PROJECT INFRASTRUCTURE DEVELOPMENT CASE STUDIES: THE TEODORO MOSCOSO BRIDGE AND THE TREN URBANO IN SAN JUAN, PUERTO RICO

By

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Submitted to the Department of Civil and Environmental Engineering in partial fulfillment of the requirements for the degree of

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ABSTRACT
Transportation infrastructure is constantly being developed in the United Sates. Its success, however, depends to a great extent on how each transportation project is actually developed. The study of project procurement is important to determine which type of delivery method and delivery finance fits best to a particular project. The case studies presented in this thesis are designed to help understand the procurement processes of two important transportation projects in San Juan, PR: The Teodoro Moscoso Bridge and the Tren Urbano.

The Teodoro Moscoso Bridge provides the opportunity to study the delivery of a facility that could really help a community of residents in grave need for less transit congestions, but that is surrounded by externalities that threaten its completion. These externalities include political pressures, and ambiguities associated to scheduling and finance.

The Tren Urbano also presents a series of events that are ideal for evaluation and analysis. Given that Puerto Rico lacks any experience with rail transit systems, the government is in the best position to implement new strategies, and learn from similar past projects. In addition, the Tren Urbano is unique in other respects. Uncertainty in all phases of the project has affected most elements of the procurement of the project, such as projected ridership, financing, scheduling, fares, and ideal delivery method.

This thesis presents possible fictional scenarios for each project that are to be used for the better understanding of each project's procurement process. They are designed to help students of infrastructure management understand which uncertainties should be given more importance and under what circumstances, as well as how these processes should be structured in general.

Thesis Supervisor: John B. Miller
Title: Associate Professor of Civil and Environmental Engineering

BIOGRAPHICAL NOTE

Marisela Morales graduated from the Massachusetts Institute of Technology in June 1999 with a Bachelor in Science in Environmental Engineering. During those four years, she had the opportunity to study French at the Sorbonne University in Paris, France. This one-semester experience allowed her to also complete a minor in French studies.

In the fall semester of 1999 Marisela joined the one-year Master in Engineering program of MIT's Department of Civil and Environmental Engineering, to focus on the technology policy aspect of the environmental engineering field.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

1.0 What is infrastructure?

Infrastructure is a relatively modern concept hard to define. The term is used to describe what is considered 'public works'. For John Miller, professor at the Massachusetts Institute of Technology and author of Construction Project Delivery Systems: Public/Private Infrastructure, the term means "collectively, (a) capital facilities such as buildings, housing, factories, and other structures which provide shelter; (b) the transportation of people, goods, and information; (c) the provision of public services and utilities such as water; power; waste removal, minimization, and control; and (d) environmental restoration" (Miller, 1999). Hence, infrastructure has three distinct definition; that which focuses on physical assets; that which focuses on ownership or control of those assets; and, that which focuses on the services provided. However, the definitions of infrastructure can vary depending on the perspective of who is analyzing it – the Producer (in many cases, a private sector firm) or the Client (in many cases, the government of public sector agency) (Miller, 1999).

1.1 Why is infrastructure needed?

Infrastructure is important for a country to build itself a strong economy and to satisfy the needs of its population. An infrastructure delivery that continually provides a population with new services of transportation and communication, new technologies, and new methods of design and construction is essential for that country to prosperously develop, and meet its people's needs for safety, health, and a clean environment (Zarrilli, 1999).

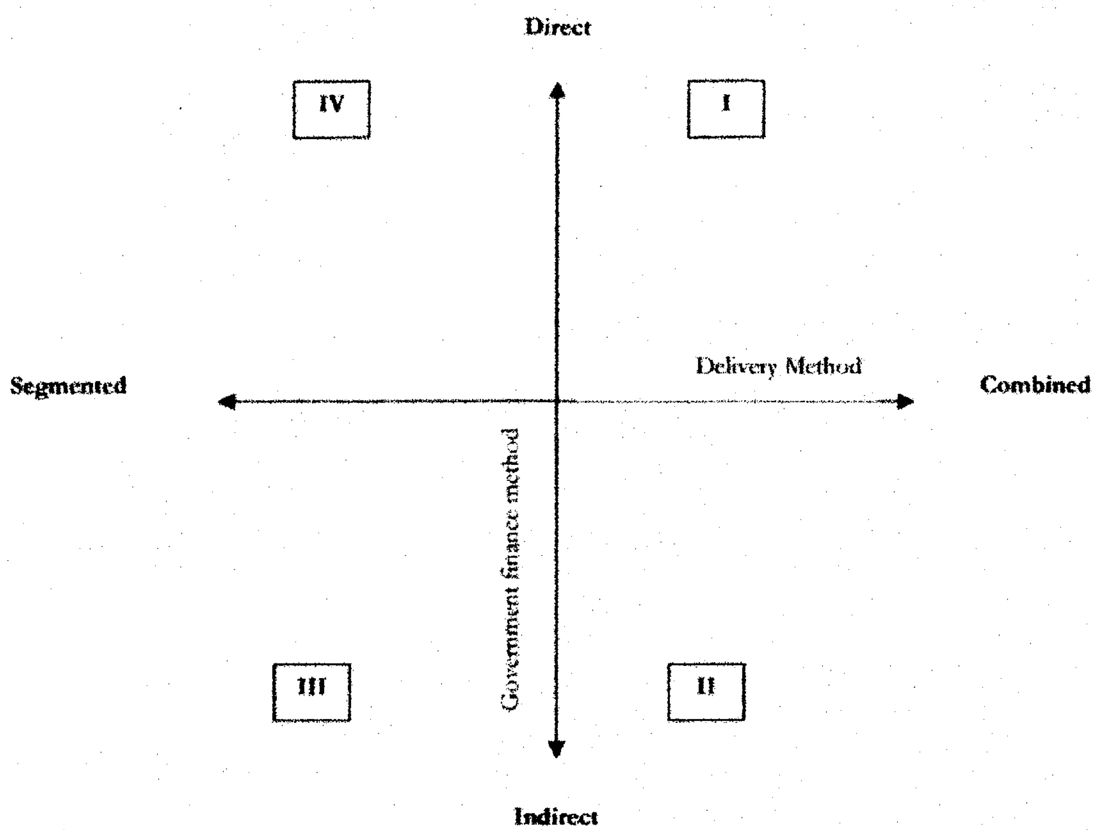
The United States, however, has been suffering during the last 20 years a crisis in its infrastructure system (Miller, 1999). The reason for this crisis lies on the way in which public infrastructure is procured, and on how this in turn has affected private sector owners. Since 1980, government commitment to public infrastructure has sharply declined, along with the federal funding assigned to it. While infrastructural needs have increased as years passed, government's lack of funds prevent it to efficiently take care of those needs. As a result, the private sector has had to cope with the public sector's lack of organization and financial involvement into projects, as well as with its own insufficient corporate resources to divide among 'new product' development, marketing, sales, and infrastructure repair, replacement, and maintenance (Miller, 1999).

Presently, Congress has made available less than 15% of the federal budget to infrastructural needs. Cities and states can no longer rely upon the federal government's aid to carry out infrastructural projects. They will now have to find alternative ways to satisfy the population's increasing needs, even if it includes new and creative arrangements with the private sector.

1.2 Delivery Methods and the Quadrant Framework

The Quadrant framework is a practical way to explain what delivery methods refer to. It was developed at MIT's Department of Civil and Environmental Engineering in the early 1990s as a tool to compare and contrast infrastructure funding and delivery methods (refer to Figure 1.1). Infrastructure funding depends on how much of the direct financial risk for producing the project the government is willing to assume. A delivery method, on the other hand, is chosen according to how typical project elements are separated from each other from a Client's point of view.

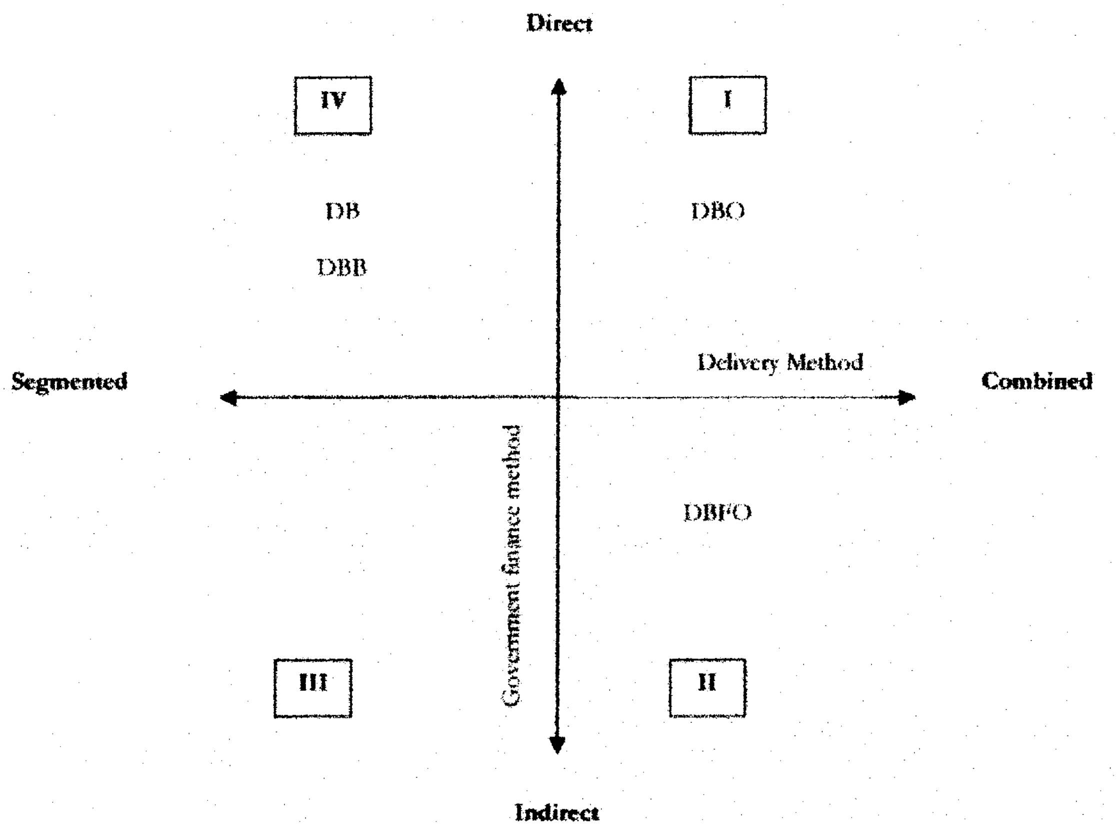
Figure 1.1 The Quadrant Framework (Miller, 1999)



Each of the two orthogonal axes that comprise the quadrant framework represents government's two fundamental strategies for promoting infrastructure development. The vertical axis represents the choices available to the government to finance projects. It could decide to 'directly' fund project through current cash appropriations, or it could decide to 'indirectly' promote projects by encouraging the private sector to finance its project goals. Government funding is only considered to be 'direct' if the government provides some, if not all, of the money necessary to finance the design and construction of a project.

The horizontal axis, in contrast, represents the delivery choices available to government to carry out a project. Because a project's completion entails several steps, such as planning, design, construction, operations, and maintenance, the government can arrange them in more than one way. The government can opt for a 'segmented' process, in which it separates each of these steps from one another in the procurement process; or, it could combine all or some of them into a single procurement process. Because there are so many potential choices to be made, the quadrant framework facilitates the task of comparing and contrasting one delivery method from another. The most common project delivery methods used today are Design-Build (DB), Design-Bid-Build (DBB), Design-Build-Operate (DBO), Design-Build-Finance-Operate (DBFO), and Pure Operations and Maintenance (Pure O&M) (Miller, 1999). These are discussed below. How these methods fit into the Quadrant framework is shown in Figure 1.2.

Figure 1.2 Delivery Methods in the Quadrant Framework (Miller, 1999)



1.2.1 Design-Build

In a Design-Build delivery method the Client (public sector) procures both design and construction from a single Producer (private sector). The Client is also responsible of other project functions, such as design criteria, financing, maintenance, and operation of the facility. These are procured separately from one another. Hence, DB corresponds to Quadrant IV (see Figure 1.2)

1.2.2 Design-Bid-Build

Government frequently uses Design-Bid-Build when it wishes to fully separate design from construction, both of which are, in turn, separated from operations and maintenance. Consequently, the design work from the architect or engineer is separate and does not involve the work of the construction contractor. Furthermore, the government is responsible of funding all of these steps of the delivery method, including operations and maintenance once the facility has been built. DBB, thus, belongs in Quadrant IV. As was mentioned above, DBB is the most common strategy currently used in the United States, primarily because it is supported by federal statute and state regulation (Miller, 1999).

1.2.3 Design-Build-Operate

The Design-Build-Operate delivery method requires that design, construction, maintenance, and operation be combined into a single procurement to be performed by a single Producer. Because the Client must provide most or all of the financing needed, this strategy, thus, falls into Quadrant I. The Client, however, must be responsible of providing initial planning and the establishment of the design criteria.

1.2.4 Design-Build-Finance-Operate

In a Design-Build-Finance-Operate strategy, also known as Build-Operate-Transfer (BOT), a single Producer is responsible of the design, construction, financing, operation, and maintenance of the facility. The Client's only tasks are initial planning and the establishment of the project's design criteria. It is important not to confuse DBFO with DBO. The main difference between them is that the public sector or Client never provides finance for DBFO, partially or wholly. As a result, DBFO corresponds to Quadrant II. The transfer of the facility at the end of the franchise lease back to the government requires a nominal charge, and must comply with the conditions set in the franchise agreement.

