Regional Architectures and Environmentally-Based Transportation Planning: An Institutional Analysis of Planning in the Mexico City Metropolitan Area

by

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B.A. in Environmental Science and Policy
Swarthmore College, 1998

Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN TRANSPORTATION

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ABSTRACT

This thesis presents research motivated by three critical issues. First, the rapid penetration of information technologies has changed the face of both transportation system management and long-term planning. Second, the federal mandate for integrated environmentally-based transportation planning in the United States was expanded with firm resolve by the Intermodal Surface Transportation Efficiency Act (ISTEA). Third, ongoing research work on the air quality problem in Mexico City demands in-depth attention to the management and planning of that metropolitan region’s transportation system because of the important contribution of mobile sources to the air pollution problem.

The purpose of this thesis is to expand an established theoretical framework that addresses the issue of data-intensive integrated management to include the relationship between transportation and environmental planning. The theoretical product of that endeavor, namely the Regional Planning Architecture framework, is tested in the context of Mexico City, in which the mobility and environmental problems are more extensive than in any city in the United States.

The result of this work is a new Regional Planning Architecture (RPA) framework to accompany the previously established Regional Service Architecture. The RPA describes the fundamental institutional relationships that surround the production and implementation of short- and long-term transportation plans. The architecture reflects the need to integrate transportation and environmental plans by incorporating the relationships between transportation and environmental planners. This is particularly important in the area of conformity planning, which was brought about by ISTEA in 1991. Initially based on the specific requirements of U.S. legislation, the use of the Mexico City case study leads to an independent platform that helps to produce original recommendations for improvement in that city’s mobility and environmental systems.

The analysis suggests that in using regional architectures as a diagnostic or prescriptive tool, one should emphasize five elements of interaction among institutions: goals, ideas/needs, funding, approval, and data. The focus on goals reflects the finding that the formulation and exchange of goal statements can help planners comprehend and incorporate the goals of their colleagues from other agencies. Funding and emissions constraints facilitate the application of goals in the prioritization/approval process. The sharing of data and ideas/needs reflects the increasing availability of information to planners on the effectiveness of prior strategies and investments.
Acknowledgements

In light of the subject of this thesis, it is especially appropriate to begin by acknowledging the network of programs, projects, institutions and individuals who have lent various forms of support to my research. First and foremost, I must thank Professor Joseph Sussman who has been my adviser throughout these two years at MIT. As the director of the Regional Strategies for the Sustainable Intermodal Transportation Enterprise (ReS/SITE) program, he has challenged me to think critically about institutional relationships underlying the planning and management of transportation systems!

With the relationship between ReS/SITE and the Cooperative Mobility Program, I have had the excellent opportunity to work with Professors Ralph Gakenheimer and Arnold Howitt. Special thanks are due to Professor Howitt from whom I have learned a great deal about the politics of transportation and environmental policy. I would also like to thank the other Mobility-ReS/SITE researchers: Chris Conklin, Georges Darido, Tracy Zafian, and Chris Zegras. Similarly, I would like to acknowledge the Mexico City Integrated Assessment Project, led by Professor Mario Molina. This includes thanks to our many Mexican colleagues, the other MIT and Harvard researchers, and the institutions that have supported the project: the Comision Ambiental Metropolitana and the MIT Consortium on Environmental Challenges.

On a more personal note, I would like to thank my friends and family for making this phase of my life an exciting and rewarding one. Most of all, I would like to thank my wife, Carla, who makes learning fun and who has expressed an amazing amount of interest in transportation planning while redefining all the useful words in the standard lexicon of evolutionary biology. I would also like to thank Carla for chocolate – lots of it.
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<th>Description</th>
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<tbody>
<tr>
<td>AQCR</td>
<td>Air Quality Control Region</td>
</tr>
<tr>
<td>CAA</td>
<td>Clear Air Act</td>
</tr>
<tr>
<td>CBD</td>
<td>Central Business District</td>
</tr>
<tr>
<td>CEQ</td>
<td>Council on Environmental Quality</td>
</tr>
<tr>
<td>CNG</td>
<td>Compressed Natural Gas</td>
</tr>
<tr>
<td>CRA</td>
<td>Comprehensive Regional Architecture</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation</td>
</tr>
<tr>
<td>DVRPC</td>
<td>Delaware Valley Regional Planning Commission</td>
</tr>
<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>FONSI</td>
<td>Finding Of No Significant Impact</td>
</tr>
<tr>
<td>FTA</td>
<td>Federal Transit Administration</td>
</tr>
<tr>
<td>I/M</td>
<td>Inspection/Maintenance</td>
</tr>
<tr>
<td>ISTEIA</td>
<td>Intermodal Surface Transportation Efficiency Act</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation System</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquid Petroleum Gas</td>
</tr>
<tr>
<td>MIS</td>
<td>Major Investment Study</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>MPO</td>
<td>Metropolitan Planning Organization</td>
</tr>
<tr>
<td>NAAQS</td>
<td>National Ambient Air Quality Standard</td>
</tr>
<tr>
<td>NEPA</td>
<td>National Environmental Policy Act</td>
</tr>
<tr>
<td>NJTPA</td>
<td>North Jersey Transportation Planning Authority</td>
</tr>
<tr>
<td>PMT</td>
<td>Passenger Miles Traveled</td>
</tr>
<tr>
<td>ReS/SITE</td>
<td>Regional Strategies for the Sustainale Intermodal Transportation Enterprise</td>
</tr>
<tr>
<td>RI</td>
<td>Regional Infrastructure</td>
</tr>
<tr>
<td>RPA</td>
<td>Regional Planning Architecture</td>
</tr>
<tr>
<td>RSA</td>
<td>Regional Service Architecture</td>
</tr>
<tr>
<td>RTP</td>
<td>Regional Transportation Plan</td>
</tr>
<tr>
<td>SIP</td>
<td>State Implementation Plan</td>
</tr>
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<td>STIP</td>
<td>State Transportation Improvement Program</td>
</tr>
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<td>STP</td>
<td>Statewide Transportation Plan</td>
</tr>
<tr>
<td>TCM</td>
<td>Transportation Control Measure</td>
</tr>
<tr>
<td>TIP</td>
<td>Transportation Improvement Program</td>
</tr>
<tr>
<td>VMT</td>
<td>Vehicle Miles Traveled</td>
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</table>
## Mexico City Institutions/Terms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Name</th>
<th>Description</th>
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<tbody>
<tr>
<td>BANOBRAS</td>
<td>Banco Nacional de Obras y Servicios Publicos</td>
<td>National Public Works Bank</td>
</tr>
<tr>
<td>CAM</td>
<td>Comision Ambiental Metropolitana</td>
<td>Metropolitan Environmental Cmn.</td>
</tr>
<tr>
<td>COMETAH</td>
<td>Comision Metropolitana de Asentamientos Humanos</td>
<td>Metropolitan Land Planning Cmn.</td>
</tr>
<tr>
<td>COMETRAVI</td>
<td>Comision Metropolitana de Transporte y Vialidad</td>
<td>Metropolitan Transportation Cmn.</td>
</tr>
<tr>
<td>DF</td>
<td>Distrito Federal</td>
<td>Federal District</td>
</tr>
<tr>
<td>EM</td>
<td>Estado de Mexico</td>
<td>State of Mexico</td>
</tr>
<tr>
<td>EM-SCT</td>
<td>Estado de Mexico Secretaria de Comunicaciones y Transporte</td>
<td>EM Department of Transportation</td>
</tr>
<tr>
<td>HNC</td>
<td>Hoy No Circula</td>
<td>No Drive Day</td>
</tr>
<tr>
<td>INE</td>
<td>Instituto Nacional de Ecologia</td>
<td>National Environmental Institute (in SEMARNAP)</td>
</tr>
<tr>
<td>MCMA</td>
<td>Mexico City Metropolitan Area</td>
<td></td>
</tr>
<tr>
<td>PEMEX</td>
<td>Petroles Mexicanos</td>
<td>State Oil Company</td>
</tr>
<tr>
<td>PROFEPA</td>
<td>Secretaria de Comunicaciones y Transporte</td>
<td>National Department of Transportation</td>
</tr>
<tr>
<td>SCT</td>
<td>Secretaria de Ecologia</td>
<td>EM Environmental Agency</td>
</tr>
<tr>
<td>SEDESOLO</td>
<td>Secretaria de Desarrollo Social</td>
<td>National Land Planning Agency</td>
</tr>
<tr>
<td>SEDUOP</td>
<td>Secretaria de Desarrollo Urbano y Obras Publicas</td>
<td>EM Land Planning Agency</td>
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<td>Secretaria de Desarrollo y Vivienda</td>
<td>DF Land Planning Agency</td>
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<tr>
<td>SEMARNAP</td>
<td>Secretaria de Medio Ambiente, Recursos Naturales y Pesca</td>
<td>National Environmental Agency</td>
</tr>
<tr>
<td>SETRAVI</td>
<td>Secretaria de Transporte y Vialidad</td>
<td>DF Department of Transportation</td>
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<tr>
<td>SMA</td>
<td>Secretaria de Medio Ambiental</td>
<td>DF Environmental Agency</td>
</tr>
<tr>
<td>STC</td>
<td>Sistema de Transporte Colectivo</td>
<td>Metro (in SETRAVI)</td>
</tr>
<tr>
<td>STE</td>
<td>Sistema de Transporte Electrico</td>
<td>Trolleybus, etc. (in SETRAVI)</td>
</tr>
<tr>
<td>PICCA</td>
<td>Integral Program Against Air Pollution in the Metropolitan Zone</td>
<td></td>
</tr>
<tr>
<td>Pro-Aire</td>
<td>Program to Improve Air Quality in the Valley of Mexico</td>
<td></td>
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Chapter 1: Introduction

The setting is New York City. Three million transponders attached to the windshields of private cars in addition to transit buses provide real time data on traffic conditions. The decennial census indicates how the population of the metropolitan region – over 20 million people get the same local news station – is distributed by age, ethnicity, and income. Cameras constantly record the traffic on bridges, avenues, and parkways. Periodic studies identify where those people live, work, recreate, and shop and by what mode. All of these data are collected by perhaps fewer than a dozen major institutions and then used by several dozen, including highway departments, transit companies, port authorities, environmental agencies and social services. Some of those organizations acquire and use the information in real-time, such as radio stations that broadcast traffic reports every ten minutes. Others develop plans that project air quality twenty years into the future.

The setting is Atlanta, Georgia. The city has earned national acclaim for hosting the longest (distance) average commute in the nation, while the distinction for most lengthy (time) commute still belongs to Los Angeles. The population of the metropolitan region is skyrocketing as major corporations install their headquarters: the city is the economic heart of the southeastern United States. The population of the downtown is dropping, however, and the demographic picture is taking on the infamous “doughnut” model seen around the country. The growing population and expanding urban space is producing an astounding rise in aggregate Vehicle Miles Traveled. The U.S. Environmental Protection Agency, Federal Highway Administration and Federal Transit Administration have found that the regional planners were unable to produce a long-term
transportation plan that adequately addresses the need for pollution abatement. The reward: the city will receive no federal funding for infrastructure projects until a satisfactory plan is produced. In response, the Governor successfully proposed a new governmental entity, the Georgia Regional Transportation Authority, to integrate transportation and environmental goals so that the “conformity lapse” will be resolved and the potential threat to economic growth will be averted.

The setting is Mexico City. The population of the largest metropolitan area in the world has nearly doubled in every decade since 1930 and the pollution generated by 39 million motorized trips per day is trapped by the mountains that surround the city. Relative to the United States, there is much less money available for improving infrastructure to relieve congestion or to deploy expensive air pollution abatement technologies for stationary as well as mobile sources. Despite the fact that 75% of trips are made on some form of transit, the region experiences chronic congestion. In 1997, for the first time, the mayor was chosen by popular election rather than by the incoming President. The two main political jurisdictions between which the metropolitan population (15 million is the official count with the real value estimated at 25% higher) is evenly divided are bitter combatants on almost every issue and efforts at metropolitan coordination appear to be largely superficial. The city represents the ultimate challenge in managing the problems exhibited in New York, Atlanta, and throughout cities in the United States and, undoubtedly, around the world.
Overview

The three situations described above correspond with three factors that have motivated the work presented in this thesis. First, the rapid penetration of information technologies within the last 15 years has changed the face of transportation system management as well as long-term planning. Second, the federal mandate for integrated environmentally-based transportation planning in the United States was expanded with firm resolve by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Third, ongoing research work on the air quality problem in Mexico City demands in depth attention to the management and planning of the transportation system in that metropolitan region. Further, it offers an excellent opportunity to apply the theoretical responses concurrently developed for the information technology opportunities and environmental planning issues.

The purpose of this thesis is to expand an established theoretical framework that addresses the issue of data-intensive integrated management to include the relationship between transportation and environmental planning. The theoretical product of that endeavor is tested in the context of Mexico City, in which the mobility and environmental problems are more extensive than in any city in the United States.

The Research Context

The work presented here is derived from ongoing research within three separate projects. It is important to understand the trajectory of each as in order to recognize this discussion as an integrated product of the three. The Cooperative Mobility Program has dealt with numerous metropolitan case studies for several years with the goal of forecasting mobility needs over an extended time horizon. The research has placed specific emphasis on considering alternative
modes, the interaction between urban form (land use) and mobility as well as the relationship between the transportation system and the larger socioeconomic context in each metropolitan region. The Regional Strategies for the Sustainable Intermodal Transportation Enterprise (ReS/SITE) project shares the Cooperative Mobility Program’s interest in long-term planning. ReS/SITE’s work has focused on two themes in recent years. First, researchers have investigated the use of scenarios of possible futures to evaluate the robustness of current infrastructure investments. Second, a sequence of investigations focusing on institutional relationships as “Regional Architectures” has linked the deployment of Intelligent Transportation Systems (ITS) with the management and planning of high-tech as well as conventional transportation services.

The scenarios work and regional architectures activity within ReS/SITE combined forces with the Cooperative Mobility Program to conduct a coordinated evaluation of Houston, Texas, where researchers witnessed a confluence of common interests. Houston is home to a transportation management consortium, TranStar, which has relied heavily on ITS technologies to address congestion and air quality problems gripping the region. The case study, with critical and unique mobility challenges (lack of zoning) and growing air quality problems, presented an opportunity to apply many of the earlier lessons learned by the two research groups including the scenarios and architectures methodologies.

As the work on Houston was reaching its logical conclusion, a new research initiative was getting underway that proposed an integrated assessment of environmental problems facing Mexico City. Led by an atmospheric scientist, this environmental research group recruited the Mobility-ReS/SITE team to examine the transportation system, which is known to contribute over two-thirds of the critical pollutants in the region, which is a much higher share than in almost any other city, especially in the U.S. The Mexico City case study offered a new
opportunity to apply the developing institutional theory of integrated transportation and environmental planning as well as elements of the scenario methodology.

The perspective presented in this discussion has been influenced by previous and concurrent research activity in each of the three programs as well as the literature on each of the subjects. In addition, the discussion of the case study was informed by two site visits to Mexico City during which approximately 20 interviews with key decision makers and analysts produced information beyond what is available in print. The end matter includes citations, general references and a list of interviewees.

Structure of the Thesis

The structure of this thesis includes an elaboration on the basic premises, the development of the theoretical framework, the application of the framework to the case study, and a conclusion that analyzes the theoretical and practical progress accomplished.

Following this introductory chapter, chapter 2 presents a discussion of the relationship between transportation and the environment, with a special emphasis on the linkage between mobility and air quality planning; this is central to the Mexico City case study. The chapter underlines the fundamental conflicts between these two goals as well as the progress that has been made in recent history.

Chapters 3 through 6 constitute the second portion of the discussion, which focuses on the institutional theory and the further development of the Regional Architecture framework. After the previous work is summarized (Chapter 3), Chapter 4 develops the service-oriented theory into the context of regional planning after which Chapter 5 demonstrates the application
of the theory to the set of plans mandated by federal transportation law. Chapter 6 introduces environmental planning to the model.

The Mexico City case study begins with Chapter 7, which presents a summary of the mobility and environmental challenges as well as the underlying demographic trends. That is followed by a review of transportation and air quality policy initiatives in Chapter 8 and an application of the Regional Architecture model to the problem of expanding Mexico City’s Metro in Chapter 9.

Chapter 10 is a final conclusion that reflects on the original issues posed here in the introduction. Recognizing its place within several ongoing research activities, the conclusion recommends future directions for work on the theoretical framework as well as the continuing work on the Mexico City case.
Chapter 2: Transportation and the Environment

Introduction & Legislative History

The growing importance of environmental concerns in the field of transportation planning has substantial implications for planning activities, such as the restrictions imposed by federal laws. In part because of those laws, environmental protection has come to be one of the dominating criteria in transportation investment decisions. To gain a full understanding of the impact of the transportation-environment linkage on the institutions responsible for administering programs in their respective fields, it is important to understand the substance of the relationships.

This chapter focuses on the mechanisms of environmental impact created by transportation activities. At a cursory level, this includes water quality, habitat preservation and the greenhouse effect in addition to the central issue of metropolitan air quality. Air quality is the focus of the debate because of the concern for the Mexico City case where transportation is a major contributor to the severe environmental circumstances. Indeed, these circumstances are the motivation for the larger research endeavor of which this is one element.

One of the earliest and most important examples of legislative recognition of the transportation-environment connection came in 1966 in the Department of Transportation Act. The 1966 law included a policy that is now known for its location within the bill: 4(f). This regulation addressed growing concern that too much public land was being consumed by the government for highway construction because it was cheaper that acquiring private property. The regulation required the operating agency to make a comprehensive evaluation of alternatives.
essentially making it harder for the government to convert parkland into roadway without considering the ecological consequences.

This policy, while significant, was only a small piece of a larger movement that was gaining momentum. In 1969, the landmark National Environmental Policy Act (NEPA) introduced the now-ubiquitous environmental impact assessment process. NEPA mandates a regimented review process of many different types of environmental impacts including noise and air pollution as well as land takings and damage to the community.

While there have been many policies since NEPA, the one that stands out most prominently, especially in light of the attention to air quality, is the Clean Air Act (CAA, the Act, herein). The Act was first passed in 1970 and experienced major reauthorizations in 1977 and 1990. The 1977 law made few substantive changes except to extend many overzealous deadlines included in the original legislation. The 1990 CAA Amendments (CAAA, the Amendments herein) did accomplish major changes that, in tandem with the Intermodal Surface Transportation Efficiency Act of 1991, changed transportation planning fundamentally. The primary mechanisms of the air quality legislation will be examined in greater detail in subsequent sections of this chapter.

Transportation, Energy and Climate Change

As a major consumer of energy products, transportation impacts the environment because of damage associated with acquiring oil, gas, and coal from various sources (mines, wells, underground fields). Many observers are concerned with secondary impacts of energy consumption such as national security but those issues are well outside the scope of this discussion. Concerns about transportation-related energy consumption have been heightened in
recent years because of rising wariness about the global climate change phenomenon. The connection is that climate change has been linked to the release of carbon dioxide, which is a product of the combustion of fossil fuels. In that manner, the volume of coal, gas, and oil consumed by transportation is associated with emissions of carbon dioxide and therefore climate change. Climate change includes global warming, the El Nino phenomenon and other symptoms, all of which are regarded by environmentalists as potentially catastrophic.

Thus, energy, as a transportation-related issue, has been motivated by concerns about diminishing fuel supplies as well as the impact on the atmosphere. In both cases, the response has been primarily technological, seeking ways to produce the same units of mobility using less energy. While the story could end at that point, there are many ancillary benefits from fuel efficiency gains in terms of local and regional air pollution. Indeed, one issue (energy) has been used to leverage action when the other (air quality) has been unsuccessful.

In the mid-seventies between the 1973 and 1979 energy crises, Congress passed a law that required auto manufacturers to achieve a “Corporate Average Fuel Efficiency” standard. The CAFE standards, as they are known, require that the average fuel efficiency of all vehicles sold by a company be above a certain level. In other words, to achieve the 28.5 mile-per-gallon (MPG) standard, Ford would have to sell enough small sedans to offset the large Sport Utility Vehicles. This provoked the production of many compact cars in the United States. As it turns out, as suggested above, the technological improvements that aided fuel efficiency also reduced pollution because of lighter vehicles and smaller engines.¹

An interesting aspect of the CAFE regulation is that when public interest motivated several states to start talking about developing their own fuel efficiency standards, the auto

¹ For more information on transportation and energy, see Greene (1997).
makers became the leading advocates for a national standard. The executives at General Motors, Ford and Chrysler were motivated by the threat of having to produce different vehicles around the country. The automakers preferred to have a single standard and therefore only one production process. This factor can have important implications in other areas that will be explored in this chapter.

Still concerned about fuel supplies, and aided by concerns about pollution, Congress pursued other policies in the mid- and late-seventies that promoted the potential role of alternative fuels. These substitutes, such as Compressed Natural Gas (CNG) and Liquid Petroleum Gas (LPG) often had advantages in terms of local versus foreign production, often reduced the impact associated with acquiring the fuel, and, by coincidence had favorable pollution characteristics. In that way, the promotion of alternative fuels based on energy concerns provided air quality advocates with “free” progress.

Other Environmental Impacts of Transportation

In the previous section, the mention of climate change and the El Nino phenomenon serves as a useful reminder of the role of popular media in such policies and planning issues. Another good example of this is sprawl, which has been adopted by many political actors as an issue that is a good route to public attention. Sprawl as a concept represents several different concerns, some of which have important connections to transportation planning.

Some opponents of sprawl focus on the consumption of open space as a scenic, ecological, or historic preservation issue. While all of these may be valid, the most important environmental concern is likely to be the disruption of ecosystems and habitats. The best way to illustrate this point is to consider an example. If a road is built through an area that is the habitat
of an endangered or threatened species, the likely opposition to the project will be lead by the
Endangered Species Act, a federal law. The basic concern is that construction of a road (not
considering residential and commercial development for the moment) will destroy the habitat.
The science of the matter is that species require a certain minimum space for breeding, grazing
and so forth. The impact of this situation and the relevant laws is that when the project begins the
environmental review process, including NEPA regulations, biologists as well as hydrologists
and geologists are all brought in to assess the situation.

The reason for emphasizing this point is that this activity has a distinct impact on the
transportation planners involved in the project. These planners are often responsible for
facilitating debates and mediating disputes. In those cases, it is part and parcel of the occupation
that the planner comprehends the issues central to the debate. The presence of extensive
environmental protection laws, such as those related to habitats and species, require planners to
be well versed in these issues as well as transportation and urban development. In some cases
this might require the presence of a specialist on a staff and at the very least, open lines of
communication between planning organizations and the institutions that conduct the
environmental reviews, such as the Army Corps of Engineers, the Federal Emergency
Management Administration (FEMA) and others.

One consideration related to this institutional point is that different kinds of transportation
agencies, such as highway and transit organizations, interact with this level of project planning in
very different ways. Specifically, highway departments deal with environmental reviews on a
very regular basis for small projects, such as road widening, as well as large projects, such as
new infrastructure or major expansions. In contrast, transit companies rarely embark on
construction-type projects that warrant environment review so that when one occurs, it appears
that they are less prepared for it. As a result, a transit planner may be relatively less capable of negotiating compromise solutions or the agency may expend greater resources achieving the same end.

A final non-air quality impact of transportation activities is not linked to air, water or any other specific media but is still very important. The term “sustainability” or “sustainable development” is often used within the sprawl debate and elsewhere. The underlying principle is that the active generation is responsible for leaving its successors with comparable or greater resources than are currently available. This is a response to concerns that finite natural resources are currently being rapidly depleted. There is a natural application of this concern to open space. Transportation is viewed as a guilty party in this because the ease of travel in private cars encourages or fails to inhibit people from building new houses far outside of the city and presumably far from their jobs. The sustainability link is also drawn to air quality (will the air be permanently polluted for generations to come or will health problems inhibit their development) and energy (will current auto use deplete the supply of fossil fuels).

Of all the transportation-environment linkages presented so far, this is the most abstract. Indeed, some critics of sustainability campaigns argue that the opportunity costs of expenditures for sustainability are excessive, even in terms of other critical environmental needs around the world (Solow, 1992). Perhaps the most reasonable question to pose in this regard addresses the trend of auto travel: that while emissions-control innovations have partially offset growth in aggregate vehicle miles traveled within the United States, is that trend sustainable in the future? Perhaps more importantly for this discussion, is that logic valid in other parts of the world where it is harder to deploy those technologies (Mexico City) or where the potential growth in auto use in the coming decades is overwhelming (China, India, etc.).
The Local & Regional Air Pollution Linkage

The Clean Air Act established a set of six “criteria” pollutants to be used as indicators of air quality throughout the United States. Ever since 1970, a complex system of monitors has measured the concentration of airborne lead, carbon monoxide, hydrocarbons (also called Volatile Organic Compounds or VOCs), nitrogen oxides, sulfur dioxide and particulate matter. The Environmental Protection Agency established National Ambient Air Quality Standards for each of these pollutants. Primary standards are maximum allowable concentrations for human health and secondary standards are determined by ecological health, such as agricultural productivity. Each pollutant has specific scientific characteristics including how it is generated or transmitted and its epidemiological effect. The importance of contribution from mobile sources also varies among the pollutants, as described below.

Figure 2.1: Current MCMA Mobile Source Contributions to Each Criteria Pollutant (percentage)
Source: Onursal & Gautam, 1997

2 Unless otherwise noted, data are gathered from the United States Bureau of Transportation Statistics. 1996 Transportation Statistics Annual Report: Transportation and Environment.
An important aspect of this illustration of mobile source emissions is emissions of lead (Pb), which was almost entirely eliminated between the passing of the CAA in 1970 and the end of that decade. This was made possible by the elimination of leaded gasoline. Mobile source emissions of lead, which are about one-third of the total, are now less than 1% of the volume emitted in 1970. An aspect of Figure 2.1 that is misleading is the contribution to particulate matter (PM-10). Much of the PM-10 carried in the air is non-anthropogenic, or naturally occurring. Within the category of man-made particulates, the contribution from transportation is naturally much higher. A major category of particulate “emissions” that are not included in this count is fugitive dust, which is dust that is added to the air by friction with the roadway: dust kicked up by passing cars.

While sulfur dioxide is primarily an industrial pollutant (a major problem downwind from the “rust belt” of the northern plains/Great Lakes region of the U.S.) and mobile source emissions are small, the opposite is true for carbon monoxide (CO). CO is almost exclusively contributed by mobile sources, in some places reaching as high as 95%. Many traffic improvements, such as signalization, are effective strategies for reducing CO emissions by reducing stop and go traffic. Similarly, nitrogen oxides (NOx) and hydrocarbons (HC/VOC) are emitted in large volumes by cars. The contribution of pollution from mobile sources varies substantially among cities. In the context of Mexico City, mobile sources (transportation) are responsible for more than most other cities in the U.S. or elsewhere. It is interesting to note that in Houston, Texas, the distribution of responsibility for pollutants lies more heavily with stationary sources because of the heavy presence of oil refining, which produces similar products to the individual vehicles but on a much larger scale.
Contributions to NOx and VOC are important because the two chemicals react to form ozone, which is the principal ingredient in urban smog. CO and PM-10 are also contributors to smog. NOx and VOCs react in the presence of sunlight to form ozone. Ground-level ozone (bad) is often misunderstood to be the ozone layer (good) which causes some confusion for observers who hear environmentalists criticizing or praising each, respectively. Because ozone is formed by a chemical reaction, one of the precursor pollutants necessarily acts as the limiting reagent. Atmospheric scientists endeavor to accurately inventory each pollutant and to simulate the reaction. Knowledge of the limiting reagent empowers policy makers to target that pollutant in order to affect a reduction in ozone by constraining the reaction.

Since 1970, due primarily to improved fuels and vehicle technology, mobile source emissions per Vehicle Mile Traveled (VMT) have decreased dramatically in all categories and especially with respect to lead pollution. This downward trend has been critical because at the same time VMT has been increasing. Emission rates have to decrease at least as much as VMT increases in order to maintain or decrease total emissions. Between 1985 and 1994, for example, mobile source emissions of CO have dropped 21%. VOCs have also decreased 25% although non-road mobile source emissions have increased 12.3% in that time. The same trend is true for NOx, where highway vehicle emissions decreased about 7% while non-road vehicles polluted over 13% more. In all of these categories, emissions rebounded slightly in the last 2-3 years of observations (1992-4).

With respect to health impacts, the pollutants can have both external (eye irritation) and internal (lung disease) impacts, and are particularly harmful to already sensitive situations, such as elderly people with respiratory illness or children with asthma. CO reduces oxygen delivery to organs and tissues: ozone inflames the lungs and aggravates lung disease and asthma; and,
especially the smallest particulates can enter and damage lung tissue. In addition to grievous epidemiological harm, these pollutants also threaten ecological health. Ozone in particular can reduce agricultural productivity by directly damaging leaf and plant functions. Smog, including ozone and particulate matter, reduce visibility and thereby hamper aesthetics of the natural environment. In some tourist areas, such as the Blue Ridge Mountains in Appalachia and the Grand Canyon, this translates into economic loss comparable reduced agricultural product and human illness.

Conclusion

Addressing Externalities

Reflecting on the information presented in this chapter, one might have the sense that air pollution and other environmental impacts of transportation are indeed serious causes for concern but that they have been mitigated to a substantial degree. With respect to air pollution and energy consumption, there is indeed a good amount of progress that has been achieved in the last quarter-century, especially with help from technological innovation. While there has been substantial improvement with pollutants such as lead, many cities and some rural areas are still subject to high levels of ozone as well as particulate matter. In 1997, the EPA tightened the air quality standards for both of those pollutants. Further, technological innovation does not mitigate the damage caused to habitat by building a road or the unconstrained growth of an urban area.

Many environmentalists of different disciplines focus on the presence of unpriced externalities as the root of the problem. Their argument, essentially, is that individuals do not pay the full price of their goods and activities and therefore consume more than they would if they confronted the full cost and therefore price. The oft-used example is a power plant that is upwind
from a laundromat does not take into consideration the cost imposed on the laundromat by the accumulation of soot in the air intake of the cleaning appliances. The cost to the laundromat may be more frequent expenditures on air filters or greater use of cleaning chemicals, etc. This is a classic externality that would be corrected if the laundromat were able to bill the power plant for the cost imposed by the pollution.

In addition to the absence of accounting or billing mechanisms to accomplish this type of transfer, there are rarely analogs of the Laundromat in nature. Many calculations are made for the cost of pollution on the increased number of children admitted to hospitals on bad ozone days. Attempts are also made to evaluate the cost of losing a species due to habitat fragmentation. Simply put, pricing the externality is the economic efficiency goal but one that is pragmatically impossible in almost every prospective application.

**Mobility Versus Environment**

To this point, nothing in this chapter indicates the underlying conflict between mobility planners and air quality advocates. If anything, there is a strong case that there is enough depth in technological innovation to offset growing auto ownership and VMT trends. While this logic may not hold for other types of environmental impact such as habitat fragmentation, it is important to understand that the ability of technology to mitigate the effects of growing VMT is not infinite. In that sense, the air quality agenda will necessarily lead to policies that address driver behavior: some of those policies may be in conflict with mobility goals.

A good demonstration of this conflict comes in the Houston context, in which transportation planners are currently working on a third ring road to serve primarily as a freight bypass on the planned I-69 corridor. The corridor is dubbed the NAFTA route because it
connects Mexico with major industrial cities in the eastern portion of the Midwest. From a mobility perspective, this is an excellent investment because it facilitates an existing desire line and reduces congestion by diverting that traffic around the city.

From an air quality perspective, however, the project is likely to facilitate substantial urban expansion by making new parts of the region accessible. A one-hour commute can now link a more distant point to the CBD than before the existence of the beltway. In air quality terms, this means an increase in VMT and, without adequate offsetting from new vehicle emission control technology, an increase in pollution. While some argue that urban growth helps to “spread out” the traffic over a larger area thereby reducing congestion, bottlenecking seems inevitable as all of those cars converge on the CBD.

If the need for driver behavior policy is finally accepted, there is a wide range of options available for implementation. On the supply side, expanding transit service is a pillar of efforts to reduce VMT. The critical feature is that the same trip is being accomplished (PMT is constant) with lower emissions (VMT is reduced, emissions per PMT and VMT are reduced). On the demand side, there are various strategies that have been sparsely implemented. High Occupancy Vehicle (HOV) lanes are a relative common example of an incentive for raising the PMT:VMT ratio. More extreme examples include various forms of road pricing that encourage commuters to travel at a different time, on a different mode or perhaps by a different route, all of which lead to lower congestion and emissions.

To some extent, the environmental agenda has aided mobility by increasing funding for transit and other system or high-technology improvements that enhance the productivity of existing infrastructure. At the same time, some of the driver behavior policies can be seen as damaging to mobility. The circulation ban in Mexico City that will receive substantial attention
later in this thesis is a blaring example of a behavior policy that substantially restricts mobility for some people by prohibiting the operation of each vehicle at least one day each week.

