

**SUSTAINABLE URBAN TRANSPORTATION IN
DEVELOPING MEGA-CITIES:
A REVIEW OF POLICIES, REGULATIONS, AND
TECHNOLOGIES**

by

Benjamin Myles Cheatham

Bachelor of Arts in Environmental Design
University of Pennsylvania (1995)

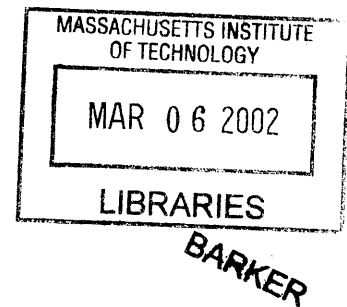
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Abstract

Of the many daunting challenges the world's developing mega-cities face, perhaps none is more pressing than the urgent need to enhance the mobility of their citizens. An efficient flow of goods and people into around and through these urban nerve centers is vital to their global economic competitiveness, environmental health, and socioeconomic development. A lack of adequate mobility is characterized by a number of detrimental externalities. Chiefly, the ensnarement of vehicles in traffic congestion, an increase in air-borne pollutants and a higher cost of travel are symptoms of poor planning, inadequate investment, and ineffective governance. Innovative policies, regulations, and technologies must be employed that enable mobility without sacrificing quality of life, clean air, or investment in other sectors. The primary objective of this study is to assist municipal governments in the development of environmentally sustainable, socially equitable, and financially self-reliant transportation policies and systems. This objective will be achieved in three stages:

- I. This study will describe and assess a portfolio of urban transportation policies, regulations, and technologies, concentrating on those policies that make use of market forces to influence travel demand.
- II. Two urban transportation case studies will be developed: Singapore and Bogotá, Colombia. These cases will be used to illustrate the interactions of policies, regulations, and technologies and to demonstrate the important roles that institutional arrangements and public opinion can play as determinants of success or failure.
- III. Finally, from this analysis we will develop a series of urban transportation policy recommendations for the city of Guangzhou. Our recommendations are based on interviews with senior municipal officials, documents produced by the administration, the city's unique context, and the telling experiences of Singapore and Bogotá.

Three primary conclusions arise from this study. First, developing mega-cities cannot focus solely on the supply of additional infrastructure to address their mobility problems; they must also manage the demand side of the equation. Second, these cities must employ a broad mixture of demand-management measures *simultaneously* in order to significantly improve mobility. Third, these cities must develop adequate institutional capacity in order to design, implement, and enforce effective transportation policies and manage sustainable urban transportation systems.

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I would like to thank my thesis advisor and mentor, Professor Fred Moavenzadeh for all of the incredible opportunities I have been afforded while conducting this research under his tutelage. Our work together has broadened my horizons and enriched my life in countless ways. I will always be grateful for his unshakable confidence, support, and companionship as we crisscrossed the globe.

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I'm deeply indebted to my dear friends Melhem Samaha and Dietrich Rogge, who always made sure I was focused on anything but this thesis. Without them, I would have been done long ago.

This thesis is dedicated to my loving wife Angie, who worked tirelessly to support us while I completed this research. She sustained me through dark moments and joyous occasions alike, always with greater devotion and patience than I possibly deserved. It's all for you.

Benjamin Cheatham
14 January 2002

Table of Contents

| | | |
|----------|--|-----------|
| 1 | Organization & Methodology | 9 |
| 2 | Conceptual Framework | 12 |
| 2.1 | Sustainable Development..... | 12 |
| 2.1.1 | <i>Sustainable Cities</i> | 12 |
| 2.1.2 | <i>Sustainable Transportation as an Integrated Concept</i> | 13 |
| 3 | Context | 17 |
| 3.1 | The Mega-City Phenomenon..... | 17 |
| 3.1.1 | <i>Urbanization</i> | 18 |
| 3.1.2 | <i>Motorization</i> | 18 |
| 3.1.3 | <i>Globalization</i> | 19 |
| 3.2 | Symptoms of an Unsustainable Urban Transport System..... | 21 |
| 3.2.1 | <i>Congestion</i> | 21 |
| 3.2.2 | <i>Air Pollution</i> | 21 |
| 3.2.3 | <i>Decreased Economic Activity</i> | 22 |
| 3.2.4 | <i>Higher Prices</i> | 22 |
| 3.3 | Causes of Unsustainable Conditions..... | 22 |
| 3.3.1 | <i>Limited Access to Capital</i> | 22 |
| 3.3.2 | <i>Poor Planning and Management</i> | 23 |
| 3.3.3 | <i>Lax Enforcement of Environmental Regulations</i> | 23 |
| 4 | Transportation Policies & Regulations | 24 |
| 4.1 | Organizing Framework..... | 24 |
| 4.2 | Market Based Policies vs. Command & Control Regulations..... | 25 |
| 4.3 | Demand-Side Strategies..... | 25 |
| 4.3.1 | <i>Travel Demand Management</i> | 26 |
| 4.3.2 | <i>Demand-Side Measures: Constraints</i> | 26 |
| 4.4 | Policy Objectives..... | 27 |
| 4.4.1 | <i>Reduction of Emissions</i> | 27 |
| 4.4.2 | <i>Transport Management</i> | 28 |
| 4.4.3 | <i>Vehicle Use</i> | 28 |
| 4.4.4 | <i>Modal Split</i> | 28 |
| 4.5 | Transport Policy Matrix..... | 28 |
| 4.6 | Demand-Side Command & Control Regulations: Examples & Assessments..... | 29 |
| 4.6.1 | <i>No Car Days (No Hoy Circula & Sin Mi Carro)</i> | 29 |
| 4.6.2 | <i>Vehicle Quotas</i> | 30 |
| 4.6.3 | <i>Peak & Location Restrictions</i> | 30 |
| 4.7 | Demand-Side Market Based Initiatives: Examples & Assessments..... | 30 |
| 4.7.1 | <i>Sponsored Car Sharing</i> | 30 |
| 4.7.2 | <i>Rebates and Incentives</i> | 31 |
| 4.7.3 | <i>Fuel, Vehicle, and Traffic Taxes</i> | 31 |
| 4.7.4 | <i>Mass Transit Subsidies</i> | 32 |
| 4.7.5 | <i>Road Pricing</i> | 32 |
| 4.7.6 | <i>Congestion Metering</i> | 33 |
| 4.7.7 | <i>Parking Pricing</i> | 34 |
| 4.7.8 | <i>Area Licensing Schemes (ALS)</i> | 35 |
| 4.8 | Supply-side Command & Control: Examples & Assessment..... | 35 |
| 4.8.1 | <i>Restricted Vehicle Zones</i> | 35 |
| 4.8.2 | <i>Restricted Parking Supply</i> | 35 |
| 4.8.3 | <i>High Occupancy Vehicle Lanes (HOV)</i> | 36 |
| 4.8.4 | <i>Public Road Construction</i> | 37 |
| 4.9 | Supply-side Market Based Initiatives: Examples & Assessment..... | 38 |
| 4.9.1 | <i>Private Transit Concessions</i> | 38 |
| 4.10 | Land-Use Planning Strategies..... | 39 |

| | | |
|----------|--|-----------|
| 4.10.1 | <i>Transit Oriented Development</i> | 39 |
| 4.10.2 | <i>High-Density Development</i> | 40 |
| 4.10.3 | <i>Urban Growth Boundaries</i> | 41 |
| 5 | <i>Transportation Technologies & Fuels</i> | 43 |
| 5.1 | <i>Intelligent Transportation Systems</i> | 43 |
| 5.1.1 | <i>In-Vehicle Technologies</i> | 43 |
| 5.1.2 | <i>Facility Based Technologies</i> | 46 |
| 5.2 | <i>Alternative Fuels</i> | 50 |
| 5.2.1 | <i>Compressed Natural Gas & Liquefied Natural Gas</i> | 50 |
| 5.2.2 | <i>Biodiesel</i> | 50 |
| 5.2.3 | <i>Liquefied Petroleum Gas</i> | 51 |
| 5.2.4 | <i>Ethanol & Bioethanol</i> | 51 |
| 5.2.5 | <i>Hydrogen & Fuel Cells</i> | 51 |
| 5.2.6 | <i>A Comparison of Alternative Fuels</i> | 52 |
| 6 | <i>Case Study: Bogotá, Colombia</i> | 54 |
| 6.1 | <i>Context & Overview</i> | 54 |
| 6.2 | <i>Institutional Arrangement</i> | 55 |
| 6.3 | <i>Transportation Policies</i> | 57 |
| 6.3.1 | <i>Sin Mi Carro</i> | 57 |
| 6.3.2 | <i>Pico y Placa</i> | 59 |
| 6.3.3 | <i>TransMilenio</i> | 62 |
| 7 | <i>Case Study: Singapore</i> | 67 |
| 7.1 | <i>Context & Overview</i> | 67 |
| 7.2 | <i>Institutional Arrangements</i> | 67 |
| 7.3 | <i>Transportation Policies</i> | 68 |
| 7.3.1 | <i>Vehicle Quota System (VQS)</i> | 68 |
| 7.3.2 | <i>Area Licensing Scheme (ALS)</i> | 69 |
| 7.3.3 | <i>Electronic Road Pricing (ERP)</i> | 72 |
| 8 | <i>Case Study: Guangzhou, PRC (Context)</i> | 76 |
| 8.1 | <i>Demographic Overview of Guangzhou</i> | 76 |
| 8.2 | <i>Economics & GDP</i> | 77 |
| 8.2.1 | <i>Public & Private Enterprises</i> | 77 |
| 8.3 | <i>Motorization</i> | 78 |
| 8.4 | <i>Congestion</i> | 79 |
| 8.5 | <i>Air Pollution & Societal Costs</i> | 80 |
| 8.5.1 | <i>Emissions by Vehicle Type</i> | 81 |
| 8.6 | <i>Political & Regulatory Framework</i> | 83 |
| 8.6.1 | <i>Transportation & Environmental Policies</i> | 84 |
| 8.6.2 | <i>Other Transport-related Initiatives</i> | 86 |
| 8.7 | <i>Guangzhou: Urban Transportation System</i> | 89 |
| 8.7.1 | <i>Urban Road Network</i> | 89 |
| 8.7.2 | <i>Public Transport</i> | 91 |
| 8.8 | <i>Institutional Organization & Structure</i> | 92 |
| 8.8.1 | <i>Guangzhou's Environmental Protection Institutions</i> | 92 |
| 8.8.2 | <i>Guangzhou's Municipal Transportation Institutions</i> | 93 |
| 8.8.3 | <i>Transportation Project Financing</i> | 94 |
| 9 | <i>Case Study: Guangzhou, PRC (Recommendations)</i> | 96 |
| 9.1 | <i>Basis for Recommendations</i> | 96 |
| 9.2 | <i>Comparative Challenges</i> | 97 |
| 9.3 | <i>Core Recommendations</i> | 97 |
| 9.4 | <i>Bus Rapid Transit</i> | 98 |
| 9.4.1 | <i>Recommendation Drivers</i> | 99 |
| 9.4.2 | <i>Operational Goals</i> | 99 |
| 9.4.3 | <i>Essential Components</i> | 99 |
| 9.4.4 | <i>Implementation Strategy</i> | 101 |

| | | | |
|--------------------------------|-------|--|------------|
| | 9.4.5 | Potential Obstacles..... | 102 |
| 9.5 | | Environmental Electronic Road Pricing (Eco-ERP) | 103 |
| | 9.5.1 | Recommendation Drivers | 103 |
| | 9.5.2 | Operational Goals | 104 |
| | 9.5.3 | Essential Components | 104 |
| | 9.5.4 | Implementation Strategy | 106 |
| | 9.5.5 | Potential Obstacles..... | 111 |
| 9.6 | | Transit Oriented Development..... | 113 |
| | 9.6.1 | Recommendation Drivers | 113 |
| | 9.6.2 | Goals | 113 |
| | 9.6.3 | Implementation Strategy | 114 |
| 9.7 | | Institutional Reform | 117 |
| | 9.7.1 | Recommendation Drivers | 118 |
| | 9.7.2 | Primary Recommendation..... | 119 |
| | 9.7.3 | Goals of an Institutional Development Strategy | 119 |
| | 9.7.4 | Steps to developing an Institutional Development Strategy..... | 120 |
| | 9.7.5 | Organizational Transformation | 120 |
| | 9.7.6 | Recommended Institutional Reforms..... | 121 |
| 10 Lessons Learned..... | | | 123 |

List of Figures

| <i>Number</i> | <i>Page</i> |
|--|-------------|
| 1. Sustainability, Synergy, and Trade-offs | 12 |
| 2. Mega-Cities with Populations Exceeding 8 Million | 17 |
| 3. Population Growth & Motorization Rate..... | 19 |
| 4. GDP Growth & Motorization Rate (by country)..... | 19 |
| 5. Mega-City Productivity: Inputs | 20 |
| 6. Policies, Regulations, and Technologies: An Organizing Framework..... | 24 |
| 7. Transport Policy Matrix..... | 29 |
| 8. Vehicle Use Options Compared..... | 31 |
| 9. Road Space Required by Mode of Travel | 36 |
| 10. The Impact of Roadway Expansion on Travel..... | 37 |
| 11. Portland's Urban Growth Boundary..... | 42 |
| 12. Navigation and Guidance Systems..... | 44 |
| 13. Display Panel on Buses in Hong Kong..... | 46 |
| 14. Benefits of Smart Signal Control | 47 |
| 15. Automatic Highway System Simulation | 49 |
| 16. San Diego AHS Trial in 1997 | 49 |
| 17. Combustion Emissions Characteristics of Alternative Fuels | 53 |
| 18. Bogotá's Projected Motorization | 54 |
| 19. A View of Bogotá's Skyline | 54 |
| 20. Bogotá's Planning Departments (Organizational Chart) | 55 |
| 21. Bogotá's Transportation Departments (Organizational Chart) | 55 |
| 22. DAMA Before Restructuring (Organizational Chart) | 56 |
| 23. DAMA After Restructuring (Organizational Chart)..... | 56 |
| 24. Car Free Day: Effect on Retail Sales..... | 58 |
| 25. Retailers Supporting Car Free Days | 58 |
| 26. Perceived Benefits of Bogotá's Car Free Day (%)..... | 59 |
| 27. Pico y Placa in Bogotá..... | 60 |
| 28. "Reversible" Roads Diagram..... | 61 |
| 29. "Contra-Flujo" Diagram | 61 |
| 30. Bogotá's TransMilenio BRT | 63 |
| 31. TransMilenio Cost Distribution..... | 65 |
| 32. TransMilenio Funding Sources | 65 |
| 33. Bogotá's Air Pollution (2000 & 2001) | 66 |
| 34. TransMilenio Socioeconomic Cost / Benefit Analysis..... | 66 |
| 35. ERP Gantry | 72 |
| 36. ERP Variable Message Sign..... | 72 |
| 37. ERP Operation Diagram (1)..... | 73 |
| 38. ERP Operation Diagram (2)..... | 73 |
| 39. ERP Operation Diagram (3)..... | 73 |
| 40. ERP Operation Diagram (4)..... | 74 |
| 41. ERP Operation Diagram (5)..... | 74 |
| 42. Population Growth in Guangzhou | 76 |
| 43. Scenarios for GDP per Capita Growth..... | 76 |

| | |
|---|-----|
| 44. Guangzhou: Vehicle Fleet by Location | 78 |
| 45. Guangzhou; Vehicle Fleet Composition | 78 |
| 46. Driving Cycles in Guangzhou and Beijing..... | 79 |
| 47. Emission Factors for Light Duty Vehicles in Guangzhou | 79 |
| 48. Health Effects of Urban Air Pollution in China..... | 80 |
| 49. Guangzhou: Correlation of Vehicle Population and Ambient NO _x Concentration..... | 81 |
| 50. Vehicle Emission Factors..... | 82 |
| 51. Guangzhou: Emissions by Vehicle Type | 83 |
| 52. Guangzhou: Current Transportation Policy Matrix..... | 88 |
| 53. Guangzhou: Emerging Transportation Policy Matrix (2001) | 88 |
| 54. Guangzhou: Vehicle Density per Km ² | 89 |
| 55. Guangzhou: Road Space per Capita & Vehicle | 89 |
| 56. Guangzhou: Urban Road Length & Area..... | 90 |
| 57. Guangzhou: Urbanized Area & Percent Devoted to Roads | 90 |
| 58. Chinese Environmental Regulation Administration | 93 |
| 59. Guangzhou's Current Transport Administration..... | 93 |
| 60. Guangzhou's Emissions Control Administration and Processes..... | 94 |
| 61. Guangzhou's Recommended Policy Matrix..... | 98 |
| 62. Elements of an Integrated BRT System..... | 100 |
| 63. Components of an Eco-ERP System | 106 |
| 64. Eco-ERP Tolling Strategy #1 | 108 |
| 65. Eco-ERP Tolling Strategy #2 | 109 |
| 66. Eco-ERP Enforcement Strategy..... | 110 |
| 67. Political Support for ERP in Hong Kong..... | 112 |
| 68. The Evolution of Municipal Transportation Agencies: Guangzhou..... | 117 |
| 69. The Evolution of Municipal Transportation Agencies: Singapore | 118 |
| 70. Drivers of Institutional Reform | 119 |
| 71. Organizational Transformation Process..... | 121 |
| 72. The Transport Planner's Dilemma..... | 124 |
| 73. Reinforcing Recommendations Loop..... | 125 |
| 74. Integrated Urban Transport Profiles..... | 126 |
| 75. A Potential Organizational Structure for Guangzhou's Transport Agencies..... | 127 |

1 Organization & Methodology

Overview

This study will seek to accomplish four primary objectives: (i) to introduce a portfolio of innovative transportation policies and technologies; (ii) to examine the application of some of these policies and technologies in two urban contexts; (iii) to distill the essential lessons from these examples; and thereby (iv) to develop a set of credible recommendations for the city of Guangzhou. An introduction to the thesis chapters and structure follows.

Chapter 2: Conceptual Framework

Our analysis of sustainable transportation systems will be conducted within a broader framework of sustainable development. As such, we will first define the concept of sustainable development as a conceptual backdrop for the analysis. Secondly, we will identify the primary criteria, components, and challenges of sustainable development that pertain to developing cities in general, and to urban transportation systems in particular. The criteria, identified in Chapter 2, will serve throughout the thesis as a prism through which we will evaluate the effectiveness of the various regulatory, technological, and policy options whose goal is to increase mobility.

Chapter 3: Context

The global context of the study will be elaborated upon; specifically the emergence of a relatively new phenomenon, the mega-city, will be discussed. The chapter will address the forces of urbanization, motorization, and globalization that affect developing mega-cities as they wrestle with the need to develop comprehensive urban transportation systems. In addition, the unique dynamics surrounding mega-cities' economic competitiveness will be discussed; these include competitive position, regional integration, and productivity.

Chapter 3 will also highlight some of the typical conditions found in urban transportation systems in developing mega-cities. Largely the present condition may be understood as a set of symptoms that are indicators of a "disease" (unsustainability). In turn, these symptoms have specific causes that must be addressed at their roots if developing cities hope to progress along the path to sustainability.

Chapter 4: Transportation Policies & Regulations

Chapter 4 will introduce a set of policies and regulations that represent a sample of the types of tools employed by municipal governments to influence transport systems' development and citizens' behavior patterns. We will also develop a framework for understanding the strategies and areas of impact of various transportation policies and regulations.

Chapter 5: Transportation Technologies

In recent years, many technological systems have been developed to reduce operational costs, increase throughput, manage travel demand, and mitigate environmental impact. However, there is a fundamental lack of knowledge, in many developing cities, about these innovative technologies. Consequently, Chapter 5 will introduce some of these emergent technologies and attempt to demonstrate how successful adoption may lead to improving overall system sustainability. In particular, Intelligent Transportation Systems (ITS), which increase throughput (supply) or manage travel demand will be reviewed. We will also explore alternative fuels and evaluate their potential to reduce the environmental impact of urban transport.

Chapters 6 & 7: Case Studies of Singapore & Bogotá

In order to illustrate integrated examples of successful municipal strategies for urban transportation, this paper will review two urban case studies. The first case (Chapter 6) is that of Bogotá, Colombia. Bogotá is a rapidly growing metropolis in a newly developing country. In spite of substantial economic, structural and institutional disadvantages, the city has been able to implement a host of measures that have contributed to greater mobility for the poor, cleaner air, and reduced congestion.

Singapore, the second case (Chapter 7), will serve as a fascinating counter point. Singapore is a highly developed city-state that has achieved tremendous operational results, set high environmental standards, and broken new ground in the fields of travel demand management and deployment of advanced transportation technologies. Our analyses will examine these cities' efforts through the "lens of sustainability" as defined in Chapter 2, and will include:

Context & Overview:

Our discussion will open with an introduction to the context in which the policies, regulations, and technologies have been employed. We will examine the demographic, economic, political, and environmental setting in which these systems have evolved.

Institutional Arrangement:

An examination of the municipal institutional structure will help to identify the organizational constraints in which policies were formulated and executed. In this review, we will address the following questions: What institutional mechanisms were developed or reformed in order to facilitate the planning and execution of transportation policies? How did institutional structure affect the capacity of these organizations to develop and implement the policies? What role, if any, can the private sector have in providing alternative institutional structures to provide services that are typically assumed by the public sector?

Implemented Policies:

We will describe the specific policies, regulations, and technologies that these cities have employed to further their objectives. Each policy description will be followed by a four-part analysis, which will appraise the impact of these strategies operationally, economically, environmentally and socioeconomically.

Operational Evaluation

This evaluation will measure the programs effectiveness in achieving its basic operational goals. These goals are often performance-based criteria such as increased average travel speed, greater capacity, or a measure of voluntary compliance with a regulation.

Financial & Economic Evaluation:

An analysis of the costs, financial mechanisms employed, and the economic impact of the policies and programs in Singapore and Bogotá will be made.

Environmental Evaluation:

The urban transportation policies and strategies will be considered within the broader context of the environmental impact associated with them.

Socioeconomic Evaluation:

The challenges surrounding equitable cost distribution, with regard to tolling and taxation policies and the difficulty of capturing secondary economic benefits will be addressed. It will be demonstrated that compliance can be bolstered by ensuring that an equitable distribution of costs and benefits is realized. We will also investigate methods by which accountability and transparency have been used to garner public support.

Chapter 8: Case Study of Guangzhou: Context

Chapter 8 will develop a comprehensive understanding of the demographic, political, regulatory, environmental, and economic context in Guangzhou.

Chapter 9: Recommendations for Guangzhou

In Chapter 9, we will seek to glean the essential lessons from the two case studies and the portfolio of policies, regulations, and technologies, and apply these concepts to the developing mega-city of Guangzhou. We will identify those policies and technologies that have the greatest probable applicability given the environmental, political, and economic context. Specific recommendations for institutional reform and innovative financing will also be made.

Chapter 10: Conclusions

Chapter 10 will summarize and distill the important lessons learned through this study, drawing on the examples reviewed herein.

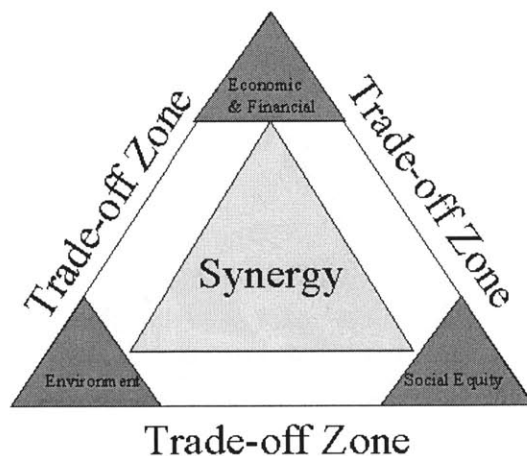
2 Conceptual Framework

2.1 Sustainable Development

The World Commission on Environment and Development defined in its report "Our Common Future" sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their needs." (Brundtland Commission, 1987)¹ Yet, it has become clear that the meaning of this definition is under constant debate, undoubtedly because it is too broad to be useful. What is equally evident is that when speaking of sustainability it is of paramount importance to consider the concept holistically and in a multi-dimensional fashion.

Sustainability, as it will be used in this study, will encompass the following major components: environmental, socioeconomic, and financial and economic. It is vital that the interrelationship between these aspects is appreciated and that recognition is made of the trade-offs implicit in taking any particular course of action. A given policy may be more environmentally sustainable than socially, and may still have a negative impact on the financial sustainability of a system. Nonetheless, we must be able to choose from the range of available options fully recognizing that no single solution will result in optimal sustainability on all fronts. Throughout the analysis, which is to follow, we will always examine policies, regulations, institutions, and technologies through these four primary dimensions, and we must remain cognizant of the inherent tradeoffs that accompany even the best choices. It is hoped that although no one initiative is likely to yield holistically sustainable systems, the employment of a range of policies, regulations, and technologies will place developing cities on the path towards greater sustainability.

Figure 1: Sustainability, Synergy, and Trade-offs



[Source: Flora]²

2.1.1 Sustainable Cities

One of the overwhelming challenges facing policy-makers in the 21st century will be to reconcile the economic and social needs of urban populations in ways that are sustainable. Cities will need to be economically efficient, socially integrated, and environmentally conscious if they are to survive and

¹ The World Commission on Environment and Development (Brundtland Commission). Our Common Future. (1987) Oxford University Press. Oxford. P.43.

² Adapted from Flora, John. (1999). Transportation and Municipal Government. World Bank Press. Washington DC. Pg.4.

prosper. Cities have become the focal points of the global sustainability challenge, as they are large consumers and distributors of goods and services. Due to their increasing growing dependencies on trade and consumption of resources, the ecological impact of these cities extends well beyond their geographic footprint.³ In order to address this disequilibrium, cities have begun to apply the criteria of sustainability to the myriad of systems, organizations, and policies under their jurisdiction. The aim of these criteria was defined concisely during the preparatory meetings for the *Urban 21 Conference*. The following definition was drafted to articulate the goals of sustainable urban development:

"Improving the quality of life in a city, including ecological, cultural, political, institutional, social and economic components without leaving a burden on the future generations. A burden which is the result of a reduced natural capital and an excessive local debt. Our aim is that the flow principle, that is based on an equilibrium of material and energy and also financial input/output, plays a crucial role in all future decisions upon the development of urban areas."
[Source: Urban 21]⁴

2.1.2 Sustainable Transportation as an Integrated Concept

The Organization for Economic Co-operation and Development conference, *Towards Sustainable Transport*, recommended the following principles to define sustainable transportation in March 1996. For the purpose of this study, the original OECD principles have been reclassified under the sub-groupings in Italics.⁵

"Sustainable transportation is achieved when needs for access to people, services, and goods are met without producing permanent harm to the global environment, damage to local environments, and social inequity."
[Source: OECD]⁶

Environmental Sustainability

"Transport needs should be met without generating emissions that threaten public health, global climate, biological diversity or the integrity of essential ecological processes. Transport systems must make efficient use of land and other natural resources while preserving vital habitats and maintaining biodiversity. All individuals and communities have a responsibility to act as stewards of the natural environment, undertaking to make sustainable choice with regards to personal movement and consumption."⁷

Socioeconomic Sustainability

The social component of sustainable transportation refers to the need to address the issues of access, affordability and livability. Certainly any policy that strives to achieve economic or environmental sustainability must also include a social dimension. The ability of people to access the benefits of a transportation system is at least as important as the financial self-sufficiency of the system. The two are of course interrelated. Likewise, it is imprudent to implement policies that reduce traffic congestion at an overwhelming social cost, such as relocating masses of people for a highway that will be used by a small percentage of the population.

³ Rees, William E. and Roseland, Mark. (1991). *Sustainable Communities: Planning for the 21st Century*. Plan Canada.

⁴ Urban 21 Conference. (2000). *Berlin Declaration on the Urban Future*. Berlin. www.urban21.de

⁵ Organization for Economic Cooperation and Development (1996). *Toward Sustainable Transport*. Vancouver: OECD.

⁶ Ibid.

⁷ Ibid.

Socioeconomic Sustainability: Access

Access to mobility is an important factor affecting the social sustainability of an urban transportation network. If a majority of city residents cannot benefit from a new mass transit system, it is of little use. Further, as the population will still demand mobility, it is likely that they will employ less sustainable means to achieve this end. Thus, proximity to affordable means of transportation is an essential criterion by which to judge various options. Equitable access to transportation modes may evolve in a number of fashions. If the lowest socioeconomic stratum cannot afford private vehicles, then new road construction will not provide additional access. On the other hand, if these populations can be served with well-designed bicycle and pedestrian thoroughfares, their access to mobility is increased with very little environmental impact. Access may also refer to the need to access places of employment, affordable living, and places of recreation. This may be generally achieved by providing access to mobility, but land-use planning to increase proximity is another important factor. The OECD principles are:

“People are entitled to reasonable access to other people, places, goods and services. In meeting the basic transport-related needs of all people, including women, the poor, the rural, the disabled, and children, nation, states and the transport community must strive to ensure social, interregional and intergenerational equity. Transport systems should be designed and operated in a way that protects the health and safety of all people, and enhances the quality of life in communities.”

[Source: OECD]⁸

Socioeconomic Sustainability: Prices & Fees (Direct Costs)

Cost is an important component of social equity in that proximity alone will not guarantee access. If the financing requirements of a new metro system require user fees that are excessively high, the effect can be similar to regressive taxation. The cost of the metro system might have been drawn from public tax dollars, but if the least advantaged population does not share in the benefits, it has unwittingly subsidized wealthier citizens. The same effect may be witnessed with policies. Congestion pricing in developed cities is likely to act regressively, once the population has become fully motorized the relative costs of tolls are higher for the poorer residents. In developing cities, however, the same policy may have a progressive implication since only the wealthiest citizen have the means to own and operate private vehicles.

Socioeconomic Sustainability: Livability (Indirect Costs)

The indirect costs borne by urban populations often determine the livability of the environment. As a component of social sustainability, the livability criterion is used to evaluate the impact of a technology or policy on the habitability of the environment. Within the sustainability framework, costs borne by populations, whether not they are also users, are considered indirect. Population relocations are the most dramatic of these costs, and historically have affected the poorest segment of the population. While there may be instances where relocation is warranted, care must be taken to provide adequate compensation for the dislocated and to always ensure that the minimum number of people is affected. Other social costs include public health, the effect of noise, and traffic accidents.

Economic & Financial Sustainability

Economical sustainability is a criterion by which governments should evaluate their expenditures and their impact on the economic health of the city. For example, it may be that a metro system would yield great benefits including increased accessibility and reduced environmental damage. However, the capital investment required for constructing the system may bankrupt the municipality, thus denying

⁸ Organization for Economic Cooperation and Development (1996). *Toward Sustainable Transport*. Vancouver: OECD

the population access to other services, it cannot be said to be economically sustainable. Likewise, economic sustainability refers to the overall impact of a policy, technology, or investment on the general economy. For instance, a policy barring the entry of commercial vehicles into a CBD may have wonderful environmental effects such as reducing pollution and noise. Nevertheless, if the impact on the city's economy outweighs the benefits gained, the policy cannot be considered economically sustainable.

“Market mechanisms must account for the full social, economic and environmental cost, both present and future, in order to ensure users pay equitable share of costs. Taxation and economic policies should work for, and not against sustainable transport.”

[Source: OECD]⁹

Many cities, with limited access to public funds, are faced with the challenge of raising capital or attracting private investment to finance their mobility projects. The long gestation period of transportation projects is not conducive to the short-term vision of many politicians. Thus, trade-offs are made for investment in other areas, where higher, more tangible payoffs are achieved within a shorter duration. Therefore, programs, policies, and systems that are financially self-sustaining have been well received. Financial sustainability, within the context of this study will refer specifically to the financial cost benefit analysis associated with a given technology or policy. We will also consider the profitability and financeability of technologies and systems. To draw on a recurring example of financial unsustainability, the private financing and development of infrastructure has been touted as the *Holy Grail* for cash strapped governments. However, if the actual revenues do not result in profitability the system becomes financially unsustainable.

Economic & Financial Sustainability: Legal & Regulatory Context

Financeability and profitability are of course interrelated; financing will be impossible to achieve without some modicum assurance of profitability. It is important to note that the determinants of financeability and profitability are not limited to the initial cost of the investment plus operating costs less revenues. The positive satisfaction of this equation is only the minimal criterion for financeability. Equally important is the political, legal, and regulatory context in which a system is to be developed. In developing countries, especially, the legal framework may be weak, corrupt, or 'dynamic'. The legal barriers and increased uncertainty can have negative implications for the financial sustainability of urban transportation infrastructure and technologies.