1.2.5 Pure Operations and Maintenance

Pure Operations and Maintenance delivery methods are only used if another delivery method that does not include the functions of operation and maintenance is used as well, such as Design-Build and Design-Bid-Build. In a Pure O&M strategy, thus, the Client procures only maintenance and operation services.

1.3 Toll road infrastructure

Toll-bridge facilities are more popular among private sector companies than urban-rail transit facilities. The main reason for this is that the financial incentives associated with toll bridges are greater. If the Producer is responsible of operating and maintaining the bridge, it will probably be able to obtain revenues from the toll fares collected. However, the Client, in writing the services contract, could stipulate how much of the money collected in fares the Producer can receive as revenue. Private sector involvement may also be hindered by the uncertain ridership of the bridge, and its high costs. Thus, it is a negotiating issue between the Client, or government agency, and the Producer, or private sector company. It is this type of negotiating that current governments are trying to promote.

The 1998 World Bank technical paper Commercial Management and Financing of Roads reported that public main road agencies are increasingly becoming involved in constructing and operating high-grade expressways and public toll roads (refer to Table 1.1). And so, a growing number of countries are questioning which roads can be realistically managed by the private sector and whether the remaining public sector roads can be managed in a more commercial manner. As opposed to the management of the trunk road network, which tends to be managed by a public-private board, managing toll roads is less defined. Some toll roads are managed directly by a set up main road agency; others are managed by the private sector under a management contract with the main road agency; others are managed through an autonomous road toll agency, and still others are owned and operated by the private sector under a DBFO or BOT contract (refer to Table 1.2).

Table 1.1 The importance of toll roads in overall road management (World Bank, 1998)

	Toll Roads		
	Publicly Managed	Privately Managed	Privately Owned
Argentina	0	9,800	0
France	5,562	0	743
Hungary	0	0	57
Indonesia	280	0	150
Italy	0	5,550	0
Japan	8,723	0	0
Korea, Rep. Of	1,840	0	40
Malaysia	0	0	1,010
Mexico	2,507	3,176	0
South Africa	0	672	153
Spain	0	0	2,023

Table 1.2 Countries with autonomous or semi-autonomous main road and toll road agencies, 1998 (World Bank, 1998)

Established	*Being established*	*Under consideration*	*For toll roads only* [a]
Australia [b]	Lesotho	Kenya	China
Colombia	Malawi	Lebanon	France
Finland	Mozambique	Peru	Indonesia
Georgia	Namibia	Philippines	Italy
Ghana	Nigeria	Romania	Japan
India	Zambia	Tanzania	Korea, Rep. Of
Ireland		Uganda	Malaysia
Latvia		Zimbabwe	Spain
New Zealand			Thailand
Sierra Leone			
South Africa [c]			
Spain [d]			
Sweden			
United Kingdom [e]			
Yemen			

Legend:

a. Both public and private toll road agencies.
b. Some states have established semi-autonomous highway authorities
c. To be established as of end-March 1998.
d. Some regions only (for example, Andalucía).
e. Highways Agency in England.

1.4 Urban-rail transit infrastructure

Urban-rail transit facilities provide a social service to the general population of a city or region, and as such governments should thus take upon their delivery completion responsibly. The services they provide benefit society in many ways, like the following:

- High carrying capacity
- Low emission levels
- Low requirements of urban space
- High average speeds
- Low per unit operating cost (Agarwal, 1998)

Rail transit systems, however, are extremely expensive, and so, even though they are primarily funded by the public sector, government is trying to increase the private sector's involvement in them, as is the case with the Tren Urbano project in San Juan, Puerto Rico. In this case a DBO procurement has been selected as the project's delivery method. However, the private sector generally does not find the high costs, long gestation period, and uncertain ridership very attractive for investment. It is estimated that a rail-based transit facility earns less than 40% of its operating revenues from fares (Zarrilli, 1999). Another influential element is that the construction of a facility of this type takes a long time. These elements can be seen in Table 1.3, which shows several other urban rail transit project in the U.S., their costs in 1998 dollars, and the years it took to complete each of them.

Table 1.3 Urban-rail transit facilities in the U.S. (Agarwal, 1998)

Project	Description	Cost ($ Million)	Years to Complete
Washington	Heavy rail, 60.5 line miles, 57 stations	7968	14
Atlanta	Heavy rail, 26.8 line miles, 26 stations	2720	9
Baltimore	Heavy rail, 7.6 line miles, 9 stations	1289	9
Miami	Heavy rail, 21 line miles, 20 stations	1341	6
Buffalo	Light rail, 6.4 line miles, 14 stations	722	7
Pittsburgh	Light rail, 10.5 line miles, 13 stations	622	7
Portland	Light rail, 15.1 line miles, 24 stations	266	5
Sacramento	Light rail, 18.3 line miles, 28 stations	188	4

Another point worth mentioning is that, in general, capital budgets are separated from O&M budgets. Capital projects (i.e. new construction, replacements) are usually the projects more sought after by the government, and are, therefore, the ones into which more money is allocated. The government, however, typically ignores maintenance projects, and so, they usually lack the funding necessary to be completed. Hence, replace is preferred to repair. (Zarrilli, 1999).

1.5 Thesis objective

The purpose of this thesis is to provide Prof. John B. Miller with a couple of case studies for him to use as reference in his class Construction Project Delivery Systems. These case studies will provide him with relevant information regarding the procurement processes of the Teodoro Moscoso Bridge and the Tren Urbano, both of which are located in San Juan, Puerto Rico. The analysis of each of these projects will allow for a better general understanding of the different delivery methods and financing strategies with which projects can be carried out.

Chapter 2

THE TEODORO MOSCOSO BRIDGE CASE STUDY

2.0 Background

2.0.1 Recent history of the SJMA

The San Juan Metropolitan area (SJMA) of the island of Puerto Rico is composed of 13 municipalities and covers an area of approximately 1,020 square kilometers. With a population of 1.3 million, it consists of close to 35% of the island's entire population according to the last census to date in April 1990.

Population densities in the SJMA are among the highest in the U.S. with approximately 3,230 people per square mile (Zarrilli, Daniel Adam "Infrastructure Management for Tren Urbano" Master's Thesis, MIT, 1999). The island in itself is considered to be one of the most densely populated areas in the world. Located about 2,000 miles southeast of Miami and 500 miles north of Caracas, Venezuela, PR has an area of 3,427 square miles. It has been estimated that its population growth will increase by the year 2010 by close to twenty percent (Greenberg, Paul Clark 1996). Along with its population, the need for better public transport also increased dramatically. As of 1990, 68.5% of the households in PR have at least one car. This percentage has probably increased as of today for several reasons. Domestic transport in PR has evolved into one that relies almost entirely on roads and private vehicles. The number of vehicle registrations between 1980 and 1990 increased by an incredible 56.9% to reach 1,321,627 (Agarwal, Om Prakash "Managing Privately Procured Rail Transit Systems: A Case Study of Tren Urbano", Master's Thesis, MIT, 1998). Additionally, the efficiency and quality of the highway infrastructure in the early 1990s was in decline. These two counteracting factors helped create an incredibly strenuous and congested traffic situation in the SJMA.

2.0.2 Political ambiance of PR in 1991

In the early 1990s PR's leading political parties were the Popular Democratic Party (founded in 1938), which advocates the maintenance of commonwealth status, and the New Progressive Party (1967), which advocates PR's becoming a U.S. state. The small PR Independence Party (1946) favors independence for the island. The political status of PR has been a controversial issue since the Treaty of Paris (December 10th, 1898) ceded the island to the U.S. in the aftermath of the Spanish-American War. On June 4th, 1951, and after its approval by referendum, a U.S. law granted Puerto Rican voters the right to draft their own constitution. On July 25th, 1952, Governor Luis Muñoz Marín, head of the Popular Democratic Party, proclaimed the Commonwealth of Puerto Rico. However, the attainment of commonwealth status did not halt agitation for total independence or statehood. Several status referendums and plebiscites regarding the status question were held throughout the three decades that followed; all of them reflected Puerto Ricans' indecisive resolutions towards the island's political status.

In the years between 1952 and the present, the PPD and the PNP have each taken turns controlling the island's government. During each party's four-year term in power, their respective governors tried to incessantly implement laws and policy that would favor their party's respective status ideal. In 1988, Rafael Hernández Colón, member of the PPD and strong supporter of the commonwealth status, was elected governor. During his four-year term, Hernández Colón had to deal with many difficult situations facing the San Juan Metropolitan area population, raging from political to infrastructure issues. On one side, a status plebiscite was on the way in 1991. On the other side, San Juan's transportation infrastructure problem continued to worsen. After losing the 1991 plebiscite on the status question, Hernández Colón was determined to win the people's vote in 1992 by completing as rapidly as possible several of the infrastructure projects related to transportation in the congested San Juan Metropolitan area.

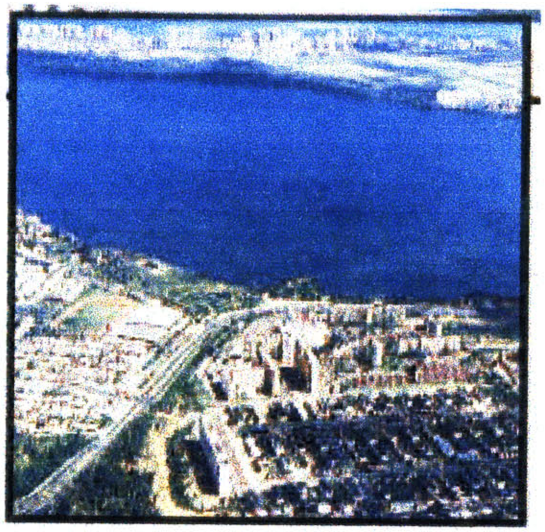
2.1 What is the problem / Project development

The government of Puerto Rico in the early 1990s was searching for a project that would, not only help them get reelected in 1992, but that would also stimulate the growing economy and the infrastructure market of the island. A way to accomplish this was by completing a new and innovative type of project. The Teodoro Moscoso Bridge would not only provide the SJMA with a modern facility, but it would also help Puerto Ricans achieve a higher quality of life, as it would allow them to save both time and money. But most importantly, the bridge would also alleviate the severe traffic congestion that occurs all around the Isla Verde and Carolina areas, especially along the Baldorioty de Castro Avenue and near the Luis Muñoz Marín Airport. It is estimated that over 100,000 drivers commute through this avenue on a daily basis. The Teodoro Moscoso Bridge would provide commuters with an alternative and more efficient route for them to get to their final destinations.

2.1.1 Development of the Teodoro Moscoso Bridge

The Teodoro Moscoso Bridge would consist of a limited-access, four -lane toll bridge facility that crosses the San José Lagoon (the "lagoon") between the municipalities of San Juan and Carolina. Refer to Figure 2.1 for a picture of the area. From the North, at the intersection of Baldorioty de Castro Avenue (PR-26) and the entrance to Luis Muñoz Marín International Airport (the "Airport") to the South in the vicinity of the Pan American Village Housing Complex on Iturregui Avenue which connects to the PR-17 (Piñero Avenue) and Trujillo Alto Expressway (PR-181). It would consist of a toll collection plaza and ancillary facilities, access roads, interchanges, overpasses, office building adjacent to the bridge and other support facilities that are necessary or incidental to the operations of a toll expressway. Refer to Table 2.1 for all toll collection costs.

Figure 2.1. Area for the proposed bridge (*provided by Autopistas of PR*)



The 2,250 meter long bridge would become the longest above water facility in Puerto Rico. It would also consist of two lanes, each with a width of 3.65 meters, plus a 3 meter wide emergency lane in each direction, separated by a New Jersey type barrier, which would make the facility equal to 24.20 meters wide. The structure would have eight lighted sections, each 23.5-meter long, sixty-five 30.10-meter long stretches up to the toll collection zone and four variably-lighted transition sections in the south ranging in length from 17 to 30.10 meters long. The toll collection zone would be located on the bridge and would consist of a total of ten lanes, six of which will be reversible to better manage vehicular movement during the worst traffic congestion times of the day.

As it can be seen, the expectations of the PRHTA and Autopistas were very high. Being the first long and ambitious over-the-water bridge project to be built on the island, PRHTA especially became concerned, not only with its technical functionality, but also with its success in attracting riders. It had to make sure that the localization and the access routes specified in the project's design were the best ones available. Hernández Colón was right in being concerned with the bridge's success for residents of the SJMA were already complaining about the high toll prices to be paid for each trip on the bridge. Toll-roads and expressways in the SJMA presently do not charge more than 70 cents, which is less than half of what each trip using the Moscoso Bridge would cost.

Table 2.1. Vehicle Toll Rates for the Teodoro Moscoso Bridge *(provided by Autopistas de PR)*

Category	Definition	Tariff (US dollars)
1	Motor-bikes	$0.75
2	Trucks and buses, passenger cars, vans, light trucks and microbuses, with 2 axles, without double tires.	$1.50
3	Trucks and buses, passenger cars, vans, light trucks and microbuses, with or without trailer, and without double tires on any axle, with 3 axles.	$3.00
4	Trucks and buses, passenger cars, vans, light trucks and microbuses, with 2 axles, with double tires.	$4.00
5	Trucks and buses, passenger cars, vans, light trucks and microbuses, with or without trailer, with 3 axles and at least one axle with double tires	$6.00
6	Trucks and buses, passenger cars, vans, light trucks and microbuses, with or without trailer, with 4 axles.	$8.00
7	Trucks and buses, passenger cars, vans, light trucks and microbuses, with or without trailer, with 5 axles.	$10.00
8	Trucks and buses, passenger cars, vans, light trucks and microbuses, with without trailer, with 6 axles or more.	$12.00

Thus, issues concerning the financial success of the bridge, while securing a just rate for riders in the SJMA were very much in the minds of the PPD government planning the project.