*The Institutional Issues*

In addition to the substantive issues of mobility and air quality tradeoffs, there is a critical institutional aspect of this: transportation planners often view the obligation to consider environmental impacts an impediment to their primary task: providing mobility. All of the factors presented in the first half of this chapter appear as constraints to mobility objectives and the task of complying with the regulations represents time and funding taken away from the mission. Transportation planners sometimes view air quality goals as unavoidable, or as a hoop through which they must begrudgingly pass. The product of this perspective is that investment in environmental quality is simply expenditure without return – a double-whammy. The more desirable circumstance would be that planners would regard transportation and environmental goals as intertwined such that success in one area is inextricably linked to the other.

In this context, it is important to consider how the planning environment has changed so dramatically in the last ten years in the post-Interstate era guided by ISTEA and the Clean Air Act. These laws have brought about substantial shifts in the institutional composition and dynamic of regional strategic transportation and environmental planning. The conformity process, as this thesis will go on to highlight, has brought transportation and air quality professionals much closer together even on a day to day basis. Taken in that light, the last ten years represent the first step forward, in which the two disciplines have been introduced. The next step is getting them to share a perspective. The goal of the rest of this thesis is to examine
the prospects, through institutional analysis, for moving in that direction, particularly in the challenging context of Mexico City.
Chapter 3: Regional Architecture Theory

The purpose of this chapter is to introduce and define the concept of a regional architecture as well as its component parts. The first step involves understanding the context for which regional architectures were developed. This will be important later when the concept is applied to the problem identified by this research, which is the integration of environmental and transportation planning. The main emphasis of this chapter will be a review of the process, established by Todd Pendleton (1998), for constructing a regional architecture for transportation service operations. In subsequent chapters, the regional architecture framework will be applied to planning, rather than operations, and the environmental agenda will be added.

What is a regional architecture?

This section begins by analyzing the key terms and the evolution of the regional architecture concept.

"Architecture"

On its own, the term "architecture" has assumed a variety of definitions over centuries all of which resound with concepts such as order, systems, links and organization. The roots of the word include the Greek words for "master" and "builder." The use of architecture in the planning context is no different: the deliberate organization of resources to achieve an objective by design. For an architect in this context, however, institutions are the important building blocks, rather than bricks and wood. Further, information is the fundamental connector, rather than mortar and nails. "Architecture" was introduced to the transportation field as a part of a trend that placed an increasing emphasis on the role of information technology as part of an overall strategy to address the key challenges to moving people and goods in the modern age. At a 1986
conference of academics and professionals in the field, four key motivating factors were identified. First, the anticipated reauthorization (ISTEA, 1991) of the major piece of surface transportation legislation provided an opportunity to make significant advances in transportation planning. Second, the massive expansion of highway infrastructure during the second half of the twentieth century failed to alleviate every mobility woe and new solutions were needed. Third, mounting societal concerns over air quality, urban growth and other factors were placing greater pressure to come up with these new solutions. Fourth, rival nations were making advances in transportation operations based on advanced information technologies that heightened the productivity of existing infrastructure (Sussman, 2000).

The attendees formulated a strategy based on information and communication technology, which reduced the need to continue expanding highway capacity through construction by focusing on making more effective use of existing infrastructure. This approach would mitigate opposition from anti-highway groups, environmentalists and others and reduce the need to build ever-costlier new infrastructure. The strategy, which was developed over several years by an extensive task force, rested on several important abilities: to sense and identify vehicles, to communicate and process large quantities of data efficiently, and to use the data in real time to make operational decisions. Recognizing the complexity associated with such data-intensive endeavors, observers were quick to identify the need for organizing and managing the information and its flow among institutions. Thus, the burgeoning area of Intelligent Transportation Systems introduced the concept of architectures to the transportation community.

Automated teller machines (ATMs) offered the most straightforward example of architectural terminology in the context of information technology. The ATM itself acted as an

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1 Extensive references in this chapter are made to Pendleton’s thesis, some of which are accompanied by page numbers within that document.
interface between the customer and the central computer of the bank. The architecture was made up of several (or many) ATM interfaces all linked to a single central computer. Each ATM served a number of functions as an interface between the central computer and the user. This example illustrates that architectures in this sense can be observed at multiple levels. In this case, one can analyze the network of ATMs connected to a central computer, or one can focus on an individual ATM and its activities. This is a critical distinction with important impacts in later applications. This example has also illustrated one of Pendleton’s observations: telecommunications architectures facilitate the sharing of information, resources and control (page 27). As stated at the beginning of this section, through the deliberate organization or resources, more productive results can emerge.

"Regional"

Identifying the appropriate geographic scope for any planning activity is a perennial challenge. Given the political, physical, historical, cultural and other lines that are drawn, it is difficult to define a service area or designate any type of district without conflicting with at least one interested party’s perspective on the matter. With respect to transportation as well as environmental planning, each field imports perspectives on the issue that often serve to further complicate the matter. The Clean Air Act established Air Quality Control Regions, for example, and State departments of transportation often have districts that do not correspond to other delineations.

This endeavor employs the metropolitan region as its scope, hoping to incorporate all elements of the metropolitan transportation system, which necessarily include origins and destinations outside the normal metropolitan region’s boundary. Because institutions are central
to the subject matter, they provide the unit of geographical analysis. The existing jurisdiction of a Metropolitan Planning Organization (MPO) establishes some precedent for identifying the physical definition of these regions. If representatives of relevant counties are included on the MPO board, for example, those counties can comprise the physical scope of the region.

There are numerous alternatives to this approach. One might use demographic measures to define the region, for example, drawing the boundary line around a certain minimum density. Often circumferential highways ("beltways") provide physical surrogates in this regard. Clearly, there are many options for defining the region. Pendleton, after reviewing recent prominent literature on regionalism, observes that "the term 'region' is used to fill a void in political and economic vocabulary" (page 73). This conclusion points to the fact that the appropriate spatial scope of urban transportation analysis is somewhere in between entities such as states and cities or counties. It also addresses the problem of aggregating multiple jurisdictions, including multi-state metropolitan regions such as New York City. The MPO's jurisdiction is supposed to cover the area expected to be included in the metropolitan region 20 years into the future.

**Arriving at Regional Architecture**

The previous sections have established the meaning of two important terms, region and architecture, in the context of transportation planning. It is clear that the appropriate physical scope corresponds to the most inclusive and extensive concept of the metropolitan area based on the full extent of the transportation system and the jurisdictions of all involved institutions. It is also evident that "architecture" has evolved in this context to describe a deliberate process of organizing institutions, information, resources and control related to the management of the services that comprise the metropolitan transportation system.
The 1986 meeting noted earlier led to a commissioned study of a national ITS architecture almost a decade later. In one of the core documents presenting the plan for the national architecture, the consultants produced the following definition: "The [National] ITS Architecture is the framework of interconnected subsystems which together provide the ITS user services through allocated functionality and defined interfaces." Pendleton made a significant contribution to the literature by proposing that:

A regional architecture is a framework that describes how various transportation institutions will interact to provide an integrated series of transportation services in a metropolitan-based region.

It is helpful to examine several of the important terms in Pendleton's definition of regional architecture. Following *framework*, the next key term is *institutions*, recognizing the centrality of organizational entities to the concept. Earlier sections have emphasized the importance of institutions in defining the relevant region and as the discussion turns to planning rather than operations, the prominence of institutions will only increase.

*Integrated* is the next term and it highlights one of the key goals of this approach, which is to seek opportunities to create synergy or to disarm conflict and competition among services as well as institutions. In his presentation on how one constructs the regional architecture, Pendleton comments that "one could say that the regional architecture equals the sum total of all service architectures" (page 143). This statement should be ignored, however, because the term *integrate*, as used in the regional architecture definition, reflects the true nature of synthesizing the many activities of the region into one network. It seems entirely inappropriate simply to *aggregate* the sub-units as Pendleton seems to suggest. Therefore, this work employs the term used in the Regional Architecture definition, *integrated*, rather than the alternative, *aggregated*.

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The final two points are perhaps the most important. First, it is critical to highlight the emphasis placed on services as a building block of this exercise. The enhanced productivity of services through institutional analysis is the driving force behind the regional architecture approach. Second, one must keep in mind that this analysis must occur across a metropolitan-based region in order to capture the full systems perspective of the demand for and supply of mobility services.

Review

This chapter has briefly summarized how the National ITS Architecture arose and explained how Pendleton's definition of Regional Architecture emerged from that process. Some challenges to Pendleton's definition and assumptions have produced a slightly different perspective on Regional Architectures but retained the fundamental underlying structure: the coordinated provision of conventional and advanced (ITS) transportation services. Furthermore, the key elements of the regional architecture framework are untouched: institutions, user services, lines of responsibility, lines of communication, and information flows. The second half of the chapter brings these concepts from the page into a useable methodology.

How to Make the Regional Architecture Operational

Overview

The remainder of this chapter summarizes the procedure that Pendleton has provided for implementing the regional architecture framework, summarized below. This protocol will be used throughout the thesis; this presentation familiarizes the reader with the methodology before it is applied to several contexts.
Stage 1: Identify the user services that the region would like to implement.
Stage 2: Analyze the ITS services.
   2.1: Identify service sub-systems and data flows.
   2.2: Map the sub-systems and data flows according to national architecture guidance.
   2.3: Identify institutions and their data holdings.
   2.4: Classify institutional inter-relationships.
   2.5: Construct "service architecture" illustrating the information gathered by the previous four steps.
Stage 3: Analyze the non-ITS services.
   The multi-step process here is the same as stage 2 but without the first two steps, which address information needs not relevant for traditional services.
Stage 4: Aggregate the service architectures to create the regional architecture.

*with other stages amended after more consideration:*

Stage 5: Evaluate the regional architecture
   5.1: Identify the institutions that may be contributing a disproportionate share of information.
   5.2: Reconsider opportunities to create new institutions.
Stage 6: Revisit the regional architecture over time.

Viewing this process, there are two important observations. First, in stages 5 and 6, Pendleton recognizes the feedback loops that must exist to assess the quality of the regional architecture. This recognition acknowledges an opinion expressed in the previous section that, in addition to being a part of the strategic plan, the Regional Architecture is also an input to the planning process. A remaining difference is that it seems these feedback loops may not fully account for the critical feature cited previously: that the Regional Infrastructure is implemented by the member institutions of the Regional Architecture. The second observation is the importance of the service architecture concept.

A service architecture, according to Pendleton (page 141), "is a framework that describes how various institutions will interact in order to provide a single transportation service to the region. It contains the same components as a regional architecture; the only difference is that it..."
only supports the implementation of one service.” Thus, the service architecture contains the same key elements as the regional architecture: institutions, lines of responsibility and communication, information flows, and - in this case - a single user service. Indeed, the regional architecture is made up of all the relevant service institutions. It is important to keep in mind at this step the assertion that where "aggregate" is used in Stage 4, we argue that "integrate" is more appropriate.

Demonstration

In his thesis, Pendleton establishes a fictional metropolitan area case study for which he develops a full regional architecture, including every relevant service architecture for conventional and advanced transportation activities. For the purposes of this discussion, a summary of the application of the framework to one particular service (incident management) in Pendleton’s illustrative case provides a useful example. An interested reader should peruse the case of the Greater Jefferson Metropolitan Area in Pendleton’s work.

STAGE 1: IDENTIFY THE USER SERVICES THAT THE REGION WOULD LIKE TO IMPLEMENT

The developers of the National ITS Architecture offered guidance by means of the Implementation Strategy on the identification of user services. They identified 30 services, grouped into six categories:

1. Travel and Transportation Management
2. Public Transportation Operations
3. Electronic Payment
4. Commercial Vehicle Operations
5. Emergency Management
6. Advanced Vehicle Control and Safety Systems
Methodologically, Pendleton recommends that conventional and ITS services are distinguished immediately because the analyses of each are different. For Jefferson, he posits four new services, three of which are ITS-based:

**ITS**
- Surface Street Control
- Public Broadcast of Traveler Information
- Incident Management

**NON-ITS**
- Coordination of Transit Agency Schedules

Pendleton notes the importance of public outreach in this stage. Essentially, with imperfect knowledge of the total set of, it is necessary to perform an outreach exercise to determine the desired services. Note that there is substantial potential for sampling bias in the exercise here. One must consider the characteristics of the group that is determining the stakeholders at whom they will direct the outreach effort. The unintended consequences of overlooking a particular group or constituency at a seemingly unimportant early stage can lead to backlash and the exercising of localized veto power at a later point in time. For example, it is clear that the identification of spatial scope for the metropolitan region is somewhat arbitrary. It is important to consider if the selected boundary leaves out individuals or groups who might still demand a voice in the project selection process. This may appear to be a burden at this stage but, as mentioned, the prospect of obstacles and opposition at later, more time-sensitive stages may be severe. Simultaneously, there is a counterposition that certain prospective stakeholders will prefer to be left out of the activity, such as suburban communities that often actively disassociate themselves with the urban core, especially in the political sense.
STAGE 2: ANALYZE ITS USER SERVICES (5 STEPS): JEFFERSON CITY AND INCIDENT MANAGEMENT

Although Pendleton establishes five explicit steps for analyzing the ITS user service, it is clear that indeed there may be others that deserve recognition. Even in his presentation of each service, the introductory paragraph consistently identifies problems that generate the need for the service. In the case of incident management, he mentions the lack of alternate routes through the city and the tardiness of emergency crews as critical factors in determining the importance of improving incident management. A subsystem that focuses on identification of the problem would help to introduce the service, possibly identify crucial stakeholders, and potentially indicate how urgently the situation should be addressed.

Step 1: Identify subsystems and data flows

A subsystem is another concept for which the national architecture developers offered explicit guidance. Subsystems, as summarized by Pendleton, can be defined based on the function provided or the equipment it employs. "Traffic management" and "autonomous in-vehicle route guidance" would be examples of each, respectively. The developers placed the 19 identified subsystems into four categories. Center subsystems closely correspond to specific institutional functions. Roadside subsystems include infrastructure technologies such as signals and signage. Vehicle subsystems support data exchange between the driver and the infrastructure. Finally, Traveler subsystems specifically provide information to individual travel decision-makers such as drivers and other operators.

Because most subsystems or combinations thereof have distinct implications for institutions, technologies, and functional activities, the national architecture developers identified 56 "market packages" that represent common sets of interacting subsystems and the
accompanying institutional roles, etc. When a planner identifies a specific subsystem as a part of the user service at hand, she can immediately employ the pre-designed market package by adapting it to the local circumstances. Indeed, "Incident management" is a specific market package designed with the knowledge that almost every municipality is interested in this area. Indeed, for this first stage in the case of Jefferson, Pendleton need only deploy the pre-fabricated market package.

In this case, there are two central subsystems, emergency management and traffic management. The auxiliary subsystems include Emergency vehicles, the information service provider, the roadway and other traffic managers. These are illustrated in the figure below, which also includes the data flows.


The relationship between traffic management and roadway is instructive with respect to the identification of data flows. Signage data, for example, is sent from the traffic management subsystem to the roadway, presumably to be displayed on public monitors. At the same time, other roadside technologies, perhaps vehicle sensors, send incident data back to the traffic
managers, perhaps containing information such as average speed, traffic counts, and video images.

Step 2: Map subsystems to the physical architecture

To this point, one is aware of what activities are required in order to provide this particular service. Given the requirements, the next question examines the mechanisms of how these activities are accomplished. The physical architecture, as illustrated in Figure 3.3 below, includes the 19 subsystems in the four categories and introduces the lines of communication such as "Wide Area Wireless" and "Vehicle to Vehicle." The mapping of the subsystems onto this framework demonstrates how the conceptual linkages between subsystems, such as Roadway and Emergency, is achieved through two distinct communication networks rather than more directly through "Dedicated Short Range Communications." One might interpret this as a shortcoming of the network that has been identified by this graphical representation.

Figure 3.3: The Physical Architecture (Pendleton, 1998, page 173)
Step 3: Identify the Institutions

Steps 1 and 2 have identified the relevant activities and the pragmatic actions associated with accomplishing them. The next step is the introduction of institutions to the framework. As noted in step 1, some of the subsystems - especially those in the center category - have specific links to generic institutional forms. The Information Service Provider, as a subsystem, has a specific link to the relevant local information institution, such as a dispatch office or perhaps the media company (radio, television, e.g.). For Jefferson's' incident management service, Pendleton identified a basic set of 14 institutions: three traffic operations centers, three transit agencies, three policy departments, three fire departments, the state turnpike authority and the Newsradio station. Pendleton (page 175) highlights the connections between institutions and subsystems:

- Emergency Management: Police and Fire Departments
- Transportation Management: Traffic Operations Centers, Transit Agencies, Police Departments, Turnpike Authority and Newsradio
- Information Service Provider: Newsradio

One must note that the institutions are identified on a functional basis. Arguably, there are other stakeholder entities that do not have an explicit functional role. A clear example of this is the traffic entities that might be involved in facilitating delivery of emergency services to the site. If a city’s ITS system includes emergency vehicle prioritization, for example, the manager of the local signal network must be involved in deploying an optimal route for an emergency vehicle from dispatch location to the scene of the accident. Less clear examples include non-emergency vehicles such as tow trucks and other secondary services. The point is that entities that are partially or not functionally linked to the activity can easily be overlooked in the stakeholder inventory.
Step 4: Make decisions concerning institutional relationships

Pendleton offers a method for approaching this critical stage. He suggests that one first identifies components of the services. In the incident management case, these components are response coordination, incident clearance and information broadcast. These categorizations represent a first order aggregation of similar contributions to the overall response. Pendleton offers three questions that are applicable to any service context (page 175); he suggests that each question be applied to each component, forming an answer matrix.

- Will the component be performed by existing institutions, or should new institutions be introduced?
- Who will control the implementation of each service component?
- How will information be distributed during the execution of each component?

The more general restatement of these questions follows:

- Does the necessary institutional capacity already exist or is expansion/augmentation needed?
- Has a leader been designated within each component?
- Is there a central source of accessible, reliable, and consistent information?

There are other questions that might also help improve the system and the involvement of each member organization. For example, one might want to study if there are any opportunities for productive overlap or synergy. Getting emergency vehicles to the scene might be easier if they can travel as a convoy to minimize conflicts with ambient traffic. This would require a new area of communication and cooperation but the effort could yield substantial results. Clearly, asking such fundamental questions is an excellent endeavor, particularly before the next and final step.
Step 5: Construct the Service Architecture

In the previous steps, the possibility of activity and institutional interactions demanded attention to mitigating conflict and managing cooperation. As subsystems, physical architectures and institutional inventories are integrated into the service architecture; a solid understanding of the micro-level interactions will improve final results for each service area. In Figure 3.4 below, the representation of the Incident Management service architecture might suggest that the foremost objective of this service is the coordination of emergency response, something that has resonated in observations throughout each step of the process. One easily recognizes the degree of complexity in a service area with a clear mission. In the next stage, multiple service architectures will be integrated into the full regional architecture with even greater complexity and consequential need for analysis and management.
Stage 3: Analyze Non-ITS User Services

This process is the same as the process of Stage 2 (ITS Services) with the important distinction that in the absence of ITS components such as subsystems and data flows, steps 1 and 2 are not necessary. While it might seem that non-ITS services are consequently simple relative to ITS-services, the actual situation is that the challenge may be equally great and indeed greater in the absence of substantial information on which to base technical decisions.
STAGE 4: INTEGRATE THE SERVICE ARCHITECTURES TO CREATE THE REGIONAL ARCHITECTURE

At first glance, a regional architecture diagram might appear prohibitively complex. Indeed Pendleton even questions the usefulness of a potentially cumbersome framework. It is critical to distinguish between two overarching approaches that one can use when employing the framework. On one hand, one might want to examine which institutions are responsible for the set of activities required to implement a specific subsystem or service. On the other hand, one might need to analyze how an institution’s resources are utilized throughout the region. From either perspective, given a clear objective in approaching the architecture, the framework appears much more accessible and useful than an intimidated reader might have initially thought.

Conclusion

The evolution of architectural thinking, from physical structures to computer networks and to institutional arrangements for system management, was well addressed by Pendleton. His thesis, which of course goes into much greater depth than the summary presented here, has provided a basis on which to further develop the architecture concept to include planning. Rather than real time system management, the perspective may be as long as twenty years. Pendleton has demonstrated that by analyzing the relationships between institutions, the decision-making architecture can be capable of producing a better system with greater efficiency and efficacy. The discussion now turns to achieving that same success in long-term capital planning as well as in the relevant areas of environmental protection.
Chapter 4: Regional Planning Architecture

Introduction

A regional architecture is a framework that describes how various transportation institutions will interact to provide an integrated series of transportation services in a metropolitan-based region.

-(Pendleton, 1998)

In the conclusion of his thesis, Pendleton recommended that future work focus on expanding the Regional Architecture framework to address transportation planning. That charge is accepted in this thesis and, working within the framework developed by the Regional Strategies for the Sustainable Intermodal Transportation Enterprise (ReS/SITE) program, applied to the goal of environmentally based transportation planning articulated here in chapter 2. The first task of this chapter is to make the necessary adjustments to Pendleton’s framework in order to describe planning rather than service activities. The second task is to re-evaluate the ReS/SITE framework in light of changes to the Regional Architecture theory.

Differentiating Planning and Services

Work on Regional Architectures is motivated by the possibility of improved institutional relationships producing more effective transportation systems, through better management of existing infrastructure and better planning of new infrastructure, thus reducing the need for costly and difficult new projects. The need to consider planning as well as services is driven by the recognition that improved institutional relationships among planning agencies could result in benefits such as more successful investments and better coordinated plans. Just as service-oriented institutions need to be organized to produce an integrated series of services, planning organizations need to coordinate the production of an integrated set of transportation plans. The concept of Regional Architectures, therefore, should be differentiated to address the subsets of
transportation institutions that focus on planning and services, respectively. Specifically, there should be a Regional Services Architecture and a Regional Planning Architecture, where the former is the subject of Pendleton’s work and the latter is a result of this research and which requires a different definition.

A regional planning architecture is a framework that describes how various transportation institutions will interact in order to provide an integrated set of transportation plans in a metropolitan based region.

The full set of institutions that participate in managing the transportation system should be referred to as the Comprehensive Regional Architecture (CRA) and within that set should be the Regional Service Architecture (RSA) and Regional Planning Architecture (RPA) subsets. Figure 4.1 illustrates this relationship:

![Figure 4.1: Comprehensive Regional Architecture and Its parts](image)

Perhaps the most important characteristic of the CRA is the relationship between the RSA and RPA and that there may be substantial overlap between them. A state Department of Transportation, for example, is likely to be a very active participant in planning activities and is also likely to be an important manager of transportation services making it part of both RSA and RPA. However, it is possible that the office or division of the DOT that participates in the RSA is a different unit of DOT than that which participates in the RPA. When communication between the RSA and RPA is important, it may be incorrect to assume that the presence of one institution in both subsets provides a reliable link.
Methodologically, the development of a RPA should be similar to that of a RSA. Indeed, the important features of the RPA are similar to the original RSA: it is a framework; the emphasis is on institutions; the analysis is an integrated exercise; and, there is a regional scope. The actual RPA should, as the RSA does, include a list of institutions, lines of responsibility and communication among the members, and the type of information flowing along those links.

One important difference is that the RPA describes the set of institutions that conduct the planning process, one output of which is a new RPA. The challenge of self-evaluation is potentially significant. Another difference is that regulation and federal mandate are major factors in the RPA. Laws and regulatory guidance have created the specific plans through which the institutions are obliged to relate. The same laws affect how the plans and associated institutions interact and influence each other. The regional architecture methodology, however, requires that these mandates be seen as dynamic. For example, the set of plans and relationships mandated by the Clean Air Act can be evaluated by developing the RPA and RSA and important innovations may emerge from that process.

**ReS/SITE and the RPA-RSA Differentiation**

The Regional Strategies for the Sustainable Intermodal Transportation Enterprise (ReS/SITE) program is the research context in which work on regional architectures has occurred in the last few years at MIT. Because the architectures are a critical element of the ReS/SITE framework, the impact of a substantial revision of the architectures, as proposed in this thesis, has important implications for ReS/SITE itself.

The ReS/SITE framework, as illustrated below in Figure 4.2, indicates several important observations about the regional strategic transportation planning process. First, diverse scenarios
of the future are inputs to the planning process. The purpose of this is to motivate the development of plans and services that are robust with respect to the set of possible outcomes.

Second, the ReS/SITE team has suggested that the Regional Strategic Transportation Plan (RSTP) has two components. The Regional Infrastructure (RI) is the set of recommendations for investments that address anticipated transportation needs based on the scenarios. The second component is the Regional Architecture (RA), which is the central topic of this discussion. As a part of the RSTP, the RA is the set of new institutions and relationships that should improve system management throughout the scenario-based possible futures. The System Management represents the operation of the RI by the RA, with feedback as appropriate to earlier portions of the framework.

The differentiation of service and planning architectures necessitates a revision of the ReS/SITE framework. The most direct interpretation of the distinction is that the RSTP would include three discrete elements (RSA, RPA, RI) and that each would be independent links between the RSTP and System Management. In addition to the disaggregation of the Regional
Architecture into the RPA and RSA, it seems likely that there is some feedback between the RPA and the earlier stages. This is, in a sense, a chicken-and-egg phenomenon. The ReS/SITE framework represents the regional planning process. Pragmatically speaking, it is the planners described in the RPA who are formulating the scenarios and producing the RSTP. Therefore, the planners, in developing the RPA, are actively reinventing their own missions and possibly the structure of their working environment. Thus, the differentiation between the RPA and RSA presents the opportunity to include this important feedback loop from the RPA to both the scenarios and the RSP. This situation is illustrated in Figure 4.3.

![Figure 4.3: Revision of the ReS/SITE Framework](image)

While this diagram captures the differentiation of the RPA and RSA, it does not fully incorporate the important features of the RPA. Most importantly, the framework must reflect the role that the RPA maintains in the development and deployment of actual projects. For example, in the ReS/SITE team's investigation of Houston, Texas, the need for additional circumferential...
highway infrastructure was a prominent element of the RI\(^5\). The actual development of the project plans, the inclusion of the project in the budget request and so forth, however, are all functions of the RPA. The extent to which the RI is actually deployed is a function of the RPA’s ability to develop and implement it. Thus, the previous representation of the framework (Figure 4.3) must be augmented to reflect the connection between the RPA and the RI. Figure 4.4, below, is the new formulation of the ReS/SITE framework, including the differentiation of the RPA and RSA and the role of the RPA in deploying the RI.

![Figure 4.4: The New ReS/SITE Framework](image)

**Figure 4.4: The New ReS/SITE Framework**

**Implications of the New Framework**

With the ReS/SITE and Regional Architecture frameworks, one should be able to develop a substantial descriptive analysis of transportation decision-making in the metropolitan area. The distinction between the service and planning architectures helps to illuminate the placement of priority within and between these two spheres. Overall, the frameworks help one comprehend how regional priorities have emerged and how they are supported. Because

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\(^5\) For more information of the Houston project, please see Mobility-ReS/SITE 1999a.
transportation managers are called on to balance multiple priorities (such as mobility and air quality), the hope is that these tools can be used to identify this balance and possibly to support recommendations that address how to shift that balance in favor of certain agendas, such as welfare-to-work programs, air quality goals and general congestion mitigation.

In the absence of this framework, a ReS/SITE-supported investigation studied the cities of Atlanta, Houston, and Portland, OR and identified what appeared to be three dramatically different philosophies of transportation management. The interim report (June 1999) suggested that several important characteristics such as time frame, geographic scope, and accountability structure could describe the local planning philosophies. Portland's land use philosophy involved a long and involved planning process with substantial public involvement and accountability that produced a geographically comprehensive, long-term plan. Atlanta's infrastructure orientation involved a medium term time horizon, a moderate physical scope, and some mostly indirect public accountability. Houston, with its high-tech operations management collaborative organization (TranStar) was near-term, focused on individual infrastructure elements and had little or now public involvement or accountability.

Because of the RPA-RSA differentiation, the revised ReS/SITE framework can effectively describe the characterization of different planning philosophies in the three cities. Specifically, the RSTP is heavily weighted toward the RSA in Houston's technology-oriented planning atmosphere. The difference between Portland and Atlanta, both of which depend on the RPA element, can be seen in the details of the RPA. In Portland, for example, the RSTP is influenced by the presence of a unique multi-jurisdictional planning agency. In contrast, Atlanta's planning institutions are primarily organized around the principal of infrastructure expansion with the Department of Transportation dominating the interactions.
Conclusion

The preceding discussion has responded to Pendleton’s suggestion to expand the regional architecture methodology to address transportation planning, in addition to services. This endeavor has produced the Comprehensive Regional Architecture concept, which includes both the Regional Service and Regional Planning Architectures. Accordingly, the ReS/SITE framework has evolved to accommodate the changes in the Architecture component, including the link between the RPA and the Regional Infrastructure and the overlap between the RPA and the RSA. The final portion of the discussion demonstrated that the new framework has greater capabilities than the earlier version. Given this progress, it seems appropriate to begin the analysis of the current planning environment in the United States.
Chapter 5: Architectures - From Theory to Practice

Introduction

The previous two chapters have introduced and developed the ReS/SITE framework and specifically the concept of Regional Architectures. The purpose of this chapter is to apply that theoretical endeavor to contemporary metropolitan planning in the United States. There are two important benefits of this exercise. First, the product is a Regional Planning Architecture template for assessing the most important institutional relationships for long- and short-term infrastructure planning. Second, that template provides a basis for the subsequent analysis of Mexico City in chapters 7-9.

This chapter follows the protocol established by Pendleton for analyzing the RSA. The first portion, Stage 1, presents a review of the major plans for which the RPA has responsibility. Stage 2 includes detailed analyses of the plans mandated by the Intermodal Surface Transportation Efficiency Act. That work leads to the presentation of the full Regional Planning Architecture model.

Stage 1: Identify the Plans

The Comprehensive Plan

During the era of urban renewal in the United States, which came approximately in the fifteen years following World War II, federal agencies sought to devise mechanisms of supervision for the spending of federal aid to downtown (re)development. Housing acts passed in 1949 and 1954 required cities applying for federal aid to produce a comprehensive city plan or demonstrate that they were actively developing one. Thus, the federal government gained the mandate to exercise its agenda for integrating transportation and land development and
encouraging urban transportation planning. Later, the 1962 Federal Aid Highway Act mandated urban transportation planning specifically as a condition for receiving highway monies.

The comprehensive plan included six major components: four plans and two ordinances. Many cities that were unable to produce a full comprehensive plan in time for the aid application, presented the land use plan, which many saw as the foundation of the larger plan. The six components (Altshuler, 1965):

- A Land Use Plan projected the locations and amounts of residential, commercial, industrial and public property.
- A Thoroughfare Plan illustrated the existing and proposed highway network including limited-access as well as secondary and arterial roadways.
- A Community Facilities Plan identified established as well as planned schools, parks, playgrounds and other public facilities.
- The Public Works Improvement Program inventoried the public works investments necessary to implement the three plans above.
- A Zoning Ordinance delimited precise locations, heights and land coverages of buildings in the community.
- A Subdivision Ordinance surveyed proposed subdivisions for characteristics such as lot size, street grade and width, utility provisions and official record-keeping to ensure conformance with existing plans.

A representative description of this planning document, based on the work of Kent (reprinted 1991, cited in Innes, 1996):

A comprehensive plan is the long-range physical plan for a city; it covers the city geographically; it addresses each function that makes the city work as a physical entity and that affects its physical form; it is a statement of policy rather than a program of specific actions; and it is intended to guide city officials in future actions.

In 1965, Alan Altshuler reinforced the perception of the land use plan as the key ingredient of the comprehensive plan: "It was expected that...the general land use plan would provide the overall assumptions on which the other plan elements would rest." While in the early sixties the land use aspect may have been fundamental to the comprehensive plan, it is now
dominant. In federal regulation, the comprehensive, general, and land use plans have been consolidated. For example, in the section of the Code of Federal Regulations pertaining to the Regional Transportation Plan (long-term), the law states that "the plan shall...reflect, to the extent to which they exist, consideration of the area’s comprehensive long range land use plan and metropolitan development objectives" (emphasis added).

In addition, it is crucial to note the role of the comprehensive plan in offering direction to other planning activities. Innes, in the excerpt above and the language in the Code of Federal Regulations connote the deference that is given to the comprehensive plan with respect to overall goals and objectives. The general sense is that the comprehensive plan should represent how the region perceives its future.

