makes it easier for people who may work within a large company to meet other people that they may live near and they have an option of carpooling together. Seattle is one of the only cities in the world that has a system like this, and it seems to be successful. Most of the commuter lots are between 90% to full capacity by 9:00am on weekdays. The reason why Seattle's Metro is so popular and so reliable is that businesses in the area have agreed to promote the system to their employees, and the government of King County has put the Metro system as a priority for funding and future planning. (King County Metro Transit at a Glance, 2005) (About King County Metro, 2005)



**Figure 7: A VanPool Van (<http://transit.metrokc.gov/tops/tri/tri-rm-vp.html>)**

A unique aspect of Seattle's Metro system is their 1.3 mile bus tunnel. The tunnel burrows directly beneath downtown Seattle, giving the option for buses to avoid the street level thoroughfares. It is the nation's first tunnel for dual powered buses. Metro owns 236 of these special buses which run on electricity when they are in the tunnel, and on diesel fuel when outside. Figure 8 shows one of these buses. Having the buses running on electricity while in the tunnel keeps down the noise and diesel fumes that the buses would emit. Forty percent of the routes that go into the downtown area use the tunnel along with thousands of commuters each day. (MetroBus Tunnel, 2005)



**Figure 8: Hybrid Bus (<http://transit.metrokc.gov/am/vehicles/hy-diesel.html>)**

Another unique aspect of the Metro system is their FlexPass. It is the first employer based program offered by a public transportation authority in the U.S. We believe that this is something that may be of interest in the Trujillo Alto area, since the FlexPass is an excellent way to promote a public transportation system to commuters. The FlexPass was developed for employers who need to provide low cost commutation

benefits for their employees. It is an annual pass which is sold at a deeply discounted rate. It offers unlimited bus service in all of King County, and cheaper VanPool charges. However, what really makes the FlexPass unique is the FlexPerks program. The FlexPerks are discounted offers from participating merchants in the area. A range of businesses from delis, shops, restaurants, etc. honors the FlexPass for discounts. We believe that this is an idea that is potentially highly applicable in the Trujillo Alto area. This helps the transportation pass promote itself by getting people interested in saving more than their bus or train fare (Employer Bus Pass Programs: FlexPass, 2005).

The main reason for the Metro being so successful was the use of transit passes. The passes directly increased ridership through efforts of getting people interested and involved. Also, 3.4 million trips are taken each year to special events. Typically, these one-time-use passengers get impressed by the level of service and become long time customers. A UPass was also created for students attending the University of Washington. This encourages students to use mass transportation to get around the city. Currently, 75% of the students use the system. Although Metro believes in promoting their system and trying to make it better in the future, customer service is never overlooked. They use the internet to deliver most of their information, and also welcome comments and suggestions on Metro Online. A nice feature that is provided is the Trip Planner. It is very similar to “MapQuest” or any website that gives directions from point to point; however, Trip Planner provides users with door to door trip planning using only mass transportation. The easier it is for people to use mass transportation, the more popular it will become. There are many ideas that ATI and the Trujillo Alto area can use from Seattle’s Metro.

#### **2.4.4 Miami-Dade Transit - Busway**

The Miami-Dade County Area has the 16<sup>th</sup> largest transportation system in the United States. The system goes from Miami Beach to West Dade and the Middle Keys to South Broward County. The Metrobus system consists of 900 buses running on 94 routes, traveling a total of about 30 million miles per year. Unlike larger transportation systems in the U.S., the Metrobus system runs 24 hours a day 7 days a week. The citizens of Miami get decent use out of the system totaling 64.5 million passengers per year. The

annual budget for the entire system is \$150 million, with total revenue of \$60 million per year. (MDT Transit Facts, 2004)

The MDT has implemented some state-of-the-art methods for abolishing their traffic congestion problems. The first is the Metromover, which is free for all to use. It is very similar to a Monorail, and connects downtown areas to Metrorail stations without forcing people to walk a great distance. It also keeps people from driving and parking in the downtown area. It makes taxis in the downtown area virtually unnecessary, making the streets somewhat congestion-free.

The other state-of-the-art method for abolishing traffic congestion problems was the construction of the South Miami-Dade Busway. It is an 8.2 mile stretch of roadway built for bus traffic only. The first phase of the project is in use today, costing \$21 million so far. When the project has completed its three phases, it will total \$43 million. It was built upon an abandoned Florida East Coast Railroad section that runs directly parallel to US-1. Having the bus stops so close to US-1, it is easy for passengers to exit the bus and visit shops, restaurants, etc. on US-1. It has already been found that business on the road has flourished since the construction of the Busway. The Busway is very popular mainly because of its direct connections to the Metrorail, which runs directly into the downtown area. (South Miami-Dade Busway 2004)

The Cutler Ridge area is somewhat similar to the Trujillo Alto area, in that many people live there and commute to the downtown area. The Busway has buses in and out of Cutler Ridge every 20 minutes, during the weekday peak hours. Citizens of Cutler Ridge find it easy to use the Busway system to connect to the Metrorail and go almost anywhere in the Miami-Dade Regional Area. A Park and Ride program has been created for commuters, offering free parking to users of mass transportation.

We found it interesting that for special events in the Miami Area, accommodations are provided. On their website, they give detailed instructions on how to use mass transportation to get to festivals, sporting events, concerts, etc. This encourages thousands of people that are heading for the same destination to use mass transportation to avoid congestion and chaos. When the mass transportation system proves to the people that it is able to handle such a task, people will tend to rely on it more and more. The



important to the area because it gives people the option of mass transportation even though they do not live in an urban area within city limits.

#### **2.4.5 JFK Air Train - The Feeder System**

The Air Train in New York City has successfully connected JFK Airport to the cities' subway network. It is a light rail system that runs 24 hours a day, 7 days a week. By making this connection, one can get to and from any point in the Metropolitan Tri-State Area (New York, New Jersey, and Connecticut) completely on rail. Before, people would come into the airport via taxi or limousine. The Air Train gives travelers the option of avoiding parking and traffic problems. Getting on almost any subway anywhere in the city, it would take about an hour from station to station, and cost only \$7 (Port Authority of NY/NJ AirTrain, 2005).

What is interesting about this project is that the Air Train is like a feeder system to the cities' subway system. Figure 10 shows this system. It operates on a continuous loop and connects two major subway stops with any terminal in JFK. The whole system is less than 9 miles long. This feeder system is very effective, and can be easily duplicated with bus routes. We believe that this ideal may be something that the buses in Trujillo Alto can follow. It is the most efficient way to move people around quickly, plus riders do not have to wait very long for the next shuttle, because multiple buses/trains are on a continuous loop.

The funding for this project was done by surcharging every airline ticket in or out of JFK \$3.00 for a couple of years. This surcharge seems minimal, especially when one is paying hundreds of dollars for air travel. This method of fundraising along with Port Authority funds raised about \$1.5 billion which covered the total cost of the project. Also, the project is expected to make an economic boom in the southern section of Queens, NY. As more people are getting on and off the train instead of just passing by in taxis, economists figure that businesses in the area will flourish.

Pros:

- Affordable (\$7 verses \$45 cab fare)
- Efficient -- 35 minutes between JFK & Penn Station (using LIRR)



Cons:

- You have to carry your own luggage
- Not always a great value for families and groups

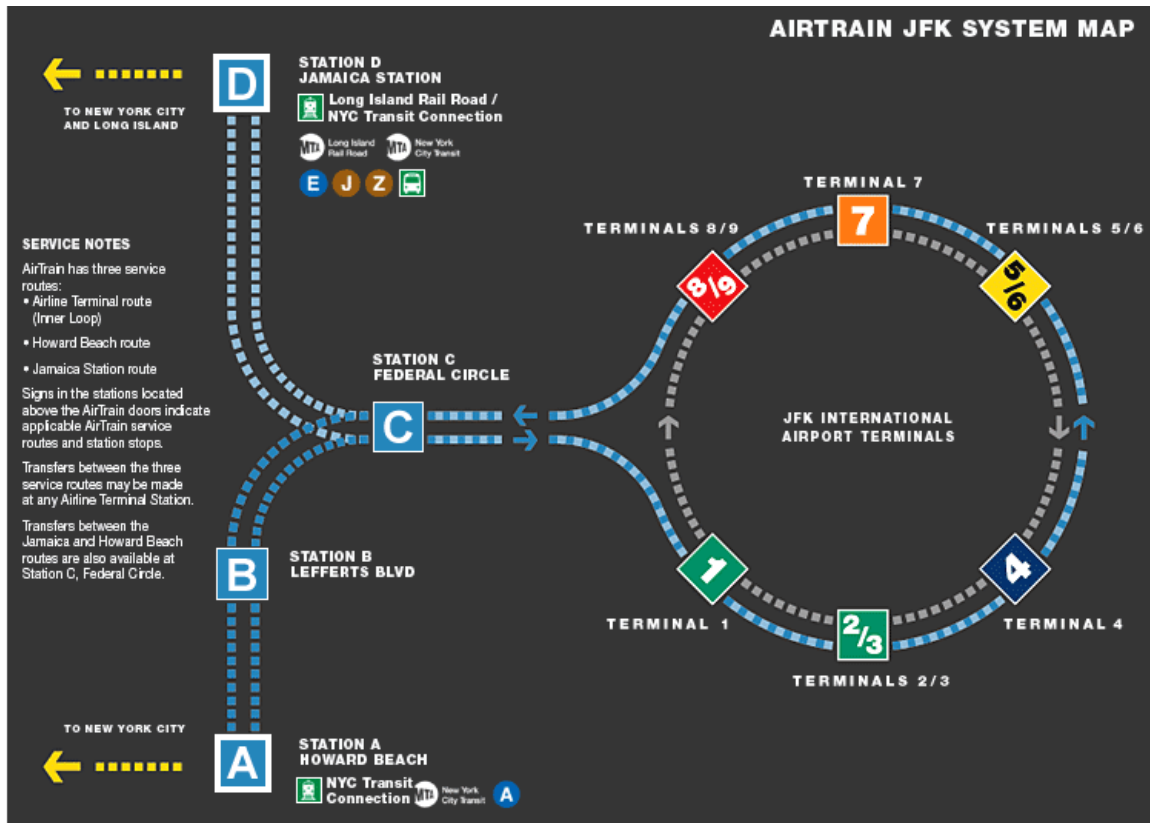


Figure 10: Feeder System Ideal (Port Authority of NY/NJ, <http://www.jfkairtrain.com/airtrain/>)

## 2.4.6 WRTA - Frequency of Service

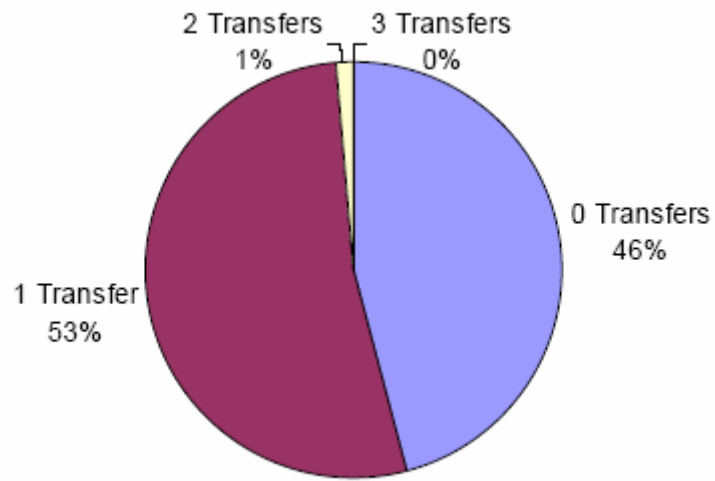
The Worcester Regional Transit Authority (WRTA) serves 37 neighboring communities to Worcester. It maintains bus service in 13 communities, totaling 28 bus routes in the region. Though the system is rather large in size, it has recently struggled to provide the region with optimal service. The main reason behind the current struggle is that the cost of operation seems to escalate each year, revenue decreases, and state funding has stayed the same. Because of all these conditions, the WRTA has been forced to cut back on their service. In July 2003, the WRTA decided to cut back their service

from 1,183 trips per day to 1,011 trips per day. These actions were necessary to keep within budgetary regulations. WRTA bus drivers earn higher wages than any other Massachusetts Regional Transportation Authority. The union that the WRTA drivers created demands these high wages, but in essence it hurts the whole system.

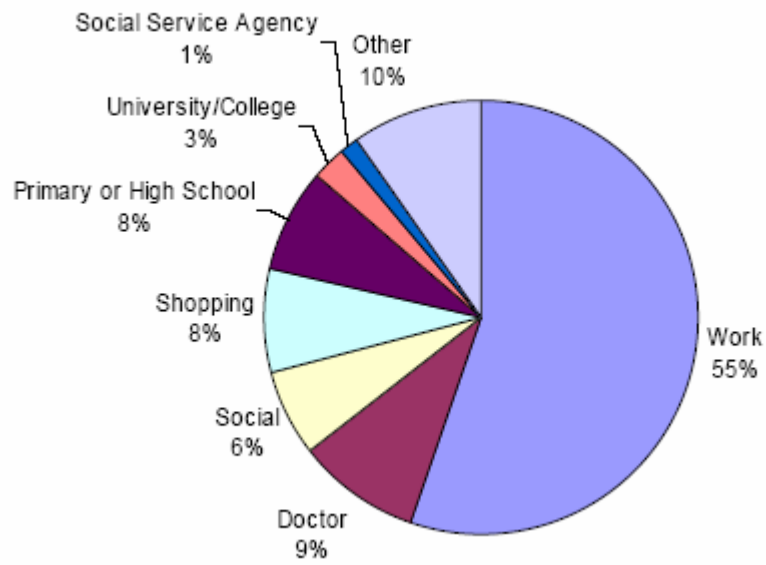
We found it amazing that most of the routes in Worcester cease operation between 6 pm and 7 pm during the week. Obviously many people need to travel later in the day than that, which brings upon the idea of people questioning the system's reliability. From 1999 to 2003, ridership on WRTA Buses has decreased 12.38%. In the study done by Urbitran Associates Inc. in November 2004, said that the declining ridership was due to the decreasing service plan that goes to a limited amount of locations, and also the frequency of the buses especially during peak hours. The average bus route peak hour frequency was one hour. That seems too long for people who are looking to get to work on time, or to get home after work. Without heavy investment into the system, this downward trend will continue for years to come.

WRTA also hired Urbitran Associates, Inc. to conduct a survey on the riders of the system and to report the results. Many questions were asked, and the responsiveness of the riders produced interesting results. Among them were:

- How many transfers are required for you to get to your final destination?
- What is the main purpose for your trip?
- What improvements would you like to see?
- What time do you start and end work?



**Figure 11: Amount of Transfers Required (Urbitran Associates, Inc.)**



**Figure 12: Main Purpose for Your Trip (Urbitran Associates, Inc.)**

Improvement	Number	Percent
More frequent service on weekdays	218	17.0%
More frequent service on Saturdays	208	16.2%
More frequent service on Sundays	271	21.2%
Serve new destinations	94	7.3%
Faster travel times	81	6.3%
Operate later hours	298	23.3%
Other	61	4.8%
Operate earlier hours	50	3.9%
<b>Total</b>	<b>1,281</b>	<b>100%</b>

Figure 13: Possible Improvements (Urbitrans Associates, Inc.)

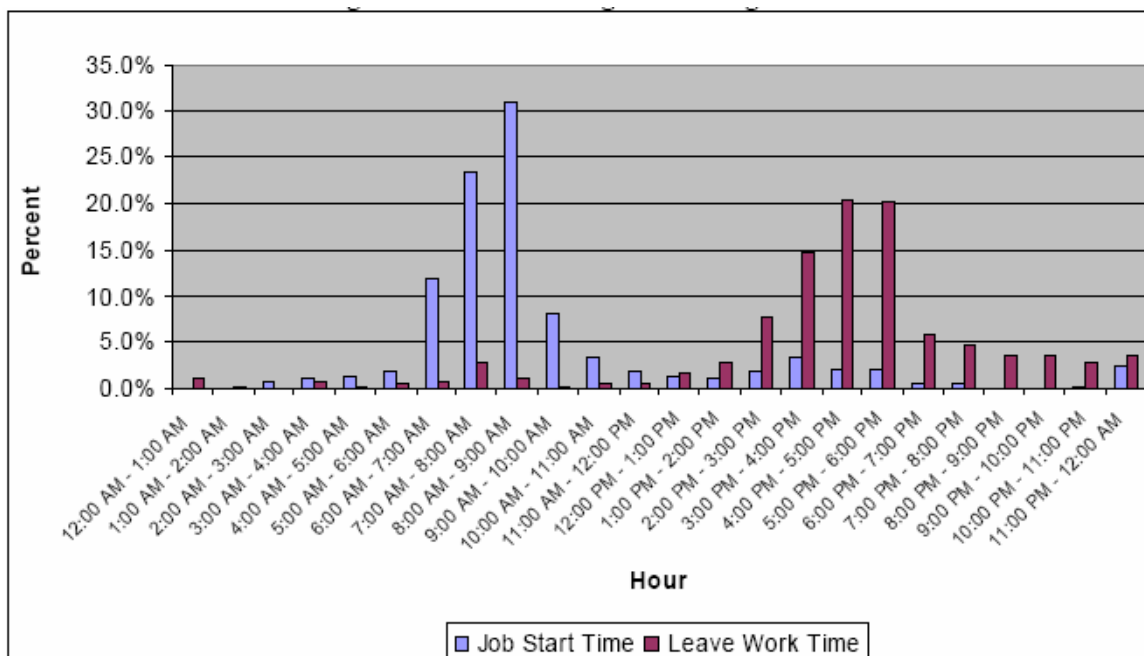


Figure 14: Rush Hours (Urbitrans Associates, Inc.)

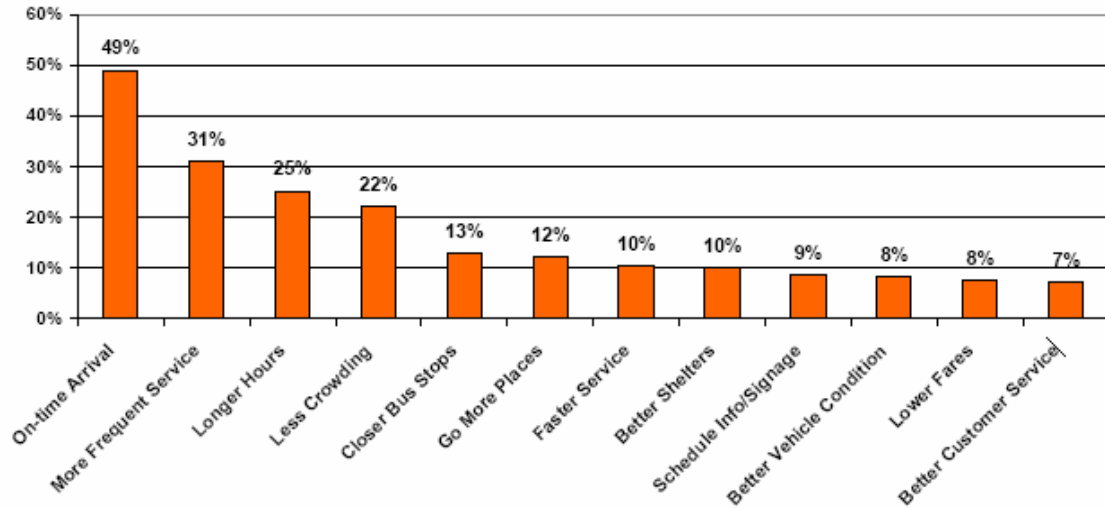
From these results (Figure 11), one can see that the amount of transfers required for one to get to their final destination could be a reason why people do not use the system more often. More direct service may be necessary in order to increase ridership. The main purpose for riders to use the system is to commute to work (Figure 12). This is obviously very important to most people because it is something that most people have to

do everyday. If better service was offered, perhaps people would use the system for other purposes. Shown in Figure 13, the most popular improvement that was suggested was to increase the frequency of bus service during the week. As stated before, the average frequency of bus services during rush hour was about an hour. People may find this to be unacceptable and find other modes of transportation. We expect that this would be a desire in Trujillo Alto, also. Most importantly, when people are looking for immediate service during rush hour, which is shown Figure 14, service should be more frequent because this is when the most amount of people are relying on the system for mobility. If it takes people the same amount of time to wait for a bus as it does to sit in traffic, than the people of Trujillo Alto will not even bother to use the system.