2.1.2 Concessionary Agreement Preparation

The Puerto Rico Highway and Transportation Authority (PRHTA) selected Autopistas de Puerto Rico and Company, S.E. (Autopistas) through an international qualification and presentation to offers process in June 1990. Autopistas was a partnership composed of Dragados y Construcciones, S.A. (74.25%), Rexach Construction Company, Inc. (4.75%), Supra and Company, S.E. (20%), and Autopistas Corporation (1%). PRHTA decided to retain a private consortium of engineering management, and economic consultants to help select the candidate who would carry out the project. It also retained Vollmer Associates to perform the traffic study used to estimate toll revenues and define the financial structure for the project.

Among the responsibilities PRHTA decided to take upon itself when writing the agreement were:

- Preparing the preliminary design,
- Obtaining the right of way acquisition
- Preparing the environmental impact statement

- Obtaining the permits from the Department of Natural

Resources, the Corps of Engineers, and the Federal Aviation Administration PRHTA had to take into account the risks they were taking when getting involved in this project. Some of these risks were changes in law, force majeure, construction of competing facilities, lower than expected traffic volume, and changes in political party control.

The main responsibilities that Autopistas had to assume were:

- Final design,
- Construction,
- Guarantee of completion, and
- Maintenance of the required insurance

Additionally, Autopistas was also facing risks associated with the project's final design and construction. However, PRHTA argued that this risk could be compensated by its return from the toll revenue. On the other hand, since the traffic volume risk is covered during the first ten years of operation, Autopistas return is limited through the sharing of profits with PRHTA.

Autopistas' concession agreement allows it to terminate such an agreement if the traffic volume does not materialize as forecasted by Vollmer and Associates. In such a case, PRHTA takes over the concession, the outstanding debt, and pays Autopistas a 12.5% before tax IRR on its investment. On the other hand, if the agreement is not terminated, Autopistas is entitled to a Base Return of 19% after tax IRR on its investment. It will receive all net income until it has received a 19% IRR. Afterwards, Autopistas will share the benefits 60/40 with PRHTA (60% to Autopistas) from the excess revenues until it reached a 22% after tax IRR on its investment. Any excess income after Autopistas has achieved such 22% IRR, Autopistas will share 15/85 with PRHTA (15%to Autopistas).

2.2 Tasks

As the Secretary of the Department of Transportation and Public Works Secretary for Governor Rafael Hernández Colón, I have been given the task of figuring out a final, efficient and effective proposal that will deal with all of the important issues surrounding the project. For example, the financial implications, the Governor's strong interest in a fast-completion of the project, and the general attractiveness of the project, such that ridership can be guaranteed to some extent. Finally, but certainly not least in importance, I cannot forget about how my job depends on the Governor's reelection. Thus, this project has become very important to me, not only professionally, but also personally.

As my assistant please help me resolve these issues once and for all by answering the following questions:

1 Prepare a cash flow analysis for the project, which allows the effect of changes in toll rates, fluctuation in ridership, change in delivery schedule, and change in development costs to be considered. Use the appendices provided for useful information.

2 How would you set up the cash-flow analysis such that a just initial/annual fee is established?

3 Based on your analysis, which of the delivery methods are viable?

4 Which delivery method could help Governor Hernández Colón complete or guarantee the completion of the bridge by the end of his four-year term?

5 Does it make any difference the fact that he might or might not want the government to aid financially?

6 How does helping the concessionary, Autopistas, financially with an annual fee/payment affect the government and the concessionary?

7 How would you set up the cash-flow analysis such that a just initial/annual fee is established? Use the appendices provided for useful information.

8 Considering the political pressures that arise every time, elections are around the corner in Puerto Rico, would you recommend extending the concessionary contract to one that consists of a long term involvement, i.e. an operations and maintenance agreement?

9 In the case where an O+M agreement is reached, for how long should the contract lease be?

2.3 Recommendations

Selecting a delivery method for a project of great importance is no easy task, and so the public entity must seriously evaluate all of the factors surrounding it before making a final decision as to how the project will be procured. The choices for delivery method range from those that provide with segmented functions and those with combined functions (refer to section 1.2). For the Teodoro Moscoso Bridge case, it is imperative that the government first determine what its priorities are for the project. According to Miller, one of the most important components of a well-procured project is a defined scope. By clearly defining the scope of the project before making any final decisions about its procurement, the government simplifies the procurement process to a great extent. After defining the scope of the project, the government will know with certainty what it wishes to accomplish, as well as what it wishes to obtain from the Producers who are writing proposals to compete for the project. In this respect, the Producers are also benefiting. A defined scope permits Producers to know what the government is expecting from them in the competition process, as well as when it is time to carry out the project. By knowing these details before to submitting a Request for Proposal (RFP), each Proposer will be able to determine whether it really wants to compete for a particular project and what it wants to include in its RFP if it decides to compete. These can save them a lot of money. Thus, defining the scope of the project does not only benefit the Client in the long term, but it will also benefit the Producers submitting an RFP, but primarily that one which ends up carrying out the project, since the government would have clearly specified what it expects him to do.

Once the government clearly knows what it needs, it will be easier for it to decide how it wishes these needs to be met. How the government wants these needs to be met is related primarily to how urgent the project is, how the government wants to finance it, and how much of the project the government wants to control directly. These three aspects of the procurement strategy, in turn, relate directly to the Quadrant framework mentioned in Chapter 1. In the Teodoro Moscoso Bridge case timing is one of the top priorities. The government, therefore, should analyze and determine what the advantages and disadvantages of each of the delivery methods available are in order to select the one they think will complete the project the fastest. The same occurs with the project's financing. Generally, Design-Build-Finance-Operate and Design-Build-Operate are both more fast-paced than Design-Build. Design-Build is in turn more fast-paced than Design-Bid-Build. The main reason for this is that, combined delivery methods, the information exchange among the distinct functions of the procurement (design, construction and operation) is much faster when design is integrated with construction, and even faster when design and construction are integrated with operations and maintenance (Miller, 1999). Additionally, in a DBO or DBFO project, because the Producer is obtaining a 'lease' for the facility in question, it is in its best interest to complete the construction phase of the facility and begin its operation as quickly as possible, such that the Producer can obtain the revenues from the facility's operation rapidly. A well defined scope will with no doubt permit a Client, in this case the government, to make such distinctions among the delivery methods and hence, choose the one most favorable for the situation. In this case, where timing is the top priority, the government can rule out DB and DBB as alternatives. DBO and DBFO are the only left alternatives. The difference between them, as mentioned in Chapter 1, is whether the government contributes financially to the completion of the project. Contributing monetarily to the project can accelerate the pace of the project, and thus, it would be beneficial for the government to provide all if not all of the funding necessary.

Another issue influencing the government's decision to provide funding is the risk associated with the procurement of the project. The more risk involved with the project, the less Producers will want to get involved with it, and the more involved the Client will have to get if it really needs the project to be completed. The government can do this in one of two ways. One way is by partially or completely funding the project, as mentioned above. The other way is by providing a financial incentive to the Producer. Financial incentives can be provided in several ways. The government could subsidize part of the expenses each of the Producers incurs in arranging the RFP. The government could also provide an annuity to the selected Producer effective once the Producer begins the operations phase. In this case, the government would be in some sense paying the Producer for operating and maintaining the facility. This last option seems the more reasonable of the two. It is more efficient to provide the incentive to the Producer that is in fact constructing and operating the facility, and not to all of the Producers during the competition process. This could end up being a waste of money and effort.

Providing incentives at the operation level, however, depends on who is chosen to operate and maintain the facility. It makes sense to provide one if a DBO or a DBFO method is used. If does not make sense to provide one, however, if the government decides to run the facility or if a Pure O&M method is used since the majority of the risk for which the incentive is provided takes place during design and construction, and so, only Producers providing combined delivery methods of design, construction and O&M would benefit from the incentive. Hence, deciding who will provide O&M services is another important element in the procurement process a Client must figure out in advance.

Another very important tool that both a Client and a Producer can utilize in order to better assess their financial positions for a project is a cash flow analysis. Although each one would be using the cash flow results in different ways, a sound analysis of the cash flow is necessary in order for each of them to rationally make final decisions in regards to delivery choices. A cash flow analysis should consist of an evaluation of costs or expenses against profits or revenues, as well as an evaluation of the resulting net present value (NPV), for each of the quarters or periods when they actually take place (Miller, 1999). Costs or expenses typically include those associated with planning, design, construction and financing costs, which usually includes debt service. Profits, on the other hand, should include all appropriations and grants provided by the government, all private investments, and all operating revenues. The analysis should also include opportunity costs, that is, those expenses and revenues that are to be expected in the future if the project is carried out. The analysis, however, should not take into account sunk costs, i.e. those costs incurred in the past, prior to the project in question. As part of the cash flow analysis, a sensitivity analysis is also very helpful in assessing how changes in some of the analysis' control variables affect the NPV. In the case of the Teodoro Moscoso Bridge, a sensitivity analysis should be done that showed how variations of the discount rate, toll rate, number of vehicles, construction costs, and O&M costs influence the resulting net present value.

Other external issues should also be taken seriously in the procurement process. In the Teodoro Moscoso Bridge case, political pressures are of great importance because of the grave consequences they are associated with in island of Puerto Rico. Big projects in the island tend to generate great controversy and are bound to be severely criticized, and even dismissed completely simply because of differences among the existing political parties. This is even greater during electoral seasons. Therefore, timing is even more precious. The soonest a project can be completed the better.

2.4 Project Update

The construction of the bridge was performed using the Fast Track Method on a cost plus fee basis (see Figure 2.2). Nevertheless, Autopistas guarantied a maximum price of $83,000,000 adjusted for inflation and changes in scope. The construction was expected to last 2 years and was completed 2 months ahead of schedule and with budget savings of $6,934,823. The bridge was open to traffic on February 23. 1994(see Figure 2.3).

Ridership during the first years of operations fell short of those anticipated by the traffic study performed by Vollmer and Autopistas. However, traffic for the last two years has increased significantly. Some causes for the initial traffic short fall have been identified by Autopistas as the following:

- Access roads to the bridge not completed
- Bottlenecks in parts of the adjacent road network
- Inadequate signage
- The perception that the tariff is high
- The lack of an adequate marketing plan

Autopistas, however, is taking action against these causes with the aid of the more flexible private sector. The PRHTA has several projects in different stages of development in order to improve the nearby access road network, thus eliminating the bottlenecks. At present, Piñero Avenue is being converted into a semi expressway and the daily traffic congestion existing therein is expected to be gone by the end of the year. Also, new and more effective signs are being installed throughout the area, and more studies are being conducted in order to evaluate the tariffs, through specific pricing experiments.

Figure 2.2. Construction of the Teodoro Moscoso Bridge ***(provided by Autopistas de PR)***

Figure 2.3. The Completed Teodoro Moscoso Bridge ***(provided by Autopistas de PR)***

Chapter 3

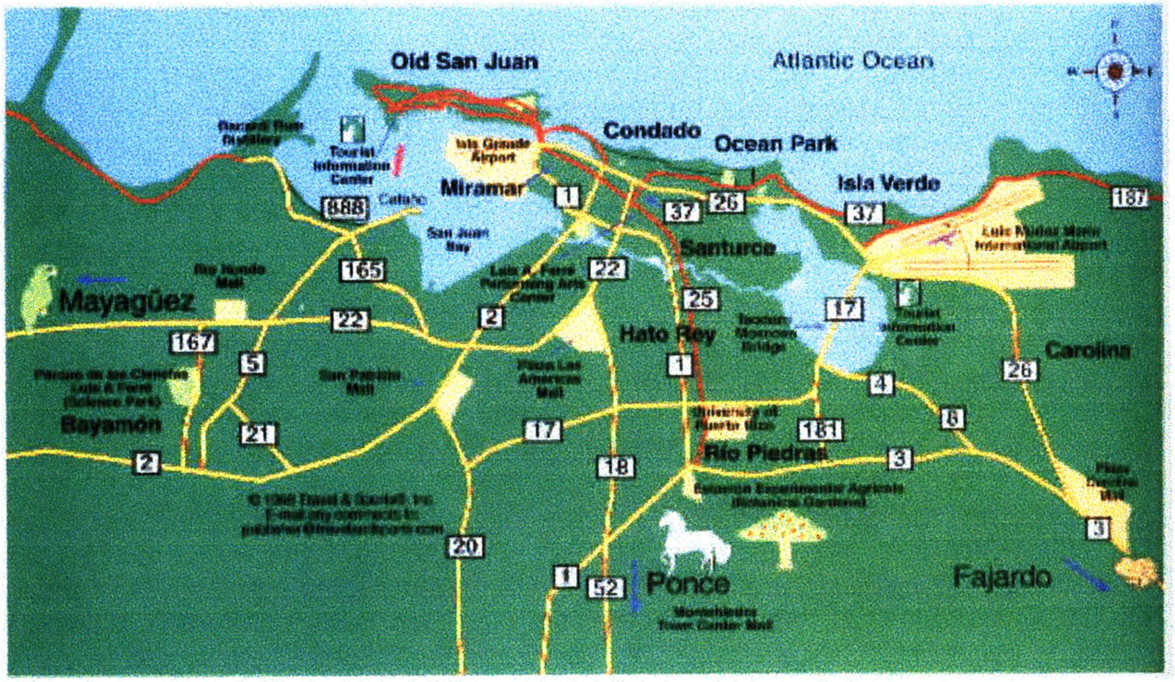
THE TREN URBANO CASE STUDY

3.0 Background

3.0.1 Overview of the SJMA

With increasing population and vehicle registration growth, the San Juan Metropolitan Area (SJMA) is in desperate need for a way to alleviate its severe traffic congestion (see Figure 3.1). The island of Puerto Rico, with an area of about 3500 square miles and a population of 3.7 million people, is considered to be one of the most densely populated regions in the world. The SJMA in itself accounts for about 37% of the total island population with close to 1.3 million people. To make the situation even worse, not only is there a heavy dependence upon private transportation as the primary means of transportation, but the population growth is also expected to increase by 20% by the year 2010.