The ISTEA Family of Plans

In 1991, the Intermodal Surface Transportation Efficiency Act (ISTEA, pronounced “Iced Tea”) restructured the planning community and reshaped the discourse of regional planning. ISTEA based the planning process on a set of plans to be produced at the state and metropolitan level; further, it promoted the centrality of the Metropolitan Planning Organization (MPO) for generating the urban transportation plans. Because they vary substantially from city to city, there is no specific definition for the MPO. Most are Councils of Government that are directed by a set of locally-elected officials from around the region. MPOs provide area-wide planning services, research, coordination between different levels of government and maintain both a technical and coordinating role in the planning environment. The table below illustrates the set of four plans mandated by ISTEA, at the state and metro levels and over short- and long-term planning horizons.

-62-
ISTEA is authorizing legislation: it establishes funding levels that must be fulfilled by appropriations decisions annually for monies actually to be available. Surface transportation laws determine how federal funding is distributed among the states and the set of plans described above reflects the role of federal money as a preeminent variable. This reinforces the importance of the fifty states in transportation planning because federal monies are distributed to the states on the basis of formulae designed in the legislative process. The states then distribute the money to municipalities and other jurisdictions based on Statewide policy.

The importance of the Transportation Improvement Program (TIP) also reflects the importance of fiscal distributions as it represents a funding request from state and federal coffers for local projects. The State Transportation Improvement Program (STIP), as an aggregation of TIPs, represents the overall state transportation investment budget proposal. The long-term plans provide the policy guidance on which basis the two improvement programs are evaluated. Thus, the term "consistency doctrine" refers to the pattern of checks and balances among the plans that is designed to ensure that transportation investments throughout each region and the state reflect the same planning ideals and objectives. This is largely the same approach that Innes (1996) points to in the context of the comprehensive plan, which does indeed guide each of these plans from an even higher level. Degrove (1992) illustrates examples of horizontal consistency, where plans of different government bodies for the same area must be in line (Portland, Oregon), and vertical consistency, where plans from multiple levels of government, such as local, regional and state, must share agendas (Florida, New Jersey).
Given the relationships among these four types of plans mandated by ISTEA, the discussion can now turn to more detailed introductions of each planning document and the supporting process. Figure 5.1, below, illustrates the relationships among the plans, showing how the STP guides each RTP, how the successive TIPs carry out the objectives of the RTP and how the STIP, as the compilation of regional TIPs, analogously implement the goals of the STP, creating a cycle.

![Figure 5.1: Relationships Among ISTEA Plans](image)

**TRANSPORTATION IMPROVEMENT PROGRAM**

*The Transportation Improvement Program (TIP) is an annually prepared report that contains the highway, transit, bicycle/pedestrian, and other transportation projects being recommended for implementation during the next three to five years for a given metropolitan area. Thus, the TIP is intended to be a short-range programming document.*

-Wisconsin DOT Guidance Document

*The TIP is the agreed upon list of specific priority projects. The TIP lists all projects that intend to use federal funds, along with non-federally funded projects that are regionally significant. The TIP represents the transportation improvement priorities...The list is multi-modal: in addition to the more traditional highway and public transit projects, it includes bicycle, pedestrian and freight related projects as well.*

-Delaware Valley Regional Planning Commission (Philadelphia MPO) Guidance

The TIP is prepared by the MPO at least every two years and must have a scope of at least three years. Some jurisdictions, including those in Wisconsin by State law, produce an
annual plan. Projects beyond the required three year horizon are considered “informational” and are non-binding. Substantively, any project included in the TIP must be “regionally significant” and must be consistent with the Regional Transportation Plan. Any project seeking federal financing must be included. The inclusion of projects that assist other plans, such as the State Implementation Plan for air quality, is done so on an informational basis.

As the Philadelphia MPO guidance comment suggests, a major change brought about by ISTEA was the emphasis on fiscal constraint in the project proposal process. Whereas State Departments of Transportation previously published so-called “wish lists” for transportation investments, the TIP process requires the MPO to consider specific categories of funding available from the federal government through the state. The actual TIP document must present the projects in funding source categories to highlight the demand from specific disbursement programs, such as the Surface Transportation Program or the Congestion Mitigation and Air Quality initiative. Projects must also be separately categorized according to project type, such as construction, utility, preservation, etc.

With respect to stakeholders, it is important to note that the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) do not participate in approval (or disapproval) of the TIP. FHWA and FTA are involved in the RPA when the region does not meet air quality standards (see Chapter 6). In order for a project to be included in the TIP, it must first acquire local approval and then be brought to the MPO by a member of its TIP committee or council. The local approval process is supposed to provide ample opportunity for input from the public and from local officials. Once that approval is obtained and the delegate nominates it, the MPO considers its relationship to current planning principles, as well as state
and federal guidance. Participation on that committee by representatives of different localities and agencies should assure the balancing of perspectives on each proposal.

**Regional Transportation Plan**

*The metropolitan transportation planning process shall include the development of a transportation plan addressing at least a twenty year planning horizon. The plan shall include both long-range and short-range strategies/actions that lead to the development of an integrated intermodal transportation system that facilitates the efficient movement of people and goods.*

-Code of Federal Regulations
Title 23, Section 450.322(a)

This policy statement, drawn from the ISTEA legislation, indicates the role of the Regional Transportation Plan (RTP) as a guidance document for the more pragmatic TIP, which shares the same geographic (i.e., metropolitan) scope. The plan, which must have a horizon of at least 20 years, is revised every three years for cities in non-attainment zones and every five years for those metropolises that do not violate air quality standards.

The guidance is based on a set of approximately two-dozen federally designed factors outlined in the ISTEA legislation that were subsequently compressed into seven in TEA-21. The factors loosely represent criteria on which plans and proposals can be evaluated. This is another clear example of the consistency doctrine mentioned earlier. Two examples of these factors include:

- (#18) Long-range needs of the State transportation system for movement of people and goods.
- (#3) Strategies for incorporating bicycle transportation facilities and pedestrian walkways in appropriate projects throughout the state.
These two examples of the ISTEA factors illustrate the goal-oriented nature of the RTP. The plan provides a trajectory of transportation investments over two decades from which projects are drawn for each successive TIP. Extensive public participation in the RTP process, relative to many other planning exercises, increases the realistic influence of the populace over the TIP, which must be consistent with the RTP. Thus, where it may be impractical to conduct major public outreach for each annual TIP, it may be very reasonable to have extensive general participation in producing the RTP and subsequently emphasize the consistency doctrine.

STATE TRANSPORTATION IMPROVEMENT PROGRAM

State Transportation Improvement Program means a staged, multiyear, statewide, intermodal program of transportation projects which is consistent with the statewide transportation plan and planning processes and metropolitan plans, TIPS and processes.

-Code of Federal Regulations
Title 23, Section 450.104

As the title suggests, the STIP is for the state what the TIP is for the metropolitan region. The STIP includes TIPs produced by MPOs as well as their non-metropolitan equivalents developed by other local entities, such as Regional Transportation or Planning Councils. For the area not covered by these plans or other special districts such as Indian Reservations, States independently draft project priorities such that the STIP represents an aggregation of TIPs and other similar documents. One implication of this is that the stakeholders of the STIP activity include more than MPOs and other types of regional councils.

As with the TIP, the STIP must be produced at least biennially and has a 3-5 year planning horizon. The STIP shares with the State Transportation Plan (see below) the same relationship that is held by the TIP with the RTP. The approved STIP represents the plan for
disbursing state and federal transportation funding for projects of different types (construction, etc.) and funding sources (the Congestion Mitigation and Air Quality Program, e.g.). The inclusion of TIPs and other plans in the STIP requires the approval of the Governor and State Secretary of Transportation and requires approval at the MPO level. In the cases of plans from non-attainment zones, only TIPs for which FHWA and FTA have approved conformity with the air quality plan may be included.

Where the State is developing new project priorities, analogous to the TIP process, TIP-like public involvement is necessary. For the aggregation of approved TIPs and other plans, however, there are no stakeholders other than the Governor, and a few others, as described. From an institutional perspective, therefore, the construction of the STIP is relatively unextraordinary.

STATE TRANSPORTATION PLAN

[A] long-range plan covering all modes of transportation, coordinated with the transportation planning carried out in metropolitan areas, with opportunity for public comment...to provide for the development of transportation facilities that functioned as an intermodal state transportation system.


In a sense, the State Transportation Plan (STP) is the most important step in translating vast quantities of federal legislation and guidance into terms that may influence the development of local plans and therefore the unfolding of transportation systems in metropolitan and other areas. The State Transportation Plan acts as a policy guidance document for the STIP, just as the RTP does for the TIP at the regional level. One of the most obvious similarities between the STP and RTP is the schedule, which also includes a 20+ year planning horizon and a 3-5 year cycle of production.
The STP presents an opportunity to create a balance. Whereas the guidance formed with substantial public participation at the local level comprises the RTP, the STP is more heavily influenced by the legislation and DOT-issued guidance. Thus, the combined influence of the RTP and STP on the more pragmatic TIP and STIP requires projects to be consistent with the theory that drives the planning process from ISTE A and the demands of the local constituents in different areas.

**UNIFIED TRANSPORTATION WORK PROGRAM**

_The Unified Transportation Work Program (UTWP) shall... (1) Discuss the planning priorities facing the metropolitan planning area and describe all metropolitan transportation and transportation-related air quality planning activities...anticipated within the area during the next one or two year period, regardless of funding sources or agencies conducting activities, in sufficient detail to indicate who will perform the work, the schedule for completing it and the products that will be produced; (2) Document planning activities to be performed with funds provided under...the Federal Transit Act_.

-Code of Federal Regulations
Title 23, Section 450.314(a)

Although it is not a transportation plan and therefore not obviously a part of the RPA, it is clear that the framers of ISTE A felt that this endeavor required substantial attention by relevant institutions and therefore it seems fitting for inclusion in this discussion. It is relevant to note in this section that ISTE A relies on self-certification by each of the MPOs with respect to implementation of the planning process. The production of the Work Program provides supervisory agents a means for observing the process. The importance of this plan is indicated by the penalty associated with failing to complete the self-certification process in two consecutive years: a 20% withholding of transportation funding.
Project Planning

Throughout this chapter, the discussion has revolved around various plans, all of which include the use of policy objectives and guidance to sort through, prioritize and promote individual projects. This section examines how those projects – the kernels of the other plans – emerge and acquire substance and shape. The Philadelphia MPO points out in a guidance document that the first three steps of the TIP process are: to identify specific transportation needs; to generate local approval for each proposal; and, for a delegate to the MPO council to nominate the project for consideration. The important point is that a significant amount of effort is invested before the MPO and operating agencies receive individual project nominations.

In the TIP, projects are categorized in two important ways. First, the type of project is important. A crucial distinction in this regard is between preservation and expansion projects. The latter demand more substantial attention and review because of prospective environmental impact and other changes associated with major system alteration. Specific projects types include construction, Right-Of-Way acquisition, utility improvements and so forth. Second, the funding source is important. Above the State level, it must be clear how quantities of money from different transportation funds are being spent in each state. This may be determined by national or State appropriations. Because of this difference, certain projects can be excluded from the TIP despite regional significance or other reasons if their funding source is from a different source or program.

The Major Investment Study (MIS) is a substantial element of the pre-TIP work involved in this process. The MIS places an emphasis on evaluating alternatives for addressing the identified transportation need, as mentioned above. The study identifies alternatives for the mode, the alignment, facility characteristics (number of lanes, e.g.) and other variables. Relevant
law requires opportunities for citizen involvement in this process, especially when alternatives and combinations thereof are being considered.

The concept of regional significance has been brought up in earlier sections. ISTEA requires that the TIP include all “regionally significant” project proposals. It is possible that the TIP will include projects that do not fit into this characterization because despite the small scale or local nature, it may receive federal funding. Transportation Control Measures and other clean air related projects, regardless of regional significance, are also included. The WisDOT guidance (1994) document provides this definition, which is only slightly paraphrased from the national legislation:

A regionally significant project is any facility with an arterial, plus any other facility that serves regional travel needs (such as access to and from the area outside of the region, to major activity centers in the region, or to transportation terminals) and would normally be included in the modeling for the transportation network.

Stage 2: Analyze Each Plan

Methodological Points: Adapting Pendleton’s Process for the RPA

The second stage of Pendleton’s protocol is the development of the architecture for each service that comprises the regional architecture. In this context, individual plan architectures are developed prior to the construction of the RPA. The difference between services and plans requires some adjustment to the architecture construction process. For ITS services, Pendleton prescribes five steps:

1. Identify subsystems and flows,
2. Map subsystems and flows to the physical architecture,
3. Identify the institutions,
4. Classify the institutional relationships,
5. Build the service architecture.
Non-ITS services, in contrast, lack the first two steps because the absence of data in the non-ITS context renders them irrelevant.

For the application to plans, rather than services, it seems appropriate to make a compromise between these two variations. First, many relationships within the RPA rely on exchange of data and information. Second, the subsystems concept can be beneficially adapted to the planning context. Thus, step 1 has a place in the RPA protocol. Step 2, however, is less relevant, because the 'physical architecture' concept does not apply to the planning context. Therefore, stage 2 in the RPA protocol should include 4 rather than five steps:

Step 1: Identify the Subsystems
Step 2: Identify the Institutions
Step 3: Classify the Institutional Relationships
Step 4: Build the Planning Architecture.

Indeed, these steps are the basis of the plan analysis that follows in the remainder of this chapter. One variation is that the construction of planning architectures is put off until all of the plans have been discussed, at which point the full RPA is presented.

An Illustrative Case Study for the RPA

The use of a fictional case study allowed Pendleton to illustrate the validity of the RSA framework in a simplified metropolitan area that had a limited number of municipalities and other straightforward characteristics. The case study proved useful as an example, however, and the same approach has been adopted here. In this case, the demonstration of the revised framework for the planning context adopts the MPO from a major metropolitan area in order to illustrate how Regional Planning Architectures can describe an existing planning program. That MPO is the North Jersey Transportation Planning Authority (NJTPA) with a primary focus is on the Transportation Improvement Program. NJTPA’s jurisdiction covers the New Jersey
component of New York City’s “commuter-shed,” which also includes suburban New York as well as southwestern Connecticut.

Transportation Improvement Program

Introduction

As described earlier in this chapter, the TIP is a short-term, annual planning product that approves state or federal investment in regional transportation investments. As a regional planning document, it is primarily the responsibility of the MPO to administer its production. The regulatory requirement placed on the TIP is that it carries out the goals of the long-term Regional Transportation Plan, which is also developed by the MPO. Overall, the TIP process is based on short-term needs assessment and investment prioritization in order to address the larger planning goals established by the RTP. It is important to note that the production of each TIP incorporates lessons learned from previous TIP experiences.

Identify the Subsystems

SUBSYSTEM 1: PROJECT IDENTIFICATION

Potential projects are brought to the attention of the NJTPA through two general means. In the first case, the MPO conducts a variety of forecasting exercises that produce scenarios. The MPO uses these scenarios to develop its own set of initiatives that address potential problems. In the second case, those stakeholders are able to submit project concepts to the MPO through a process of local nomination. NJTPA’s Board of Trustees includes representatives of the 13 counties and 2 cities within the region as well as an official from the state DOT, New Jersey.

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In adopting this approach, the author has obtained the most recent planning documents (TIP, STIP, RTP, STP, UTWP) and the application of the framework to this set of plans represents original analysis.
Transit, The New York – New Jersey Port Authority, a proxy for the Governor and a citizen representative (nominated by the Governor). Each of these stakeholders can nominate transportation issues from around the region. Each Trustee may depend on some process of deliberation with his constituents including referenda. Alternatively, some delegates may be susceptible to influence by special interests and organizations.

**SUBSYSTEM 2: STUDYING OPTIONS**

The implementing agencies, of which the New Jersey Department of Transportation and NJ Transit are key examples, conduct assessments of the projects identified in the first subsystem. Project concepts that demonstrate a need for further study, consistency with other plans, and no overlap with existing projects or programs become Project Proposals. Any project ideas that fail any of these criteria are discarded from the process. Subsequently the implementing agencies rank the project proposals and discard those projects that do not possess adequate appeal. The agencies then conduct feasibility analyses based on engineering, environmental, financial, historic preservation and public support factors. Projects that do not meet the feasibility requirements in any category are discarded. Finally, the Agencies determine the “level of action” needed to accommodate requirements of the National Environmental Policy Act (NEPA). Projects that pass through this gauntlet are eligible for TIP funding.

In tandem with this process, NJTPA maintains a “Local Scoping and Lead Program” that utilizes NJTPA resources to identify and develop projects of specific local interest from the initial conceptualization stage through the NEPA determination.
SUBSYSTEM 3: SELECTING/PRIORITIZING PROJECTS

NJTPA receives the set of project proposals that have completed the steps contained in Subsystem 2 (above). In each TIP cycle, the Authority also considers projects from previous TIPs as well as other old proposals that were eligible but not included in the TIP. At this point the projects selected by the MPO are distinguished from the projects supported by legal mandates, such as the Americans with Disabilities Act. In this subsystem the MPO adopts a planning methodology, which includes decision criteria, for prioritizing the project pool. It also applies planning goals and considers additional factors, in this case deliverability, serviceability, and fundability. Based on these sets of criteria, NJTPA selects the prioritized project pool to the Implementing Agencies.

The different sets of criteria are derived from different sources of guidance of which the longer-term Regional Transportation Plan is a key example. This plan establishes long-range mobility goals for the region. In NJTPA’s case, the long-term scope has produced six planning goals that are designed to guide planning decisions. These goals are:

- **Environmental Quality**: Protect and improve the quality of natural ecosystems and the human environment.
- **User Responsiveness**: Provide affordable, accessible, and dynamic transportation systems responsive to current and future customers.
- **Economic Vitality**: Retain and increase economic activity and competitiveness.
- **Land Use Transportation Planning**: Select transportation investments that support the coordination of land use with transportation systems.
- **System Coordination**: Enhance system coordination, efficiency and intermodal connectivity.
- **Repair Maintenance Safety**: Maintain a safe and reliable transportation system in a state of good repair.

This connection between the TIP and other plans incorporates the participation of stakeholders indirectly. The Governor, for example, influences development of the TIP through his representative on the board of trustees at the MPO but now also through her influence over
the Statewide Transportation Plan, which contributes to the goal formulation. Similarly a substantial amount of public outreach was involved in developing the goals and thereby the public has the opportunity to be (indirectly) involved in the prioritization of project investments.

**Subsystem 4: Adopting Projects**

On the basis of the prioritized project pool produced by the MPO Board of Trustees, the Implementing Agencies formulate Capital Construction Programs (CCPs) for their own activities, such as highway and transit in the cases of NJDOT and NJ Transit, respectively. The MPO then endorses the CCPs and with those generates a fiscally constrained draft TIP. The fiscal constraint refers to the requirement created in ISTEA that the final project list be constrained by available funding sources in type and quantity. The stakeholder impact appears in the subsequent subsystem. The draft TIP receives public comment and that is incorporated into the final TIP, which requires approval by the MPO Board of Trustees. The TIP also must receive approval from FHWA and FTA.

**Subsystem 5: Appropriations**

As mentioned, ISTEA required that all TIPs be fiscally constrained, meaning that each project included in the TIP had to identify the specific funding program and needed funding level. Thus the TIP presents the total request to different State and national coffers. Part of the appropriations process is the aggregation of TIPs from around the state into the State TIP, which requires approval by the Governor. The state and national legislative branches therefore have influence over transportation investments by determining appropriations from the different funding sources to the districts. To the extent that these decisions hold legislators publicly
accountable, this step provides an additional connection between the process and the general populace.

Identify the Institutions

From the description of the TIP process and subsystems above, it is clear that the MPO and Implementing Agencies are the focal points of the network of active institutions. NJTPA (the Authority), as mentioned, has a Board of Trustees that is made up of 15 geographically-based representatives, a citizen representative, a representative of the Governor and delegates from NJ DOT, NJ Transit and the Port Authority. The Authority also has three functional committees whose membership is drawn from the board of trustees: Planning, Project Prioritization and Economic Development. There is also the Regional Transportation Advisory Committee (R-TAC).

The Project Prioritization Committee is obviously a critical institution in the TIP process, particularly with respect to the prioritization subsystem. R-TAC plays a central role in formulating the goals and other criteria that are used in the prioritization process. The other committees, Economic Development and Planning, are influential in preparing the forecasts that motivate many of the project identifications at the beginning of the process.

As described, NJ DOT and NJ Transit are the main Implementation Agencies whose role in the option assessment subsystem (#2) is very important. There are other agencies with implementation responsibilities, such as The Port Authority of New York and New Jersey, the New Jersey Turnpike Authority, and the New Jersey Highway Authority (which runs the Garden State Parkway). Other related interests include the New Jersey Office of State Planning, neighboring MPOs (Delaware Valley Regional Planning Commission for the Philadelphia Metro
Area and the South Jersey Transportation Planning Organization for the balance of the state). Finally, there is the populace and sets of organized interests such as builders associations, labor unions, environmental advocacy groups and so forth. There is also an extensive network of planners, engineers and officials in the “sub-regional” public sector. The “Local Scoping and Lead Program,” for example, links NJTPA resources to these planning entities in order to address local issues that otherwise do not have access to adequate planning facilities for project development.

To this point, the identification of institutions has focused on those entities immediately involved in the TIP process. In part because New Jersey has a state planning law that emphasizes horizontal consistency but also more universally, certain aspects of the framework indicate opportunities for interests in other jurisdictions (regions) to influence policy decisions in the northern Jersey area. Specifically, because the goals that determine the prioritization emerge from the Statewide Transportation Plan and its activities the NJTPA TIP is influenced by so-called “outside interests.” This reflects the extent to which it is difficult to draw definitive boundaries around a metropolitan area.

Classify the Institutional Relationships

A central observation on institutional relationships is that two of the subsystems, option assessment and prioritization, are dominated by one of two institutions each: NJTPA and DOT/NJ Transit, respectively. One implication of this is that each subsystem reflects a different perspective. The initial step (project identification) is regionally based with proposals being prioritized within each jurisdiction within the region. In the second step (option assessment), the implementing agencies establish priorities in the project pool based on their functional agendas.
In the third step (prioritization), the MPO committee applies the principles and goals established through an extensive outreach and communication program. In the fourth step (adoption), the different entities interact through a set of checks and balances (public comment period, e.g.). Finally in the fifth step (appropriations), the legislature and governor exercise their judgement on behalf of the public for investment decisions.

The overarching philosophy of this structure is that each task is assigned to an institution (or several) that achieves its objective based on its primary expertise. The Implementing Agencies apply functional analysis; the MPO manages goals, objectives and principles. As it is presented, the clear preeminence of a distinct institution in each subsystem limits continuous horizontal integration of agendas but also facilitates it as each step leads to the next. In that sense, by the final product, every stakeholder has participated although with potentially limited direct interaction or debate.

The State Transportation Improvement Program (STIP)

Introduction

After the TIP, the State Transportation Improvement Program (STIP) process is straightforward. The purpose of the STIP is to link the combination of regional plans throughout the state with state and federal transportation financial resources provided by a set of funds and specific allocations. This activity provides an opportunity to confirm that transportation investments are consistent with state goals and priorities. These two activities, fiscal matching and statewide consistency, are the subsystems of the STIP process. As with the TIP, the STIP has a 3-year minimum horizon and is updated annually.
Identify the Subsystems

SUBSYSTEM 1: MATCHING FINANCIAL DEMAND AND SUPPLY

The State Transportation Improvement Program is the aggregation of all metropolitan TIPs within the state, which includes other regional investment programs as well as direct state expenditures. Because of the intensity of infrastructure in urban areas, the MPO TIPs are likely to be the dominant element in the STIP. The fiscal matching subsystem identifies the available financial resources from federal and state funding sources and compares them with solicitations made by each of TIPs. It is important to note that each TIP is required to be financially constrained and has to identify funding sources.

Under ISTEA, the major funding sources include Federal Aid Highway (Title 23), which includes the Interstate System and the National Highway System (or Surface Transportation Program), and Federal Transit Assistance (Title 49). The Interstate System includes Interstate completion, substitution and maintenance. The Surface Transportation Program establishes minimum allocation requirements for urban, rural and other parts of each state as well as enhancement and safety activities. There are also several specific “equity adjustment” categories that include minimum allocation, donor state bonus and others. The Congestion Mitigation and Air Quality Improvement Program (available in non-attainment or maintenance areas), the Bridge Replacement and Rehabilitation Program, the Federal Lands Highways Program, and demonstration projects are other specific areas. One should note that Demonstration Project funds did not have to pass the prioritization elements of the TIP process because the funds are already dedicated.

As dictated by ISTEA, the state should give each MPO a reasonable estimate of expected funds for the upcoming authorization. Unless the actual authorization differs greatly from the
estimate, the state can directly incorporate the TIP without any alteration. In general, the input provided by the state to the region occurs in the form of goals in the State Transportation Plan that are incorporated in the Regional Transportation Plan that therefore influence the TIP. The State, through the Secretary of Transportation, may establish some policy based on general desired funding allocations to different activities such as rehabilitation, new construction or between highway and transit.

A final note is that the FHWA and FTA have the right to disapprove of the STIP or the process that produced it. In this case, if the problems cannot be immediately remedied, the Administrations can approve operating assistance to sustain ongoing activities. The purpose of the approval is to allow the Administrations to ensure that the funds provided through the different programs (Interstate, STP, etc.) are being allocated as Congress envisioned.

**SUBSYSTEM 2: CONSISTENCY WITH STATEWIDE PLANNING GOALS**

The STIP shares the same relationship with the Statewide Transportation Plan (STP) that the TIP does with the RTP. Furthermore, just as the TIP is only approved when the projects included therein are consistent with the regional planning goals, the STIP is only authorized by the Secretary of the State DOT when all of the expenditures are found to be consistent with statewide planning goals.

This element of the process primarily relies on conformity with the goals being established at the regional level. As noted earlier, projects are only included in a TIP when they match the goals of the RTP, which are adapted or taken directly from the STP. Thus, any projects proposed for inclusion in the STIP should already be in line with the STP. The provision primarily addresses projects that do not go through a regional planning process. It also provides
for some level of equality across multiple metropolitan regions as well as rural areas within one state.

There is no explicit protocol in this subsystem as there is in others, particularly within the TIP but the role of public involvement is certainly an important element. The consistency provision exists to ensure that statewide investments are on par with statewide goals, which are formulated based on the interests of the voting public through the Governor and her administration. By including public involvement and comment at the statewide level, the process allows individuals to address concerns about the externalities imposed by actions in one part of the state or region on another. Such horizontal accountability is an important part of the consistency principle emphasized in this subsystem.

 Identify the Institutions

The state DOT is the hub of the STIP; the process relies on communication with that agency and the institutions involved in producing the regional TIPs. In addition to providing the initial input, these institutions outside of the DOT provide feedback for changes made during the draft STIP production and the revision process. When questions arise over local expenditures, perhaps at public meetings, these local administrators must represent their own interests. The process is designed to encounter minimal conflicts such as these, however, so in successful instances, the DOT should be on its own to produce the STIP and earn approval from the administrators of the FHWA and FTA. One should consider legislatures important constituents of this process because of their ability to dictate the allocations of state and federal funds for different purposes. By establishing the funding levels in different categories, they can shape state and therefore regional transportation spending.
There are additional relevant parties that are involved indirectly. Because the STIP is approved based on consistency with statewide goals, one must consider the advocates of those goals, who may be other agencies or special interest groups. For example, the Americans with Disabilities Act motivates one aspect of statewide transportation goals. Therefore, advocacy groups are likely to be vigilant in ensuring that adequate funds are authorized and appropriated for expenditure on providing access for disabled persons. Another example in this category are the agencies and organizations interested in any flexible sources of funding. For example, ISTEA may establish minimum allocations to transit but allow additional highway money to be spent on transit services. As a result the transit agencies within the state and related lobby groups will attempt to influence the distribution of funds at the point when the DOT informs the MPO about expected funding levels in each category.

**Classify the Institutional Relationships**

Clearly, the State DOT is the central player in this activity. MPOs, other local governments and the DOT itself submit requests for funding in the form of TIPs and related documents. The state, through multiple agencies, provides input in the form of statewide goals that are represented by the Statewide Transportation Plan. Legislators participate by establishing rules and process for the allocation of funds, often exercising an agenda in favor of certain spending purposes. Interest groups attempt to influence the process in order to divert extra spending in the direction of their interests. Overall, while the extent of pressure and attention-getting may seem to encumber the process, the magnitude of participation enhances the opportunity to ensure that there is consistency between the goals articulated in another plan and the way that measures to address those goals are supported financially. A final and important
institutional relationship is between the state DOT and the FHWA/FTA, which have the power to decline a STIP and therefore provide a check on how the funds were intended to be spent and how they are actually being spent.

Long-term Plans: STP and RTP

Introduction

The ISTEA planning process depends on the Statewide Transportation Plan (STP) and the Regional Transportation Plan (RTP) as the core documents for envisioning the future of mobility and accessibility in the relevant area. The STIP and TIP, in abstract, represent the measures that the operating agencies will take in order to pursue the goals established by the STP and RTP, respectively. Each Plan has a 20-year time horizon and must be updated periodically to reflect the progress accomplished during the interval and the evolution of the goals. Thus the major activities associated with each include assessing and forecasting the supply of and demand for transportation infrastructure and services as well as an articulation of transportation goals for the region.

That the goals articulated in the RTP are adopted from the STP follows from the STP being the beginning of the planning cycle. The STP recognizes goals, objectives and priorities established under other acts or policies that are relevant to transportation planning and incorporates them as needed. The Clean Air Act and Americans with Disabilities Act are good examples of these. Special to New Jersey, the State Development and Redevelopment Act is an important example because it designates development goals for municipalities and therefore creates distinct objectives for specific corridors and elements of infrastructure. By identifying these related goals at the statewide level, the process ensures that each regional plan will
recognize the efforts of neighboring jurisdictions and incorporate their prospective impacts when appropriate.

Because the STP and RTP processes are inherently similar, it is only necessary to elaborate one. Given the metropolitan orientation of this research, the RTP therefore occupies the spotlight in this context.

An important difference between the construction of the TIP and RTP architectures is that whereas the TIP process is highly protocol-oriented, the production of the RTP has less of a clearly defined procedure. As the following discussion explains, there are two subsystems within which there are categorical activities but no specific steps. On one hand, this has to do with the fact that the RTP is produced every 3 to 5 years rather than annually. While the task is more substantial, the time is less constrained than in the context of the TIP. The reader may be surprised to see less structure in this section than in the treatment of the TIP but it is important to comprehend that the architectures methodology is still very important, valid, and useful.

Identify the Subsystems

**SUBSYSTEM 1: ASSESSMENT AND FORECAST OF MOBILITY AND ACCESSIBILITY CONDITIONS**

The TIP process is based on an understanding of current problems in the transportation system and devising solutions to be implemented in the short term. The thrust of the long-range planning exercise is based on the anticipation of future challenges that can be met preemptively by well-designed TIPs. The responsibility for such modeling exercises falls primarily on the MPO responsible for crafting the RTP. In some cases the actual technical study is carried out by the DOT or the Environmental Agency (where air quality modeling is involved) but many MPOs have developed their own travel forecast model capacity.
Forecasts are based on baseline data including an accurate inventory of current data as well as the historical path. The MPO, therefore, also has the responsibility for maintaining a comprehensive inventory of relevant information pertaining to all aspects of passenger and freight mobility trends. Recall that the MPO is not an operating agency as are NJ DOT, NJ Transit, and the numerous local public works and highway commissions. Because of this, the data available to NJTPA is acquired through communication with other organizations. While it may appear on the surface that this is a simple task of exchange reports or diskettes, in fact such a task requires communication about the format and type of data needed.

For example, Transcom is a regional ITS organization that coordinates transportation services around the New York City metropolitan area including NJTPA's jurisdiction. Transcom collects enormous quantities of real time data almost exclusively on the network of Interstate highways in the region. Simultaneously, state and local transportation or highway departments collect traffic data on their own roads. NJTPA therefore has to integrate these datasets from diverse platforms in order to produce a coordinated assessment of traffic problems in the region. This context provides an excellent demonstration of the nexus between the Regional Services Architecture and Regional Planning Architecture.

The forecasting activities are often accomplished using a generic software product adapted to the local circumstances including jurisdictions, infrastructure, and activities. Some of the major issues that are the subject of the forecasts are population (demographics), auto ownership, and employment. The forecasting exercise is something that is simultaneously conducted on a more qualitative basis by planners throughout the region. Accordingly, the forecasting activity is the subject of extensive inter-agency communication to confirm that the
projections of travel factors accurately reflect the expected trajectories posited by local managers who are familiar with the actual situation.

The output of the forecast is extensively the product of modeling assumptions, including changes in supply (infrastructure, services) and demand (population and jobs, etc.). Therefore, the forecasts provide some indication of what actions are needed to mitigate areas of concern, such as sources of congestion, pollution or inaccessibility and to advocate kinds of solutions that have proven effective. In essence, the forecasts can provide the decision-makers with a set of possible outcomes for which they chose to prescribe investments that later become part of the TIP.