#### **2.4.7 WMATA - Importance of Customer Desires**

The bus service in and around Washington D.C. is one of America's best transportation systems. The system was created in 1967 and currently transports more than one third of the federal employees, and millions of tourists a year (WMATA Facts, 2005). The WMATA (Washington Metropolitan Area Transportation Authority) owns and operates the fifth largest bus system in the United States.

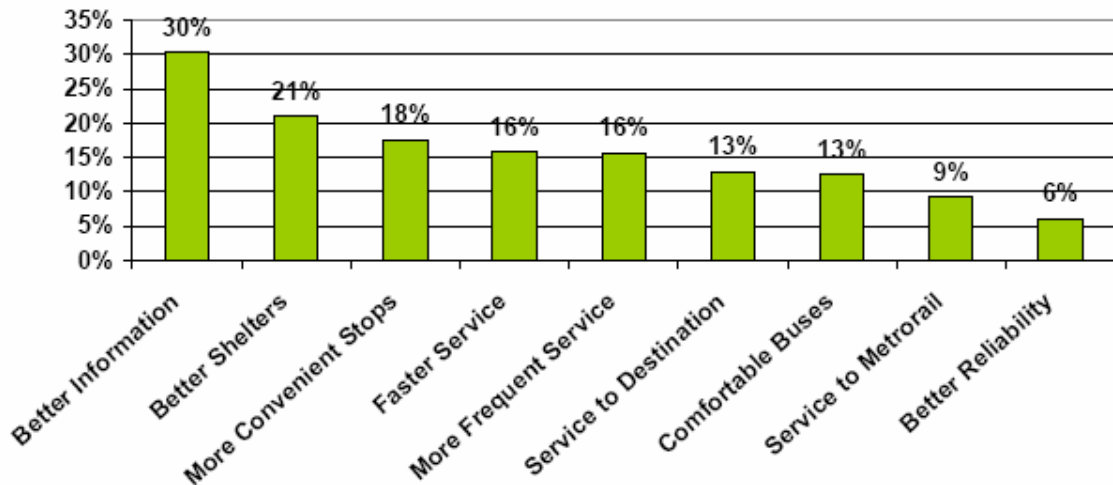
In 2003, a survey was developed to see what can be improved upon in the system. Current riders of the system took the survey while riding on the bus. Figure 15 shows the results of the survey from the final report of the study of the WMATA by TransSystems Corporation (5).



**Figure 15: Improvements Desired by Bus Riders (WMATA Regional Bus Study)**

The majority of the complaints given by current users had to deal with operations of the system. Riders’ demands include that the buses be on-time, have a more frequent schedule of service and have longer hours of operation.

The research study also contacted non-riders by telephone in order to determine why they do not currently use the WMATA system. Figure 16 shows the chart of the results from the survey (TransSystem Corp., 6).



**Figure 16: Improvements Desired by Non-riders (WMATA Regional Bus Study)**

The most common answer as to why they do not use the bus system was that not enough information about the system is given. No advertising is done. Alerts about delays, fare

adjustments, and policy modifications are very rarely posted and thus get left unknown. There are very rarely pamphlets in bus stations to see where buses are going, or what time they are coming. For being such a tourist area, visitors to the city have little idea which bus to get on, or what time they will arrive to their destination (TransSystem Corp., 5). Other improvements desired by people who currently do not use the system were more frequent service, more direct origin to destination routes, and more express routes to popular places with a minimal amount of stops. Another main point uncovered by the research study was the idea of a feeder bus route to rail stops: “The analysis supported the hypothesis that providing feeder service to Metrorail or to other high quality services with a seamless transfer would attract riders” (TransSystem Corp., 5).

By attracting more and more non-riders to become riders, the WMATA and the Washington D.C. regional area will hope to flourish. Like most American cities, urban sprawl is a large problem that needs to be addressed sooner rather than later. People more typically would rather raise their family in a quieter, cleaner neighborhood than the inner-city area. Growth is projected to increase the most in the suburbs, accounting for 81% of the total growth of the Regional Area (TranSystem Corp., 8). As population moves farther and farther away from the city, jobs are usually still within city limits. This makes commuting very popular, and when it becomes too popular, new methods of transportation need to be applied.

Perhaps a very similar study can be done in San Juan. Outreach to the public is very critical. For the Washington D.C. study, a total of 19 meetings were conducted with civic, business, institutional, and government interest groups. These meetings helped identify the critical issues that needed to be improved upon:

**Service:**

- Extended (earlier and later) service hours
- Midday service for seniors, tourists, and lunchtime travelers
- Better linkage between the activity and employment centers inside the Beltway
- Good access to rail and community destinations
- Better coordination between all transit and shuttle services
- Updated routing to match current travel patterns

- Improved travel time

**Information:**

- More information at bus stops and rail locations
- Subregional and systemwide maps
- Better and more user friendly information (and service) for tourists
- More marketing

**Amenities:**

- Safe access to stops particularly in suburbs
- Better lighting
- Bus shelters
- Clean and reliable vehicles

If one was to look at this list of concerns and desires from local groups, one can see how they feel that these issues are important to them. These issues need to be addressed in the planning of new projects, or redevelopments. I believe that ATI could use this sort of information if they were to perform a study much like TranSystem Corp. did for the WMATA. Attracting ridership is the driving force behind the studies. In the early stages of the Tren Urbano Project, studies similar to the Regional Bus Study are designed to address unmet needs and under-tapped ridership markets in the near and long term future. This will position the bus system so it will have the capacity, the structure, and the attractiveness to meet the growing and changing demand of regional mobility (TranSystem Corp., 13).

## ***2.5 Key Components for a successful Transit system***

Now that we have looked into examples of successful transit systems, it is important to analyze these studies in order to gain a better understanding of what it takes to create an efficient transit system. Asking key questions such as: what strategies did transit developers take to overcome challenges? More importantly, what were the results of those strategies for the transit system? Through analysis of case studies it is made possible to answer these questions and construct basic guidelines for emerging transit systems to follow, increasing their chances for success.



*Transit Cooperative Research Program (TCRP) Report 40* was sponsored by the Federal Transit Administration and published in 1998. The report focuses on strategies and measures that can be taken to attract auto users to public transportation. Getting people to use public transportation systems is one of the most challenging problems faced by transportation and transit systems. The *TCRP Report 40* provides essential information to assist in overcoming the problem. This chapter will look at general guidelines that should be followed and then expand in much greater detail the impact of each of the key components of the general guideline. Researchers and developers have concluded that there are many areas that are critical to consider when implementing a new transit system. These areas include the following:

- Economic Feasibility- Assessing the financial value and costs of implementing the system
- Parking- Evaluating parking situations
- Routes and Coverage- Determining what area the system will cover
- Customer Information- Information about the system given to users and potential users
- Vehicles- Determining mode of transportation. For example using, buses or a light rail system.
- Integration between modes of transportation- Designing a system using multiple modes of transportation that complement one another.
- Legislation feasibility- Assessing the ability to legally implement the system.
- Schedules- Times of departures and arrivals
- Operation hours
- Technology- The technology to run your system.
- Land use and Design- The actual design of structure or routes for the system
- Transit Pricing and fares
- Employee training

All these areas are important when developing a transportation system. For the purpose of this proposal we have decided to focus on only the following three areas:

- Parking and its role
- Customer Information and Promotion
- Frequency and Scheduling

The reason we decided to focus on these specific areas is because we feel that for the scope of this project they are the most important and most feasible areas to concentrate on. We felt that these areas are important to the success of the Tren Urbano and other supporting transportation systems in San Juan such as the bus system. The following subsections will illustrate how each component is crucial to the development of a transit system, briefly explain strategies, and touch upon the results and conclusions of the studies. We are using *Transit Cooperative Research Program*, or *TCRP*, reports as the foundation for our research in these areas. Later in our methodology we will examine each of the components more closely in order to formulate our strategy to alleviate the traffic problem in Trujillo Alto.

### **2.5.1 Parking**

The first area of concentration will be on the importance of parking. When thinking about public transportation systems, one would not initially suspect parking as playing a significant role in the system. It turns out that parking and parking regulations play a vital role in the planning and implementation of transit and public transportation systems.

The study *Employer-Paid Parking: A nationwide survey of employers' subsidy parking*, states that 95 percent of a pool of 48,400 commuters surveyed in 1990 claim that they are able to park at work for free (Shoup & Breinholt, 1995). Having such a large percentage of workers with the benefits of free parking at work is a very large reason to why they drive to work in the first place rather than using any public transportation or transit systems that may be available. The 1990 survey also shows that 91 percent of all commuting trips made in the United States are done so by car (Shoup & Breinhold, 1995). It is clearly apparent that employers supplying adequate and, more importantly, free parking are one of the reasons for a dependence on automobiles. This dependence on automobiles is a problem for transit systems.

Before trying to develop solutions to this specific problem of parking it is important to understand parking management itself. The *TCRP Report 95 chapter 18*, which is sponsored by the Federal Transit Administration, deals specifically with parking and park management. The report defines several different types of parking supply management strategies. The strategies they define are:

- **Minimum or Maximum Parking Requirements-** This type of parking management deals specifically with what building codes and zoning ordinances deem to be the correct number of parking spaces allowed in that area (Kuzmyak et al., 2003).
- **Employer/Institutional Parking Management-** Specifically the parking management plans that employers institute at their work sites (Kuzmyak et al., 2003).
- **On-Street Residential Parking Management-** This management specifically deals with the measures that the local jurisdictions enforce in their city or town (Kuzmyak et al., 2003).
- **On-street commercial Parking Management-** This type of parking management is imposed by communities in order to control street parking in their city or town (Kuzmyak et al., 2003).
- **Peripheral Parking-** The parking management that deals with the parking activities in or around an activity center (Kuzmyak et al., 2003).
- **Park-and-Ride-** Parking management that encourages drives to park their cars in a remote area and transfer to public transportation for the remain duration of their trip (Kuzmyak et al., 2003).

Having now defined the types of parking supply managements, it is important to look into how parking affects the public transportation and transit systems. The *TCRP Report 95 Chapter 18* has a large number of case studies that specifically address the affects of parking on public transportation.

One case study from the *TCRP Report 95* is on San Francisco, California. The case study shows how controlling parking lead to the control of traffic. The system in

San Francisco stresses having very limited parking. The city only has “48,000 parking spaces for 250,000 employees” (Kuzmyak et al., 2003). T. J. Higgins, as cited by Kuzmyak (2003), states that due to the parking regulations that San Francisco implemented, there had been no increase in traffic flows and in 1983 only 17 percent of commuters drove alone while 60 percent used the local transit system. Clearly San Francisco was able to discourage driving because of their very limited parking.

A second case study from the *TCRP Report 95* is on Los Angeles, California. The case study is an example of how controlling parking can increase in the use of public transportation. In LA the goal was to help promote their local transit and public transportation system by re-evaluating their city’s parking regulations. One of the first measures they took was to lower the minimum number of parking spaces needed per area in the downtown area. The pre-existing minimum had been 3 spaces per 1000 square feet and was lowered to 1 space per 1000 square feet (Kuzmyak et al., 2003). These measures lead to a small increase in the use of the transit system. Higgins, as cited by Kuzmyak (2003) states 25 percent of commuters in LA used the local transit.

*TCRP Report 40* concentrates on how to encourage commuters and travelers to use public transportation. The report has a section that examines parking and parking measures. From the analysis of five major cities, including Los Angeles, San Diego, San Francisco, Sacramento, and Seattle, the researchers deduced that there are five major areas that need to be accounted for to determine the effectiveness of a transit system. The five areas are, effectiveness in increasing the number of users; the scope; political feasibility; economic efficiency; and lastly ease of administration (Dueker et al., 1998). We feel that if transit system developers use this method of analyzing their parking situation that it will lead to greater success.

The *TCRP Report 40* also provides a study of parking strategies using the method described above. The results of there study can be seen in Table 2.

Table 2: Results of Parking Analysis (Ducker et al., 1998)

Strategy	Effectiveness	Scope	Political feasibility	Efficiency	Ease of administration
Increasing the price of parking, based on a tax on revenues	Moderate	temporal: broad functional: moderate-narrow spatial: moderate-narrow	Moderate	Low to moderate	Moderate to high
Increasing the price of parking, based on a tax on parking spaces	High in CBD with good transit service; lowest in suburban business districts or where transit service is low	temporal: broad functional: broad spatial: broad	Low	Low	Low
Cashing-out employer provided parking	Moderate	temporal: narrow functional: narrow spatial: narrow	Moderate	Moderate	Moderate
Expanding meters and accompanying residential permit programs	Low to moderate	temporal: broad functional: moderate-narrow spatial: narrow	Moderate	Moderate to high	Low to moderate
Parking impact fees	Very low in short term; somewhat greater in long term	temporal: broad functional: broad spatial: narrow	Moderate to high	Low to moderate	Moderate
Changes in zoning ordinances to restrict parking supply: <ul style="list-style-type: none"> <li>• Decreased minimums</li> <li>• Parking maximums</li> <li>• Conditional-use permits</li> </ul>	Very low in short term; somewhat greater in long term	temporal: broad functional: broad spatial: narrow	Moderate to high	Low to moderate	Moderate
Shared parking	Low	temporal: broad functional: broad spatial: narrow	Moderate to high	Moderate	Low to moderate
TDM: <ul style="list-style-type: none"> <li>• Satellite parking-shuttle lots</li> <li>• Preferential parking for carpoolers</li> <li>• Transit-incentive programs</li> </ul>	Low to moderate	temporal: narrow functional: narrow spatial: narrow	High	Moderate to high, unless high subsidies are required	Low to moderate

The results from Table 2 show that not one strategy alone will solve all the parking problems that are facing a city. Each of the types of strategies are strong in one or two of the five areas used to analyze the situation, therefore as in any problem there are tradeoffs that transit developers must be willing to make. Researchers feel that it may be best in using a parking strategy that combines one or two different parking measures. Table 3 is a table of six examples of combination parking that researchers looked into.

**Table 3: Parking Combinations (Dueker et al., 1998)**

Combination and Components	Policy Goal and Problem Context
<p><b>Parking Market</b></p> <ul style="list-style-type: none"> <li>• Increased parking prices</li> <li>• Cashing-out employer-provided parking</li> <li>• On-street meters and residential permit zones</li> </ul>	<p>Encourage transit ridership through explicit parking pricing in areas of congested peak-hour travel and parking</p>
<p><b>Cashing-Out</b></p> <ul style="list-style-type: none"> <li>• Cashing-out employer-provided parking</li> <li>• TDM</li> </ul>	<p>Encourage transit ridership by workers who park free in employer-leasued parking</p>
<p><b>Special Generator</b></p> <ul style="list-style-type: none"> <li>• TDM</li> <li>• Increased parking prices</li> <li>• Cashing-out employer-provided parking</li> </ul>	<p>Encourage transit ridership by employees and users of "special generators": high-density employers with limited parking supply, such as hospitals, universities, and airports</p>
<p><b>New Growth</b></p> <ul style="list-style-type: none"> <li>• Cashing-out employer-provided parking</li> <li>• TDM</li> </ul>	<p>Address parking problems and decrease SOV use in suburban activity centers or other noncentral areas of new growth</p>
<p><b>Commercial District</b></p> <ul style="list-style-type: none"> <li>• On-street meters</li> <li>• Shared parking</li> <li>• TDM</li> </ul>	<p>Encourage transit ridership through explicit parking pricing in non-CBD commercial areas with parking problems</p>
<p><b>Residential District</b></p> <ul style="list-style-type: none"> <li>• Residential permit zones</li> <li>• On-street meters</li> </ul>	<p>Address parking problems in high-density housing areas susceptible to spillover parking from nearby commercial areas</p>

Using combinations of different types of parking methods is a great way to balance out the weaknesses of individual parking strategies, providing a much more complete parking method. Combined parking strategies could definitely prove to be a possible solution in

San Juan, Puerto Rico, if parking regulations turn out to be a problem facing the success of the Tren Urbano and other transportation systems.

*The TCRP Report 95 chapter 18 and TCRP Report 40* would serve as excellent resources for the ATI in dealing with parking measures and how they could affect public transportation in San Juan, Puerto Rico. The reports clearly show that there is a distinct connection between parking management and public transportation use. This relationship of parking and public transportation is one that we suggest the ATI takes a serious look into. An examination of current parking regulations of both the city of San Juan and that of major employers in San Juan would benefit the ATI. *TCRP Report 40* would help assist the ATI in formulating possible measures that could be taken to provide a parking situation that complements the Tren Urbano.

## **2.5.2 Customer Information and Promotion**

From the WMATA research study that we discussed earlier, one of the top complaints given was that information about the system was not easily assessable. Having easy to find and easy to follow information is always a key component for producing a successful product. The same applies to public and transit transportation systems.

Information and promotion is used to accomplish a number of goals for public transportation systems. Turnbull (2003) undertook this issue of information and its effects. They published their research and findings in *TCRP Report 95 Chapter 11*. Turnbull and other researchers concluded that the goals of information are as follows:

- Retaining existing riders
- Increasing frequency of use
- Attracting new users to the system
- Decreasing automobile use
- Increasing fare-box revenues
- Smoothing the introduction of changes in fares and services
- Encouraging rider shifts to more cost-effective services
- Increase off-peak rider-ship

- Increasing awareness of available services
- Improving image of public transportation

Turnbull (2003) analyzed information and promotion efforts in several cities including Chicago, Southeast Wisconsin, and Pittsburgh. In each of the areas the goals of the transit providers were to increase rider-ship and promote a better image of the transit system to the public. Strategies taken by the transit providers in the case studies dealt mostly with advertising campaigns. They targeted radio, television and newspapers. The transit providers stressed that the transportation was comfortable, reliable and safe. In Wisconsin the transit providers even made television spots during the Green Bay Packers football games in order to maximize the number of people they reached.

Turnbull (2003) examined how effective these strategies were. A major finding was that there was a large amount of people who had seen and/or heard about the transit promotions in one way or another. They found in Pittsburgh that the frequency of current riders using the system increased. In Wisconsin 30 percent of follow up respondents were able to recall the promotion of the transit system and of those who had been exposed to the advertising campaign, over 60 percent had been positively influenced. Furthermore, 6 percent of the respondents whom were exposed to the advertisements reported that the advertisements influenced them to use the transit system more (Turnbull, 2003). Another conclusion that was found from the case studies was that consistent advertising is vital. Researchers found that the percentage of people who were exposed to the advertisements increased the longer the campaign endured. Therefore having just an eight week campaign will result in a positive influence among viewers and users but the more consistent and longer the campaign will result in greater results (Turnbull, 2003).