Figure 3.1. The San Juan Metropolitan Area (Department of Transportation and Public Works website)



Along with an increase in population, the SJMA has suffered an exorbitant increase in vehicle registration of 56.9%, between 1980-1990 reaching 1,321,627 vehicles. In 1990, it was estimated that more than 90% of all work related trips were made in personal automobiles. As a result, mornings and evenings are times of extreme traffic congestion in the SJMA. The ratio between car and mile of paved road is the highest in the world at 146. The SJMA is believed to have 4,286 cars per square mile. The situation is made even worse by the low quality and efficacy of the road and highway infrastructure on the island. Less than a quarter of all major streets have four or more lanes. It was estimated in 1990 that close to 50% of all directional lanes were congested during rush hours.

The SJMA is composed of 12 municipalities. They are: Bayamón, Caguas, Canóvanas, Carolina, Cataño, Dorado, Guaynabo, Loíza, Río Grande, San Juan, Toa Alta, and Trujillo Alto. The region is about 400 square miles in area with a population density of 3,230 people per square mile. Its development can be viewed on two axes. One runs out from North to South in the city of San Juan, from Old San Juan to Rio Piedras through Santurce and Hato Rey. The second axis runs from east to west, from Carolina to Bayamón, through Torrimar, Villa Nevárez and the Centro Médico. It is within these three municipalities; San Juan, Carolina, and Bayamón that 60% of the region's population reside, and that 83% of the regional jobs are found (Dietrich, Matthew C. 1998).

These two problems, heavy reliance on private automobiles and increasing population growth rates, have led the government of Puerto Rico to seek new ideas and ways to ameliorate the public transportation problem of the SJMA.

3.0.2 Political Ambience

As with any other project in PR, the Tren Urbano was bound to become the focal point on politicians' agendas since its conception. Although the need for a rail-based system in the SJMA that could alleviate the critical traffic situation in the area was on the agenda of many governors for many years, the Tren Urbano project was not materialized for along time in part for political reasons (Dieterich, Matthew 1998). The island possesses a long-lasting and unresolved political status dilemma.

There are three political parties, two of which represent the majority of Puerto Rican voters. These are the New Progressive Party (PNP) and the Popular Democratic Party (PPD). The third party, the Puerto Rican Independence Party (PIP) represents a small percentage of the population. Whenever election time approaches, the PPD and the PNP fight, not only for its respective gubernatorial candidate to be elected, but also for its status resolution to be embraced by more people. Hence, any decision made or project developed by one of the prominent parties could be harshly criticized, if not completely halted, by the opposing party.

At the end of Pedro Roselló's first four-year term (1992-1996), he and his administration became concerned that the opposition would discredit and end up eliminating the Tren Urbano project from the agenda if the latter won the approaching elections. Roselló felt it was imperative for his administration to award as many construction contracts as possible before the next election. As a result, timing of the design and contractor selection became critical to the overall success of the project. The preliminary schedule decided upon expected construction to begin in mid 1996, after the certification of the Final

Environmental Impact Statement and the Record of Decision were obtained (Dieterich, Matthew 1998).

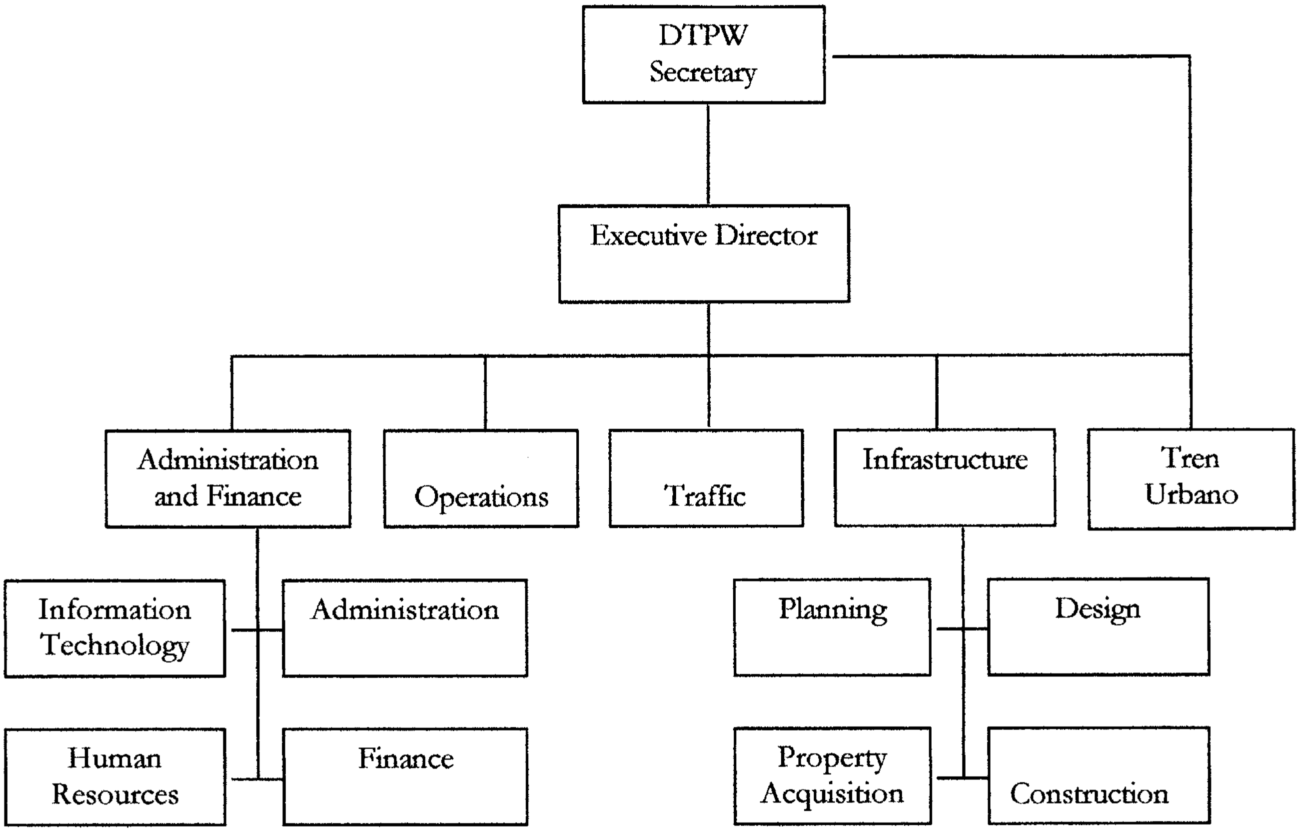
3.0.3 Public Transportation in the SJMA

Public transportation in the SJMA consists of bus routes. Three different types of bus services provide these services. Two of these services are operated on a "fixed-route" basis, while the third one is operated by Públicos.

The fixed route bus services are operated in two ways. One is a publicly run service operated by AMA, and the other one is provided by a privately contracted company, Metrobus, contracted by the Puerto Rico Highway Authority (PRHTA), an autonomous public corporation created in 1965 that later attached to the Department of Transportation and Public Works in 1971. The Secretary of this Department is in charge of designating the Executive Director of the Authority. The PRHTA is divided into four subdivisions that are Infrastructure, Finance & Administration, Traffic, and Operations. Refer to Figure 3.2 for an organization chart of the PRHTA.

AMA services are generally described as very unreliable. AMA operates 43 routes in the central part of the SJMA, using 159 full-sized buses. These routes generally tend to aim for wider coverage, such that small roads are not operated. Additionally, buses are not particularly run frequently and even have a reputation of not meeting their schedules. The current fair per trip is 25 cents.

Figure 3.2. PRHTA Organization



On the other hand, the Metrobus service has somewhat of a better reputation. It consists of two routes that serve high demand corridors with frequent and reliable service. One route operates mainly on a reserved contra flow bus lane along one of the most congested traffic sections of the SJMA (Rio Piedras -Hato Rey - Santurce - Old San Juan). The second route operates partially along the first route, but eventually branches off to run to Bayamón. The current fair per trip for both of those routes is 50 cents.

Jitneys called Públicos provide the third type of bus service operating in the SJMA. These are regulated and privately operated vans that generally follow fixed routes, but are free to deviate from them in order to let out passengers whenever they indicate so to the driver. They do not necessarily follow any fixed schedule, and most of them stop running at 6 PM. Although the PRHTA is responsible for Públicos planning, its public oversight is fragmented. The Public Service Commission (DTOP) is in charge of operator and vehicle licensing and the regulation of the location and design of terminals and stops along the right of way of the state roads. In spite of the Públicos' success in ridership, concerns have begun to spread due to the lack of formal regulations and enforcement on safety and maintenance of the Públicos vans (Agarwal, Om Prakash, 1998)

3.1 What is the problem / Project development

3.1.1 Phase I

Phase I construction began in 1996. Its completion, as well as the beginning of operations is scheduled for late 2001. It will provide service to the congested SJMA, from Bayamón to Santurce, through a 17 km line consisting of 16 stations serving major commercial and residential areas of Bayamón, Guaynabo and San Juan.

The Tren Urbano Office was responsible of, not only managing the overall development of the project, but also of up to 30% of the conceptual and preliminary design of the system. It was also responsible of scheduling, budgeting, contract administration, and quality assurance. The total estimated construction cost of this the Phase I of the Tren Urbano is $1,200 million.

A Design-Build approach was used as the procurement strategy for the project, with direct finance from PRHTA. The project was then divided into seven different Alignment Section contracts, which are described in Table 3.1.

Table 3.1. Alignment Section Contracts (*Almodóvar, Israel, M.S. 1997*)

Segment	Distance	Stations	Cost	Consortium
Bayamón	2.9 km	Bayamón Centro Complejo Deportivo	$68 M	Grupo Metro San Juan
Río Bayamón	1.7 km	Río Bayamon	$37 M	Redondo-Entrecanales
Torrimar / Las Lomas	2.6 km	Torrimar Las Lomas	$544 M	Siemens Transit Team
Centro Medico	2.5 km	San Alfonso De Diego Centro Medico	$72 M	Redondo-Entrecanales
Villa Nevárez	1.9 km	Villa Nevárez	$72 M	Redondo-Entrecanales
Río Piedras	1.8 km	Río Piedras UPR	$226 M	Grupo Kiewit
Hato Rey	3.6 km	Centro Judicial Doménech Hato Rey Centro Nuevo Centro Sagrado Corazón	$117 M	Necso-Redondo

The reason for this division was to permit the participation of local contractors into this project. Six of the contracts, Bayamón, Río Bayamón, Centro Médico, Villa Névarez, Río Piedras, and Hato Rey are pure Design-Build projects. Contractors for these sections are only responsible for the civil work of the respective stations and guide ways. The seventh contract, known as the STTT, includes the construction of the Torrimar and Las Lomas stations. It also includes the following:

- Procurement and installation of all systems of the project,

- The design and manufacturing of the vehicles,
- The design and construction of the test tracks,
- The maintenance and storage yard,
- The operations and maintenance of the system for five years, with an option for a five-year extension, and
- The coordination of the design and construction with the other six civil contracts.

These responsibilities were contracted to a partnership of Siemens Transportation Partnership, Alternate Concepts, and Juan A. Requena and Associates. In contrast, the main provisions of the contract for operations and maintenance services between PRHTA and Siemens Transportation Partnership are summarized in the following list:

- Responsibility for the maintenance of the system rests with Siemens. However, the cost of all such maintenance in excess of $25,000 per item will be reimbursed by PRHTA, except if the needed repairs are due to any negligence or fault of Siemens, in which case no reimbursement would be made.
- The PRHTA would be responsible for setting the level and hours of service, the performance standards, and fares. It can require changes in the level of service with appropriate adjustments in the compensation payable.

- Fares are to be set by the PRHTA and would accrue to PRHTA. However, they are to be collected by Siemens. The amount collected would be set off against the annual compensation payable to them.

- Siemens has to submit monthly reports on the operations that would indicate the level of performance achieved.

- Siemens is required to maintain an ongoing training program for the entire O&M period to ensure adequate training and testing of new employees. They are also required to implement a prescribed technology transfer program during this period that would consist of an university program, and employee mentorship program, and a peer partnership program.

- There is a provision for an elaborate Management Information and Decision Support System (MIDSS) to be developed by Siemens, to generate the required monthly and daily reports that can be used for monitoring and service planning.

- Siemens would be responsible for security and the provision of security personnel. PRHTA will arrange for a public police force, with powers of arrest, to patrol the stations and /or trains for additional protection for patrons. Siemens is also responsible for public relations with the communities served by the project.