SUBSYSTEM 2: DEVELOPING PRIORITIES AND GOALS

Perhaps the most important role of the RTP is to present a shared vision of the future of the region with respect to mobility and accessibility. The fundamental aspect of this subsystem is the effort to reach consensus among the many decision makers and constituents in the transportation planning community within the MPO’s jurisdiction. If the planner is often said to have two jobs: technical expert and professional mediator, this task is clearly one for the mediator.

In Portland, Oregon, the long-term planning process that has generated respect and admiration throughout the planning community in the last fifteen years is based on extensive public participation. That is just one example of how the development of goals that lead to successful planning programs can be achieved. Again, there is no strict protocol followed in North Jersey, Portland, or anywhere else when it comes to long-term planning. The process is based on the broad and deep involvement of interested parties.
Because long-term planning is so expansive, it may be helpful to divide the work into two categories: input and output. In the first case, the planners are responsible for assimilating the perspectives of an exhaustive set of constituents. Public meetings, comment periods, focus groups and sub-committees are all leading examples of this sort. One might imagine a local environmental group advocating for cleaner air, a historic preservation association requesting respect for certain properties, business groups seeking infrastructure improvements, or rights activists seeking better service for a disadvantaged population. In the same vein, the planning process receives input from other pieces of legislation such as the Clean Air and Americans with Disabilities Acts and the regulatory agencies that represent them.

In addition, planners are responsible for output, namely informing and educating many of these same constituents. The public input process, such as town meetings, provide an opportunity for planners, as technical experts, to inform the public about certain initiatives such as open space preservation or commercial corridors. One of the important outcomes of these efforts is that when specific projects appear in the TIP, residents understand the motivation for those investments based on what they learned during the RTP process.

In both contexts, an important element is the forums in which these interactions occur. The media is a critical link between the planning community and the public. Professional meetings are another link as is direct publicity by the planning authority. From a political perspective, the activity demonstrates benefits to each group and assuages fears about potential or perceived costs.

At the stage in which the goals are concretely defined, the planner is responsible for being aware of how the wording of the goal statements is perceived by interest groups. Goals can be devalued by excessively vague definitions that lose the support of the core supporters but run
the risk of alienating or antagonizing opponents by being too aggressive in their specificity. In other words, the task of articulating a set of six goals, as in the case of NJTPA, from what was undoubtedly a vast field of perspectives, is a daunting one.

Identify the Institutions

The description above has suggested the central role of the MPO in this activity. With input from very many other institutions, including the general public, the MPO has the challenge and responsibility of formulating goals that will guide regional transportation thinking and that will serve as criteria during the prioritization process in the TIP development. With respect to the data collection and forecasting tasks, it is clear that the MPO must exercise its capacity as technical expert in addition to professional mediator in order to fulfill its duty to the region.

The interested parties can be segmented in a variety of ways, of which the following is a straightforward example. There are obviously institutions within the public sector, at the local, state, national and other levels. These institutions will include regulatory and operational agencies, commissions, legislatures and members of the executive branches at state and national level. Some of these have a larger role than others due to relationships with particular legislation. There are also important institutions in the private sector such as businesses and associations, chambers of commerce, and individuals concerned with their place of employment. There is obviously the general public as well as organized groups with special interests and lobbying agendas. There are also non-governmental organizations and sometimes international entities that take a particular interest in the planning process.
Classify the Institutional Relationships

Many of the types of relationships have already been described, including the input or output nature of the link between any of the constituents and the MPO, which is clearly at the center of this topic. In addition, the complexity of data-sharing relationships in the modeling and forecasting subsystem add a very different dimension to this overall process. In that context, there is more interaction among the entities than the predominantly one-way interactions in the goal-development setting. One question that is important to address in each different circumstance is how different entities outside the MPO relate to each other when they sense a need to compete for the planners’ attention. Jockeying among the interest groups may help fuel debate over the critical issues facing the region or they may damage the fragile consensus needed to advance statewide or regional goals.

Build the Regional Planning Architecture

The presentation of the subsystems has been based on the plans, established by ISTEA, that structure the planning process in the United States. The RPA should focus on the institutional relationships that are formed around these activities, which have been identified in the preceding discussion. For each of those relationships, one should note the flow of information, data, or resources between the two or more entities.
The arrangement of the actual forms in this diagram indicates the relationships between the institutions and the plans mandated by ISTEA. The purpose is to de-emphasize the individual plans and instead to focus on the institutions and the connections among them. For example, the MPO is present in the RTP and TIP. The arrow between “State DOT” and “MPO” represents the flow of statewide goals between those institutions as an output of the STP and an input to the RTP. There are important flows within the MPO from one plan to the other, such as the transmission of goals, formulated in the RTP and applied during the TIP.

Perhaps most important feature of this architectural illustration of institutional relationships is the central role of the Metropolitan Planning Organization. The involvement of the implementing agencies as well as the other entities seems to revolve around the MPO. The
depiction also conveys the orientation of this process toward the production of projects. The overall structure of the planning process reflects the fundamental roles of goal formulation, needs assessment and forecasting, solution development and adoption/authorization.

The RPA reflects the duality of the planning profession: the MPO serves several technical functions, especially in the development and evaluation of solutions for specific project problems. The MPO also acts as a mediator in bringing together the interests of each locality within its jurisdiction with the goals developed by the state DOT as well as the funding levels and agenda of the legislature and Congress. Going back to the consistency doctrine, these observations indicate that the RPA is highly effective with respect to the vertical integration of plans at different levels: local, regional, state, and national. The challenge of horizontal consistency among different plans at the regional level, such as those for environmental concerns, is the subject of chapter 6.

**Conclusion**

This chapter represents the first stage in testing the hypotheses presented in the introduction of this thesis; it has demonstrated how one can go about applying regional architecture theory to any U.S. metropolitan area. The product of this exercise, the illustration of the RPA in Figure 5.2, represents a template that can be recast to suit the circumstances of a specific metropolitan region, such as North Jersey.
One important point is that the individual subsystems of the four different plans merged during the integration of the plans into the RPA. The major subsystems of the full architecture include:

- formulation of goals,
- provision of data and forecasts,
- incorporation of public comment and local feedback,
- identification of needs,
- articulation of responses,
- prioritization of investments (based on the goals),
- matching of demand for and supply of funding

These subsystems point to the fact that between any two institutions, there are five things that can be communicated or shared:

1. data
2. goals
3. money
4. project needs/ideas/solutions
5. approvals

For example, between the MPO and Congress, the link carries demonstration project requests and, via the state legislature, funding levels for different types of projects. Comparably, the link between the state DOT and the MPO carries goals.

Thus, the task of constructing a basic descriptive Regional Planning Architecture consists of using these five areas of common interaction to characterize institutional relationships. This can be used as a diagnostic tool when one expects certain links between institutions to exist. For example, ISTEA depends on higher levels of the federal system providing guidance, through goal statements, to the lower institutions. If one did not observe goals being communicated by the state DOT to the MPO, one might identify a possible shortcoming in the metropolitan governance under consideration. In order to use the RPA for prescriptive purposes, the analyst would have to possess a sense of how specific elements of the RPA should appear in order to compare the observed relationships with the ideal form.
The next chapter applies the same RPA methodology to the National Environmental Protection Act and the Clean Air Act in order to expand the RPA to include environmental plans. This will enhance the RPA's ability to address the full set of planning relationships in a metropolitan region.
Chapter 6: Introducing Environmental Plans to the Regional Planning Architecture

Introduction

In the United States in the 1960s, environment joined other major social concerns in an era of public activism that changed many aspects of society and politics. In 1969, the National Environmental Policy Act (NEPA) was passed by the U.S. Congress; NEPA required any major federal action to consider more environmentally benign alternatives before proceeding. This included many transportation projects, including the latter stages of the Interstate Highway construction era.

Following NEPA, other major environmental laws include the Clean Water Act (1972), Clean Air Act (1970), Resource Conservation and Reclamation Act (1976), the Endangered Species Act (1973), as major examples. Together with the creation of the Environmental Protection Agency in the early 1970s, these laws influenced, as intended, almost every area of activity in American society.

Chapter 2, “Transportation and the Environment,” examined the substantive issues underlying the link between transportation and the environment, including discussions of the relevant policy items. The purpose of this chapter is to examine the structure and function of NEPA and the Clean Air Act in the terms of the Regional Architectures methodology. By integrating the environmental plan architectures with the RPA developed in the previous chapter, it will be possible to examine the complete regional architecture, including the Regional Service Architecture as well. This discussion proceeds by applying the same protocol used for building the RPA to NEPA and the Clean Air Act. At the end of the chapter, the architectures of these two plans will be integrated into the RPA presented at the end of chapter 5.
The National Environmental Policy Act

Introduction

The era of massive highway construction initiated by the creation of the Interstate Highway System eventually led to large-scale opposition to major infrastructure installations by community activists. Called the “anti-highway revolt” by some, the wave of citizen participation prompted a legislative response to make the Department of Transportation responsive to this concern. Earlier in 1969, the Federal Highway Administration published a memorandum that required a two-stage public involvement process in project development. The first of two hearings focused on the need for and location of a proposed highway facility. The second, later in the project development, focused on specific alignment issues and design characteristics.

NEPA formalized the link between such construction projects and the impact on the environment. NEPA is not specifically an air quality, wetland, water, open space, or species protection bill; its goal is to require the responsible agency to consider all possible environmental impacts and, when appropriate, to consider more benign alternative paths to the same objective. In order for NEPA to apply, the project or action in question must be major, federal, and have a clear impact on the environment.

Identify the Subsystems

SUBSYSTEM 1: ENVIRONMENTAL ASSESSMENT

The first step in the process established by NEPA is the Environmental Assessment (EA), which produces a document referred to by the same name. The EA report is a brief (10-15 pages) public document that summarizes the essential issues relevant to the potential environmental

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impact of the project. The reason for the EA’s existence is that the Environmental Impact Statement (EIS, subsystem 2) is very time and cost intensive. If the EA reveals that there is no major impact, it avoids the cost of having to go through an entire EIS to arrive at the same conclusion.

The EA establishes the need for the proposed action as well as alternatives and provides a basic view of the environmental impacts of each option. The document assesses the set of agencies and individuals involved in the EA process, which is an initial indication of the stakeholder group for the full process. If the EA reveals potential impacts, the implementing agency is required to conduct a full EIS. If the agency finds that impacts are insufficient to warrant that course, it issues a Finding Of No Significant Impact (FONSI).

The FONSI is also a public document and can be appealed by concerned parties. If an anti-highway coalition or any other entity disagreed with the DOT’s FONSI, it could file a suit. The court evaluates such cases based on the “arbitrary and capricious” action standard. That is, if the court finds that the implementing agency reached the FONSI conclusion in an arbitrary or capricious manner, its conclusion is nullified and an EIS is required.

The Environmental Assessment, as a public document, is subject to a public comment period, especially if it produces a FONSI. The hearings and comments sometimes reveal critical issues that the EA did not unearth and that sometimes resolve conflict or sources of confusion. NEPA created the President’s Council on Environmental Quality (CEQ) to administer NEPA and to oversee related rulemaking by agencies such as DOT.
SUBSYSTEM 2: ALTERNATIVE ANALYSIS

If by the agency’s finding or as the result of a court appeal, the Environmental Assessment leads to an Environmental Impact Statement (EIS), the process of alternatives analysis begins. The EIS is a comprehensive assessment that is often 200-800 pages and must be sufficiently technical for scientific analysis but also adequately clear for the lay person to understand in the public comment period. The process begins when the “Notice of Intent” is publicly released, informing any interested party of the schedule of hearings, reviews, and activities planned for the analysis period.

Following the Notice of Intent, the Lead Agency initiates the Scoping Process, which requires it to perform certain tasks:

- include a comprehensive set of stakeholders
- determine the set of issues under consideration and the significance of each
- identify and eliminate insignificant issues
- allocate responsibilities to related agencies
- identify related EA’s or EIS’s
- prevent duplication of efforts
- manage the review process relative to the project development schedule

Perhaps the two most important aspects of the EIS process are the identification of alternatives and the assessment of direct and indirect impacts. With respect to the alternatives, the law requires the involved agencies to:

- rigorously explore all reasonable alternatives and explain the reasoning for eliminating any options
- provide a thorough discussion of each fully evaluated option
- include alternatives beyond the normal scope of the lead agency
- include “no-build” alternative
- identify each agency’s preference
- include mitigation measures
The differentiation between direct and indirect impacts is an important one, especially in the context of long-term transportation planning because of the possibility of induced as well as diverted demand for travel on the facility in question. A traditional example of this is the expansion of a facility in order to mitigate congestion and thereby reduce pollution. A byproduct of the improved facility, however, is that travel is more feasible for people who previously preferred to avoid the trip or took a different mode. Thereby the improvement indirectly led to increased pollution.

The alternatives analysis provides an important opportunity to evaluate different mechanisms for achieving the same objective. If, for example, a project is motivated by a need to provide access between an origin-destination pair, it may be crucial to consider a modal alternative, such a train or bus service on dedicated infrastructure, rather than expanding highway capacity.

Identify the Institutions

Because a major goal of the NEPA legislation and the pursuant rules generated by CEQ was the involvement of a comprehensive stakeholder set, the set of involved institutions in this activity can be immense. In addition to the obvious set of public agencies, including federal and state institutions, NEPA makes every attempt to incorporate the public into the process directly or through public comment periods and hearings.

It is important to note that project managers sometimes try to avoid the NEPA review process by turning down federal financial assistance. If this is the case, a project only has to pass the state level environmental review (which is now universal) which may be more lenient. In
those cases, the stakeholder set of the analogous state-level process is likely to be the same but with the absence of the national spotlight and participants.

A participant that has not had any or much of a presence in the other activities discussed here is the court system. The inclusion of judicial review in most environmental analysis legislation around the country introduces a new factor that potentially boosts the position of the individual and coordinated activists in conflict with major state and federal agencies with generally greater resources. While the courts are often less technically sophisticated than most of the defendants and some of the plaintiffs in these cases, the emphasis on the arbitrary and capricious standard allows this participant to ensure that at least the process is working consistently with congressional intent.

*Classify the Institutional Relationships*

NEPA changed the face of project development in the late sixties and early seventies by giving the public and the courts an explicit role in the activities of major governmental institutions that previously had almost unrestrained control in this arena. The loudest opponents of NEPA and its requirements commonly voice a concern that the effort involved detracts from the agency’s ability to achieve its mission. NEPA established a change in mission, however, that incorporated both the growing concern for environmental quality and the widespread demands for greater public involvement in public policy, which were major themes of the times. All of this has required traditional agencies, such as DOT, to expand its horizon to make considerations of issues that were previously off the research and planning radar.
Build the Plan Architecture

This architecture reflects the fact that the EIS process is part of the deployment of projects by the implementing agencies. The prominence of the public in the development of the actual project design reflects two issues: that the public comment period may illuminate options or alternatives that the prior stages of the planning process had missed; and, that the involvement of the public is an important goal of public policy. The participation of the courts does not include any of the major forms of interaction (money, goals, etc.) but does reflect their role as an intermediary to resolve conflicts between the agencies and the public. Overall, the architecture reflects that the EIS process is fundamentally a check on the activity of the implementing agencies and that new inputs are not a major factor. The case is very different in the context of the Clean Air Act, which undergoes the same analysis in the next section.

The Clean Air Act

Introduction

In some environmental arenas, dramatic events led to policy: the Cuyahoga river was so polluted that it actually caught on fire and hazardous waste was found at Love Canal near Niagara Falls, New York. While some major events raised concern about specific air toxics (industrial gases released from a plant in Bhopal, India killed thousands suddenly), the impact of
the basic air pollutants is widespread and gradual. Nonetheless, the Clean Air Act (CAA) was the first major environmental policy to follow NEPA and the first media-specific law. There had been early laws, dating back to the early 1950’s, but none had the scope of the CAA.

The primary mechanism of the Act is the set of six “criteria” pollutants that are used as indicators of overall air quality. For each pollutant, the Environmental Protection Agency (EPA) was responsible for creating National Ambient Air Quality Standards (NAAQS): maximum allowable concentrations of each pollutant in the atmosphere for protecting human health. Secondary standards were also created pertaining to ecological health and agricultural productivity. The standards are monitored on the geographical basis of Air Quality Control Regions (AQCRs), which were created by each state environmental agency. By comparison, the delimitation of metropolitan areas seems to have a simple logic. Indeed, many metropolitan areas have corresponding AQCRs.

Any AQCR in which an excessive concentration of any pollutant is found is labeled to be a “non-attainment zone.” The state is required to develop a plan that will reduce pollution to the point that the region has attained the standard. Thus, a State Implementation Plan (SIP) outlines the actions that are necessary in all of the non-attainment zones within its borders in order to achieve attainment in a certain period of time. Accordingly, the following discussion examines two subsystems involved with the SIP: attainment schedule and strategy selection.

It should be noted that while this discussion addresses only mobile source (transportation related sources), the Clean Air Act is involved with the larger realm of stationary source pollution as well. The policy arena is much different in that context in which the number of entities is much more limited.
Identify the Subsystems

**SUBSYSTEM 1: ATTAINMENT SCHEDULE**

When the Clean Air Act was passed in 1970, it envisioned the NAAQS being established within three months. State Implementation Plans developed within four months after that and the achievement of the standards within three years. These expectations were so grossly out of line with what was feasible that the EPA ended up granting extensive exemptions and extensions such that the credibility of the program was significantly undermined in the early years. Thirty years later, in fact, many AQCR’s, including most of the major urban areas around the country, are still struggling to attain the standards for at least one pollutant.

In its current form, the State Implementation Plan is a twenty-year projection of how air quality will improve and be maintained at a level within conformity with the standard. The plan indicates concentrations of the offending pollutants at various milestone years during that period. The projections are based on models that predict the impact over time of implementing certain technologies and actions (subsystem 2, below).

The SIP is developed by the state environmental agency and must be approved by the EPA. If the EPA does not approve, the state has an opportunity to revise it to the EPA’s satisfaction, after which the federal agency can usurp the state authority and enforce its own acceptable plan.

**SUBSYSTEM 2: STRATEGY SELECTION**

As with environmentally-based transportation planning in general, the two categories of highway-related strategies available include driver behavior and vehicle or fuel technologies. The SIP depends on a combination of these to achieve sustainable reductions in pollution over
the twenty-year horizon, especially in the context of constantly growing Passenger Miles Traveled (PMT) as discussed in Chapter 2. In the thirty year history of the Clean Air Act, the installation of catalytic converters on new vehicles, the tightening of vehicle emission standards, and the reformulation of gasoline (including the elimination of lead) have all made significant contributions to emissions reductions.

In the same amount of time, less has been done to curb growth in VMT, despite efforts from the very beginning to deploy policies influencing driver behavior. The 1990 Clean Air Act Amendments specify 16 types of Transportation Control Measures (TCMs), some of which are explicitly designed to be included in transportation plans and programs.

- Trip Reduction Ordinances
- Vehicle use limitations or restrictions
- Employer-based transportation management
- Improved public transit
- Parking management
- Park and ride or fridge parking facilities
- Flexible work schedules
- Traffic flow improvements
- Area-wide ride sharing incentives
- Major activity centers
- Special event controls
- Bicycling and pedestrian programs
- Extended vehicle idling controls
- Extreme cold start controls

Recalling the discussion of the TIP process (Chapter 4), there was a link that specifically gave priority to projects with congressional or other significant mandates. Projects contained within the TCM categories above are outstanding examples of items subject to that fast-track mechanism.
SUBSYSTEM 3: CONFORMITY

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and its reauthorized form, the Transportation Equity Act for the 21st Century (TEA-21) altered the face of this planning environment by drastically strengthening the link between transportation and air quality planning. The core of the conformity regulation is that if the Regional Transportation Plan does not meet the emissions reductions schedule drawn out in the State Implementation Plan, it will not be approved by the Federal Highway and Transit Administrations. This requires the RTP to include a network-based transportation emissions model that identifies how TCM’s and other actions, in tandem with other proposed projects, will not violate the pollution reduction trajectory of the SIP.

The motivating factor is that if the state and the region cannot produce a “conforming plan,” federal transportation funds to all new projects are suspended. The EPA and FHWA have demonstrated their conviction to enforce this policy by actually withholding transportation funds from Atlanta, Georgia, for example. Obviously, the primary goal of this regulation is to force transportation planning to consider air quality as a dominant constraint so that the NAAQS can be attained on schedule. A major secondary goal is that the institutions responsible for developing the transportation and air quality plans will work more closely together. This brings the MPO, state DOT, and state Department of Environmental Protection (DEP) much closer together on data sharing, technical analysis, policy development, and overall communication about long-term planning goals.
Identify the Institutions

At the center of the SIP is the State Department of Environmental Protection working closely with the Environmental Protection Agency. Many DEPs have regional offices, especially near metropolitan non-attainment AQCRs. When it comes to the technical aspects of the attainment schedule, there are usually relatively few interested parties outside of the regulatory agency. Often, political actors who prefer to defer the costs associated with acting on the clean air agenda may attempt to make the near-term obligations less critical than those in 10 to 15 years. This reinforces the tendency to adopt politically and technically simple short-term measures, many of which are less effective in the long run at curbing VMT growth and other factors such as urban growth.

When it comes to adopting or at least advocating TCMs, there are more constituents. Immediately, the DOTs are likely to be very interested as are any entities that will be affected commercially by the initiative. For example, traffic flow improvements involve streets departments in cities; parking management and pricing schemes influence the individuals or companies that might benefit from higher revenue but also the parties that are responsible for enforcement.

Up until the point that the conformity process gained strength, the SIP process was so remote from transportation planning that many of these interest groups only became active when the issue acquired public notice. When the conformity link was reinforced by ISTEA, however, the connection became much closer. After all, a major objective of the regulation was to bring the immediately relevant institutions into closer contact and communication to produce more integrated synergistic plans. The relationship of federal transportation funding to the conformity
process alerts the many politicians who earn credit with their constituents through pork barrel transportation bills. The potential to have such funds withheld motivates these actors to support the process that provides their lifeline.

*Classify the Institutional Relationships*

According to Howitt and Moore (1999), the combination of the CAA Amendments of 1990 and ISTEA succeeded where earlier policies failed by providing effective incentives - on top of the threat of suspending funds - to the relevant stakeholders to cooperate productively. Most importantly, the statutes provided funding for the planning activities and threatened stiff penalties for failing to comply with the regulation. It also handed down a procedure for agencies in each metropolitan area to follow rather than having to try to deal with the complicated institutional network.

A second important point that Howitt and Moore emphasize is that the formal or explicit interaction among the stakeholders is only one part of the overall picture and perhaps only a small one. The conformity process has created an environment in which planners from the MPO, DOT and DEP interact more frequently – sometimes even on a daily basis – such that individual communication improves and enhances the effectiveness of the formal interactions. These relationships are difficult to capture in the architectural context but must be recognized in prescribing policy or institutional reform.
The SIP architecture reflects several crucial additions to the overall Regional Planning Architecture. Most of all, the attainment schedule, developed as a part of the SIP, appears to the MPO in the same way that the estimated funding levels from the legislature do. The schedule indicates the presence of a budget, in this case for pollution rather than money, that forces the MPO to prioritize its selection of projects according to the emissions constraint.

The architecture also illustrates the point made by Howitt and Moore that the conformity process results in extensive interaction among the MPO, the FHWA and, by extension, the EPA and DEP. For both formal and informal contact, this process helps professionals in the different fields to understand both technical and policy aspects of the other agenda. Thus, transportation planners develop a more thorough understanding of air quality planning, empowering them over time to develop transportation plans that incorporate air quality concerns, independent of the regulations.
Conclusion

Before summary statements can be made about the progress achieved by this chapter, there is one major task ahead: the integration of the SIP and EIS architectures into the Regional Planning Architecture. The placement of the plan architectures is fairly obvious: the SIP is primarily related to the MPO and the EIS involves the implementing agencies. The resulting complete RPA is shown below, incorporating both transportation and environmental elements of the Regional Planning Architecture.

Figure 6.3: The Revised Regional Planning Architecture

This revision of the RPA reaffirms some of the observations made at the end of chapter 5. First, the centrality of the MPO and implementing agencies is clear. The goals, needs, projects and money all converge on the MPO and projects are ultimately deployed by the implementing agencies. Recalling the changes made to the ReS/SITE framework, the revised RPA supports the...
argument that the planning architecture has a crucial role in the development and deployment of the RI.

Second, the RPA, including the environmental plans, provides further evidence of the dual role played by the MPO. On one hand, there is a major function of technical expertise and supervision. The MPO provides planning resources to local planning boards and as it deals with project plans and forecasts generated by the implementing agencies as well as the DEP. Indeed, the MPO must be technically proficient in both transportation and environmental realms. One can imagine that in the course of promoting a single project, planners at the MPO deal with air quality studies, demand forecasts, engineering studies, and impact assessments dealing with hydrology, biology and so forth. On the other hand, the MPO also serves as the mediator for the other institutions. Perhaps the most important case is the integration of transportation and environmental plans. This represents the horizontal consistency doctrine in that the MPO helps to coordinate plans from different institutions within the same region.

The inclusion of the SIP and EIS architectures marks the end of the theoretical development process of this thesis. The framework, designed to address institutional relationships in the provision of transportation services, has been expanded to fit the general parameters of the planning process in the U.S. under ISTEA. As stated at the end of chapter 5, this model is a template for metropolitan planning that can be adapted to the specifics of any city.

The thesis now turns its attention to applying the framework to an actual city with a severe transportation and air quality problem: Mexico City. The case study unfolds in three chapters, the third of which includes the actual application of the regional architecture procedure and an RPA diagram. Chapters 7 and 8 provide background information on the circumstances that have produced this challenge and the prior policy responses.
Chapter 7: MCMA Background Information

Introduction

To many, Mexico is best known for its history, which is substantial in the “modern era” (going back to 1600) but also extensive in what is known as the “pre-history,” which goes back to the rise of the Olmecs in the Preclassic period around 2500 BC. Today, the city that gave the republic its name is also widely known as one of the largest cities on the planet. With almost twenty million residents in the metropolitan area, it is a member of the “mega-city” group. Mega-cities, according to a popular definition (Linden, 1996), have more than 10 million people and demonstrate many of the same qualities as any other city but on a massive scale. In some cases, the sheer magnitude alters the nature of the problem and its solution; Linden argues that administrative complexities of managing a mega-city increase at a higher rate than population.

In addition to its history and its size, Mexico City is relatively affluent within the category of metropolitan areas in the developing world. Further, its physical proximity to the United States allows Mexico economic opportunities not available to other countries. As a case study, the MCMA offers several opportunities: to examine one of the small but growing number of mega-cities; country and city at an advanced stage of development; and, to analyze a city with a strong history of transportation policy debate. It is an exciting case study that offers the opportunity to apply a new methodology to an ongoing problem: pursuing environmental goals in harmony with economic development.

Demographic Trends

Mexico City emerged as a megalopolis during the twentieth century through a deliberate national economic policy that centralized industry and commerce in Mexico’s capital. In the
The geography of the city has had an important role in shaping its metropolitan growth. Topographically speaking, the urbanized area is contained within a mountain basin that is open on the north and northeast sides. Thus, after all of the space in the south was consumed, new arrivals have only been able to settle on the north and east sides of the city, continually expanding the footprint of the region.

Another important dimension of the growth is the relationship between the city and political boundaries. Historically, Mexico City was contained within the Distrito Federal, which is referred to by its Spanish acronym DF or its English translation, Federal District. As the national capital, the President appointed a Mayor to administer the District. Most of the DF is bordered by the Estado de Mexico, otherwise known as the EM or State of Mexico. The state capital is located in Toluca, a substantial distance to the west of Mexico City. Other states, such
as Hidalgo, are also nearby to the east. The map below illustrates the current metropolitan area in relation to the political boundaries and the mountains.

![Map of Urban Growth in the MCMA](image)

**Figure 7.2: Map of Urban Growth in the MCMA**
Source: COMETRAVI, 1999

The actual urbanized area is extensively debated by planners in the MCMA. The metropolitan footprint includes all sixteen *delgaciones* of the DF and between 28 and 56 of the 125 *municipios* of the EM. The metropolitan institutions recognize 17 *municipios* although it is
clear that 28 are at least partially urbanized. Some planners consider the region to include a total of 56 municipios constituting an area referred to as the corona, or crown, of cities. The definition of the region obviously impacts the physical size and population attributed to the city. The standard values, presumably associated with the 28 municipios, corresponds with approximately 5000 square kilometers in which 17% of the national population resides. Up until the mid-1940s, the population was almost entirely contained within the DF. Over the last fifty years, a significant portion of metropolitan growth has occurred in the EM and now the population is evenly shared between the two districts. Figure 7.3 represents this population dynamic.

![Figure 7.3: Demographic Trends in the MCMA, 1950 onward.
Source: COMETRAVI, 1999](image)

The impact of such massive population growth in 50 years has been dramatic as the city has encountered problems of water supply, air pollution, human waste, human services and traffic. The diversity of causes of the expansion warrants careful differentiation of responses to the transportation and air quality problems identified in this study. The most important distinction is between the poor migrants who obtain land as close to the city center as they can
afford and the affluent urbanites who have recently begun generating a suburban exodus from the declining urban core.

Historically, wealth has been distributed in Mexico City in a pattern common in Latin America but quite unlike the traditional city in the United States. The richest live closest to the historic downtown with access to commercial and cultural activity; wealth diminishes with distance from the central business district and the poorest live at the periphery. Until the end of the twentieth century, suburbanization was rare. More recently, however, the rich have begun to leave the downtown and a substantial amount of the relocation has occurred in the southwest section of the DF. This trajectory conflicts with governmental efforts to conserve land on the slopes of the mountains where the natural aquifer is recharged. Because most water is imported to the region from over 200 kilometers away, protection of the natural resource is a major priority for local administrators. The influence of the rich residents is substantial however and restrictions on development in the protected zone are frequently violated.

As noted, the pattern of migration to the edge of the city creating cumulative layers of new development has been ongoing since the national revolution (1920s) and has been mitigated only by attraction to other cities, such as Monterrey. Throughout the second half of the century, the government has failed to control the consumption of land conversion by arriving migrants. In general, huge colonies of squatters have simply transformed large areas of land into habitats without infrastructure such as roads, sewers or power. Much of this has been accomplished on land classified as *ejido*. This type of land was communally owned after the revolution and the lack of clear property rights interfered with attempts to control use for non-agricultural purposes.

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8 For a complete discussion of ejido land and policy, see Cymet, 1992.
Thus, the trends illustrated in Figure 7.3 were generated by a combination of poor job seekers creating additional layers of urbanization at the periphery and, to a lesser extent, the exodus of rich residents from the center of the city. Overall, the highest rates of growth (more than 7-8% per year) are currently witnessed in the areas of the EM being converted into urban uses while the downtown is actually losing population; most intermediate areas are experiencing moderate levels of growth on the order of 3% per year. At the end of the 1990s, average densities (thousand persons per hectare) in the region ranged from 137 in the boroughs around the urban core to 26 in the peripheral municipalities. The rural districts outside of the urban area have fewer than 10 inhabitants per hectare.

Transportation System

Beginning in the late 1950s, political managers of the Federal District argued about the need for a high-capacity subway system to aid mobility in the city. Leading the opposition to the subway movement was the powerful mayor of the city, Ernesto Uruchurtu. Uruchurtu wanted to focus investments on improving the city within its traditional boundaries and opposed the subway on the basis that it would allow the city to expand beyond its historical shape and size. Uruchurtu’s own political agenda and his close ties with the bus drivers union supported this stance throughout his tenure. Long after the original three subway lines were constructed in the late 1960s, congestion and pollution now maintain a grip on a metropolitan region that far exceeds the service area of the ten-line underground system that carries nearly 5 million passengers per day. The sheer size of the MCMA’s population and the characteristics of its

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9 Davis, 1997, presents a comprehensive political history of Mexico City in the twentieth century with a strong emphasis on the subway debate.
distribution present enormous challenges to finding any solution to both mobility and air quality problems.

Unlike most cities in the United States, various forms of transit dominate the urban transport environment of Mexico City. Private autos, while increasing rapidly, have only about one quarter of the mode share in the metropolitan area. In contrast, autos generally carry 90-95% of trips in U.S. cities. The transit trips are distributed among the subway, buses, and various shared-ride carriers known as colectivos. As this section will explain, the worrisome trends include the increasing rate of auto ownership and the shift from large transit vehicles, especially buses, to the smaller colectivos. These two trends contribute to rising Vehicle Miles Traveled (VMT) and exacerbate the problems of congestion and air pollution.