The *TCRP Synthesis 17* from 1996 examines the effectiveness of providing information at bus stops. Information found at bus stops usually consist of route maps, scheduling information, and fare information. Using signs at public transportation stops has a number of benefits. One benefit is that if proper signs are provided it lessens the need for riders to rely on operators for information. Another benefit that was found from the study was that good signage of scheduling; operation hours and bus routes could



reduce the need to print pamphlets of this information, therefore reducing the cost of production and distribution of such pamphlets (Dobies, 1996).

The Federal Transit Administration, or FTA, is starting to see the importance of information and promotion of public transportation systems. The FTA is currently funding a research program that is using a specific type of method of marketing that was developed in Europe. The method is known as Individual Marketing (FTA Individualized Marketing Campaign Demonstration, 2004). Individual Marketing is a technique that involves personalized dialog between transit suppliers and customers. The goal of the personalize dialog is to demonstrate to customers or potential customers that the public transportation system is able to provide the services that the customer wants. The participants were given a ticket that granted them free use of the public transportation system of a set amount of time (Broeg, 2003).

The FTA is funding this Individual Marketing technique in four pilot cities. They hope to experience the same level of success as was found in Europe. The FTA cites that over 15 European transit suppliers had used this system of marketing and experienced great success. The European cities experienced between 10-14 percent reductions in car use (FTA Individualized Marketing Campaign Demonstration, 2004). The use of the Individual Marketing technique could be one that we use in San Juan, Puerto Rico in order to enlighten people about the benefits of the Tren Urbano.

The *TCRP Report 40* and *TCRP Synthesis 17* are both essential resources for any transportation provider. We highly suggest that these studies be read thoroughly. They hold a great deal of information about strategies that will have positive results. ATI would benefit a great deal from these studies. We believe that making sure information is provided and that advertisements of the services are critical to the success of the Tren Urbano. We plan on examining the information system that is in place in San Juan, using the information from the *TCRP* reports to help us formulate our own strategy.

### **2.5.3 Frequency and Scheduling**

Among many users and non-users of public transportation there is a major complaint, which has to do with frequency and scheduling of the transit system. Frequency and scheduling includes a lot of different areas, ranging from the actual

schedule of arrivals and departures to the hours that the transit system is in use, all of which greatly impact the system. The frequency and scheduling of a transit system is directly related to the public image of the system. If the system does not appear to be operational at peak hours or does not supply frequent trips the system appears unreliable. This subsection will demonstrate how frequency and scheduling is important and some strategies that transit systems may follow to improve their situation, in addition suggest viable resources for transit systems to look into. We believe that this will be of great importance to the situation in San Juan, Puerto Rico and the success of the emerging Tren Urbano system.

John E. Evans, head author of *TCRP Report 95 Chapter 9*, along with other researchers, defines several different types of scheduling and frequency changes:

- **Frequency Changes-** This strategy deals with increasing or reducing the number of trips by transit vehicles (Evans et al., 2004).
- **Service Hours-** Either lengthening or shortening the service day hours (Evans et al., 2004).
- **Frequency Changes with Fare Changes-** The pairing of frequency changes or service hour changes with fare changes. Reducing frequency and increasing fares is an example of this (Evans et al., 2004).
- **Reliability Changes-** Changes that result in reduced passenger wait times, delays and uncertainty (Evans et al., 2004).

Simply increasing the frequency of service does not always increase rider-ship. Holland as cited by Evans (2004), states that there are no observations that support that there is a numerical relationship between frequency of service and rider-ship changes. Each situation must be examined individually in order to determine the best course of action.

One solid conclusion that Evans and researchers were able to make dealt with transfers and how riders felt about them. Researchers found that overall “riders were willing to accept longer journey times to avoid transfers” (Evans, 2004). The ATI should really try to eliminate transfers as much as possible.

Researchers also found that reliability is one of the important aspects to riders. Studies reveal that reliability has a much more prominent impact on riders compared to the impact that waiting times had on riders. Reliability hinges on a multiple of different factors; including traffic conditions, number of drivers, number of vehicles, and even number of passengers. All of these factors determine whether or not the transportation arrives on time and arrives at its destination on time (Evans, 2004).

We believe that making the Tren Urbano as reliable as possible is important. We plan on using *TCRP Report 95 Chapter 9* as a valuable resource in determining the best methods to use to ensure success for the Tren Urbano in the Trujillo Alto area. *TCRP Report 95 Chapter 9* also includes several case studies of transit systems in the United States. The case studies examine how the strategies either improved or hurt the existing problem.

Frequency and scheduling is a large topic and we plan on specifically focus on making the system more reliable. Making changes to schedules and the number of trips in and out of a location collectively determine the reliability of the system; therefore our study would encompass all of the defined areas of frequency and scheduling changes but gear the changes to making the system more reliable to the user. We will go more in-depth in the case studies later on in the methodology chapter of this report in order to identify what measures should be taken in Trujillo Alto area.

### 3.0 Methodology

In an effort to relieve the traffic on PR-181, as well as provide an expedited way for people to get to the Tren Urbano stop on the future Carolina Extension, we have researched the feasibility of installing a Busway on the PR-181 corridor. We are proposing a Busway to be constructed from the intersection of Via Encantada Avenue and PR-181 and to have the Busway run north along PR-181. The Busway would end at the proposed Tren Urbano station which is to be constructed in the eastern part of the intersection between PR-181 and PR-3. This section of PR-181 that we propose for the Busway is approximately four miles long, which is the focus area of our project

Our initial thoughts were to make use of the median, which separates the north and south bound sides of PR-181, by constructing a lane that would be designated for buses and possibly other public transportation modes. Figure 17 shown below demonstrates the idea of how the Busway would operate.

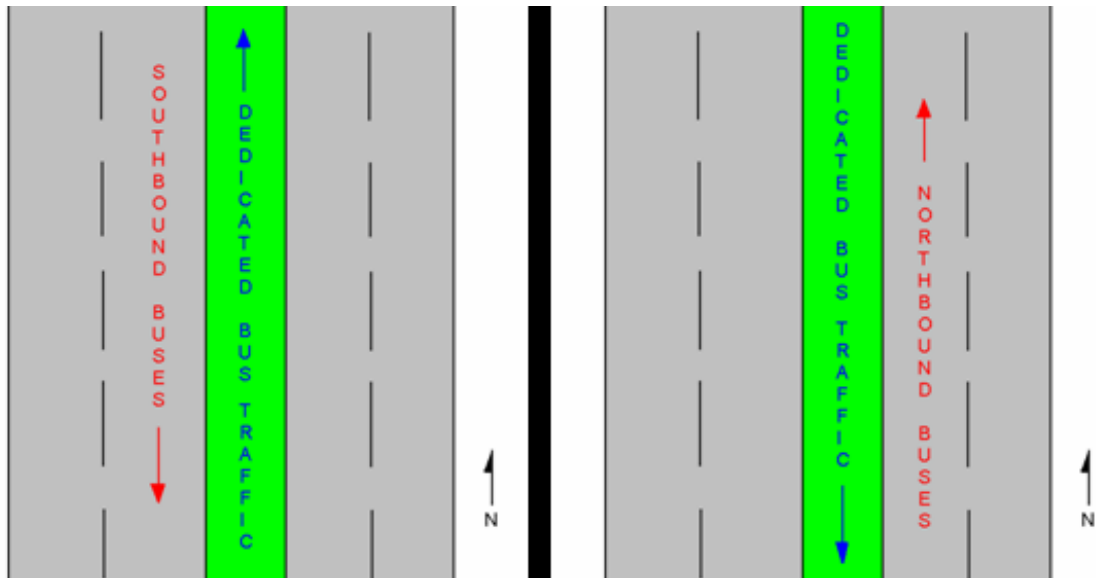


Figure 17: Diagram of Bus way

The Busway is reversible, so in the morning when the traffic is congested on the northbound side of PR-181 the bus will ride in the bus way going north and then on the southbound side when returning back to Trujillo Alto. The diagram on the right shows the evening commute. Since traffic is more heavily flowing going south, the bus will ride

in the bus lane going southward and buses returning to the Tren Urbano stop will ride on the northbound side where there is less traffic.

There are many factors that need to be taken into account when analyzing the feasibility of such a project, but we will not have time to go into all of them. To make the best use of our time, we have chosen the following three main areas to look into that we deem most important.

- Location of the starting and ending terminals of the Busway.
- The entire corridor of Route 181.
- The number and location of intermediary stations.

We chose these three areas because they represent the main physical aspects of the Busway. There are the endpoints of the Busway, the entire route that it takes, possible stops in between, and alternative uses for the Busway. In this section, we will go into more detail on the methodology we plan to use to analyze the different elements of each of these areas.

Along with analyzing the PR-181 corridor we will also spend time generating alternative ways that a Busway could be installed other than the layout of having it in the median. We are aware that our initial layout for our system may not turn out to be the most effective for PR-181. Generating and documenting a number of alternatives will provide city planners with options and possibly spark their own ideas of what could be done along PR-181.

### ***3.1 Terminal Locations and Design***

The first area that we need to address is the location of the outer terminals of the Busway. One of the terminals will be somewhere in the Pueblo Barrio of Trujillo Alto since this area already serves as the center for the Publicos and is a convenient location for many people. It is also, where Route 181 going south turns into a narrow and windy two-lane road, which would not be practical for a Busway. In order to pinpoint the exact location that would be optimal for the terminal, we will need to do an analysis of the area. With help from city planners and GIS technicians, Miguel Martinez and Elba Torre, from ACT, we were able to look at the different land uses in the area and determine which site would be best for the terminal. In doing so, we took into account how the bus will be

integrated with traffic in the area. The bus must be able to exit the station quickly and easily, but must not disrupt the flow of traffic too significantly.

The other terminal will be at the future stop of the Tren Urbano that is near the intersection of Routes 3 and 181. There is construction happening right now at this intersection that will make things a little more complicated, and we will need to see if the future train station here will be suspended over the road or underground. In order to come up with a basic design for the station as well as the route into and out of this area we analyzed detailed maps and consulted with experts from the highway authority to determine which ideas are practical and effective and which are problematic. As before, this terminal must integrate seamlessly into the traffic of the area, and also provide a smooth transition to the train.

Because of the technical issues involved with the design of these two terminals we worked closely with the traffic engineers and city planners of both Trujillo Alto and ACT. We also consulted the plans for the proposed train stop at the intersection of Routes 3 and 181 as well as the plans for the finished intersection itself.

### ***3.2 PR-181 Conditions***

Examining the current conditions of PR-181 is vital to our project. Since our project is proposing the implementation of a Busway along the PR-181 corridor, it is essential that we understand conditions, issues, and any other factors that could affect a plan to install a bus way.

In order to install a bus-only lane along the median of the PR-181 corridor it is necessary to understand exactly how that section of roadway operates. The first step that we took in examining this section of PR-181 was to review aerial photographs, maps, and blueprints of the roadway. Having these resources allowed us to identify physical limitations of the corridor as it is currently. The second step we took in order to examine PR-181 was to interview city planners and city engineers. The goal of these expert interviews was to identify areas along PR-181 that could potentially pose problems.

In addition to map analysis and talking with city planners we have also collected data from the field. We developed a data sheet that we used to examine different aspects of PR-181. We evaluated PR-181's overall road conditions. This includes number of

lanes, and overall layout or design of the road. Evaluation of intersections was another aspect that we looked into. We took note of areas such as pedestrian accessibility and number of left turn only lanes. The actual data collection sheets for the intersections that we examined can be found in Appendix B along with a photograph of the intersection.

The first three pieces of data that we recorded deal with who on the team recorded the information, time taken, and the location. This information was recorded for logistical purposes. The next pieces of information concentrate on the setup of the intersection. Recording the number of lanes and number of left turn only lanes was important to us because it gave us an idea of how busy the intersection is. Observing the number of traffic islands present at the intersection also factored later into how we evaluated the intersection as far as pedestrian safety goes.

Assessing the intersection and the area near the intersection for pedestrian safety and accessibility is the next set of data. Pedestrian access is a criterion that rates the area for overall pedestrian safety when crossing PR-181. The rating system for this was mostly subjective, though we did take into account if the area had crosswalks and other measures for pedestrian safety. Recording whether or not the intersection had crosswalks and pedestrian crossing lights were also observations that we made at each intersection. Lastly, we evaluated what the level of need for a pedestrian bridge was for the area. Again this criterion was mostly subjective, but we did take into account attractions in the area such as restaurants, strip malls, and other businesses. We felt that areas with a lot of attractions were potential places for pedestrian bridges.

The next section of data that we collected dealt with overall road conditions. The first piece of data in this section is rating the traffic volume at each intersection. We rated the traffic volume as high, medium or low traffic. We also felt that recording the speed limit was important, as vehicle speed along the roadway could potentially affect pedestrians and cyclists who try to use the intersection. We also recorded the major traffic generators. Identifying these major traffic generators is important to us because we want to understand where people are coming from and also what is their destination. Understanding this information aided us in developing the Busway design. The last piece of information in this section of the data sheet has to do with the physical conditions of

the roadway. By physical conditions, we are referring to whether or not the roadway is kept in good repair.

We were interested whether there are currently bus stops along the roadway at certain points and rating the overall feasibility of implementing a Busway along a section of PR-181. We wanted to identify current bus stops because we could possibly use these stations in our system. Rating the overall feasibility of implementing a Busway at each intersection is complex and would require further analysis, but we did consider several factors, including:

- One factor we considered was the traffic volume of the intersection. Having a bus traveling through the median at high traffic intersections is potentially a major problem.
- Also taking into account the road design at the intersection affected our decision for the feasibility of a Busway. Road design refers to how many lanes are present and more importantly the presence of left hand turn lanes. Having left turn only lanes at intersections often results in the loss of the median space.

Those are the factors that we took into account when rating the feasibility of implementing a Busway.

The data sheet we developed aided us in making the most of the time we had during our trips with Trujillo Alto planners to PR-181. We used the data sheets to identify other possible issues that we were unable to identify from map analysis and discussions with other city planners.

After we determined the issues that could affect the physical implementation of a Busway, we determined possible ideas that were developed into solutions to the problems. Also, we spoke with city planners in order to gain knowledge on how experts deal with similar types of problems. Through expert advice and our own creative and fresh perspective on the situation, we feel that we were able to formulate ideas that could later be developed in plans to deal with issues facing physical implementation of a Busway along the PR-181 corridor.



### **3.3 Bus Stops**

One of our most important tasks for our project is proposing potential locations for bus stops along the PR-181 corridor in Trujillo Alto. Many different aspects need to be considered when proposing these locations. Some of the most important aspects include the demographics of the area, the traffic flow, pedestrian accessibility, and the land use that is necessary for the construction. It is important, however, that not too many stops are along this corridor. When passengers use the Busway from Trujillo Alto, they will not want to make several stops before getting to their final destination. This is why we must make sure that when we place a bus stop, we have considered all aspects, and have absolutely found the need for a bus stop in that area.

We believe that the pedestrian accessibility is very important to consider in these bus stops. We must always be thinking of how our plans will affect the pedestrian and bicyclist traffic. By creating more pedestrian friendly traffic, we can strive to make an alternative for people to not use their cars to just cross the highway or tie up intersections. Discussing what intersections will need such pedestrian traffic accommodations will have some effect on where we decide to place the Busway station.

Land use will be something that needs to be considered by the group. We need to keep in mind how this Busway will affect certain communities. This can be done by interviewing planning officials to see the reaction people will give towards the idea of our project. In certain areas, the project may affect the land so much that people in that area will be very much against it. Identifying and exploring these potential issues will lead us to making recommendations on how to best select sites for bus stops and how to utilize the land most efficiently.

## **4.0 Analysis of PR-181 Considerations**

This section presents the issues that complicate the implementation of the Busway along PR-181. To gauge whether a Busway is feasible to install along this corridor, we looked at the different aspects of the entire area that could pose a problem. The first major aspect deals with the Northern Terminal at the intersection of PR-181 and PR-3. This section discusses the problems that will hinder the installation of the Northern Terminal. Potential obstacles and issues will also be identified at the location of the Southern Terminal at the intersection of PR-181 and Via Encantada.

Issues that complicate the entire corridor of PR-181 are then presented. The three main areas discussed include: intersections, bus stop analysis, and road conditions. Major intersections along PR-181 pose a problem for the Busway and the issues they provide are analyzed. Current bus stops are taken into consideration and potential sites for future bus stops of the Busway are evaluated. Finally, the general conditions of the road are examined with regard to major traffic generators and pedestrian access.

All of the issues discussed in this chapter are important pieces of information which contribute to the overall problem of implementing the Busway. It is vital that this initial step was taken in order to initiate further developments along PR-181.

#### **4.1 Terminal Location and Design**

The PR-181 and PR-3 intersection is an appropriate location for the Northern Terminal. The future Tren Urbano extension includes a station at this intersection (Figure 18).



**Figure 18: Planned Concordia Station 2004**

It is beneficial to utilize the Concordia station for the Busway. Travelers could use the Busway to transfer to the Tren Urbano and be connected with the entire San Juan Transit network. Not only does the Busway provide people with an alternative mode of transportation, but it also sets the stage for other creative projects directing Trujillo Alto towards new urbanism.

The first step was to identify issues that the intersection of PR-181 and PR-3 would pose in the planning process of a Busway along PR-181. This was accomplished by examining aerial photographs of the intersection as well as looking over engineering design maps of the intersection. Through the help of city planners major issues were identified and explored.

The first major issue is how to get the bus off the Busway and to the Concordia station. The green circle identifies PR-181 while the blue circle identifies PR-3 (Figure 19). The area circled in red is where the Concordia Station is going to be located.



**Figure 19: Aerial photograph of PR-3/PR-181 2002**

In order for the bus to reach Concordia Station, it will need to exit the median. This poses a major problem for a number of reasons. Exiting the median will result in the bus merging with traffic at a busy intersection. This could result in further complications at the intersection. Increasing the complexity at this intersection would also result in reinforcing the image of PR-181 being non-friendly to pedestrians and cyclists. Therefore, it will be important to consider these issues when developing plans for how to get the bus off the Busway to the Concordia Station.

During the morning commute, the bus will need to return to Trujillo Alto using the southbound side of PR-181. This means that buses will need to get across the northbound side of PR-181 and enter onto the southbound side. The green dashed line (Figure 20) represents the need to get buses from the station to the southbound side, while the blue dashed line indicates the issue occurring in the evening.