During the first year of operation, the operations and maintenance costs of this first phase are estimated to be close to $47.7 million. The annual increase is expected to be roughly of 5%. Table 3.2 shows the inflation linked base compensation fees to be paid to Siemens for operating the system. The TUO expects to gain about 40% of these costs as fare box collection. This is according to an average daily ridership by the year 2010 of 115,000 passengers. The initial ridership is expected to be about 64% of the total foreseen for the year 2010.

As for the project financing, PRHTA has a full funding grant from the Federal Transit Administration, which amount to close to $400 million, or a third of the total project cost. The rest of the costs will be handled through bond issues, PRHTA budget, and other federal formula programs. The fact that the Tren Urbano project is one of four Turnkey Demonstration projects of the Federal Transit Administration facilitates the funding coming from the federal government.

For reference a map of the Phase I alignment is shown in Figure 3.3.

Table 3.2 Compensation fees payable to Siemens for operating the system

(Agarwal, 1999)

Service Year	Labor	Materials	Total
1	$20,773,059	$6,587,868	$27,360,927
2	$20,400,892	$7,449,680	$27,850,572
3	$20,790,754	$8,708,461	$29,499,215
4	$20,763,915	$8,594,502	$29,358,417
5	$20,874,054	$8,902,069	$29,776,123
6	$22,354,361	$10,284,579	$32,638,940
7	$22,504,204	$10,680,818	$33,135,022
8	$22,764,833	$10,342,845	$33,107,678
9	$23,076,306	$10,790,129	$33,866,435
10	$23,395,136	$11,003,803	$34,398,939

Performance standards have been set with regard to the following:

- On time performance
- Vehicle preventive maintenance
- Facilities maintenance
- Train air conditioning
- Exterior and interior cleaning of trains
- Cleaning of stations
- Customer service response quality

Figure 3.3. Phase I Alignment Line ***(provided by the DTPW website)***

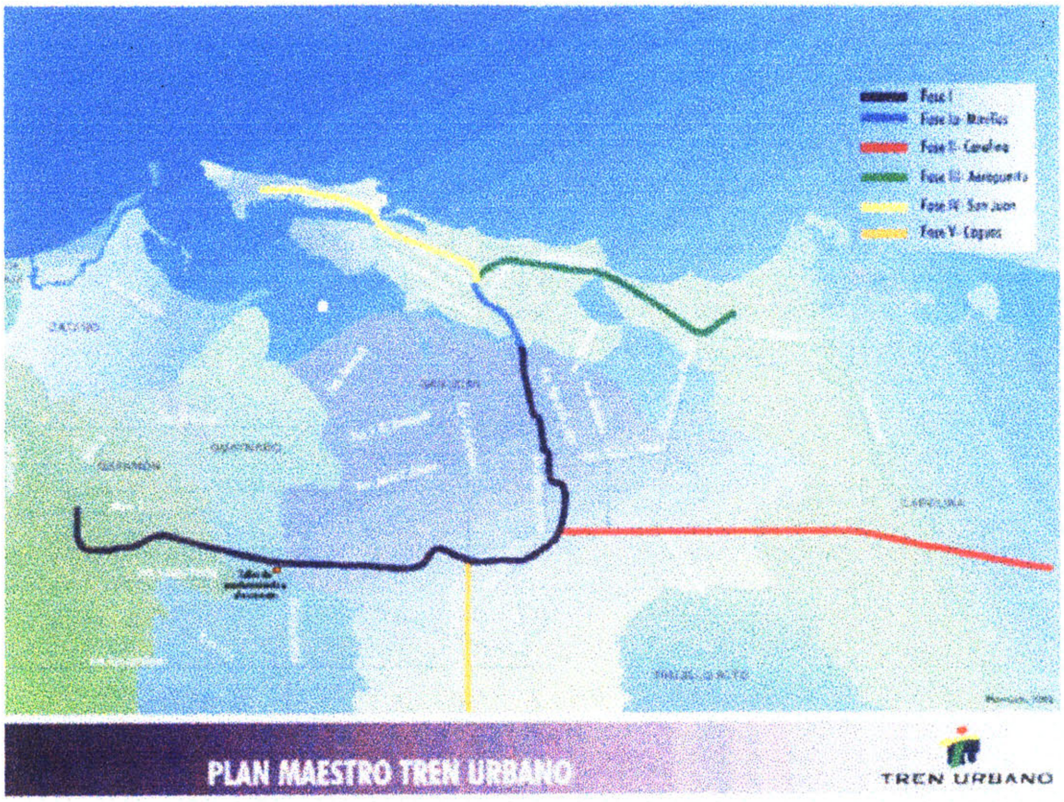
3.1.2 Other Extensions

Phase I of the Tren Urbano is only the first phase of a series of phases that comprise what PRHTA has called the Master Plan, which includes future extensions to other major commercial and congested areas. A map showing the three next phases for the Tren Urbano is provided in Figure 3.3. Phase II will provide services to the municipality of Carolina. Phase III will extend to Old San Juan area. Phase IV will reach the Luis Muñoz Marín International Airport, as well as the zones of Isla Verde and El Condado. Service to the town of Caguas is currently under thoughtfulness.

For the purposes of this case study, the timeframe of the construction of phases II, III and IV has yet to be established by the TUO.

The cost estimates for the project's extensions are based on the actual costs of Phase I, contained in each of the Alignment Section Contracts.

Figure 3.4. Master Plan Alignment Line Map ***(provided by the DTPW website)***



The unit costs were divided into four categories shown in Table 3.3, which are stations, guide way, systems and operations and maintenance. Additionally, the extensions' cost estimates include capital, operations and maintenance, contingency, engineering and construction management, and bond and insurance fees.

Table 3.3. Unit Costs of TU Phase I *(Almodóvar, Israel, M.S. 1997)*

	Item	Cost ($) / Unit	Unit
Stations			
	Above Grade	$13,206,313	Each
	Below Grade	$8,352,540	Each
	Underground	50,371,523	Each
Guide way			
	Above Grade	$18,224,809	$/km
	At Grade	$10,291,629	$/km
	Below Grade (ret. Cut)	$32,757,981	$/km
	Below Grade (tunnel)	$69,472,756	$/km
Systems			
	Vehicles	$2,854,411	Each
	Train Control	$6,607,367	$/km
	Communication	$816,459	$/km
	Power Supply	$2,725,498	$/km
	Track work	$3,288,886	$/km
	O&M Preparation	$19,143,998	$/makt*
Other Major Items			
	Engineering and CM	9.5% of total	
	Bond and Insurance	3% of total	
	Contingency	11% of total	
Operations and Maintenance			
	Annual Costs	$7,666,595	$/makt*

*Makt = million of annual kilometers traveled

3.1.2.2 The Carolina Extension

The Carolina extension, or Phase II, will consist of nine stations:

- Carolina Centro (above grade)
- Roberto Clemente (above grade)
- Plaza Carolina (above grade)
- Colegio Regional
- PR – 8 (above grade)
- Country Club (above grade)
- Simon Madera (above grade)
- Degetau (above grade)
- San Antonio (above grade)

Phase II will have an approximate length of 11 kilometers. It will run from the Carolina Town Center to Rio Piedras, where it will be connected to Phase I by two tunnels that are already in construction. These tunnels were included as part of the Rio Piedras Alignment Section Contract of the Bayamon Line. As seen from Table 3.4, the estimated capital cost of Phase II to Carolina is $963 million, with an annual O&M cost of $26 million (1997 dollars).

Table 3.4. Cost Estimate for the Carolina Extension (*Almodóvar, Israel, M.S. 1997*)

	Item	Estimated Cost ($)
Stations		
	San Antonio Station	17,000,000
	Degetau Station	17,000,000
	Simon Madera Station	17,000,000
	Country Club Station	17,000,000
	PR-8 Station	17,000,000
	Colegio Regional Station	17,000,000
	Plaza Carolina Station	17,000,000
	Roberto Clemente Station	17,000,000
	Carolina Centro Station	17,000,000
Guide way		
	Above Grade	262,000,000
Systems		
	Vehicles	269,000,000
	Train Control	95,000,000
	Communication	12,000,000
	Power Supply	39,000,000
	Track work	47,000,000
	O&M Preparation	84,000,000
O&M		
	Annual	26,000,000

Table 3.5, on the other hand, shows how different delivery methods affect the construction cost, the construction duration, and how soon the O&M period can begin of Phase II (Almodóvar, 1999). This model was done using a modeling tool designed at MIT in the early 1990s by the Department of Civil and Environmental Engineering called CHOICES©MIT 1998. The planning and duration times are based on a 16-quarter construction project.

Table 3.5. Effect of Delivery Method in the Carolina Extension (*Almodóvar, Israel, M.S. 1997*)

	Item	Design-Bid-Build	Design-Build	Design-Build-Operate
Cost ($ Million)				
	Construction Cost	1,119.9	979.4	920.9
Time (Quarters after 2000)				
	Planning time	16	15	11
	Construction Start	17	17	17
	Construction Time	16	13	13
	Begin O&M	32	29	29

3.1.2.3 The Old San Juan Extension

Old San Juan is the most important tourist and government center in Puerto Rico. It is also the location of the San Juan Harbor, on of the most important cruise ship harbor in the hemisphere. The extension at Old San Juan, or Phase III, will run from the San Juan Harbor to the Minillas tunnel and will have an approximate length of 4 kilometers. It will consist of 4 stations, as follows:

- Old San Juan (at grade)
- Capitolio Sur (at grade)
- San Agustín (at grade)
- San Antonio (underground)

Once the Tren Urbano is fully operational, the Old San Juan station will be one of the most important due to heavy ridership expected, not only by local commuters, but also by tourists that travel to the area. The cost estimate for Phase III is $390,000,000 (1997 dollars). The annual operations and maintenance costs are expected to be $9,000,000 per year (see Table 3.6).

Table 3.6. Cost Estimate for Old San Juan Extension (*Almodóvar, Israel, M.S. 1997*)

	Item	Estimated Cost ($)
Stations		
	Old San Juan Station	11,000,000
	Capitolio Sur Station	1,000,000
	San Agustin Station	11,000,000
	San Antonio Station	66,000,000
Guide way		
	At Grade Guide way	40,000,000
	Underground Guide way	91,000,000
Systems		
	Vehicles	60,000,000
	Train Control	34,000,000
	Communication	4,000,000

	Power Supply	14,000,000
	Track work	17,000,000
	O&M Preparation	30,000,000
O&M		
	Annual	9,000,000

As with the previous section, Table 3.7 shows the results of the CHOICES ©MIT 1998 model on the effect of delivery method on construction cost, planning time, construction time, and how soon O&M services can be provided (Almodóvar, 1999).

Table 3.7. Effect of Delivery Method in the Old San Juan Extension (*Almodóvar, Israel, M.S. 1997*)

	Item	**Design-Bid-Build**	**Design-Build**	**Design-Build-Operate**
Cost ($ Million)				
	Construction Cost	509.0	442.9	416.1
Time (Quarters after 2000)				
	Planning time	17	17	12
	Construction Start	35	35	35
	Construction Time	17	14	14
	Begin O&M	51	48	48

3.1.2.4 The Airport Extension

Phase IV, as of 1999, will consist of a separate line from the rest of the system that will connect with the other lines at the R.H. Todd stations. The Airport extension will have 7 stations, as follows:

- Airport (at grade)
- Villamar (above grade)
- Atlantic view (above grade)
- Llorens Torres (above grade)
- Las Flores (above grade)
- De Diego (above grade)
- Condado (above grade)

This line will be an eight-kilometer extension, mostly in an elevated structure. Due to aviation constraints, however, it will become an at grade alignment at the entrance of the airport. Phase IV will have an estimated capital cost of $563,000,000. The estimated annual O&M cost is of $19,000,000 (refer to Table 3.8).

Table 3.8. Cost Estimate for Airport Extension (*Almodóvar, Israel, M.S. 1997*)

	Items	Estimate Cost ($)
Stations		
	Condado Station	17,000,000
	De Diego Station	17,000,000
	Las Flores Station	17,000,000
	Llorens Torres Station	17,000,000
	Atlantic View Station	17,000,000
	Villamar Station	17,000,000
	Airport Station	11,000,000
Guide way		
	At Grade	13,000,000
	Above Grade	167,000,000
Systems		
	Vehicles	75,000,000
	Train Control	69,000,000
	Communication	9,000,000
	Power Supply	29,000,000
	Track work	34,000,000
	O&M Preparation	61,000,000
O&M		
	Annual	19,000,000

Finally, as with the other two phases, Phase IV's analysis of delivery methods using the CHOICES©MIT 1998 model is shown in Tale 3.9, which shows how delivery method (DB, DBB, DBO and DBFO) affects the construction cost, the planning and construction times, and how soon the O&M services will begin (Almodóvar. 1999).

Table 3.9. Effect of Delivery Method in the Airport Extension (*Almodóvar, Israel, M.S. 1997*)

	Item	Design-Bid-Build	Design-Build	Design-Build-Operate
Cost ($ Million)				
	Construction Cost	842.8	733.3	688.9
Time (Quarters after 2000)				
	Planning time	17	16	12
	Construction Start	57	57	57
	Construction Time	17	14	14
	Begin O&M	73	70	70

3.2 Tasks

It is June 2008, and the 5-year contract with Siemens to operate and maintain the Phase I line is about to end. Construction for Phase I was delayed a year and a half due to discrepancies between some of the Contractors and Siemens that took too much time to resolve. As assistant to the Secretary of Transportation and Public Works, it is my responsibility to advise the Secretary in regards to what PRHTA should do next, considering especially that Phases II, III, and IV are to be procured by the end of this 5-year period. I have set up a meeting with some of the graduate students in the MIT/University of Puerto Rico exchange group to hear what they have to say about this since they have been following all of the events regarding the Tren Urbano. I have brought with me some questions I have been struggling with to see if they can help figure out the best way to resolve this. The questions are the following:

- Which of the available delivery methods available do you think are the most viable and beneficial for the PRHTA for building Phases II – IV, and why? To answer this question use the tables provided in the previous section and ignore inflation. Also, assume the project takes 4 years to build if DBB is used, with cash flow distributions as shown in the table below. These values correspond to those calculated using the same CHOICES©MIT 1998 model as in the previous sections. Cost values are presented as percentages of the input value.