![Mode Shares in the MCMA](image)

**Figure 7.4: Mode Shares in the MCMA**  
Source: COMETRAVI, 1999

Increasing auto ownership is a common trend for an area experiencing economic growth. As Figure 7.5 demonstrates, the economic recessions of the mid-1980s and 1990s limited buying power and consequently car purchase. Estimations of the rate of increase of auto ownership
range from 6% per year (COMETRAVI) to 10% (Molinero). Cervero asserts that ownership has increased at twice the rate of population, which would mean 8-10% per year, regionally.

Numbering over 2 million, private cars represent a very large portion of the metropolitan vehicle fleet, as shown in the table below.

<table>
<thead>
<tr>
<th>MODE</th>
<th>FLEET SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Automobiles</td>
<td>2,301,445</td>
</tr>
<tr>
<td>Taxis</td>
<td>91,625</td>
</tr>
<tr>
<td>Colectivos</td>
<td>52,158</td>
</tr>
<tr>
<td>Buses DF</td>
<td>2,794</td>
</tr>
<tr>
<td>Buses EM</td>
<td>1,284</td>
</tr>
<tr>
<td>Other Buses</td>
<td>4,013</td>
</tr>
<tr>
<td>Trucks</td>
<td>463,962</td>
</tr>
<tr>
<td>Others</td>
<td>240,453</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,157,734</strong></td>
</tr>
</tbody>
</table>

Although autos have a very small mode share by U.S. standards (20%), they represent a much larger portion of VMT (>70%) (Cometravi, 1999; World Bank, 1991). Villegas (1999) cites occupancy rates of 1.4 to 1.8, which are higher than the average occupancy rates in U.S. cities but which are still much lower than even a colectivo that carries 15-25 passengers. Molinero
(1991) also observes that autos have a higher mode share on longer trips, especially those from the growing market between the EM periphery areas and the urban core in the DF.

An important characteristic of the auto ownership trend is the profile of the fleet. Because older cars tend to pollute at significantly higher rates and consume much more gas per mile than newer models, the prevalence of old vehicles is a source of grave concern for air quality planners. An additional note in this area is that the fleet profile issue is also very relevant in the freight sector, in which many of the trucks managed by small firms or owner-operators are antiquated.

In the transit arena, the Metro has been the backbone of Mexico City’s transportation industry since it opened in the late sixties. Carrying nearly five million passengers per day, it is the third largest subway system in the world behind Tokyo and Moscow. There are now ten lines including one that connects the DF to the EM (Line A).
In the last fifteen years, despite substantial expansion and investment, Metro ridership has been stagnant or decreasing. The original three lines, which have operated at or above capacity since opening, carry a over 65% of the ridership for the whole system. Many blame the poor performance of the other lines on flawed alignments that do not coincide with concentrations of demand. In some cases, the lines simply do not go far enough from the downtown to reach such ridership sources. Overall, a major problem facing the Metro is that a majority of the region's population no longer lives in the areas served by the fixed route service. Given the very high cost of expanding an underground network, it is generally thought to be impossible to expand the
system to reach the new growth areas. In addition, there are political obstacles (historical antagonism between the DF and EM) to constructing Metro lines in the *Estado de Mexico*.

This problem is addressed by planning surface transportation services to provide feeder service from the extremities of the region to the Metro terminals. Cervero (1999) promotes the MCMA’s “hierarchical” system of transit on the basis that the Metro provides trunk service and that lower capacity modes including buses, colectivos and taxis, serve lower density populations as feeders. In practice, this system concept has achieved very limited success. On one hand, the sheer volume of feeder services arriving at the terminals overwhelms the available infrastructure. On the other hand, the provision of service on each route is determined by individual owner-operator profit motives rather than by rational planning. The control available to the government as granter of concessions is limited and poorly exercised. Many high volume corridors, including some with Metro service, attract colectivo drivers who recognize the opportunity for substantial revenues. As a result, links that Cervero would like the Metro and buses to serve are dominated by colectivos. While the system is hierarchical, supply and demand are not paired according to a planner’s ideals.

The large bus niche is segregated between the DF and EM. From 1981 until 1995, a public monopoly formed from private bus companies, known as *Ruta-100*, provided bus service in the DF. Intended to introduce innovative management practices and insure service on non-profitable routes rather than aggressively competing within high-revenue markets, the service was destined for the bankruptcy that it found after 15 years of struggle. Several years after the collapse, the DF Transportation Secretary is attempting to reorganize the bus industry based on concessions to several private companies and one new public initiative. The largest threat to their success continues to be the colectivo sector (see below) which operates with higher frequency...
and more customized service but at a higher fare. In the EM, buses provide an important service and without public control. There are approximately 65-70 private companies operating in the EM, most of which provide feeder service to the Metro terminals. DF regulations prohibit buses from driving further into the DF beyond these stations.

Perhaps the most important transit sector at this time is the colectivos, which carry 59% of all trips. In the city, these 10-25 passenger vehicles compete against buses and the Metro by traveling faster and serving more origins and destinations. Passengers perform a classic tradeoff decision by tolerating higher fares for enhanced levels of service on other dimensions (travel time, frequency). In the rural areas, colectivos can respond to new areas of population faster than buses under corporate management and much faster than the subway which has to construct guideway in order to expand service. In general, each colectivo has a single owner and sometimes a second driver to share shifts with the owner. Although routes are granted under concession, in practice operators go wherever the demand is to maximize profit. Figure 7.8, below, describes the colectivo fleet.

<table>
<thead>
<tr>
<th>Seating Capacity</th>
<th>Operating Ranges (one-way kilometers)</th>
<th>Vehicle Inventory</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Federal District</td>
<td>State of Mexico</td>
</tr>
<tr>
<td>Taxis</td>
<td>2-3</td>
<td>3-6</td>
<td>56,059</td>
</tr>
<tr>
<td>Peseros: Sedans</td>
<td>5-6</td>
<td>2-4</td>
<td>763</td>
</tr>
<tr>
<td>Peseros: VW Vans</td>
<td>10-14</td>
<td>5-10</td>
<td>22,690</td>
</tr>
<tr>
<td>Minibuses</td>
<td>22-25</td>
<td>10-20</td>
<td>20,493</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>100,005</td>
</tr>
</tbody>
</table>

Figure 7.8: Colectivo Characteristics
Source: Cervero, 1999.

The competition between colectivos and buses in the MCMA has been a centerpiece of transportation planning debates. Ruta-100 was driven out of business in the early nineties because of aggressive tactics of the individual colectivo drivers. Although Cervero envisions a system in which colectivos feed the higher capacity trunk lines of the Metro, trolleybus and bus
routes, in fact the colectivos operate origin-destination services that compete directly with the other modes. Several attempts to establish new bus service through concession after the collapse of Ruta-100 have failed because the government lacks any ability to protect the buses from colectivo competition on any route. If there is a possibility for revenue, it is certain that colectivos will be present, driving ahead of the buses to capture the fares. Any attempts to alter the legal environment to favor buses or the Metro are opposed by a highly organized and influential set of lobbyists for the colectivo owners and operators. The colectivo system is commonly described as mafioso by transportation planners and critics familiar with the Mexico City situation.

There are several other modes at work in the region. Taxis are important, although they only provide 3.9% of passenger trips. They generate more VMT than Passenger Miles Traveled (PMT) because they drive around “empty” for extensive periods between active fares. From a congestion and air pollution perspective, this is very troublesome. The trolleybus and light rail services carry just under 2% of the mode share combined, providing service along certain fixed routes. Although the infrastructure associated with the trolleybuses is easy to install relative to the light rail and especially the Metro, the rate at which such services can expand is almost nil compared to the colectivos and taxis.

Figure 7.9 demonstrates the trend in mode-share in the metropolitan area over the last twenty years. The shift to larger numbers of smaller vehicles, including colectivos, is clear. During this period the average size of a colectivo vehicle has increased from the small shared-ride sedans to minibuses. This increasing ratio of PMT:VMT for colectivos helps to mitigate the impact of mode share shifting from high capacity modes (bus and subway) to moderate capacity modes such as the colectivo.
It is important to keep in mind that what has been presented as an undesirable pattern of development with respect to congestion and air pollution has substantial positive attributes with respect to access and mobility. The accessibility of jobs in the city to poor migrants living in the periphery is a major accomplishment in such a large city. It represents a major element of the economic development that Mexico is actively pursuing. There need to be clear balanced policies to promote mobility with strategies to limit congestion and air pollution.

The pattern of urban growth described in the previous section and the evolution of travel modes explained in this section generate a cycle of increasing VMT that produces greater congestion and worsening air quality. The worst aspect of this situation is that the poorest people live the greatest distances from their jobs and can only afford the dirtiest cars if they are driving to work. The next section examines the impact of the explosive population growth and struggling transportation system on air quality.
Air Quality Situation

Even before some of the factors introduced in the previous sections are considered, Mexico City faces a difficult problem with respect to air pollution. The metropolitan region is located in a high elevation basin, which means two things. First, the elevation implies a lower concentration of oxygen, which limits the automobile’s ability to completely combust motor fuel and prohibits the use of emission control devices that are designed for a different atmosphere. The elevation, coupled with the city’s latitude, exposes the region to greater solar radiation than the average U.S. city. The sunlight stimulates the reaction between two pollutants, nitrogen oxides and hydrocarbons, that produces ground level ozone (smog). As a result, the same amounts of the so-called “precursor pollutants” produce more smog in Mexico City than they would in Los Angeles. The basin compounds the problem because prevailing winds trap the pollutants in the valley increasing opportunities for the photochemical reaction and preventing the smog from dissipating. The effect of these climatological and meteorological factors is that there is more air quality degradation for each unit of pollution than in a “normal” city.

The link between transportation and air quality has two elements. The first is the volume of traffic as measured by Vehicle Miles Traveled (VMT). The second is the amount of pollution generated by each unit of travel. The full process includes the number of people traveling, the frequency of trip-making, occupancy rates (PMT/VMT ratio), and the emissions per PMT and VMT. The previous discussion highlights some trends that are bad omens for air quality: the city is expanding (increase of VMT); there is general economic growth (more trips); occupancy rates are falling (decreasing PMT/VMT); and, there are many old vehicles in use (high emissions per VMT).
Many of these factors interact to compound the problem. For example, the urban growth favors lower occupancy modes, such as the colectivos, which have higher emissions per passenger than their larger counterparts. Furthermore, the poorer communities concentrated in the periphery are often served by older, more polluting vehicles that can afford to charge the lower prices acceptable to poorer clientele. Across the board, the infrastructure in the periphery is worse than in the DF if it exists at all and higher congestion rates and more pollution results, including “fugitive dust” generated by vehicles on dirt roads.

Policy Overview

All of the relevant government agencies have made various attempts to influence this general problem in order to mitigate the impacts on open space, infrastructure, and air quality. Actors are motivated by different goals including historic preservation in the downtown, economic vitality as derived from open roadways, and breathable air. This section provides an overview of the policy responses in the MCMA.

In the arena of urban growth, land planners have made limited attempts to control the conversion of rural land for urban purposes. Particularly where the land is being consumed by poor settlers from other parts of the county, legal mechanisms have been largely ineffective. Attempts to limit growth by controlling the provision of sewer and road infrastructure have failed because squatters have been continually content to live without such presumed necessities. The presence of ejido property has exacerbated this aspect of the problem because the lack of clear property rights has constrained officials’ ability to even attempt to limit growth. In a different context, the wealthy participants in suburbanization have continued to buy scarce land in
protected areas within the DF. In some cases, such developments have continued despite government prohibitions on construction in certain areas.

With respect to congestion, the government has sought to stem the flow of travelers to lower occupancy modes by expanding the Metro system and investing in the bus network. The latter effort has failed consistently due to competition from the colectivos which itself has been a major source of employment in the region. Indeed, there are strong vested interests opposed to any policies that might reduce employment in the colectivo sector. The Metro strategy has also been unsuccessful. As noted, most riders continue to concentrate on the original three lines while the other seven have not been located so as to attract demand around the city.

Private car drivers have been a policy target as well. In 1991, the national government deployed a program called Hoy No Circula, which translates as “No Driving Day.” The program prohibited each vehicle from circulating in the city one day per week. The goal was to achieve reductions in daily auto VMT by 20% leading to reduced fuel consumption, congestion, and pollution and increases in transit ridership. After the program became a fixture (it was initially a short-term experiment), every driver with enough resources purchased a second car for use on the day that the first car was banned. This resulted in a change in the used car market: the region went from being a net-exporter to being a net-importer. Traffic also worsened. Some critics have observed that VMT actually increased because the availability of a second vehicle in many households facilitated new trips and a net increase in VMT that offset any reductions from those drivers unable to afford a second car. Dissenters have also pointed out that the program disproportionately restricted the mobility of those too poor to afford a second car.

The program has now been adapted to suit a different set of objectives. Now vehicles face restrictions based on their age. The oldest vehicles are banned more than two days per week.
recent models are banned 1-2 days weekly and the newest cars are exempt. This approach encourages fleet turnover which reduces the average emission rate of the vehicle pool. This new arrangement is even more regressive than the previous one, however, because those drivers unable to purchase a newer vehicle are punished the most severely. While some may argue that this proves the policy is effective in limiting the use of old cars, it is clear that mobility among the less affluent is being disproportionately sacrificed.

Other traffic initiatives have included expansion of the roadway network and restrictions on freight traffic. Trucks over a certain weight are prohibited from the downtown altogether and policies that encourage nighttime deliveries have been deployed on an experimental basis. This policy raises two issues that have not been addressed to this point. First, this context illuminates the constraint that air quality can place on economic growth by inhibiting the movement of goods and services. Second, freight is an important player in the mobility/air quality arena, contributing an estimated 10-20% of mobile source pollution (Cometravi, 1999). Freight-specific policy proposals include expanding rail service further into the city and improving management practices in the largely owner-operator trucking sector.

The roadway expansion has focused on the beltway roads in the city and some of the major arterial highways connecting the region to other cities beyond the basin. Initiatives to build highways in the new growth areas have been supported by those most concerned with congestion mitigation but they have been opposed by some who recognize such an effort as providing an incentive for auto ownership and use.

Environmental initiatives have been numerous, structured within two major legislative programs: PICCA (1991-95) and Pro-Aire (1995-2000). These programs have promoted hundreds of individual initiatives of which several warrant special attention. These include fuel
and vehicle standards and inspection maintenance. Coupled with *Hoy No Circula*, these programs represent policies that address technological as well as behavioral aspects of mobile source emissions reduction efforts.

A keystone of the vehicle/fuel efforts has been the implementation of the catalytic converter. This emission control device was deployed in the United States in the late seventies but was not useable in the Mexico City region due to the oxygen deficiency in the high elevation basin. Finally in 1993 converters were required on all new models. The catalysts required unleaded gasoline to function properly and this was also introduced to Mexico the early 1990s. In the course of this decade, unleaded fuel has taken over 100% of the market (leaded fuel was eliminated outright in the region in 1997) but less than 40% of the private vehicle fleet is equipped with catalytic converters. The government tightened the standard on tailpipe emissions in 1988 as much as possible in the absence of the catalyst. The standard was raised in 1993 in accordance with the new technology. In 1999, all new cars were required to meet the most recent standards implemented in the United States (in 1994), known as Tier 1.

The Inspection/Maintenance (I/M) program was designed to address the fact that cars deteriorate over time. I/M programs ensure that cars do not deteriorate excessively over their natural lifetime and that cars with broken emission control systems, known as gross-emitters, are repaired or eliminated from use. In its early days (beginning in 1990), the program was administered by individual mechanics at garages around the region. Rampant fraud limited the effectiveness of the program until it was centralized at fewer than 26 facilities. The queues that occurred at those facilities led the government to reduce the requirement to one rather than two annual inspections and later to a more decentralized network of approximately 75 inspection stations managed on concession and closely monitored.
The I/M and vehicle/fuel standards strategies rely on reductions in the per-VMT emissions rates to accomplish overall reductions of pollution. These and other emission rate policies are most effective in the short run to counteract the increasing number of vehicles in use. Efforts to limit VMT growth, including strategies to change driver behavior and restrain urban expansion, can have longer term impacts on pollution control. As in the U.S. experience, policies targeting driver behavior are politically unpalatable and consequently difficult to implement. The Mexican strategy to combat air pollution from mobile sources, therefore, has focused on the technological aspect through programs such as I/M and vehicle as well as fuel standards. While this strategy may succeed in offsetting growth in auto ownership, the lack of attention to driver behavior severely limits any opportunities to mitigate the chronic congestion that is becoming commonplace throughout the region.

Institutional Dimension

A milestone in Mexico City’s history was its expansion beyond the boundary of the Distrito Federal, around the middle of the 20th century. At that time all matters of urban management became intergovernmental. Up until that point the major players were from the national government and the President’s appointees in the city government. With the population evenly split between the districts, with more growth expected in the EM, the balance of power should favor the DF only to the extent that most of the jobs are still concentrated there.

One major change came in 1997 when the mayor of the DF was popularly elected for the first time. While the President of Mexico and the Governor of the EM were from the traditional ruling party (the Partido Revolucionario Institucional, or PRI), the elected mayor of the DF was
from one of the leading opposition parties, the Partido de la Revolucion Democratica (PRD). This circumstance has contributed to the tension between the mayor of the DF and his (now her) colleagues in the federal government and the EM. In December of 2000, elections will be held for the Presidency, a new mayor and a leader for each of the sixteen delegaciones.

In the areas of air quality and transportation, inter-district consortia exist to harmonize policy and facilitate communication among policy makers. The Comision Metropolitana de Transporte y Vialidad (Metropolitan Commission on Transportation and Roads) is led, on a rotating basis, by a major official from the DF, the EM and national government. The Comision Ambiental Metropolitana serves the same function in the air quality arena. Both of these organizations, which have taken on several different forms in the last ten to fifteen years, are dominated by the DF delegation. Members of these organizations attribute this imbalance to the distribution of human and capital resources in each jurisdiction as well as the emphasis placed by the national government on the DF. A factor limiting the effectiveness of the EM participants is that the capital of the State is in Toluca, which is far removed geographically from the MCMA. As a result, each of the EM municipios in the metropolitan area vies for its own interests with some degree of autonomy from EM control. The delegaciones are well organized and appear as a coordinated front while the EM municipios are more fragmented. This pattern obstructs any effort to enhance the EM’s role in metropolitan governance.

A good example of the discord among the jurisdictions is the policy promoted by the DF to ban vehicles over a certain age from circulation within the District. While these vehicles might ideally be retired and demolished, they were merely exported into the EM where they could operate freely as long as they did not cross into the DF. As an environmental initiative, this effort is essentially useless. Except for local pollutants, such as carbon monoxide, the relocation of the

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10 In addition to the center-left PRD, there is also the conservative Partido Accion Nacional (PAN).
polluting vehicles accomplishes very little or no reduction in regional pollution and garners substantial political opposition. Such an initiative is valuable for stemming the pollution from dilapidated vehicles but must be implemented on a broader geographic scale.

In transportation planning, the same is true. Political structures make construction of the Metro in the EM very difficult or impossible. The new Line A (see map, Figure 7.7) extends southeast into the EM and Line B is supposed to do the same but construction has currently stopped at the border due to fiscal disputes. Acknowledging that the Metro has been constrained by its inability to tap areas of demand and that demand is growing primarily in the EM, this is an obstacle that is critical to overcome in order to facilitate high occupancy service to a larger segment of the metropolitan population.

This chapter has established a cursory view of the critical issues in Mexico City: massive population and urban growth in the 20th century; intractable transportation and air quality problems; and, a turbulent recent history of policy and institutional solution formulation. The next chapter presents a more in-depth analysis of the policy response, focusing primarily on the major air quality initiatives.
Chapter 8: Policy Responses in Mexico City

Introduction

The previous chapter has introduced the problem faced by environmental policy makers and transportation planners in the Mexico City Metropolitan Area (MCMA). The city, growing at an extraordinary rate throughout the twentieth century, has exceeded the capacity of its highway and Metro network creating massive congestion and air pollution that is exacerbated by its unusual climate and meteorology. Retaining and expanding mobility as an economic strategy while improving environmental conditions is the goal. The chapter briefly identified the policy response to these problems and suggested that the jurisdictional complexity of the region has contributed to an inadequate formulation of solutions. This chapter expands the investigation of the solutions that have been tried, particularly in the last ten years. The following chapter, through the lens of the regional architectures approach and an aspect of the policy activity, will attempt to clarify the institutional relationships at work in environmental, transportation and city planning in the MCMA.

Environmental Policy History for MCMA

As in the United States, Mexico has been struggling with air pollution problems throughout the second half of the century. For the last 20-25 years, major national and regional policies have sought to address the problem. Also consistent with the U.S. experience, Mexico’s efforts to implement policy and affect a reduction in pollution started slowly and only acquired real teeth after many years of experimentation. For the U.S., the 1970 and 1977 Clean Air Acts were the major steps forward, followed by another advance in the 1990 CAA Amendments. In
Mexico, the earliest policy, in 1979, did very little. The real work began in the mid and late eighties with a series of major policy initiatives.

In 1986, the “21 Concrete Measures to Control Air Pollution” were enacted by the national legislation for the MCMA, followed by the “100 Necessary Actions Program” in 1987. While these programs contained many of the same ingredients of later, more successful policies, limited scope, lack of coordination among government agencies and lack of collaboration with relevant professionals (scientists, administrators, etc.) substantially constrained their effectiveness in reducing pollution (Lezama, 1999).

The 1989 “Emergency Program” broadened the extent of environmental policy and acquired major financial support from the World Bank, along with that institution’s intellectual resources. The program included 7 elements, some of which evolved into the major components of the long-term strategy:

- Adoption of tighter vehicle emission standards, effective 1991
- Hoy No Circula: each vehicle is banned from circulation one weekday per week; initially applied only to autos.
- Addition of 5% MTBE to reduce HC and CO emissions, coincident reduction of lead in the gasoline
- Implementation of an inspection and maintenance program of the private vehicle fleet.
- (Temporarily) switching oil-fired thermoelectric plans to natural gas fuel
- Engine replacement and general rehabilitation for 3,500 R100 buses
- Expansion of air monitoring network

This was the stage in which Hoy No Circula (“No Drive Day”) was introduced as a short-term program, to be applied permanently in the subsequent policy. In this phase, the program was extremely successful as a restraint on VMT and fuel consumption. The installation of an Inspection/Maintenance program was also the start of a major aspect of regional policy during
the 1990’s. The use of World Bank funds to retrofit and rehabilitate buses also introduced the basis for future policy initiatives.

In 1990, the Integral Program Against Air Pollution in the Metropolitan Zone (PICCA) represented the change from short-term, hastily organized, uncoordinated policy programs to the opposite: long-term (five years), integrated, better-planned initiatives. PICCA not only adopted a five year time horizon but included a much broader set of complementary programs. It has 6 program areas, each of which includes a set of actions. The following list includes only the transportation-related actions.

- Oil Industry and Fuels
- Changes in fuel composition
- Unleaded gas for catalyst-equipped cars
- Reformulated gas
- Desulfurization of diesel and fuel oil
- Changes in refining and distribution infrastructure
- Transport Sector
- Catalytic converters and associated standards
- High-use vehicle replacement (taxis, combis)
- LPG conversion of freight trucks
- Expansion of I/M
- Continuation of HNC, expansion to taxis, some transit vehicles (colectivos)
- Improved parking/traffic systems
- Expansion of the Metro/surface transit (LRT, trolleybus)
- Authorization of new private bus routes
- Private Industry and Services
- Nighttime deliveries
- Thermoelectric Plants
- Reforestation/Sanitary Measures
- Research, Education and Communication

As with the Emergency Program, PICCA benefited from a substantial World Bank loan, especially in the capital-intensive activities such as buying and replacing vehicles or components, such as engines for retrofit.
Jose Luis Lezama, a Mexican academic and critic of the unfolding set of policies, argues that the inability of the policy-makers to heed the scientific community limited the effectiveness of these early policy programs. The same shortcoming applies to the role of citizens in policy formulation, especially on topics that affect daily behavior and activity. The fact that pollution levels continued to rise during the early and mid-nineties led Lezama to believe that even PICCA was poorly conceived and a failure. While this may be true, it is important to consider the lag time between the implementation of a program and its benefits. New vehicle emission standards, for example, become more effective as the new vehicles they affect gradually penetrate the market and the fleet composition changes.

In 1995, at the end of PICCA’s authorized period, the national legislature formulated the Program to Improve Air Quality in the Valley of Mexico (Pro-Aire). Lezama, in his critique of the earlier policies, believes that the circumstances improved by 1995 such that Pro-Aire incorporated more scientific knowledge and understanding. Due in part to the accomplishments of PICCA, greater air quality data and scientific information was available to and included in the policy-making process that produced Pro-Aire. In many ways, the program is not very different from PICCA. Nearly 100 individual actions can be categorized in the following groups:

- New standards for industry activities
- Re-engineering at thermoelectric facilities
- Higher fuel standards
- Fuel pricing policy (to encourage Magna Sin)
- Fiscal mechanisms to assist these actions
- Hoy No Circula (as instrument to aid fleet turnover)
- Tighter emission standards for new vehicles
- Extension of I/M program
- Full costing (for environment) of fuel prices
- Reconstruction/Expansion of surface transport (including Metro, trolleybus, trains)
- Reorganization of transit operations
- New policies of urban development
- Preservation of special land
Pro-Aire was approved for the period of 1995-2000. At the time of this writing, the successor policy is being developed in the national legislature. The timing of the current policy highlights a major issue that has influenced previous programs and that has influenced a major characteristic of Pro-Aire II. In Mexico, a new president is elected every 6 years and is limited to a single term. Many analysts feel that environmental policies in the metropolitan area have been hampered by the turnover of the President and his government. The discontinuity inhibits the effectiveness of program management. As a result, Pro-Aire II is being approved for a ten year period, 2000-2010. This means that the next major deliberation will occur in the middle of a term, instead of in an election year (at present), which will allow the new policy to be fully implemented before the election of 2012.

Analyzing the Policies

Clearly, the current air quality problem does not result from lack of effort on the part of Mexican administrators and officials. The history of Pro-Aire, PICCA, the emergency program and the earlier initiatives makes it clear that the Mexican governments have struggled extensively. Within those policy programs there are hundreds of individual initiatives. In assessing the policy response, the goal of this chapter is to consider those efforts that have earned particular attention locally or globally as well as those with special characteristics. In general, the discussion takes the approach of comparing Mexican experience with that of the United States.

In order to proceed, the set of policies have been set in three categories: emission rates, quantities of travel, and urban form (land use, e.g.). As noted above, the policies enacted in the MCMA have recognized the need for a coordinated or integrated approach and the same philosophy that motivates this thesis.
Altshuler and Howitt (1999) make clear a central argument in favor of vehicle and fuel technology policies that reduce emissions on a per-VMT basis.

"Experience with [vehicle and fuel policies] suggest that environmental regulation can succeed when it targets a small number of large corporations and focuses on inducing significant (not radical or technologically infeasible) changes in product technology."

For transportation and air quality managers in Mexico City, this means working with a set of dozens or perhaps several hundred decision makers rather than 20 million individual travelers. Mexico has the added advantage that gas is supplied by a public monopoly (PEMEX), which further reduces the number of active players in the field. The relationship allows the government to directly control the supply and price of fuel, thus allowing the environmental agency to exercise policy through the public oil monopoly.

The main weakness that Altshuler and Howitt acknowledge is that the cost effectiveness of technology mandates decreases in each successive policy. In the U.S. experience, the tightening of emission standards and the reformulation of gasoline achieved such reductions that subsequent efforts (new vehicle types, enhanced I/M schemes) had only limited potential. In other words, the effectiveness of a technology mandate relies on the net benefit of replacing the old with the new. When the “old” has already been much-improved, only drastic changes can achieve large emissions reductions and such changes are likely to be very expensive, as in the case of electric vehicles. The table below illustrates this point.
As one might expect and as one sees in the descriptions of Pro-Aire and PICCA, air quality policy has focused on strategies in this category to reduce mobile source pollution. In the cost-effective area of fuel and vehicle technologies, Mexico has made many of the same major accomplishments as seen in the U.S. A clear example of this is the deleading of gasoline. In the United States lead was eliminated from gas in less than a decade after the 1970 Clean Air Act made it a objective. Additives have been used to counteract some problems associated with early forms of unleaded fuel, including MTBE, which is also used in Mexico City for the same purpose.

Until *Magna Sin* (unleaded) was introduced in the early 1990s, *Nova* (leaded) was the only gasoline available in the MCMA. By 1997, *Nova* was completely eliminated and a second unleaded fuel of higher grade, Premium, was introduced. In the early stages of the unleaded
In order to keep demand limited, Magna Sin was priced higher than Nova to deter interest. One very undesirable consequence of this action was that owners of vehicles with the newly introduced catalytic converters, destroyed the catalyst by using leaded fuel, thus rendering the installation of the emission control device useless.

Once production was sufficiently advanced, the pricing of Magna Sin and Nova was equalized and eventually favored Magna Sin in order to encourage use of the unleaded fuel. As noted, by 1997, Nova was eliminated from distribution in the MCMA. Around the same time, PEMEX introduced a higher grade of unleaded gas, called Premium. More recently, PEMEX refineries have moved ahead in the process of desulfurization, which has helped to reduced sulfur dioxide emissions. These are an important part of the air pollution problem but less critical than other chemicals, such as ozone and particulate matter.

In addition to tightening standards and reformulating traditional gasoline, there have been limited efforts to adopt alternative fuels, such as compressed natural gas and liquid petroleum gas. Both of these fuels have air quality advantages relative to standard gasoline but extensive use depends on the deployment of capital in vehicles and a distribution infrastructure. Conventional vehicles can actually be adapted to use LPG and this has been done in Mexico as well as in the U.S. Naturally, new CNG and LPG vehicles can be obtained as well. The cost of deploying infrastructure to support such an initiative, however, is substantial. In addition, concerns about the potential damage to a natural gas pipeline network from an earthquake dominate many related debates. Limited pilot experiments have been successful, however, and the DF Secretary of Transportation has begun to grant concessions for colectivo services with a preference for operators who use alternative fuel vehicles.
In the area of vehicle technology, Mexico has made accomplishments in tightening emission standards on new cars comparable to those in the United States. As in the U.S. experience, this appears to be a very cost-effective approach. Figure 8.2 shows the standards for several pollutants over the last fifteen years in the U.S. and in Mexico. As the subsequent discussion of the catalytic converters will describe, the elevation of the MCMA prevented deployment of that emission control technology at the same time as in the U.S. Consequently, emission standards could only be tightened to a limited degree. To illustrate this lag time between the U.S. and Mexico, one can consider the fact that the set of emission standards promulgated by the U.S. Environmental Protection Agency in 1994 called “Tier 1” were required of new cars in Mexico in 1999. This example illustrates that once the critical technology (catalytic converter) was in place, the policy was able to advance rapidly.

Figure 8.2: Evolution of HC and NOx Emission Standards in the MCMA and United States
Source: Data from BTS, 1996 and Onursal & Gautam, 1997.

Figure 8.2 illustrates the importance of the catalytic converter on auto manufacturers’ ability to produce relatively low-polluting vehicles. The catalytic converter is a critical element
of emission control technology currently in use in the United States and throughout the world. It catalyzes the engine exhaust before it is released from the vehicle. The lower concentration of oxygen in the air in the MCMA prevents the standard catalyst from functioning properly, however. In 1993, a new converter to accommodate the lower concentration of oxygen was introduced and these were required on all new vehicles. Emission standards, as noted, were raised in coordination with the new technology.

The effectiveness of the strategies mentioned so far depends on the market penetration of new vehicles after the implementation of new standards and the introduction of new fuels and technologies. In general, auto ownership has been growing rapidly in Mexico City during recent decades. In the mid-1980’s and mid-1990’s, however, economic downturns constrained buying power and fewer new cars were purchased. Especially in the latter event, new technologies were not deployed. An additional dimension of the car-buying trend is that new cars sometimes displace, rather than simply replace an old car. If the old car is simply displaced (relocated) to a different part of the Mexico City airshed, there has been no effective reduction of emissions. This is exactly the case of old cars being sent from the DF to the EM.

The Inspection/Maintenance (I/M) program, which is an important example of a strategy to enhance the effectiveness of emission control technology, has evolved from the policy programs of the mid-1980’s through the turn of the century. The problem that I/M targets is the deterioration of many vehicle functions during its life-cycle. In general, inspections address safety issues (bad brakes, e.g.) as well as pollution concerns but the present concern is for the latter. I/M programs rely on a set of emission standards that dictate the performance of a vehicle at the end of the assembly line and after years of use. The main goal of I/M is to assure that each vehicle’s emission control components are still functioning, despite deterioration, over time. I/M
also serves to identify vehicles whose emissions control devices have failed entirely, which are known as “gross emitters.” If a vehicle is not functioning properly for its age, the program requires that it be repaired or retired.