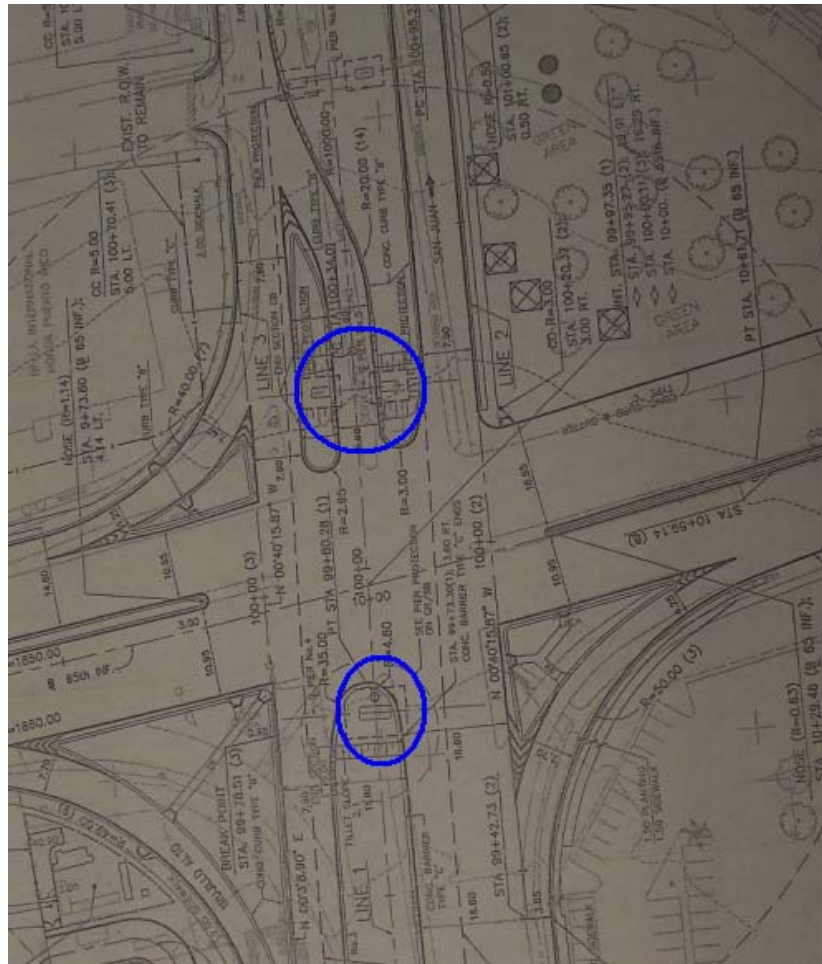
**Figure 20: Bus leaving and Entering Station 2002**

The challenge of getting the bus from the northbound side of PR-181 to the Concordia Station becomes an issue. Planners would need to develop strategies to effectively deal with this issue.

After meeting with Mr. William Pitre, an ACT city planner, we became aware of the construction of an overpass for PR-181. This presents a major challenge for the integration of a Busway in the median. Mr. William Pitre informed us that as of April 10, 2005, the overpass currently is 65 percent complete and has cost approximately 22.5 million dollars. The overpass will extend from the intersection of Park Gardens and PR-181 to the intersection of Julio Andino and PR-181, crossing directly over the intersection of PR-3 and PR-181 as shown in Figure 21.



**Figure 21: PR-181 Expressway**



**Figure 22: Blue prints of intersection of PR-181/PR-3**

The areas circled in blue in Figure 22 are overpass support structures located within the median of PR-181. It will not be physically possible to have a Busway that shares the median with these support structures.



The first major issue with the Southern Terminal is deciding where exactly to place it. The location needs to allow easy access for the bus to get into the Busway without disrupting the flow of traffic of the intersection. Encantada is a residential neighborhood, which has 2,800 housing units in a thickly settled area. With over 7,000 cars coming out of the Encantada area onto PR-181 per day, this proposed location for a bus terminal will attract the people who experience hours of traffic a week going to and from work along PR-181 (Oficina de Planificacion y Ordenacion Territorial, 2005).



**Figure 23: Intersection of Via Encantada and PR-181**

Figure 23 displays a 2002 satellite enhanced image of the Via Encantada intersection and its surrounding communities. The red oval shows the Busway's



Southern Terminal. The arrows shown above on PR-181 indicate the direction of travel in the morning, as well as the desired route on PR-181 taken by the cars coming from the Encantada region. The yellow oval represents the location of the recently constructed shopping plaza, which must be taken into account when evaluating the issues of the proposed terminal location. The black oval area labeled in Figure 23 is a historic bridge. The teal oval is the area we initially selected as the parking area. However, after being informed by the City Planners from the Municipality of Trujillo Alto that there are plans for a family park to be assembled in this area and will not be available for parking. The proposal also includes the use of the historic bridge for pedestrians in the area to gain safe access to the family park. The recently constructed shopping plaza (Figure 24) also affects the creation of a terminal at this intersection. These factors need to be addressed in future investigations regarding the opportunity to use this particular section of land.



**Figure 24: Encantada Intersection**

Pedestrian access is a vital issue that must be addressed in the Busway implementation. To accommodate for pedestrians in the most efficient manner, a

pedestrian bridge from the parking lot to the terminal would be suitable. The pedestrian bridge would focus on being pedestrian and bicycle friendly. Figure 25 has the parking lot outlined in red with an informal sketch of the pedestrian bridge attached, connected to the South Terminal. The route that the Busway operates on is outlined in black (Figure 25). The route would begin at the terminal, which is indicated by the bold red oval.



**Figure 25: Map of Encantada Intersection Busway Route & Terminal**

## **4.2 PR-181 Conditions**

The following sections focus on issues concerned with current conditions of PR-181. The three major areas evaluated are:

- Intersections
- Bus stop analysis
- Road conditions

Each of the following subsections examines major issues in regard to the three areas listed above. Identifying and understanding potential challenges that would impede the implementation of a Busway along PR-181 is important for planners to comprehend. This information allows planners to design a system that best fits the situation.

## 4.2.1 Intersections and bus stop analysis

	Encantada	199 & 876	848	846 & 876	Park Gardens	PR-3
# of Lanes per side:	4	3	5	5	4	5
# of Left Turn Lanes per side:	2	1	2	2	1	2
Traffic Islands?	Yes	Yes	Yes	Yes	Yes	Yes
Pedestrian Access:	High	Medium	Medium	Low	Low	Low
Pedestrian Crosswalk:	Yes	Yes	Yes	Yes	Yes	No
Pedestrian Traffic Lights:	Yes	No	No	No	No	No
Need for Ped. Bridge:	Medium	Medium	High/ Medium	Low	High/ Medium	High
Traffic Volume:	High	High	High	High	High	High
Speed Limit:	45 MPH	45 MPH	45 MPH	45 MPH	45 MPH	45 MPH
High Traffic Generators:	PR 181 merging with traffic from Encantada	Hospital, School	Strip Mall (McDonald's, Pueblo)	846 from Cuevas	Restaurants, Housing Units, from 877	PR-3 traffic from Carolina, Residential communities, plaza
Road Conditions:	Good	Fair	Good	Fair	Bad	Good
Very Good / Good / Fair / Bad / Very Bad	No	No	Yes	Yes	Yes	No
Current Bus Stop Present:	Very Hard	Hard	Hard	Hard	Very Hard	Very Hard
TOTAL Busway Feasibility:	1	2	3	4	5	6
Very Hard / Hard / Sufficient / Easy / Very Easy	South Terminal					North Terminal

Figure 26: Intersection Data Analysis

Figure 26 is a chart of all the intersections we analyzed with information regarding number of lanes, traffic volume, pedestrian friendliness and others.

The major problem identified throughout the analysis of the six main intersections along PR-181 is that the median and shoulder disappear at each intersection. This occurs because of the presence of left-hand turn only lanes and right-hand turn only lanes. This is a major issue because the Busway is either in the median or the shoulder.

In order to assess the feasibility of implementing bus stops along PR-181 for the proposed Busway, we went into the field and developed analysis sheets for all of the essential intersections along PR-181. We were fortunate enough to be accompanied by two city planners from Trujillo Alto, Mr. Juan Jacob and Mr. Jafed Llerandi while going into the field to answer any questions we had and to provide expertise in any of the areas we were studying. The main factors used for developing the analysis of possible future bus stops and current bus stops were:

- The Actual Location/ Intersection
- The Median Size
- A Brief Explanation of the Surrounding Community
- The Need for a Pedestrian Bridge
- Identifying and Evaluating Current Bus Stops Near The Intersection

Important destinations such as the Petre Cenon High School and the CDT Trujillo Alto Hospital along PR-181, serve as areas which will be taken into account. To help manage traffic flow, Dr. Gabriel Rodríguez Fernández emphasized the importance of having a limited amount of bus stops in distinct areas. The bus route would not be as attractive to passengers if numerous amounts of intermediate stops were made.

### **PR-181 & Via Encantada Intersection**

The first main intersection that we evaluated was the Via Encantada and PR-181 in Trujillo Alto. The intersection presents itself with a medium pedestrian bridge need. There is little median space available, which provides the Busway with adversity in locating bus stops.



This intersection deals with great difficulties over the amount of vehicles traveling to and from the intersection. The shopping plaza may attract people to the area, but with the proposed terminal being located at the Encantada intersection, an additional intermediate bus stop near this intersection will be unnecessary.

**PR-181 & PR-199—PR-876 Intersection**

The need for a pedestrian bridge is high at the PR-181 & PR-199–PR-876 intersection. The CDT Trujillo Alto Hospital located in this area draws not only a great influx of people, but in many instances elderly who may lack the transportation needed to get across the street. This serves as an obstacle for people, especially when dealing with public transportation. Another key area is the Petre Cenon High School of Trujillo Alto, shown in Figure 27. This area also attracts a large amount of people, particularly at 8:00 AM and 3:00 PM everyday due to the start and end of the school day.



**Figure 27: Petre Cenon High School of Trujillo Alto along PR-181**

Across the PR-181 corridor with respect to the Petre Cenon High School of Trujillo Alto and The CDT Hospital, there are no destinations, which create an issue for proposing a pedestrian bridge. Dr. Gabriel Rodríguez Fernández states that in order for a pedestrian bridge to be needed, there must be important destinations on both sides of the corridor. Figure 28 shows an example of a pedestrian bridge crossing Route 26 in Carolina with main buildings on both sides of a corridor which supports this idea. The idea of having important buildings or destinations on both sides of a corridor is a common theme which can be useful in determining where to propose pedestrian bridges.



**Figure 28: Example of Pedestrian Bridge along PR-26**

### **PR-181 & PR-848 Intersection**

At this intersection there is a fairly large plaza on both sides of the PR-181 corridor. These locations are among the major culprits for traffic generation at the intersection. Due to these heavy traffic generators and parallel buildings on both sides of the corridor, the need for a pedestrian bridge is leaning towards a medium to high level in

the data analysis. There is a current bus stop located at this intersection which is utilized solely by the Publico system. The bus stop that currently exists at this intersection is in poor condition. Improving the conditions of the bus stops is important when trying to improve the quality of life along PR-181.

### **PR-181 & PR-846—PR-876 Intersection**

The need for a pedestrian bridge is graded as quite low at this location. Reason being, this specific area has little commercial activity. This intersection marks the end of Trujillo Alto, but also marks the last AMA, Autoridad Metropolitana de Autobuses, bus stop. Also, this intersection does have a current bus stop which is shown in Figure 29.



**Figure 29: Current bus stop at the PR-181--PR-846-PR-876 Intersection**

The bus stop showed aging with cracks running through all of the material. The concrete near the bus stop has been neglected providing an unsafe walking area. The current bus stop also lacks the necessary information regarding routes, and frequency.



This demonstrates the sub par condition and design of the current bus stop. Considering that the area does not have a great need for pedestrians to cross, the practicality of instituting a pedestrian bridge is very low.

### **PR-181 & Park Gardens Intersection**

This intersection currently deals with a host of construction because of the beginning stages of the new overpass being constructed at this point (Figure 30).



**Figure 30: Overpass Construction**

The need for a pedestrian bridge is evaluated as medium to high because the area is heavily settled with commercial and residential buildings. There are no sidewalks on either side of the road posing an issue for pedestrians. Implementation of a bus stop near this intersection does not look attractive because of the construction as well as the lack of pedestrian friendly routes.

## **PR-181 & PR-3 Intersection**

This intersection hosts an immense amount of vehicle and commercial activity. The overall need for a pedestrian bridge is evaluated at a very high level. PR-3 along with PR-181 serves as an area that attracts a large amount of vehicle activity due to these key factors:

- The commercial stores on both sides of the intersection
- Housing developments nearby the intersection
- The overall need to gain access to PR-181 for travel
- Vendors in the middle of the intersections

Figure 31 is a clear picture of the commercial activity along with the housing development located directly next to the commercial stores at the intersection.



**Figure 31: Commercial Stores & Housing Development near PR-181 & PR-3 Intersection**

## 4.2.2 Road Conditions

Another important area that affects the implementation of a Busway along PR-181 is the condition of the roadway. The condition of the roadway includes pavement condition, traffic signaling, painted markings on the pavement, street lighting, etc.

The first major road condition deals with the median of PR-181. Since the major idea utilizes the median as a bus lane, it is vital that the median of PR-181 is accessible. During field research, it was observed that utilizing the median is an issue. For many sections of PR-181 the median is full of trees (Figure 32), bushes, and at some parts streetlights.



**Figure 32: Trees in PR-181 Median**

In order to install a bus lane in the median, all of the objects that currently exist would need to be removed. Proposing the removal of trees and bushes from the median is potentially an issue. Trujillo Alto city planners have stated that people in the area are very sensitive when it comes to modifications to the road resulting in the removal of trees and plant life. In Figure 33, the area circled in red is where residents painted on the barriers in protest to the proposed idea of removing trees from the area.



**Figure 33: Protest to removal of Trees**

Gaining support for a proposal that involves the removal of all plants from the median of PR-181 is necessary because of the high protest threat. This issue would need to be addressed by planners in future works dealing with modifications to the PR-181 corridor.

The second major issue that we observed deals with the shoulder lane of PR-181. Initial ideas have used the shoulder lane to widen the road in order to accommodate the bus lane in the median. However, the shoulder lane is not continuous. Some sections of the corridor have a shoulder lane that would serve the plan for widening very well, but other sections of the roadway do away with the shoulder lane.



## 5.0 Busway Concepts

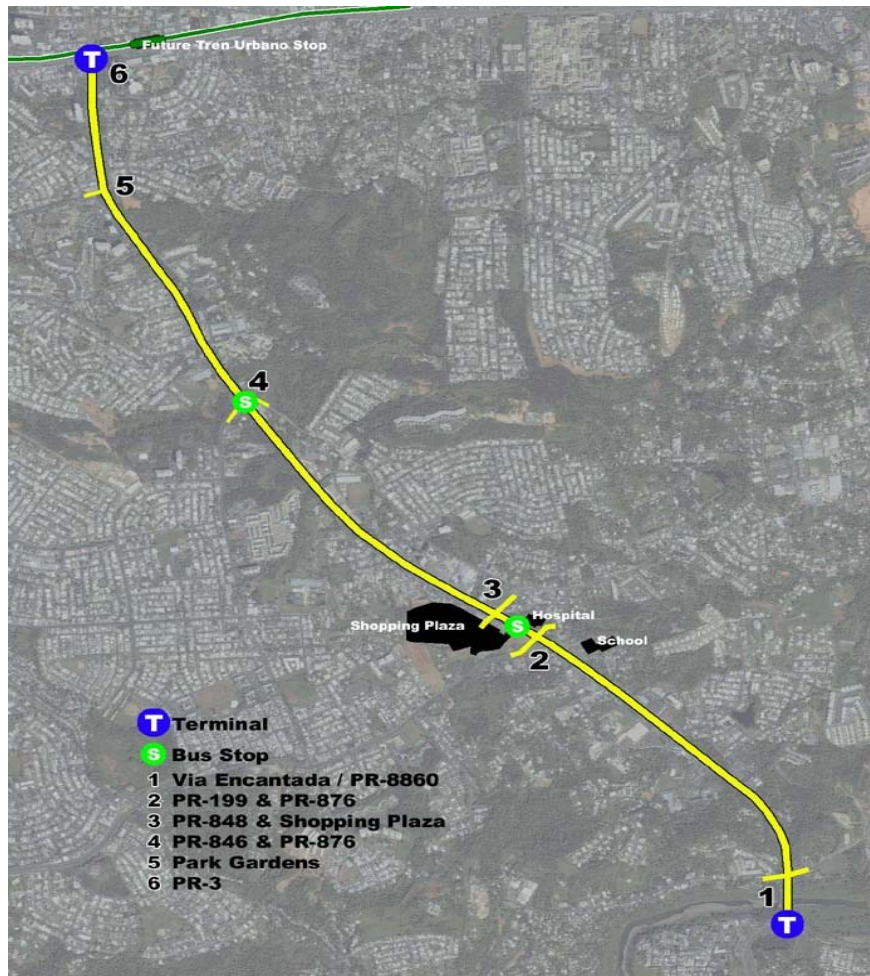


Figure 34: PR-181 Proposed Busway Route

This section presents numerous ideas for overcoming the challenges of installing the Busway (Figure 34). These ideas, although not highly detailed, are important first steps in the process of analyzing the placement of a Busway along PR-181. The primary focus is how to physically put the Busway in the median and get it through the six major intersections that were analyzed. For each of the six intersections, concepts were developed for maneuvering the bus through the intersections. Four additional concepts are presented for placing the Busway in the shoulder of PR-181. Recommendations were made for the locations of intermediate stops along the Busway that take into account areas of high pedestrian and vehicular activity. Later in this chapter are

recommendations for the application of technology used to run and maintain the Busway successfully.

### 5.1 Median Busway Design Concepts

The initial idea is to utilize the median space of PR-181 and install a lane designated for a bus.

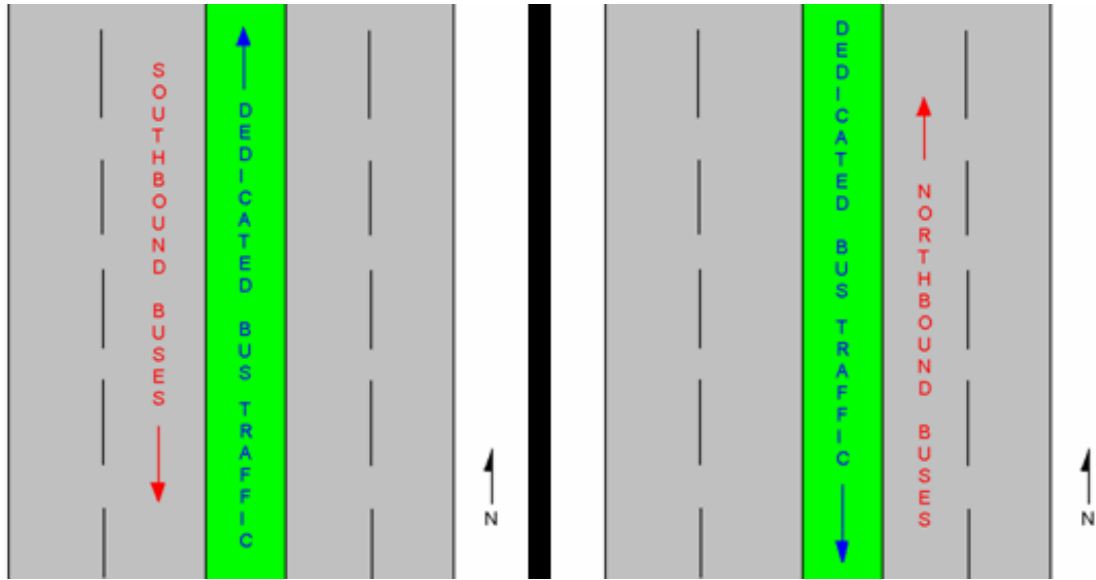


Figure 35: Median Busway Diagram

Figure 35 is a diagram of how the bus lane would operate. The Busway is reversible, so in the morning when the traffic is congested on the northbound side of PR-181 the bus rides in the Busway going north and then on the southbound side when returning to Trujillo Alto. The diagram on the right shows the evening commute. Traffic is heavily flowing going south, therefore the bus rides in the bus lane going southward and buses returning to the Tren Urbano stop ride on the northbound side.