Economic & Financial Sustainability: Pricing

The efficient pricing of goods and services is another important component of financing and profitability; the user fees must generally be determined by market forces and not government regulation to ensure sustainability. There are cases when government subsidies may be appropriate to help ensure equitable access but in those cases, special attention must be paid to the effect on economic sustainability (above).

Institutional Sustainability

Institutional sustainability is concerned with all the activities that go into improving the capacity of an organization to execute its mission in an ongoing, efficient, and effective manner. Within the context of urban transportation, this is an integral concept. The ability of a municipality to design, develop, implement, and enforce transportation policies is largely dependant on the organization of the

⁹ Organization for Economic Cooperation and Development (1996). *Toward Sustainable Transport*. Vancouver: OECD

institutions responsible for these tasks. Institutional deficiencies can lead to the failure of even the most robust policy. At the municipal level, especially in developing countries, this problem is acute. These new mega-cities have developed at such a rapid pace that planning was either poorly executed or absent altogether. As such, those regions that are often the most in need of effective mobility solutions are least capable of providing them. City-level governments are often ill equipped financially, lacking in prestige, and poorly staffed. Within this very common weak institutional context, it becomes harder to apply concepts and policies that encourage sustainability. When evaluating policies and technologies it is vital to keep the institutional context in mind. A progressive policy or innovative technology will likely fail to realize its potential impact if the institutional context is unable to properly oversee its implementation.

“People and communities need to be fully engaged in the decision-making process about sustainable transport, and empowered to participate. Transport decision-makers have a responsibility to pursue approaches that are more integrated to planning. These decision-makers must involve partners from relevant sectors such as environmental, health, energy, financial, urban design, etc. Finally, developed economies must work in partnership with developing economies in fostering practices of sustainable transport.”

[Source: OECD]¹⁰

¹⁰ Organization for Economic Cooperation and Development (1996). *Toward Sustainable Transport*. Vancouver: OECD

3 Context

3.1 The Mega-City Phenomenon

The recent agglomeration of human populations into these massive *mega-cities* is shaping the primary challenges to sustainable global development in the twenty-first century. Mega-cities are generally defined as concentrations of urban populations with over 8 million inhabitants.¹¹ The unprecedented concentration of people into dense urban networks has resulted in a myriad of daunting challenges that have significant impact on economics, transportation, the environment, social equity, and governance. The turn of the twenty-first century marks a divide from a predominantly rural world to one where the majority of people live in cities. There are now more than 400 cities in the world with over one million inhabitants. Of these, 28 are *mega-cities* with populations exceeding 8 million, and two-thirds of these mega-cities are in the developing world. The management of these urban giants, the provision of shelter, services, mobility and a livelihood to their inhabitants in an economically, socially, and environmentally sustainable manner will be a major challenge in the coming years.

Figure 2: Mega-cities with populations exceeding 8 million (1980, 1990, 2000*)

| 1980 | millions | 1990 | millions | 2000 | millions |
|----------------|----------|----------------|----------|----------------|----------|
| Tokyo | 16.9 | Mexico City | 20.2 | Mexico City | 25.6 |
| New York | 15.6 | Tokyo | 18.1 | Sao Paulo | 22.1 |
| Mexico City | 14.5 | Sao Paulo | 17.4 | Tokyo | 19.0 |
| Sao Paulo | 12.1 | New York | 16.2 | Shanghai | 17.0 |
| Shanghai | 11.7 | Shanghai | 13.4 | New York | 16.8 |
| Buenos Aires | 9.9 | Los Angeles | 11.9 | Calcutta | 15.7 |
| Los Angeles | 9.5 | Calcutta | 11.8 | Bombay | 15.4 |
| Calcutta | 9.0 | Buenos Aires | 11.5 | Beijing | 14.0 |
| Beijing | 9.0 | Bombay | 11.2 | Los Angeles | 13.9 |
| Rio de Janeiro | 8.8 | Seoul | 11.0 | Jakarta | 13.7 |
| Paris | 8.5 | Beijing | 10.8 | Delhi | 13.2 |
| Osaka | 8.3 | Rio de Janeiro | 10.7 | Buenos Aires | 12.9 |
| Seoul | 8.3 | Tianjin | 9.4 | Lagos | 12.9 |
| Moscow | 8.2 | Jakarta | 9.3 | Tianjin | 12.7 |
| Bombay | 8.1 | Cairo | 9.0 | Seoul | 12.7 |
| | | Moscow | 8.8 | Rio de Janeiro | 12.5 |
| | | Delhi | 8.8 | Dhaka | 12.2 |
| | | Osaka | 8.5 | Cairo | 11.8 |
| | | Paris | 8.5 | Metro Manila | 11.8 |
| | | Metro Manila | 8.5 | Karachi | 11.7 |
| | | | | Bangkok | 10.3 |
| | | | | Istanbul | 9.5 |
| | | | | Moscow | 9.0 |
| | | | | Osaka | 8.6 |
| | | | | Paris | 8.6 |
| | | | | Tehran | 8.5 |
| | | | | Guangzhou | 8.5 |

[Source: UN] * Data for 2000 are estimated based on total urban agglomeration.

¹¹ Guest, Philip. (1994). *The Impact of Population Change on the Growth of Mega-Cities*. United Nations Population Program. Bangkok.

3.1.1 Urbanization¹²

Urbanization must be distinguished from urban growth. Urban growth refers to an increase in the population of urban settlements while urbanization is a increase in the proportion of the population residing within urban areas. Thus, if urban growth is accompanied by a corresponding increase in rural population, urbanization need not increase. While there is generally a strong correlation between overall population growth and urban growth, it is often observed that urbanization can increase dramatically in the absence of population growth as is evidenced in the People's Republic of China. In China and other East Asian countries, where population growth has diminished significantly, economic development becomes the greatest determinant of urbanization. This effect may be attributed to rural-urban migration, which is triggered by the relatively diminishing size and importance of the rural economy.

The relationship between urban growth and urbanization is complex. Largely, urbanization is the product of internal rural-urban migration. This is true as long as the rural population is substantial enough to contribute large numbers of people to fuel the growth of cities. While the traditional analysis regarding urbanization has posited that it is driven by an increased share of natural resources allocated to cities forces rural populations to seek employment in urban areas, there are corollaries that are more accurate. For instance, growth in GDP per capita has a positive correlation with levels of urbanization.¹³ Cho and Bauer (1987) demonstrated that a high level of economic development is generally characterized by high levels of rural-urban migration. This is generally the case for the fast developing economies of East Asia. In China specifically, rural-urban migration accounts for over 80% of urban growth in mega-cities. East Asia also contains the largest number of mega-cities, and has the highest percentage of urban populations living in mega-cities.¹⁴

“Increasingly, mega-city growth is taking the form of extended metropolitan regions covering 50-100 kilometers from the city center, with polycentric structures acting as focal points in the movement of people, goods, and services. Metropolitan regional growth has typically sprawled along major highways, expressways, and railroad lines radiating out of urban areas, superimposing new towns, industrial estates, housing projects, and other urban forms onto areas that were previously predominantly agricultural and rural. Without strategic interventions in land-use management and transportation planning, environmental and economic constraints will increasingly affect mega-cities.”

[Source: Guest]¹⁵

3.1.2 Motorization

During the past fifty years, while the velocity of road based vehicles quadrupled, the mobility of the average city resident has declined tremendously. In some developing mega-cities, it is less than half of what it was half a century ago. “The phenomenal increase in motorization all over the world has been accompanied by tremendous traffic congestion, lack of adequate, efficient and low-cost public transport, and detrimental impacts on public health due to transport induced air pollution.”¹⁶ As demonstrated by Figures 3 and 4 below, the rate of motorization generally surpasses the population growth rate and is positively correlated to growth in GDP per capita. In light of both the tremendous population increases and rising incomes found in many developing mega-cities, it is not difficult to conclude that however congested these cities are today, tomorrow will be worse.

¹² Guest, Philip. (1994). *The Impact of Population Change on the Growth of Mega-Cities*. United Nations Population Program. Bangkok.

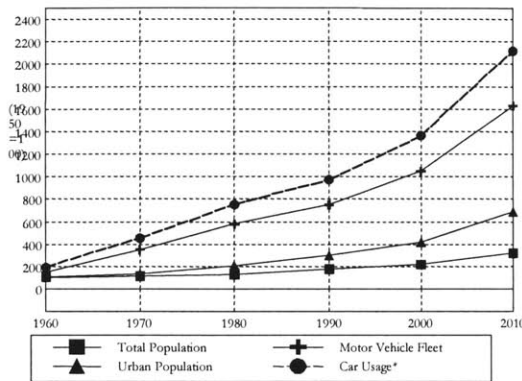
¹³ Cho, Lee-Jay and John Bauer. (1987). “Population Growth and Urbanization: what does the future hold?” *Urbanization and Urban Policies in East Asia*. Westview Press. Boulder.

¹⁴ Guest, Philip. (1994). *The Impact of Population Change on the Growth of Mega-Cities*. United Nations Population Program. Bangkok.

¹⁵ Ibid.

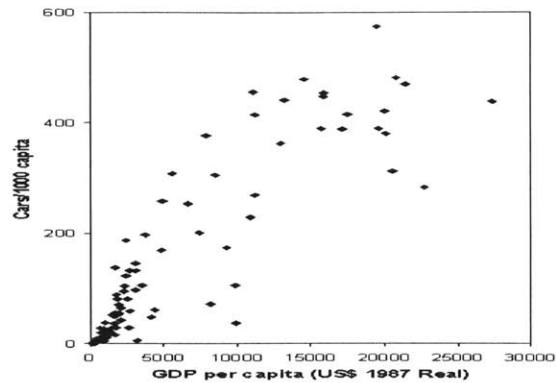
¹⁶ Pendakur, Setty. (1998). *Urban Poor and Access to Urban Transport*. International Forum on Urban Poverty. Nairobi.

Figure 3: Population Growth & Motorization Rates



[Source: Faiz]¹⁷

Figure 4: GDP Growth & Motorization by Country



[Source: Faiz]¹⁸

3.1.3 Globalization¹⁹

Globalization has had both positive and negative ramifications on the development of mega-cities. The core activities and location of industries are now largely determined by global market forces and not the nature of local or regional markets. In this highly competitive global arena, cities are enticed to build new infrastructure to attract multinational enterprises. Once these investments have been made, however, the municipalities rarely receive guarantees with regard to how long the enterprises will remain. The result is that businesses have succeeded in obtaining tax concessions, special infrastructure, and attracting new migration. Then, due to the vagaries of the market, the companies have suddenly withdrawn. When enterprises withdraw, they can leave cities over invested in specialized infrastructure and faced with growing unemployment. Thus, while cities are no longer reliant on federal governments to attract high-quality labor and private investment; they are not equipped to deal with sudden influxes and flights of capital that distinguish the globalized age. Long-term sustainable strategies must therefore be designed to avoid the harmful “ballooning and deflating” effect, which is created by regional competition for global enterprises.

As local, regional, and international barriers to trade continue to fall, cities are at the forefront of those affected by globalization. As the economic nerve centers of developing countries, *mega-cities* generate a disproportionate percentage of national GDP. Increasingly, cities and metropolitan areas are also becoming the primary venues for access to global capital markets. This increase in economic power and financial influence, however, has not always been accompanied by a corresponding increase in political influence.

3.1.3.1 Mega-city Competitiveness²⁰

Globalization and rapid technological change will determine the development trajectory of developing mega-cities depending on their location, potential for profitability, available labor skills, and adaptability. According to the ADB Report “The Challenge of Rapid Urbanization” (2001), there are two important ways that these external factors will influence mega-cities. “First, there is increasing competition among cities as multinational firms compare labor and other input costs and assess the

¹⁷Faiz, A. (1993). *Automotive Emissions in Developing Countries: Relative Implications for Global Warming, Acidification, and Urban Air Quality*. In: Transportation Research #27A (3): P.167-186.

¹⁸ Ibid.

¹⁹ Conversations with Professor Fred Moavenzadeh. (2001) MIT Department of Civil and Environmental Engineering. Cambridge.

²⁰ The Asian Development Bank. (2001) *The Challenge of Rapid Urbanization*. Urban Sector Strategy Review. Manila. www.adb.org

available economic incentives, the regulatory climate, the presence of market-based laws and institutions, flexibility of the labor force, and political stability.” Mega-cities that succeed in meeting these requirements will develop at much faster rates than those will not or can not. “Second, the emergence of information-based service industries including financial and producer services, research and development, and media is benefiting larger cities that can the most efficient conditions for information dissemination.”

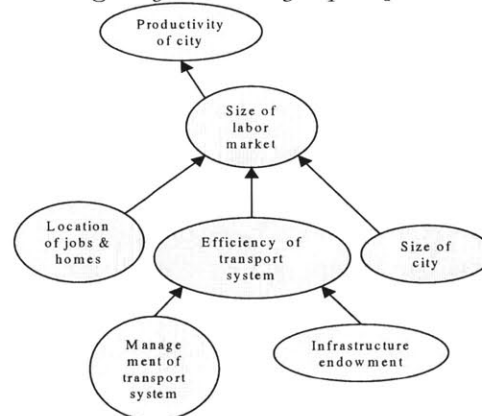
3.1.3.2 Regional Cooperation, Development, and Competition²¹

According to the Asian Development Bank report, “The process of globalization through the international trade of goods, capital flows, and labor mobility has created an increasingly integrated world economy and growing competition between urban centers for foreign and domestic investment. Interdependencies are being created between urban centers across national boundaries, often creating links that are stronger than those found between an urban center and its own hinterland. Trade liberalization, while often painful in terms of the required restructuring across sectors, is creating new opportunities and synergies within and between regional growth zones.” Competition between regional centers will ultimately not only be based on location and production advantages, but effective governance, regulatory transparency, and government support for private enterprise.

3.1.3.3 Mega-City Productivity²²

Cities have greater output per capita than rural and suburban areas. This explains why incomes are higher in urban areas, why so many people have moved from rural areas to urban areas, and why the rural-urban migration has been beneficial to economic development. Workers moving from a low productivity area to a higher one increase the average productivity of their country and, consequently, its wealth. They contribute more to the national budget than they get from it, in effect subsidizing the rest of the country. One hypothesis is that megacities are more productive because they have larger labor markets. The justification for this hypothesis is twofold. First, the larger the labor market, the higher the probability that an enterprise can find the workers it wants, and that workers can find the jobs they want. A larger labor market also justifies and facilitates specialization of workers and jobs, a well-known way of increasing productivity. The impact of the labor market size on city productivity is the result of the interaction of a number of variables, including, the city population, the relative location of jobs and households, and the efficiency of the transportation system; which is a function of the transportation infrastructure and the quality of the management of the transportation system.

Figure 5: Mega-City Productivity Inputs [Source: ADB]



²¹ The Asian Development Bank. (2001) *The Challenge of Rapid Urbanization*. Urban Sector Strategy Review. Manila. www.adb.org

²² Ibid.

3.2 Symptoms of an Unsustainable Urban Transport System

The forces of globalization, urbanization, and rapid motorization have contributed to an increasingly dire situation for many of the world's developing cities. These tremendous pressures have pushed developing municipal institutions to the brink of their capacity. Having earlier defined the criteria by which to evaluate the sustainability of an urban transportation system, we will now describe the common symptoms of a typically unsustainable condition prevalent in developing mega-cities.

3.2.1 Congestion

Rapidly increasing motor vehicle populations occupying a fixed or slowly increasing roadway supply results in a deterioration of a transportation system's performance. Average travel speed in OECD country cities is estimated to be 18km/h, with optimal desired travel speeds of 25-30km/h continually eluding even those cities best equipped to deal with the problem. In contrast, in developing cities travel speeds of 4-8km/h are common. Further, rush-hour peaks once limited to a few hours in the morning and evening, are now stretching throughout the day in effect causing a permanent traffic jam.²³ Vehicular traffic on urban roads results in a number of severe external ramifications with environmental, social, and economic implications. Among the effects resulting from traffic congestion air pollution, decreased economic activity, and higher prices are the chief symptoms.

3.2.2 Air Pollution²⁴

The growing use of private vehicles is an increasingly important component of human activity that contributes to greenhouse gas creation and global warming. In urban centers, especially, the percentage of pollutants generated by mobile sources is increasing dramatically, and now accounts 40-80% of the total atmospheric pollutants in a city's air shed. In developing cities, especially, the range is consistently between 60-80%. Road traffic also accounts for 90-95% of lead and carbon monoxide, and 60-70% of nitrogen oxides and hydrocarbons. Therefore, of urban transportation systems has the potential to significantly reduce the rate at which local and global pollutants are introduced into the atmosphere.

Types

Internal combustion engines used in most vehicles generate atmospheric pollutants by burning fossil fuels, namely gasoline and diesel. These fuels generate a number of environmentally harmful pollutants including Particulate Matter (PM), Nitrogen Oxides (NOx), Lead (Pb) and Carbon Monoxide (CO). Vehicles are also the primary sources for Volatile Organic Compounds (VOCs) which when combined with NOx and exposed to sunlight are the precursor to ground level ozone (O₃).

Health Effects

The health consequences of continuous exposure to contaminated air are considerable. "On a global basis, estimates of mortality due to outdoor air pollution run from 200,000 to 570,000, representing about 0.4% - 1.1% of total annual deaths. As the range of these estimates indicates, it is difficult to quantify the toll of outdoor air pollution. The health impacts of urban air pollution seem likely to be greater in some of the rapidly developing countries where pollution levels are higher. The World Bank has estimated that exposure to particulate levels exceeding the WHO health standard accounts for roughly 2% - 5% of all deaths in urban areas in the developing world."²⁵

²³ Flora, John. (1999). *Transportation and Municipal Government*. World Bank Press. Washington DC.

²⁴ Ibid.

²⁵ China On-Line. (2001). *Breathing Dirty Air*. Chennai Interactive Business Services (P) Ltd. Chennai.

Particulate Matter (PM) is a generic term for a range of suspended particles that can be carcinogenic and lead to acute and chronic respiratory problems. Nitrogen Oxides (NO_x) also contribute to the formation of acid rain and global warming.²⁶ NO_x and the pollutants formed by NO_x can be transported over long distances. Thus, problems associated with NO_x are not confined to areas where NO_x is emitted. Therefore, controlling NO_x is often most effective if done from a regional perspective, rather than focusing on sources in one local area. Carbon Monoxide (CO) has been shown to damage both cardiovascular and respiratory functions. Lead is a leading agent responsible for underdevelopment of higher cognitive ability in children, and a leading cause of hypertension. Ground level ozone (O₃) accumulation resulting from NO_x, hydrocarbons, and sunlight reacting, is a major contributor to respiratory problems.²⁷

3.2.3 *Decreased Economic Activity*²⁸

As traffic flows slow the movement of goods and people in urban centers, the impact on the economic health of the city can be profound. It is estimated that the United States loses over \$43 billion yearly as a direct consequence of delays resulting from traffic congestion. In the UK estimates range from \$20-\$25B per annum. In developing cities the effect can be even more dramatic, by some estimates Bangkok loses an estimated 1/3rd of its annual GDP, nearly \$4M a day.

3.2.4 *Higher Prices*

For consumers and producers alike, the effect of traffic congestion on prices is detrimental. The delays associated with late shipments, extra fuel cost, and more man-hours are passed on to the consumer in the guise of higher prices. The consumer is doubly impacted, first he is forced to pay for the additional cost of production, second he must spend more time and fuel to purchase goods than would otherwise be required. These higher prices limit the economic resources of the residents of the city and deprive consumers of access to affordable goods. This effect, of course, is even more pronounced in developing cities, where the level of disposable income is lower and the relative cost of access to travel is higher.

3.3 **Causes of Unsustainable Conditions**

There are three primary causes which have lead to the current unsustainable state described above, namely limited access to capital, poor planning and ineffective management, and lax enforcement of environmental regulations. Each is described in detail below.

3.3.1 *Limited Access to Capital*²⁹

Developing mega-cities impose staggering demands on fiscal resources. The ADB has estimated that: "Annual municipal infrastructure requirements alone in developing mega-cities will rise from about \$38 billion in 1998 to \$292 billion in 2020. This is the estimate minimum level of investment required to provide sufficient services to sustain urban productivity and achieve some improvement in the quality of life. The investment estimates include the cost of renewing existing infrastructure and providing new infrastructure as urban population increases. Transport and communications, energy, water supply, and sanitation will consume the largest shares. Without these sustained high levels of expenditure, cities will become increasingly inefficient and unpleasant places to live and work in as

²⁶ US EPA. (1998). *The Regional Transport of Ozone: New EPA Rulemaking on Nitrogen Oxide Emissions*. Office of Air Quality Planning and Standards. Research Triangle Park, NC. <http://www.epa.gov/ARD-R5/naaqs/rto.pdf>

²⁷ World Resources Institute. (2000). *Health Effects of Air Pollution*. Washington DC.

²⁸ Flora, John. (1999). *Transportation and Municipal Government*. World Bank Press. Washington DC.

²⁹ The Asian Development Bank. (2001) *The Challenge of Rapid Urbanization*. Urban Sector Strategy Review. Manila. www.adb.org

pollution, overcrowding, social friction, and deteriorating environmental conditions reduce the quality of life. Enhanced sources of funding for urban development are urgently required in most developing mega-cities as part of the need to overhaul their financial management systems. Local governments are being given greater responsibility for the provision and operation of urban services without the authority to raise extra revenues or enjoy fiscal independence.”

*3.3.2 Poor Planning and Management*³⁰

The ADB report also states that: “Many local governments desperately lack the required skills to manage growth, provide urban services, and maintain infrastructure. Often training and capability building initiatives are undertaken in an uncoordinated, unfocused fashion, replicating previous programs and failing to enhance skills of urban managers and their staff. In addition, there is an urgent need to promote and strengthen existing and new institutional structures that are responsible for, or can facilitate urban development.”

*3.3.3 Lax Enforcement of Environmental Regulations*³¹

Until recently, evidence suggested that developing mega-city governments were driven by a fear of discouraging investment or hampering economic development through enforcement of environmental regulations. The prevailing argument was that labor and pollution-intensive industries relocated from high-income countries with the strict regulatory environments, to low-income countries because of lax enforcement capacity and significant job creation needs. However, as the adverse economic, social, and environmental ramifications of this stance have grown, many developing cities have acknowledged that, far from creating a competitive disadvantage, the enforcement of environmental regulations can create an advantage and attract higher paying industries. Unfortunately, municipal administrations and populations of these cities are now faced with the challenge of undoing decades of environmental damage and restoring credibility to the enforcement regimes.

³⁰ The Asian Development Bank. (2001) *The Challenge of Rapid Urbanization*. Urban Sector Strategy Review. Manila. www.adb.org

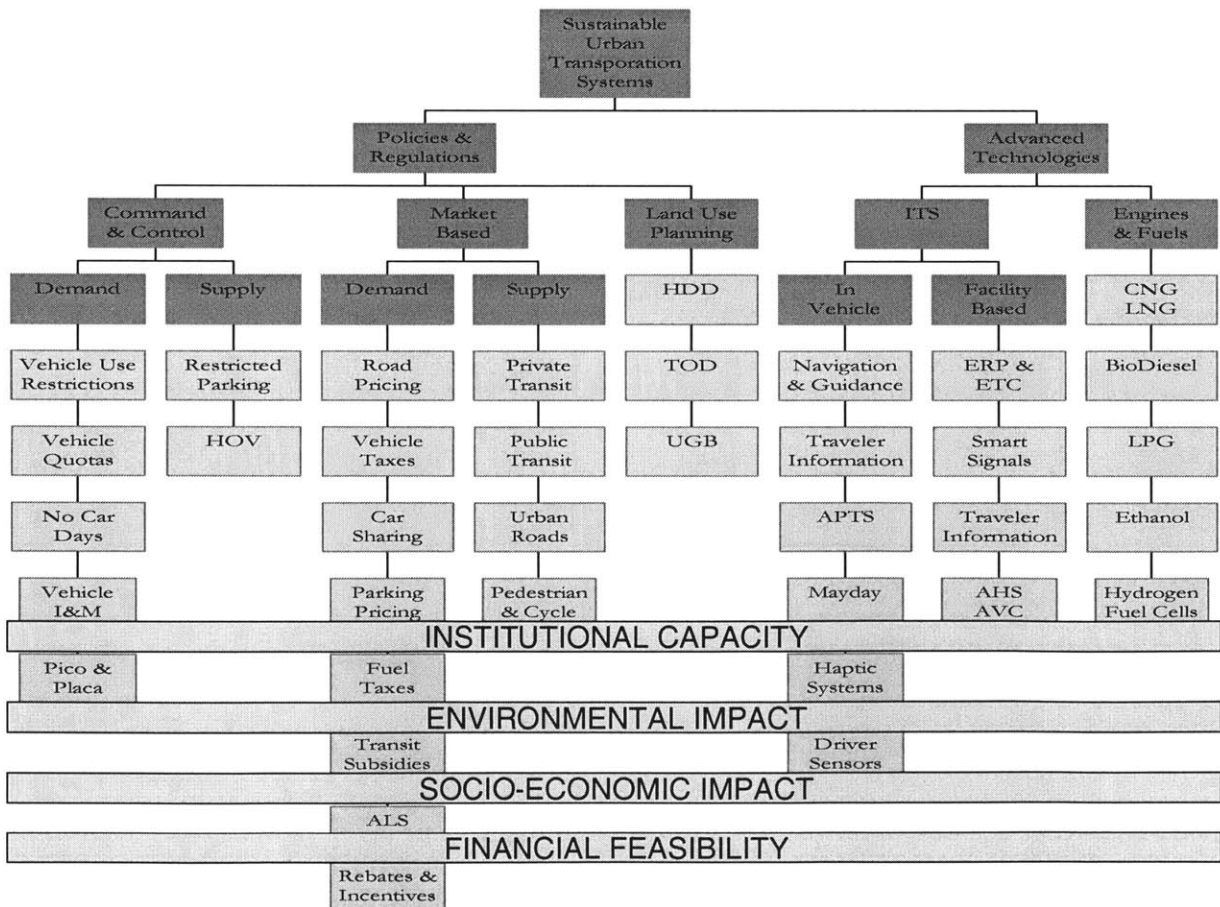
³¹ Wheeler, David. (2000). *Racing to the Bottom? Foreign Investment and Air Quality in Developing Countries*. Development Research Group. World Bank Press. Washington DC.

4 Transportation Policies & Regulations

4.1 Organizing Framework

To assist the development of a clear catalogue of policy, regulatory, and technological options the matrix below organizes some of the tools available to city governments when formulating urban transportation policies. At the primary level, the options are divided into Policies & Regulations and Technologies. Within the Policy & Regulation sub-group, the options are categorized as either Command & Control, Market Based, or Land-Use Policies. At the tertiary level a determination of the general area of impact is made, a policy primarily impacts either supply of or demand for transportation infrastructure. A brief list of the options to be discussed herein is found under each classification. Technological options are divided into ITS (Intelligent Transportation Systems) and Engines & Fuels. ITS, for the purpose of this study, includes all advanced technologies which can be employed to either increase throughput or manage demand for transport infrastructure. For the sake of brevity and focus, this study will primarily focus on developing an understanding the demand-side options, particularly the market-based initiatives, but will touch on all the options shown below. The bars running across the policy columns represent the important considerations that must be made in evaluating and selecting the most effective options. Satisfaction of these requirements is a prerequisite for successful implementation leading to beneficial results.

Figure 6: Policy, Regulation, and Technology Organization Framework



4.2 Market Based Policies vs. Command & Control Regulations

Broadly, two basic approaches have been developed to address the challenges of urban transportation, one is a regulatory (command & control) strategy and the other is primarily economic (market based).³² Command and control regulations generally aim to restrict access, reduce trips, or lower emissions through legal mechanisms based on performance standards. Market based initiatives (MBIs) create financial incentives or disincentives for individuals to change their behavior (mode of travel, time of travel, or product preference) using prices. The key to MBI's is that they allow discretionary market choices to be made by the individual, not for him. Proponents of regulation-based policies insist they are distributively equitable and politically more feasible than pricing. However, supporters of a market-based approach argue that employing market forces is the most cost-effective method for achieving the same objectives.³³

Market based initiatives include tolls, congestion pricing, electronic road pricing, transport allowances, fuel taxes, and parking pricing. Command and control programs include vehicle licensing limitations, no-driving days, and restrictive no car zones. Each of these programs has a differing degree of effectiveness in modifying behavior, and differing economic and social costs. The advantage they share over the creation of additional road capacity is that they are far cheaper to realize. Many of the MBI programs also serve as revenue generating mechanisms. When this revenue is redistributed equitably, it can help to boost policy effectiveness and provide for greater equality in access to mobility. Further, MBI's are largely self-enforcing, as they only require that consumers act in their own best interest. These market-based strategies allow for full costing (including all social costs) of consumer choices. As will be discussed later, Singapore generally places few absolute restrictions on private car mobility, but has achieved a great degree of demand reduction through application of full costing on the choice to own and operate a vehicle. Whether achieved through regulation or market forces the reduction of access to a certain mode of travel does not limit the latent demand for mobility itself. Thus, if the interconnected system is not analyzed in its entirety there is a danger of negative tangential effects in the form of spill over demand.³⁴

4.3 Demand-Side Strategies

Until recently, transportation agencies focused mainly on methods to increase transportation system capacity. Nevertheless, expanding road and parking capacity is expensive. Furthermore, increasing capacity often increases total vehicle traffic, which defeats the purpose of adding capacity. This demand creation effect is known as the law of latent demand. Consequently, there is growing interest in alternative approaches to solving transportation problems by using existing capacity more efficiently.³⁵ Demand-side management has emerged as a promising tool to reduce demand for limited resources, when road-supply cannot be expanded without severe external consequences. Travel demand may also be influenced by positive incentives such as transit subsidies for the economically disadvantaged. Although most demand-side strategies only affect a small portion of total travel, the cumulative impacts of a comprehensive demand management program can be significant. Demand management policies cannot be thought of as 'magic bullets' where one solution yields the desired results. Rather, these policies must be implemented in 'suites' where the entire system is considered and negative tangential results are predicted and mitigated.

³² Giuliano, Genevieve. (1992) *Managing Transportation Demand: Markets versus Mandates*. Reason Public Policy Institute. Los Angeles

³³ Markandya, A. (1998). *The Costs of Environmental Regulation in Asia: Command and Control vs. Market Based Instruments*. Asian Development Review. Manila.

³⁴ Leautaud, Juan & Perez-Barnes. Cesar (1997). *Energy and Infrastructure Policies for Mitigating Air Pollution in Mexico City*. MIT. Cambridge.

³⁵ Litman, Todd. (1998). *Evaluating Criticism of Transportation Costing*. VTIPI (www.vtppi.org)

4.3.1 *Travel Demand Management*

The failure of traditional supply-side solutions to sufficiently reduce air pollution, lessen congestion, or improve mobility has led to a growing realization that demand management strategies must be employed. The family of policies and regulations that aim to reduce demand for private vehicle travel is termed Travel Demand Management (TDM). TDM is a general term for strategies that result in a more efficient use of transportation resources by impacting the level of demand for these resources. TDM can also encourage people to use the optimal transport mode. There is a variety of TDM strategies, each with differing objectives and results in terms of travel behavior modification, the basic goals of TDM policies may be summarized as:

- ❑ To Increase travel mode choices
- ❑ To provide incentives for use of optimal travel mode
- ❑ To increase economic efficiency
- ❑ To increase travel choices for disadvantaged residents
- ❑ To reduce emissions from motor vehicles
- ❑ To improve the livability
- ❑ To complement other environmental initiatives
- ❑ To achieve reduced costs of implementation, monitoring, and enforcement

4.3.2 *Demand-Side Measures: Constraints*

Demand-side measures can create cleavages between those who bear the costs and those who reap the benefits. This is especially true when governments attempt to toll existing infrastructure, which users have grown accustomed to using free of charge. In contrast, tolling newly developed infrastructure is less contentious because the linkage between the costs and the benefits is tangible to the user. The use of revenues generated by tolling and taxation to fund mass transit allows a redistribution of benefits to the economically disadvantaged. Failure to do so can result in a public backlash against tolling. There are also a myriad of arguments that propose that travel demand management policies are ineffective, interventionist, and regressive, offsetting the greatest costs to the most disadvantaged of city residents.

“When considered individually, the impacts of most TDM strategies appear modest, affecting just a few percent of total vehicle travel. However, their effects are cumulative and synergetic. A comprehensive TDM program that includes an appropriate combination of complementary strategies can have significant impacts.”