Table 3.10 Assumed costs and duration of Phases II – IV ***(Almodóvar, 1999)***

Delivery Method	Assumed Cost	O&M Cost	Planning and Design Duration (quarters)	Construction Duration (quarters)
DBB	111%	12%	1 - 16	17 - 32
DB	100%	11%	1 - 15	16 – 29
DBO	95.5%	8%	1 - 11	12 – 25
DBFO	4%	0%	1 - 11	12 - 25

- What funding scenarios should you explore?

- What toll structures (rates and volumes) are required for one or more of the extensions to be delivered in Quadrant II?

- Should PRHTA set up a new competition to decide who will operate Phase I alignment? Should they rely again on Siemens? Or, should they decide to provide the services themselves?

- For phases II, III, IV, should PRHTA consider or forget about how Phase I was procured? Is dividing the alignment contracts again a wise decision?

- With increasing costs over time, PRHTA will have to find ways to finance the higher expenses the TU extensions will bring about in the future. How could they increase their private funding?

- Was it wise waiting all these years to begin procurement process of Phases II, III, and IV? What were the advantages and disadvantages?

- Think about the possible role of Siemens in the scenarios above. Should they continue their involvement with the Tren Urbano in Phases II-IV? What should they do regarding the O&M contract of Phase I?

As an experienced graduate student in the field on Civil engineering and

Construction Management, what is your opinion regarding to the questions above?

3.3 Recommendations

At the end of O&M contract between PRHTA and Siemens Transportation Partnership, PRHTA will have to decide what to do, not only with Phase I, but also with Phases II, III, and IV, which are next in their construction list. PRHTA is able to choose from several. In regards to the O&M services of Phase I, it could renew Siemens' contract for another 5 years; it could take over the operations and maintenance; it could set up a new bidding competition for a new O&M contract with revised terms; or, it could choose to sell off the Tren Urbano system to a private company for management and operations. In order to select the one most advantageous to PRHTA, it must study all of its alternatives in depth. This necessity is enhanced because rail transit systems are new in Puerto Rico, and so there is no local capability for operating and maintaining such a system; and also, because the demand or ridership is very uncertain and projections of the demand may prove incorrect.

An extension of the contract may offer several advantages. At the time of the signing of the contract, there were hardly any private companies engaged in the operation and maintenance of rail transit systems. Siemens became involved in the operation and maintenance of the Tren Urbano primarily because PRHTA tied O&M services into the procurement of the system itself. And so, it is very probable that in five years time there will not be many more companies that will be able to compete with Siemens if they decide to re-bid. Moreover, five years seem too short a time for Siemens to build up in-house capability to operate the system. Perhaps, a longer service period would allow for a more competitive bidding process and for Siemens to become more experienced in operating and maintaining rail transit systems like the Tren Urbano.

Another alternative is the government's take over of the O&M services of the Tren Urbano. If this alternative is selected, PRHTA will have to consider all of the changes its role will have to endure. Some of these are:

- It will have to expand considerably its O&M role, despite the decrease of its monitoring role, as it will not have to determine any compensation to be paid to a private operator.

- Its workload on personnel management will go up, as the operations personnel will become part of its work force. This will mean more work in terms of recruitment, training, career planning, wage settlement, etc.

- Its workload on financial management will also go up as it will have to maintain detailed information of the finances and costs with regard to the O&M as well.

- It will have to collect fares and maintain accounts.
- Its materials management responsibilities will also increase since it has to manage all spares and undertake the work of placing orders and managing inventory.
- Its responsibilities towards providing security cover will go up.
- All other responsibilities will also increase considerably, such as public relations, marketing, public accountability, and O&M financing.
- There will no longer be a need for dispute resolution mechanisms or elaborate arbitration since the private operator is no longer involved.

In sum, while some of PRHTA's responsibilities would decrease, most of them will be considerably expanded. PRHTA would also have to think about what it will do with the Tren Urbano Office. Should it be subordinate to PRHTA, or should it become an independent Authority, directly under the DTOP? Because taking over O&M significantly increases its responsibilities, TUO would be better capable of dealing with them if it were directly under DTOP, as more financial resources would become available (Agarwal, 1999).

The third alternative consists of carrying out a new competition process that would result in a new management contract. If this alternative is selected, the role of the TUO would also be changed significantly, depending on the nature of the new contract. The new contract could involve changes in the duration of the contract, the extent of ridership or demand risk, and the reimbursement of repair costs. Reimbursement could occur on a cost plus basis or the private operator could receive an agreed amount to be paid annually. Obtaining a new contract, thus, could cause the following changes to the role of TUO:

- Its responsibilities associated with the oversight of maintenance quality comes down if the contract duration is longer than 5 years, since the operator will want to maintain the facilities in good condition so as to reduce his operating costs.

- If a high ridership/demand risk is involved for the operator, the marketing and public relations responsibilities of the TUO would decrease.

- Full reimbursement for all repairs would also decrease the monitoring responsibilities of TUO, as there is little incentive for the operator for delaying or not carrying out the maintenance. Proper maintenance would benefit the operator since it reduces his operating costs, and so TUO may not have to so intensively check maintenance quality.

In short, with a new bidding process, the responsibilities that TUO will have to continue to bear remain basically the same, as their role in the procurement process would not have changed very much.

Another alternative is providing a concession agreement to a private party. This type of agreements generally runs over a much longer period of time – of the order of 25 - 30 years. Additionally, the risks borne by the private concessionaire in this type of agreements are far greater, primarily since the government entity generally does not bear the risks associated with demand and cost. The government entity would be involved in the coordinating and strategic planning of the facilities. As for the operations of the Tren Urbano, the government would be responsible for enforcing the safety and for the environmental regulations; for ensuring that any commitment the government may have made are fulfilled; and finally, for monitoring the quality of maintenance, especially towards the end of the concessionary agreement.

The last alternative, finally, is selling the facility, in which case the system would be operated under private ownership. In this situation, the government would not be able to intervene in any matter except in the enforcement of safety and environmental regulations. The Tren Urbano Office, thus, would no longer be necessary since there is no longer a need for the management of the facility (Agarwal 1999).

A summary of the procurement options available to the Phase I of the Tren Urbano and how each of them would affect the status of the Tren Urbano facility is provided in Table 3.10.

Table 3.11 Summary of procurement options and their effects on the TU *(Agarwal, 1999)*

Procurement Option	Status of the Tren Urbano Office
Takeover by government entity	Separate it from PRHTA and make it an independent authority like the PRHTA
Fresh management contract	Let it remain as a separate organization, subordinate to PRHTA
Long term concession	TUO can be merged with PRHTA and allowed to function as a unit within PRHTA
Sale / Divestiture	Wind up TUO

In regards to the procurement of Phases II, III, and IV, PRHTA also has several alternatives to choose from. PRHTA could allow Siemens Transportation Partnership, that which is responsible for the construction and O&M of Phase I, to also be responsible for the construction and/or O&M of the extensions. In this situation, PRHTA will have to determine how efficient Siemens was in carrying out its responsibilities concerning the design, construction and O&M services of the Phase I alignment line. They should also consider in such a case if dividing the phases into several contracts among several local contractors, like it was done for Phase I, represented major problems to either Siemens or themselves. If it did present problems to either one, then a different type of strategy would be needed. Another important aspect to consider about Siemens' performance is how well and smoothly it operates and maintains the facility during the 5-year period it had it by contract. This should be easily accomplished if the PRHTA properly monitored Siemens and made sure that the performance standards that had to be met were in fact followed. Still, another important issue to analyze is the financial terms established in the contract with Siemens for the O&M of Phase I. Important questions to be answered are whether compensation costs were enough, as well as fair, to reimburse Siemens for their services, and also, whether repair costs per item frequently surpassed the $25,000 amount, in which case PRHTA would have had to reimburse Siemens for whatever amount that exceeded this quantity. If this is case, perhaps it is wiser for PRHTA to set up a competition process for the procurement process of the extensions, such that other private companies can bid for them and PRHTA can change or alter the terms established in their first O&M contract according to the lessons they learned previously during their experience with Siemens.

If PRHTA decided to set up a new competition process for Phases II through IV, they will also need to study what their alternatives are. These are dependent on what they wish to accomplish and how. Money and time are usually the priorities. However, they will also need to determine what their future goals are in regards to the facilities. They need to know in advance whether they will want to operate the facilities in the long term or they will want a private operator to be in charge of them indeterminably. If operating the facility in the future is something they desired, an agreement that allows PRHTA to become technically and conceptually trained is indispensable, particularly because of the lack of this type of infrastructure in the entire island of Puerto Rico. They would also discard the option of future sale of the facility. On the other hand, if PRHTA wished to never have the burden of operating and maintaining the facility, they will most probably want to closely study the options of a long concessionary agreement, as well as private ownership or the selling of the Tren Urbano. These decisions would with no doubt accelerate the procurement process, since they will already know at the time of the bidding process what kind of commitment to look for from private companies.

The government, however, is not the only entity to have to evaluate all of the alternatives available at the end of the 5-year O&M contract between Siemens and PRHTA. Siemens also needs to profoundly analyze all what it wishes to do regarding the Tren Urbano. As for Phase I, Siemens has the option of renewing its O&M contract for yet another 5 years or maybe 10. In making such decision, it too needs to evaluate how efficiently and smoothly the O&M period was, and in doing this all aspects of the operations and maintenance must be taken into account, not only the financial aspect, although it one of the most important, if not the most important one. Other aspects to be studied are how successful and well accepted the service was by the community, how difficult it was to train local people to manage the facilities, as well as to communicate and develop constructive working relationships with the locals, how difficult it was to properly maintain the level of service PRHTA desired, and finally how difficult it was to maintain the desired scheduling and timing of operations.

Siemens should also be prepared for new changes in the agreement that PRHTA may want to include, like extending the duration of the contract, or decreasing the annual compensation fee if risks are now lower. Siemens must bear in mind that as time passes, more and more competition is developing for the O&M services of urban-rail transit systems. And so, it is to their advantage to expand their services in their realm, and the best way to do this is by being exposed to it reasonably and by obtaining as much experience as possible.

Siemens could also obtain much more experience in the field of urban-rail transit systems by choosing to carry out the work for Phases II, III, and IV. Their analysis of Phase I would definitely help them in their decision, as they will have already known what it is like working with the Tren Urbano Office and PRHTA. Just like PRHTA, Siemens should analyze how successful its role was in the design and construction of Phase I. It should especially think about how easy the coordination and management among the other several local contractors turned out to be, in the case where PRHTA again wanted to divide up the extensions into smaller contracts. Siemens should also determine how successful was the first phase of the Tren Urbano in the SJMA since it is a new concept in the island. Obviously, they will want to become newly involved with the TU only ridership meets the projected estimates and is increasing. Otherwise, the risks involved would be too high and the financial aspects of the project would also have to be newly determined. As to the financial agreements, the risks involved are a great influence, as is the type of procurement being desired by PRHTA. As said above, timing and money are very important in the process. As can be seen in tables 3.4 through 3.9, each of the alternative delivery methods has very different results in terms of timing and costs. As far as timing is concerned, DBO is more fast-paced than DB, which is in turn more fast-paced than DBB. Similarly, money-wise DBO result less expensive than DB, which is in turn less expensive than DBB. However, BOT is far less expensive than the other three alternatives. This option, though, is only viable if the government wishes to not have future control of the Tren Urbano, which seems unlikely.

In sum, the planning stages of Phases II, III, and IV, as well as the continuation of the operations and maintenance of Phase I, entail a lot of work by both PRHTA and Siemens. The Agency needs to determine what it is they want from a project, what can be competed by private parties, and what are the benefits to the agency and general public. Before deciding upon a particular way or method to carry the extensions, PRHTA should not only think about the most obvious elements, such as the scheduling and financing of the project. They should not ignore important aspects like what is needed by the community and the population of the SJMA. Indeed, the immense necessity for the relief of traffic congestions in the area was what originally pushed the idea of the Tren Urbano, and so it is imperative that the government of the island does not forget that the bottom-line is to satisfy the increasing and alarming necessities of the residents of the SJMA.

Chapter 4

CONCLUSION

4.0 Recommendations and Lessons Learned

In order to properly and efficiently satisfy the infrastructure needs of a region or city, the process of involving the carrying out and the completion of the infrastructure facility needs to fully integrate, not only those aspects of the project that are obvious to the engineer or the architect, but also those externalities influencing the project one way or another. The two case studies here discussed demonstrate this in detail. The Teodoro Moscoso Bridge case study, for example, integrates political pressures into the process, and this affects more obvious issues like project's schedule. Political pressures are in some way also felt for the Tren Urbano project, although the urgent need of effective and reliable means of transportation is the most crucial outside influence affecting the completions of the project. Similarly, this urgency has a direct effect on the scheduling of the project, and in turn in the financing of the project. However, a project's completion involved much more than this. According to Miller, a procurement strategy is based on ten fundamental elements. These ten elements are:

1. Client defined scope.

2. Head to head competition among Producers.

3. Fair treatment of actual competitors.

4. Transparency.

5. An independent engineering check on the efficacy of Producer's design.

6. Competitions open to technological change.

7. Sound financial analysis by Clients and Producers over the project life cycle.

8. Re-establishing the Dual Track procurement strategy of Quadrants II, III, IV, and I.

9. Client decision-making at the portfolio level with the assistance of scenarios.

10. Re-establishing pace of infrastructure investment as a variable in public and private sectors.

Incorporating these 10 elements into a procurement strategy, regardless of the type of infrastructure facility and the type of delivery and finance method used, would result in the completion of a reliable and high-quality infrastructure facility.