Developing design concepts for physically installing a Busway along the PR-181 corridor is challenging. We decided to approach the task by addressing each of the six major intersections that we visited and developing ways to overcome any issues that were identified.

### 5.1.1 Via Encantada and PR-181 Intersection Concepts

The first intersection we looked into was the intersection of PR-181 and Via Encantada. This is a very crucial location in our Busway system. It is in this area that we discussed having our Southern Terminal for the Busway.



**Figure 36: Via Encantada Intersection**

Figure 36, you can see an aerial photograph of the intersection. The area circled in yellow is the proposed location for our Southern Terminal.

## Concept 1

We developed three different concepts to integrate the Busway into this intersection. Figure 37 is the current design of the intersection, and Figure 38 is the design for the first concept we developed.

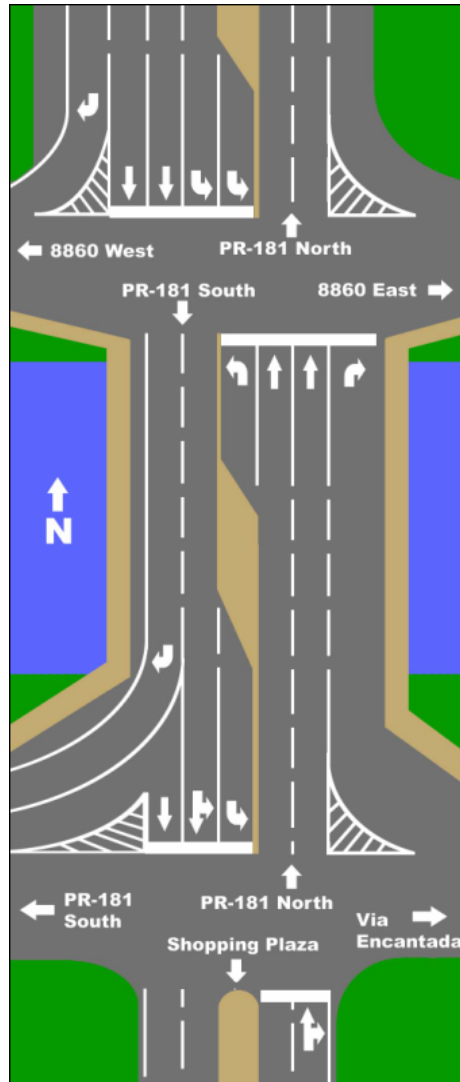


Figure 37: Current Intersection Configuration

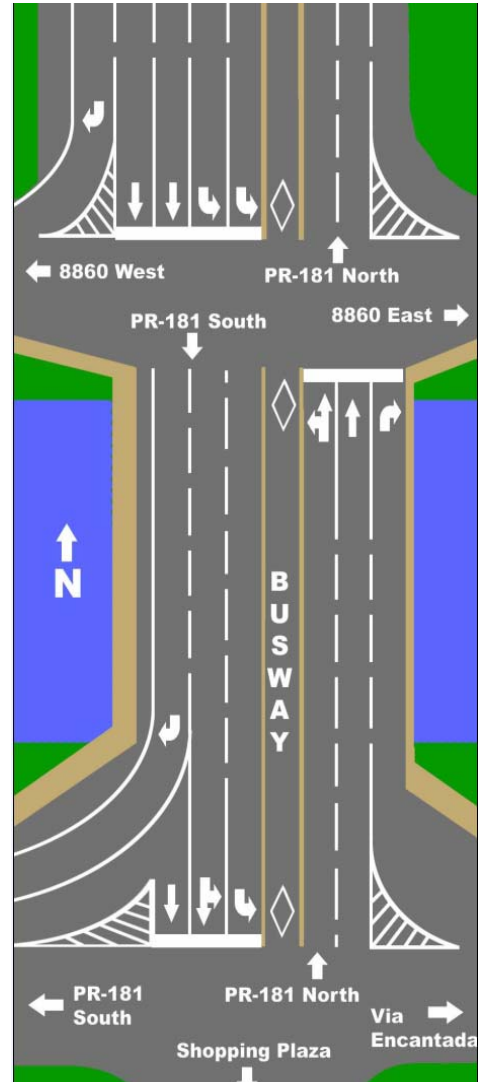


Figure 38: Concept #1 for Via Encantada

### Concept # 1 Pros

- Reduces car traffic

### Concept #1 Cons

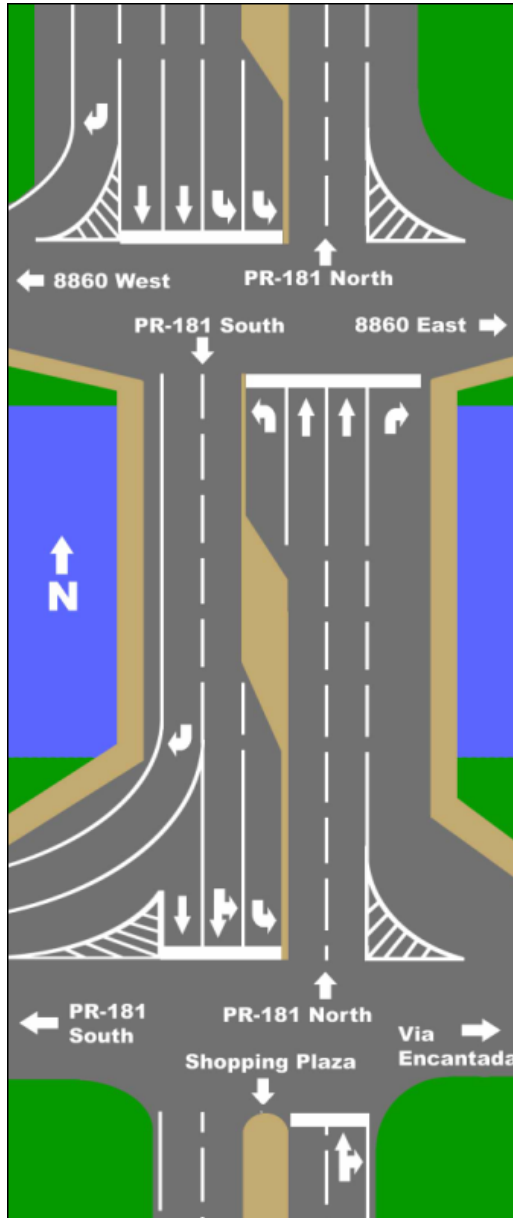
- Requires major modifications
- Reduces pedestrian access to bridge
- May not be cost efficient



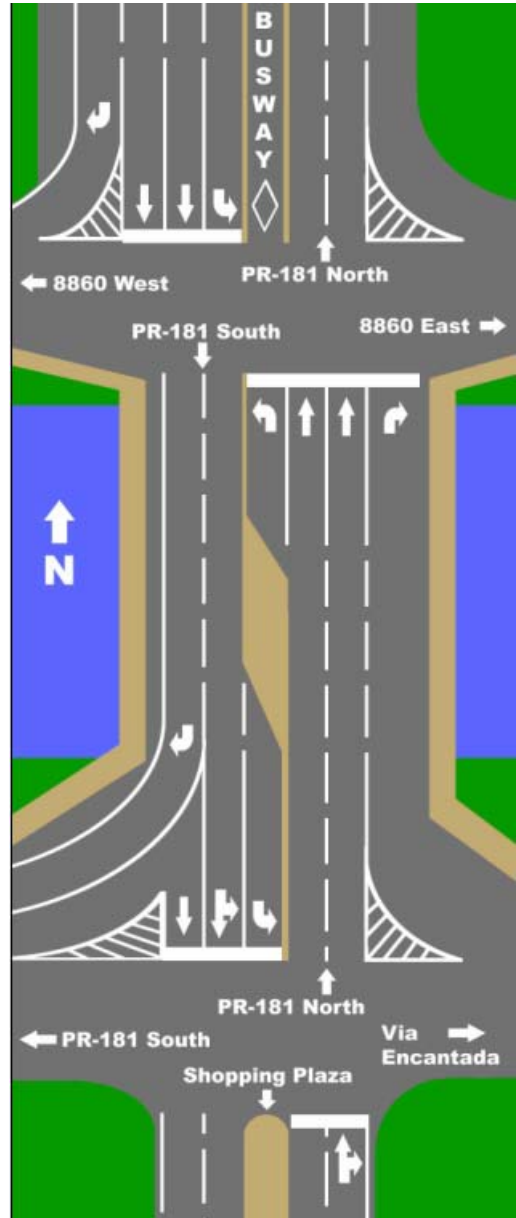
Concept 1 involves the bus leaving the terminal and entering the median before going over the bridge. The Encantada Bridge is indicated by the blue oval in Figure 36. To accommodate a Busway along the bridge, modifications are necessary. There is a lack of space in the median. The median ends at the intersection of PR-181 and 8860 due to the left turn lanes on the north and south bound sides of PR-181. The right hand turning lane is significantly wider than other lanes along the northbound side of PR-181.

The first modification is eliminating the left hand turn lanes on the northbound side of PR-181. A dual lane for straight and left turns would be a sufficient configuration. The lanes will be shifted over to the right on the northbound side of PR-181. This lane shift will require the removal of the sidewalk along the northbound side of PR-181, allowing for a seamless lane shift for the northbound side. We realize that by removing the side walk on the northbound side of the bridge will reduce the pedestrian accessibility. To compensate for this reduction, the use of the Historic Bridge will be available for pedestrian traffic.

**Concept 2**



**Figure 39: Current Intersection Design**



**Figure 40: Concept #2 for Via Encantada**

**Concept #2 Pros**

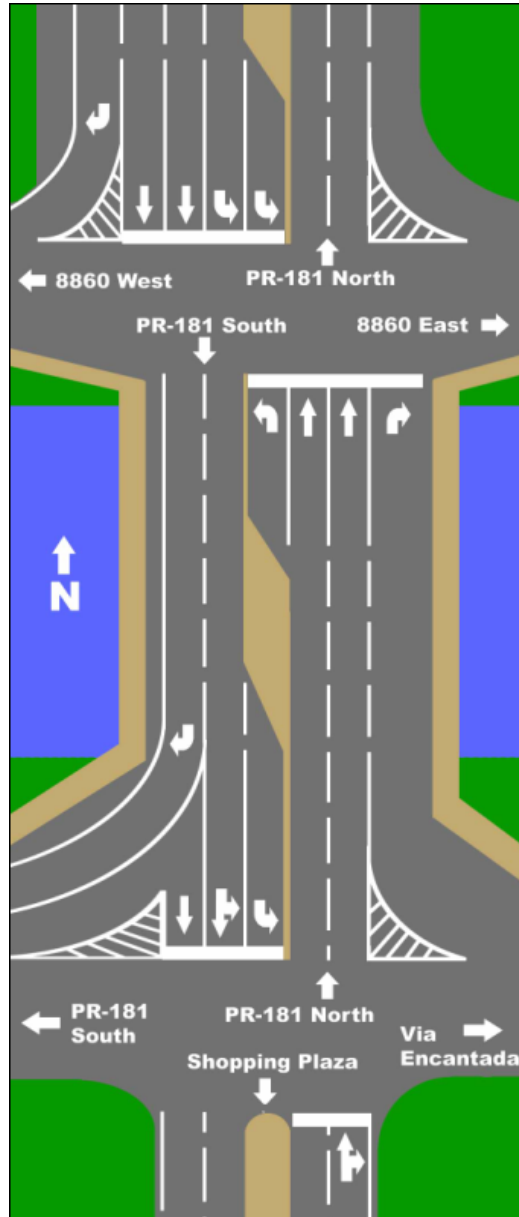
- No major bridge modifications
- May be more cost efficient

**Concept #2 Cons**

- 8860 int. slightly complicated
- Bus involved with car traffic

Concept 2 involves less modification to the road design of the Encantada Bridge. In Figure 40 a diagram of the design concept 2 is compared to the current design at the intersection. The bus remains in normal traffic until after it travels over the bridge. As the bus reaches the end of the bridge at the intersection of PR-181 and 8860, it remains in the left hand turn lane. Once the bus reaches the intersection, the smart traffic lights, which will be discussed later on in the Applying Technology section of the report, stops all other traffic to allow the bus to cross the intersection and enter the Busway. Since the Busway begins on the northern side of the intersection of PR-181 and 8860, the left turn lane on the southbound side of PR-181 at this intersection is removed. The elimination of the left turn lane will not significantly affect the flow of traffic since there will be one lane designated for left turns only. Other modifications to the roadway would include slightly widening on both the northbound and southbound sides. The road needs to be widened to supply ample room for the bus to maneuver.

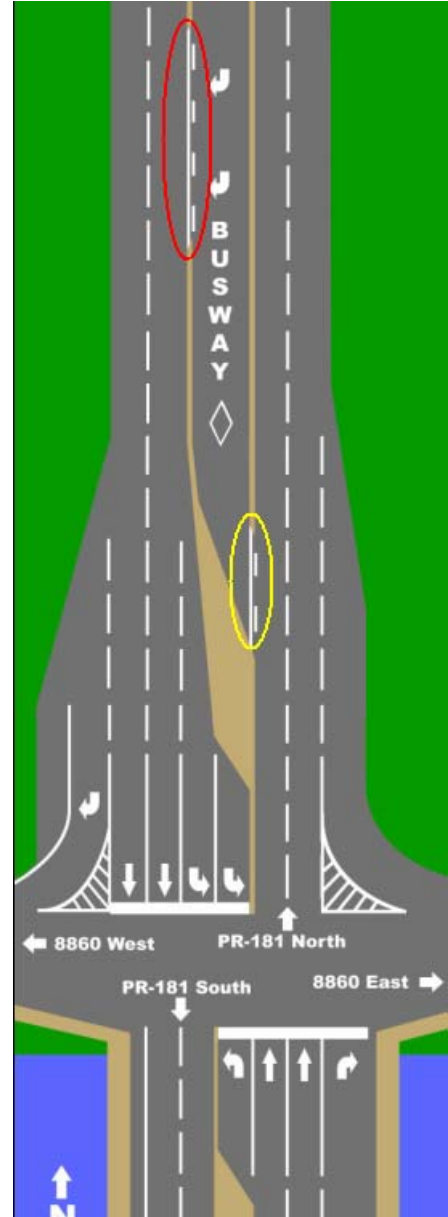
**Concept 3**



**Figure 41: Current Intersection Design**

**Concept #3 Pros**

- No bridge modifications
- No intersection modifications



**Figure 42: Concept#3 for Via Encantada**

**Concept # 3 Cons**

- Possibly dangerous merging points
- Involved in car traffic
- Potentially confusing for car drivers

Concept 3 is a slight modification to concept 2. As with the second concept, the bus continues in normal traffic. The bus continues in normal traffic going through the intersections of PR-181 and Via Encantada and PR-181 and 8860. In Figure 42 a diagram of the modified design is compared to the current intersection design.

The bus travels through the two intersections staying in normal traffic. After it passes through the two intersections, it will remain in the left most lane of the northbound side of PR-181. The bus will use an entrance ramp to enter the Busway, which is indicated by the yellow circle in Figure 42. There will be an exit ramp indicated by the red circle in Figure 42 for the bus to exit the Busway when returning south. The bus will merge back into normal traffic before reaching the intersection of PR-181 and 8860. PR-181 needs to be widened slightly on both the northbound and southbound side to insure room for the bus to travel.

## 5.1.2 PR-181, PR-199 and PR-876 Intersection Concept

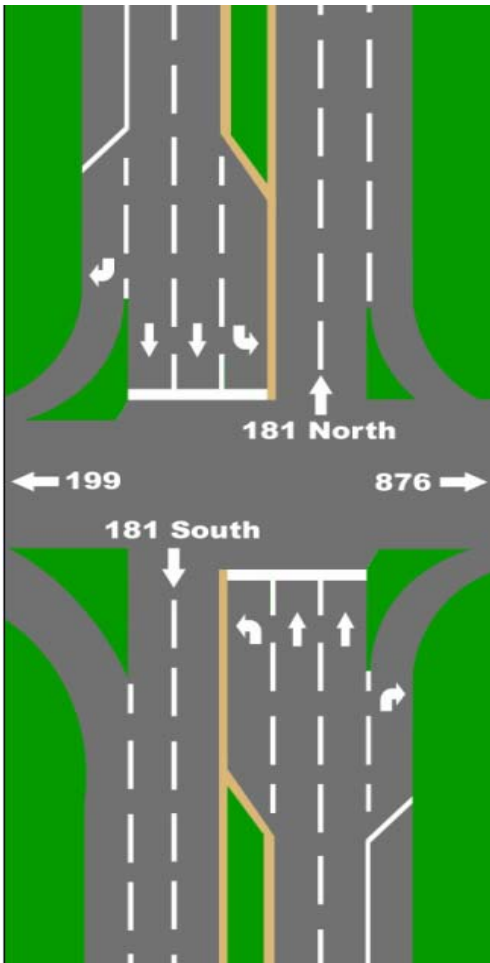


Figure 43: Current PR-181,PR-199,PR-876 design

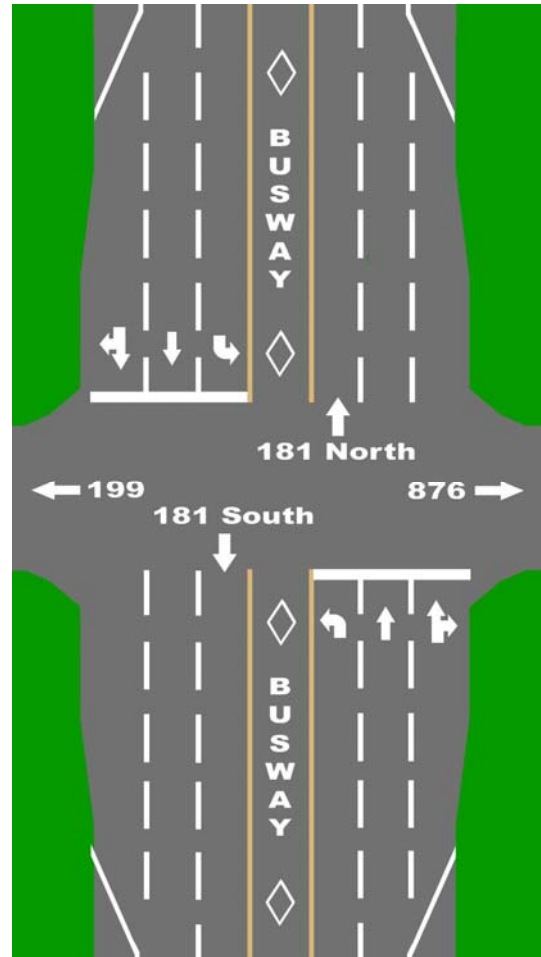


Figure 44: Modified 199 Intersection

### Modification Pros

- More feasible for Busway to travel in median
- Minimal overall changes to design of road

### Modification Cons

- Increased traffic due to reduced lanes
- Environmental concerns (possibility of removing trees)
- Heavy construction (overpass)

Figure 43 shows a diagram of the current road design of the intersection. There is a left turn lane on both the northbound and southbound sides of PR-181. There are also right turn only lanes, which are referred to as spurs. These spurs are not controlled by

traffic signals, allowing drivers to freely use them to merge into traffic of the intersecting roadway.