[Source: Litman]³⁶

The counterpoint to the argument that TDM programs are regressive is that lower income people tend to value having good transit. Some TDM strategies do involve regressive fees. Congestion pricing tolls and parking pricing increases represent a greater portion of income for the poor. However, these policies are no more regressive than any other taxation mechanisms, particularly if there are viable travel alternatives that allow lower-income people to avoid the fees. The social-equity impact of road pricing largely depends on how the revenues are used. When revenues are redistributed into public transportation systems in ways that benefit underprivileged populations, these groups can achieve net gains. TDM strategies that induce shifts to public transit use can benefit lower income people and non-drivers by improving the utilization, profitability, and quality of these transport alternatives.³⁷

³⁶ Litman, Todd. (1998). *Evaluating Criticism of Transportation Costing*. Victoria Transport Policy Institute (www.vtpi.org)

³⁷ Litman, Todd. (1996). *Using Road Pricing Revenue: Economic Efficiency and Equity Considerations*. Transportation Research Record.

Criticism of TDM policies often focuses on specific objectives such as direct congestion reduction benefits or agency cost savings. These analyses fail to consider that TDM programs can provide multiple tangential benefits, many of which tend to be neglected in conventional transport policy planning.

“Widening a highway provides just one benefit: reduced motor vehicle congestion on that highway. A TDM program can provide several benefits: reduced motor vehicle congestion on that highway and downstream, parking facility cost savings, reduced delay to pedestrians trying to cross streets, reduced crashes, increased travel choice, consumer cost savings, reduced air, noise and water pollution.”
[Source: Litman]³⁸

TDM policies have also been criticized for their lack of effectiveness at managing travel demand. Historically non-pricing incentive policies have not been very effective. The data analyzed by Litman of the Victoria Transport Planning Institute (1998) indicated that stand-alone, incentive based TDM policies typically result in no more than $\pm 1.5\%$ reduction in demand. Additionally, some TDM initiatives require heavy capital investments in order to achieve a single trip reduction. For instance, construction of pedestrian and bicycle paths typically require an investment of USD \$10.6 per trip eliminated. The same VTPI study concluded that the most effective incentive based policies include direct transit subsidies, parking discounts, and High Occupancy Vehicle lanes. Litman concludes that in order to achieve statistically significant results, in terms of reduced demand, that TDM incentive policies must be combined with pricing mechanisms.³⁹

“Many countries are assuming that growth of motorization means they have to start building highways as fast as they can, which is probably true. But it would be a mistake to think they could build them fast enough to meet the needs of this demand. The only real option that cities of the developing world have to avoid horrendous congestion in the coming years is some combination of congestion pricing and traffic management.”
(Source: Gakenheimer)⁴⁰

4.4 Policy Objectives⁴¹

The policies and regulations, which will be described herein, are aimed at promoting the development of sustainable urban transportation as described in Chapter 2. However, in order to achieve these goals, each policy seeks to influence a unique component of the transportation system, thereby adding to the overall sustainability of the system. The four primary policy-specific goals may be classified along these lines:

4.4.1 Reduction of Emissions

Policies that seek to reduce the emissions generated by vehicles often aim to optimize the vehicle fleet in order to reduce the total emissions profile. These policies include vehicle quotas, emissions regulations, green technology incentives, vehicle registration fees, and fuel taxes. These policies may be generally classified as “carrots” or “sticks”. Sticks ban, limit, or raise the price the ownership of “non-optimal” vehicles, while carrots encourage the ownership of cleaner vehicles by reducing their relative cost.

³⁸ Ibid.

³⁹ Litman, Todd. (1998). *Evaluating Criticism of Transportation Costing*. Victoria Transport Policy Institute (www.vtpi.org)

⁴⁰ Gakenheimer, R. (1996) *What to do with all those cars?* MIT Center for Transportation Studies. Newsletter #39. Cambridge.

⁴¹ Moavenzadeh, Fred. (1999). *A Total Package: Transportation Management*. Presentation to the Alliance for Global Sustainability. MIT. Cambridge.

4.4.2 *Transport Management*

Policies and regulations that aid in the management of the transport system include prioritized signal timing for transit vehicles, enforced speed limits, and HOV lanes. These initiatives generally seek to optimize use of existing infrastructure in order to maximize the per capita throughput and performance of the system.

4.4.3 *Vehicle Use*

Policies and regulations that restrict or prohibit the use of private automobiles include: private vehicle restrictions, alternate driving days, area licensing schemes, limiting parking space, parking fees, congestion pricing, fuel taxes, closing areas to private vehicles, and expanding public transit to reduce road supply (segregated bus-lanes).

4.4.4 *Modal Split*

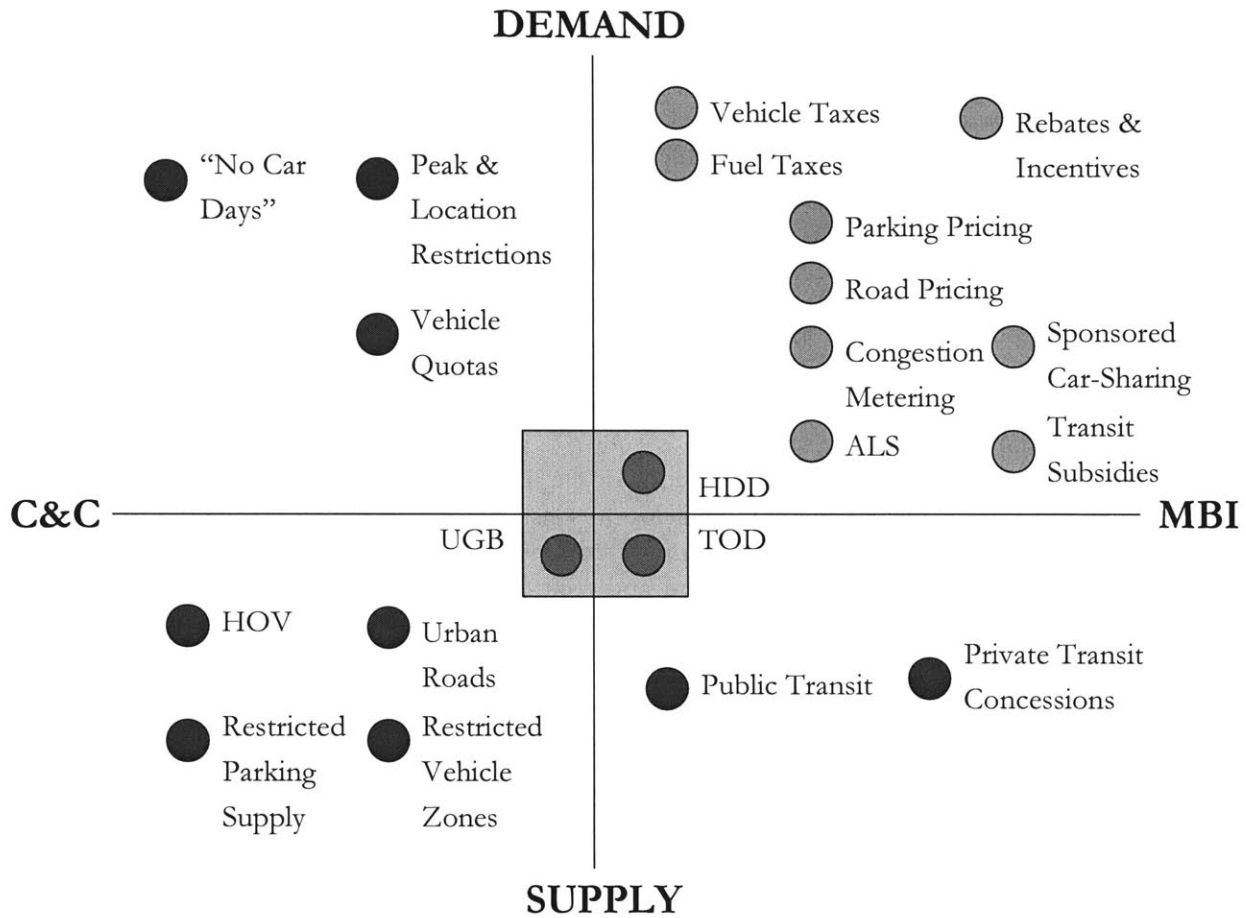
Policies and regulations that aim to shift the modal split of the city include improvements to mass transit, construction of pedestrian and cycle infrastructure, vehicle purchase taxes, vehicle quotas, fuel taxes, annual ownership fees, public transit subsidies, road pricing, and parking fees.

4.5 **Transport Policy Matrix**

The policy matrix below illustrates the continuum along which most transportation initiatives may be classified. Some programs such as “No Car Days” fall squarely within the defined quadrants and are easily categorized. Other initiatives span across the quadrants and may influence both supply and demand, or have characteristics that are not easily designated as Command and Control or solely Market Based. An example of one such policy would be High Occupancy Lanes. HOV lanes are mandated by the government, and do not offer a market-based incentive for compliance or avoidance (traffic police tickets are not a legitimate market incentive). However, the reduction of the available road space for single-user private vehicles may induce a modal shift in commuters thereby increasing demand for public transit in lieu of commuting by private car.

Likewise, the land-use planning (LUP) strategies in the central gray box affect both the supply of and demand for road-space. These LUP strategies may be dictated or induced through market-incentives. Transit Oriented Development, discussed in detail in Chapter 9, sits at the intersection of both continuums. TOD must be driven by a rational land-use and mass-transit policy (thus has C&C characteristics), but is simultaneously dependant upon individual choices made by city inhabitants and real-estate developers that are dictated by market forces. TOD complements and is often a prerequisite for mass transit development (thus increases supply). Concurrently, TOD may contribute to a lower demand for private vehicle use as the proximity of residential areas to mass transit reduces the cost effectiveness of private automobile use. The matrix is particularly useful to illustrate how collections of policies, regulation, and strategies may be employed to achieve sustainability in the urban transport sector. Clusters of policy choices along the left or right side of the matrix may be more or less effective, costly, and equitable as will be demonstrated in Chapters 6, 7 and 9.

Figure 7: Transport Policy Matrix



4.6 Demand-Side Command & Control Regulations: Examples & Assessments

4.6.1 No Car Days (*No Hoy Circula* & *Sin Mi Carro*)

No Car Day policies generally mandate that residents of the city avoid using their cars during a specific day of the week, month, or year. Car use restrictions may apply to all vehicles or to certain categories of vehicles. Alternately, no car days may only apply to vehicles with certain license plates numbers, often alternating between even and odd numbered plates.

*Example & Assessment: Mexico City “No Hoy Circula”*⁴²

The No Hoy Circula policy stipulated that cars with even numbered license plates would have access to the city center on alternating days with odd numbered plates. The results were catastrophic. Many wealthy residents acquired a second older vehicle; grandfathered by the emissions law, and drove this vehicle on days when their normal car was prohibited. Lower income residents shifted travel mode and began using taxis with increasing frequency. The increase in demand for taxis led to a predictable increase in the taxi fleet supply. The number of cars circulating remained roughly unchanged, while the average travel speed decreased, levels of air pollution increased, and social costs (in terms of inconvenience and delay) mounted.

⁴² Makler & Zegras. (1999). Regional Strategic Transportation Planning in Mexico City. Mexico City Project Seminars. MIT. Cambridge.

Example & Assessment: Bogotá's "Sin Mi Carro"

See Chapter 7 for a detailed discussion.

4.6.2 *Vehicle Quotas*

Vehicle quotas set limits on the number of vehicles of a given type that are allowed within the boundaries of the city. This is most commonly enforced through restricting vehicle ownership and limiting the number of driving licenses for a particular vehicle type.

Example & Assessment: Singapore's VQS & Guangzhou's MC Policy

Singapore's very successful, highly specialized VQS policy is discussed in detail in Chapter 6. Guangzhou's attempt to limit the number of licensed motorcycles within the city bounds is reviewed in Chapter 8.

4.6.3 *Peak & Location Restrictions*

Peak and location restrictions are modified versions of the vehicle bans and "no car days". Essentially the regulations operate identically. Certain vehicles (by class, license plate number etc.) are forbidden from entering a specified zone during highly congested times, often during the morning and evening rush hours. P&L restrictions are the command and control alternative to Singapore's Area License Scheme which stops short of prohibiting entry, instead charging drivers for the marginal cost of contributing to congestion.

Example & Assessment: Bogotá's "Pico y Placa" Regulation

Bogotá's innovative attempt to respond to changing levels of congestion using P&L regulations is covered in Chapter 7.

4.7 **Demand-Side Market Based Initiatives: Examples & Assessments**

4.7.1 *Sponsored Car Sharing*⁴³

Sponsored car sharing is a subsidized automobile rental service intended to substitute for private vehicle ownership. Municipalities provide direct subsidies to users or indirect subsidies to companies offering car-sharing services. To induce a modal shift from car ownership to car sharing, the program must be accessible, affordable, convenient and reliable. The typical charge to users is \$1-\$2 per vehicle-hour plus an additional charge of 15-25¢ per kilometer. Charges typically cover all the vehicle-operating expenses including fuel, maintenance, insurance, repair, and cleaning. Analysis by VTPI has demonstrated that car sharing becomes an attractive and viable alternative to ownership if the vehicle is driven less than 10,000 km/year. Car sharing provides a good incentive to minimize trips with 40-60% reduction per capita. Car Share vehicles typically replace three to four private vehicles. Sponsored car sharing may be an innovative way to encourage clean fuels, fuel efficiency, and to discourage motorcycle ownership.

⁴³ Litman, Todd. (2001). Car-sharing Vehicle Rental Services That Substitute for Private Vehicle Ownership. VTPI On-Line Encyclopedia. British Columbia. <http://www.vtpi.org/tadm/tadm7.htm>

Figure 8: Vehicle Use Options Compared

| Criteria | Carsharing | Private Ownership | Conventional Rental | Taxi | Public Transit |
|---------------|-------------|-------------------|---------------------|-------------|----------------|
| Convenience | Medium | High | Varies | High-Medium | Medium-Low |
| Fixed Charges | \$100/yr | \$2,000-4,000/yr | None | None | \$600/yr max |
| Time Charges | \$1.50/hour | None | \$20-40/day | None | None |
| Charge / Mile | 20-40¢ | 10-15¢ | 5-10¢ | \$1.00 | 21¢ |

[Source: VTPI]⁴⁴

*Example & Assessment: San Francisco's Station Car Initiative*⁴⁵

The Station-Car Demonstration field-test was conducted from 1995 to 1998 to determine viability of electric vehicles for short, daily trips. The demonstration also sought to increase mass transit ridership and to discourage inefficient commutes between home, Bay Area Rapid Transit stations, and workplaces. Forty prototype 2-seat battery-powered electric vehicles were deployed at a cost of \$1.5M. During the 3-year test period, these vehicles logged 154,800 VMT, while private vehicle use by participants dropped by 94%. Correspondingly, a drop in emissions of VOCs (-94%), NO₂ (-98%), CO₂ (-90%) per capita was achieved. Use of the BART system increased by 56% among participants generating an additional \$18k in revenue for BART. It was estimated that were the program to be expanded to 10,000 vehicles, the result would be an increase of \$32.8M per year in BART revenue.

4.7.2 *Rebates and Incentives*

Tax rebates can be employed to encourage businesses and individuals to alter their travel modes and commute time, and to participate in voluntary TDM programs.

*Example & Assessment: Seoul's Traffic Tax Rebate Program*⁴⁶

After decades of rapid economic expansion, coupled with a ballooning private vehicle fleet, the city of Seoul imposed a "traffic tax" on businesses and individuals to help fund mass transit investment. In the mid 1990's the city began experimenting with a number of innovative, voluntary TDM programs including staggered work hours and car pool programs. To encourage business to provide the needed infrastructure and support, the city government began a program of traffic tax rebates for businesses that agreed to implement TDM measures. Thus, if businesses voluntarily instituted staggered work hours, provide company buses, or provided their employees with transit subsidies they benefited from a rebate of the traffic tax on a predetermined scale.

4.7.3 *Fuel, Vehicle, and Traffic Taxes*

Taxation mechanisms have been employed to achieve three objectives: (i) to reduce congestion; (ii) to generate income for mass transit; and (iii) to discourage car ownership.

*Example & Assessment: Seoul's Taxation Strategy*⁴⁷

Tremendous population and income growth resulted in a 20% increase in private vehicle ownership annually in Seoul. By the late 1980's, the traffic congestion problem was severe, the morning and evening peaks extended for the majority of the day especially around the Central Business District.

⁴⁴ Litman, Todd. (2001). Car-sharing Vehicle Rental Services That Substitute for Private Vehicle Ownership. VTPI On-Line Encyclopedia. British Columbia. <http://www.vtpi.org/tdm/tdm7.htm>

⁴⁵ The Initial San Francisco Bay Area Station Car Demonstration. (1998) National Station Car Association Web Site. www.stncar.com

⁴⁶ Kuranami, Winston, Kimura, Rose and Nakagawa (2000). Study on Urban Transport Development. PADECO Co. Ltd. World Bank Press. Washington DC.

⁴⁷ Ibid.

Further, mobile source emissions accounted for 77% of Seoul's air pollution, with diesel fumes as a major contributor. Congestion and pollution were further exacerbated by a decline in diesel prices.

The "traffic tax" was imposed on businesses residing in Seoul's CBD during the early 1990's to fund mass transit initiatives. Vehicular taxes were imposed to reduce private car ownership, and thereby congestion, but also to encourage saving and restrict consumption of luxury goods. Taxes on vehicles were levied by both municipal and national governments. Vehicular tax measures in Seoul are drastic by Western standards, in place since 1985; these taxes account for up to 75% of the original vehicle price. At first, the tax strategy was successful at reducing vehicle ownership, however by 1995 the government began reducing constraints and lowering emissions standards.⁴⁸ In general, the low elasticity of travel demand coupled with an opaque charging mechanism results in the need for very high taxes to achieve a substantial reduction in vehicle use. Taxation is less efficient in altering user behavior than road use pricing because it is levied without regard to location, time, and congestion.

4.7.4 *Mass Transit Subsidies*

Direct subsidies to economically disadvantaged citizens can bolster ridership on mass transit system reducing demand for private vehicle use. Subsidies may be made by government or employers (see example above). Alternately, but less effectively, subsidies may be granted by governments directly to the operators of mass transit system in order to reduce user fees.

4.7.5 *Road Pricing*

Road pricing policies seek to encourage optimal use of the road system and to reduce congestion by charging drivers for the marginal cost they are contributing to congestion. As traffic levels increase towards saturation the marginal cost of one additional vehicle increases dramatically. Therefore, road pricing is most effective when the charge is sensitive to the current congestion level or alternately to a time of day when the congestion levels may be approximated. By pricing the externalities caused by use, road pricing achieves a highly efficient allocation of resources.

Due to the low elasticity of travel-demand, road pricing has the potential to generate substantial revenues. These revenues are typically employed to recover the cost of providing roads and to fund mass transit investment. However there are serious considerations regarding road pricing's effect on social equity. In developed cities, the tolls required to alter travel patterns will be a greater burden for poor residents. In the absence of viable public transportation alternatives, road pricing becomes a regressive tax. Equity concerns are minimal in developing cities as most drivers of private vehicles are in the upper income categories. Further, the use of marginal pricing without a clear understanding, on the part of the public, of the full external costs of congestion may generate strong public resistance. To ensure effective implementation of road pricing policies governments must understand that road pricing is feasible only if there are viable transit alternatives. It is also vital that revenues are distributed back into the public transport system; that the program provide tangible benefits to community; and that marketing and public consultation are incorporated into the planning process.

*Example & Assessment: Stockholm's Road Pricing Experiment*⁴⁹

Stockholm's road pricing experiment, known as the Dennis Package, was conceived of with the primary goal of generating revenue for road and public transport investment, not congestion relief.

⁴⁸ Kuranami, Winston, Kimura, Rose and Nakagawa (2000). Study on Urban Transport Development. PADECO Co. Ltd. World Bank Press. Washington DC.

⁴⁹ Gomez-Ibanez & Small. (1994). Road Pricing for Congestion Management: A Survey of International Practice. Transportation Research Board. National Research Council. Washington DC.

The Dennis Package established a cordon around the city center and levied a toll on all vehicles passing into the city-center during the day. The Dennis Package was primarily an investment plan whose total price was projected to be USD\$6.1B. The use of tolls for cost recovery was meant to finance 1/10th of the total cost of the new ring roads, which were intended to relieve congestion in the city center by allowing high-speed by-pass of the city center. The aim there was to enhance the speed and safety of city buses servicing the city-center.

The tolling cordon around the city-center employed both cash and electronic payment systems. Electronic payments were made by anonymous smart-card technology and enforced using digital photography of violating vehicles' license plates. Congestion reduction as a direct consequence of the pricing scheme is difficult to isolate as the new by-pass roads diverted a large percentage of traffic from the city center by themselves. However, the analysis of projected traffic volumes concluded that the combination of tolls and by-pass roads would result in a significant increase in travel speed and a steep decline in automobile use. The net effect was that total vehicle miles traveled (VMT) remained unchanged from pre-investment levels, with the result being a dramatic increase in accessibility without adding any environmental externalities. The scale of the cordon increased its effectiveness by eliminating untolled entries. To counter public resistance to the program seasonal passes were made available to commuting families, to reduce the individual burden of the tolls.⁵⁰

The success of the Dennis Package road-pricing scheme has led to further study being conducted on differential pricing schemes on a national level. The study conducted by Sveder and Nylander (2001) criticizes the cordon scheme for reducing city-center traffic by inducing regional traffic. They claim that the net effect on traffic, regionally, has been a modest reduction of 2%. Their recommendation is to expand the cordon scheme for Stockholm into a comprehensive 5-zone plan, and to replicate this for all Swedish cities with populations over 60,000. The initial estimates of revenues generated would be in excess of USD\$9B per annum, or more than the total state income in 1997. Furthermore, the social cost-benefit analysis determined that congestion is the primary source for social marginal cost for road traffic. As such, differentiated road user charges have the potential to improve social benefits while efficiently utilizing existing road capacity.⁵¹

4.7.6 Congestion Metering

The concept of congestion metering takes road pricing to its absolute theoretical limit. The marginal cost of congestion induced by the vehicle would be calculated and charged in real time without any pricing inefficiency. The prices adjust automatically in response to the actual level of congestion encountered, falling to zero in free-flow conditions. This can be technically achieved by linking the in-vehicle transponder to the speedometer and odometer. Once the vehicle enters a tolled zone, the calculation of travel speed and distanced traveled would provide the data needed to compute the applicable marginal charge.

*Example & Assessment: Cambridge, England Congestion Metering Trial*⁵²

In the Cambridge metering trial, cars within a 12-15 mile radius of the city were to be fitted with an electronic metering device. This device connected to the odometer, so that congestion could be

⁵⁰ Gomez-Ibanez & Small. (1994). Road Pricing for Congestion Management: A Survey of International Practice. Transportation Research Board. National Research Council. Washington DC.

⁵¹ Sveder & Nylander. (2001) Internalization of External Cost: An Assessment of Road Pricing in the Stockholm Region. Transek AB. Solna, Sweden.

⁵² Ison S. (1998). A concept in the right place at the wrong time: congestion metering in the city of Cambridge. Transport Policy No.5. London

monitored based on speed and distance traveled. The owner of the vehicle had an onboard metering device that would be issued with a smart card, which could be refilled electronically at garages, gas stations, and banks. The meter would be dormant outside the center, but activated by beacons in the center sending information via microwave transponders to it, to charge for units of congestion. The original proposal called for an initial charge of \$0.36 (1990) for traveling a certain distance at speed of less than 10km/h with more than four stops. The transponders would deactivate when departing. Visitors would be accommodated with daily passes sold at a fixed price.

Brian Oldridge, the champion of Cambridge's congestion metering trials, retired in 1993 and the plan died soon thereafter. The county council was particularly concerned with a severe public backlash to a scheme whose charges are unpredictable and unavoidable. They were also concerned that from a driver's perspective the highest charges would be levied while the user was stuck in traffic and already aggrieved. There is also a potential legal danger to assessing congestion charges, since drivers will undoubtedly challenge the notion that they, rather than city-planners, construction work, accidents etc. were the cause of the congestion for which they were being charged.⁵³

4.7.7 *Parking Pricing*⁵⁴

Parking pricing initiatives use the cost of parking to alter consumer travel behavior. Full-cost parking pricing requires that motorists pay directly for the cost of using parking facilities, including all external costs. Parking pricing may be implemented as a TDM strategy to reduce vehicle traffic in an specific area, to recover parking facility investment costs, or to generate revenue for other investments. Full-cost parking charges represent a significant shift from the status-quo application of charges. "Most vehicle parking is provided free or significantly subsidized. Of the 95% of U.S. employees who commute by automobile, only 5% pay full parking costs and 9% pay a subsidized rate, and parking is unpriced at more than 98% of non-commute trip destinations. When parking is priced, there are often substantial discounts for long-term leases and sometimes there is no hourly or daily rental option, leaving motorists with little financial incentive to use alternative modes."⁵⁵

*Example & Assessment: Eugene, Oregon Parking Price*⁵⁶

In the mid 1980's Eugene, Oregon raised rates at two municipal garages and several surface lots. Rates at the garages increased from \$16 to \$30 over a period of one year. Surface lot rates increased from between \$6-16 to \$16-34. Meter rates remained unchanged, but fines were increased for commuters parking in short-term stalls for shoppers. Monthly parking-permit sales declined from 560 to 360, a decline of 35%. Half of the daily-parking facility users became car-poolers or rode the free shuttle, while the other half changed parking locations. The Eugene parking program demonstrated the potential for using pricing to shift user preferences for where to park, and highlighted the need for enforcement strategies to accompany pricing.

⁵³ Gomez-Ibanez & Small. (1994). Road Pricing for Congestion Management: A Survey of International Practice. Transportation Research Board. National Research Council. Washington DC.

⁵⁴ Litman T. (2000). Parking Pricing: Direct Charges for Using Parking Facilities. TDM Encyclopedia. Victoria Transport Policy Institute. British Columbia.

⁵⁵ Bureau of Transportation Statistics - USDOT (1992). A Summary of Travel Trends. National Personal Transportation Survey. www.fhwa.dot.gov/ohim/nptspage.htm.

⁵⁶ Marwick, P. & Mitchell and Co. (1985). West University Neighborhood Parking Pricing Demonstration Program in Eugene, Oregon. Final Report for the U.S. Department of Transportation. Houston.

4.7.8 Area Licensing Schemes (ALS)

Area licensing schemes are crude versions of road pricing which define tolled areas within a city during peak congestion times. Essentially, there is little difference between an area licensing program and a location restriction, aside from the obvious choice given to “purchase” access to the restricted zone.

Example & Assessment: Singapore’s Area Licensing Scheme

Singapore’s ALS program is discussed in detail in Chapter 6.

4.8 Supply-side Command & Control: Examples & Assessment

4.8.1 Restricted Vehicle Zones

Private vehicle bans have been employed to reduce congestion in city centers by forbidding all private vehicle from entering specified zones during certain times of days, or all day long. Typically, road space previously used by private vehicles is use solely for mass transit (buses) or for pedestrian and cycles only.

Example & Assessment: Tebran’s RTZ⁵⁷

In 1983, in response to a burgeoning private vehicle fleet and poor air-quality Tehran instituted a Restricted Travel Zone, which limited 90% vehicles from 23Km² in the center of the city. Exempted vehicles included taxis, buses, and emergency vehicles. In order to obtain a permit to travel through the Restricted Travel Zone, all vehicles must pass a rigorous mandatory emission inspection and control program. Enforcement of the RTZ however has been greatly compromised by a lack of resources and trained officers. Consequently, subversion of regulations and restrictions is the norm. In spite of the private vehicle ban the average CO, PM10, SO₂ levels in the CBD in 1998 were three times the WHO minimum standard. However geography, fuel quality, average fleet age, lack of public transport, inefficient planning, a lack of green space, poor enforcement, and low fuel prices all contributed to off-setting any environmental benefits of the RTZ.

4.8.2 Restricted Parking Supply

Reduction of the total available parking supply or restricting the expansion of the current supply can induce a shift in driving behavior by increasing the time spent searching for parking. Reducing parking supply also tends to increase parking prices, and supports strategic transportation and land use objectives if implemented as part of an extensive TDM initiative.⁵⁸ The strategy can be effective if strong enforcement capacity is prevalent but may also lead to harmful spill-over effects in the forms of “moving parking lots”, as drivers circle areas in search of parking locations. This effect is difficult to overcome due to the information asymmetry caused by the small yet persistent chance that a spot will be available, or open up in short course. Therefore, it is imperative that a reduction in supply be accompanied by a corresponding increase in price, to discourage driver speculation.⁵⁹

Example & Assessment: Mexico City

Mexico City severely curtailed the number of public parking spaces available. The “extra” cars started double-parking in the city streets, reducing capacity. The parking police were overwhelmed with infractions and could not adequately enforce the double-parking prohibition. The result was that the number of cars stayed constant, the pollution level per car increased, road capacity decreased, and mobility for the entire city including the public buses was severely hampered.⁶⁰

⁵⁷ Gozaresh. (2000). Get Your Masks Ready; Tehran's Poisonous Air is on the Way. Social and Economic Monthly. Tehran.

⁵⁸ Litman, Todd. (2000). TDM Encyclopedia. Victoria Transport Policy Institute. British Columbia.

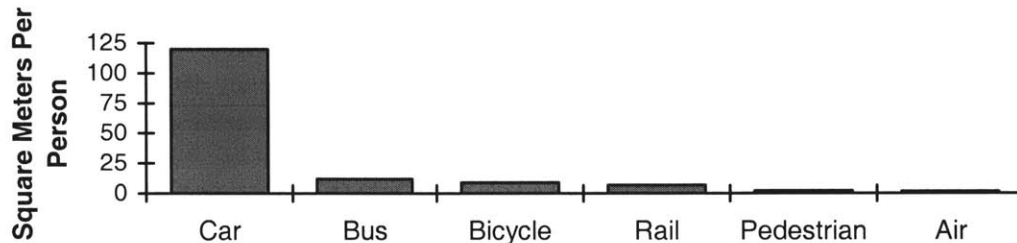
⁵⁹ Conversations with Professor Fred Moavenzadeh. (2001) MIT Department of Civil and Environmental Engineering. Cambridge.

⁶⁰ Leautaud, Juan & Perez-Barnes. Cesar (1997). *Energy and Infrastructure Policies for Mitigating Air Pollution in Mexico City*. MIT. Cambridge.

4.8.3 High Occupancy Vehicle Lanes (HOV)

High Occupancy Vehicle lanes are a road-supply reallocation strategy employed by governments to reduce congestion on major thoroughfares. The concept is to increase the number of people travelling on the roadway without increasing the number of vehicles. Since single occupant vehicles (SOVs) are one of the least efficient modes of transport, encouraging ride-sharing using HOV regulations has the potential to dramatically increase the number passenger serviced.

Figure 9: Road Space Required by Mode of Travel



[Source: Teufel]⁶¹

An added benefit is that as groups assemble to take advantage of HOV, the overall congestion level of the roadway decreases. This poses an inherent dilemma for policy makers however. If HOV lanes are properly utilized, their positive impact on the flow of traffic on non-HOV lanes may discourage their use. There is also an environmental concern regarding HOV lanes. As HOV use frees-up additional road space for SOV vehicles, the net effect may be to increase the total number of vehicles using the road and thus negative impacts such as air and noise pollution will be increased.⁶²

Example & Assessment: Jakarta

Since 1993, the city of Jakarta in Indonesia has had an HOV lane program that was applied to major roads in the central region of the city, during the morning rush hour. It is better known as the “three in one” scheme. The idea was to increase the number of passenger moving through the congested areas at the height of the morning rush while at the same time reducing congestion. However, due to the presence of many “jockeys” who were willing for a fee to ride in vehicles, to raise vehicle occupancy to the requisite three, the scheme has been widely abused:

“You may have noticed that Jakarta traffic isn’t getting any better, even without demonstrations by students or other activities as Indonesia reinvents itself. A new form of entrepreneurship has arisen: kids are hiring themselves out as extra bodies to qualify for the HOV lanes, helping harried drivers get to work—and themselves to school.”

[Source: Nilles]⁶³

Theoretically, the police department was responsible for traffic management and HOV enforcement. However, they did not have the skills, experience, or inclination to do this job properly, and in Jakarta, since there was no law against the paid passengers, the scheme eventually collapsed.⁶⁴

⁶¹ Teufel, D. (1989). The Future of Motorized Transport. Transportation the Environment and Sustainable Development. Die Zukunft des Autoverkehrs. p. 184.

⁶² Humphrey, N. (2001). Reviewing the Status of HOV Lanes. TR News Number 214. Transportation Research Board. Washington DC.

⁶³ Nilles J. (1999). *The Olympics, Jakarta Traffic, and Telework*. Pacific Link Newspaper. Jakarta.