As discussed in Chapter 2, a well Client defined scope consists of establishing the scope of infrastructure services to be procured by contract from private sector firms. Not clearly defining the scope of work of a project will probably send wrong messages to the Producers, who, in trying to figure out what it is the Client needs, end up wasting their time and money, as well as that of the public entity.

Head to head competition during the competition process helps both the public and the private sectors involved. It permits the Client to include objective criteria in the selection and award of contracts for infrastructure services and construction. These objective criteria, in turn, help Producers know how the projects are judged, such that they can concentrate in those criteria more heavily judged by the Client, rather than in some other aspects of the project perhaps ignored by the Client.

The third element involves the fair treatment of actual competitors. This is also another element that ultimately benefits both the public and the private entities. All private sector companies consider how fair they think they will be treated before becoming involved with the public sector. Ultimately, the logic is that few actual competitors will participate in a time consuming and costly competition when the rules, requirements, and evaluation factors are presented prior to the actual competition.

Similarly, transparency is another element benefiting competitors. If competitors see and understand the acquisition process before making a commitment to participate, and if they can rely on the public sector to impartially implement this process to its conclusion, they will not only feel more comfortable when offering their time, resources and expertise to such a project, but they will also provide services and goods of better quality.

An independent engineering check on the efficacy of the design is beneficial for the Client in that it will satisfy the public's interest in the safety of public infrastructure facilities and services. This element particularly is needed when combined project delivery methods are used, such as DB, DBO, and DBFO.

The sixth fundamental element is openness to technological change. Giving private sector companies the liberty to innovate and implement new technologies will provide them with opportunities to use and try new alternatives that could result in higher quality and better performance activities. "A deft strategy today is very likely to be poor strategy tomorrow" (Miller, 1999).

A sound financial analysis, like a discounted cash flow analysis, over the project life cycle is also needed in the procurement processes. These are needed in order to compare multiple delivery options for the same project. The key elements of a sound financial analysis include revenues, expenditures, condition assessment, activity based cost systems for the existing facility, and sensitivity analyses.

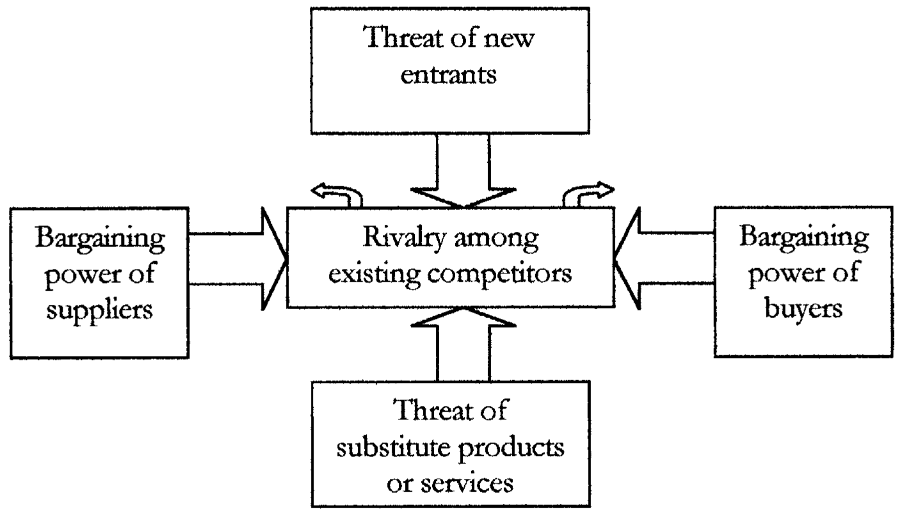
Restoring the dual track strategy as a key element of American infrastructure strategy is also important, especially because it is the mix of project delivery methods that are applied to a collection of desirable infrastructure projects that is becoming increasingly important. Thus, the simultaneous use of indirect project delivery methods in Quadrant II and direct project delivery methods in Quadrant I and IV should be legislatively restore.

The ninth element is scenario building for portfolios of infrastructure projects. Computer simulations of the technical and financial effect of different project delivery methods on the complete portfolio of infrastructure projects will provide an objective means for infrastructure strategists to plan and implement long-term capital programs. An example of this is the model used at MIT, CHOICES©MIT 1998, mentioned in Chapter 2, in the Teodoro Moscoso Bridge case.

Finally, the last element is one mentioned frequently in the previous chapters, and that is pace, or how fast governments choose to work on infrastructure problems. Decisions on pace are very important, particularly because they are partially driven by the available funding and by public demands.

The market of infrastructure is also influenced by Michael Porter's model on competitive advantage. Michael Porter is a world-famous economist and one of the world's leaders on competitive strategy and international competitiveness. Porter believes that any industry's nature of competition is embodied in five competitive forces: (1) the threat of new entrants, (2) the threat of substitute products or services, (3) the bargaining power of suppliers, (4) the bargaining power of buyers, and (5) the rivalry among the existing competitors (see Figure 4.1) (Porter, 1990).

Figure 4.1 The five competitive forces that determine industry competition ***(Porter, 1990)***

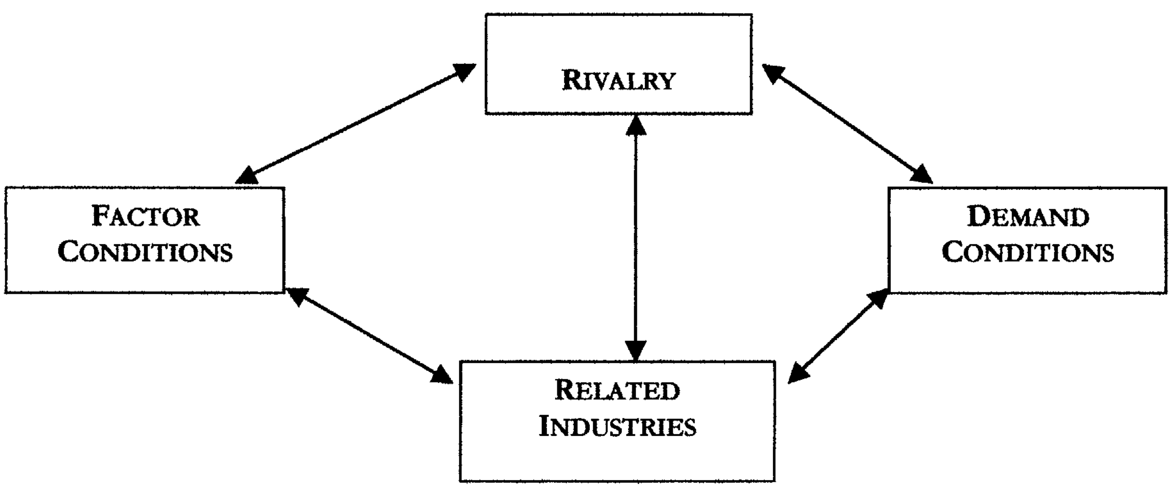


According to Porter these 5 forces determine the industry's profitability because they basically dictate what prices firms charged, how much costs they will have to bear, and the investment required to compete in the industry. The threat to new entrants limits the overall profit potential in the industry since new entrants bring new capacity and seek market share. The bargaining power of buyers and suppliers also limit profits. A lot of rivalry among competitors decreases profits by requiring higher costs of competing., or by lowering the prices of the goods or services offered to consumers. And finally, substitutes limit the price competitors can charge without inducing substitution and eroding industry volume.

Porter also describes those elements that determine national advantage(see

Figure 4.2). These are: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry. Factor conditions refer to factors of production needed to compete, such as labor or infrastructure. Demand conditions correspond to the nature of home demand for the industry's product or service. Related and supporting industries refer to the presence in a nation of supplier industries or related industries that are internationally competitive. Lastly, firm strategy, structure, and rivalry refer to how companies are created, organized, and managed in a nation.

Figure 4.2 Determinants of national advantage *(Porter, 1990)*



According to Porter, these 4 determinants both affect and depend on one another. Advantages throughout the entire "diamond" model are necessary for achieving and sustaining competitive success in the industry. Two additional variables can also influence the national system in may ways, and these are chance events, meaning accidents and other events not controlled by the industry, and government, meaning regulations and laws that could alter one or more of the model's determinants.

The types of factors that are created in a nation are influenced by the other determinants. A cluster of domestic rivals stimulates factor creation. Perceived national challenges also stimulate factor creation. Home demand influences priorities for factor-creating investments, and finally, related and supporting industries create or stimulate the creation of transferable factors. However, factor creation is most strongly influenced by domestic rivalry, because rivalry stimulates the rapid development of skilled human resources, related technologies, market-specific knowledge, and specialized infrastructure so that firms do not fall behind.

The rest of the diamond's determinants also influences demand conditions for an industry. Sophisticated factor-creating mechanisms attract foreign students and participation by foreign firms that pulls through the nation's products. Related and supporting industries also pull through foreign demand for the industry's product. However, demand conditions are also most strongly influenced by the effects of rivalry. Active domestic rivalry makes home demand more sophisticated, and thus more demanding since they are expecting more from the industry.

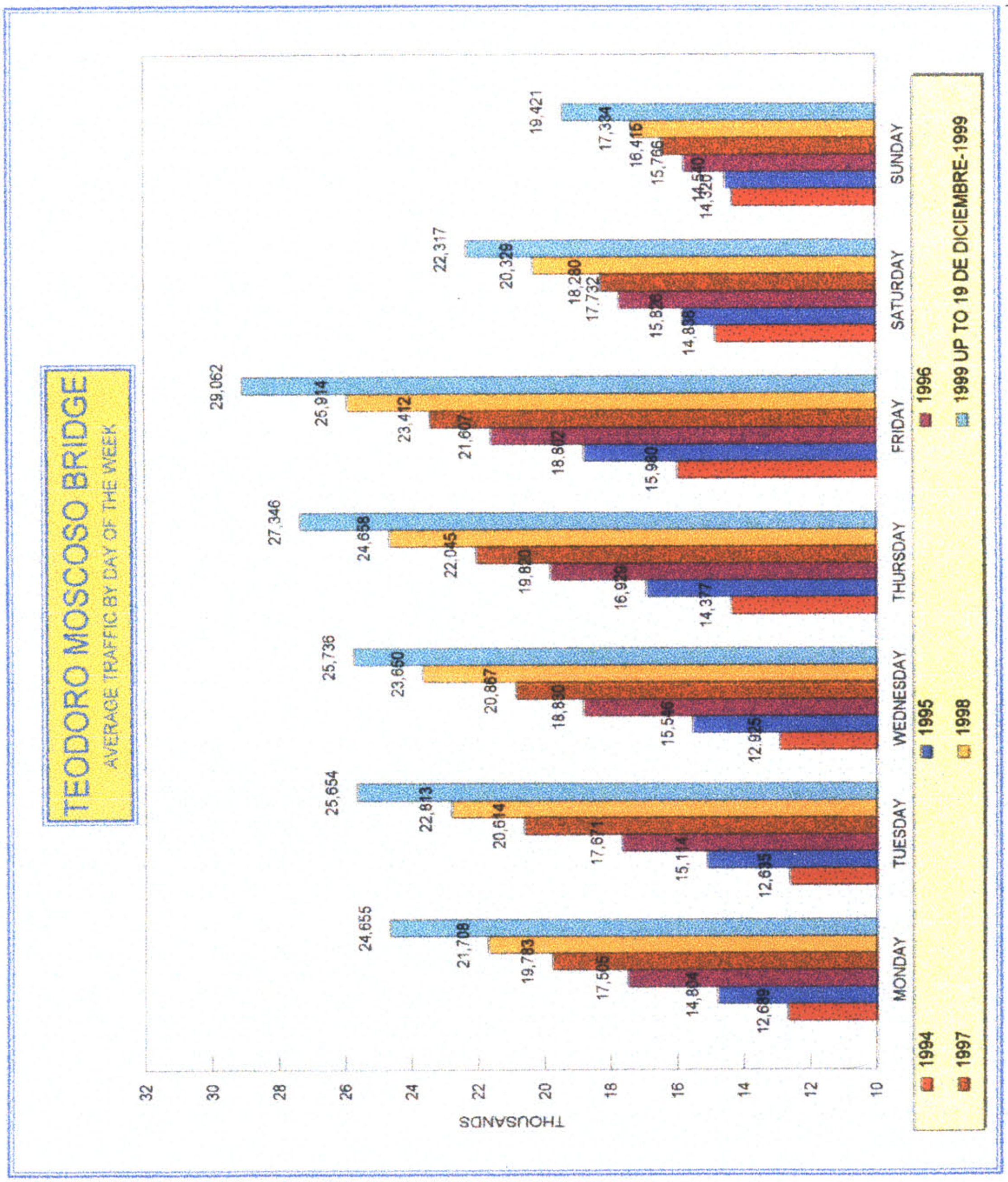
Related and supported industries also benefit from greater factor conditions, since skills, knowledge and technology created in an industry are easily transferable to other industries. Increasing demand also stimulates the growth of related and supporting industries. And lastly, more rivalry encourages the formation of more specialized supplier as well as related industries.