Figure 44 is a diagram of the modified road design. The modifications would involve widening the roadway, providing sufficient space for the Busway. Widening the road permits the northbound lanes to shift to the right, creating the current lane configuration. Rather than using spurs for right hand turns, the use of a lane for both straight and right hand turns will be constructed.

### **5.1.3 PR-181 & 848, and PR-181, 846 & 876 Intersection Concepts**

This subsection focuses on intersections: PR-181 and 848 & PR-181, 846, and 876. The design concepts are similar for the two intersections because of the common intersection layout.

The 848 and PR-181 intersection is very congested because it serves a number of traffic generators, which includes: The Trujillo Alto Shopping Plaza, restaurants, other small strip malls, and 848 brings traffic from other municipalities. Figure 45 shows a diagram of the current design of the intersection.

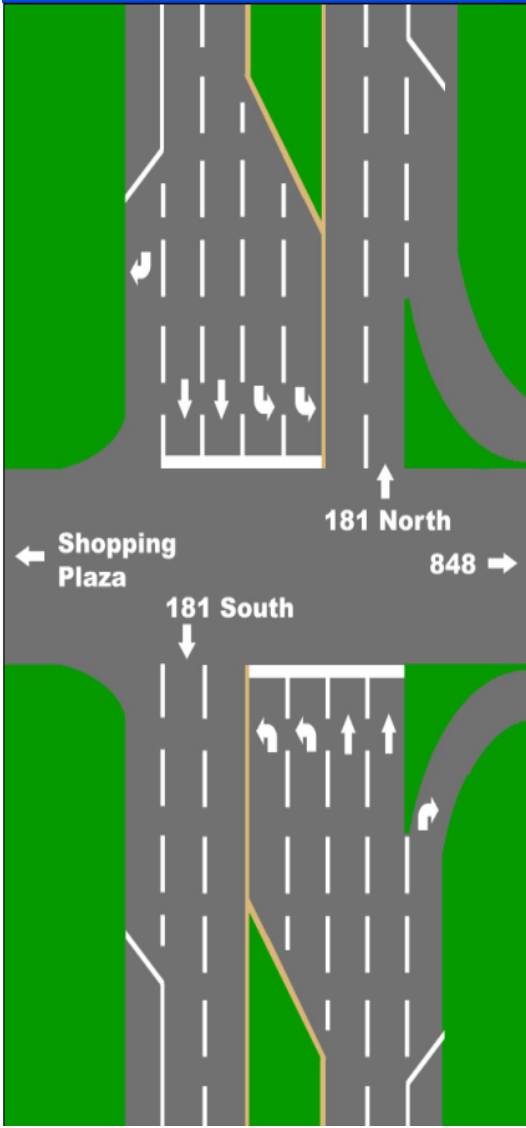


Figure 45: PR-181 & 848 Current Design

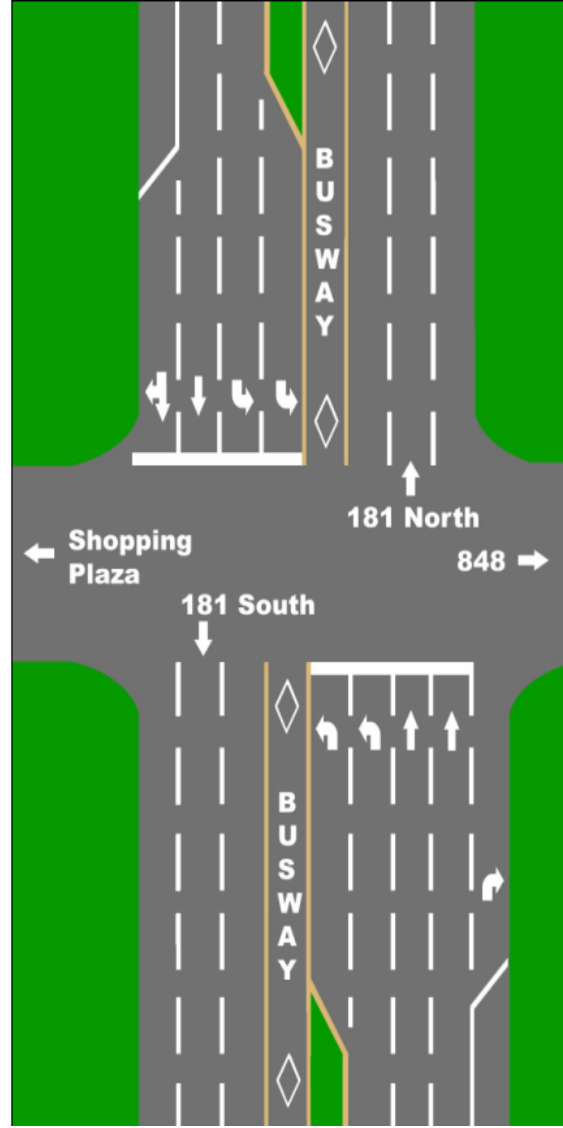


Figure 46: Modified PR-181 and 848 Intersection

**Modification Pros**

- Sufficient room to accommodate
- Better traffic control on spurs
- Safer for pedestrians

**Modification Cons**

- Environmental concerns
- May cause more confusion in intersection

The current design consists of four lanes on both the northbound and southbound sides of PR-181. There are two lanes for straight through traffic, two lanes for left turns, and a right turning lane. On the southbound side, the right lane is for traffic heading



towards the Shopping Plaza. The northbound side's right turn lane is a spur for traffic trying to merge onto 848.

To accommodate the Busway, the road will be widened slightly. Figure 46 displays modifications for the roadway. On the southbound side it is recommended to convert a right hand turn lane to a right turn and straight through lane, leaving two left hand turn lanes, a straight lane, and a combined straight and right hand turn lane.

The northbound side involves eliminating the right hand turning spurs. Also, the northbound side will be widened. It is not recommended to widen the roadway on both sides because on the southbound side there is a Shopping Plaza and parking area. Expanding the roadway on the northbound side is feasible because it has more available space.

The PR-181--876- 846 intersection is very similar to the previous intersection. The only difference between the two is the spurs are located on the southbound side of PR-181 rather than the northbound side. Figure 47 exhibits the diagram of the current design.

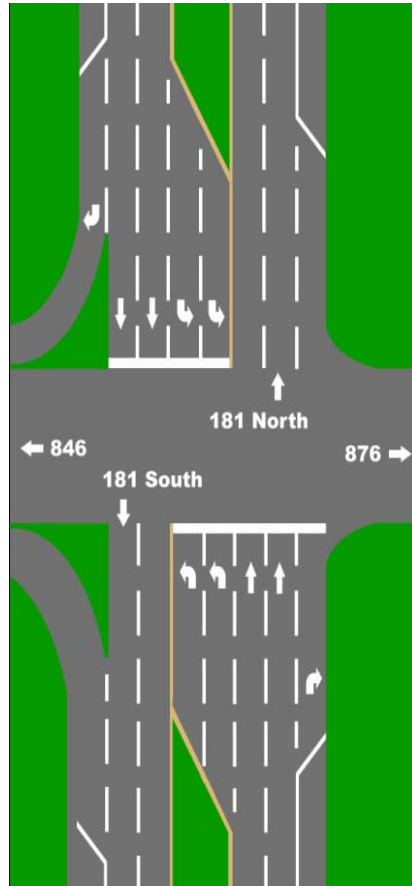


Figure 47: Current Design of PR-181, 846-876

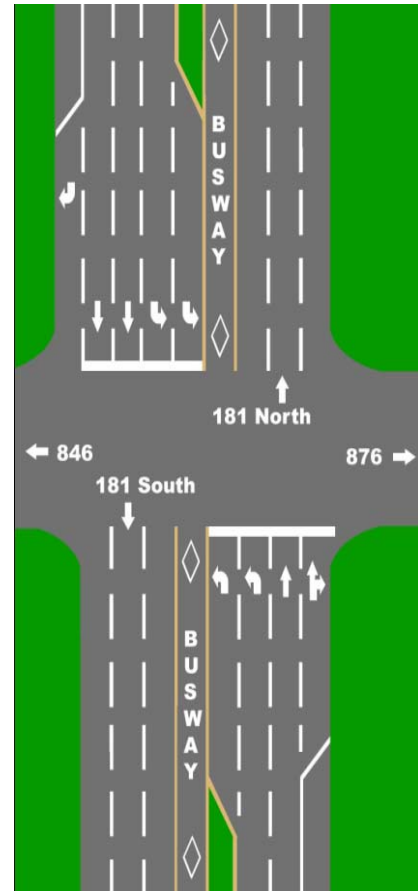


Figure 48: Modified Intersection of PR-181, 846-876

The design for the new intersection can be viewed in Figure 48. There is enough available space on both sides for an expansion of lanes. Also, removing spur lanes is necessary for the modified design. For the most part, the intersection remains similar as it exists now.

#### 5.1.4 Park Gardens and PR-181 Intersection Concepts

This intersection marks the end of the Busway's median route due to these vital factors:

- heavy construction
- deficient median space available
- lack of space available for road widening
- overpass presence

Figure 49 shows a diagram of the current design of the intersection, while Figure 50 displays the elevated bus route concept.

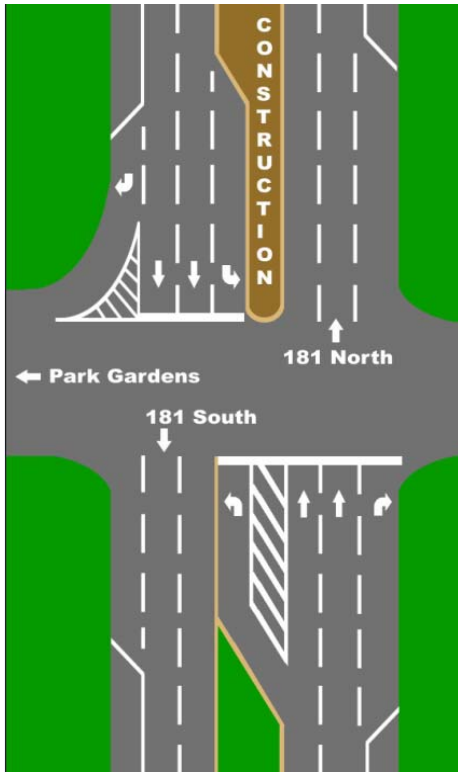


Figure 49: Current Park Gardens design

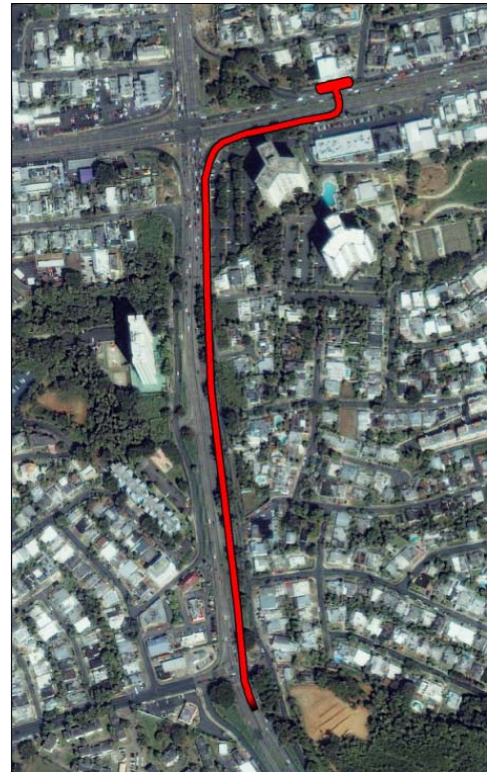


Figure 50: Elevated Bus Route

#### Elevated Bus Route Pros

- Efficient path of travel to Tren Urbano Station
- Reduced travel time
- Won't affect normal traffic flow on PR-181

#### Elevated Bus Route Cons

- Cost of Project
- Heavy construction
- Issue with getting bus back down to ground level

Figure 50 shows the elevated route from the PR-181 and Park Gardens intersection. The proposed Carolina Tren Urbano extension stop is to be located near the PR-3 intersection. It is recommended that the Busway seek an elevated route, which would run directly to the Tren Urbano stop. This concept could truly serve to be beneficial for all riders. The elevated route would run parallel to the newly constructed overpass and continue along PR-3, ending at the future Tren Urbano station.

Concept 2 is to direct the Busway out of the median into normal traffic along PR-181 until it reaches the Northern Terminal. Figure 52 shows the end of the Busway's route in the median.

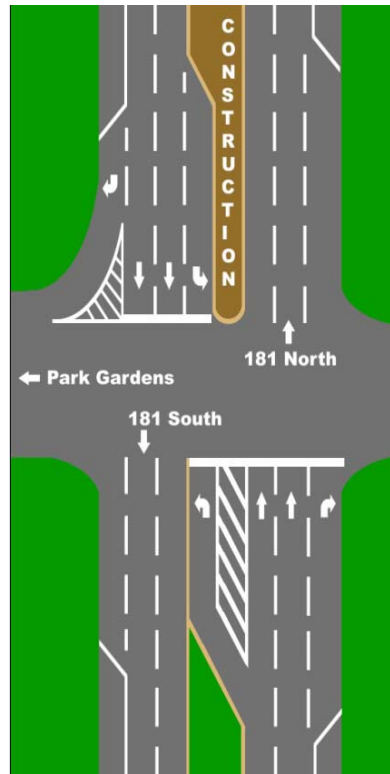


Figure 51: Current Park Gardens design

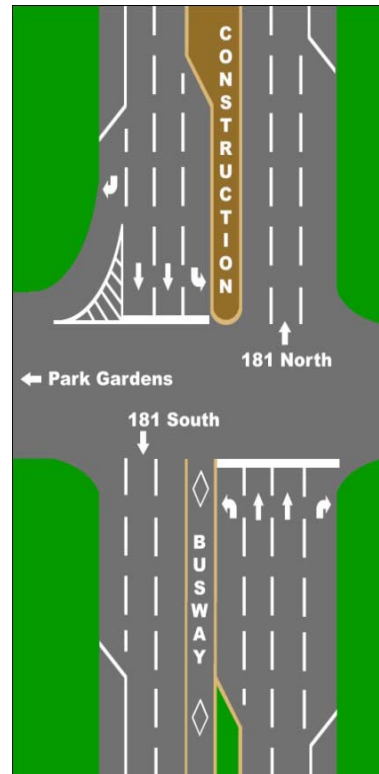


Figure 52: Concept 2 configuration

**Concept 2 Pros**

- May be cost effective
- Not complicated
- Avoids conflict with overpass

**Concept 2 Cons**

- May disrupt normal traffic
- Difficulty in maneuvering bus from median into PR-181

This configuration requires the road be widened slightly to accommodate the Busway. Also, the empty space that currently separates the left turn lane and straight through lane on the northbound side of PR-181 is eliminated.

## 5.2 Alternative Shoulder Concepts

In addition to the median concept, we have developed multiple suggestions for the Busway to be routed. The main focus of these alternative shoulder concepts deals with the utilization of the shoulder along PR-181. In the following subsections, other potential ways for the Busway to be maneuvered are described.

### 5.2.1 Alternative A

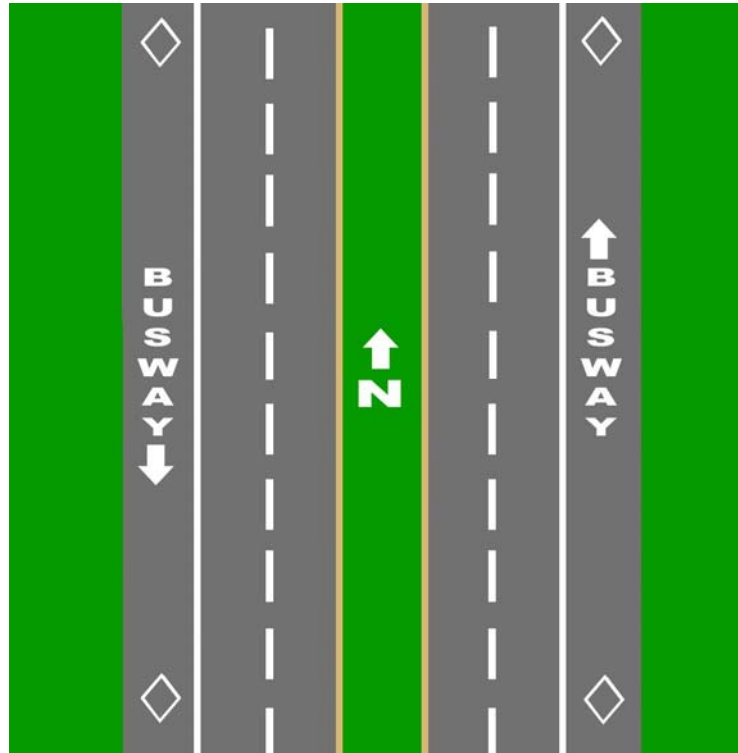


Figure 53: Illustration of Shoulder Concept Alternative A along PR-181

#### Alternative A Pros

- Possibly will not require extensive construction
- Buses are segmented from traffic
- May be very cost effective
- May be environmentally friendly
- Convenient bus stop locations

#### Alternative A Cons

- Normal traffic could enter Busway
- Right hand turns are dangerous
- Traffic could be altered in right lane

Figure 53 shows the direction of the Busway along PR-181 in the shoulder of the road. The capital letter N located in the middle of the graphic depicted in white shows the Northern direction along PR-181. Also, the center of the graphic shown in green with tan borders is the median. Graphics later mentioned in the shoulder concept alternatives follow the same layout.

In this concept, the buses will run in the same direction as the traffic along the shoulder of the road, both northbound and southbound. This concept involves removing existing sidewalks and using the space for a new lane. Compared to other alternatives, this alternative may have the least construction and cost involved with implementation. Bus stations will be on the right side of the road rather than the median or to the left side of the road. This would improve rider's safety when they are entering and exiting the bus. A bus lane can be created using the current shoulder that is not being used. This alternative is environmentally friendly because very little grass and trees will be affected by the new lanes.

At each intersection along the PR-181 Busway route (Encantada intersection to PR-3), the right hand spur lanes will be removed to assist the route of the Busway in the shoulder of the road. The lane located all the way to the right along the road will still be available to take a right hand turn with the option to continue to go straight. It would be easier to see an oncoming bus if it was to the left of the car, due to the driver's blind spots.

Also, with the right spur lane being removed at these intersections, traffic could be heavily altered. The vehicles aspiring to make a right turn may get held up due to vehicles having the option to go straight.

### 5.2.2 Alternative B

The Alternative B concept deals with the Busway running against the direction of traffic along the shoulder of PR-181 on both sides of the corridor (Figure 54).