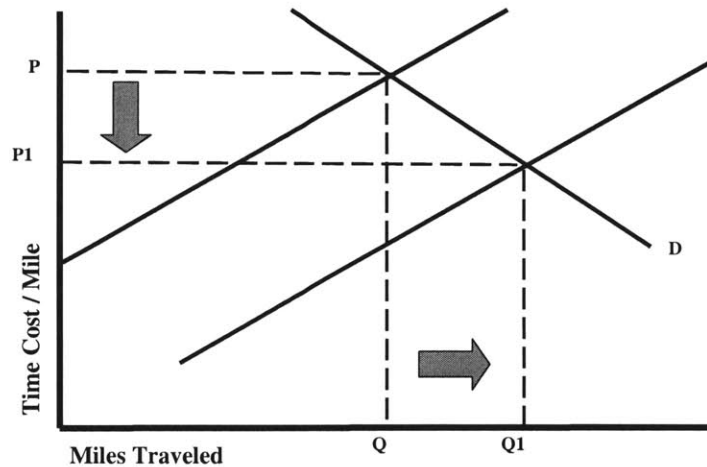
⁶⁴ Sayeg P. & Bray D. (1999) Prospects For Implementation of Electronic Road Pricing. Traffic Technology International. London

4.8.4 Public Road Construction

As previously stated, the construction of additional urban road capacity is problematic. There are three primary reasons for this; first new road supply tends to unleash pent-up demand, which eventually leads to additional congestion; second, expenditures on roads pose an unrecoverable financial burden on municipal governments. Finally, increasing road capacity can degrade transit service and revenues by encouraging car use. Transportation supply optimization measures such as HOV lanes and signal timing do not appear to be sufficiently effective to compensate.

Lewis Fulton of the International Energy Agency provides this analysis of induced demand: “The basic theory underlying the concept of induced travel demand is straightforward. The addition of roadway capacity, either through additional miles of roadway or additional lanes on an existing roadway, reduces the time-cost of travel. At some level of congestion, drivers will choose to avoid dealing with that congestion, either by choosing an alternative route or mode, changing the departure time of the trip, selecting a shorter trip to a similar activity, or avoiding the trip entirely. Since each traveler experiences declining utility with each mile traveled, at some point the cost of travel exceeds the benefit to the driver. This increase in generalized cost is primarily the time cost associated with increasing congestion. This is shown as point *a* in the figure. If, however, congestion is relieved through the addition of roadway capacity, the entire cost curve shifts out-ward, reflecting a shift toward lower travel time cost. This allows higher aggregate levels of travel before a given level of congestion is reached.”⁶⁵ The aggregate impact on vehicle miles traveled of these behavioral effects is shown in Figure 10.

Figure 10: The Impact of Roadway Expansion on Travel



[Source: Fulton]⁶⁶

Roadway land is often treated incorrectly as a “sunk” cost. Douglass Lee points out, “Land in urban right-of-way has alternative uses, and this value is included in published figures only when the purchase of new land is a part of current expenditures. Normally, any long-lived business investment is expected to earn a rate of return at least equal to the interest rate on borrowed funds.”⁶⁷ Failure to

⁶⁵ Fulton L. et al. (2000). A Statistical Analysis of Induced Travel Effects in the US. Journal of Transportation and Statistic. Paris.

⁶⁶ Adapted from Fulton L. et al. (2000). A Statistical Analysis of Induced Travel Effects in the US. Journal of Transportation and Statistic. Paris.

⁶⁷ Lee, Douglass. (1992) An Efficient Transportation and Land Use System. Volpe National Transportation Research Center, Cambridge <http://ohm.volpe.dot.gov>.

collect rent on land used for roads imposes a financial burden on municipal governments, encourages urban expansion to replace land “lost” from the tax rolls, and skews expenditures toward roadway transportation, reducing the overall efficiency of the economy.⁶⁸

4.9 Supply-side Market Based Initiatives: Examples & Assessment

4.9.1 *Private Transit Concessions*

The public sector is increasingly incapable of providing adequate financing for urban transport infrastructure. Further, the relatively inefficient provision and operation of the public transport services by public entities has resulted in increasing reliance on the private sector to provide these facilities and services. At least 80% of all urban bus services around the world are privately owned and operated. Increasingly cities are arranging concessions or other arrangements for the private provision of urban transport infrastructure including roads, light rail, and subways. Cities are becoming facilitators of public transport provision and moving away from ownership and operation.⁶⁹

Private provision and ownership of infrastructure assets may be the best possible route in some developing markets. However, private sector participants (investors, contractors, and technology providers) face a number of daunting challenges in attempting to engage the developing-world’s infrastructure markets. Namely, the current regulatory, economic, and cultural contexts are ill equipped to suit traditional ‘Western’ private investment. Special consideration must be made when structuring municipal concession contracts to provide adequate returns and acceptable risk levels to potential investors. Likewise, unique guarantees and agreements will have to be devised to suit municipal governments and users alike. Creative funding mechanisms may also be required (such as private land-development revenues, potential property taxes, and realized savings resulting from reduced government expenditure on road infrastructure) to guarantee economic feasibility. Financial returns must be distinguished from economic impact, but capturing economic benefits generated by transportation investments influences the financeability of projects. As is the case when increased economic activity increases land prices and thus generates additional tax revenue for city governments.

Where the private sector is underdeveloped or constrained by regulation, the issues of financial sustainability do not evaporate. It is increasingly evident that public entities can benefit from the introduction of market forces and discipline into their operations. Corporatization, public-private partnerships, and short-term O&M contracts are some of the vehicles that help to increase efficiency and accountability in publicly administered systems. Each of these strategies solves certain problems while creating new challenges, determining which to use must be done on a case-by-case basis. O&M contracts are ideal for situations where access to capital is not the primary constraint, but where inefficiency is endemic. In these situations, O&M contracts may be used to extract operational efficiencies. Driven by the profit motive private enterprises will generally out perform entrenched public-service bureaucracies. Thus, the issues related to financial sustainability can and should influence policy makers, investors, developers, and regulators alike.

*Example & Assessment: São Paulo Bus System Privatization*⁷⁰

In 1995, the city of São Paulo sought to revamp its aging and inefficient public bus system. São Paulo’s buses were characterized by obsolete ticket collection systems and poor access for bus

⁶⁸ Litman, Todd (2001). Land Use Impact Costs of Transportation. Victoria Transport Policy Institute. www.vtpi.org

⁶⁹ The World Bank Group. (2001) Urban Transport: An Overview. www.worldbank.org

⁷⁰ Rebelo & Benvenuto. (1995). Concessions of Bus-ways to the Private Sector: The São Paulo Metropolitan Region Experience. The World Bank Group. Washington DC.

passengers. The service schedule was unreliable and average bus speeds were 13 km/h. São Paulo decided to pursue a privatization plan to reap the benefits of private sector ownership and operation. Bid documents for ten bus corridors were issued, defining the rules for private implementation and operation of trunk-line services. All the costs associated with implementing the service, including improvements to street systems and facilities, were to be borne by the winning consortium. This innovative project demonstrated that private companies were prepared to delve into public transport finance at an unprecedented scale. Regulatory and controlling power remained in government hands with the public authorities controlling tariffs and monitoring the level of service offered against the pre-agreed targets. Although São Paulo's municipal authorities were successful in attracting private investors, by carefully designing the concessionaire compensation packages, the program failed because investors had problems securing financing. One hypothesis is that the capital markets perceived that the risks involved outweighed the potential profits. Investors were leery of the Brazilian market, felt it was not yet prepared to accept such a challenge, and wanted better partial risk guarantees.⁷¹

4.10 Land-Use Planning Strategies

4.10.1 *Transit Oriented Development*⁷²

Transit Oriented Development (TOD) refers to a group land-use planning strategies geared toward the creation of residential and commercial areas designed to maximize access by public transit. TOD is intended to increase accessibility and travel choice through land use clustering and public transportation improvements. This strategy makes it possible to reduce the frequency and distance of car trips, and enables reduced car ownership. TOD also reduces total transportation costs and helps to create a livable community, in addition to supporting other TDM objectives. By focussing commercial and residential development around mass transit systems, TOD facilitates association with adjacent land uses.

“Transportation and land use policies that encourage reductions in automobile travel and development of more multi-modal transportation systems are likely to provide marginal reductions in the land use costs. For example, more optimal transportation pricing, zoning codes that encourage transit-oriented development patterns, and encouragement of in-fill development and urban revitalization, can provide benefits such as savings in municipal service costs, preservation of greenspace and habitat, and increased travel choices.”

[Source: Litman]⁷³

A TOD strategy may also include the expansion of transit systems into poorly served suburbs, including cross-urban and orbital rail lines, and the creation of new urban villages around them. In this manner, Transit Oriented Development strategies also help to increase mobility in economically disadvantaged communities.

Example & Assessment: Hong Kong, Singapore, and Porto Alegre

When governments are effective in controlling land use, especially when they are important providers of housing, TOD strategies can fundamentally change city structures. In Hong Kong and Singapore, the city administrations practice rigorous land-use and transport planning, and have adopted policies to

⁷¹ Rebelo & Benvenuto. (1997). Lessons from São Paulo's Metropolitan Bus-way Concessions Program. The World Bank Group. Washington DC.

⁷² Litman, Todd. (2000). Transit Oriented Development: Using Public Transit to Create More Accessible and Livable Neighborhoods. Victoria Transport Policy Institute. British Columbia.

⁷³ Ibid.

enlarge the metro's catchment area by concentrating high-density public housing and commercial development close to metro stations. In these cities, the impact of a TOD strategy is clear. In these examples “true” TOD has been achieved by a combination of public sector land ownership, housing and infrastructure provision, major development over stations and depots, and private sector development. However, when these conditions do not apply, which is the case in many developing cities, TOD strategies are less effective. Often, expected developments at and near stations did not occur. When only the metro was used to guide city development, as was the case with the Porto Alegre suburban rail system, a ‘white-elephant’ project resulted.⁷⁴

4.10.2 High-Density Development

Low-density development encourages automobile dependency, which requires more land for roads and parking than other forms of transportation. Automobile dependency, necessitated by low-density development, encourages urban sprawl. Urban sprawl increases a number of economic and environmental costs, and increases future transportation costs. The impacts of urban sprawl include:

“Increased costs to construct roadway facilities, increased land requirements for roads, environmental and aesthetic costs from reduced green space, and higher per capita municipal and utility costs to serve lower density development.”

[Source: Litman]⁷⁵

While lower density land development provides some benefits to some individuals, many of the external costs are borne by society as a whole. Because of the many negative externalities of low-density development, many developing cities have pursued development strategies meant to foster high-density (HDD). These strategies go hand in hand with TOD, as the major benefits to be reaped from HDD are reliant on the availability of viable transit. Land-use-planning focussed on attaining higher densities, together with well-integrated transit development can substantially reduce travel demand. The connection between HDD and reduced travel demand is well established (Newman & Kenworthy).⁷⁶ For example, a recent study by the Regional Planning Association (1997) demonstrated that cities with rail transit induced high-density commercial development because they represented a long-term commitment through an investment in fixed facilities.⁷⁷ Other studies have concluded that well planned mass transit systems can induce concentrated housing around transit axes and stations, thereby reducing reliance on cars. “Total travel demand in regions that have successfully integrated HDD and transit may be lower than in other areas by factors of four to eight.”⁷⁸ Finally, where urban sprawl increases municipal service costs, municipalities can share the costs of expanding transit services with the developers who benefit from access to their projects.

Efficient public transport is essential to the continuing growth of large cities’ central areas. Bus systems, however well organized, have a maximum capacity of 20,000 people per hour (per direction), which when reached on the major arteries can limit the continued growth of the center. Consequently, either the natural growth of the center is forced to the perimeter, or a high-capacity metro is built to alleviate the public transport bottleneck. The role of the metro is permissive, it allows dynamic central growth to continue allowing the city to function with a strong center, but it does not create the underlying growth. In the absence of strong land-use planning regulations, which require considerable

⁷⁴ Fox, Halcrow. (2000). Mass Rapid Transit in Developing Countries. World Bank Urban Transport Review. Department for International Development. London

⁷⁵ Ibid.

⁷⁶ Newman and Kenworthy. (1989). Sustainability and Cities: Overcoming Automobile Dependence. Brookfield, VT. Gower.

⁷⁷ Regional Planning Association. (1997). Building Transit Friendly Communities. New York. <http://www.rpa.org/>

⁷⁸ Holtzclaw. (1994). Using Residential Patterns and Transit to Decrease Auto Dependence and Costs. NRDC. San Francisco.

institutional strength, the effect of a metro is less certain. This is partly because metros are nearly always located in the densest part of big cities, where land ownership is fragmented. Where land assembly is difficult and requires government action, developing city-governments have often failed to direct development constructively. However, in either case, the long-term impact of a metro network is generally to create a more concentrated city structure, which contracts strongly with the geographical sprawl, which characterizes many developing cities.⁷⁹ It can be concluded that high-density developments along the transit alignment do not just happen. HDD and TOD require strong government action either by the municipal government acting as the developer or by strategic land assembly.

Example & Assessment: Hong Kong & Singapore

See TOD examples above.

4.10.3 Urban Growth Boundaries

Urban Growth Boundaries (UGBs) are tools for growth management that establish lines around metropolitan areas, outside of which growth is discouraged or prohibited. "Development outside the ring is discouraged through down-zoning, tax incentives not to develop and prohibitions on providing services. Development inside the boundary is encouraged by expedited approval processes and up zoning. Thus, an urban growth boundary protects open space on the outside, and encourages increased density on the inside."⁸⁰ UGBs exist in several forms, Urban Services Boundary (USBs) and Greenbelts are other methods that, in essence, do the same thing. The UGB concept was first applied in Lexington, Kentucky in 1958, when the Urban Services Area was delineated as the basis for the Fayette County land use plan. Growth boundaries have since been adopted in only a handful of places.⁸¹

Example & Assessment: Portland

Portland's UGB was created as part of the statewide land-use-planning program in Oregon in the early 1970s. It encompasses an adequate supply of buildable land that can be efficiently provided with urban services for twenty years. The primary objectives of the Portland UGB are to promote the efficient planning and use of urban land; to improve the efficiency of public facilities and services; and to preserve prime farmland and forestlands outside the boundary. Portland's UGB has hemmed in development, fostered higher density development, and encouraged redevelopment of blighted urban areas. The average housing density in Portland increased from five homes per acre to eight homes per acre. Multifamily housing units account for half of all new building permits. High rates of in-fill and redevelopment were associated with low overall levels of housing production.⁸²

Portland's successful implementation of a UGB has led to many vocal detractors. According to the National Association of Homebuilders, eighty thousand single-family homes became "unaffordable" to Portland residents because of housing price inflation. According to the NAHB, Portland also ranks in the top 10% of the most expensive housing markets in the US, and the area is expected to have a housing deficit of 9,000 housing units by 2040. The defeat of new funding for the regional-rail system

⁷⁹ Litman, Todd (1999). Land Use Impact Costs of Transportation. Victoria Transport Policy Institute. British Columbia.

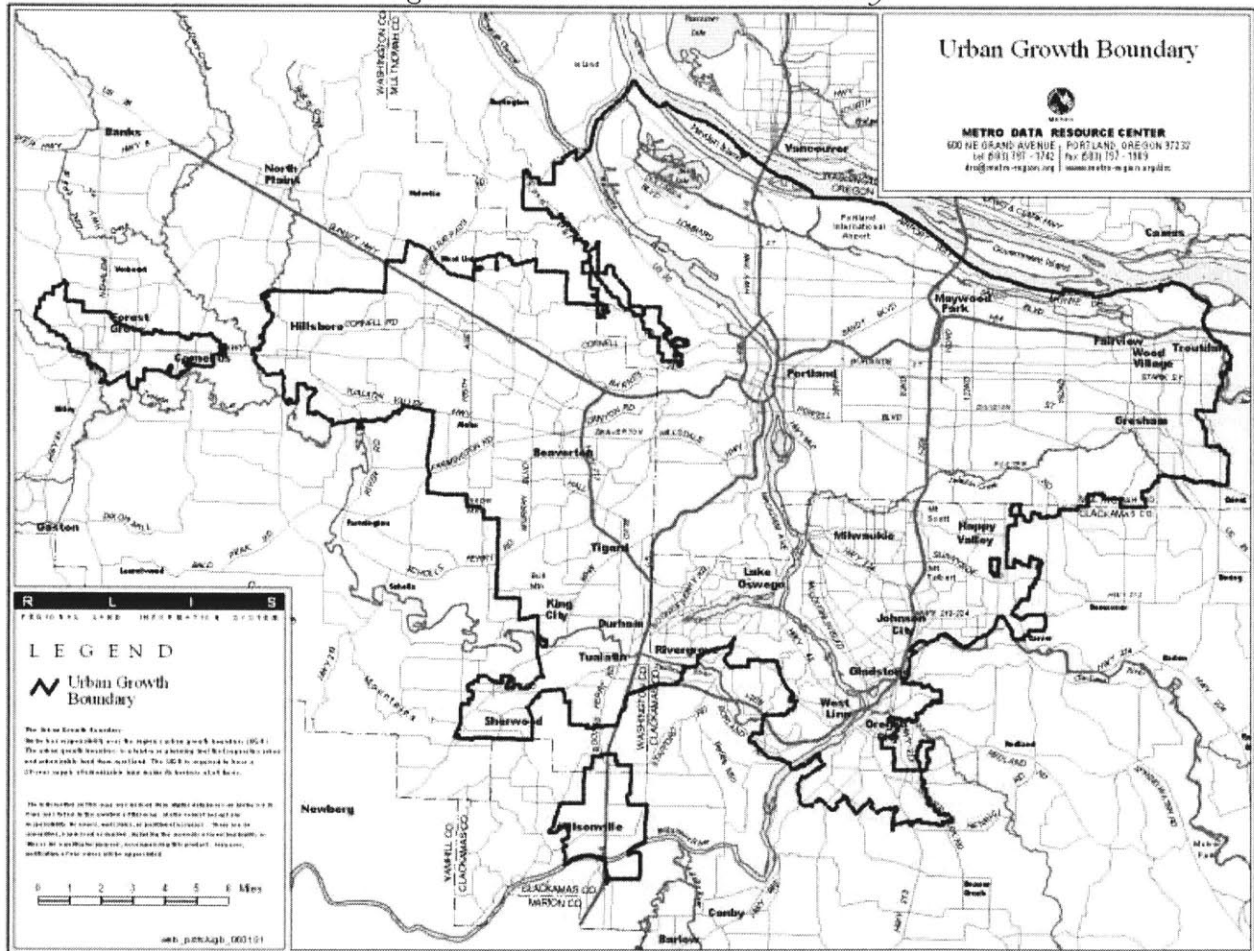
⁸⁰ Franciosi, Robert. (1998). A Tale of Two Cities: Phoenix, Portland, Growth and Growth Control. The Goldwater Institute. Phoenix.

⁸¹ National Association of Homebuilders Web-site. (2001). *Urban Growth Boundaries Portland Style: A Response*. http://www.nahb.net/growth_issues/growth_management/growth_portland.html

⁸² Knaap, G. (2000). The Urban Growth Boundary in Metropolitan Portland, Oregon: Research, Rhetoric, and Reality. University of Illinois. Urbana-Champaign.

suggests that public support for urban-growth boundaries in Portland is weakening.⁸³ UGB supporters contest these findings. “1000 Friends of Oregon”, an environmental group based in Portland, claims that the UGB has not been a major factor in the increase in home ownership prices. Citing a recent study by the American Planning Association, they point out that the effect of a booming economy in the late 1990’s was a far more decisive factor in housing price increases.⁸⁴ The UGB strategy is controversial nonetheless. While the degree to which a constrained land supply or increased demand may have been a more important contributor to increased prices is arguable, that the UGB reduced the quantity of land available for development is not.

Figure 11: Portland’s Urban Growth Boundary



[Source: Metro Data Resource Center]⁸⁵

⁸³ National Association of Homebuilders Web-site. (2001). *Urban Growth Boundaries Portland Style: A Response*. <http://www.nahb.com/>

⁸⁴ 1000 Friend of Oregon. (2001). *Myths & Facts About Oregon’s Urban Growth Boundaries*. Portland. <http://www.friends.org/>

⁸⁵ Metro Data Resource Center. (2001) *Portland’s UGB*. Portland. <http://www.metro-region.org/growth/ugbursa/ugbursa.html>

5 *Transportation Technologies & Fuels*

5.1 Intelligent Transportation Systems⁸⁶

There is a pressing need to develop transport systems that are both economically efficient and environmentally sound, and this objective requires a new way of looking at and solving transportation problems. “The decades-old panacea of pouring more concrete to address chronic transportation problems neither solves these problems nor promotes truly efficient transportation systems.”⁸⁷ A broad range of diverse technologies, known collectively as intelligent transportation systems (ITS), provides a set of tools to address these issues in a more sustainable manner. ITS is comprised of a number of technologies, including information processing, communications, control, and electronics. These technologies are aimed at improving safety, increasing efficiency, and cutting the cost of transporting people and goods. By doing so, they can contribute to a city’s ability to maintain a competitive position in the world economy. ITS can be applied to the entire transportation infrastructure including streets, tunnels, and parking lots, as well as to a vehicles, including cars, buses, and trains. These information and communications technologies can also be used to improve the manner in which transportation providers such as municipal transit agencies provide services to the public.

“After years of research and hundreds of operational tests, we know that the promise of ITS is real. ITS can save lives by preventing crashes -- it can give us the capacity for mobility that we need at less cost than new construction -- and it can save money by making transportation more efficient. This efficiency can also reduce pollution and energy consumption. It can do this -- and already *is* doing it.”
[Source: Slater]⁸⁸

ITS systems can be classified according to function or technology type. Functionally ITS technologies generally improve efficiencies by either increasing effective road capacity or by reducing demand for private vehicle travel. Some systems aim at improving efficiency through increased operation safety of vehicles. For this analysis we will divide ITS into vehicle based (in-vehicle) and facility-based technologies. However, some technologies such as traveler information systems may be provided both inside vehicles and along roadways with variable message signs (VMS). For developing cities the promise of ITS has begun to be realized. Advanced traffic management systems and advanced public transport systems, which employ some of the technologies discussed herein, are in use in nine developing countries including Brazil, China, Korea, Malaysia, Thailand and Uruguay.⁸⁹

5.1.1 *In-Vehicle Technologies*

Advances in sensor and data processing technology during the past decade have enabled the collection of large amounts of data from the vehicle environment. Sensor and communication technologies permit the detection of vehicle locations and transmission of information between vehicles. Technology such as Differential Global Positioning System (D-GPS) allows the position of a vehicle to be determined with an ever-increasing degree of accuracy. Other systems, such as the Mercedes-Benz Stability Enhancement System, illustrate the potential to detect collision situations, and to control the stability of the vehicle during a collision avoidance maneuver. Application of these and other state-

⁸⁶ US DOT. (2001). ITS Web site. <http://www.its.dot.gov>

⁸⁷ ITS America. (2001). Intelligent Transportation Systems Help Meet the Transportation Challenge. Washington DC. <http://www.itsa.org/>

⁸⁸ Slater, R. (2000). US Secretary of Transportation. *Remarks Prepared for National Intelligent Vehicle Initiative Meeting*. Washington, DC.

⁸⁹ ITS International. (2001). Route 1 Publishing. Kent, UK. www.itsinternational.com

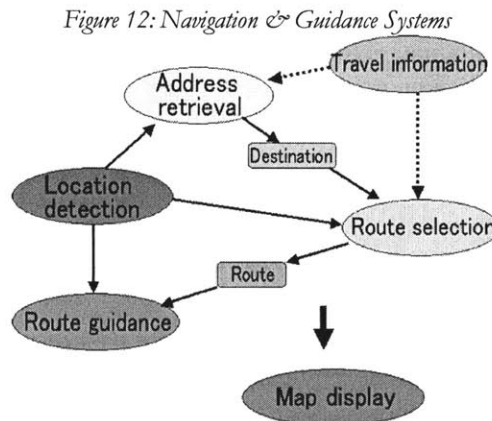
of-the-art technologies is part of a trend that has the potential to revolutionize road transportation by integrating sensors and processing equipment into automobiles to increase their safety and utility.⁹⁰

*Traveler Information Systems*⁹¹

In-vehicle Traveler Information Systems are devices that acquire, analyze, communicate, and present information to travelers to assist in moving from origin to destination with enhanced safety, efficiency and comfort. Travel information may be delivered for single or multiple modes of travel and may be employed for many types of transport. In-Vehicle information is provided in real-time inside cars and transit vehicles via electronic LCD displays and enunciators. In trains and subways, enunciators are frequently used to announce the next stop. Very few systems have been deployed on buses. Currently, a few in-vehicle information systems are in operation in private vehicles, of which the most prevalent are navigation and guidance systems.

*Navigation & Guidance Technologies*⁹²

The term "telematics" is derived from blending telecommunications and informatics, the science of obtaining and transmitting information.⁹³ While a broad range of telematic applications is currently under development for use in vehicles, the most common applications are navigation and guidance. Current telematic systems use a combination of digital map databases and GPS technology to help drivers optimize their travel paths. Optimized travel routes, which take into account current traffic conditions, accidents, and weather, hold the promise of reducing travel time substantially and thus helping to alleviate congestion and air-pollution. Vehicle navigation and guidance systems typically have six primary functions, as shown below. The telematic system locates the vehicle using GPS and plots the location on an electronic map, the system prompts the driver for a destination address and using the available data plots the fastest route. Some systems rely on text-based directions, while other now employ LCD screens and computerized voices to give directions.



[Source: Masao]⁹⁴

⁹⁰ Pierowicz et al. (2000). Intersection Collision Avoidance using ITS Countermeasures. Veridian Engineering. Buffalo.

⁹¹ US DOT (1996). Advanced Public Transportation Systems: A Summary of Projects. Office of Mobility Innovation. Washington DC.

⁹² Masao, S. (1999). Technological Approaches to Construction of ITS. Maebashi Institute of Technology. Maebashi, Japan.

⁹³ WST. (2001). Vehicle Telematics: A Much Needed Convenience or Driver Distraction? Wall Street & Technology Magazine. New York.

⁹⁴ Ibid.

*Motorola's iRadio Telematic System*⁹⁵

Motorola has developed a wireless application that provides drivers with a navigation service that synchronizes with real-time traffic and weather information, as well as up-to-date digital maps. Motorola's iRadio System is an in-vehicle platform that combines entertainment, information, navigation, emergency calling and communication into one system. The information is downloaded in real-time to the vehicle through a wireless (satellite based) radio-frequency connection.

On-Board Safety Technologies

The US-DOT cites driver error as the primary cause of 90% of all crashes involving passenger vehicles, trucks, and buses.⁹⁶ The primary goal of on-board safety technologies is to help drivers operate vehicles more safely and effectively. There is also strong correlation between safe vehicle operation and reduced congestion. Congestion on inter-city routes is often caused by back ups resulting from motor vehicle accidents. In fact, long after an accident scene has been cleared the traffic pattern remain affected by the "memory" of the crash. Therefore, a reduction in the number of traffic accidents has the potential to increase throughput on roads. There are numerous emerging ITS technologies that increase driver safety. These new technologies include mayday devices, haptic warning systems, and "drowsy-driver" detectors, below are a brief discussions of each.

*Mayday Devices*⁹⁷

Mayday devices seek to reduce crash fatalities and improve accident response times by automatically notifying emergency personnel and police when a crash has occurred. Robert Slater, the US Secretary of Transportation, launched a "National Mayday Readiness Initiative" in the US in 2000. Slater. Addressing the Society of Automotive Engineers said "Often crash victims die, or their injuries become more critical, because the accident is not discovered or emergency personnel cannot locate the crash site."⁹⁸ When an airbag deploys in a telematics-equipped car, an automatic emergency button is pushed. This switch notifies a private call center from which assistance is dispatched to the victim. The On-Star system, developed by GM, is the first functional Mayday system in the world and is fully integrated into the US emergency response system.

*Haptic Display Warning Systems*⁹⁹

Collisions may be avoided by providing early warnings to the driver through haptic displays. Haptic displays are felt instead of seen or heard. Various haptic display concepts for rear-end collision avoidance are being studied by the US DOT including "mono-pulse" braking and active steering displays. Mono-pulse displays are brake pedal reactions that cause a vibration or pulse in the brake pedal when a vehicle is approaching from the rear at a speed at which a collision is likely. Active steering displays use a similar vibration in the steering wheel to notify drivers of an impending collision. Neither system has been fully developed or deployed but they are thought to be promising technologies that will reduce driver reaction time, without undo distraction.

⁹⁵ ITS Network. (2001) Motorola And Navigation Technologies To Form Alliance To Develop Wireless In-Vehicle Navigation Application. Las Vegas. www.its-network.com

⁹⁶ Bishop, D. (1997) First International Workshop on Vehicle-Highway Automation. US DOT General Chair. San Diego.

⁹⁷ Halley, P. (2000). The National Mayday Readiness Initiative Report. Washington DC.

⁹⁸ Slater, R. (2000). US Secretary of Transportation. *Remarks Prepared for National Intelligent Vehicle Initiative Meeting*. Washington, DC.

⁹⁹ National Highway Traffic Safety Administration. (2000) Preliminary Studies in Haptic Displays for Rear-End Collision Avoidance System and Adaptive Cruise Control System Applications. Washington DC.

*Drowsy Driver Sensors*¹⁰⁰

The U.S. Department of Transportation is conducting initial evaluations of technologies that have the potential to “sense” when a driver is getting tired. In 2001, the US-DOT submitted a request for proposal to develop a device that will be used for drowsy-driver detection field tests. The device was required to monitor eye closure, without touching the driver.

*Advanced Public Transportation Systems*¹⁰¹

APTS applies advanced and emerging technologies to providing more efficient and effective solutions to current transit problems. APTS include a large array of technologies, from providing dispatchers a means for visually tracking buses to giving passengers an audio and visual display of the next bus stop. APTS focuses on developing innovative solutions to increase schedule adherence, operational efficiency, and quality of service; to reduce travel times and operating, training, and maintenance costs; and to improve driver and passenger safety. APTS seeks to make transit more reliable and easier to use, and thus a more attractive transportation option. APTS is broadly categorized into three different groups: Transit Management Systems, Electronic Fare Payment Systems, and Traveler Information Systems.



Figure 13: Display Panel on Buses in Hong Kong [Source: Zen]¹⁰²

5.1.2 Facility Based Technologies

While most in-vehicle technologies are market driven by nature, i.e. manufacturers develop them to meet consumer demand, facility based technologies are largely driven by governments. These technologies require relatively sophisticated transportation agencies working in partnership with the private sector to develop. Further, often considerable financing, legal, and policy issues surround their deployment and use.

*Smart Traffic Signal Control Systems*¹⁰³

Smart signal control systems collect and use information about traffic volume and automatically adjust signal timing for optimum operation. Optimally timed traffic signals are cost-effective ways to reduce congestion, air pollution, and fuel consumption. By responding dynamically to changing traffic conditions, these systems increase throughput or effective road supply. Adaptive signals and transit vehicle priority signaling are two “Smart” systems local governments can employ in a cost-effective way to improve traffic flow and street operations. These electronic flow-management systems are often preferable to expensive, lengthy, and disruptive road construction.

¹⁰⁰ NHTSA. (2001). NHTSA's Drowsy Driver Technology Program. US DOT. Washington DC. <http://www-nrd.nhtsa.dot.gov>

¹⁰¹ US DOT (1996). Advanced Public Transportation Systems: A Summary of Projects. Office of Mobility Innovation. Washington DC.

¹⁰² Zen, Tony. (2001). ITS in Hong Kong: An Overview. Hong Kong Department of Transport. Hong Kong

¹⁰³ US DOE. (2001). Traffic Flow: Keeping it Moving. Energy Efficiency and Renewable Energy Network (EREN). <http://www.eren.doe.gov>

Figure 14: Benefits of Smart Signal Control

| | |
|--------------------------------------|-----------|
| Travel Time Decreased | 8% - 25% |
| Travel Speed Increased | 14% - 22% |
| Vehicle Stops Decreased | 41% |
| Delay Decreased | 17% - 44% |
| Fuel Consumption Decreased fuel used | 6% - 13% |
| Emissions Decreased HC emissions | 4% - 10% |
| Decreased CO emissions | 5% - 15% |

[Source: US DOT]¹⁰⁴

*A) Adaptive Signaling Systems*¹⁰⁵

Adaptive signaling systems can be programmed to make timing changes either on a time-of-day basis, or dynamically, in response to actual traffic conditions. The systems can also notify operations staff of equipment failures. This function allows the staff to rapidly change the intersection timing to help alleviate the problem, and to dispatch maintenance crews immediately. In Hong Kong, average journey times were reduced by 30% following the installation of an adaptive signal control system; furthermore, the number of stops by vehicles dropped by 28% and stopping time was cut by 52%.¹⁰⁶

*B) Transit Vehicle Priority Signals*¹⁰⁷

Using transit vehicle priority signals, municipal transit and traffic control agencies can cooperate to provide selected transit vehicles first priority at signalized intersections. Selected bus routes can be granted priority right-of-way at traffic signals to assist the buses in adhering to their schedules. This can improve transit on-time service and may help convert automobile drivers to transit use. Transit vehicles, in turn, can be used to provide current traffic flow conditions to the traffic signal control system.