In Mexico City, the program was initially deployed using over 1,500 private garages throughout the region for conducting periodic inspections. In the earliest stages, the quality of the emission control was determined visually by the mechanic who made a personal judgement about the vehicle’s status. Fraud was prevalent in many forms: vehicle owners bribed mechanics to give them false-negatives (pass), mechanics issued false positives (fail) in order to generate work required to “fix” the problem, and so forth. The extent of fraud can be seen by certain statistics, such as one that reported the failure rate at private facilities being less than half of that at the few publicly-operated garages (Onursal & Gautam, 1997).

In response to this situation, the government required vehicles to be inspected at one of only 42 publicly-operated facilities. The drastic cut in inspection facilities led to so much queuing that the frequency of the test was reduced from biannual to annual. In the mid-1990’s, the government created a distributed network of inspection facilities operated under concession and closely monitored by public supervisors. This arrangement has reduced fraud and the queuing associated with the centralized facilities.

As stated, one possible outcome of the inspection was that a vehicle would be retired rather than repaired. In the United States, such a vehicle is stripped for reusable parts and then demolished – permanently removed from service. In Mexico City, many vehicles were sent out of the city or at least to the periphery zone where enforcement would be lax if present at all. Under PICCA and Pro-Aire, several attempts were made explicitly to ban certain vehicles from operation, particularly within the DF. As with vehicles retired after failing to pass inspection,
these confiscated cars were generally “deported” rather than destroyed. Counter-productively, however, many of these ended up in the EM where their emissions still contribute to the metropolitan air quality problem.

In 1992, for example, pre-1986 taxis and pre-1984 colectivos were banned from operation in the DF. Almost all of these were relocated across the boundary into the EM. While most of those legally operated in the EM, some continued to operate in the DF providing inter-jurisdictional service in violation of the vehicular and other constraints. When one considers the fact that prevailing winds carry pollution from the urban municipios into the DF, it is apparent that investment in the vehicular-deportation policy are not cost-effective overall.

A major factor driving this process that counteracts the effectiveness of the vehicle technology initiatives is the demand for low-cost vehicles by the poor people living at the city’s periphery. As described in the previous chapter, these areas at the edge of the city are not served by the Metro and often not by buses. With taxis and colectivos as the transit options, many rely on any personal vehicle they can access. Efforts to intervene in this process are stymied by poor enforcement practices in these parts of the city.

Perhaps one of the most important policies developed in the MCMA to address mobile source pollution and congestion is Hoy no Circula (HNC), which means “No Drive Day.” Based on a color code on each license plate, every vehicle is banned from operation one day in each week, according to the original design. In this sense, Hoy no Circula was originally designed as a circulation ban and thus it may seem counterintuitive that it is being described in this section. Although it initially aimed to reduce pollution by influencing driver behavior, it evolved in a program that today is dedicated to fleet turnover and therefore is more accurately described, in its present form, as a vehicle technology initiative.
By restricting auto use, HNC was designed to alleviate congestion, reduce fuel consumption, boost auto ridership and thereby reduce pollution. When it was originally implemented as a part of the Emergency Program in 1989, its impact was striking. Congestion was reduced, fuel consumption dropped, and Metro ridership increased by 6% over several months. Almost as soon as its permanent status under PICCA was announced, however, every driver with adequate resources obtained a second vehicle which would be prohibited on a different day of the week. There are three important implications of this result.

First, many drivers, especially from the affluent part of the city to the west, were no longer restricted at all so that the congestion mitigation was derived only from that share of the population that could not afford a second car. Second, the backup vehicle purchased to subvert the policy was often the least expensive one available which was almost certainly more polluting that the first. One of the few quantitative pieces of evidence of HNC’s failure was a study that showed the region shifted from a net exporter to net importer of used cars in the early-1990’s. Thus, the vehicle being driven on the “fifth day” polluted more than if the ban did not exist. Third, each affected household now had two vehicles. This meant that a second driver could travel around the city independently on three of the four days that the backup vehicle was not being used (the fourth day it was banned from circulation).

In its original form, therefore, HNC was a regressive and failing policy in that the mobility of poor drivers was harmed and the rich drove just as much and in a more polluting vehicle one day per week. Recognizing this, policy makers sought a remedy. Rather than rescinding it altogether, however, they found a solution that explains why HNC is now more relevant to the vehicle/fuel technology category.
Under Pro-Aire, Hoy no Circula now targets the oldest vehicles most severely and is more lenient on newer vehicles, even exempting the most recent from I/M as well as the circulation ban. Vehicles in the MCMA are now grouped into four categories: pre-1988, 1988-93, 1993-99, and post-99 corresponding to the initial tightening of emission standards, the introduction of the catalytic converter and the implementation of Tier 1 standards. On a weekly basis, cars in group 1 (pre-88) are banned up to 2 weekdays and 1 weekend day; cars in group 2 (88-93) are banned 1 weekday; and cars from groups 3 (93-99) and 4 (post-99) are exempt. Group 4 is distinguished from 3 because cars meeting Tier 1 standards are also exempt from the Inspection/Maintenance program for 3 years.

While the new HNC is more effective, it is possible even more regressive than the earlier form as only the most affluent are able to buy new vehicles without financial assistance. Also, as more vehicles in the fleet are post-1993 (a desirable goal), fewer vehicles will be subject to the circulation ban and it will be effectively phased out of existence.

Assuming for the moment that old cars are replaced rather than simply displaced within the region, vehicle and fuel technology policies are most effective when the net pollution reduction between old and new car is maximized. Then perhaps the most cost-effective pollution reducing transaction is the replacement of a 1992 vehicle by one from 1993. The price difference is minimal and the emission control change is substantial. From the driver’s perspective, the most effective trade is from a group 1 to group 3 vehicle in order to substantially reduce the constraint of the circulation ban. These are examples of tradeoffs perceived by drivers and decision makers about how to target the program. In the past, the World Bank has loaned significant funds in order to replace or retrofit vehicles or engines and these relationships perhaps
point to the most cost-effective pollution reducing exchanges available in the arena created by Hoy No Circula.

Policies Targeting Driver Behavior

The policies that were described in the previous section have in common the objective of reducing the quantity of pollution generated per vehicle mile traveled. The second category of policies attempts to reduce the total number of vehicle miles traveled which reduces total emissions (but not the emissions rate). One of the most important points to emphasize in this context is that it is critical to avert the possibility of constraining Passenger Miles Traveled at the same time. Truly, the fundamental objective is to increase the ratio of PMT:VMT. One can view this in effect as reducing the emissions per PMT. To allay a common concern, this objective assumes that the increasing vehicle occupancies outweighs the higher emissions associated with larger vehicles such that the increasing PMT:VMT conclusion is valid.

The most common form of driver behavior policy attempts to take the driver of a single occupant vehicle and encourage them to carpool or take transit, make their trip at a less congested time, or not make the trip at all, if it is extraneous. Altshuler and Howitt (1999) suggest that I/M programs are another form of driver behavior policy. While the argument that I/M generates driver awareness and a sense of responsibility, this auxiliary benefit is not adequately convincing and I/M remains, for the purposes of this discussion, in the category of vehicle and fuel policy.

Altshuler and Howitt present the bleak prospect faced by driver behavior policies:

With few exceptions, regulatory efforts under successive versions of the clean air act to limit motorists' use of their cars or to impose direct charges with the intent of reducing travel have proved politically infeasible.
Congestion pricing is perhaps one of the most inflammatory examples in this regard. Many observers in the academic literature site elected officials who fear political backlash as a prime example of why such policies are not adopted and implemented. A common theme in discussions of this subject highlight the distribution of costs and benefits perceived by each individual driver. The benefits of transportation demand management, such as better air quality, are diffuse and often take time to appear. In contrast, the costs, such as paying a toll or sharing a ride with a stranger, are very obvious and immediate.

Some forms of driver behavior policy are not nearly so dramatic. Enhanced transit service for example, is an important means of encouraging solo drivers to contribute to the PMT:VMT effort. As described in Chapter 7, the shift to lower occupancy modes as the MC region expands has contributed to rising congestion and pollution and many want to reverse that trend in order to combat the smog. Mode choice for each traveler depends on many factors such as cost, travel time, waiting time, comfort, and the accessibility of a service to the home and workplace.

In the Mexico City context, competition between the Metro, buses and colectivos exemplify these factors. It has been previously noted that the rise in colectivo ridership is largely due to the fact that in many parts of the periphery, it is the only transit mode available. If a person cannot reach buses or the Metro, she is unlikely to use them. In other cases, riders take a colectivo on the same boulevard that is served by a bus, despite the higher fare, because the colectivos come more frequently and travel faster because of their greater agility and more aggressive drivers. The policy issue is how the government, which manages the Metro and buses and controls the concessions for colectivo activities, should invest in vehicles and infrastructure to best attract travelers to the services. The focus of the case study, in the next chapter, is the expansion of the fixed infrastructure transit services (Metro).
In addition to transit infrastructure and vehicles, the provision of roadways is another important form of demand management and driver behavior policy. Only ten years ago, much of the infrastructure that served the city from the municipios of the EM was incomplete. As a result, many desire lines were unmet by adequate facilities and substantial congestion resulted in such situations. The completion of the Pereferico beltway road and several major inter-city highways have improved access. Most of these facilities are saturated throughout the day, however. Additional high performance infrastructure can help to configure the links between areas of origin and destination for travelers and freight. In the periphery, roadways are infamously poor or nonexistent. In most cases paving brings the advantage of assuring better traffic flows, less congestion and therefore less pollution. At the same time, however, induced travel may counterbalance those pollution savings through new or more frequent trips.

Land Planning

In addition to how much people travel and how much pollution is generated as they travel, the matter of where the origins and locations are located relative to each other is an important determinant of congestion and pollution levels in a metropolitan area. In Mexico City, the massive growth that has occurred during the second half of the twentieth century alone has made this item a major concern for transportation and air quality planners. The previous discussion of mode choice highlights the importance of where people live relative to transportation infrastructure. The original three lines of the Metro carry more than 70% of daily ridership in a system even after seven other lines have been constructed. That fault has been attributed to poor locations of the transit facilities relative to established population and employment locations.
Land planning is affected by the two forms of urban growth occurring in the MCMA: poor people arriving from throughout the country and living in squatter settlements in successive layers around the city as well as rich residents participating in a process of suburban flight. Planners have had two primary agendas as a result. One task is to protect land within the DF that protects the valuable aquifer at the feet of the mountains circling the region. The second task is to develop and enforce rational plans for the massive areas of land being converted for urban use along the northern and eastern periphery. The latter task is obstructed by unusual property rights established after the revolution in the 1920's. The communal status of the land inhibits the government's ability to dictate effectively what can and what cannot be developed. Opportunities to encourage density are thwarted by the "unofficial" nature of the development process. The agencies that hoped to control development through the deployment of roadway, water and sanitation infrastructure found that new arrivals were happy to establish homes without those fundamentals.

The Cometravi Study

Throughout this thesis, many references have been made to the study conducted by the Comision Metropolitana de Transporte y Vialidad (Cometravi). The report entitled Integrated Study of Transportation and Air Quality in the MCMA concludes with recommendations for 31 transportation-related measures to reduce pollution as well as congestion (see list in Appendix 2). The recommendations represent a strategy for reducing pollution over a twenty year period with an estimated cost of 233.2 billion pesos (10 pesos = ~$1). The study is not a law or a policy program, however, and while it cannot be regarded in the same light as Pro-Aire, it does provide
an important opportunity to observe the direction in which transportation policy might be moving.

The study includes many of the types of policies that have been mentioned in this chapter including previously implemented measures as well as actions taken in the United States that Mexico could adopt. The 31 measures are presented in four categories: passenger, freight, infrastructure, and technology. The passenger category includes investments in expanded transit networks for the metro, trolleybus, light rail as well as articulated buses and busways. The freight actions address the need for transfer facilities regionally and locally and the fact that government freight vehicles are not subject to emission standards. An important element of the infrastructure strategy is the recognition of poorly functioning infrastructure, including basic traffic engineering of intersections throughout the city. This extensive problem is immediately evident to any eyewitness. Finally, the technology strategies encourage a shift to natural gas and press the issue of replacing old cars with newer, cleaner ones.

There is one specific measure, among the 31, that illuminates an important institutional element that will be important in the subsequent application of the regional architecture framework in chapter 9. One of the five recommendations in the freight category is the formation of “mercantile societies.” This action addresses the fact that 79% of freight vehicles are owner-operated. Similar to the case of colectivos, this means that there are almost as many managers as vehicles (345,000 private trucks, see Figure 8.3). For the air quality agenda, this presents an obstacle because of the difficulties associated with effectively communicating with such a broad audience and with accomplishing the tasks associated with making so many managers adapt to and comply with new policies.
<table>
<thead>
<tr>
<th>Freight Market Segment</th>
<th>Fleet Size</th>
<th>Share of Fleet</th>
<th>Share of Cargo</th>
<th>Average Fleet Age</th>
<th>Emission Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interurban - Public &amp; Private</td>
<td>68,636</td>
<td>16%</td>
<td>69%</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>Local - Private</td>
<td>344,708</td>
<td>79%</td>
<td>29%</td>
<td>22%</td>
<td>78%</td>
</tr>
<tr>
<td>Local - Public</td>
<td>22,444</td>
<td>5%</td>
<td>2%</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>435,788</td>
<td>100%</td>
<td>100%</td>
<td>28%</td>
<td>72%</td>
</tr>
</tbody>
</table>

Figure 8.3 Fleet Characteristics of the Freight Sector

This is a problem because owner-operator services cannot sustain certain operating attributes of normal, even small, companies. For example, a company might have its own repair shop, lowering the time and financial cost of maintenance. In addition, it is likely to have facilities that provide storage for vehicles and space for the transfer of goods, which allows optimization of the operation, such as grouping shipments to similar destinations. Indeed, two of the other freight policies include the creation of distribution facilities for goods moving through the city. An owner-operator service has none of these capabilities.

The formation of companies, or mercantile societies, facilitates change in this respect. Such societies can allow owner-operators to benefit from the characteristics of the company, such as those mentioned in the previous paragraph. There are also environmental benefits that led to the inclusion of this measure in Cometravi’s study. A good example of this is the transition from gasoline to natural gas, which has many emissions benefits. This shift requires a capital investment in the distribution infrastructure. To this point, all alternative fuel experiments have involved large fleets, primarily in the public sector: police cars and garbage trucks. If companies with facilities provide freight services, providing the infrastructure necessary for the switch to natural gas is feasible. There are also pollution and congestion reductions that result from freight vehicles having legitimate parking facilities, rather than storing vehicles on the streets.
This situation is very similar to colectivos, where there is generally a 1:1 owner-operator ratio. The law allows an individual to own up to three microbuses but successful owners often license additional concessions under the names of relatives. While the benefits of owning a small fleet have been realized in the colectivo market, the formation of companies with property holdings has not. There are route associations that provide services for owners and operators, including legal representation. The presence of these associations, however, serves the function of facilitating information dispersal and collection for agencies such as the DF secretariat for transportation. There are approximately 75 associations throughout the metropolitan region, which means that if Cometravi wants to communicate with all of the operators, it can release information through 75 contact points, rather than to tens of thousands of individual drivers.

The effort to form companies in the colectivo arena has another purpose: to substitute large vehicles for the smaller microbuses. Currently, the transportation agency in the DF is attempting to persuade multiple owners of microbuses to trade in their vehicles for a bus. By replacing two 25-seat micros with one 50-seat bus, the operators can maintain or even increase revenue and decrease costs. In its very recent history, the initiative has had limited success.

The policy of forming companies out of individual owner-operators is clearly a substantial theme in both passenger and freight areas of transportation management. There are mobility, economic, and environmental reasons, which offers the prospect of a broad base of support. It also represents a policy direction that coincides with a purpose of this thesis: to examine opportunities to improve productivity through institutional management. The organization of mercantile societies reflects exactly this philosophy.
Relating Experiences in Mexico and the United States

Before moving on to the next chapter, in which the theoretical framework developed in the first half of the thesis is applied to this case study, it is enlightening to compare the experiences of battling pollution and congestion in Mexico City and the United States. This is not a new exercise, as many of the policies developed for the MCMA are modeled after the U.S., including the adoption of U.S. emission standards and technologies.

In most respects, the pattern of experience in the two countries is very similar. Primarily, both places have relied heavily on technological improvements to provide substantial reductions in emission rates that offset growth in VMT. While some of those changes came later in Mexico, the results were just as effective. The elimination of lead, for example, occurred within ten years of policy implementation in both the U.S. and Mexico. Similarly, the introduction of advanced emission control technology (catalytic converter) allowed substantial reductions in emission rates. A major difference between the countries is that the vehicle fleet is much older in Mexico than in the U.S. Because older cars dominate the total fleet, new vehicle technology has limited impact on the average fleet characteristics.

The similarity also applies to efforts to affect driver behavior. In the United States, attempts to implement mandatory ride sharing through the Employer Trip Reduction (ETR) program created substantial outcry against the EPA and state environmental agencies that rapidly abandoned the initiative. The experience with Hoy no Circula is comparable, where policymakers persisted in the implementation of the program but have struggled to adjust to the substantial problems it has encountered.

Market incentives are one important area of policy in which the U.S. has had some important successes but which Mexico has not yet explored. In the U.S., this has applied almost
exclusively to stationary sources, however, so there are not many lessons in the transportation sector. The Clean Air Act Amendments of 1990 established a tradable permit system for emissions of sulfur dioxide (SO$_2$) that is based on a fixed amount of total pollution distributed among companies. The companies buy and sell permits from each other at an economically efficient price (marginal cost of reducing an additional ton of emissions equals the price of a permit to emit that ton).

The economic argument in favor of this policy is that it allows each company to use the cheapest means for reducing its emissions. The main obstacle, among several, to applying this approach in the transportation sector is that there are so many agents (drivers) in the market that the administrative costs are prohibitive. However, economic theory shows that a tax can be equally efficient as lower administrative costs, resulting in precisely the same reductions as the permit scheme.

Ramiro Tovar Landa (1995) presents a brief assessment of the prospects for market-based air quality policy for the transportation sector in Mexico City. He includes in his analysis a vehicle ownership tax, a gas tax and electronic road pricing (ERP). He concludes that ERP is the best policy, which represents sound economic thinking, because it most accurately links the driver behavior with the pollution by charging on a per-mile basis. The ownership tax is possibly the easiest to apply but, as he points out, it discourages the purchase of new vehicles and thus the rate of fleet turnover, which is contrary to other major areas of policy. The gas tax is also good economic policy in linking the charge with the amount of driving. If one recalls from earlier in this chapter. Pemex actively manipulated prices to encourage the use of Magna Sin relative to the leaded alternative.
Overall, the Mexican and U.S. experiences are not nearly as different as they might seem. Mexico certainly started later than the U.S. but they have been able to take advantage of the lessons learned during the history of the Clean Air Act. In addition, Mexico City faces a problem much more severe than that of Los Angeles, Houston, or Atlanta. They are similar with respect to the common emphasis on technologically-based solutions. Despite these similarities, a fundamental difference is that Mexico’s policy approach has been largely piecemeal, aggregating many good individual programs into an overall policy.

Conclusion

An old, polluting car carrying one or two individuals from a poor squatter settlement to an industrial job in a distant section of the region is emblematic of the cause of Mexico City’s air quality problem. Particularly in the last ten years, the city’s government has attempted to control the vast quantities of pollution generated in the worst imaginable meteorological and climatological conditions. Their attempts have included improvements in vehicles and fuels that have had mixed success in penetrating the market. They have expanded the Metro network but failed to generate much new ridership. They have struggled to exercise even some control over land use and the development spurred by over a quarter million new residents every year.

As the current environmental policy, Pro-Aire, comes to the end of its tenure this year, the formulation of the successor program is trying to overcome past mistakes and build on accomplishments. The keystone program, Hoy No Circula, is being phased out and the prospects for advancing transit-oriented\textsuperscript{11} development are slim. One of the strongest prospects in the next

\textsuperscript{11} "Transit-oriented development" incorporates medium to high densities and a mix of land uses in a development pattern that encourages greater transit utilization.
ten years is the growing presence of advanced emission control devices (catalytic converters) and reformulated fuels in use throughout the region.

One of the most important policy concerns, however, is the current decline in occupancy rates (PMT:VMT). The expansion of the Metro network to reach high demand areas is one important means by which that trend can be reversed. However, the difficulty of developing and enforcing land use policy presents an obstacle to linking high-occupancy transit modes (buses, metro) with areas with demand, even if the fiscal and political obstacles can be overcome. Finally, the most recent policy publication, the Cometravi study, includes recognition of using institutional/managerial reform to reduce congestion and pollution, offering hope that a new, untested policy option may have some benefits for the region.

Reflecting on the paths taken by the United States and Mexico in deploying air quality policy, one can see that Mexico has effectively implemented policies proven successful in the U.S., such as emission standards and the catalytic converters. The main challenges, based on this assessment, include the greater resistance to market penetration of new vehicles and the absence of long-term plans. The next chapter, which applies the regional architecture framework to this case study, seeks to examine these issues by focusing on institutional relationships. By design, the approach should illuminate the extent to which friction among institutions restrains the effectiveness of policies enumerated in Pro-Aire and the Cometravi study.
Chapter 9: Regional Architecture and the MCMA Case Study

Introduction

This chapter represents the culmination of the Mexico City case study as the regional planning architecture methodology, developed in chapters 4, 5 and 6, is applied to the institutional network of the MCMA. The two previous information chapters have highlighted the key issues that underlie the challenge of addressing both air quality and mobility objectives in the midst of economic growth.

The purpose of the Mexico City case study is to test the regional architecture framework in one of the most complex institutional environments available. Rather than attempting to address the full extent of the case, the approach taken for this thesis is to select a particular example of planning challenges in the region that fulfills three major criteria by:

- involving environmental and transportation issues;
- having a full regional character; and,
- including enough institutional complexity to challenge the framework.

By using a representative sample, it is possible to examine all of the relevant issues in a reasonable amount of time and space. Also, by limiting the scope in this way, it is more likely that it will be possible to parse the methodological issues from substantive ones. The expansion of the Metro system into the Estado de Mexico satisfies all three of these conditions fully and is also a significant topic of contemporary debate.

After a brief introduction to the nature of the problem, the analysis will follow the protocol established by Pendleton for analyzing the RSA and adapted in this thesis for the planning context. There is one important respect in which this discussion will depart from the established protocol: the identification of institutions will be the first task rather than following the identification of subsystems. The simple reason for this is that a majority of the audience is
unlikely to be familiar with the institutions, which, in addition to having names in Spanish, do not fit the mold of a typical U.S. city.

Thus, the case study will begin with an inventory of the institutions involved with the planning of Metro expansion in the MCMA. Subsequently, the identification of subsystems will present all of the subsystems together, in contrast to chapter 5 in which the subsystems were presented within each of the four ISTEA-mandated plans. The absence of ISTEA in Mexico City provides the opportunity to consider the subsystems independently and autonomously. One related concern is that the absence of ISTEA may prove that the framework is inextricably tied to the legislation if the methodology does not function well in the MCMA context.

After the identification of the subsystems, the next step is the classification of institutional relationships, which leads to the construction of the regional planning architecture. In addition to the conclusion section here, the following chapter is a conclusion for the entire thesis, which integrates the lessons of the theoretical and applied sections of the full endeavor.

Background Information

The Mexico City Metro, which only began operation at the very end of the 1960s with three lines, carries approximately 5 million trips per day, a mode-share of 14%. Twenty years after opening, the system has nine Rubber Tire Rapid Transit (RTRT) lines and one light rail line in operation with one new line partially completed (total, approximately 200 kilometers). The organization that runs the Metro, Sistema de Transporte Colectivo (STC), has developed a new master plan detailing a massive construction and expansion over the next twenty years.

The critical factor driving the need for Metro expansion is that since the system was originally planned - conceived as early as the mid-1950’s - the area of land occupied by the
metropolitan population has expanded dramatically. Indeed, when the Metro was first proposed it was seen as a threat to the tight-knit neighborhood character of a medium-sized city because of its ability to carry travelers greater distances at reasonable speed and low cost. Based on a fixed guideway, the Metro has been unable to expand as rapidly as the population and more flexible modes, especially the owner-operated colectivos, have commanded an increasing share of trips throughout the region.

The need to expand the Metro is motivated by mobility as well as air quality concerns. Because more than two-thirds of regional employment is still concentrated in the central business district, the convergence of commuters from throughout the region is immense. The delays resulting from this regional bottleneck have important economic impacts and the constant traffic jams contribute to the pollution problem. Many planners recognize the potential for congestion mitigation by increasing regional use of the high-capacity Metro network. This depends on linking supply with demand, however, and that requires extending the Metro into the State of Mexico.

The current plan, most recently articulated in the Cometravi study, calls for 6 lines into the EM, totaling 126.5 kilometers. That construction would cost 60.7 million pesos but would yield over 4 million passengers per day. Assuming that these are all new passengers, that would nearly double current ridership. The new riders would presumably be diverted from other transit modes, such as colectivos, as well as private cars. In both cases the congestion mitigation and emission reduction benefits could be substantial.

There are many obstacles that restrict expansion of the Metro and its ridership. Security concerns, increasing availability of autos and access to services are the main sources of resistance to more Metro use. Security concerns, which permeate all transit modes, underline the
difficulty of making transit appeal to people with greater resources, especially those who can afford their own car.

In addition to constraints on ridership, there are challenges to the development of the system, many of which are institutional and therefore make the issue especially amenable to the regional architecture analysis. The agency that operates the Metro, STC, is a branch of Setravi, the DF transportation secretariat. This implies that the Metro has no authority in the EM, without cooperation of the EM and its transportation agency. The existence of Cometravi has perhaps eased the abundant tension between these organizations but negotiations on this topic are still very difficult. In fact, one of the proposals for expansion of the Metro is an independent EM subway system that would connect with the Metro at transfer stations. The technological and marketing challenges of this arrangement seem daunting, however.

One additional obstacle that the planning effort faces is the abundant failures of previous efforts to add lines to the original set of three. There are local planning agencies in both states as well as a federal agency and a metropolitan commission that have a better understanding of housing and employment locations than earlier planners possessed. Use of that knowledge requires interaction, however, and communication between the DF and EM is generally complicated by bickering.

The analysis in this chapter focuses primarily on the partially-constructed Line B, which is currently stopped at the DF-EM border. In order to capture other relevant issues and institutions, the discussion also considers a proposal to develop a regional rail corridor on the west side of the city. This service would be very different from existing Metro operations. Figure 9.1 shows the current plan of the Metro, including the intended Line B corridor.
Line B is the central theme because it is a direct extension of existing service. Its objective is to provide the normal type of service to a new area, thereby initiating Metro service in the EM and establishing a precedent for further construction. The regional rail line is an "executive service" that features higher fares, higher security, and caters primarily to a affluent geographic sub-area of the city. It connects with one of the Metro terminals on the west side of the network. An interesting feature of the proposal, which is a major reason that it has received so much attention, is that it is planned in an existing rail corridor in which passenger rail service was planned at an earlier time. Train-sets were obtained at that time and then set aside when the operation was abandoned. Thus, the Right-of-Way is already established, substantially reducing the projected cost.

Clearly, the challenge of extending the Metro is one that involves numerous substantial hurdles. Those hurdles fit nicely in the institutionally-centered scope of regional architecture analysis, however, so the case seems well suited for the methodology at hand. The discussion moves ahead with an introduction of the relevant institutions and then proceeds with the application of the RPA framework.
Figure 9.1: Plan of the Metro Network
Step 1: Identify the Institutions

The fragmentation of jurisdictions is critical in the institutional arena as much as or more than it is in the substance of planning the Metro or other aspects of the transportation-air quality problem. The full set of stakeholders includes the Federal District, the State of Mexico, the Republic of Mexico and the metropolitan region. In addition to the segmentation of public entities, there are also private enterprises that are not affiliated with a particular jurisdiction. The colectivo owners, operators, and route associations, for example, are not jurisdictionally linked. There are also international interests, including the World Bank and other lending agencies as well as foreign governments. This presentation of the stakeholder set attempts to identify the key constituents in each of these categories, recognizing that no list can be truly exhaustive in this regard.

It is also possible to differentiate among the institutions according to area of interest. The primary categories in this regard are air quality, transportation, and urban development; secondary categories could include, among others, commerce/economics, housing, and industry. Within each of those categories there are more specific foci, such as standards, enforcement, as well as long and short-term planning. As in the case of North Jersey, there are implementing agencies with specific responsibilities. Considering the large set of institutions in a chart (Figure 9.2 at the end of the section) might help to explain how these institutions, at least superficially, interact.

It is important to note that in addition to the agencies that are included below based on their organizational mission, there are various political offices that are relevant stakeholders. The National Congress for example, approves the federal budget and has the power to authorize or

12 Because of the extensive use of acronyms based on names of the Mexican institutions, the reader may want to refer to the table of acronyms at the beginning of the thesis (page 13).
veto debt proposals for the DF budget as well. Thus the President, the Mayor, the DF legislature, the EM Governor and its legislature are all participants in the planning process. One can take this extension further to indicate the entire populace as a stakeholder but as a group it seems irrelevant. As with the Route Associations described in this chapter, there may be special interest groups that lobby for their agenda but those are not dominant or obvious participants in general.

**FEDERAL DISTRICT**

Perhaps the most central institution is the *Secretaria de Transporte y Vialidad* (Secretariat of Transportation, SETRAVI). In addition to transportation analysis and planning functions similar to a state Department of Transportation in the U.S., SETRAVI includes the operating agencies of the transit system in the DF. The *Sistema de Transporte Colectivo* (STC) is the organization that runs Metro. *Sistema de Transporte Electrico* (STE) runs the trolleybuses, light rail, and – at least in the short term – some functions of the defunct bus system, Ruta 100. SETRAVI maintains responsibility for administering the concessions for taxis and colectivos within the DF as well. Until the popular election of the DF’s mayor in 1997 and the associated autonomy granted to the District at that time, the operating subsidies for STE and STC were provided by the federal government. In the new era, the district is responsible for providing that subsidy despite the fact that the federal government retains the original tax revenue. Critical to that change is that the national legislature must approve any new debts acquired by the District. The District also has a dedicated urban development Secretariat, SEDUVI (*Secretaria de Desarrollo Urbano y Vivienda*) that is responsible for the administration of land acquisition and building permits in the DF. A major program of SEDUVI is the preservation of the aquifer-recharge area at the base of the mountains encircling the region (within the DF). SEDUVI is also
in the position to assist transit-oriented development efforts but only within its jurisdiction. Because only a very small fraction of land is available for new development in the DF, much of SEDUVI's efforts have focused on "recycling" property within the city in order to retain the declining population. One part of this program is the conversion of defunct or abandoned commercial property for residential uses. SEDUVI is responsible for three levels of plans: a general plan for the DF, plans for each of the delegaciones, and partial plans for special-use projects.

The DF air quality agency is a component of the Secretaria de Medio Ambiental (SMA), which deals with all environmental issues in the city, including drinking water and solid waste disposal. The agency's primary activity related to transportation and air quality is the implementation of policies such as Inspection and Maintenance. Many of the vehicle and fuel standards are implemented by the federal government (see below). Furthermore, it appears that SMA attempts to apply itself to advocating the importance of the drinking water issue, which is indeed critical but entirely unrelated to transportation and air quality.

**STATE OF MEXICO**

The most important feature of the institutions from the EM is that they are located in the state's capital, over 40 miles west in Toluca. In that sense, whereas the DF agencies are completely dedicated to issues of the metropolitan area, the responsibilities of EM agencies are divided between Toluca, the municipios in the MCMA, and the rest of the state. In that sense, this discussion of the EM institutions pertains only to their activity in the MCMA municipios without much perspective on other work throughout the state.
The Secretaria de Comunicaciones y Transporte (EM-SCT) is the EM's analog of SETRAVI in the DF and is responsible for administering concessions and managing the infrastructure in the metropolitan municipalities. One major challenge facing EM-SCT is that as land has been converted from rural to urban, infrastructure that had been inter-urban and therefore the responsibility of the federal government, now is in the hands of the EM. This is of major importance and the increase in responsibility for SCT has grown in the last few decades of rapid urbanization. At the same time, expenditures on a per capita basis are much higher in the DF, in some cases by a factor of ten, throughout the transportation sector. In general, the EM tax base is lower but, as noted, many funds are directed to locations other than the MCMA portions of the state.

The Secretaria de Ecologia (SE) is the EM’s environmental organization that, as with SMA in the DF, is divided among several different environmental issues including air, water and trash. For two reasons, it is clear that SE is than other environmental agencies. In the first place, the air quality problem is carried from the EM to the DF by the prevailing winds just as most of the congestion is concentrated in the DF where traffic from all over the region converges. The problem is not felt in the EM as badly as it is in the DF. In the second place, standards, rules and enforcement are inferior to those in the DF such that some of the problems are exported back to the EM. A good example of this includes old vehicles that are banned from circulation in the DF but are accepted in the EM. People with less wealth live in the periphery of the city where the willingness to accept poorer conditions is greater.