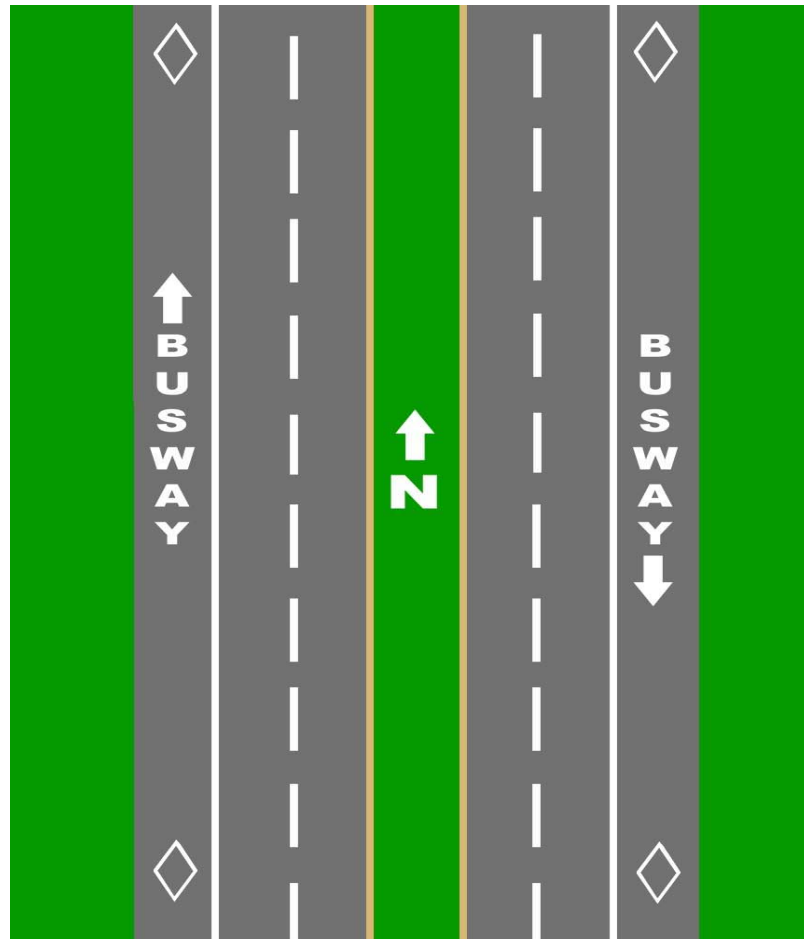


Figure 54: Illustration of Shoulder Alternative Concept B along PR-181

#### Alternative B Pros

- Denied access for normal traffic
- Buses are segmented from traffic
- May be cost effective
- Could be environmentally friendly
- Convenient bus stop locations

#### Alternative B Cons

- Buses will need doors on both sides
- Connecting to terminals is confusing
- Traffic could be altered in right lane

The first aspect discussed is access for normal traffic in the shoulder will be denied because the buses will be running against traffic. This alleviates issues that may

arise if vehicles or other forms of transportation decided to utilize the shoulder for traveling along PR-181.

The buses are segmented from the traffic in the shoulder. The amount of construction necessary will be minimal and the cost will be feasible in the implementation process. In addition, since the Busway travels in the shoulder of the road and not in the median, the amount of trees and grass being removed will be nominal. The bus stop locations are convenient for the riders since they are on the side of the road, creating safe and well-situated conditions.

The vital drawbacks of this alternative concept include the doors on the buses being located on both sides of the bus. This presents a cost issue to the bus design. The Busway route will need to connect to the terminals so if buses are moving southbound on the northbound side, the bus needs to reach the terminal without interfering with oncoming traffic. It may not be clear how to solve this problem, but it is crucial that it is mentioned. Right hand spur lanes are removed and similar problems to those of Alternative A may become apparent.

### **5.2.3 Alternative C**

Alternative C involves “Zipper” machines which are explained in more detail I in the Applying Technology section of the report. In this alternative, lanes are adjusted according to the time of day along with traffic volume. Figure 56 shows the configuration the lanes will have in the morning. During the lunch hour, the lanes are adjusted to the configuration shown in Figure 55. Three lanes are available for rush hour traffic, while the Busway is on the opposite side of the road.



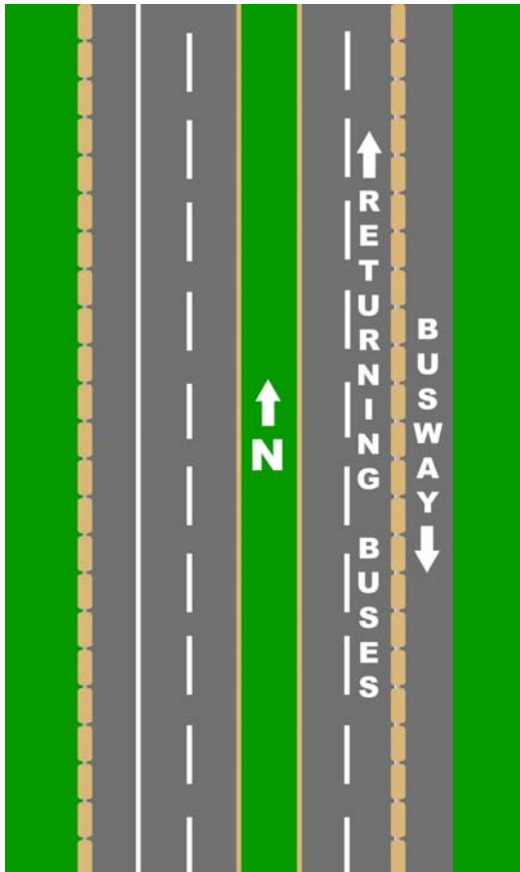


Figure 55: Configuration in the Afternoon

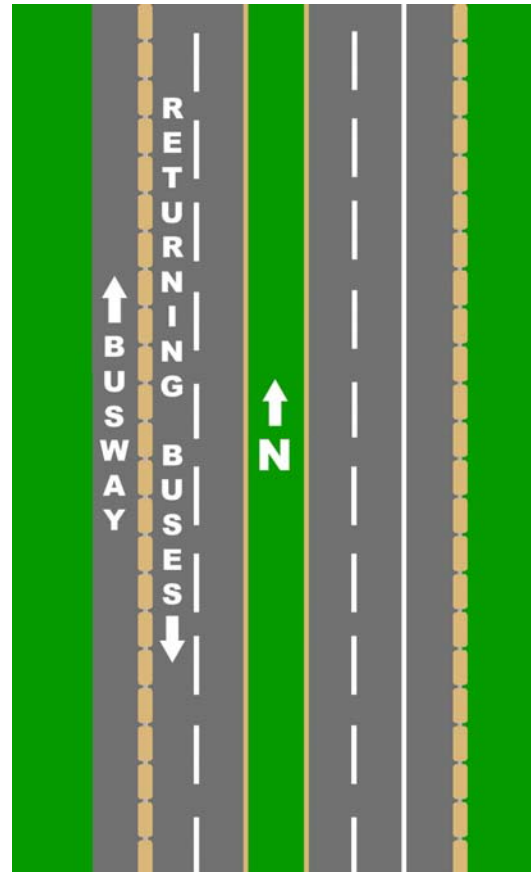


Figure 56: Configuration in the Morning

#### Alternative C Pros

- Prohibits access for normal traffic
- Collision friendly
- Adjust lanes to accommodate for volume
- Buses are segmented from traffic

#### Alternative C Cons

- May take over an hour for zipper to adjust lanes
- Promotes car usage
- May be costly
- Complicates most intersections
- No breakdown lanes available

The first advantage of this alternative is having jersey barriers prevent normal traffic from accessing the Busway, guaranteeing the bus free passage through the corridor. The barrier would keep collisions from reaching the side of the road, or into the Busway. This will not only improve the safety of the buses, but also pedestrians that may be walking on the side of the road.

Lanes will be adjusted to accommodate the traffic flow according to the time of day. The zipper machine will go northbound on PR-181 early in the morning to accommodate for the morning rush hour, and around mid day return down the corridor to accommodate for the evening rush hour.

A downside to this alternative is that it may take an hour or more for the zipper machines to fully adjust the entire barrier. Adjustments of the lanes need to be done at calm traffic periods during the day. The configuration may promote car usage, which is not necessarily good for the Busway system or Trujillo Alto. Running this system may prove to be costly because of the purchase and usage prices of the zipper machines. Controlled traffic signaling is necessary with this alternative to alleviate intersection complications. This configuration eliminates the breakdown lanes, creating danger for drivers having car trouble who need a designated area to pull over and service their vehicle.

#### 5.2.4 Alternative D

Alternative D consists of creating one dedicated bus lane running along the shoulder of PR-181 on the northbound side of the corridor (Figure 57).

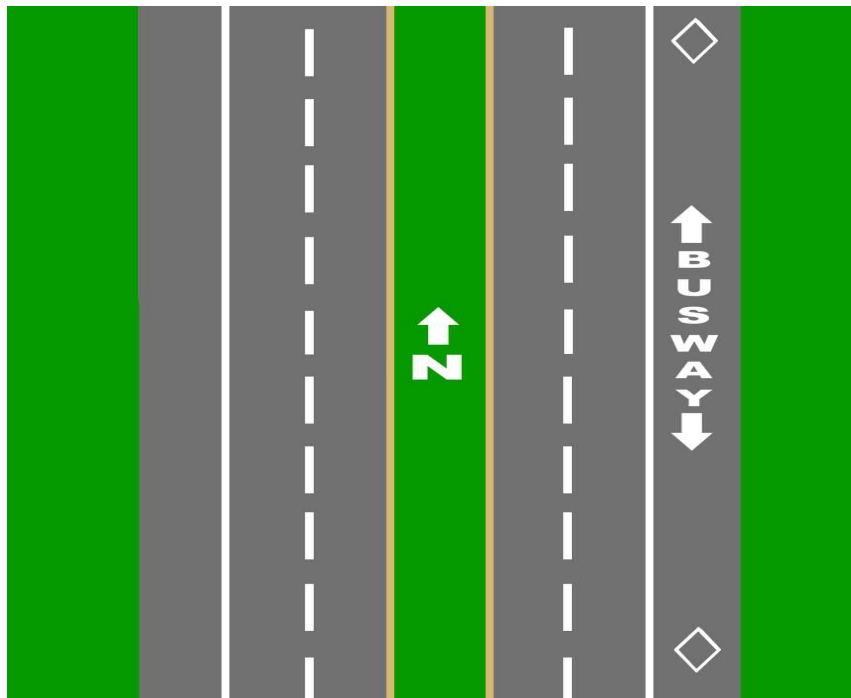


Figure 57: Illustration of Shoulder Concept Alternative D along PR-181

### **Alternative D Pros**

- May be minimal changes to road
- May be environmentally friendly
- Easily accessible to Northern Terminal
- May be cost effective
- Buses are segmented from traffic

### **Alternative D Cons**

- Buses will need doors on both sides
- Right hand turns are dangerous
- Traffic could be altered in right lane
- Lack of break down lane northbound
- Traffic may potentially have access

The amount of construction and removal of land will be minimal because the bus lane is created using the existing shoulder. Similar to previous alternatives with the shoulder being used rather than the median, the conflict with trees and other parts of nature are reduced.

One important attribute to this alternative is the convenient bus accessibility to and from the Northern Terminal. Since the dedicated bus lane runs on the northbound side of PR-181, the bus is able to reach the Northern Terminal more easily opposed to coming from the southbound side of PR-181 where it would have to cross the entire corridor.

The first negative aspect deals with the recurring issue dealing with the buses needing doors on both sides. It may be more costly in designing a bus with doors on both sides. Once again the right hand turns along the northbound corridor of PR-181 will be dangerous especially when the bus is running in parallel fashion to the traffic in the same direction. The vehicle driver's blind spots along with the bus traveling in the same direction pose an issue.

Another habitual aspect that doesn't necessarily support this alternative is the possibility that traffic may be altered in the right lane. Vehicles trying to easily make right turns will no longer have that convenience since the right turn spur lane will be removed in this alternative. The lack of a break down lane on the northbound side could serve to be a detriment to any vehicle that encounters vehicle difficulties. Lastly, the possibility of traffic gaining access to the Busway could particularly occur when the buses are running in the same direction as the northbound traffic.

### **5.3 Bus Stop Location Recommendations**

As mentioned previously in our analysis section of bus stop locations at the six major intersections, we were looking to minimize the amount of intermediate bus stops along PR-181 as well as fitting the needs of the people. After carefully reviewing the surrounding areas at each intersection and considering other determining factors, we concluded that two bus stops are the most reasonable for the proposed Busway.

The first bus stop for the Busway is located between the PR-181 & PR-199—PR-876 Intersection and PR-181 & PR-848 Intersection. Due to the heavy traffic generators bulleted below located near the PR-181 & PR-199—PR-876 Intersection, a bus stop location is sensible in this area:

- CDT Trujillo Alto Hospital
- Petre Cenon High School of Trujillo Alto

Also, at the PR-181 & PR-848 Intersection, the Pueblo supermarket and a large shopping plaza are located here. Since both of these intersections produce such commercial activity along with attracting the general needs of the people, a bus stop located in between these two intersections has been concluded as a desired recommendation.

The second and final bus stop location is going to be at the PR-181 & PR-846—PR-876 Intersection. With there being only 2 intermediate stops in between the two terminals, this will help the Busway with regards to reliability and dependability which hopefully in turn will attract people. Figure 58 is a 2002 satellite enhanced image of the PR-181 Busway route indicated with a teal color along with the two bus stop locations marked by two red ovals.



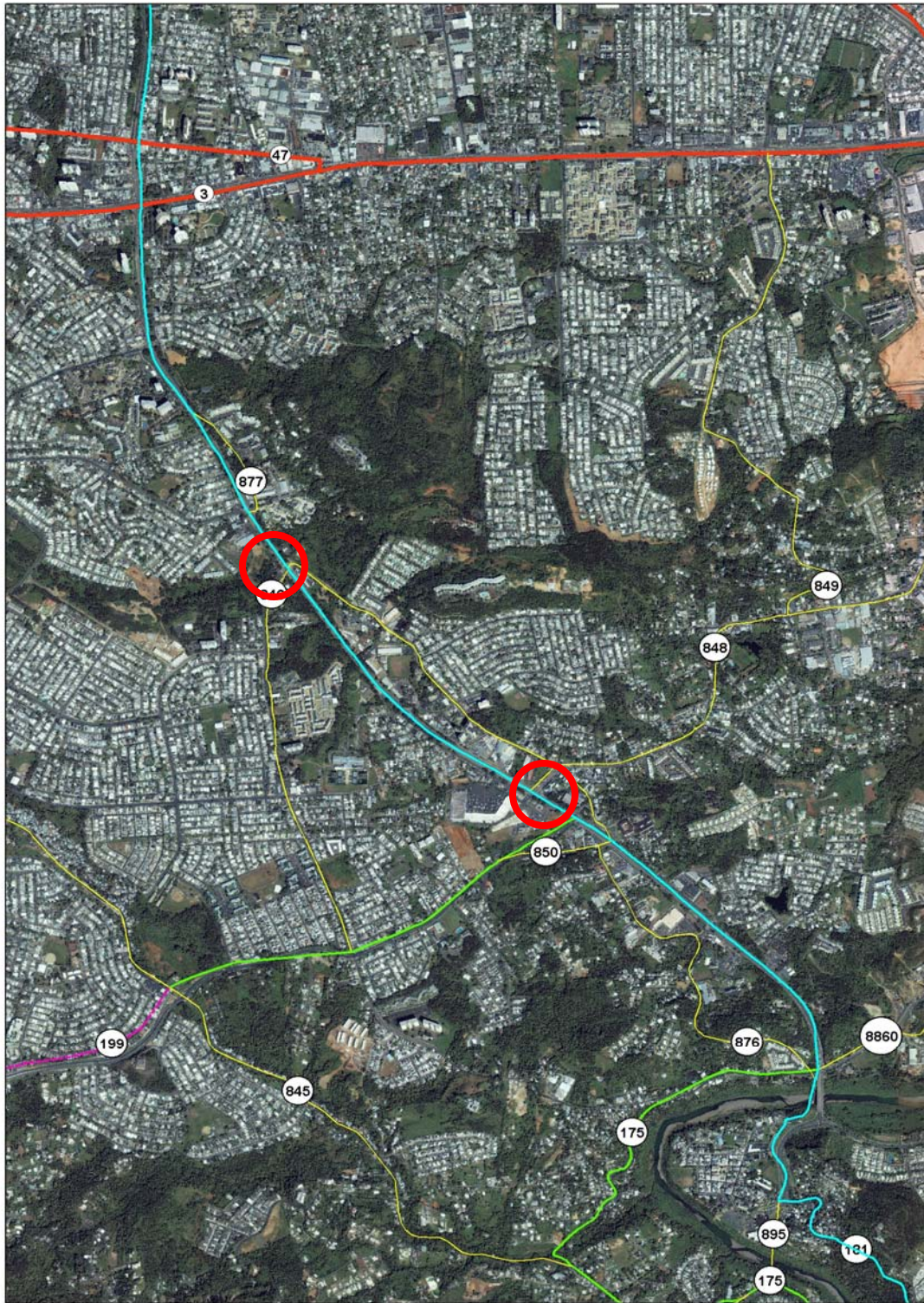


Figure 58: Bus Stop Locations on PR-181

## **5.4 Applying Technology**

Along with all the planning and construction of the proposed Busway, the use of modern technology is necessary. This modern technology includes equipment that helps build and maintain the Busway, producing optimal efficiency. The technologies that are recommended include a signal controlled traffic system, mechanical gates or arms, and moving barriers.

The signal controlled traffic system is imperative to the overall operation of the Busway. The signaling system will control the traffic at intersections, providing the bus safe passage through busy intersections. The signaling system consists of transponders on the buses and sensors at the intersection. As the bus approaches the intersection, the sensor will detect the transponder and change the traffic signals accordingly. For the bus to move quickly and safely through the intersection, lights in all directions would be red, and then resume to their normal signal timing once the bus is safely through the intersection. Another alternative to the signaling system is underground cables that sense the weight of the bus, send a signal to the traffic lights, and change them accordingly. Both the signal controlled system and underground cable sensors are alternatives that could be used to control traffic at intersections insuring safety for both the buses and cars.

The use of gates or mechanical arms helps discourage cars from entering the Busway. The gates will be operated similarly to the signal controlled traffic system mentioned previously. They will be equipped with either transponders or underground cables to sense the approaching bus. In the mean time, the gates will be closed, preventing traffic from entering the Busway. As the bus approaches, lights will flash to warn drivers and pedestrians. The shoulder configuration of the Busway will also need to utilize gates. The gates are used at the intersection similarly to those used at railroad crossings. The gates prevent cars from being in the path of the bus as it is going through the intersection.

Jersey barriers will be used to reduce the confusion caused by reversible lanes. These barriers will be shifted according to the traffic demands in order to accommodate optimal flow. The barriers will be shifted by a zipper machine (Figure 59), which will pick up the sections of the barrier and place them on the other side of the lane.





**Figure 59: Zipper Machine**

The zipper machine is thin enough to allow traffic to pass on neighboring lanes. There are machines that can also move two lanes at a time (Figure 60).



**Figure 60: Zipper Machine moving two lanes**

## **6.0 PR-181 Recommendations**

The background information gathered, along with the analytical field work performed, led us into formulating recommendations to deal with the overall problem facing Trujillo Alto, Puerto Rico. Traffic congestion along PR-181 as well as limited options for alternative modes of transportation serves as the current problem. There are many challenges in addressing this problem and we developed a set of concepts to help alleviate the issue facing Trujillo Alto.

The key recommendation discussed in the report involves the integration of a Busway with the PR-181 corridor. We have proposed two general concepts for the implementation of a Busway. The first concept deals with utilizing the median along PR-181, while the second deals with the use of the shoulder along PR-181. These two general concepts were developed into further detail providing a thorough evaluation, from which we concluded that the shoulder configuration discussed in section 5.2 of the report is the most feasible. Compared to the median configuration, the shoulder concept for the Busway presents fewer obstacles, less expensive to implement, and has the least impact on the environment. Though the Shoulder Busway configuration is more feasible, there is much work that needs to be completed in order to make the concept a reality. Future studies need to focus on a detailed design for the integration of the Busway and the Concordia Tren Urbano station as well as the design of the Southern Terminal. A cost analysis is necessary in order to judge whether the project is financially feasible.