Electronic Toll Collection

ETC systems use various communications and electronic technologies to support the automated collection of payment at tollbooths and other collection points. Collectively, the application of these technologies increases system throughput, improves customer service, enhances safety, and reduces environmental impacts. Newly developed ETC systems allow car drivers to pass through tollgates without stopping or slowing. Electronic toll collections can double the capacity of a toll lane, from 500 to 600 cars per hour to up to 1,400 vehicles.¹⁰⁸ By effectively increasing the road capacity, the system helps reduce the need to build more roads. For this purpose, an antenna at a tollgate exchanges radio signals with ETC devices mounted in vehicles going through the gate. Electronic Toll Collection (ETC) systems have been deployed in fourteen developing countries including China, Philippines, Argentina, Turkey, Hungary and India.¹⁰⁹

¹⁰⁴ US-DOT. (1998). Developing Traffic Signal Control Systems Using the National ITS Architecture. Washington DC.

¹⁰⁵ US-DOT. (1998). Developing Traffic Signal Control Systems Using the National ITS Architecture. Washington DC.

¹⁰⁶ Zen, Tony. (2001). ITS in Hong Kong: An Overview. Hong Kong Department of Transport. Hong Kong.

¹⁰⁷ US-DOT. (1998). Developing Traffic Signal Control Systems Using the National ITS Architecture. Washington DC.

¹⁰⁸ Bacque, Peter. (2001) Smart Tag a Quiet Success. In The Times-Dispatch. Richmond, VA.

¹⁰⁹ Up-date on International ITS. (2001) City of Auckland web-site. <http://www.akcity.govt.nz/>

*A) Interstate-15 San Diego*¹¹⁰

Single occupant cars (SOVs) properly equipped with radio transponders can use HOV lanes on Interstate 15 in San Diego for a variable toll (\$0.50 to US\$4.00) depending on current traffic conditions. Variable message signs located at the entrance to the HOV lanes inform drivers in advance of the toll, which is collected automatically upon entering the HOV lane. Carpools and buses are able to use the lanes free. Officials are using differential pricing to evaluate the value commuters place on time saved traveling and are hoping to find better ways to manage traffic on the I-15.

*B) Melbourne City-Link*¹¹¹

A contract has been awarded for the supply of 600,000 electronic transponder tags for the 22km Melbourne City Link. When the City Link opened in 1999, tags were distributed free of charge to motorists. Tolls are now deducted electronically from pre-paid accounts as vehicles pass beneath the toll gantries. Occasional users and visitors are able to buy day-passes by telephone or at retail outlets.

*C) Cross-Israel Highway*¹¹²

The third fully automated ETC system in the world is likely to be the US\$750M, 86km Cross-Israel Highway. Frequent travelers will be issued free transponders. A sophisticated system of digital cameras will capture the license plates of vehicles without a transponder, or insufficient funds. As debit cards are more popular than credit cards in Israel, charging is to be by direct debit to users' checking accounts. A thirty-year concession has been awarded to operate the highway that is expected to earn US\$44.4M in the first year of operation.

*Electronic Road Pricing Technologies*¹¹³

There are currently two different electronic road-pricing technologies. The technology used in Singapore is referred to as 'Dedicated Short-Range Communications' (DSRC). A DSRC system employs gantries equipped with electronic devices using 5.8 GHz microwave transmissions to communicate with transponders in passing vehicles. The second technology is referred to as Vehicle Positioning System (VPS) technology. Each vehicle is equipped either with a GPS receiver that fixes its position by satellite or from terrestrial beacons. With either technology, payment can be by "smart card" or debited from a bank or credit-card account. Significant privacy concerns have been raised in the past but they have now been overcome using "smart cards" and data encryption. VPS technology is generally more expensive. However, VPS-based systems also potentially offer much greater flexibility in defining, or refining, charging systems. There is some evidence of problems arising with GPS tracking mechanisms in urban environments; the GPS signal can be lost in the canyons between high-rise buildings.¹¹⁴

*A) Hong Kong's ERP Study*¹¹⁵

In 1997, Hong Kong embarked on a feasibility study to determine the cost and effectiveness of ERP when deployed in and around central business districts. The projected initial capital cost of the system was USD\$30m, with annual operating cost of approximately USD\$6m. The Annual revenue estimates for Hong Kong's ERP system ranged from USD\$20 to USD\$70m, clearly demonstrating the lucrative opportunity posed by such systems. Hong Kong commissioned studies of both ERP technologies:

¹¹⁰ California Department of Transportation. (2001) Interstate 15 Express Lane: Fact Sheet. <http://www.dot.ca.gov/dist11/facts/15hov.htm>

¹¹¹ Melbourne City Link Authority Homepage. (2001). <http://www.citylink.vic.gov.au/pages/h2.html>

¹¹² Cross-Israel Highway Electronic Toll and Traffic Management System. (2001). www.raytheon.com

¹¹³ ISO TC204 Committee of Japan. (2001). DSRC: Vehicles and Roads Start a Dialogue to fulfil the Dreams of the 21st Century. Tokyo.

¹¹⁴ Catling, I. (2000). Giving the Gantry Virtual Teeth. In ITS International. February 2000. Kent, UK.

¹¹⁵ Zen, Toni. (2000). Hints to Successful Implementation of Electronic Road Pricing System. ITS Hong Kong. Hong Kong.

Microwave-based DSRC and the Vehicle Positioning System (VPS) using Global Positioning Satellites. Based on public-opinion polls, Hong Kong determined that ITS Integration as essential to bolster support for ERP. Thus, Hong Kong planned to provide motorists with real time traffic information, entertainment, and navigation guidance. In a recent reappraisal of the ERP trial tests, however, the Hong Kong government decided to shelve the implementation of ERP as traffic and environmental conditions were not perceived as warranting such drastic control measures.¹¹⁶

Automatic Highway Systems (Automatic Vehicle Control)

Automated Vehicle Control (AVC) refers to a set of steering, speed, headway, and overall system control elements that can be combined into what is known as an Automated Highway Systems (AHS). AHS will eventually allow for fully automated control and operation of vehicles equipped with the necessary communication subsystems, similar to autopilot systems in aircraft. The vehicle's guide-way will be similar to today's highways but will be supplemented with advanced sensors, detectors, and

communication beacons. Initial deployment and operation of these high performance systems is expected to focus on congested high priority routes located in major urban and inter-city freeway corridors. "AHS offers the potential for substantial improvements in throughput (both peak and average), safety, trip predictability, level of service, inclement weather operation, mobility and air quality."¹¹⁷ There are two basic approaches to AHS a facility-supported and independent-vehicle. In the facility-based approach, the highway is fitted with lines of magnets. The vehicles have sensors to detect and determine their position

Figure 15: AHS Simulation [Source: USDOT]



relative to them. The magnets transmit codes to the vehicle, informing it that there is an exit approaching. Automated control of vehicles operating on AHS dedicated lanes in high-priority traffic corridors may hold a realistic promise of being the next means of sustainably improving the performance of roadway systems.¹¹⁸

A) San Diego's AHS Trial¹¹⁹

The trial of the facility-supported Automated Highway in San Diego received considerable attention in 1997. Despite the press coverage and public curiosity, the US Department of Transport decided to withdraw funding. "It was decided that automated highways would not provide an answer to freeway problems in urban areas, because of the large number of transitions between "manual" and "automated" roads." It has been suggested that the concept may be more viable for inter-urban routes with longer travel times and greater safety problems.

Figure 16: San Diego AHS Trial in 1997



[Source: FLA]

¹¹⁶ Footman, Robert. (2001) Commissioner for Transport in Hong Kong. No need for ERP to be implemented. Hong Kong Government web-site: <http://www.info.gov.hk/gia/general/200104/24/0424209.htm>

¹¹⁷ National Automated Highway System Consortium. (1997). AHS Program Web Site. <http://ahs.volpe.dot.gov>

¹¹⁸ Ibid.

¹¹⁹ *An Automated Highway to Heaven?* (1997). In *Automotive*. Issue No.5. Fédération Internationale de l'Automobile. www.fia.com

5.2 Alternative Fuels

Substantial reductions in air-borne pollutants can be achieved through a combination of technological and policy options working coherently together. As discussed previously, many municipal governments are experimenting with innovative green-incentive programs to encourage a shift to cleaner fuels and engines. However, in order to implement meaningful change efficiently and effectively the incentives must be structured to realistically induce beneficial results. For instance, a massive tax break for zero-emission vehicles (ZEV) is not likely to be effective if such cars are not available on the market. Likewise switching a public transit bus fleet to low-sulfur diesel may be less cost effective and less environmentally friendly than switching to compressed natural gas (CNG). Therefore, the following section will provide brief descriptions of the current inventory of alternative fuels and discuss their emissions characteristics and suitability for transport. In so doing we hope to provide a rudimentary menu of options the municipal governments may consider when formulating green incentives, tax policies, and procuring public transit vehicles.

5.2.1 *Compressed Natural Gas & Liquefied Natural Gas*¹²⁰

Natural gas is a mixture of hydrocarbons, mainly methane (CH₄), and is produced either from gas wells or in conjunction with crude oil production. Some CNG can also be considered a renewable fuel for vehicles as it can be purified from the biogas and extracted from waste treatment facilities. Natural gas is generally stored onboard a vehicle in a compressed gaseous state (CNG), though it is also possible to liquefy it and store it in liquid form (LNG).

*Emissions Characteristics & Delivery Infrastructure*¹²¹

Compared with most gasoline-powered vehicles, dedicated natural gas vehicles typically reduce exhaust emissions CO by approximately 70%. Due to CNG's low carbon to hydrogen ratio, natural gas vehicles also emit virtually no particulate matter emissions. CNG also produces less carbon monoxide than diesel. It has a lower flame temperature than diesel, leading to a reduction of 87% of NO_x emissions. Natural gas can produce at least 20% less tailpipe greenhouse-gas emissions than gasoline or diesel fuel. CNG is often readily available to end-users through the existing utility infrastructure, and therefore natural gas has become increasingly popular as an alternative transportation fuel.

5.2.2 *Biodiesel*¹²²

Biodiesel is a clean burning diesel replacement fuel made from renewable natural sources including animal and vegetable oils. Blends of up to 20% biodiesel mixed with petroleum diesel can be used in nearly all diesel vehicles. Blends of 20% and less do not require engine modification and can provide the same payload capacity and fuel economy as diesel. Higher blends, and even pure biodiesel, can be used in many engines built since 1994 with little or no modification.

*Emissions Characteristics & Delivery Infrastructure*¹²³

Emissions of unburned hydrocarbons (HC), carbon monoxide (CO), sulfates (SO₂) and particulate matter (PM) can be substantially reduced by using biodiesel in a conventional diesel engine. These environmental benefits increase with the proportion of biodiesel blended into diesel. Biodiesel infrastructure is same as petroleum diesel. No modification of the equipment currently used to store,

¹²⁰ Beer, T. et al. (2000). Lifecycle Emissions Analysis of Alternative Fuels for Heavy Vehicles. CSIRO Atmospheric Research Report. Melbourne.

¹²¹ Natural Gas Coalition web-site. Natural Gas: The Environmental Solution Now. (2001). www.ngvc.org

¹²² US Department of Energy. (2001). Biodiesel Offers Fleets a Better Alternative to Petroleum Diesel. www.biodiesel.org

¹²³ Ibid.

transport, and deliver diesel is required for biodiesel handling. Biodiesel is safer than petroleum diesel as it does not emit dangerous vapors or fumes.

5.2.3 *Liquefied Petroleum Gas*¹²⁴

Liquefied petroleum gas (LPG) consists mainly of propane, propylene, butane, and butylene in various proportions according to its processing origin. LPG is a by-product from two sources: natural gas processing and crude oil refining. Motor vehicle grade LPG is a mixture of propane and butane in approximately equal ratios.

*Emissions Characteristics & Delivery Infrastructure*¹²⁵

LPG has particularly low particulate levels, which make it an attractive fuel for urban buses and delivery vehicles. LPG-powered vehicles also have less carbon build-up compared to gasoline- and diesel-powered vehicles. LPG vehicles can produce 30-90% less carbon monoxide (CO) and about 50% fewer toxics and other smog-producing emissions than gasoline engines. Propane or liquefied petroleum gas (LPG) is a popular alternative fuel choice because an infrastructure of pipelines, processing facilities, and storage already exists for its efficient distribution.

5.2.4 *Ethanol & Bioethanol*¹²⁶

“Ethanol is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Primary ingredients for ethanol include corn, barley and wheat. Ethanol that is produced from biomass such as trees and grasses is called bioethanol. Ethanol is most commonly used to increase octane and improve the emissions quality of gasoline. Ethanol can be blended with gasoline to form an E10 blend (10% ethanol and 90% gasoline), but it can be used in higher concentrations” (85-95%). Vehicle manufacturers have produced flexible-fuel vehicles that can operate on any combination of ethanol and gasoline.

*Emissions Characteristics & Delivery Infrastructure*¹²⁷

10-percent ethanol blends reduce carbon monoxide by more than 25% in comparison to other reformulated gasoline blends. The emissions produced by burning ethanol are less reactive with sunlight than those produced by burning gasoline. This results in a lower potential for forming the damaging ozone. Ethanol-blended fuels as E85 reduce the net emissions of greenhouse gases by as much as 37.1%. By promoting a more complete combustion process, ethanol blends lower the levels of CO emitted by 30%. Toxic octane enhancers in gasoline such as benzene, toluene and xylene can be safely replaced by Ethanol. The estimated cost of infrastructure modifications that would be required to enable traditional gas stations to receive, store, and blend ethanol are thought to be minimal. Proponents point to the current use of ethanol in the Mid-western US as demonstrating the feasibility of delivering, storing, and blending ethanol at traditional facilities.¹²⁸

5.2.5 *Hydrogen & Fuel Cells*¹²⁹

Hydrogen gas (H₂) may yet play an important role in developing sustainable around the world,

¹²⁴ The National Propane Gas Association web-site. Propane Powered Fleets. www.npga.org

¹²⁵ Ibid.

¹²⁶ American Coalition for Ethanol. (2001). Ethanol Information Fact Sheet. www.ethanol.org

¹²⁷ American Coalition for Ethanol. (2001). Ethanol Information Fact Sheet. www.ethanol.org

¹²⁸ California Energy Commission. (1999). Supply and Cost of Alternatives to MTBE in Gasoline. <http://www.energy.ca.gov/mtbe>

¹²⁹ Cannon, James. (1996). Harnessing Hydrogen: The Key to Sustainable Transportation. National Hydrogen Association. www.hydrogenus.com

because it can be produced in virtually unlimited quantities using renewable resources. Pure hydrogen and hydrogen mixed with natural gas (hythane) have been used effectively to power concept automobiles. However, hydrogen's real potential rests in its future role as fuel for fuel cell vehicles. A fuel cell is an electrochemical device in which the energy of a chemical reaction is converted directly into electricity. Unlike an electric cell or battery, a fuel cell does not run down or require recharging; it operates as long as the fuel and an oxidizer are supplied continuously from outside the cell. Typically, hydrogen and oxygen when fed into a proton exchange membrane (PEM) fuel cell produce enough electricity to power an electric automobile.

*Emissions Characteristics & Delivery Infrastructure*¹³⁰

Most notably, the fuel cell's only emissions are water and heat, in sharp contrast to internal combustion engines, which produce CO, CO₂, NO_x, SO₂ and other pollutants. While no hydrogen-delivery infrastructure currently exists, for hydrogen transportation use, the ability to create the fuel from a variety of resources and its clean-burning properties make it a desirable alternative fuel. Manufacturers are leery of building vehicles that cannot be easily refueled, and energy companies are reluctant to build infrastructure that has limited use. Given the lack of a delivery system for hydrogen, (Turner, 1999) favors a system of large-scale local reformers to produce hydrogen from natural gas. Hydrogen fuel would first be used in modified internal combustion engines, as fuel cells and a hydrogen delivery infrastructure are developed.

*5.2.6 A Comparison of Alternative Fuels*¹³¹

It is difficult to compare and rank the emissions characteristics of different alternative fuels. This is due primarily to the fact that it is rare for studies to have examined similar engines using similar pollution control equipment. This means that there can be extreme variability in the available emissions data, and it is possible to produce misleading comparisons where the best result from one fuel is compared to the worst result from another fuel.¹³² Also, there are often trade-offs between total carbon emission reductions (GHG) and lower pollutant emissions such as NO_x, CO, and PM. For this reason we will briefly compare both the overall GHG emissions reduction and separately examine the reduction in toxic pollutants.

*Greenhouse Gas Emissions*¹³³

Other than Hydrogen, Biodiesel has the lowest greenhouse gas emissions on a life-cycle basis. Life cycle is defined here as the costs associated from initial extraction to final use, i.e. well to tail pipe. Surprisingly, biodiesel emits more CO₂ than conventional fuels, but as most of these emissions are from renewable carbon stocks, that fraction is not counted towards the greenhouse gas emissions from the fuel. Ethanol comes next and then the gaseous fuels (LPG, CNG, and LNG). The extra energy required to liquefy and cool LNG means that it has the highest life-cycle greenhouse gas emissions of all the fuels that were considered. In addition, due to chronic problems with the engine and fuel system components CNG vehicles have had a significantly greater defect rate than diesel vehicles.

¹³⁰ Turner, John. (1999). A Realizable Renewable Energy Future. Science Magazine.

¹³¹ For an exhaustive report comparing the emissions characteristics of alternative fuels see Ref #132 (Beer et al.)

¹³² Beer, T. et al. (2000). Lifecycle Emissions Analysis of Alternative Fuels for Heavy Vehicles. CSIRO Atmospheric Research Report. Melbourne.

¹³³ Beer, T. et al. (2001). Comparison of transport fuels: Final Report (EV45A/2/F3C) to the Australian Greenhouse Office. Aspendale, Victoria: CSIRO Atmospheric Research.

Air Pollutant Emissions

Based on estimates of risk to human health and a life-cycle basis, the LPG and CNG contribute least to air pollution followed by ethanol. The use of waste oils as diesel extenders in biodiesel mixtures actually increase air pollution. In fact, biodiesel scores very poorly in relation to air quality because its production and use generate considerable amounts of particulate matter (PM).¹³⁴ Recent tailpipe emissions tests comparing compressed natural gas (CNG) with propane showed that propane is 87% lower in total hydrocarbons, 50% lower in nitrogen oxides (NOx) and 40% lower in particulate matter (PM).¹³⁵

Figure 17: Combustion Emissions Characteristic of Alternative Fuels

| Emission | Unit | Unleaded | | | | | | |
|------------|---------|----------|------|------|-----------|------|---------|----------|
| | | Gasoline | CNG | LNG | Biodiesel | LPG | Ethanol | Hydrogen |
| Greenhouse | kg CO2 | 0.07 | 0.05 | 0.05 | 0.00 | 0.06 | 0.00 | 0.00 |
| VOC urban | g HC | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 |
| NOx urban | g NOx | 0.09 | 0.11 | 0.18 | 1.16 | 0.05 | 0.80 | 0.00 |
| CO urban | g CO | 0.91 | 0.00 | 0.00 | 0.14 | 0.02 | 0.29 | 0.00 |
| PM10 urban | mg PM10 | 33.06 | 6.13 | 6.13 | 27.38 | 3.55 | 26.08 | 0.00 |

[Source: Beer et al.]

¹³⁴ Beer, T. et al. (2000). Lifecycle Emissions Analysis of Alternative Fuels for Heavy Vehicles. CSIRO Atmospheric Research Report. Melbourne.

¹³⁵ The National Propane Gas Association web-site. Propane Powered Fleets. www.npga.org

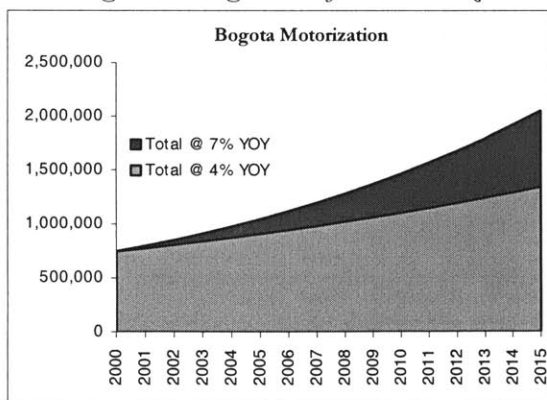
6 Case Study: Bogotá, Colombia

6.1 Context & Overview

Santa Fe de Bogotá, the capital of Colombia, is a rapidly expanding city of more than seven million inhabitants. It occupies an urbanized landmass of 320 square kilometers. The population is growing by 160,000 people per year, a growth rate of approximately 2%.¹³⁶ Continued guerilla violence has caused massive displacements of Colombia's rural populations, and a flood of refugees has crowded into Bogotá and other cities. The population of Soacha, a poor neighborhood on the outskirts of Bogotá, for example, has jumped from 300,000 to 1 million in the past six years.¹³⁷ Columbia is recovering from a recession that began in late 1996 that bottomed-out in 1999 with a 4% economic contraction. The recession was the result of tight monetary policies that were meant to drive down inflation, which is still running at more than 9% per annum. Bogotá's GDP per capita is estimated at USD\$3,300 (purchasing power parity of USD\$6,200) and is growing at a rate of 3.1% annually. The unemployment rate, at 20%, is at its highest level in decades.¹³⁸

832,000 private vehicles crowd Bogotá's streets, and the number is projected to increase by an astounding 70,000 vehicles annually. Yet, the current motorization rate is quite low by western standards at 12%. As the country emerges from the recession, the motorization rate is expected to increase dramatically during the next decade. Estimates range from a low 4% annual growth to 7%, depending on the future economic climate.¹³⁹ Although more than 80% of city residents use public transport daily, 95% of the current road space is occupied by private vehicles. Further, private vehicle trips in Bogotá are overwhelmingly inefficient with 80% of trips less than three miles long. Private automobiles account for 70% of urban air pollution: 700 tons of carbon gases (CO_x), 57 tons of hydrocarbons (HC), 24 tons of nitrogen oxides (NO_x) and 2 tons of sulfuric monoxide (SO) are emitted per day.¹⁴⁰ The result is that unless drastic measures are taken, transportation emissions will cause increasing high-level atmospheric pollution that will degrade human health. This situation is particularly alarming in Bogotá, since it is located 2600 meters above sea level where there is 27 percent less available oxygen than at sea level.¹⁴¹

Figure 18: Bogotá's Projected Motorization



[Source: Diaz]

Figure 19: A View of Bogotá's Skyline



[Source: Hinrichsen]

¹³⁶ The Bogota Project. (2000). Referendum Context – Vote Bogota 2000. www.ecoplan.org

¹³⁷ Otis, John. (1999). Political cleansing in Colombia Rising. *Houston Chronicle*. Houston.

¹³⁸ U. S. Department of Commerce - National Trade Data Bank (1999). Colombia Demographics. www.tradeport.org

¹³⁹ Diaz, Oscar. (2001). Car Free Bogotá: the response to the transportation challenge. *The New Colonist*. Duncanville, PA

¹⁴⁰ The Bogota Project. (2000). Sin Mi Carro: Bogota's Car Free Day. www.ecoplan.org

¹⁴¹ Diaz, Oscar. (2001). Car Free Bogotá: the response to the transportation challenge. *The New Colonist*. Duncanville, PA

6.2 Institutional Arrangement

Information in English on the organizational structure and institutional arrangements in Bogotá is scarce. Nonetheless, the office of the mayor has extensive organizational charts available to the public to explain the basic structure of the municipal government. Bogotá, like many developing cities, has a highly compartmentalized organizational structure, which is largely subservient to the mayor's office. The urban planning, environmental protection and transportation departments are not integrated, but Bogotá's success in integrating their functions appears to be largely due to the overarching authority of the mayor and his office. The diagrams below have been translated from the mayor's office web-site. Notably, the transportation secretary, reporting directly to the mayor, has an Information Technology division, which has played an important role in Bogotá's efforts to deploy advanced transportation technologies and dissemination of information to the public via the Web.

Figure 20: Bogotá's Planning Departments

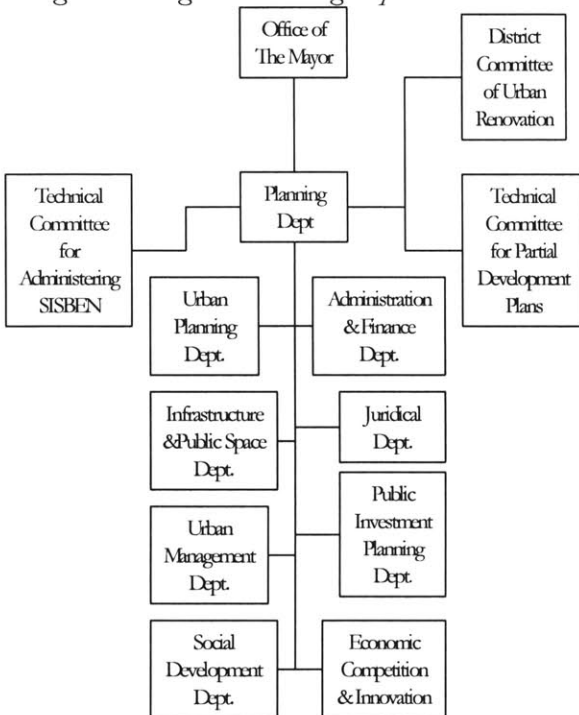
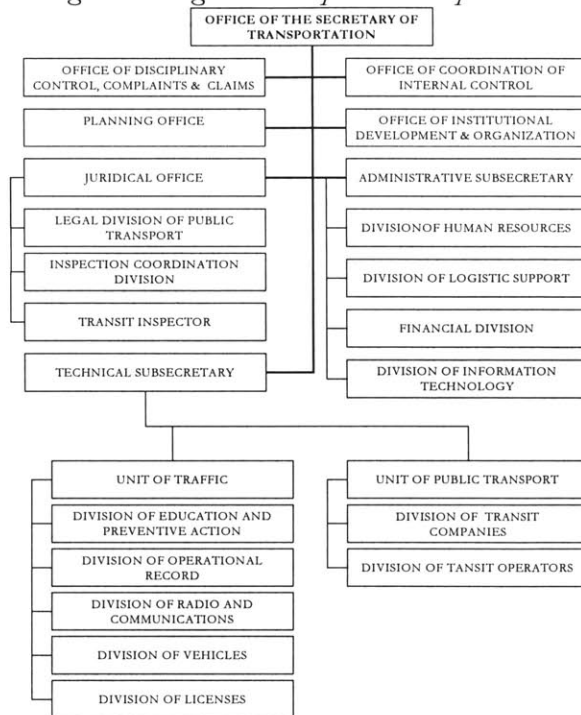


Figure 21: Bogotá's Transportation Departments



[Source: Bogota Planning Dept Web-site] [Source: Bogota Mayor's Office Web-site]

The SINU-POT Initiative ¹⁴²

In 2000, Bogotá's mayor and city council approved a new law called POT, which integrates all aspects of the city's urban development. The POT law includes general land use restrictions, zoning restrictions, delineation of areas for environment conservation, and new routes for public transportation systems. In an effort to promote the democratization of information, the city government commissioned a public information project called SINU-POT (Normal Urban Information System). SINU-POT is one of the first public Internet sites designed to allow graphical geographic queries regarding urban planning policies and use land regulations. The SINU-POT systems will assist in the distribution of information by improving citizens' access to information about new regulations that affect the city's development.

¹⁴² Castillo, Andres. (2001). The Democratization of information a technological challenge in Bogota. PROSIS. Bogota.

Organizational Restructuring of DAMA¹⁴³

DAMA is Bogotá's environmental protection agency. In 2001, DAMA underwent an extensive restructuring organizationally. The restructuring program began by defining specific objectives that the reorganization was to bring about. These goals included the integration and redistribution of functions, the rationalization of public expenditures, and increasing the efficacy, efficiency, and operational capacity of the organization. Work areas were grouped together by function with a coordinator, who was rotated every six months. The work groups were divided by processes and projects, of different areas and dependencies. With this review, the organization hoped to become more flexible and allow greater stakeholder participation in the management of the department. The conclusions of the institutional development review were:

- (i) The agency should seek to use specialized employees, with professional degrees, to concentrate efforts on the agency's primary mission;
- (ii) The agency should adopt a more horizontal structure to create a less hierarchical organization.
- (iii) In order to cut costs the agency should also explore eliminating, fusing, or reclassifying some positions, reducing absenteeism, and cut back on over-time.

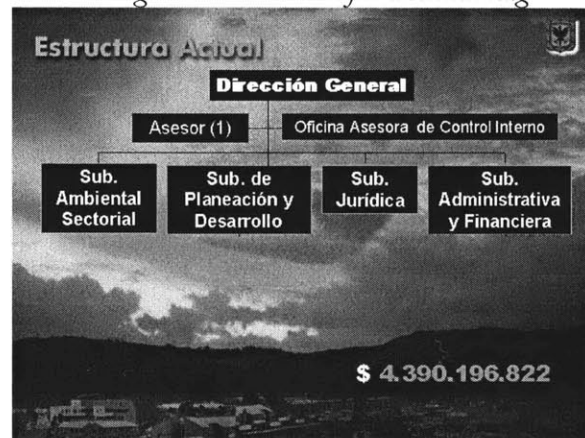
The result of the successful restructuring program are illustrated below:

Figure 22: DAMA before Restructuring



[Source: Londono]¹⁴⁴

Figure 23: DAMA after Restructuring



[Source: Londono]¹⁴⁵

Such determined efforts by a developing city municipal government are commendable. The success of the DAMA restructuring may serve as a potent reminder that in the face of capital constraints there may be great inefficiencies to be eliminated within large municipal bureaucracies. Whether Bogotá will seize the opportunity to apply these lessons to other part of the city government is still to be seen.

¹⁴³ Londono, Julia. Director of DAMA. (2001). Reestructuración Organizacional del DAMA. Bogotá. www.dama.gov.co

¹⁴⁴ Ibid.

¹⁴⁵ Ibid.

6.3 Transportation Policies

6.3.1 *Sin Mi Carro*

On February 24, 2000, the mayor of Bogotá Enrique Penalosa declared the first “Car Free” day in Latin America. For twenty-three hours, almost all 832,000 private vehicles remained parked, and the city’s residents took to the street on foot, bicycle, bus and taxi. The effects were dramatic with a significant decrease in noise pollution, air pollution, and traffic accidents. More importantly however, there was an overwhelming public support for the effort. *Sin Mi Carro* was designed less as an effective traffic-management tool than as a public relations campaign aimed at raising consciousness and changing attitudes.

Objectives

As stated, the experimental Sin Mi Carro initiative’s primary goal was to garner bottom-up support for innovative transportation policies. The mayor sought to instill a new vision in the minds of his constituent about the potential for increased livability in a city renowned for its frustrating traffic jams and high traffic-accident mortality. Sin Mi Carro sought to create a “collective learning experience” so that other relatively drastic traffic policies might enjoy greater support in the future.

“The real objective was to provide those who care with an opportunity to see their city and its transport arrangements with fresh eyes, and perhaps as a result begin to gather their thoughts and resources to begin to do things a bit differently.”

[Source: Britton]¹⁴⁶

Sin Mi Carro had a number of secondary objectives as well. As a result of the reduction in automobile use, the city aimed to demonstrate tangible benefits including increased accessibility, lower accident rates, and reduced air and noise pollution. The city also sought to leverage international expertise and support for the Car Free Day initiative. Bogotá worked closely with The Commons (www.ecoplan.org) and the international community of scholars and practitioners to organize Sin Mi Carro and make use of innovative information technology to disseminate information and monitor the results. Bogotá was rewarded with the Stockholm Challenge Award in 2001.¹⁴⁷

Implementation & Operation

Sin Mi Carro began at 6:30am on the morning of February 24, and lasted until 7:30pm. The private vehicle ban spanned the entire urban area, and was supported by a broad-based, region-wide, multi-level planning and mobility effort. *Sin Mi Carro* was implemented after more than a month of planning, consulting, and marketing. The municipal government convened numerous public feedback forums and built information kiosks around the city to inform and educate the public. The city also designed an extensive monitoring system that allowed continual, real-time, on-line monitoring of compliance, air quality, and noise levels. Following the successful implementation of the car free day, the city conducted extensive interviews with the public. The results of these polls are discussed below.¹⁴⁸

¹⁴⁶ Britton, Eric. (2000). An Overview of Bogota’s Sin Mi Carro. The Commons. www.ecoplan.org

¹⁴⁷ The Stockholm Challenge Award. (2001) City of Stockholm Economic Development Agency. www.challenge.stockholm.se

¹⁴⁸ Bajak, Frank. (2000). Traffic-choked Bogota breathes free for a day. The News Times. Feb 25, 2000. Danbury, CT.