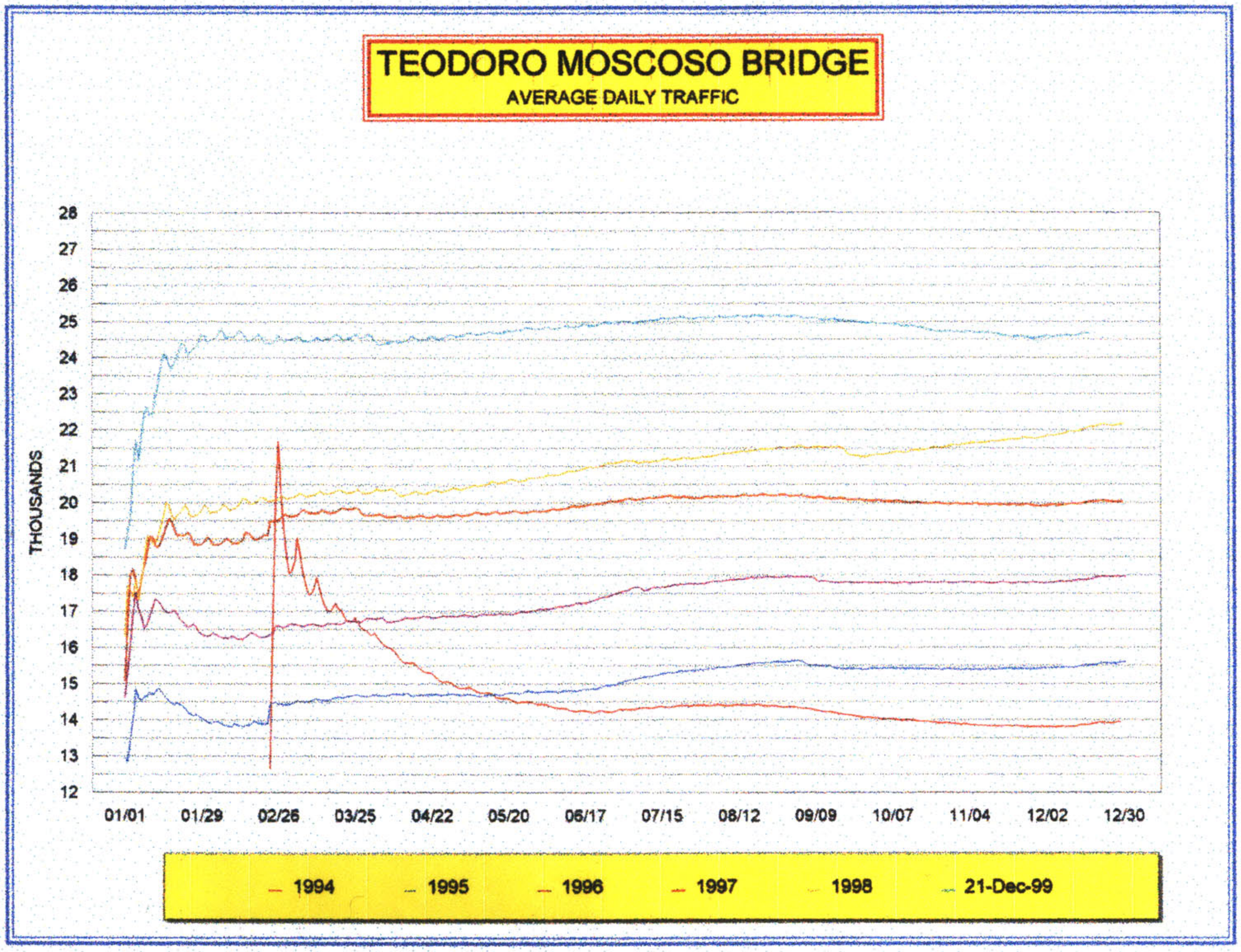
But because this diamond model is a dynamic one, rivalry is also influenced by the other 3 determinants. Factor abundance or specialized factor-creating mechanisms spawn new entrants to the industry. Some of these new entrants may be from related and supporting industries, and others may have been encouraged to enter the industry by increasing demand conditions that have forced them to seek new industries (Porter,1990).

And so, since Porter's model for competitive advantage can be applied to any industry in a country, it fits well into the infrastructure market of the U.S. The four determinants agree with Miller's 10 fundamental elements for a procurement strategy in that competition, defined scope, fair treatment of actual competitors and transparency, and new technologies are some essential aspects of the process that are key to determine how successful the overall project will be in the long run. Miller's head to head competition can be associated with Porter's rivalry. Defined scope can be associated with demand conditions. New technologies would correspond with factor conditions. And a level playing field and transparency can be linked to related and supporting industries.

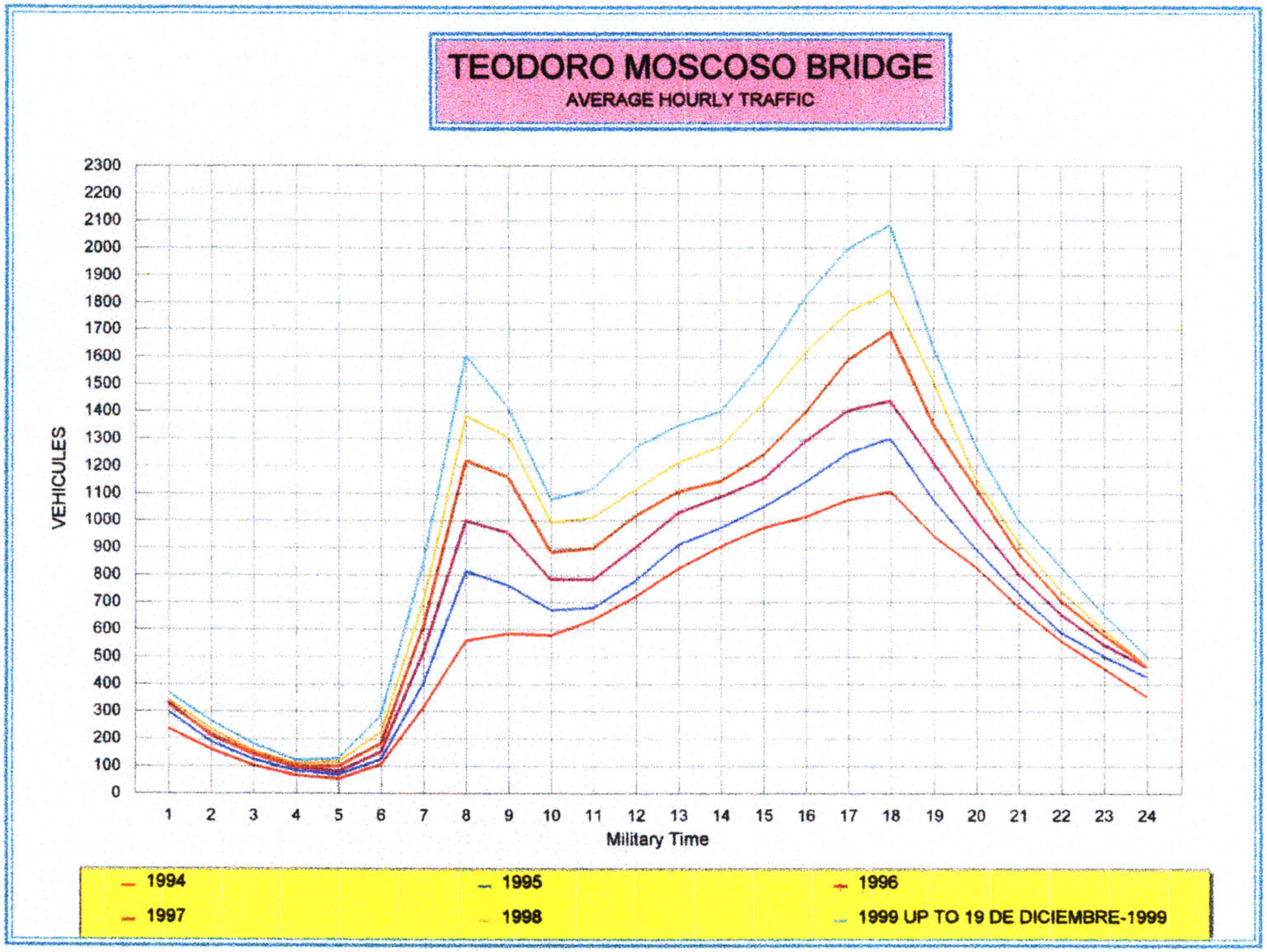
In sum, the infrastructure industry, especially that related to transportation facilities, require the commitment of all parties involved in it, be they from the private or the public sector. Both of them wish to ultimately obtain the best available facility and service. The cases of the Teodoro Moscoso Bridge and the Tren Urbano included in this thesis show how complicated procuring a project can become without a clear identification of the government's needs and without an authentic commitment from both sectors to work together in obtaining a high quality and reliable procurement, facility, and service. Case studies like these, therefore, are an excellent way to analyze, not only past experiences, but also future projects and the way they are planned and procured. Each of these cases can provide infrastructure strategists with valuable information about how each of them was procured and why. The successes or failures concerning each case study can provide future Clients and Producers with valuable lessons to be learned.

Appendix 1 Average Traffic by Day of the Week ***(provided by Autopistas de Puerto Rico)***

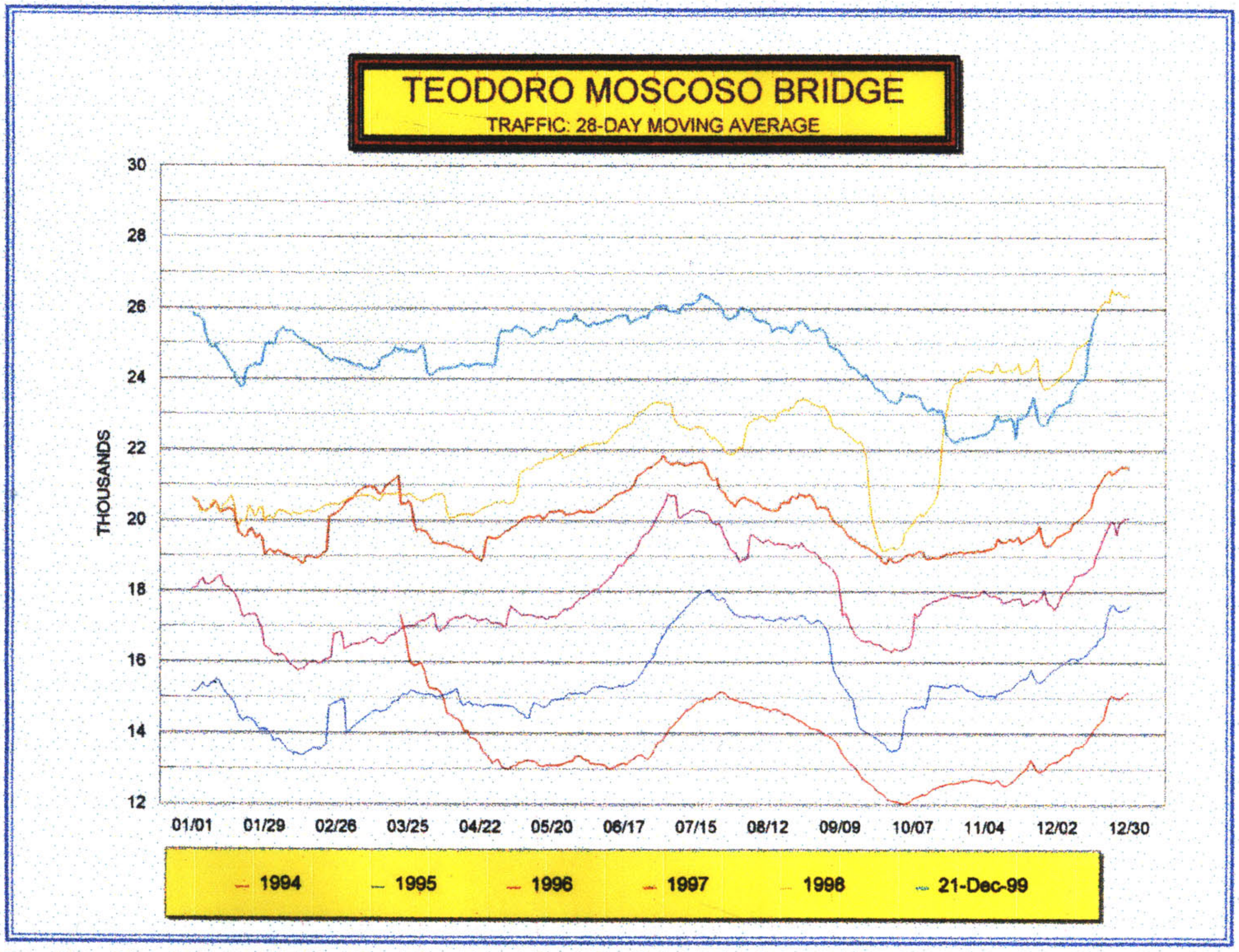




Appendix 2 Average Daily Traffic *(provided by Autopistas de Puerto Rico)*



Appendix 3 Average Hourly Traffic *(provided by Autopistas de Puerto Rico)*



Appendix 4 Traffic 28-Day Moving Average *(provided by Autopistas de Puerto Rico)*

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