With respect to urban planning in the State of Mexico, there exists the Secretaria de Desarrollo Urbano y Obras Publicas (SEDUOP) or Secretariat of Development and Public Works, which serves a function similar to that of SEDUVI in the DF. In keeping with the general
contrast, however, SEDUOP has accomplished very little to earn attention in this context and participates nominally in a metropolitan coordination with SEDUVI and SEDESOL. Also, in contrast to SEDUVI, SEDUOP is responsible for Toluca, the metropolitan municipios as well as a vast rural area.

**FEDERAL GOVERNMENT**

The federal agencies have substantial technical capabilities in both transportation and air quality as well as in urban development. Further, because of the strong connection between the federal government and the MCMA relative to other parts of the country, both human and capital resources are focused heavily on the issues addressed here.

The Secretaria de Comunicaciones y Transporte (SCT) is the national transportation agency. As noted in the previous section concerning EM-SCT, a major change has been the re-classification of inter-urban roads as intra-urban roads, thus delegating responsibility for their upkeep to the EM. Another major change has been the decentralization of the DF, shedding substantial responsibility to the local authorities. In this sense, the importance of SCT in metropolitan planning issues has been decreased in the last decade. However, the national agencies maintain a clear role in establishing standards and policy that is handed down to local agencies and in that sense SCT remains very important in the MCMA. The most important aspect of this is the oversight that SCT would have of the suburban rail proposal that would run through the DF, EM and possibly other states to the north (Hidalgo). The probability of SCT generating revenue for this project through a gas tax has been extensively discussed by relevant agencies. This fiscal role is an important one. In the past, a gas tax raised by SCT was put in a
special environmental trust fund that provided revenue for the installation of vapor recovery systems in filling stations throughout the city.

The Instituto National de Ecologia (INE) is the federal environmental agency, analogous to the Environmental Protection Agency in the U.S. INE is responsible for establishing standards for vehicles and fuels. Until the “Northern Border” area became a major environmental concern in recent years, the MCMA commanded almost all of INE’s attention and resources. As a result, the decentralization that has changed SCT’s role in metropolitan issues so dramatically has had less of an effect on INE. The Institute is extensively involved in developing policy and implementation programs, such as Inspection and Maintenance as well as advocating policies such as the prohibitions against aged vehicles. A very important point is that INE provides most of the analytical capabilities with respect to emissions inventory and forecasting. In that regard the State and District agencies have meager capabilities.

It is also important to note that INE is assisted by PROFEP, the national Attorney General for environmental issues. Profepa has had an important role in pursuing certain policies with other entities such as Pemex (see below). In the course of various rearrangements of institutions in the last fifteen years, INE and Profepa have been contained within various agencies. At the current time, they are joined under an Environmental Authority called Secretaria de Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP).

The Mexican Petroleum Corporation, PEMEX, is the national producer and retailer of gasoline as a public monopoly. Although this raises some concerns from an economist’s perspective, the arrangement has proved very effective for environmental policy. PEMEX has complete control over what fuels are refined (standards, etc.) and also determines their price. As noted in the policy review (Chapter 8), Pemex manipulated prices throughout the 1990s to
manage demand for Magna Sin until Nova was eliminated and Premium was also introduced. PEMEX is now refining a low sulfur gas that is cleaner than U.S. standards. Many credit the public monopoly with effectively reducing pollution through fuel standards.

SEDESOL (*Secretaria de Desarrollo Social*) is the national urban development agency. As with SCT, SEDESOL’s direct involvement with the MCMA is limited. An important part of the agency’s activity has very important implications for Mexico City, however. One major policy is focused on developing different cities and towns throughout the country in order to decentralize economic activity and therefore population in order to moderate the explosive growth that is related to Mexico City’s monopoly on jobs and overwhelming contribution to GDP. The industrial zone in the north of the country has contributed to this effort significantly, as has investment in other cities such as Guadalajara and Monterrey. In this sense, SEDESOL has a very active but indirect role in development around the MCMA.

One final federal entity is the public works bank, BANOBRAS, which manages domestic and international funds and loans for infrastructure and especially housing projects throughout the country. As usual, Mexico City acquires a lion’s share of these resources. BANOBRAS, to this point, does not operate with an active agenda for encouraging transit-friendly development or considering air quality characteristics of its investments but evaluates projects simply on the basis of the rate of return. Thus, while the bank could be a major asset in funding transportation and housing projects that support the mobility/air quality agenda, there is no precedent for doing so.
METROPOLITAN COMMISSIONS

In the areas of air, transportation, development, water, and solid waste, coordination commissions have been created among the EM, DF and Federal agencies on each topic. There have been metropolitan commissions for these topics for more than ten or fifteen years in most cases but some have gone through substantial reforms and revisions, often related to the installation of a new President (and Mayor, Governor). For example, the environmental commission was overhauled in 1994 and renamed. Many of the programs are carried over from one administration to another, generally with only moderate changes. Multi-jurisdictional entities, however, are at least semi-permanent fixtures in the institutional inventory for Mexico City.

The Metropolitan Commission on Human Settlements (Comisión Metropolitana de Asentamientos Humanos, COMETAH) is the alliance of SEDUVI, SEDUOP, and SEDESOL. It has recently (1996) produced a voluntary “General Plan” that outlines strategies that the agencies can employ to pursue certain goals, such as transit use and equity. Of the various commissions, this one appears to have the least muscle.

The Comision Metropolitana de Transporte y Vialidad (COMETRAVI) is the transportation alliance that has recently published a major transportation assessment with the assistance of a local engineering consultant (1999). Among the commissions, COMETRAVI can boast about the implementation of Hoy No Circula as one of its accomplishments, despite that program’s limited success. As with COMETAH, COMETRAVI is made up of the transportation agencies from the DF, EM and Federal governments.

The Comision Ambiental Metropolitana (CAM) serves this coalition function in the area of air quality. In contrast to COMETRAVI, CAM has access to independent financial resources.
primarily from the Environmental Trust Fund originally created to fund the installation of vapor recovery systems. Also, CAM was created by a cooperative agreement of over a dozen agencies from the EM, DF and Federal governments while COMETRAVI was endorsed only by the member agencies (SETRAVI, EM-SCT, and SCT).

Each of the metropolitan commissions has evolved through several forms in the last twenty years to their current status and function. One problem faced by each is the distinction of boundaries. The inclusion of all sixteen delegaciones of the DF is obvious but it is more challenging to include certain municipios but not others. Currently, CAM includes 17 municipios although between 25-30 are at least partially urbanized. The 20 year population projection on which studies in all disciplines are based spreads out over 56 municipios, including some in states other than the DF or EM (Hidalgo, e.g.).

For congestion and air quality, the metropolitan commissions serve an important function in helping to identify region-wide strategies that will mitigate the problem. It is widely recognized, however, that each coalition lacks the authority to actually implement these strategies without the participation of the individual governments. Thus, while COMETRAVI’s recent report (1999) presents an excellent set of transportation measures to reduce air pollution, progress depends on SETRAVI’s and the EM-SCT’s abilities to persuade the state governments.

**Other Institutions**

Fiduciary institutions play an important role in the stakeholder group of urban, transportation and environmental planning for the MCMA. The World Bank, in particular, has provided extensive loans for a variety of projects. One consistent objective of Bank funding has been the replacement of high-use vehicles or their engines, such as Ruta-100 buses. As noted
above, most Bank loans are processed by BANOBRAS. One benefit of these loans is that the Bank has conducted a substantial amount of research regarding its investment, which benefits most of the planners in related fields, including transportation, air quality, and urban development (the last to a lesser extent).

There are also many major consulting firms that are involved in planning activities as well as direct management of various systems. The Japan International Cooperation Agency, for example, conducted the Origin-Destination study in 1994 that has provided the basis of all subsequent planning activities. A Mexico City-based firm, Ochoa Associates, prepared the COMETRAVI study in 1999. ICA produced the Master Plan for the Metro. In this way, many international interests drive a portion of the important policy and planning decisions. In some cases, an international firm presenting a plan for a new service and selling a new product has motivated the construction of a new Metro line.

A major non-public institution in this area is the set of colectivo Route Associations active in the transportation arena. There are approximately 75 of these associations, which are similar to unions in the United States and which represent large numbers of individual colectivo owners and operators in the development of policies around the city. Approximately 25 of these associations are within the DF representing the routes within the district. While these associations are capable of capitalizing on economies of scale by providing repair and maintenance facilities for the operators, this is rarely done. The most important role of the Route Association is to lobby SETRAVI and EM-SCT on policy issues in order to leverage the position of the colectivos.

In the same vein, private developers are important constituents. The new residential developments at the periphery often include seven thousand housing units built by a single firm.
This scale of construction allows the developer to have some interest in the infrastructure provided in the area and the kind of transit service provided, especially when the population is overwhelmingly too poor to own their own cars. In this way these private developers are in the position to make important decisions that determine the direction of urban development patterns throughout the metropolitan region, thus having a significant impact on congestion and pollution.

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Figure 9.2: Key members of the MCMA Regional Architecture

Step 2: Identify the Subsystems

Based on the inventory of institutions that will comprise the Regional Planning Architecture for the MCMA, the next step of the process is to analyze the subsystems on which the institutional relationships are based. Recalling the methodological discussions in chapters 3 and 4, subsystems are activities, such as "needs assessment," that represent steps in the planning process. The introduction to this chapter stressed the fact that, in contrast to chapter 5, the subsystems presented here do not correspond to specific plans because ISTEA, as a piece of U.S. legislation, is not a factor in the MCMA planning environment. Thus, this step includes 12 subsystems that have been integrated from the RTP, TIP, SIP, STP and STIP into one set. This chapter is fundamentally diagnostic, culminating in the production of a Regional Planning Architecture diagram at the end of the analysis. The prescriptive element of the exercise is
reserved for chapter 10 in which draws conclusions regarding the methodology as well as the
substance of the case study.

**Subsystem 1: Assessment and Forecast**

The most recent origin-destination survey, which is the building block of travel
forecasting, demand analysis and therefore much of the activity that follows, was conducted by
the Japan International Cooperation Agency (JICA) in 1994. It must be noted that there is
extensive anecdotal questioning of the study's validity. This uncertainty is influenced by the fact
that in addition to the rapid growth in the region, much of the population lives in "irregular"
settlements that cannot easily be accounted for by traditional surveys or censuses. A new
important source of data collection has been the Inspection/Maintenance Program. The deputy
director of the DF Environmental Agency, Secretaria De Medio Ambiental, commented that the
I/M program has led to a wider appreciation of automotive maintenance and, perhaps more
importantly, has produced a vast annual tabulation of the vehicle fleet in the region including
many of the most important vehicle statistics (age, emission rates, odometer reading, etc.).

When the federal transportation agency, Secretaria de Comunicaciones y Transporte,
initiated a study of demand on a prospective passenger rail corridor, the consultant began with
the 1994 O-D survey. He subsequently collected additional data through further study within the
corridor and then utilized an industry-standard demand forecasting software, EMME-2.

There are other agencies that are also actively involved with aspects of data collection,
analysis, and forecasting. PEMEX is interested in the profile of demand for different
petrochemical products and is directly involved in the effort, working with the federal
environmental agency, to understand the inventory of emissions from stationary and mobile sources.

An additional subject that receives a great deal of data-intensive attention is the mode-share dynamic, which has witnessed a dramatic shift from large buses to smaller vans and micros in the colectivo family of services. The Metro, for example, has substantial data about ridership trends that affirm the overwhelming success of the first three lines and the subsequent failure of the later lines, through the present. This trend has made Metro more sensitive to the importance of locating new fixed route service with demand information produced by forecast models.

A final data/forecasting topic is related to demographic models that influence land use/urban development policies and shape the nature of demand for trips and eventually VKT. As noted, any census-like approach is nearly impossible in light of the irregular settlements at the periphery, in addition to the high cost of conducting such a study in a massive city with limited resources. A decennial census is conducted however, and the data reaffirm the population trends that are obvious from the ground or even from a flight over the city.

**SUBSYSTEM 2: DEVELOPING GOALS**

It is clear that each discipline (environment, transportation, urban development) makes some effort to develop its own goals and in some cases a good faith effort is made to do this with delegations from the EM, DF, and Federal government. For example, the metropolitan urban development commission, COMETAH, produced a voluntary plan for development throughout the region. While these planning efforts may or not be truly coordinated across political boundaries, it is clear that there is no coordination among professionals of different specialties. To some degree, this lack of coordination can be benign in light of the improbability that any of
these plans actually influence decisions. In another sense, however, the possibility that COMETAH is designating one area for high density growth while COMETRAVI has ignored the same area for transit service seems all too likely.

As argued in Chapter 2, the result of segmented planning is that each discipline regards the objectives of the others as rivals for limited financial resources in the region. In that way, even opportunities for synergy are lost because of presumed conflict among groups from different organizations. In other words, each discipline regards the others’ objectives as constraints. The 1999 COMETRAVI report demonstrates better planning; this report is dedicated to transportation measures capable of reducing pollution. It recognizes the proper objective: to pursue both clean air and mobility rather than just one at the expense of the other. This potentially offers an important step forward.

With respect to the Metro expansion, the project is influenced by the goals of each discipline. The transportation agencies are obviously interested in the project as a solution to chronic congestion on a number of corridors. To the extent that new services will cross the DF-EM boundary, the service will also mitigate the congestion associated with many different surface routes all serving the large Metro terminals. Still, the EM agency sees the DF being the primary beneficiary of reduced traffic. At the same time, all of the environmental agencies see a possible reduction in pollution, especially if poor people driving very dirty cars are diverted to high-occupancy transit operations. Finally, the urban development planners see an opportunity to concentrate development as a means to the goal of shifting mode share to high-occupancy modes from private cars and small taxis or colectivos. Ultimately, however, there is no mechanism for bringing together these obviously related agencies or their agendas.
SUBSYSTEM 3: IDENTIFYING PROGRAMS

The final stage of the Regional Transportation Plan process is the identification of general program solutions to the problems that have been identified by the travel forecasts and highlighted by the new goal statements. In this case, the major program in question is fixed guideway service from the central business district in the DF (source of jobs) to the growing periphery of the EM (source of workers). While busways and other less capital-intensive options may be available, the potential ridership volumes require higher capacity services.

Within the general plan of extending mass transit service to the State of Mexico, there is a need to articulate potential corridors. Already, the Line B project has established a route but construction is stopped at the border over political disputes concerning land acquisition for the alignment and the stations. Indeed, the Master Plan calls for 6 new lines to connect the EM and DF as well as several heavy rail regional rail service that would connect the DF, EM and perhaps more distant States, such as Hidalgo. In this case, there are two sets of consultants advocating for different options. One group has been retained to study the possibility of regional rail. The proposal includes several corridors with a focus on a north-south line along the western, affluent side of the city. The other group is working on extensions for existing transit lines into the EM from the DF, especially the currently underutilized systems.

The Metro master plan, appropriately, has been administered by STC, within SETRAVI. The major alternative, a set of suburban heavy rail lines developed under the aegis of SCT, has been studied as a part of the COMETRAVI report. COMETRAVI is heavily dominated by DF interests through SETRAVI directly but also through the director of SCT, based in the Federal District. In this sense, although the most important challenges are in the EM segments of these projects, most of the work and discussion is happening on the DF side of the border.
SUBSYSTEM 4: ATTAINMENT SCHEDULE

Mexico differs greatly from the United States in this area. While there are national standards for concentrations of the same criteria pollutants, environmental policy is not driven to attain those standards on some schedule. Most mention of reductions, for example, refer to reducing the number of days in which the severity of the pollution exceeds a critical level (comparable to "red-alert" days in Washington DC and other cities). There is little mention of reducing the degree to which the standard is violated – such would be practically useless.

The standards, expressed in a unit known as IMECAS, are created by the Instituto Nacional de Ecologia (INE) which is a part of the Secretaria de Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP). INE administers most of the related programs, working with the DF and EM Secretariats of environment (SMA and SE, respectively) to accomplish these tasks. According Miller (1991), the 1990-95 environmental program, PICCA, was created from a set of available projects, some of which were already underway. The program was so oriented to the path of least resistance that reductions were made in pollutants that weren’t problematic in the region and the critical ones, such as NOx and CO, were largely ignored.

The approach taken in Mexico City to reducing pollution is focusing on the best available policies (not always the most needed) and implementing them to achieve the maximum emission reduction. The investments are driven primarily by the aim of reducing as much pollution as possible, probably with a realistic hope of offsetting growth in emissions but less so that such actions will lead to acceptable pollution levels in a reasonable amount of time.
As a subsequent subsystem, Conformity, indicates, the lack of clear guidance from tangible environmental objectives reduces the ability of environmental and transportation planners to communicate expectations effectively.

**Subsystem 5: Transportation Control Measures**

INE, SEMARNAP and the related environmental agencies have been fairly successful at identify key strategies for reducing pollution from mobile sources and have touched upon many of the 16 TCM types referenced in Chapter 8. Indeed, the Emergency Program (1989), PICCA (1990-95) and Pro-Aire (1995-2000) have all been based on a set of primarily mobile source reductions. Many of these have focused on vehicle and fuel technologies but some of the major programs fit the description of TCM's. Of these, *Hoy no Circula* is clearly a dominant example.

The major constraint is that while INE and its associates have been able to identify and advocate these strategies, most have been difficult to implement. *Hoy no Circula* and I/M, for example, have been pillars of the anti-pollution/congestion campaign of the last ten years. Transit management, however, has been less successful. This is primarily due to the fact that the necessary actions are in the jurisdiction of a different agency with which INE and CAM have little or no influence.

The production of the COMETRAVI report on transportation measures to reduce air pollution represents a major step in the right direction. Namely, the transportation agency is adopting objectives out of its normal field of vision. This may be because the agencies involved recognize the availability of funding aimed at environmental causes from domestic as well as international sources. Alternatively, it may be that EM-SCT is joining SETRAVI in recognizing the need to mitigate congestion and thereby pollution. In this regard EM-SCT could be motivated
by a number of factors including the availability of money but also an awareness of increasing congestion on its side of the boundary.

**Subsystem 6: Long-term Conformity**

In the Clean Air Act/ISTEA context, conformity (the requirement that transportation plans meet the emissions budgets of the air quality plan) is the major step that links transportation and air quality planning and has encouraged (or forced) different agencies to share objectives, goals and resources. In Mexico City, there is no comparable legislative mandate to coordinate in this way although self-interests may be motivating the transportation agencies to pursue this course anyway.

It is important to remember that a central component of the conformity process is the matching of the long-range transportation plan emissions implications with the air quality attainment schedule. It has been noted in the preceding sections that the Mexico City planning environment lacks both of these planning processes, particularly in the long-term.

The greatest extent to which such a plan exists is that both PICCA and Pro-Aire were five-year programs that outlined a set of investments that had expected emissions-reduction benefits. If a transportation plan with a comparable horizon existed, one could argue that Pro-Aire (or PICCA in its time) could be compared against it to make an analysis similar to a conformity determination. This exercise is addressed in a later subsystem (“Short-Term (TIP) Conformity”). The current design of Pro-Aire II has a ten-year time horizon, primarily for the purpose of outliving the upcoming “sexenio” (six-year term) of the President to be elected in the fall of 2000.
In addition to adding durability, the longer time frame of the environmental plan creates the opportunity to compare long-term transportation and air quality plans, as in the United States practice. Thus, there is a need for a comparable long-term transportation plan. As with Pro-Aire, a federal mandate might be necessary for developing such a plan. The TCM-oriented 1999 COMETRAVI study indicates that transportation planners recognize this need. For the study to become an effective policy program, however, it is likely that it would have to be adopted by the Congress for it to be supported by the force of law. As it stands, COMETRAVI does not appear to have a strong enough authority to implement the necessary programs based on the voluntary participation of SETRAVI, SCT and EM-SCT.

**Subsystem 7: Needs Assessment**

Recalling the protocol-intense structure of the TIP framework in chapter 5, the next step in the process is the identification of mobility and accessibility needs in the region. This element is derived directly from the RTP, which, in Subsystem 3, “Identifying Programs,” provided general guidance on investments over a 20 year period. Indeed, ISTEIA and the conformity process requires that TIP projects be a part of the approved RTP. Doing so is supposed to ensure that TIP projects are in conformity if the entire RTP has been approved.

In Mexico City, this type of activity suffers the same fate as the air quality attainment schedule. In the absence of long-term goal-oriented thinking, investments are generally programmed on the basis of best-available options. For that reason, this subsystem is generally passed over for the subsequent stage. Of course every project idea evolves from some identification of need. The triggers that warrant concern in Mexico City tend to be related to
acute congestion. As a result, attention is paid to the need for new infrastructure in rapidly urbanizing areas of the periphery and bottlenecks in the highway system.

In other words, consistent with the U.S. model, transportation expenditures from tax revenue are spent on the basis of public interest. By contrast, in Mexico a substantial amount of transportation spending is motivated by the availability of funds from donors such as the World Bank or specific funds (the Environmental Trust Fund) in which case decisions are made on the basis of best-available options, once again. In these cases, “best available” might be determined by the interest of the donor, as in the case of the World Bank. In this context, expenditures are frequently made for projects which are not needed as much as others.

The actors in this process are generally either the implementing agencies directly (SETRA VI, SCT, EM-SCT) or the infrastructure bank, BANOBRAS. The latter is unabashedly interested in rate of return, rather than effectiveness in pursuing a specific goal. In that sense, the “free money” is not often spent on the immediate need. This is in distinct contrast to the U.S. where the MPO, through its consensual constituency process, is responsible for identifying regional needs.

**SUBSYSTEM 8: OPTION DEVELOPMENT**

In the New Jersey context, it was clear that the articulation of planning and engineering solutions to transportation problems was the domain of the implementing agencies. The same is the case in Mexico City in one of the few cases of congruity between the different contexts.

In the realm of Metro expansion, two different consultants (Mercer/Ochoa and ICA) have contributed to developing the plans and conducting the necessary analyses. The experiences reveal two different approaches to project development, however, in the comparison between the
suburban rail project and the Metro expansion. The latter (ICA) follows the typical pattern of planning in Mexico City. Sponsored by a DF agency, SETRAVI in this case, the plan has the center-city in its primary interest and views the EM and its institutions as a necessary evil. The former (Mercer), in contrast, is more directly linked to the national SCT and thus, while still focused on the downtown as a radial service, has a broader perspective.

The different approaches don’t vary too much, however. Both projects face the same challenge of getting the EM to cooperate, particularly on the subject of Right-of-Way acquisition, although the Metro faces a greater challenge in that regard. In essence, this subsystem is fundamentally about a technical exercise of evaluating the merits of a physical investment. It is a test of admissibility. In that sense, any observer of the institutional workings of this stage are only interested in seeing that the best available technical skills are being utilized to evaluate the different alternatives to the same objective, which, in this case, is high-capacity service between the central business district and the heavily populated periphery.

**Subsystem 9: Prioritization**

In this subsystem, the crucial event is the adoption of goals set out in the long-term plan followed by the application of those goals to the options forwarded by the previous subsystem. Obviously, the work in Mexico City is challenged by the absence of a long-term planning process that produces such goals. By default, the main source is the ongoing discourse within COMETRAVI, which reflects inter-jurisdictional cooperation as an essential priority. In other words, there aren’t goals available to adopt because of the absence of long-term planning. In that void, however, goals are developed without the equivalent of the RTP.
The most important feature of the goal formulation is the inclusion of diverse interests at the table. In North Jersey, the MPO board is based on geographical representation as well as delegates from the key implementation agencies. Within COMETRAVI, which is the closest analog to an MPO, at least the transportation agencies from the region are represented. As noted previously, there is no explicit recognition of other values, however, such as urban development and air quality. Although COMETRAVI appears to recognize air quality on its own this is not enough for the formulation of air quality goals.

An important example in the context of Metro expansion is the emphasis on planning for demand. The history of the Metro is plagued by the selection of route locations because of constraints that have outweighed the availability of a demand pool. As a result ridership on all of the lines after the initial construction of the first three have been poor. Clearly, the new lines need to be guided by a strong objective for reaching centers of demand. In this sense, to the degree to which the areas of new service are still developing, there is a critical opportunity to understand the goals and objectives of the land planners, who might be in the position to designate high density areas that are more likely to facilitate transit demand.

The bottom line is that the U.S. MPO, by using geographical representations, hears multi-disciplinary input from its members. While COMETRAVI has succeeded in getting the DF and EM to the same table, it has yet to attract delegates from other disciplines. For the same reason that NJ DOT and NJ Transit must have delegates to NJTPA, COMETRAVI must acquire input from CAM and COMETAH and thereby reach those other constituents.
SUBSYSTEM 10 & 11: ADOPTION & AUTHORIZATION

One of the great challenges in transportation planning in Mexico City is converting a good idea into real action. The proposed Metro expansion is a prime example. The plan is developed with a heavy DF influence but requires substantial participation by the EM. In this case, implementation requires contribution of Right-of-Way and station areas by the EM to the Metro. Even if COMETRAVI elected to advocate the suburban rail alternative, the burden on the EM would be the same.

The authorization and appropriation of funds is central to this obstacle because money is a major source of the EM’s opposition to investment in either the Metro or the suburban rail. Both projects, at present, place most of the benefits on the DF side of the border in terms of congestion relief and pollution abatement. It is the obligation of the planners to convey to the EM administrators that there are also important incentives for them in terms of emissions reductions and congestion.

For example, investment in Line B should lead to the diversion of trips from cars, colectivos and buses to the Metro. In a best-case scenario, continued Metro expansion would encourage new development to focus around transit facilities with high densities. These factors would limit growth of land consumption and road travel, which in turn reduce the costs associated with building and maintaining road infrastructure. Currently, the EM is very concerned about a growing highway budget because formerly inter-urban roads have been redesignated as intra-urban due to metropolitan expansion. In that way, an investment in transit that would decrease highway expenditures would be highly appealing to officials in Toluca.

Here a major difference between the U.S. and Mexico City is that the mechanism of an expected funding level is not present in the MCMA. In contrast, much of the funding for such
large projects comes from loans or through the concessionaire. The financial constraint imposed under ISTEA that has led to improved TIP development is not available in Mexico.

**SUBSYSTEM 12: SHORT-TERM (TIP) CONFORMITY**

Under ISTEA, the TIP is derived from the RTP every year and as long as the RTP conforms to the SIP, the TIP does as well. The TIP is still subjected to a thorough conformity determination but with more attention to the impact of the actual project details, in contrast to the general prescription of the RTP. Another important reason is that projects in the TIP are sometimes added and subsequently amended to the RTP during the 3-year intervals. Although there is no attainment schedule included in Pro-Aire, there is no reason that the general objectives of the air quality policy could not be used as criteria for evaluating individual transportation projects. As criteria, the objectives of Pro-Aire can indicate that certain investments are in conflict with other initiatives. For example, such a mechanism might eliminate a roadway expansion project on a corridor in which simultaneous efforts are underway to encourage private drivers to take transit. Without an emissions-reduction schedule on which to base an emissions budget, it would be impossible to do so on a systematic basis.

It is important to keep in mind that one of Howitt’s/Moore’s (1999) key findings was that the conformity process in the U.S. greatly enhanced interactions among transportation and environmental agencies. This relationship would have many benefits, which are discussed in this chapter’s conclusion. A good example is the development of goals, which is lacking from the current framework, as noted.
Step 3: Classify the Institutional Relationships

Relationships among these key institutions are manifested in the formation of the metropolitan commissions. It has already been noted that CAM, COMETRAVI, and COMETAH are made up of the relevant agencies from the DF, EM and Federal governments. However, these relationships are not even-sided triangular relationships with reasonably shared power. The geographic relationship between the DF and Federal Government is likely to be an important factor in the dominance of DF interests in each of the metropolitan commissions. The contrastingly distant location of the EM capital in Toluca is a compounding factor. Because of these and other issues, representatives to these coalitions from the EM willingly express their frustration about the focus of the voluntary associations on DF issues.

With respect to vertical power relationships, the significant political changes that have occurred in the last few years, especially the popular election of an opposition-party mayor for the DF, make it difficult to assess how effectively national, state, and local governments are cooperating on these and other issues. As seen in the previous topic, the federal government traditionally has had a close alliance with the mayor of the DF, especially before the election in 1997. Part of the political decentralization effort underway is intended to allow local decisions to be made locally rather than depending on the central agencies to administer national policy as well as minor local issues. Traffic management is an excellent example of this: traffic committees each of the delegaciones are expected to mitigate chronic traffic problems by performing basic traffic engineering on a case by base basis. Nationally, this effort can be seen in SEDESOL’s effort to fortify regional centers of economic productivity.

The discussion of the conformity process in the subsystems highlights the need to bring the various commissions closer together in order to accomplish integrated planning with
transportation, environmental, and urban development considerations all together. The key incentive for achieving this sort of unity is to develop goals that can shape the choices of investments to make in the infrastructure, such as the Metro expansion. At a very different level, enhanced communication among the institutions will greatly increase their ability to synthesize any available data and possibly, by pooling resources, to achieve economies of scale in data collection. Naturally, better data would facilitate better inventories and forecasts.

**Step 4: Build the Architecture**

![Figure 9.3: MCMA (Metro Expansion) Regional Planning Architecture](image)

The conclusion of chapter 5 suggested that there was a very straightforward approach for applying the RPA diagnostically. For the lines of communication and responsibility connecting each institution pair, one should consider the presence of:

- data/forecasts
- approvals
- needs
- goals
- money
Even in the absence of the ISTEA framework, one can learn a great deal in this manner.

The dominant theme is that institutions are organized according to discipline. Through the metropolitan commissions, there is a strong association among the environmental institutions very separately from the relatively close grouping of the transportation or land planning agencies. In actuality, these groups are not very tight; the inclusion of SEDUVI and SEDUOP in COMETAH indicates very little about their ability to cooperate in the implementation of well-conceived plans. There are no apparent links between the disciplines at any level. The only possible exception is the common accountability to the administrator, such as the mayor, for the different agencies within a specific jurisdiction. Thus, to the extent that different agencies share an agenda (an agenda could represent a set of goals), it is because it is distributed and enforced by a senior public executive, such as the mayor, governor, or president.

One might expect that the metropolitan commissions would provide some important function for its member organizations. Indeed, it appears that in the case of Cometravi, the commission’s technical staff can provide some resources to SETRAVI and EM-SCT, particularly. Cometravi also has a sufficiently broad perspective to develop the study that has provided a basis for much of the analysis in this review. One can assign the link between Cometravi and its members as conveying data/forecasts. A similar relationship is not obvious for Cometah or CAM. However, it appears that CAM has some role in helping its member agencies to develop goals. This derives primarily from the fact that environmental policy is federally driven so SEMARNAP/INE, through CAM, distributes objectives for SMA and SE.

Cometah and its members are substantially inhibited by the problems associated with land planning in the MCMA. Without any meaningful regulatory mechanisms available at their disposal, the land planners primarily act to collect data. One might hope that this data would be
used to help the formulation of policy in other arenas, such as transit planning, but there is no
evidence of any effort in this direction.

Pemex plays an important role in providing data to some of the agencies at each level, especially in the environmental field. It serves the primary function in air quality modeling in the metropolitan area, and that information is used to leverage any other activity that draws its mandate from the pollution reduction agenda. At the same time, Pemex has received goals from the environmental agencies, such as the initiative for which Pemex manipulated the prices of Magna Sin and Nova in order to benefit air quality.

The funding for projects comes from the legislatures and national congress, both of which are subject to the agendas of the administrators and the political parties. Money also comes from the World Bank, primarily through BANOBRAS. The World Bank is likely to maintain some goal-oriented notions that can influence the distribution of money.

Conclusion

The purpose of this chapter was to demonstrate the effectiveness of the methodology and, in doing so, to generate some observations about institutional relationships in Mexico City – based on the Metro expansion example – that could lead to more general conclusions about the Regional Planning Architecture. As a diagnostic endeavor, this chapter has been very effective and has verified the usefulness of the methodology.

The preceding analysis of the Metro expansion corridor has highlighted several themes of institutional relationships in the MCMA. One, the formulation and distribution of goals is extremely limited, essentially involving the political agendas of the elected leader as well as the World Bank. Two, the institutions are organized predominantly by discipline with no significant
interactions except the sharing of project ideas. Because of the voluntary nature of the organizations, even this sharing of ideas tends to have little impact on policy formation. Three, the metropolitan commissions serve a clearinghouse-like function and only in the case of COMETRAVI does one provide data/forecasting information. Four, Pemex plays an important role in generating models and forecasts for the environmental community.

In addition to some of these themes that the architecture illuminated, there were some that were strikingly absent. Of these, the most important example is the absence of the colectivos, including the route associations, in any form. This could possibly be addressed by linking them to the transportation agencies as a lobby group, which would involve the communication of goals, through an agenda to the relevant entity. Another important example is the absence of geographical representatives in this network, such as representatives of the delegaciones and municipios.