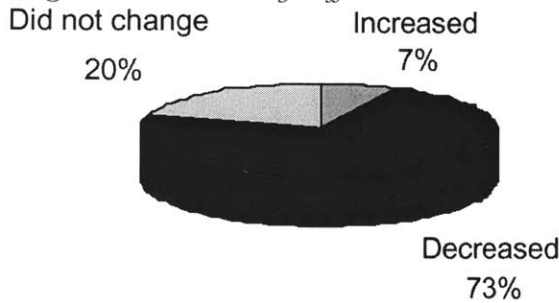
Operational Evaluation ¹⁴⁹

It is estimated that 830,000 vehicles were kept off the road during Sin Mi Carro. On that day, 75% of the residents of Bogotá used 55,000 taxis and 25,000 small buses (colectivos) to make long distance trips. For shorter trips, more than 250km of dedicated cycle paths were reserved. Compliance with the car use restrictions was by all measures very high, only 406 fines for illegal car use in target area were issued. This represents a 43% drop when compared with an average of 930 fines on a typical alternative odd and even day (Pico y Placa) restrictions.

Economic Evaluation

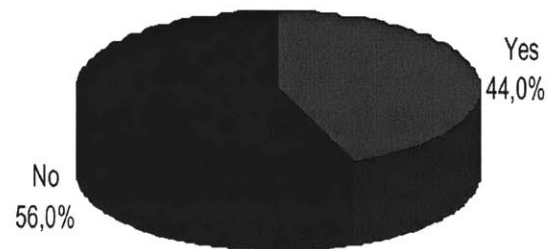
The economic impacts of the car-free day were measured in two ways by the government. First, there was an evaluation of absenteeism and late arrival at businesses by employees. Secondly, a survey of storeowners attempted to quantify the impact of the policy on retail sales. Retailers were the most adversely affected during the car free day, 73% of them reported a 36% to a 100% decrease in their sales. The causes to which they attributed their losses were that people went out less (57.5%), businesses remained closed (12.3%), and that many companies gave their employees a day off (11.0%).¹⁵⁰

Figure 24: Car Free Day: Effect on Retail Sales



[Source: Acevedo]¹⁵¹

Figure 25: Retailers Supporting Car Free Days



[Source: Acevedo]¹⁵²

92% of companies and universities indicated that there was no additional absenteeism of the employees during Sin Mi Carro. 60% responded that late arrival of employees had not been an issue. 19% of businesses within Bogota prepared for the car free day, including encouraging bicycle use, pre-reserving taxis, and asking employees to arrive and depart early.¹⁵³ Clearly, the economic impact of the initiative was mixed. While generally supported by a large majority of citizens, the negative effects on merchants would have to be addressed if the city hopes to permanently institute this measure. Additionally, more analysis must be performed to determine which merchants suffered, and to isolate the causes. It may very well be that those merchants that were not accessible by public transport suffered the greatest losses, and this effect could be remedied by supplementing the existing transit routes during the car free days.

Financial Evaluation

No financial data were available publicly on the implementation costs of the Sin Mi Carro initiative.

¹⁴⁹ The Stockholm Challenge Award. (2001) City of Stockholm Economic Development Agency. www.challenge.stockholm.se

¹⁵⁰ Acevedo, Yankelovich. (2000). Results Of The "Car Free Day" Held In Bogota. Bogota. www.ecoplan.org

¹⁵¹ Ibid.

¹⁵² Ibid.

¹⁵³ Ibid.

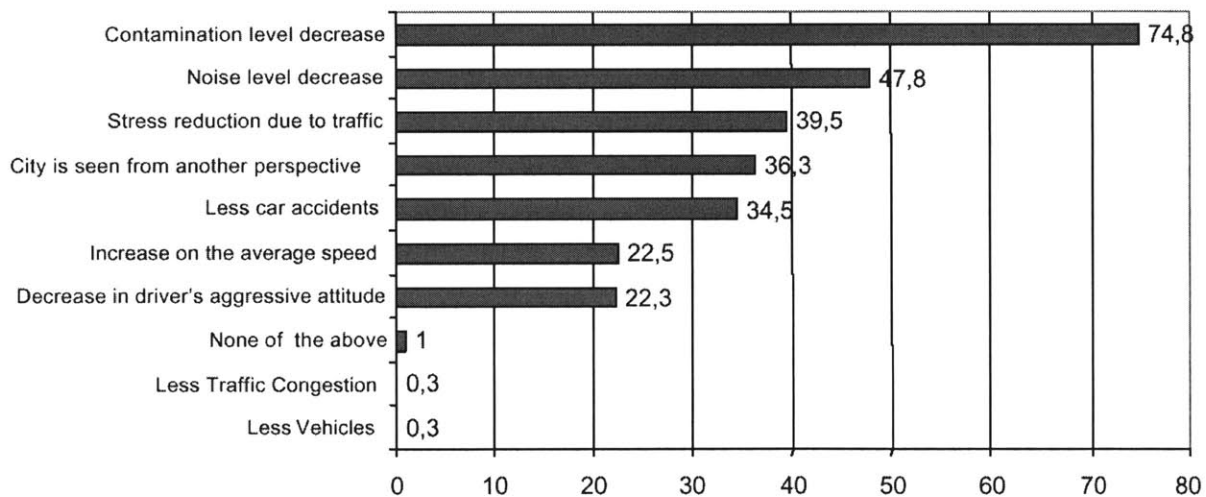
*Environmental Evaluation*¹⁵⁴

Bogotá is normally one of the world's most polluted cities, it ranks fifth in Latin American after Mexico City, Santiago, Sao Paulo and Rio de Janeiro. 70% of air borne pollutants in the city are caused by motor vehicles. Consequently, the temporary impact of a significant decrease in car use had the expected result of lowering ambient air pollution considerably. On February 24, 2000 the city registered significant decreases in the major air pollutants including a drop of 8% for NO_x, 22% for CO₂, and 21% for particulate matter (PM). However, it is important to realize that the effects were fleeting, without a determined effort to sustain the Car Free Day program on a regular basis its long-term environmental impact is negligible.

*Socioeconomic Evaluation*¹⁵⁵

Sin Mi Carro was an unqualified success with a majority of Bogotá's citizen. Polls conducted after the first Car Free Day indicated that 80% believed it was a great success, and nearly 95% favored at least a yearly repeat of the trial; 51% thought it should be regular monthly event. City officials were confident that the effort raised public awareness of congestion, pollution, and public transit. Sin Mi Carro may have also contributed to a lower policy barriers for future initiatives aimed at curbing automobile use. Other socioeconomic benefits included a drastic reduction in motor vehicle accidents that fell by 73% on February 24. Bogotá typically has between 3 and 4 fatal crashes per day, during Sin Mi Carro there were none. The city polled citizens to determine which benefits were most highly regarded; the results of which are shown below:

Figure 26: Perceived Benefits of Bogota's Car Free Day (percentage)



[Source: Acevedo]¹⁵⁶

6.3.2 *Pico y Placa*¹⁵⁷

In Bogota, 30% of trips are made in the expanded downtown area, creating congested corridors. A vast majority of these trips is under 8km in length. Approximately 70% of Bogota's air pollution is caused by automotive vehicles, of which 50% is attributed to private cars. These factors, in conjunction with a high rate of motorization growth, and low public transport vehicle speeds impelled

¹⁵⁴ Diaz, Oscar. (2001). Car Free Bogotá: the response to the transportation challenge. The New Colonist. Duncanville, PA.

¹⁵⁵ Acevedo, Yankelovich. (2000). Results Of The "Car Free Day" Held In Bogota. Bogota. www.ecoplan.org

¹⁵⁶ Ibid.

¹⁵⁷ The Commons. (2000). Pico y Placa. Paris. www.ecoplan.org/votebogota2000.org.

the municipal government to act to reduce the number of vehicles in circulation. The Pico y Placa (Peak and License Plate) restrictions were instituted to combat ever-worsening traffic congestion in the city center, to reduce air pollution, promote public transport use and to increase livability. Pico y Placa is a regulation that restricts 40% of privately owned vehicles from traveling into and within the entire urban perimeter during peak weekday hours. The restriction on private vehicles is made according to the last number on the license plate. Restrictions are in effect from Monday through Friday during the morning and evening rush hours (7:00am - 9:00am and 5:30pm - 7:30pm). Pico y Placa affects a large portion of the total vehicle fleet with 99.9% private vehicles and 90% total fleet affected.

Figure 27: Pico y Placa in Bogota



[Source: Carmago]¹⁵⁸

Objectives¹⁵⁹

Pico y Placa's short-term objective was to raise public awareness of the benefits that reducing the number of private vehicles can have on the city, and in the long-term, to generally reduce car dependency. The implementation of Pico y Placa also provided an opportunity to reorganize transit routes, rationalize the hierarchy of public road space, reduce private automobile use, and to increase utilization of alternative means of transportation.

Implementation & Operation¹⁶⁰

Pico y Placa was phased in gradually after incremental policies such as “Reversible Roads” and “Contra-Flujo” were instituted to foster understanding and public support. Reversible roads are still in effect in Bogotá today. Two main arteries leading into the city are made one-way during the rush hours to increase capacity into the city in the morning and out of it in the evening. The Contra-Flujo measures were temporarily employed to reverse a single lane of traffic on the arterial routes during peak travel times. However, Contra-Flujo was quickly abandoned as rate of accidents along these partially adjusted routes increased dramatically. Nonetheless, the objective of raising awareness of the interaction of capacity and congestion enabled smoother implementation of the Pico y Placa scheme.

¹⁵⁸ Carmago, Andres. (2000). Gestión de tráfico en Bogotá - Pico y Placa - Sin Mi Carro en Bogotá. Presentation given to the World Bank Urban Transport Strategy Group. Santiago, Chile. Available at: http://www.mtt.cl/subtrans/seminarios/tal_est_tra_urb/cepnov00-01.htm

¹⁵⁹ Ibid.

¹⁶⁰ The Commons. (2000). Pico y Placa. Paris. www.ecoplan.org/votebogota2000.org

Figure 28: "Reversible" Roads Diagram

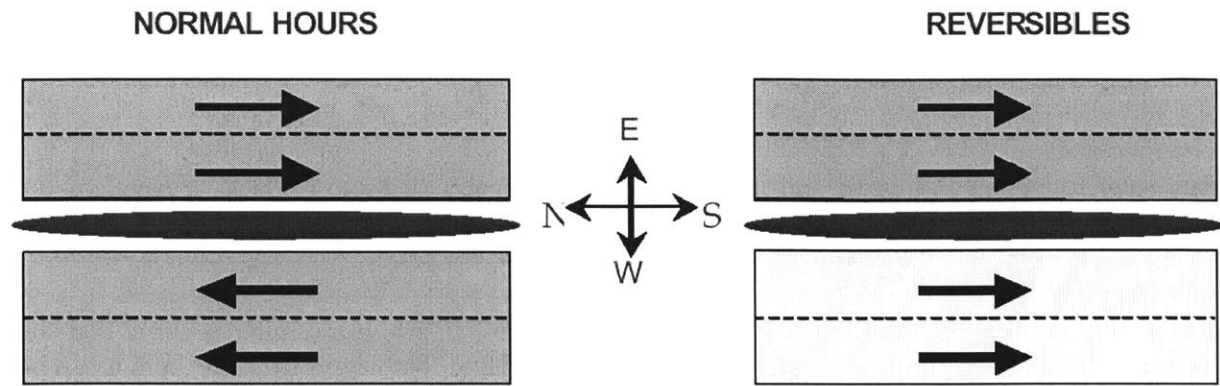
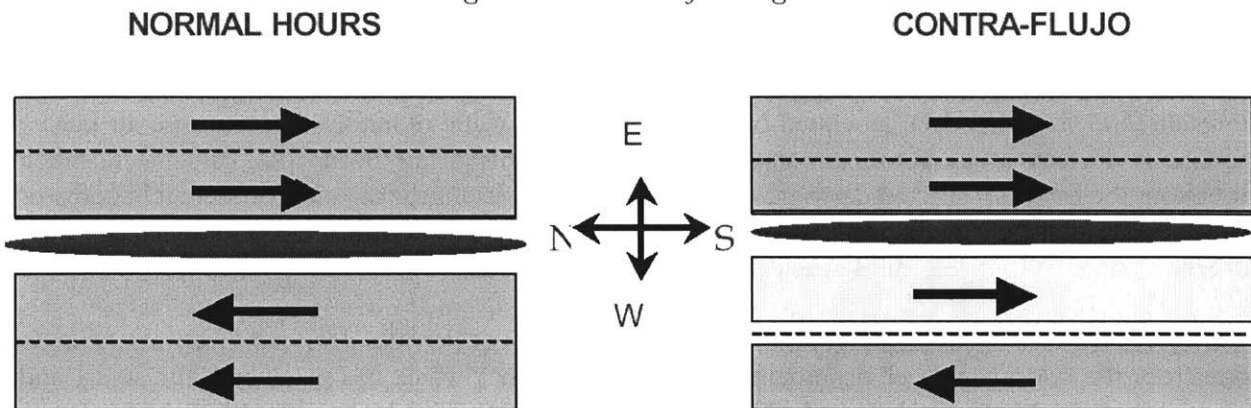


Figure 29: "Contra-Flujo" Diagram



[Source: *The Commons*]¹⁶¹

Additionally, the city gathered traffic flow data on the major routes to establish a baseline with which to judge the effectiveness of Pico y Placa. The city conducted extensive traffic flow analysis and demand forecasting on the major arterial routes. In planning Pico y Placa, the city assumed a normal distribution of license plate numbers to simplify the analysis. It was determined that in order to achieve maximum benefit the entire area within the urban perimeter had to be restricted to avoid 'leaks'. In its final form, Pico y Placa was implemented only during peak congestion times, but there is a current motion to substantially expand the length of restricted access times. Pico y Placa restricts four digits per day, which theoretically should result in a 40% decrease in vehicles. The actual effective reduction is closer to 30%. There are a number of vehicles that are exempt from the restrictions, including public transportation buses, emergency vehicles, diplomatic vehicles, and school buses. Violators are fined USD\$20, a relatively heavy toll, and the sanctions can be repeated until the violating vehicle exists the restricted zone.¹⁶²

*Operational Evaluation*¹⁶³

The primary objective of the Pico y Placa policy, to reduce the number of vehicles in circulation during the weekday rush hours, has been achieved. In contrast to the experiences of other cities, where car

¹⁶¹ The Commons. (2000). Pico y Placa. Paris. <http://www.ecoplan.org/votebogota2000/general/pico.htm>

¹⁶² Ibid.

¹⁶³ Londono, Julia. Director of DAMA. (2001). Comunicados di prensa. www.dama.gov.co

use restrictions have led to severe externalities (such as the purchase of a second more polluting vehicle), the citizens of Bogota have adjusted their travel behavior through a modal shift. The results are an increase in average travel velocity of 58%; a 28% drop in the accident rate; and increased utilization of public transportation.

Economic Evaluation

No data were found on the direct and indirect economic impacts of Pico Y Placa. Several of the socioeconomic benefits with economic implications have been identified below.

Financial Evaluation

No data were found on the financial cost and benefits of Pico Y Placa. One might assume that the high compliance rate may indicate a tradeoff in terms of financial profitability for the city, and it can be surmised that the social and environmental gains are considered of higher importance.

*Environmental Evaluation*¹⁶⁴

The Administrative Technical Department of Bogota's environmental protection agency, DAMA, estimates that Pico y Placa has had a considerable impact on air quality in Bogota. In order to obtain the results, DAMA used data generated by a network of automatic monitors that measure air quality throughout the city at 14 automatic stations. Measurements of air borne pollutants were taken throughout the city on restricted days and unrestricted days to determine the environmental benefits of Pico y Placa. DAMA cited reductions in the concentrations of Carbon Monoxide (CO) 13%, Nitrogen Oxides (NO_x) 4%, and Particulate Matter (PM₁₀) 14%.

*Socioeconomic Evaluation*¹⁶⁵

Aside from the considerable environmental benefits that Pico Y Placa has produced, the social and socioeconomic benefits are substantial. The average duration of trips taken with public transportation was reduced by nearly an hour. This translates to a savings of nearly 26 days, per year, per traveler. Even at a relatively low "time-cost of money" ($\$3300/356/24 = \$0.39/\text{hour}$) the added utility is USD\$2.7m per year. Perhaps more importantly, the accident Rate has fallen by 28%, in Bogota this means nearly *300 lives are saved per year*. It is also estimated that each vehicle saves approximately \$50 per year because of lower use, accounting for an additional \$37.4m in circulation. Finally, Pico Y Placa, despite being drastic by US standard, enjoys wide support among the city residents with support for the program holding at over 73%.

*6.3.3 TransMilenio*¹⁶⁶

Seventy two percent of Bogota's population is transported in urban buses daily. Yet, private vehicles occupy 95% of the road capacity while transporting only 20% of the population. Faced with an ever decreasing average travel speed (10Km/h at its lowest) Bogota sought to develop a high-capacity, cost effective, and environmentally friendly mass transit system. In lieu of the more traditional (and expensive) underground metro, Bogota chose to develop a comprehensive system of Bus Rapid Transit. TransMilenio is 104km of new bus feeder routes that are integrated into Bogota's existing bus system. TransMilenio introduced a number of innovative technologies and operational systems that have resulted in a highly successful and low-cost public transport alternative.

¹⁶⁴ Londono, Julia. Director of DAMA. (2001). Comunicados di prensa. www.dama.gov.co

¹⁶⁵ The Commons. (2001). Pico y Placa. <http://www.ecoplan.org/votebogota2000/general/pico.htm>

¹⁶⁶ Bogota Institute of Urban Development Web-Site. (2001). What is TransMilenio? www.idu.gov.co/proyectos/transmilenio.htm

Figure 30: Bogota's TransMilenio BRT



[Source: Guerrero]¹⁶⁷

*Objectives*¹⁶⁸

TransMilenio sought to address a number of severe transit and traffic related problems that Bogotá faced. Bogotá's existing bus system was a loosely regulated, uncoordinated, and highly polluting. The large number of buses that competed for the most profitable routes caused much of the congestion on the arterial roads, and the highly polluting diesel engines used by the operators were major contributors to Bogotá's severe air pollution problem. Since the average capacity of the old buses was under 60 persons, a significant number of vehicles would have been required to move the estimated 5 million buses customers daily. The chaos that ensued from the disjointed public transport system was called the "War of the Cent". Whereby an ever-greater number of buses competed for highly congested routes by cutting fares, lowering the quality of service, and hiring unqualified drivers. The following were the troubling symptoms of the ailing system:

- ❑ Drivers behaved recklessly often racing from stop to stop.
- ❑ Delays at stops were prolonged due to the exchange of cash between the passengers and drivers.
- ❑ Consequently, trip times increased while distances were very short.
- ❑ Air and noise pollution along the arterial routes increased.
- ❑ Average travel speed decreased to 10 Km/hr
- ❑ Equipment deteriorated and there was a general absence of structure and control in the operation.

*Implementation*¹⁶⁹

The technical, operational, design, managerial, legal, and financing aspects of the TransMilenio project were incredibly complex. To tackle the multifaceted issues surrounding TransMilenio the city brought together a coalition of local and international experts and advisors. These companies were employed as a cohesive team, for eighteen months. They were charged with defining the conceptual structure of the new transport system. These companies were Steer Davies Gleave (Technical & Operational

¹⁶⁷ Guerrero, Dario Hidalgo. (2001). "TransMilenio: The Mass Transport System of Bogotá". A paper prepared for the Latin American Urban Public Transport Congress. Havana, Cuba.

¹⁶⁸ Bogotá Institute of Urban Development Web-Site. (2001). What is TransMilenio? www.idu.gov.co/proyectos/transmilenio.htm

¹⁶⁹ Sandoval, Edgar. (2001). Manager of TransMilenio SA. Interview with Terra Networks SA. www.terra.com.co/proyectos/transmilenio

design), McKinsey and Company (Organizational Structure), Capital One (financial structure), Taboada Hoyos (legal advisors), and Temporary Union Guide LTD was employed as the chief architectural and urban development designer of the project. TransMilenio SA was formed in September 1999, as an umbrella organization representing the city. TransMilenio SA was created as a public industrial and commercial company with five representatives from the city government: IDU, Fondatt, Metrovivienda, Institute of Culture and Tourism, and the Mayor's Office of Bogotá.

*Advanced Technologies at Work*¹⁷⁰

The TransMilenio buses are tracked via GPS satellite to ensure an even distribution along the corridors, and to help achieve accurate schedules. All passenger information including schedules, bus location, and routes are electronic and provide passengers with accurate real-time information. Payment is made via pre-paid electronic cards, thus eliminating the delay at loading stations and increasing security. Passengers pay for one-way trip tickets when entering the loading platforms, and pay a single flat tariff even if multiple transfers are required.

*Infrastructure*¹⁷¹

The system infrastructure includes segregated bus-ways on major arterial roads, roads for feeder buses, loading platforms, and secondary facilities. The trunk-line loading platforms are fully enclosed facilities with one to three bays of varying lengths. Loading platforms are located on the median, approximately 500m apart. The trunk lines are serviced by articulated diesel buses with capacity of 160 passengers, while the feeder-lines are serviced smaller buses with capacity of 80 passenger each. By the end of 2001, more than 800,000 passengers per day are expected to utilize the 41km of exclusive bus-lanes. There will be 62 stations, 470 trunk vehicles, and 300 feeder buses. The city intends to expand the system to 388km of exclusive lanes with 22 corridors before 2015.

*Operations*¹⁷²

To maximize capacity, trunk lines accommodate express services stopping at selected stations only, as well as local service stopping at all stations. This segmented service approach allows the system to carry up to 45,000 passengers per hour per direction. Services are operated by private consortia of traditional local transport companies, associated with national and international investors procured under competitively tendered concession contracts on a gross cost basis. The private operating companies are required to use professionally trained personnel. Conductors work under contract with regular schedules, and must pass rigid qualifications for bus operation and measures to safeguard the security of passengers. Since the conductors do not receive money, there is little risk of corrupt activity and bus-robbery. Remuneration to the companies is made according to total traveled kilometers per day and quality of service, thus eliminating the "War of the Cent" price wars.

*Operational Evaluation*¹⁷³

From the eighteenth through the twenty-fifth of December 2000, the first phase of the TransMilenio system was operational. To encourage Bogotá's residents to use the buses the mayor suspended tariffs for the initiation period. Starting on December 26 the single, integrated tariff for the new services was set at 800 Pesos (USD\$.35). TransMilenio was undoubtedly the most important project of the Peñalosa Administration; it took the municipal government nearly three years of planning to organize

¹⁷⁰ Bogota: World Example in Mobility. (2000). www.juguetones.com/sincarro/otras/bogota_ejemplo.htm

¹⁷¹ Guerrero, Dario Hidalgo. (2001). "TransMilenio: The Mass Transport System of Bogotá". A paper prepared for the Latin American Urban Public Transport Congress. Havana, Cuba.

¹⁷² Ibid.

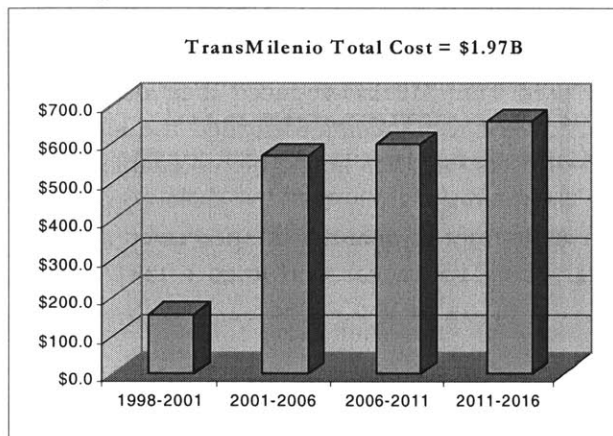
¹⁷³ TransMilenio: A New Option for the People of Bogota. (2001). www.terra.com.co/proyectos/transmilenio

and to create a system of public transport that was well organized, efficient, comfortable, and secure. The first phase consists of a 41km extension along three main routes. There are 470 buses in operation at a capacity of 160 people per vehicle. The TransMilenio system currently has a total capacity to transport 660,000 passengers per day at an average travel speed of 25km/h, a 150% improvement in mean velocity.

*Financial & Economic Evaluation*¹⁷⁴

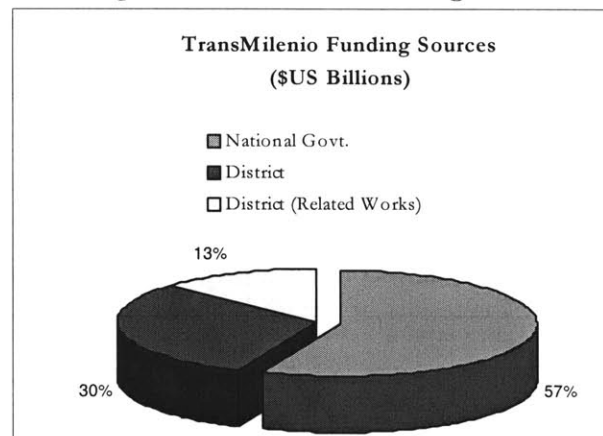
The TransMilenio project was almost entirely financed by the public sector. The exception to this being the purchase, maintenance, and operation of the vehicles which was borne by the private operators. At a projected total cost of nearly USD\$2B the city was forced to raise the capital in innovative ways. The bulk of the funding eventually came from the national government. However for the remaining tab of USD\$847M the city chose to find alternate sources for funding aside from raising property taxes. Bogotá instituted a gasoline tax, which helped to discourage automobile use, and raised USD\$100M. It also privatized the municipal telephone company (ETB Telecom) and sold stock in the local electrical company (EEB), thereby generating an estimated USD\$3.5B, for use on a number of other public works projects including TransMilenio.

Figure 31: TransMilenio Cost Distribution



[Source: TransMilenio SA]

Figure 32: TransMilenio Funding Sources



[Source: TransMilenio SA]

While separate data on the economic impact of TransMilenio on Bogota could not be found, the study done by TransMilenio SA, referred to below, captures social, environmental, and economic impact of the system. Finally, it is noteworthy that through negotiations with the concessionaires the city avoided any direct operator subsidies thus ensuring a more financially sustainable system.

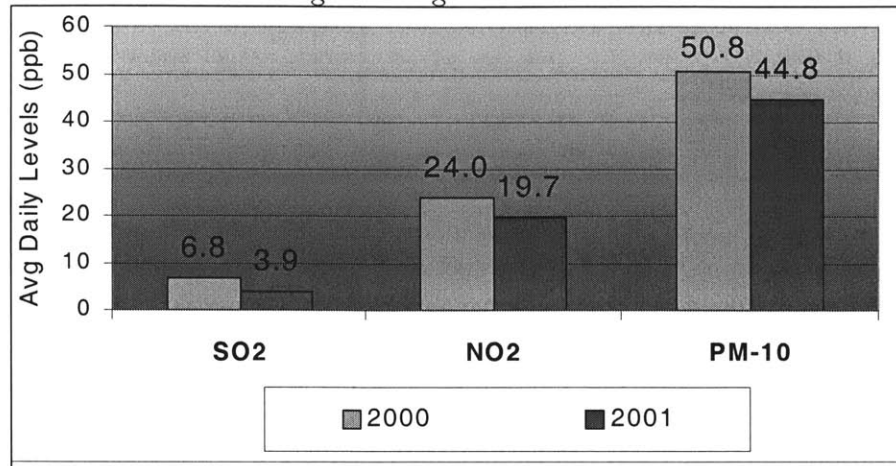
*Environmental Evaluation*¹⁷⁵

Although the TransMilenio system uses diesel buses, there have been considerable environmental advantages. Levels of particulate matter (PM) have fallen by as much as 30% along the BRT corridors. It is estimated that the new high-capacity articulated buses generate as much as 80% less air pollution than the run-down vehicles they replace. While it is difficult to attribute a global reduction in air pollution to any specific measure, TransMilenio SA in cooperation with DAMA produced the following table showing considerable drops in the major contaminant categories.

¹⁷⁴ The TransMilenio SA Web Site. (2001). <http://www.transmilenio.gov.co>

¹⁷⁵ Dario Hidalgo Guerrero. (2001). El Sistema de Transporte Masivo de Bogotá. Presentation to the First International Seminar on Urban Transport. Bogota.

Figure 33: Bogota Air Pollution

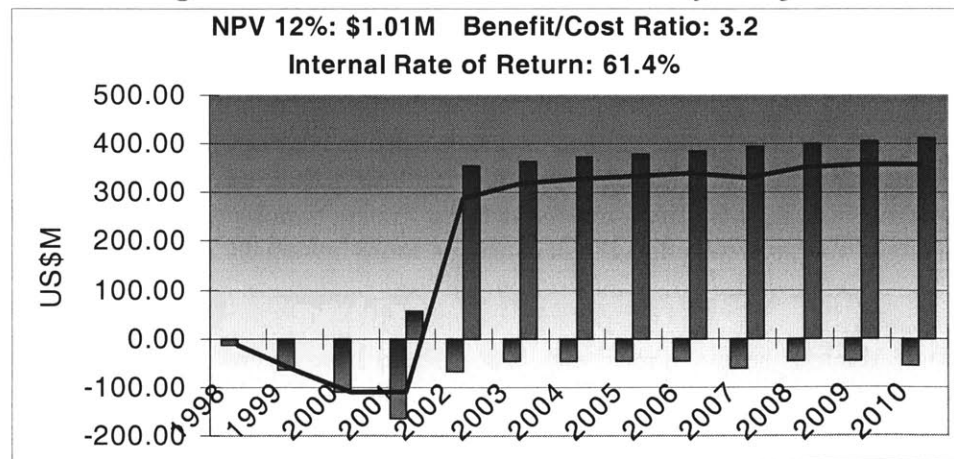


[Source: Guerrero]¹⁷⁶

*Socioeconomic Evaluation*¹⁷⁷

The socioeconomic impacts of a comprehensive mass transit system are complicated to calculate. The city government took a citywide poll in November of 2001 to determine the general perception of city residents. They found that, on average, residents that used TransMilenio reduced their daily travel time by 32%, when compared to the old bus system. 83% of respondents identified the increased travel speed as the biggest advantage. In addition, 37 % of users said that TransMilenio enabled them to spend more time with their families, and less time commuting. Fully 88% of daily commuters ranked the system as either “good” or “very good”. In an attempt to quantify the perceived and real benefits, financial, economic, social, and environmental TransMilenio SA performed a cost/benefit analysis. The results of the study are shown below.

Figure 34: TransMilenio Socioeconomic Cost / Benefit Analysis



[Source: Guerrero]

¹⁷⁶ Guerrero, Dario Hidalgo. (2001). El Sistema de Transporte Masivo de Bogotá. Presentation to the First International Seminar on Urban Transport. Bogota.

¹⁷⁷ Ibid.

7 Case Study: Singapore

7.1 Context & Overview

Singapore consists of the main island of Singapore and 60 offshore islands within its territorial waters. It lies at the southern tip of the Asia, just north of the Equator. The main island is 26 by 14 miles, or 364 square miles. Singapore is strategically located on major Asian sea-lanes. This fact, in conjunction with a famously industrious population, has given the country an economic footprint disproportionate to its small landmass. Currently, Singapore has a population of just over 3 million people. From 1960 to 1999, Singapore sustained economic growth that averaged 8%. Due to the Asian financial crisis and global economic slowdown and, Singapore's growth started slowing in 1997 leveling out at 0.4% in 1998. The economy began to pick-up again in 1999 with a growth rate of 5.4%, and the growth rate for 2000 was 8%. Singapore's GDP per capita is among the highest in the world at USD\$28,600 per year. The annual population growth rate for 1999 was 2.8%.¹⁷⁸ Labor shortages are chronic and persist in many low-skilled positions. Foreign workers help make up for this shortfall.