The following section focuses on recommendations and suggestions that need to be addressed in the near future. Small physical changes that will improve the quality of life in the area around PR-181 are discussed along with minor, inexpensive projects that can be carried out in the near future. There is also a recommendation for an origin and destination survey that should be carried out, providing planners with information regarding where commuters are traveling to and from.

### **6.1 PR-181 Immediate Improvements**

We noticed areas along the PR-181 corridor that are in need of repair. Applying immediate changes to the discrepancies in the road will overall improve not only the road conditions, but also the quality of life. Many of these immediate recommendations may



come across as obvious or tedious, yet they could be contributing to the traffic issues that have been identified along PR-181.

At the intersection of PR-181 and PR-846-PR-876 there is a pothole that needs to be filled. Potholes were observed in numerous areas, but this one particularly stood out immensely. Another immediate improvement we identified was to re-paint the yellow lines near the curbs along the median. As of now, they are in poor condition and are not clearly visible when driving. This is dangerous especially at night because along some parts of the PR-181 corridor there are no streetlights and trees lie in the middle of the median.

Also, re-painting the crosswalks in the areas where it applies would be helpful. Many of the crosswalks are faded and cannot be identified by the driver, in turn, causing the pedestrian crossing to be unsafe. Clearly visible crosswalks could possibly encourage pedestrians to cross the street. Another attribute to making more visible crosswalks is that it may even attract more people to travel from one place to another by foot rather than vehicle. Adding and fixing pedestrian walk lights is something to take into consideration. If repairs and changes were made with regard to pedestrian traffic lights, then the walk across the corridor would be made safer for both drivers and pedestrians.

One of the last immediate improvements observed was the overall landscaping along the road. Numerous sections of PR-181 suffer from under maintained landscape where:

- Garbage lies along the side of PR-181 as well as on the actual road
- Leaves from the trees covering traffic lines
- Dirt covering many parts of the shoulder where vehicles make sharp turns

All of these landscaping issues contribute to the quality of life along the PR-181 corridor, where we have graded as unfavorable.

These immediate recommendations will serve to be beneficial for any government agency or transportation department who is searching for alternative ways to improve the road conditions and quality of life along PR-181. It is important to remember that the goal of the Busway is to not only provide an alternative mode of transportation, but also help develop the land area along PR-181 geared towards people.

One area that is of great importance is pedestrian and cyclist safety along PR-181. In order to improve PR-181 for people, there needs to be safety measures in place for pedestrians to securely travel along, and cross the corridor. One of our initial ideas to improve pedestrian safety is to construct pedestrian bridges at high pedestrian and vehicle traffic points. The primary goal for these pedestrian bridges is to provide a safe method for pedestrians to cross PR-181 without affecting the traffic flow.

After speaking with the Chief Planner of ACT, Dr. Gabriel Rodríguez Fernández, we became aware that pedestrian bridges can serve as a way to promote growth along PR-181. In order to get people to use pedestrian bridges, there needs to be a destination that pedestrians are trying to reach other than just the other side of the road. This opens the door for new businesses to be developed along PR-181. If these new businesses offered products and services that currently are only accessible by car travel, people would have more reason to travel by walking or bicycling.

Making walking and/or cycling more enjoyable is an issue that should be taken into consideration in the planning process for any modifications to PR-181. Possibly constructing small parks and picnic areas would allow for people who are walking or bicycling to enjoy nature and also have areas to sit and rest. These kinds of ideas would help promote walking and bicycling to destinations along PR-181.

These are just some possible ideas that could be further developed to help improve PR-181 for people. The issue of improving is not only the commute from Trujillo Alto to San Juan, but also improving the overall area for people is an aspect that should be pointed out as being equally important.

## ***6.2 Origin and Destination Survey***

We have proposed a survey in order to determine the origin and destination needs of the general population who utilize the PR-181 corridor. Our project group will not formally conduct this survey; rather it will be submitted as a recommendation for the Municipality of Trujillo Alto to use as a resource. Since our project group is not conducting the survey, we will not be exploring the scientific methods that are required

for success when performing a survey. We will explain two key areas of interest that we considered when developing the survey:

- Developing the Precise Questionnaire Design
- Choosing the Successful Survey Method

Some basics that we had to cover first before coming up with the necessary questions to ask in our survey were (Woods, 2004):

- Is the question able to be answered easily through one's experiences?
- Can the question be read and answered simply, and specifically enough?
- Is it clear to the respondents how the answers are defined?
- Does the question focus on one topic or many different topics that should be broken down into sub questions?
- Can any assumptions be made through answers to the questions?

After carefully going through each of these questions, the development of the survey became easier to comprehend. These are just some of the preliminary questions that were asked in order to screen the survey developed. In reality, it may take weeks to properly screen the questions in a survey but we are in no position to go through an entire screening process. Rather, we are dealing with a brief process of research methods to provide credibility to the survey.

We also would like to make it aware of the types of survey methods that could be most feasible in conducting the survey. One of the most important decisions in the entire process is how to facilitate the survey itself. Do you want to conduct the survey over the phone, face-to-face, or via e-mail or mail? All of these options are among the most common of practices and come with varying strengths and weaknesses that must be taken into account. We illustrate some of the factors that may assist in making key decisions with regards to what type of survey to employ. In order to reach success with regards to a survey's objectives, then one must consider specific factors such as (Woods, 2004):

### **1. Available resources**

As in many cases in life with anything, money is a big issue. Labor costs are factors that must be considered when trying to fit the most suitable method of

choice for a survey. The amount of resources one has available is reliant upon the organization who administers the survey.

## **2. Time availability and restraints on results**

Performing surveys over the telephone in many cases can yield instantaneous results and a little amount of overall time to reach desired results. For a survey to be conducted and fulfilled through the mail or face-to-face, time can become a great issue. Both of these options yield a great amount of time commitment for not only the surveyor but the surveyed. Time is money in this world; therefore one must be aware of this when making the survey choice decision.

## **3. Simplicity of questions**

The complexity of the questions in the survey also could have a significant bearing on the success of one's survey. Written questions in front of a person in a face-to-face survey may be a lot easier for the surveyed to understand and ask any questions with the ability to communicate better than on a telephone. Over the telephone, it may be a lot more difficult for one to comprehend a particular question. Hence, it may be prudent to produce simple, yet specific questions in order to draw sufficient conclusions.

## **4. Characteristics of respondents**

Also, you may want to be knowledgeable of the type of people you are sampling. The types of questions along with the wording and design of the questions may prove to be very beneficial when constructing a survey that fits the needs of the people in a certain area.

Considering all of the factors discussed above, an organization can figure out which survey choice they want to utilize that best fits their needs. With a concise research period with regards to surveying, our project group was able to formulate a survey which will serve as a beneficial deliverable for the Municipality of Trujillo Alto. The survey can be found in Appendix C.

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# Appendix A: Library of Studies Matrix

Resources	Economic Feasibility	Parking	Routes and Coverage	Customer Information	Mode of Transportation	Transferring	Schedules	Operation hours	Technology	Land use and Design	Transit Pricing and Fares	Causes	Environmental Effects
Transportation Dilemma (Boyd)	2	2	2	1	1	1	3	3	3	3	3	3-Urban Sprawl	2
Bay Area Rapid Transit (Stokes)	5	4	2	2	1	1	1	1	4	4	4	5-Draws users	
King County Metro Transit at Glance (Metro)		2	1	1	3				2				1
Employer Bus Pass Programs (Metro)		1	2								5		
About King County Metro (Metro)	4	1	3	1	1				1	1	1		
MetroBus Tunnel (Metro)			1		3		2	3	2	4		3-Adding another	1
Miami Special Events Shuttles (MiamiDT)		2	2	1	1							3-B. Many people, 1 destination	
Miami Park and Ride (MiamiDT)		3	3	2	2	3					3		
South Miami Dade Busway (MiamiDT)	2	2	4	1	1	3				4	1		
MDT Facts (MiamiDT)	4				2						3		
Miami Metro Bus Information (MiamiDT)			3	3	1			2			2		
Airtrain JFK (PANYNJ)			3	2	2	2		1				3-2.Airport is accessible by rail	
Airtrain (MTA) (PANYNJ)			2	2	2	1		1			1		
Regional Bus Study: WMATA (TransSystem)	2	1	1	5	1						2		
Draft Final Report: Worcester (Ubitran)	4	4	3	4	4	4	3	4	4	2	2	3-3.Awful Hours	
Europe Train Train (Bugania)	2	2	4	4	5	2			3	3			
	5	In-depth Research w/ Case Study											
	4	In-depth Research											
	3	Substantial Information											
	2	Revealing Information											
	1	Mentioned											

## Appendix B: PR-181 intersection data sheets

<b>Intersection Data Sheet</b>	
<b>Taken By:</b>	Eric Gebrian
<b>Time Taken:</b>	12:00
<b>Intersecting Street Name:</b>	Via Encantada
<hr/>	
<b># of Lanes per side:</b>	4
<b># of Left Turn Lanes per side:</b>	2
<b>Traffic Islands?</b>	Y / N (3 main pedestrian islands)
<hr/>	
<b>Pedestrian Access:</b>	High / Med / Low
<b>Pedestrian Crosswalk:</b>	Y / N
<b>Pedestrian Traffic Lights:</b>	Y / N
<b>Need for Ped. Bridge:</b>	High / <b>Med</b> / Low
<hr/>	
<b>Traffic Volume:</b>	High / Med / Low
<b>Speed Limit:</b>	45 mph
<b>High Traffic Generators:</b>	PR 181 merging with traffic from Encantada
<b>Road Conditions:</b>	Very Good / <b>Good</b> / Fair / Bad / Very Bad
<hr/>	
<b>Current Bus Stop Present:</b>	Y / N
<b>TOTAL Busway Feasibility:</b>	<b>Very Hard</b> / Hard / Sufficient / Easy / Very Easy
<hr/>	
<b>Comments:</b>	
<p><b>No real median - elevated, rocky area south of intersection.</b>  <b>Bus may have to go through intersection as is and enter the dedicated buslane when it gets out of the intersection.</b>  <b>Small Plaza: Need to create another entrance into intersection for buses.</b>  <b>Crosswalks and lights along with Ped. Islands.</b>  <b>Median small on bridge but large after intersection.</b>  <b>Parque Familia: Point of interest.</b>  <b>8860: Has the most accidents here; it is a 4 lane road with no stop lights, so cars tend to speed: Dangerous for pedestrians and merging cars.</b>  <b>Dynamite was used in the area, but the rock didn't blow up.</b>  <b>Possibly put terminal on other side of bridge.</b></p>	



**Figure 61: Encantada Intersection Looking South**



**Figure 62: Encantada Intersection Looking Northwest**

<b>Intersection Data Sheet</b>	
<b>Taken By:</b>	Eric Gebrian
<b>Time Taken:</b>	1:05
<b>Intersecting Street Name:</b>	199 (850) & 876
<b># of Lanes per side:</b>	3
<b># of Left Turn Lanes per side:</b>	1
<b>Traffic Islands?</b>	Y / N
<b>Pedestrian Access:</b>	High / <b>Med</b> / Low
<b>Pedestrian Crosswalk:</b>	Y / N
<b>Pedestrian Traffic Lights:</b>	Y / <b>N</b>
<b>Need for Ped. Bridge:</b>	High / <b>Med</b> / Low
<b>Traffic Volume:</b>	<b>High</b> / Med / Low
<b>Speed Limit:</b>	45 mph
<b>High Traffic Generators:</b>	Hospital, School
<b>Road Conditions:</b>	Very Good / Good / <b>Fair</b> / Bad / Very Bad
<b>Current Bus Stop Present:</b>	Y / <b>N</b>
<b>TOTAL Busway Feasibility:</b>	Very Hard / <b>Hard</b> / Sufficient / Easy / Very Easy
<b>Comments:</b>	<p>People need to cross 181 from hospital.            Kids cross 181 from school.            No median due to left turn lanes.            Traffic affected by parents dropping kids off.            After intersection, good median space.            199 was 850; they changed the name.</p>





**Figure 63: 199 & 876 Intersection Looking North**



**Figure 64: 199 & 876 Intersection Pedestrian Islands**

<b>Intersection Data Sheet</b>	
<b>Taken By:</b>	Eric Gebrian
<b>Time Taken:</b>	1:07
<b>Intersecting Street Name:</b>	848
<b># of Lanes per side:</b>	5
<b># of Left Turn Lanes per side:</b>	2
<b>Traffic Islands?</b>	Y / N
<b>Pedestrian Access:</b>	High / <b>Med</b> / Low
<b>Pedestrian Crosswalk:</b>	Y / N
<b>Pedestrian Traffic Lights:</b>	Y / N
<b>Need for Ped. Bridge:</b>	<b>High</b> / <b>Med</b> / Low
<b>Traffic Volume:</b>	<b>High</b> / Med / Low
<b>Speed Limit:</b>	45 mph
<b>High Traffic Generators:</b>	Strip Mall (McDonald's, Pueblo, etc.), 848 from Carolina
<b>Road Conditions:</b>	Very Good / <b>Good</b> / Fair / Bad / Very Bad
<b>Current Bus Stop Present:</b>	Y / N
<b>TOTAL Busway Feasibility:</b>	Very Hard / <b>Hard</b> / Sufficient / Easy / Very Easy
<b>Comments:</b>	<p>Still have to cross many lanes of traffic to walk to other side.            Big plaza is here (McDonalds, Pueblo).            Pedestrian Crosswalks.            Left turn lanes again so loss of median space.            After intersection, good median space, but full of trees.</p>



**Figure 65: 848 Intersection Looking North**



**Figure 66: 848 Intersection Shopping Plaza**



<b>Intersection Data Sheet</b>	
<b>Taken By:</b>	Eric Gebrian
<b>Time Taken:</b>	1:15
<b>Intersecting Street Name:</b>	846 & 876
<hr/>	
<b># of Lanes per side:</b>	5
<b># of Left Turn Lanes per side:</b>	2
<b>Traffic Islands?</b>	Y / N
<hr/>	
<b>Pedestrian Access:</b>	High / Med / <b>Low</b>
<b>Pedestrian Crosswalk:</b>	Y / N
<b>Pedestrian Traffic Lights:</b>	Y / <b>N</b>
<b>Need for Ped. Bridge:</b>	High / Med / <b>Low</b>
<hr/>	
<b>Traffic Volume:</b>	<b>High</b> / Med / Low
<b>Speed Limit:</b>	45 mph
<b>High Traffic Generators:</b>	846 from Cuevas
<b>Road Conditions:</b>	Very Good / Good / <b>Fair</b> / Bad / Very Bad
<hr/>	
<b>Current Bus Stop Present:</b>	Y / N
<b>TOTAL Busway Feasibility:</b>	Very Hard / <b>Hard</b> / Sufficient / Easy / Very Easy
<hr/>	
<b>Comments:</b>	
<p>Marks end of Trujillo Alto.  Pedestrian bridge may not be that necessary; not a lot around.  B26 bus comes out of 846.  Loss of median due to left turn lanes.  Last AMA bus stop.  Shoulder space.  Median after intersection is full of trees.  Space to widen.  876 runs parallel to 181.</p>	



**Figure 67: 846 & 876 Intersection Looking South at Route 181**



**Figure 68: 846 & 876 Intersection Looking West at 846**

<b>Intersection Data Sheet</b>	
<b>Taken By:</b>	Eric Gebrian
<b>Time Taken:</b>	1:21
<b>Intersecting Street Name:</b>	Park Gardens
<b># of Lanes per side:</b>	4
<b># of Left Turn Lanes per side:</b>	1
<b>Traffic Islands?</b>	Y / N
<b>Pedestrian Access:</b>	High / Med / <b>Low</b>
<b>Pedestrian Crosswalk:</b>	Y / N
<b>Pedestrian Traffic Lights:</b>	Y / <b>N</b>
<b>Need for Ped. Bridge:</b>	<b>High</b> / <b>Med</b> / Low
<b>Traffic Volume:</b>	<b>High</b> / Med / Low
<b>Speed Limit:</b>	45 mph
<b>High Traffic Generators:</b>	Restaurants, Housing Units, from 877
<b>Road Conditions:</b>	Very Good / Good / Fair / <b>Bad</b> / Very Bad
<b>Current Bus Stop Present:</b>	Y / N
<b>TOTAL Busway Feasibility:</b>	<b>Very Hard</b> / Hard / Sufficient / Easy / Very Easy
<b>Comments:</b>	<p>Construction.  Bad for pedestrians.  Beginning of new overpass.  No median.  Not much room on shoulder for possible widening of road.  Possibly put busway underground to avoid conflicts with overpass.</p>



**Figure 69: Park Gardens Intersection Facing South**



**Figure 70: 181 South Heading to Park Gardens Intersection**

<b>Intersection Data Sheet</b>	
<b>Taken By:</b>	Eric Gebrian
<b>Time Taken:</b>	1:26
<b>Intersecting Street Name:</b>	PR-3 or 65th Infanteria
<b># of Lanes per side:</b>	3
<b># of Left Turn Lanes per side:</b>	0
<b>Traffic Islands?</b>	Y / N
<b>Pedestrian Access:</b>	High / Med / <b>Low</b>
<b>Pedestrian Crosswalk:</b>	Y / <b>N</b>
<b>Pedestrian Traffic Lights:</b>	Y / <b>N</b>
<b>Need for Ped. Bridge:</b>	<b>High</b> / Med / Low
<b>Traffic Volume:</b>	<b>High</b> / Med / Low
<b>Speed Limit:</b>	45 mph
<b>High Traffic Generators:</b>	PR 3 traffic from Carolina, Residential communities, plaza
<b>Road Conditions:</b>	Very Good / <b>Good</b> / Fair / Bad / Very Bad
<b>Current Bus Stop Present:</b>	Y / <b>N</b>
<b>TOTAL Busway Feasibility:</b>	<b>Very Hard</b> / Hard / Sufficient / Easy / Very Easy
<b>Comments:</b>	<p><b>Very big intersection.</b></p> <p><b>In the future, there won't be an intersection due to supports of the overpass.</b></p> <p><b>People selling stuff in median poses minor problem.</b></p>





**Figure 71: PR-3 Intersection Looking Northwest**



**Figure 72: PR-3 Intersection Looking West**

## Appendix C: Destination and Origin Survey

Please clearly indicate responses below with a check and/or writing where applicable.

*How often do you travel on PR-181 or the Expreso Trujillo?*

More than once a day     Once a day     A few times a week     Less than once a week     Never

*How many cars do you have in your household?*

0     1     2     3     3+

*How many licensed drivers are in your household?*

0     1     2     3     3+

*Do you use the Tren Urbano? And if so, how often?*

More than once a day     Once a day     A few times a week     Less than once a week     Never

*Do you use buses? And if so, how often?*

More than once a day     Once a day     A few times a week     Less than once a week     Never

*Do you use Publicos? And if so, how often?*

More than once a day     Once a day     A few times a week     Less than once a week     Never

*When traveling on Expreso Trujillo what is your usual destination?*

---

*When traveling on Expreso Trujillo where are you usually coming from?*

---

*What time do you start and end work?*

Start: \_\_\_\_\_ End: \_\_\_\_\_

*As a pedestrian, do you ever cross PR-181? If so, where?*

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*What transportation improvements would you like to see on the Expreso Trujillo?*

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