The purpose of this chapter as a diagnostic effort is satisfied by these findings. In chapter 10, more prescriptive comments underline some of the critical flaws of this arrangement and identify some directions in which institutional reform could move in order to enhance the RPA’s ability to more effectively implement future policy programs.
Chapter 10: Conclusion

Regional Architecture

Review

This thesis began where Todd Pendleton left off on the topic of Regional Architectures. Pendleton’s charge to future researchers was to expand his framework to address transportation planning whereas his focus had been on the administration of real time services. Indeed, this thesis has demonstrated the applicability of the Regional Architectures approach to institutional relationships in the context of planning. In so doing, this effort has redefined some of the core concepts of the methodology and revised the ReS/SITE framework of which Architectures are a vital part.

The first step was the differentiation of the Regional Planning Architecture (RPA) from the Regional Service Architecture (RSA) to reflect the important subsets of transportation institutions. The Comprehensive Regional Architecture (CRA) is the combination of the two subsets.

![Comprehensive Regional Architecture](image)

Figure 10.1: Components of the Comprehensive Regional Architecture (Figure 4.2)

This conclusion will focus on the relationship between the RSA and the RPA as an important characteristic of the CRA and the transportation system as a whole. One of the other implications of the RPA-RSA distinction was the role that the RPA maintains in the deployment
of the Regional Infrastructure (RI). These changes lead to a revised ReS/SITE framework, shown below.

Figure 10.2: The New ReS/SITE Framework (Figure 4.4)

The second step was the application of the new RPA and the new ReS/SITE framework to the planning process established by the Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA requires a set of plans around which institutional relationships are formed. There are four such plans that create a cycle. The evaluation of each plan's effectiveness informs its revision and the other elements of the cycle. The Statewide Transportation Plan (STP) is designed primarily by the state Department of Transportation. It establishes a vision, including planning goals, that are adopted by each of the Regional Transportation Plans (RTP). In turn, the RTP provides guidance for the annual creation of a Transportation Improvement Program (TIP) which is a fiscally-constrained capital investment plan. Finally, the state adopts a State Transportation Improvement Program (STIP) which is the direct combination of TIPs and other
non-metropolitan investment programs. The cycle is completed when the revision of the STP evaluates the recent STIPs’ content and effectiveness.

The third step was the expansion of the RPA to include relevant environmental plans. Of the numerous environmental regulations that relate to transportation, the National Environmental Protection Act (NEPA, 1969) and the Clean Air Act Amendments (CAAA, 1990) were the most relevant. For regional planning, however, NEPA was less important – its impact is greatest at the later project planning phase. The most important element of the air quality regulations was the conformity process, which requires that the expected emissions from the long-term RTP be congruent with the projection of the State Implementation Plan (SIP). Considering this, the full set of plans around which the RPA is built appears in the following way:

![Figure 10.3: Family of ISTEA Plans](image)

Integrating Figures 10.2 and 10.3 produces one change in the ReS/SITE framework that effectively illuminates an important component of the ISTEA process. Under the ISTEA framework, the TIP is the set of short-term measures that are promoted by the MPO in order to achieve the objectives established by the RTP. In ReS/SITE terms, the RPA is responsible for deploying the RI. If one integrates these definitions, it is obvious that the RTP is the traditional infrastructure component - the RI - of the Regional Strategic Transportation Plan (RSTP). It is interpreted by the RPA (represented by the MPO), which produces (“deploys”) the TIP. This can be represented in the following way:
With these three steps, this thesis has effectively responded to Pendleton’s change. One can now recognize the Comprehensive Regional Architecture has having two components that address services and planning. Correspondingly, the ReS/SITE framework has been adjusted to incorporate this change. The following section addresses the implications of this evolution.

**Findings**

With the work advanced here, and the earlier work by Pendleton and Conklin (1999), extensive attention has been placed on the RPA and RSA, respectively. The differentiation also creates a need to understand the relationship between the two subsets of institutions. While the present discussion makes several suggestions, this is an area that deserves further attention, just as planning did at the conclusion of Pendleton’s thesis.

Within the RPA, one of the most important characterizations are the differences between the MPO and the implementation agencies. In the TIP process, for example, the DOT and transit organization dominate the development of technical responses for needs identified by the RTP and by the local scoping activities. As suggested at the end of Chapter 4, the main concern with
this arrangement is that the segmentation of project analysis and goal development means that goals appear to the implementation agencies as constraints rather than as objectives.

There are two forms of connection between the RSA and RPA. First, there is institutional overlap. The fact that there are members of the RSA that are involved in the RPA highlights the importance of the previous paragraph. As it currently appears, the RSA presence in the RPA is through the implementing agencies: NJDOT and NJ Transit, for example. The role of these institutions in the RPA is to convey technical information regarding the feasibility of certain project ideas. The RSA brings technical expertise to the planning process and a first-hand perspective on the operation of the transportation system. However, the RSA, through its representatives, is minimally involved with the formulation of goals.

One aspect of this that the framework does not appear to capture is the relationship between the agencies and the political atmosphere. For example, the heads of the DOT and DEP may be hierarchically equivalent in state government but the Governor may be more concerned with one department or the other for personal or public appearance reasons. Similarly the legislature may be partial to one department or another. This is especially important because the majority of the MPO’s board of directors are elected local officials who are often dominated by the governor’s administration.

In addition to the institutional linkage between the RSA and RPA, there is also an important flow of information. The RSA, by definition, has direct access to information about the operation of the transportation system, perhaps on a modally-specific basis, such as NJ Transit. The MPO, within the RPA, depends on these sources of data for developing the short and long-term regional models of transportation demand and supply. In general terms, the relationship between the members of the RSA and RPA may determine how freely that
information flows between the two subsets. In technical terms, it is important to realize the challenges of sharing such data, comparing models and so forth. In addition to consistency within each of the subsets, the Comprehensive Regional Architecture must be able to share information smoothly. This challenge highlights the roots of this work in computer architectures and the data-intensive character of Pendleton’s work on the RSA.

In a different area, a major challenge identified by the framework is the task of developing and applying goals. Most critically, it is clear that secondary goals, such as air quality in this case, often appear to decision makers as constraints rather than as objectives. While the presence of air quality as the dominant constraint on transportation planning is substantial progress compared with the pre-ISTEA/CAAA era, it is clear that transportation strategies should ideally embrace air quality as a goal.

The ReS/SITE framework captures this issue very effectively. One might represent the conformity issue, as in Figure 10.3, as a hoop through which the RTP and TIP must jump. The status-quo requires transportation plans to “pass” the conformity test, which provides no incentive to do better. If air quality was a goal of the planning process, it would be included in the RTP and it would be included as a criterion on which project concepts are evaluated. Attending to air quality would yield a better transportation project, rather than simply an expenditure from which planners see no benefits. Each year, when the RPA interprets the RTP according to the established set of planning goals, it would consider air quality when producing a TIP, as demonstrated by figure 10.4.
Outlook

In order to evaluate the effectiveness of the changes proposed in these chapters, one must consider the purpose of regional architectures. Perhaps the most important goal is to understand how one can identify institutional relationships in order to propose changes to the membership or line of communication and responsibility. One of the purposes of this effort is to enhance productivity of existing infrastructure through improved management techniques.

The recognition of the RPA creates the opportunity to identify the institutions that are actively involved with two important elements of the Comprehensive Regional Architecture, which includes all institutions and relationships. First, by developing the long-term plans for the region, the RPA has a major role in determining what institutions will maintain certain responsibilities. Second, by developing the goals for subsequent planning activities, the RPA determines how planning decisions will be made throughout the institutional network. Therefore, in contrast to the RSA, the RPA is both a product of the regional strategic planning process and the principal actor.

It is important to emphasize, in these concluding remarks, that while the Intermodal Surface Transportation Efficiency Act has provided a model for this discussion, the set of plans established by the specific legislation are not fundamental to the theoretical framework. ISTEA provided a model from which a framework was constructed. The individual plans, such as the TIP, provided a gravitational center around which the relevant set of institutional relationships formed. Once ISTEA is removed from the framework, however, it is possible to recognize that the relationships, which are based on exchange of information, needs, goals, funding, and approvals, exist independently of the legal framework.
The extension of this point is that the current set of institutional relationships are a function of the current legal mandate and are not, as the discussion of the ISTEA plans showed, necessarily the optimal arrangement. The purpose of the ReS/SITE work is to show that institutional innovation is a critical element of regional strategic transportation planning. This requires recognition of the fact that the current set of institutional relationships in metropolitan planning is dynamic. Local planners should be encouraged to seek out improvements for the Comprehensive Regional Architecture rather than to wait for national legislature to impose change.

The changes proposed in these chapters have enhanced the methodology's capabilities in analyzing institutional relationships. The ability to distinguish between and relate the services and planning architectures is a critical improvement. The second major contribution is the identification of goal formulation as a key step to incorporating policy goals as objectives rather than as constraints. This aspect is particularly important for advancing the area of environmentally-based transportation planning.

The case study of Mexico City, which is reviewed in the following section of this conclusion, provided an excellent opportunity to examine the special problem of making air quality an objective for transportation planning. It also demonstrated the challenge of developing and relating the related long-term and short-term transportation plans. Further examination of the relationship between the RPA and RSA is an important direction for future research.
Mexico City

Review

As one component of the Mexico City Integrated Environmental Assessment Project, the work of the Mobility-ReS/SITE team created an excellent opportunity to apply the Regional Architecture theories, including those developed in this thesis. Mexico City has dramatic challenges in both the mobility and air quality arenas and those two are closely linked due to the substantial contribution of vehicle emissions to the air pollution problem.

The case study involved three major activities, the findings of which are summarized in the subsequent section. The first task was to achieve a comprehensive assessment of the current transportation and air quality situation in Mexico City. Working with other researchers from the Integrated Assessment project, the Mobility-ReS/SITE team focused its energies on the transportation system. The second task was to survey previous policy programs and to comprehend how the successes and failures of those failures contributed to the current situation. The third task was the application of the Regional Planning Architecture framework to the case study.

The product of the research, presented in chapters 7-9 of this thesis, is largely descriptive. At the time of publication, the Integrated Assessment project is developing a set of recommendations for the new air quality policy, Pro-Aire II, based on the findings of the Mobility-ReS/SITE team and other working groups. The application of the RPA framework to the case study presents an opportunity to assess the effectiveness of the methodology and to identify possible strategies for improving the institutional relationships identified during the process. Thus, the conclusions are also prescriptive for the methodology, for relevant parties in
Mexico City, and for future researchers on the Integrated Assessment or Mobility-ReS/SITE projects.

**Findings**

**Assessment**

Mexico City is in a relatively small but growing family of “mega-cities” around the world having 20-25 million residents in the greater metropolitan area. The sheer size of such cities presents a number of critical problems: the provision of mobility on a massive scale is a key example. Other major issues include housing, drinking water, sanitation, and air quality.

Two very different forces have driven Mexico City’s growth. First, since the post-revolutionary period (1920s), migration from the countryside has brought millions of poor people to the city’s periphery adding layer after layer of “irregular” settlement. Second, the upper class residents who have historically dominated the downtown (contrary to U.S. model) have begun the familiar pattern of suburbanization, pushing out on the periphery from within. The city now covers all of the DF as well as parts of the EM and is reaching into other adjacent states.

The suburbanization by the upper class combined with accumulation of impoverished at the periphery generates two distinct and simultaneous mobility pressures. The distribution of infrastructure (highway and transit rail) encourages highway modes of transportation (cars for rich, colectivos for poor) in areas of expansion. The concentration of industry and commerce in the CBD produces intense freight traffic in the same corridors. The impacts of land use patterns and public investment have led to a decline in regional occupancy rates in passenger travel. This has resulted in chronic congestion.
Increasing PMT due to population growth and urban growth coupled with the decline of occupancy rates induces even faster growing VMT, which, without system or demand management has produced increasing congestion. This with other factors (stationary sources and the unique meteorology/topography) produces a terrible air quality problem.

Land use planning efforts have focused on protecting the southern DF in which water arrives from the mountains. Attempts to limit illegal conversion of ejido land have been futile. Congestion management has centered on the Hoy No Circula driving ban, some infrastructure development, and continuing plans to improve transit and rejuvenate occupancy rates. Transportation-related air quality policy has focused on technological improvements and not on demand management, with the exception of the disappointing circulation ban policy.

The city now includes two states, one of which is home to the federal government, which administered the city until 1997 through a Presidentially-appointed mayor; the mayor is now popularly elected. In transportation, air quality and land use (and other areas), the challenge of policy formulation and implementation is complicated by conflicts among the different branches of government, which are being further decentralized during the current round of elections.

Hypothesis Testing

As noted earlier in this chapter, it seemed that applying the Regional Planning Architecture theory to a non-U.S. context would encounter many obstacles due to incompatible policy environments. For advancing the methodology, this fact proved productive. For the purpose of the case study, however, the benefits were not so clear.

One critical challenge to any investigation of the MCMA is to develop observations or recommendations that go beyond earlier work. Because the problems in Mexico City are chronic,
many of the important points were made long ago and have been repeated extensively since. However, because a significant portion of the problem lies in the deployment of well-constructed policies, the regional architecture approach is capable of casting old, familiar problems in a new and revealing light. For instance, the RPA diagram constructed based on the Metro expansion example indicated that there is very little in the way of goal formulation within the planning agencies. While it is obvious through any lense that the absence of a long-term emissions reduction schedule is a problem, the architecture approach illuminates the fact that the schedule represents a goal that guides other decisions; lacking that, it is difficult to strategically integrate air quality into the transportation planning process.

An area of critical importance in which the methodology both struggled and thrived was the linkage between transportation and air quality planning, which occurs in the conformity subsystem. As described in chapter 6, conformity is based on annual emissions budgets derived from a long term emissions reduction schedule. Transportation projects that would lead to emissions in excess of the budget in a future year are not acceptable. In the U.S. context, transportation planners have to pick among candidate projects, typically based on a tradeoff between construction and emissions. In Mexico City, however, the absence of emission reduction plans prevent the use of emission budgets as a mechanism to influence transportation investments.

Because Mexico City lacks the data and modeling capabilities to produce attainment schedules or the long term emissions impact of proposed projects, the conformity process is not applicable. Certainly it is possible to assess generally the emissions impact of certain projects and to eliminate those that are grossly incompatible with air quality policy. However, this type of thinking underscores the importance of the finite emissions budget as an effective tool for
making transportation planners prioritize prospective investments. The presence of a budget, whether for pollution or money, acts effectively as a surrogate for a goal, which influences every other decision.

The other challenges that the framework might illuminate include the chronic conflict between the Federal District and the State of Mexico. A full assessment of EM institutions emphasizes the point that while the DF is devoted to metropolitan issues, the EM can give them only partial attention. Among the implications of this issue is the bias of federal and international spending toward the DF because of its strong ties with the institutions at those levels, such as the National Environmental Institute (INE) and the World Bank.

Another problem that the framework attempts to capture is the political volatility of the region. The Mexico City RPA makes clear the importance of political agendas, which are the closest thing to goals present in the framework. By highlighting this influence of the mayor, governor, and president, the RPA points to the impact that political volatility and turnover can have on the development, implementation, and maintenance of policy programs.

Pro-Aire II has deliberately been designed with a ten year scope to ensure that its programs outlive the next president. In addition to being an obstacle to institutional planning, however, the political dynamic and the elections can also be a resource to institutional reform. The 1997 elections, for example, made the DF autonomous from the federal government in most respects. In the 2000 elections, the mayor will be popularly elected again and leaders of the delegaciones will also be elected. The presence of political change could open the doors to other institutional reform activities, stemming from a RPA-based proposal.
Outlook

The opportunities for institutional innovation in Mexico City are abundant, although sometimes constrained by political pressures or other cultural factors. One important answer found in this experience, however, is that by examining the institutional relationships surrounding environmental and transportation planning, one is able to identify approaches that could amplify the effectiveness of existing or proposed strategies in the metropolitan region.

The first recommendation is to bring the metropolitan commissions on transportation and air quality, and possibly land planning, closer together functionally. The lack of communication among these groups exemplifies the need for coordinated formulation of goals. To the extent that COMETRAVI is concerned about air quality, CAM is much better prepared to articulate reasonable air quality goals for the future. The link between COMETRAVI and COMETAH is also an important one because efforts at transit-oriented development could significantly assist the effort to reduce VMT growth in the areas of rapid urban expansion.

The second recommendation regards information, which is often lacking or poorly organized in most areas within the MCMA. Even in the DF, which is superior to the EM in this regard, origin-destination data is of poor quality as is the emissions inventory upon which any attainment schedule would have to be based. As noted in the discussion of the theory earlier in this chapter, such data is generally acquired by the operating agencies and provided to the planning institutions; from the RSA to the RPA. The reauthorization of Pro-Aire offers an opportunity to designate a budget for data and information collection and perhaps the development of an attainment schedule. A second important dimension of the need for more data, information, and accurate forecasts is the need for greater public involvement. The Mexico City RPA lacks the geographical representation that the MPO brings to the ISTEA-based RPA.
COMETRAVI, for example, should have a mechanism for receiving regular input from representatives of the delegaciones and municipios.

With respect to the conflict between the DF and the EM, some may argue that reconciling that obstacle may be outside the scope of this framework. One possible exemption from that charge is that the deliberations over inter-jurisdictional policy could be revised. One possible solution, in line with the scope of the architecture framework, is that the locus of decision making shift from the Governor of EM and Mayor of DF to the delegaciones and municipios.

This is a response to the position that EM is less involved with the MCMA because it is also concerned for Toluca and the rural parts of the state. One resolution is the delegation of authority to regional offices. A more extreme option is the empowerment of the local districts, which may perceive advantages and disadvantages differently than the state government. For example, of the delegaciones and municipios in the region, only 10 are served directly by the Metro. In discussions of Metro expansion, therefore, those ten might be consolidated to develop a strategy that they would be organized to promote to the rest of the region. Even at this simplified level, the proposal indicates that shifts in the lines of communication and responsibility and the inclusion of local government could aid the promotion of regional strategies.

A fourth recommendation addresses the need for the formulation of goals. This point has been made in several points because it is fundamental to the development of long-term plans that guide short-term plans. Goals also provide the basis for the development and use of performance measures so that more can be done to evaluate progress, represented as feedback loops to subsequent planning exercises. In the ISTEA context, this thesis has argued that the environmental efforts would be aided by emphasizing the emissions budget as a goal rather than
as a constraint. It is clear that the budget is an important first step that Mexico City would have to achieve before implementing such a goal. However, the experience with conformity in the U.S. underlines the effectiveness at such goals for achieving the policy aim, such as cleaner air, but also the institutional objective of integrating across disciplines.

A fifth and final recommendation is to address the strong division between the RPA and RSA in Mexico City. While the RSA was not the subject of this analysis, the discussion of the Metro did lead to the observation that the colectivos and their route associations, which are a major force in the provision of mobility, are not involved at all in planning. It is equivalent to leaving the highway departments out of transportation planning in the United States. The ReS/SITE framework makes clear that there is important overlap between the RPA and the RSA and that data and information exchange is a major outcome of those connections. The colectivos are clearly an entity that needs to be included in the planning process. The route associations represent the most obvious opportunity to involve them in decision-making.

Conclusion

Textbook scientific method suggests that one formulates a hypothesis, designs a reasonable mechanism for testing it, observes the outcome, and then confirms, abandons, or revises the hypothesis, potentially resulting in a re-testing. In good scientific form, then, this thesis has developed a hypothesis, tested it, and confronted the theory’s strengths and weaknesses. As outlined in the introduction, the work for this thesis was motivated by three factors:

- the impact on institutional relationships of rapidly increasing information
- the need to address conflicts between transportation and the environment,
- and the daunting challenge of applying these lessons to the case of Mexico City
Based on those factors, the thesis began with a clear hypothesis. By applying Pendleton’s service-oriented regional architecture theory to the planning process, one could identify a strategy for developing environmentally-based transportation plans. Indeed, Chapter 6 demonstrated in the supplementation of the ISTEA-based RPA that by incorporating air quality as a goal of the transportation planning process, pollution reduction could be viewed as an objective, rather than as a constraint. The regional architecture framework illuminated the importance of long-term goal setting on the adoption of project selection for each Transportation Improvement Program.

One of the most important tasks of developing the Regional Planning Architecture was to evolve from the protocol-oriented ISTEA planning process to an institution-based framework. By following Pendleton’s procedure for developing a regional architecture, Chapters 5 and 6 produced a summary of the ISTEA planning environment according to regional architecture requirements: institutions with lines of communication and responsibility.

The challenge of the testing procedure, accomplished in the form of a case study, was to show that the framework was independent of the ISTEA model on which it was based. The selection of Mexico City for its extreme mobility and air quality challenges raised some concern about the importation of an American planning process to the Mexican setting. While there were some points of friction, such as the absence of a long-term emissions reduction inhibiting the conformity subsystem, it appears that a non-U.S. case study was the most effective mechanism for proving the independence of the RPA.

If the theory had been tested in the United States, it would have been very difficult to prove conclusively that the framework was independent of the legislation. While the same substantive conclusion might have been reached, the important task of liberating the theory from
the model would have been lost. By working on the Mexico City, therefore, the methodological challenge was met.

Indeed, the Intermodal Surface Transportation Efficiency Act represents a major step forward for the regulatory mandate that imposes structure on most planning activities, especially in the area of environmental planning. At this time, extensive debate is occurring over streamlining the Major Investment Study/Environmental Impact Statement process under NEPA. The debate is based almost entirely on changing the nature of institutional relationships and the series of reports that are exchanged in order to expedite the project development process. This very neatly fits the criteria of a ReS/SITE endeavor in that the active planning institutions are involved with reinventing the entities and interactions surrounding this particular planning activity.

Based on the testing of the theory in the Mexico City case study, one can identify six major subsystems of the Regional Planning Architecture. These correspond closely to the longer list of subsystems included in the various ISTEA plans and those used in the case study as well as the five concepts used to classify institutional relationships (data, goals, etc.). They represent the most important areas of institutional interaction and information sharing in the RPA including the linkages between the RPA and the RI as well as RSA. These six subsystems should guide future analyses of institutional relationships surrounding the production of short- and long-term capital investment plans.

**Data Collection, Analysis and Forecasting of Mobility and Air Quality.**

This places a critical emphasis on the relationship between the RPA and RSA and focally on the members of the RSA that are part of the RPA, usually referred to as
implementing or operating organizations. The activity includes the collection of data, which is likely to include interactions with non-transportation and non-air quality agencies such as the Bureau of the Census as well as the local jurisdictions that maintain records that could inform the planning process (incidents, etc.). This also includes analysis and forecasting based on the data sets, which must be shared among the active institutions, such as DOT, DEP and the MPO.

**Development of Goal-Oriented Vision.**

Perhaps one of the most critical steps in the planning process and in the successful sharing of information within the RPA, is the presence of commonly-held goals. Every other planning activity, include the forecasting work, depends on logical assumptions that are based on goals. The development of a vision, including these goals, is an intensely consensual process that requires extensive interaction among stakeholders of all levels, sometimes including the populace. Under ISTEA, goals are first developed at the state level and then adopted regionally such that the same basic assumptions are shared within the state government. A major obstacle in Mexico City is the conflict of goals and values between the EM and the DF.

In addition to aiding integration and cooperation, the formulation of goals also provides the opportunity to acknowledge non-traditional metrics of transportation planning, such as air quality or equity. The answer provided here to the historical transportation-environmental conflict is that air quality goals should be articulated simultaneously with transportation goals. The idea is to make such goals appear as
objectives rather than as constraints. The mechanism for enforcing this appears in a subsequent item (Option Evaluation).

The goals are the first element of the long-term transportation plan that ReS/SITE has previously called the Regional Infrastructure and that ISTEA calls the Regional Transportation Plan.

**IDENTIFICATION OF NEEDS**

Recognizing the need for future investment takes on two forms. In the first place, the long-term plan must translate the vision into general-scale projects, such as increased transit use in a specific corridor, reduction of a certain pollutant within an Air Quality Control Region and so forth. These types of projects provide direction for the articulation of specific investments, which must be evaluated on the basis of the goals. As with the relationship between the RTP and TIP, the long-term plan provides some guidance as to how the short-term plan should develop. For the institutions, this is an exercise that requires the implementation of the vision without the commitment of funds. To some extent, this allows decision-makers to focus on regional interests, rather than the benefits to their own agencies.

Subsequently, the identification of needs includes the articulation of specific project ideas, such as improvements of an intersection, new rolling stock on a rail line and so forth. This stage has a distinctly bottom-up character, much in contrast to many of the other interactions presented so far. This needs identification relies on each locality, perhaps through its delegate to the MPO, to identify mobility-related challenges in the area. While this process could rely on the models and forecasts generated by separated
analysts, the institutional relationships thrive on feedback from municipalities, townships, and counties.

**ARTICULATION OF RESPONSE ALTERNATIVES**

As with the data analysis and forecasting, the overwhelming technical character of developing responses and alternatives for the identified needs is a task primarily delegated to the relevant implementation agency. The benefit of this arrangement is that the complicated engineering is left to the experts. The disadvantage is that when it comes time to present the projects publicly, there is a large disconnect between the experts and the critics. A process by which the public is involved with design issues would seem very cumbersome and costly, especially regarding the amount of time necessary for such an approach. However, the cost of negotiating with an angry public is also very high. Many experiences with the presentation of project ideas and growth of the conflict resolution industry suggest that early public involvement, in certain circumstances, might reduce the cost of production over the long run. It represents a major shift from the status-quo but it also addresses a major problem in the current system.

**TECHNICAL AND GOAL-BASED OPTION EVALUATION (INCLUDING BUDGET MECHANISM)**

It is in this area of institutional interactions that ISTEA has made its most important contribution. Common to both the fiscal-constraint and the conformity regulation is the concept of budgeting. At this stage of regional planning, the state has informed the MPO of the total funds available for the upcoming budget cycle and the categories in which they are provided. The division of funds into specific categories
allows the federal government to affect some distribution of money for different purposes while allowing the state and region extensive latitude. The presence of a constraint means that the planners are obliged to make rational prioritization among the candidate projects.

A comparable mechanism is present with the conformity regulation, which provides maximum emission budgets for each year into until the region is no longer in violation of the standards. This also requires planners to pick carefully among options. The MPO must make tradeoffs. One can imagine the MPO board of directors having an objective function that must satisfy air quality, mobility, and fiscal goals. By emphasizing conformity in the goal application process, it places a greater responsibility on a larger number of institutions to consider air quality as one of their objectives.

**PROMOTION OF ACTIONS**

The adoption, authorization, and appropriation process is one that is largely absent from regional planning in the U.S. context because of the funding mechanisms between the national and state governments. In that sense, it has little bearing on the regional institutions except where lobbying the state or national congresses is a reasonable strategy for increasing funding. In Mexico City, however, the funding mechanisms were very important. On one hand, the national congress maintain debt-approval authority over the federal district even after the popular elections of 1997. On the other hand, fiscal policy of the EM prohibits expansion of the Metro system beyond the DF border. These activities are not within the purview of the RPA but because they influence the institutional relationships, it is important to recognize them.
Summary

There are several questions to confront at the conclusion of this thesis. In addition to confirming that the methodology functioned well and that it revealed interesting answers, it is important to demonstrate that the regional architecture approach generated a perspective that a different methodology could not have produced. Given the Mexico City case study, this is especially difficult because, as an extraordinary situation, it has received extensive attention in academic and professional literature.

At the surface, one might perceive limited results in this respect. After all, previous works, such as Lezama (1999) and Miller (1991) have pointed out critical institutional and legal flaws in the metropolitan region. The conflict between the DF and the EM, the declining mode share, all of these are familiar problems. However, by following the exchange of goals, data, funding, approvals and information between institutions as the methodology prescribes, the regional architecture approach illuminated deeper features of the familiar problems. Among these, the observed lack of goal formulation as a fundamental weakness is, it appears, an original contribution to the literature on Mexico City policy debates.

Further, the perspective shown by the RPA configuration also points to reform measures that are not common in the literature. For example, the identification of the colectivos’ absence from the RPA leads one to observe that there needs to be more careful integration of the RSA and RPA. The RPA also highlights the absence of public input, even through geographic representation. When leaders are elected this year for each of the delegaciones, it will create an opportunity to include a new layer of participants in Cometravi and the other metropolitan commissions. This change would enhance both the acquisition and dispersal of public information. The creation of a new Pro-Aire presents an additional opportunity to reform the
planning environment. The new legislation could include a revised set of air quality goals. It would be very unusual but potentially effective to involve transportation planners in the production of the legislation.

There are many directions for future research on the regional architectures methodology and the work in Mexico City. For the former, the next task could be a careful examination of the relationship between the RSA and RPA. For the latter, the next phase of work needs to advance the understanding of policy formulation within the agencies and the legislatures. Continued work at the nexus of these topics will also be fruitful. While fully resolving the problem for the largest and most-polluted city in the world will not be easy, improving institutional relationships around goal development would be a major first step in the right direction.
Bibliography

Works Cited


Mobility-ReS/SITE, 2000. “Mexico City Transportation System: Planning for Air Quality and Mobility”

Mobility-ReS/SITE, 1999a. “Mobility Scenarios for Houston in the Year 2020” MIT.


Villegas, Alejandro, 1999a. “Land Use and Travel Patterns of MCMA.”


Recommended References


Greene, David. 1996. Transportation and Energy. Eno Transportation Foundation


Mobility-ReS/SITE, 1999b. “A Scenario Platform for Regional Strategic Transportation Planning” MIT.


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Appendix: Elements of the National ITS Architecture

There are 19 Subsystems, 30 User Services, and 56 Market Packages in the National ITS System Architecture Implementation Strategy. These elements, which are presented below, are the building blocks of the service and regional architectures discussed by Pendleton.

User Services

Travel and Transportation Management
1. En-Route Driver Information
2. Route Guidance
3. Traveler Services Information
4. Traffic Control
5. Incident Management
6. Emission Testing and Mitigation
7. Demand Management and Operations
8. Pre-trip Travel Information
9. Ride Matching and Reservations
10. Highway-Rail Intersection

Public Transportation Operations
11. Public Transportation management
12. En-Route Transit Information
13. Personalized Public Transit
14. Public Travel Security

Emergency Management
15. Emergency Notification and Personal Security
16. Emergency Vehicle Management

Electronic Payment
17. Electronic Payment Services

Commercial Vehicle Operations
18. Commercial Vehicle Electronic Clearance
19. Automated Roadside Safety Inspection
20. On-board Safety Monitoring
21. Commercial Vehicle Administration Processes
22. Hazardous Materials Incident Response
23. Freight Mobility

Advanced Vehicle Control and Safety Systems
24. Longitudinal Collision Avoidance
25. Lateral Collision Avoidance
26. Intersection Collision Avoidance
27. Vision Enhancement for Crash Avoidance
28. Safety Readiness
29. Pre-crash Restraint Deployment
30. Automated Highway System

Subsystems

Center Subsystems
1. Traffic Management
2. Commercial Vehicle Administration
3. Information Service Provider
4. Emergency Management
5. Planning
6. Toll Administration
7. Emissions Management
8. Transit Management
9. Freight and Fleet Management
10. Roadway
11. Parking
12. Toll Collection
13. Commercial Vehicle Inspection

Vehicle Subsystems
14. Personal Vehicle
15. Commercial Vehicle
16. Transit Vehicle
17. Emergency Vehicle

Travel Subsystems
18. Personal Information Access
19. Remote Traveler Support

Market Packages (Categories)
There are 56 market packages, grouped into the following seven categories:

1. Advanced Traffic Management System
2. Advanced Public Transportation Systems
3. Advanced Traveler Information Systems
4. Advanced Vehicle Safety Systems
5. Commercial Vehicle Operations
6. Emergency Management
7. ITS Planning
Appendix 2: Recommendations of the COMETRAVI Report

The report, Transportation and Air Quality in the MCMA, which provided extensive background information for the case study, included the following measures to address congestion and regional air pollution.

Passenger Transport
- Expand the trolleybus network
- Expand the Metro network
- Build lines of the regional rail
- Expand the Light Rail network
- Continue bidding on bus service in DF
- Construct busway network
- Utilize articulated buses on intermediate-demand routes
- Introduce express (bus) routes
- Introduce executive bus service
- Substitute buses for micros (colectivos)
- Create training programs
- Continue central-area restrictions
- Parking policies

Cargo Transport
- Apply emission standards to federal vehicles
- Form mercantile societies
- Build transfer facilities (“break-bulk”)
- Build local distribution centers
- Increase rail share into the city

Infrastructure
- Intersection improvements
- Improve maintenance
- Strategic road expansions
- Complete major corridor roads
- Additional beltways

Vehicle/Fuel Technology
- Use of natural gas vehicles for fleets, minibuses, buses
- Installation of catalytic converters
- Scrappage programs for cars and trucks
- Special emission standards for taxis.