Singapore, a small city-state experiencing rapid industrial growth, found itself faced with severe urban traffic congestion during the 1970's. A dense population, with a strong preference for automobiles, coupled with a high concentration of industries on a small land area led to severe traffic conditions including congestion, reduced traffic speeds, and air pollution. Singapore had three primary responses to this situation. It built more road capacity, instituted stringent standards for industrial and vehicular emissions, and became the first country to implement effective Travel Demand Management (TDM) policies: the Area Licensing Scheme and Vehicle Quota System. By 1996, there were more than 645,000 registered motor vehicles on Singapore's roads and the island had about 3000km of high-quality roads with traffic management measures in place. Between 1981 and 1991, vehicular trips rose by 9.3% annually, whereas road capacity increased by 4%. Roads currently occupy 11% of the island, about the same percentage as housing. If road-building trends continue, roads will take up 16% of Singapore's land area by 2010. Today, on average, air pollution levels in Singapore are below the requirements specified by the US EPA. The air quality was in the healthy range 60% of the time and in the moderate range for the remainder.¹⁷⁹

7.2 Institutional Arrangements

Since the 1960's, Singapore has grown from a Third World country to become one of the wealthiest nations per capita. "Consequently, industrial expansion and its associated infrastructure have ballooned, creating the need for environmental regulations and control. The Ministry of the Environment (ENV) was established in 1972. The ENV develops and implements environmental protection and public health programs. There are four major divisions within ENV; these are the Environmental Engineering Division, Environmental Public Health Division, Environmental Policy and Management Division and Corporate Services Division."¹⁸⁰ Singapore attributes its impressive environmental achievements to the regular monitoring and assessment of air and water quality and to enlightened policies that have placed a high-priority on a clean environment. Notably these priorities have been maintained even in the face of rapid economic growth, industrialization, and urbanization. Singapore's objective is to be the regional center for environmental management and technology by the year 2010. Singapore is seen as having the advantage of being well managed

¹⁷⁸ U.S. Department of State. (2000) Bureau of East Asian and Pacific Affairs Background Notes: Singapore

¹⁷⁹ STAT-USA on the Internet. (2001) US Department of Commerce. Washington DC. <http://www.stat-usa.gov>

¹⁸⁰ Viswanathan, Shekar. (1999). *Environmental Regulations and Developments in Singapore*. National University of Singapore. Singapore.

environmentally, and therefore serving as a role model for the industrializing nations in the region. The region has good cause to listen; Singapore has a proven record of achieving high growth rates while maintaining a relatively clean environment. The authorities have pursued vigorous pro-public transport policies, with restrictions on car use in the city center, feeder bus services and high-density development clustered round the transit network. Consequently, the economy has also expanded rapidly, benefiting from growth in Malaysia and uncertainty over the future role of Hong Kong as a regional trade center.

Singapore's Land Transport Authority (LTA), under the Ministry of Communications, was established in 1995. The LTA was formed through a merger of four departments: the Roads and Transportation Division of the Public Works Department, the Registry of Vehicles, the Land Transport Division of the Ministry of Communications, and the Mass Rapid Transit Corporation. This merger has led to the aggregation of all the diverse activities of each of the organizations under one roof. The responsibilities of the LTA include management, development, and planning of all land transport policies and infrastructure.¹⁸¹

7.3 Transportation Policies

Singapore has had unparalleled success in managing demand for private vehicle transport and in so doing reducing congestion and air pollution levels dramatically. A survey completed by the Land Transport Authority (LTA) in November 2000 revealed that 90% of respondents felt that the quality of Singapore's roads was "good" and that the road network was "efficient". Over 80% of the respondents also believed that the traffic flow was "smooth", that parking spaces were "ample", and the level of road safety was "high". With regard to public transport, 90% responded that Singapore system was excellent in terms of cleanliness, comfort, safety and efficiency.¹⁸²

The Singapore government has implemented two effective policies to address the problem of increasing traffic congestion in the city. The two most notable schemes are the Vehicle Quota System (VQS), which directly controls the number of private vehicles in Singapore; and the Area Licensing Scheme (ALS), which charges drivers for the use of private vehicles in the CBD during peak travel hours. In 1998, Singapore began replacing the ALS with a comprehensive Electronic Road Pricing (ERP) scheme that is still in the phase-in stage today. Our discussion will focus on these policies, as they have had the greatest direct impact on Singapore, and are currently being investigated by the city of Guangzhou for future applicability.¹⁸³

7.3.1 *Vehicle Quota System (VQS)*

Objectives

The Vehicle Quota System (VQS) fixed an annual limit on the number of vehicles that could be purchased in Singapore. Instead of allowing the market to determine the optimal number of vehicles on Singapore's roads, the government controlled the vehicle population in order to achieve a specific target for vehicle population in line with traffic conditions and road capacity.

¹⁸¹ Singapore LTA. (2001) <http://www.lta.gov.sg/index.htm>

¹⁸² Singapore LTA. (2000) http://www.getforme.com/Info_vehicles_newssnipetarchives.htm

¹⁸³ Third World Network. (1999). Control of Private Vehicles in Urban Areas: The Vehicle Quota System and The Area Licensing Scheme. United Nations Development Programme - Special Unit for Technical Cooperation among Developing Countries. New York.

Implementation & Operation

The target growth rate of the vehicle population is determined annually, based on advice given by the Public Works Department. This growth rate is dictated by the level at which traffic is projected to be able to flow easily, given projected infrastructure investment. This figure is also modified by consideration of prevailing traffic conditions and the rate at which old vehicles are decommissioned permanently. The government publicizes the number of Certificates of Entitlement (COE's) that are available by vehicle category and prospective buyers bid for a COE in the category of vehicle that they wish to purchase. Each prospective buyer is allowed to submit one bid only.¹⁸⁴

Operational Evaluation

The VQS system is a Command and Control policy that interferes with normal free market operation by imposing a strict limit on the number of vehicles populating Singapore's streets. The result is that a market was created for the COE's, which were initially transferable. The bidding system became inflated as speculators sought to secure vehicle ownership rights that would be sold for a profit to private consumers. This particular irregularity was removed when the Singapore government outlawed transference of titles. Non-transferability resulted in an initial dip in COE prices, but prices for COE's have continued to rise. Car dealers began to bid to secure more COE's which were then registered in another person's name. These cars were then sold to buyers as "used cars" thus subverting the intent of the VQS policy.

Socioeconomic Evaluation

The quotas, when coupled with rising personal incomes and increasing demand for cars, have led to a cost of ownership that is still exceedingly high. COE's for standard cars cost are now in excess of USD\$30,000. Car ownership in Singapore is on average five times more expensive than the US.¹⁸⁵ The high up-front cost of owning a vehicle also serves to discourage the effect of other TDM policies as the marginal cost per trip is actually reduced with each trip taken. Thus, the policy has resulted in maximizing the use of the vehicle fleet, and encouraging the purchase of large expensive foreign vehicles that are in effect taxed at a lower relative rate than smaller cheaper cars. This translates into an effectively regressive tax. The high fixed costs result in people feeling relatively less impact from the variable costs of fuel taxes, parking fees, and congestion charges.¹⁸⁶ Further, since an increase in COE prices directly benefits the government (a COE price increase is increased revenue) it is vital to realize that the welfare of the public depends on how the money is spent. The public has less discretionary income, which leads to reduced welfare and lower consumption, certainly not the intended consequences of the VQS.

7.3.2 Area Licensing Scheme (ALS)

Objectives

The Area Licensing Scheme was introduced in Singapore's central business district in 1975. The primary objective of the ALS was to limit traffic and alleviate congestion during the peak commute times in only the most congested areas. By raising the cost of driving to the CBD in privately owned cars the LTA created a strong disincentive for their use.¹⁸⁷ The secondary objectives of the Area Licensing Scheme (ALS) were to improve overall accessibility and mobility within the CBD.

¹⁸⁴ Third World Network. (1999). Control of Private Vehicles in Urban Areas: The Vehicle Quota System and The Area Licensing Scheme. United Nations Development Programme - Special Unit for Technical Cooperation among Developing Countries. New York.

¹⁸⁵ Ibid.

¹⁸⁶ *The Economist* (1998). "A Survey of Commuting" September 5. pp. 3-7, 10-18.

¹⁸⁷ Third World Network. (1999). Control of Private Vehicles in Urban Areas: The Vehicle Quota System and The Area Licensing Scheme. United Nations Development Programme - Special Unit for Technical Cooperation among Developing Countries. New York.

Accessibility and mobility were thought to be of paramount importance to the area's economic life and vitality.

*Operation*¹⁸⁸

The core of the CBD was designated a "Restricted Zone" with regard to private vehicle operation. Entry into the Restricted Zone was allowed if the vehicle owner pre-purchased a colored entry license. The Restricted Zone encompassed 720 of the most congested hectares in the city, and its boundary was demarcated by overhead gantry signs. The words "In Operation" were lit up during restricted hours. Initially, these entry points were manned by traffic personnel from 7:30am to 10:15am. In 1989, the LTA significantly expanded and revised the ALS. The revamped ALS extended tolling operations during the evening rush hour, from 4:30pm to 6:30pm on weekdays. In its final incarnation (1997) the ALS was extended to a full-day scheme, from 7:30am to 7:00pm. All vehicles had to display a valid license during the restricted hours, which cost S\$1, S\$3, and S\$6 per day for motorcycles, privately owned vehicles, and company cars respectively. The corresponding monthly fees were S\$20, S\$60 and S\$120. During less congested hours, from 9:30am to 4:30pm part-day licenses were available at a cost of S\$0.70, S\$2, and S\$4 respectively. Distinctive shapes and colors differentiated these license types. Traffic personnel stationed at the CBD entry points recorded the registration number, make, and color of any vehicles that failed to display the proper license. All violations were recorded without stopping the offending vehicles in order to promote a smooth flow of traffic. Identified violators were sent tickets by mail (S\$30) that had to be paid within two weeks. Motorists also had the option of contesting the ticket and seeking a court trial.

*Operational Evaluation*¹⁸⁹

The ALS was a Market Based Initiative, as it made use of the pricing function to influence demand, but did not prohibit anyone from entering the Central Business District at any given time. More than anywhere else, Singapore has emphasized that people can drive as much as they would like, as long as they pay the full social costs of doing so. The effectiveness of the ALS in the Singapore CBD has been tremendous. Traffic flow was substantially eased and pollution from mobile sources in the CBS dropped dramatically. Total traffic in the CBD decreased 73% shortly after the ALS was instituted; the congestion was partly transferred to the surrounding districts, which faced an increase of 23%. Carpooling increased by 33%, resulting in a net decrease of 44%. Travel speeds in the CBD were typically three times those in New York or Bangkok. However, although congestion was brought under control in the CBD, elsewhere congestion worsened. Public buses took longer to reach their destinations, as boarding times increased due to higher demand. The high cost of monitoring and enforcement of this complex system was also a problem. In a city with a well-educated population and severe labor shortages, the ALS required literally hundreds of inspectors at each of the 27 gantries that lead to the CBD. Each of these toll monitors visually inspected the license color and shape and noted violations. This resulted in a susceptibility to human error and the location and time of day that the city could vary pricing was limited. Singapore's solution to the high cost of monitoring and enforcement has been to institute the most advanced and successful Electronic Road Pricing system in the world.

¹⁸⁸ Ibid.

¹⁸⁹ Ibid.

*Economic Evaluation*¹⁹⁰

There were some initial fears that the ALS would adversely impact the viability of the CBD as the commercial center of Singapore. These fears were proven unfounded. There was no evidence of negative impact on rents, land utilization, or labor availability in the district. In fact, the evidence was to the contrary. Reduced congestion, air pollution, and noise created a more livable city center and this improved environment attracted financial and service-oriented businesses. Employment in the CBD rose by 30% in the years following the ALS implementation.

*Financial Evaluation*¹⁹¹

The ALS had an initial capital cost of just S\$6.6M (USD\$3.7M). The ALS monthly operating costs from 1975 to 1985 were approximately S\$59,000. The 1989 expansion of the restricted zone and extension of the tolling hours had an initial cost of S\$170,000 and increased the monthly operating to S\$295,000. During this period, 1975 to 1997, the average annual revenue from licenses was S\$38M and an additional S\$3.85M was generated from fines, for a total of \$41.85M per year. It is estimated that the Singapore government achieved a rate of return of 1590% from its Area Licensing Scheme.

Environmental Evaluation

The ALS was successful from an operational standpoint, and helped to contribute to better air quality through reduced congestion. However, isolating the explicit effect of the ALS on ambient emission levels is nearly impossible. The reduction in congestion was coupled with higher emission standards, improving engine technology, and the development of a mass transit system. Thus, we will examine the efficacy of the ALS from a purely congestion-relieving perspective. When originally instituted inbound morning traffic decreased 73% at a toll rate of S\$5, this reduction exceeded expectations. The operational goal was a 40% reduction in inbound traffic and so the toll was lowered to S\$3, which led to a traffic reduction of 56%. From 1975 to 1989, Singapore's total vehicle population grew by 77% but traffic within the CBD dropped by 70%. These statistics would indicate either that more vehicles were used less often, or that the vehicles were used elsewhere. In 1975, 33% of Singaporeans commuted by transit, by 1989, this figure rose to 69%. This fact reinforces the first conclusion, that the ALS helped to induce a modal shift in the population and that despite a growing vehicle population, the total VMT decreased. Average travel speeds within the CBD increased correspondingly from 18km/h to 25 km/h by 1997.¹⁹²

Cars are responsible for 65% of air pollution in Singapore. In general, air pollution in Singapore has decreased considerably since the implementation of the ALS. Since the ALS was implemented, nitrogen oxides (NO_x) decreased significantly, while reductions in carbon monoxide (CO) and particulate matter (PM) levels were marginal. These reductions cannot be solely attributed to the ALS. Singapore concurrently instituted regulatory controls that have inevitably affected the amount of air pollution.¹⁹³ Due to the introduction of the ALS and VQS programs, Singapore car ownership (motorization rate) has remained at 11 vehicles per 100 people, which is very low compared with other countries with the similar per capita economic output. In 1995, the average road transport fuel consumption was 0.34 tons of oil (equivalent) per capita; resulting in 0.29 tons of carbon emission per

¹⁹⁰ Tay, R. (1996). *Congestion Alleviation in Singapore: A Review of Demand Management*. In C. Lim (Ed). Economic Policy Management in Singapore (pp. 313-44). Singapore: Addison Wesley.

¹⁹¹ Menon A. et al. (1993). "Singapore's Road Pricing System: Its Past, Present and Future". In ITE Journal. Vol. 63, No. 12.

¹⁹² Gomez-Ibanez, Jose (1994). NCHRP Synthesis 210: Road Pricing for Congestion Management. Research Board. Washington, DC.

¹⁹³ Chin A. T. H. (1996). "Containing Air Pollution and Traffic Congestion: Transport Policy and the Environment in Singapore". Atmospheric Environment. Vol. 30, No. 5.

capita, which is also comparatively low. In addition, over 80% of the cars are less than 1600cc and are well maintained, with a fuel-efficiency of 9-litres of gasoline per 100 km traveled.¹⁹⁴

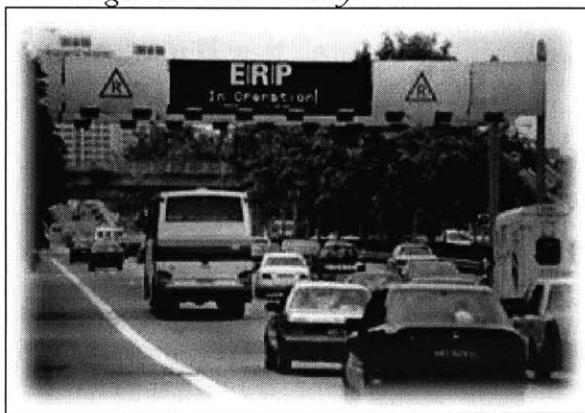
Socioeconomic Evaluation

There were a number of important social benefits to the ALS and VQS programs. Singaporean drivers reported “significant improvements in travel speed and travel time in the restricted zone during the restricted hours.”¹⁹⁵ At the same time, pedestrians generally felt safer walking in Singapore. A public opinion poll indicated that people perceived a marked reduction in noise. Finally, the public tended to view the ALS tolls as a “necessary nuisance and grudgingly accept it.”¹⁹⁶ The ALS and VQS programs worked in Singapore because they were complemented with legislative and fiscal measures, rigorous land use planning, reorganization of transport policy institutions, investments in the public transport system, traffic management measures, and effective enforcement. To attempt to isolate the direct impacts of these policies without taking into account the impact of the other measures would be foolhardy and inaccurate.¹⁹⁷

*7.3.3 Electronic Road Pricing (ERP)*¹⁹⁸

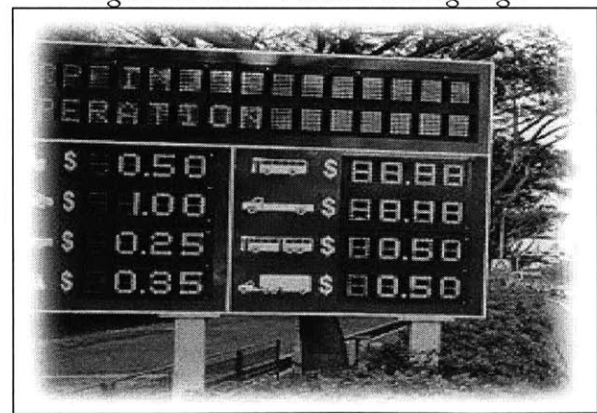
Since April 1998, Singapore has begun to implement a system of Electronic Road Pricing (ERP) whereby payments are debited as cars fitted with transponders travel into the Restricted Zone. The ERP system has been designed to replace the ALS. Vehicles are outfitted with refillable electronic cards that are charged as the cars pass under the electronically equipped gantry. The “smart” cards can be refilled at a number of electronic debit machines, and thus eliminate the hassle of purchasing a new CBD license each month. The rate of toll is varied by the hour of day, in a pricing structure similar to the ALS. ERP will initially automate the existing ALS road-pricing program; there are plans to extend the tolling systems to a number of additional highways and roads. One of the biggest advantages of the ERP system is that it does not require hundreds of enforcement personnel to man the entry-points of the CBD.

Figure 35: ERP Gantry



[Source: Zen]¹⁹⁹

Figure 36: ERP Variable Message Sign



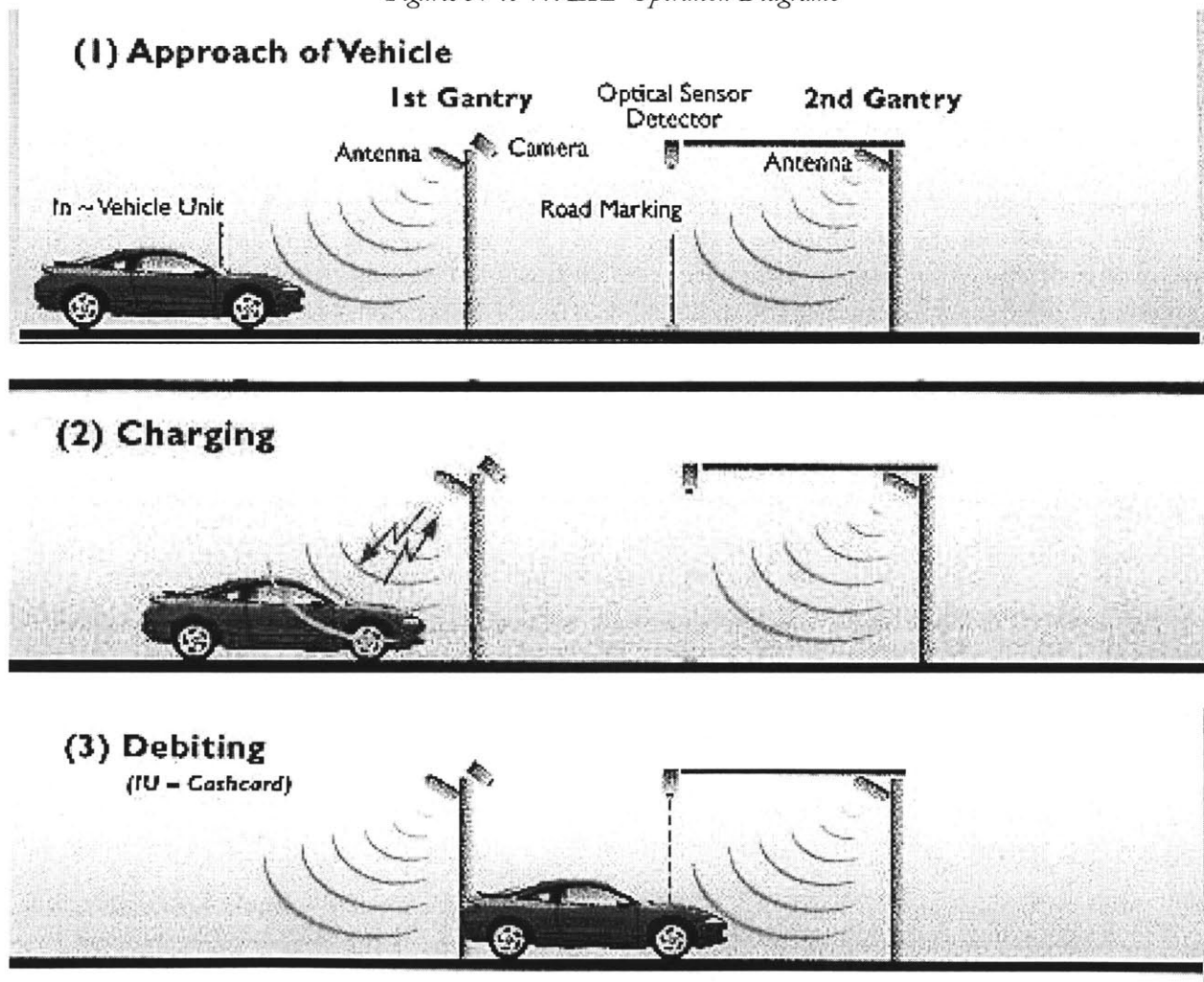
[Source: Zen]

¹⁹⁴ Topfer & Obasi. (2000). Methodological and Technological Issues in Technology Transfer. Intergovernmental Panel on Climate Change. Washington DC.
¹⁹⁵ Chin A. T. H. (1996). “Containing Air Pollution and Traffic Congestion: Transport Policy and the Environment in Singapore”. Atmospheric Environment. Vol. 30, No. 5.
¹⁹⁶ Menon, A. et al. (1993). “Singapore’s Road Pricing System: Its Past, Present and Future”. In ITE Journal. Vol. 63, No. 12.
¹⁹⁷ Tencer, Stephanie. (1998). Singapore’s ALS: An Evaluation. University of Toronto. Toronto.
¹⁹⁸ Third World Network. (1999). Control of Private Vehicles in Urban Areas: The Vehicle Quota System and The Area Licensing Scheme. United Nations Development Programme - Special Unit for Technical Cooperation among Developing Countries. New York.

*Implementation & Operation*²⁰⁰

Singapore sought to replace the cumbersome ALS with an advanced ERP system in 1998. Singapore wanted a more flexible system that could respond to changing traffic conditions. It also wanted to reduce operating costs and use less manpower. The ALS system was inconvenient to motorists and the government believed that ERP held the promise of user-friendliness, lower cost, and higher travel speeds. The municipal government issued a tender for bid from private technology providers in a competition. The winning consortium proposed a system based on 2.45GHz Dedicated Short-Range Communication gantries employing microwave signals. The system was rolled out to three ring-road expressways and at all 37 entry points to the Restricted Zone. Six classes of vehicles, based on road space use, were fitted with electronic tags. The ERP system is in operation from 7:30am to 7:00pm. During this time charges are varied at half-hour intervals depending on the actual congestion level within the CBD.

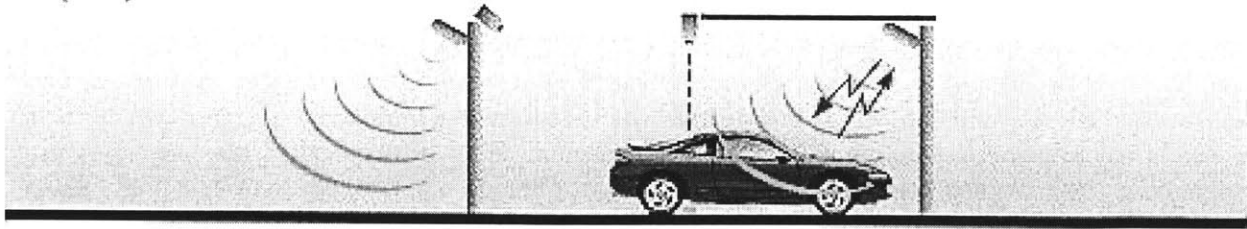
Figures 37 to 41: ERP Operation Diagrams



¹⁹⁹ Zen, Toni. (2000). Hints to Successful Implementation of Electronic Road Pricing System. ITS Hong Kong. Hong Kong.

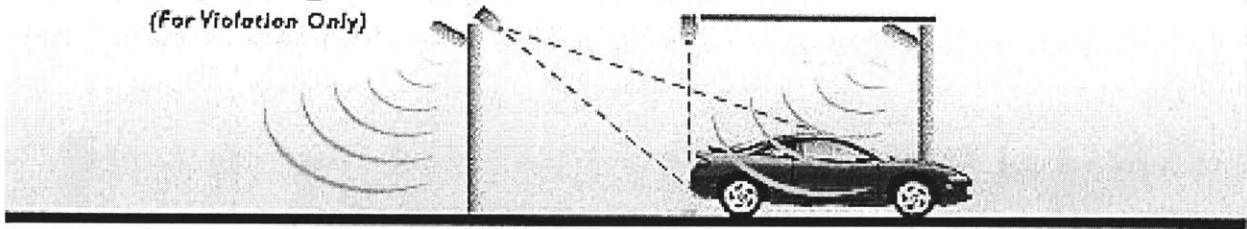
²⁰⁰ Kahn, Ata. (2001). Electronic Road Pricing: Policy and Technology Factors. Carleton University. Ottawa, Canada.

(4-1) Verification



(4-2) Capturing Photo of Rear Licence Plate

(For Violation Only)



[Source: Lee]²⁰¹

*Operational Evaluation*²⁰²

The effectiveness of the ERP system in Singapore has been remarkable. The plan for the replacement of the ALS initially called for the expansion of pricing schemes to the outlying expressways, however, this summer the minister of State for Communications issued the following statement:

"The ERP system, which was implemented in April 1998, has kept our roads relatively smooth flowing," he said. "Motorists have been very responsive to the system. They have adjusted their travel behavior and learnt to plan their trips and routes more judiciously. As such, ERP will not be expanded to new roads this year and the erection of some 12 gantries in phase 2B of the system planned for this year will now be deferred."

[Source: Chen]²⁰³

In 1999, testing of five million vehicles on Singapore's roads was completed the ERP system achieved an incredible 99.9% reliability rating. To garner public support the LTA reduced the average ERP toll to 30% below the existing ALS Fee. Within a single year, the city achieved a compliance rate of 97%. As a direct consequence of the operation effectiveness of the ERP system, the government announced that it will issue more COEs in 2001. In effect, the increased effectiveness of the ERP system is allowing an additional expansion of the car population by 1%.

*Financial Evaluation*²⁰⁴

Initial capital cost of the ERP system was approximately US\$140M, and while the monthly operating costs are a tightly held secret, the results were surprising. Some of the projected cost-savings for the replacement of the ALS scheme with the ERP were overly optimistic and 1999 revenues from the

²⁰¹ Lee, James. (1998). The Emerging Digital Cash in Asia-Pacific Economies. Presentation to Asia Pacific IT Summit. Kent Ridge Digital Labs. Singapore.

²⁰² Zen, Toni. (2000). Hints to Successful Implementation of Electronic Road Pricing System. ITS Hong Kong. Hong Kong.

²⁰³ Chen, John. (2000). Minister of State for Communications and Information Technology. Interview with the Singapore Business Times. Singapore.

²⁰⁴ Tan, Christopher. (2000). SINGAPORE: ERP won't be extended for now, says minister. Singapore Business Times. Singapore.

ERP were down 33% compared with the last year that the ALS was in place. The drop in revenue may have been the result of driving adjustments made by motorists, or the financial structuring of the investment to develop and build the electronic system.

*Socioeconomic Evaluation*²⁰⁵

As the Asian economic crisis hit home in Singapore, the government came under tremendous pressure to alleviate the regressive taxation burden of road pricing. Consequently, the municipal government introduced a set of tax rebates for economically disadvantaged drivers to partially offset the social equity imbalance. From September 2000 to August 2001, private vehicle owners received a one-time rebate of S\$150, owners of larger vehicles received an even larger rebate. The rebate plan was part of a five-year program to reduce the financial burden of ERP during difficult economic times. The rebate program resulted in a net loss for the LTA. The 2001 round of rebates will amount to S\$98 million, which is S\$30 million more than total ERP revenue collected in 1999.

*Environmental Evaluation: ERP Green Incentives*²⁰⁶

From early next year (2002), buyers of electric and gas-electric hybrid cars will be entitled significant ERP and road-tax rebates for three years. The move to encourage motorists to purchase “green” technology is part of Singapore's efforts to battle air pollution. The rebates will be given both as “one-off” payments to encourage clean technology utilization, and as yearly discounts to reduce the operating costs of “green” vehicles. Owners of “green” cars will receive a 20% reduction in ERP tolls charged in the Restricted Zone and road tax rebates of 10% for hybrid cars and 20% for electric cars. The rebates will be in place until 2003.

²⁰⁵ Tan, Christopher. (2000). SINGAPORE: ERP won't be extended for now, says minister. Singapore Business Times. Singapore.

²⁰⁶ Chen, John. Minister of State for Communications and Information Technology. 10 Nov 2000. Singapore.

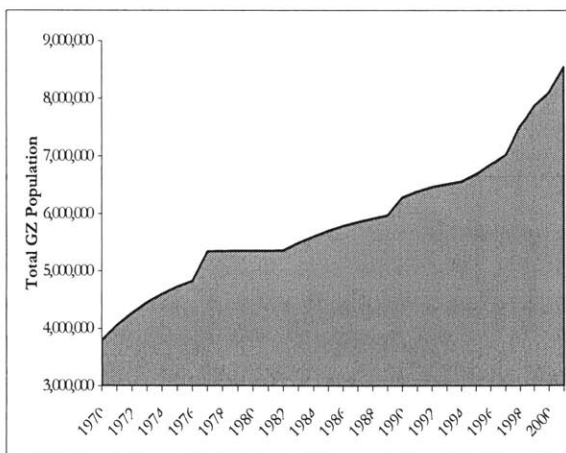
8 Case Study: Guangzhou, PRC (Context)

As one of China's largest cities, Guangzhou has absorbed an influx of millions of people from the countryside; concurrently, its need for efficient urban transportation has mounted. Coupled with this increase in population Guangzhou has experienced fantastic economic growth. This growth has led to a dramatic increase in disposable income, and a corresponding increase in ownership of private means of transportation. These new vehicles are leading to extreme environmental externalities including traffic congestion, air pollution, and traffic accidents. These effects, in turn, are constraining economic development by increasing the cost of transportation, slowing the movement of good and people, and increasing healthcare costs.

8.1 Demographic Overview of Guangzhou

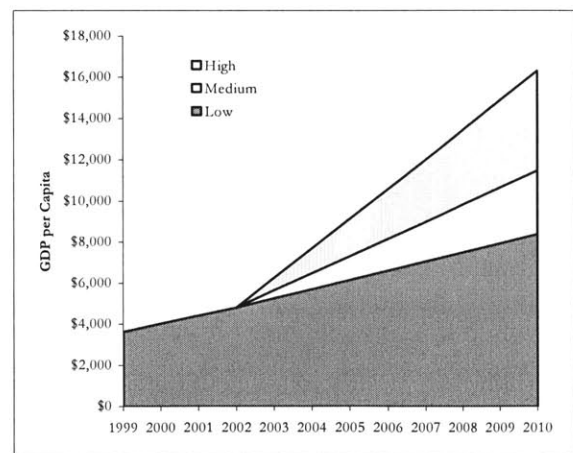
Guangzhou is the political, economic, and cultural capital of Guangdong Province in southern China. It is one of the most important transportation and communication hubs in China, and is known as China's "Southern Gateway". Guangzhou is located on the Pearl River Delta in close proximity to the South China Sea, Hong Kong, and Macao. Guangzhou is comprised of eight districts and four county-level cities. There are 105 sub-district offices, and 76 towns within its administrative border.²⁰⁷ The total area of Guangzhou is 2870 square miles, of which 557 square miles are urbanized. The official population of Guangzhou is currently 6.85 million, of which 4 million live in the urbanized center. There are however more than 1.7 million "floating" residents, who though lacking legal citizenship, reside within the city. As of 2000, Guangzhou qualified as an "official" *mega-city* with a combined population of 8.55 million inhabitants. At current growth levels, Guangzhou's population is projected to reach 13.8 million by 2010.²⁰⁸

Figure 42: Population Growth in Guangzhou



[Source: Lahmeyer]²⁰⁹

Figure 43: Scenarios for GDP per Capita Growth



[Source: Vennemo et al]²¹⁰

Guangzhou's population is undergoing three important demographic shifts. First, the population is dispersing from the city center to the outlying regions. Consequently, the downtown population density, still one of the world's highest, is beginning to lessen. Second, the population is aging with

²⁰⁷ GRIEP & Center for Environment Peking University. (2001). *Capacity Development for NO_x Pollution Control in Guangzhou*. Beijing.

²⁰⁸ UN Department of Economic and Social Affairs Population Division. (1996). *Urban Agglomerations Table*. New York.

²⁰⁹ Lahmeyer, Jan. (2001) "Populstat" Web-site. University of Utrecht. Utrecht. <http://www.library.uu.nl/wesp/populstat/populhome>

²¹⁰ Vennemo, Trong & Changzhong. (1999). *General Development Scenarios During 1995-2010 in Guangzhou*. ECON/NILU. Norway

nearly 10% of the population over the age of 65. Third, the city is absorbing new immigrants at an incredible rate. In 1998, the city counted 1.75 million immigrants of which 36% came from within Guangdong and 62% from other Chinese provinces. As the city develops further, there is likely to be increased migration from the mainland, this emergent growth places additional strains on infrastructure systems.²¹¹

8.2 Economics & GDP

Since large influxes of foreign capital began flowing into China in the 1970's, it has entered a period of unprecedented economic growth. Rapid industrialization and the relaxation of foreign trade policies have further accelerated this trend. Countrywide GDP growth for the last three years exceeded 7%.²¹² This growth has been fueled by an accelerating transition to a free-market economy. Within this framework of economic expansion, the growth of the major urban areas along the East Coast has been breathtaking.

Guangdong province absorbed one quarter of all foreign investment in China from 1992-1996. Average annual GDP growth in this eastern province has reached and maintained double-digit growth.²¹³ Guangzhou's total GDP rose 12% in 1999 to 2063 Billion Yuan (USD\$24.9 Billion) and GDP per capita in Guangzhou rose nearly 12% in 1999 to USD\$3,638. Guangzhou ranks second only to Shanghai in terms of GDP per capita. It is forecast that Guangzhou's GDP per capita for 2002 will be USD\$4,825.²¹⁴ Projections for economic growth to 2010 vary considerably, but the ECON center for economic analysis in Norway has developed an extensive scenario planning method that predicts that GDP per capita will range between USD\$8,390 and USD\$16,316. The most probable scenario, as defined by the ECON study, predicts a GDP per capita of USD\$11,472.²¹⁵ The rapid rise in the standard of living of city residents, coupled with a relaxation of internal movement laws, has been the primary driver of migration from the Guangdong countryside to the city. Guangzhou's economic production base is primary driven by light industry (45%) and tertiary service sector (50%). Among the most important contributors to the local economy are automobile assembly, electronic component manufacturing, construction, real estate, and information technology.²¹⁶

8.2.1 Public & Private Enterprises²¹⁷

Guangzhou's largely export driven economy has continued to attract foreign investment with low cost labor, access to Hong Kong's harbor, and a favorable legal climate. Growth in foreign joint ventures, joint stock, and wholly owner foreign companies has been tremendous at 26%, 16%, and 50% respectively. Joint ventures now account for 45% of Guangzhou's industrial output. From 1995 to 2000 investment promotion activities in the US, Canada, Japan, Korea, Singapore, Malaysia and Hong Kong have resulted in the signing of 263 foreign contracts, direct investments totaling USD\$3.58 billion. A number of multinational corporations have set-up operations in Guangzhou including Honda Motor Company.

²¹¹ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NOx Pollution Control in Guangzhou. Beijing.

²¹² World Bank Group, PID #CN3614, GCCTP Project Leading Group, 3/4/1998

²¹³ Ibid.

²¹⁴ China / Hong Kong Fact Book. (2000). www.canada.org.hk

²¹⁵ Vennemo, Trong & Changzhong. (1999). General Development Scenarios During 1995-2010 in Guangzhou. ECON/NILU. Norway

²¹⁶ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NOx Pollution Control in Guangzhou. Beijing.

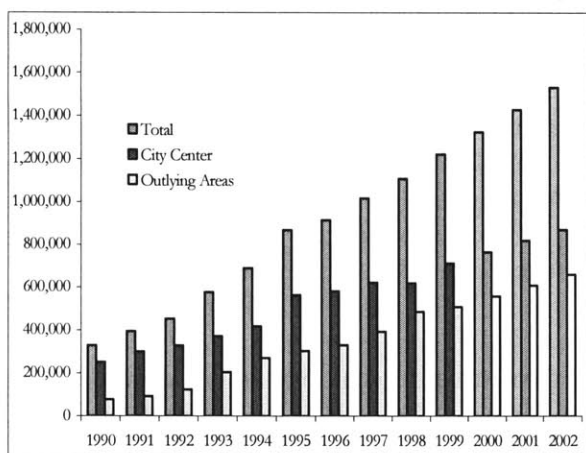
²¹⁷ Ibid.

8.3 Motorization

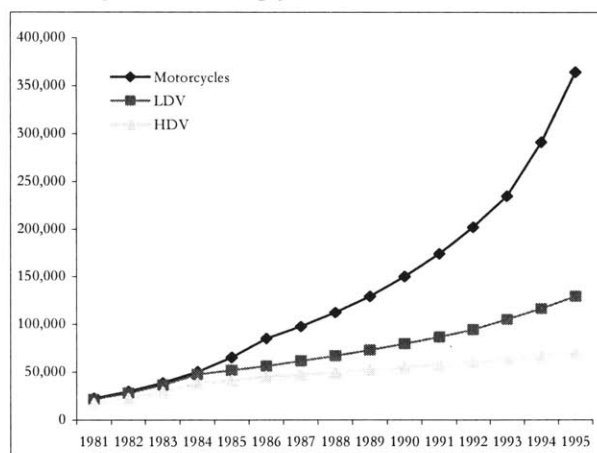
Since the economic liberalization program began in 1978, economic growth in China has been accompanied by a rapid rate of motorization. As new private enterprises began to develop the previously strong linkage between the home and place of employment began to unravel. People were required to travel greater distances and sought to find economical solutions to their mobility needs. As personal income levels rose, so did the ownership of private vehicle. In fact, the number of motor vehicles on China's roads has more than trebled since 1984, climbing from 6.4 million to 20.3 million by 1995. By 2020, the total vehicle population is expected to be 13 to 22 times greater than it is today.²¹⁸

The shift toward private vehicle use is most apparent in China's big urbanized provinces. Guangdong province accounts for nearly a quarter of China's total vehicle fleet. Guangzhou accounts for a similar proportion of Guangdong's total vehicle population, and 70% of its motorcycle fleet. The province and city are thus witnessing an average annual motorization growth-rate in excess of 25% year over year.²¹⁹ From 1986 to 1996, the number of vehicles in Guangzhou increased fourfold, from 325,000 to nearly one million.²²⁰ By the year 2002, the fleet is expected to reach more than 1.5 million vehicles. This trend will likely have a major influence on the future of Guangzhou's air quality.

Figure 44: Guangzhou Vehicle Fleet by Location Figure 45: Guangzhou Vehicle Fleet



[Source: GRIEP]²²¹



Composition

[Source: GRIEP]²²²

Guangzhou's motorization rate of approximately 14% is still a relatively low when compared with developed countries. However, the fuel consumption of these vehicles is 1.5x as high per 100km, and emissions rates are 10x higher per vehicle than in developed OECD countries. The higher fuel consumption is largely due to the vehicle fleet composition. Guangzhou's fleet is distinguished by an extraordinary number of motorcycles (70%), and a burgeoning population of diesel trucks.²²³ The

²¹⁸ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NOx Pollution Control in Guangzhou. Beijing.

²¹⁹ Ibid.

²²⁰ World Resources Institute. (1999). Air Pollution and Health Effects. Washington DC. <http://www.igc.org/>

²²¹ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NOx Pollution Control in Guangzhou. Beijing.

²²² Ibid.

²²³ MVA Asia Limited. (1995). Guangzhou Urban Transport Study. Kuala Lumpur.

average travel speed in Guangzhou City is below 14km/h compared to 19km/h in developed cities. Vehicles caught in traffic congestion are at their most polluting. Slower moving engines have a lower combustion temperature, and as the temperature of the combustion drops so does its efficiency. Thus, even with a fleet that is one-tenth the size of Tokyo or Los Angeles, the amount of pollution generated by Guangzhou motor vehicles is comparable.²²⁴

8.4 Congestion

As shown in Figure 45, driving cycles in Guangzhou have different characteristics than driving cycles in European cities. As previously stated, the average speed in Guangzhou is only 13.7km/h, whereas European cities have an average speed of 18.7km/h. The lower average speeds in Guangzhou generally imply that traffic congestion and pollution are problematic.

Figure 46: Driving Cycles in Guangzhou and Beijing

| Driving cycles | Mode length km* | Mode duration sec** | Max. Speed, km/h | Average speed, km/h | Idling, % | Acceleration, % | Deceleration, % | Free flow, % |
|------------------------|-----------------|---------------------|------------------|---------------------|-------------|-----------------|-----------------|--------------|
| Guangzhou Urban | 3.720 | 960 | 50.4 | 13.7 | 17.8 | 29.1 | 27.2 | 26.0 |
| Guangzhou Highways | 23.360 | 1200 | 102.0 | 32.8 | 1.2 | 27.1 | 22.9 | 48.8 |
| Beijing Urban | 5.700 | 1026 | 65.3 | 20.0 | 16.5 | 25.3 | 30.9 | 27.3 |
| European Urban | 4.052 | 780 | 50.0 | 18.7 | 30.8 | 21.5 | 18.5 | 29.2 |

* Mode length refers to the average trip length from point to point in the city

** Mode Duration corresponds to the length of time required to complete the trip.

[Source: Dagang Tang]²²⁵

The results in Figure 47 corroborate the hypothesis that driving speed and emissions are linked. As shown, the carbon monoxide and hydrocarbon emissions are much higher in Guangzhou than in developed cities. This may be explained by the absence of catalytic converters, the inferior quality of domestic cars and fuels, as well as congestion. Another contributing factor to higher emissions rates is the use of air conditioning for more than half the year in Guangzhou. Air conditioning units in vehicles decrease fuel economy considerably, raising the aggregate emission factor of Guangzhou light-duty cars even higher.

Figure 47: Emission Factors for Light Duty Vehicles in Guangzhou

| Light-duty Vehicles | Emission Factor: GZ urban roadways (@13.7 km/h) g/km | | | Emission Factor: GZ urban highways (@32.8km/h) g/km | | |
|---------------------|--|-----------------|-----------------|---|-----------------|-----------------|
| | Hydrocarbons | Carbon monoxide | Nitrogen oxides | Hydrocarbons | Carbon monoxide | Nitrogen oxides |
| Minivan | 1.9 | 13.5 | 0.9 | 0.7 | 5.7 | 2.2 |
| Sedan | 2.2 | 26.5 | 1.0 | 0.8 | 9.5 | 2.4 |
| Other | 3.4 | 22.6 | 1.8 | 1.2 | 7.6 | 3.6 |
| Average | 2.5 | 20.9 | 1.2 | 0.9 | 7.6 | 2.7 |

[Source: Dagang Tang]²²⁶

Assuming an evenly distributed vehicle-fleet composition, we may extrapolate that if Guangzhou were able to raise the average travel speed from 13.7 Km/h to 32.8 Km/h a reduction of hydrocarbon and CO emissions by 64% could be achieved. However, nitrogen oxides levels would increase in this

²²⁴Hughes, Gordon. (1997). Can the Environment Wait? Priorities for East Asia. World Bank Report. Washington DC.

²²⁵Dagang, Tang. (1998). Guangzhou Vehicle Emission Characteristics. Atmospheric Environment Institute. China Research Academy of Environ. Beijing.

²²⁶Ibid.

scenario by 125%.²²⁷ This is the seminal trade-off for motor vehicle emissions; increased travel speeds (higher temperature combustion) lead to a reduction in most pollutant, but to a dramatic increase in NO_x.

8.5 Air Pollution & Societal Costs

“Rapid urbanization and heavy reliance on coal for industrial and residential use have left China's cities with very poor air quality. Ambient levels of total suspended particulate matter, NO_x, and SO₂ are among the highest in the world.”²²⁸ Since the 1980's, the Chinese government at the national, provincial and local levels has undertaken a number of actions aimed at reducing air pollution. These measures include the promulgation of a series of regulations and standards and the establishment of governmental organizations responsible for environmental protection, environmental monitoring, clean production, energy conservation, and implementation of Local Agenda 21. Nevertheless, TSP, NO_x, CO and SO₂ levels in the urban centers remain exceedingly high, often falling below the WHO's minimum ambient air quality standards. Alarming, NO_x levels in some cities, such as Guangzhou and Beijing are still increasing.²²⁹

Figure 48: Health Effects of Urban Air Pollution in China

| City | Population (Millions) | Premature Deaths (Thousands) | Chronic Bronchitis Cases (Thousands) | Respiratory Symptoms (Thousands) | Health Benefits Air Quality Urban Income |
|------------------|-----------------------|------------------------------|--------------------------------------|----------------------------------|--|
| Beijing | 7.0 | 10.3 | 81 | 270 | 28% |
| Chengdu | 3.0 | 3.5 | 29 | 92 | 22% |
| Chongqing | 4.0 | 6.3 | 44 | 172 | 30% |
| Guangzhou | 7.6 | 4.0 | 32 | 102 | 10% |

[Source: Hughes]

Increased demand for motor vehicles, especially motorcycles, is the primary cause of high TSP and NO_x emissions levels in Chinese cities. “Estimates of the effect air pollution has on health have been made for people living in the major urban areas. In 1995, combustion emissions caused 218,000 premature deaths, 2 million cases of chronic bronchitis, 1.9 billion additional ‘restricted activity days’, and nearly 6 billion additional cases of respiratory symptoms in Chinese cities.”²³⁰

"If policies to tackle urban air pollution are not implemented, premature deaths will increase to more than 850,000 (11 million life-years lost), new cases of chronic bronchitis will be nearly 7.4 million, additional restricted activity days will reach 7 billion, and excess cases of respiratory symptoms will reach 22 billion per year."

[Source: Holland]²³¹

According to a 1999 UNDP report: “Vehicular emissions are the primary cause of air quality concerns in the city (Guangzhou). Air quality levels due to NO_x are already amongst the worst in the world.”²³² Motorized transport is the overwhelming source for the dominant air pollutants, with mobile sources contributing 80% of NO_x and 90% of CO. Guangzhou generated 830 billion cubic meters of vehicle

²²⁷ Ya-hui Zhuang, Roger Rauber, Weili Wang. (1999). Air Quality Management Initiatives in the UNDP Air Pollution Control Programme. Research Center for Eco-Environmental Sciences and The University of Pennsylvania. Philadelphia.

²²⁸ Hughes, Gordon. (1997). *Can the Environment Wait? Priorities for East Asia*. World Bank Press. Washington DC.

²²⁹ Ibid.

²³⁰ Ibid.

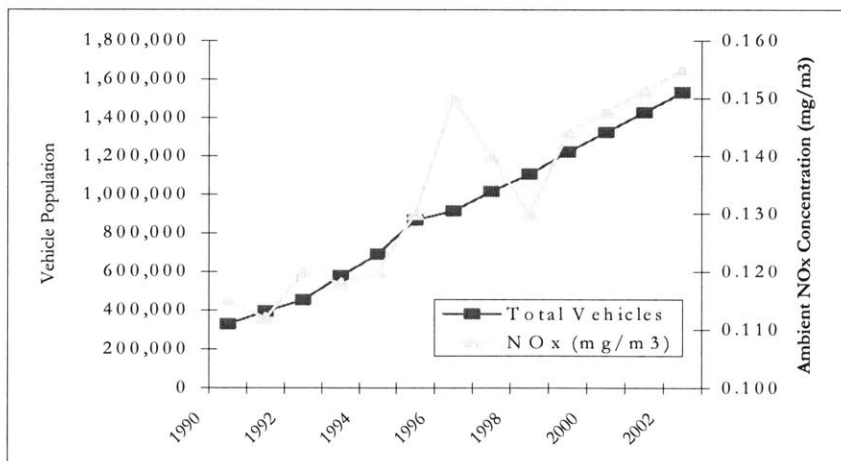
²³¹ Holland, F. 1997. China Chokes - The economic boom is taking a heavy toll on health. *New Scientist*.

²³² Hongjun, Miao. (1999). UNDP Project No CPR/96/305. 4/30/99. New York

exhaust in 1996, leading to the highest level of ambient NO_x pollution of all Chinese cities. The city also experiences acid rain at a frequency approaching 70%.²³³ The human toll of such pollution is estimated at 4,000 premature deaths per year, with an additional 32,000 cases of chronic bronchitis. The economic costs are estimated at more than 10% of the total income of the city's residents, or USD\$2.4 Billion.²³⁴

The continuing increase in NO_x concentration in Guangzhou's air shed is primarily driven by the rapid motorization, and increased vehicle density. From 1987 through 1996, there was a .98 correlative coefficient between vehicle population growth and mean ambient NO_x concentration in the city.²³⁵ It is interesting to note that although mobile source emissions account for 80% of ambient NO_x in the urban atmosphere, this constitutes only 39% of the total NO_x emission from the city as a whole. This surprising effect is due to the height of the stationary source stacks. While mobile sources (cars) emit pollutants close to the ground, industrial smokestacks generally emit NO_x at a higher altitude. The ground level emissions are trapped by buildings and thus have a greater effect on ambient air quality, while the high altitude emissions are more readily dispersed.²³⁶ It therefore follows that a correlation may be expected between growth in the urban vehicle population and the level of ambient NO_x concentration, as depicted in Figure 48 below. As is evidenced by the chart, increased vehicle density far outweighed the drop in NO_x emissions, which correspond to slower travel speeds. We may therefore conclude that Guangzhou must not only reduce the congestion level on its streets, but must also take measures to reduce the total number of vehicles utilizing the road space if it is to reduce ambient NO_x concentration.

Figure 49: Correlation of Vehicle Population and Ambient NO_x Concentration



[Source: GRIEP]²³⁷

8.5.1 Emissions by Vehicle Type Buses & Heavy Duty Trucks²³⁸

²³³ Huang, Christina. (1997). Air Pollution Control In Guangdong. US State Department. Washington DC.

²³⁴ Holland, F. 1997. China Chokes - The Economic Boom Is Taking A Heavy Toll on Health. New Scientist.

²³⁵ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NO_x Pollution Control in Guangzhou. Beijing.

²³⁶ Ibid.

²³⁷ Ibid.

²³⁸ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NO_x Pollution Control in Guangzhou. Beijing

Guangzhou's public bus system has 4000 vehicles, of which 100 are electric trolley buses. Sixty percent of the buses run on diesel fuel, with the remainder operating on gasoline. It is estimated that by 2010, the largest contribution of vehicular emissions in Guangzhou will be from diesel buses and trucks. Diesel buses and trucks emit 30x to 70x times more particulates (PM) than gasoline. This is especially important because the annual kilometers traveled by buses and heavy trucks are exceeded only by taxis. Their impact on the environment, therefore, is much higher and their relatively small population size makes them an attractive target for emissions improvements.²³⁹

Figure 50: Vehicle Emission Factors

| | |
|---------------|------------|
| Motorcycle: | 11.9 g /km |
| Diesel truck: | 11.5 g /km |
| Diesel bus: | 9.70 g /km |
| Car: | 0.85 g /km |

[Source: Freed]²⁴⁰

*Taxis*²⁴¹

Guangzhou has an extensive taxi fleet composed of 14,500 vehicles. These vehicles also share some unique characteristics with buses. Guangzhou taxis are typically in operation 16 hours a day, and travel an average of 300-350km. This makes taxis the most heavily utilized means of transport in Guangzhou.

*Motorcycles*²⁴²

Approximately 70% of the motorized fleet in Guangzhou is made up of 2-stroke motorcycles. Each of these engines pollutes 14x-17x the average imported car. A significant reduction of emissions of TSP and CO could be achieved through replacing existing 2-stroke motorcycles with 4-stroke ones. On average, a motorcycle with a 4-stroke engine consumes 30% less gasoline. The emission of particulate matter (PM) from a 2-stroke engine motorcycle is 1.0 gram per passenger kilometer whereas it is 0.2 grams per passenger kilometer for a 4-stroke one.

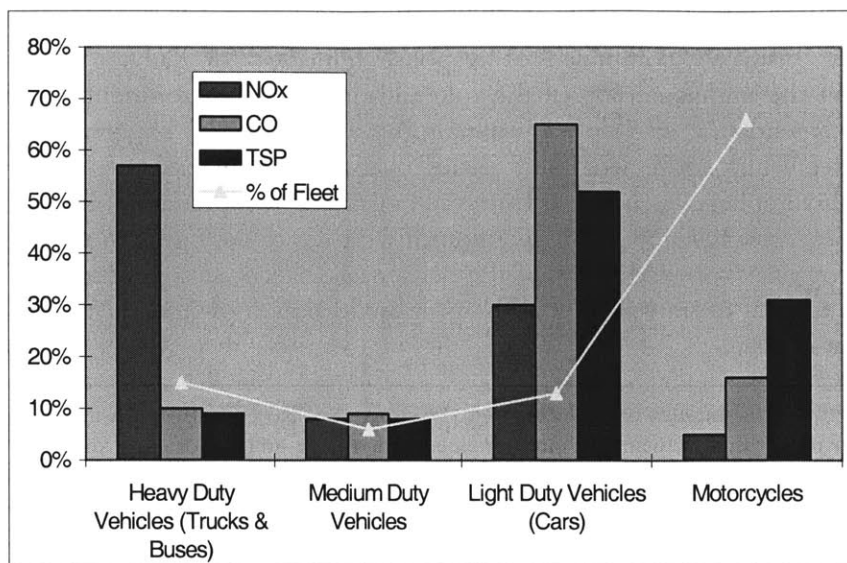
Figure 51: Emissions by Vehicle Type

²³⁹ Freed, Charles. Et al. (2000). *Controlling Pollution from Diesel Engines*. Presentation to GRIEP. Guangzhou.

²⁴⁰ Ibid.

²⁴¹ GRIEP & Center for Environment Peking University. (2001). *Capacity Development for NOx Pollution Control in Guangzhou*. Beijing

²⁴² Asian Institute of Technology (2000). *Alternative Policy Study: Reducing Air Pollution in Asia and the Pacific*. UNEP GEO-2000. Bangkok.



[Source: GRIEP]²⁴³

As Figure 51 demonstrates, there are different correlation factors between vehicle types and the types of pollutants emitted. Likewise, the quantity of any given pollutant is more a factor of the vehicle type than it is the population of vehicles within the total fleet. From a per capita emissions factor view buses are 60% less polluting than cars and 80% less than motorcycles. Thus, as Guangzhou struggles to deal with its enormous congestion and pollution problems it should perform careful cost-benefit analyses to determine which policies or technologies may have the greatest effect at the least possible cost. There must also be an analysis of per capita road-space use and per capita emissions factors to determine the least cost solution.²⁴⁴

8.6 Political & Regulatory Framework

Guangzhou failed to address environmental protection issues until the late 1980's. The drafting of China's Agenda 21 in 1994 as a follow up to the 1992 Rio Accord marked the formal introduction of sustainable development criteria into China's planning strategy. The policies and legislation stemming from Agenda 21 form the framework for the development of China's environmental protection legislation today. As such, an overview of the contents of the national agenda is crucial to the understanding of China's present regulatory environment. In many ways, the omissions in China's Agenda 21 are as interesting as its contents. The basis of China's Agenda 21 rested on the following premise:

"In order to achieve sustainable economic and social development, China can not follow the old path of "polluting first and cleaning later" or "damaging first and repairing later", but must rely on full use of economic measures and market mechanisms to promote sustainable development, based on existing conditions and work."

[Source: China's Agenda 21]²⁴⁵

²⁴³ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NOx Pollution Control in Guangzhou. Beijing

²⁴⁴ Ibid.

²⁴⁵ China's Agenda 21. (1994). White Paper on China's population, environment, and development in the 21st century. Chapter 4. Beijing.

There was therefore an understanding built into China's Agenda 21 that environmental protection predating 1992 was primarily comprised of response remedies for damage already done. This fundamental shift in the understanding of the role and timing of environmental protection is a key feature of China's Agenda 21, and an important turning point in the country's development. The national agenda specifically addressed many issues relating to both environmental protection and development, but the emphasis, as inferred from the omissions, was primarily on encouraging growth. Of particular interest is the absence of any mention of the need to curb growth in automobile use and road construction, or an acknowledgment of the deleterious effects of congestion and mobile source air pollution. With regards to transportation, the proposed solution of Agenda 21 was to promote the use of motorized transport:

"The overall transportation network is incomplete. Its structure is flawed, with an unsuitable division of transportation means in which railways are burdened with a large amount of short distance transferal which would be more suitably carried by motorized vehicles...Low grade highways which are limited in number, in poor condition and with low carrying capacities combine with heavy utilization and result in serious traffic congestion. Vehicles cannot reach economical speeds for which they are designed, and urban traffic facilities are very backward"
[Source: China's Agenda 21]²⁴⁶

The solution proposed in China's Agenda 21 to the inadequate supply of motorized transportation infrastructure was:

"In the 1990s, the central government will concentrate on the construction of main state highways, so that by the year 2000, 18,500 km of high-grade motorways will have been built. Local governments should construct local highways or county and village highways, based on the central government's overall plan. At the same time, present highways should be improved and their grades raised."
[Source: China's Agenda 21]²⁴⁷

Regarding air pollution, China's Agenda 21 does not refer to mobile sources, and focuses exclusively on the development of effective pollution removal techniques for boilers, combustion furnaces, and the development of technologies for controlling sulfur dioxide (SO₂) generated from coal-fired power stations.

8.6.1 Transportation & Environmental Policies

Environmental legislation and enforcement and public environmental awareness and did not keep pace with rapid economic development. Until the late 1980's, The Guangzhou municipal government did not address many environmental protection issues. For many years, the problem of air pollution in Guangzhou took a back seat to other emerging environmental troubles, such as wastewater treatment, solid waste collection and disposal, and drinking water resource protection.²⁴⁸

In 1996, the Guangzhou municipal government formed a Leading Group to draft the city's own interpretation of China's Agenda 21. The Local Agenda 21 differed from the national one of four years earlier in subtle but important ways. The continued development of the concepts introduced in the national agenda is an important indicator of the city's ability to be self-determining in its policies. For instance, the Guangzhou Agenda 21 calls for the "improvement of economic growth" for the "purpose" of sustainable development. It also explicitly stated need for "balanced development of the

²⁴⁶ China's Agenda 21. (1994). White Paper On China's Population, Environment, And Development In The 21st Century. Beijing.

²⁴⁷ Ibid.

²⁴⁸ Huang, Christina (1997). Air Pollution Control in Guangdong. US State Department. Washington DC.

economy, society, population, resources, and environment...” is undoubtedly a departure from the original wording and intent of China’s Agenda 21.²⁴⁹ In 1998, Mayor Lin Shusen chaired a standing committee that discussed and ratified the Local Agenda 21, and drafted a notice detailing Guangzhou’s implementation strategy.²⁵⁰

In contrast to the national level agenda, by 1996, Guangzhou shifted the focus of transportation development away from sole reliance on the supply of additional road capacity, and toward the management of modal choices. Chapter 10 of the local agenda states:

“Implement the traffic improvement plan for Guangzhou and ameliorate the road system of the central area. Combine the intensification of infrastructure construction with that of traffic control measures to fully rectify the traffic, increase the capacity of the road network, *limit the growth of cargo trucks, private cars, and gradually downsize the number of motorcycles. Vigorously expand public transport to set up an extensive network that gives priority to public traffic.*” (Emphasis added)
[Source: Guangzhou’s Local Agenda 21]²⁵¹

The expansion and inclusion of ‘restrictive’ measures on the number of private motorized vehicles is a dramatic shift away from the previous assumption that ‘more is better’. While there is the acknowledgement that road capacity is still lacking in some respects, there is an emerging understanding of the inadequacy of employing only supply side remedies to address the problem.

Since publication of the Local Agenda 21 in 1996, Guangzhou has made a determined effort to institute a number of policies to mitigate air pollution from mobile sources. Although research into demand-side policies has been initiated, the policies implemented to date are largely technologically driven. As of March 2001, the following technologically driven command and control programs were implemented in Guangzhou to reduce mobile source emissions.

1. Institution of vehicle emissions standards
2. Mandatory vehicle emissions inspection and monitoring
3. Phasing out of leaded gasoline
4. Requiring catalytic converters in all new cars
5. Mandatory retrofitting older vehicles with 3-way catalytic converters
6. A mandatory scrappage program for older vehicles
7. Placement of stricter manufacturing guidelines for domestic vehicle production (requiring electronic fuel injection for post Y2000 production)

In addition, the municipality instituted a number of traffic management programs. These programs generally focused on two major strategies, increasing road capacity in the outlying neighborhoods, and developing affordable mass transit systems for the dense urban areas. In conjunction with the development of public transport, the administration also focused on the control of the private vehicle fleet, the construction of urban roads, and a road rationalization program to define an effective operational hierarchy.

²⁴⁹ Leading Office of Guangzhou’s Agenda for the 21st century. (1996). *Guangzhou’s Agenda for the 21st Century*. Chapter 2.

²⁵⁰ Enhe, Hao. (2001) *Sustainable Development in Guangzhou*. Office of the Leading Group of Guangzhou’s Agenda 21. Guangzhou.

²⁵¹ Leading Office of Guangzhou’s Agenda for the 21st century. (1996). *Guangzhou’s Agenda for the 21st Century*. Chapter 10.

8.6.2 Other Transport-related Initiatives

Guangzhou has also supplemented these programs with a range of complementary policies that seek to garner public support, reduce motorcycle use in the city center, and encourage the development of the local market for emissions control technologies and alternative fuels.

Air quality reporting to public: Community awareness, participation, and involvement can strengthen the credibility of and compliance with TDM policies. Guangzhou has made some first tentative steps in this direction. Since 1999, the air pollution levels have been published on a weekly basis in the city's largest paper. The reporting has had an impact on the perception of the problem, a recent poll indicated that 80% of city residents indicated that auto emissions are the most significant contributor to air quality degradation, and would support measures to reduce them.²⁵² While clearly not a prerequisite for policy making in China, public support can lead to lower monitoring and enforcement cost that are a vital concern to financially strapped municipal government agencies.

Elimination of all new motorcycle operator licenses: Since 1998, Guangzhou has stopped issuing new motorcycle driving licenses to the public. They have also invalidated the license of any operator whose old motorcycle was scrapped under the vehicle retirement regulation. Motorcycle use has been greatly reduced in the city center by prohibitions on many roads and during certain times of the day. In those areas where motorcycles are still allowed to operate there has been an attempt to segregate the motorcycle traffic flow using demarcated "motorcycle-only" lanes.

Development of the catalytic converter market: Guangzhou reduced the tariff rates on imported catalytic converters and low pollution cars in an attempt to encourage a transfer of lower-cost technologies to the domestic production market. These tariff reductions have been complemented by new manufacturing guidelines for catalytic converters and electronic fuel injection systems. Compliance with the new standards has been aided by the small number of automobile manufacturing plants, which limits monitoring and enforcement costs.²⁵³

Development of alternative fuels: The development of alternative fuels is in its nascent stage and currently less than 6% of the bus and taxi fleets run on LPG (liquefied petroleum gas).²⁵⁴ There has been a concerted effort to develop the LPG delivery infrastructure through the building of LPG gas stations to service the 2500 LPG vehicles currently on Guangzhou's roads.²⁵⁵

It is evident that the local authorities understand that regardless of what technological improvements are made, there will be a need for managing the growth of the fleet and providing viable alternatives for public transportation. The city also faces significant problems related to the implementation of technological programs. Compliance with the inspection and monitoring program is almost impossible to ensure, and with widely acknowledged subversion at the lower levels of enforcement, circumventing these standards has become commonplace. The most successful of the implemented policies has been the leaded gasoline phase-out, which has been completed, and has resulted in a significant drop in lead concentration in Guangzhou's air. In 2001, the Guangzhou municipal government officially acknowledged that the demand-side of the equation would also be addressed in the long-term. The publication of the Guangzhou Transport Demand Management Study by the Guangzhou Transport Planning and Research Institute signaled an important shift in the acceptance of

²⁵² STAT-USA. (2001). US Department of Commerce. Washington DC. <http://strategis.ic.gc.ca/SSG/dd73739e.html>

²⁵³ Huang, Christina (1997). Air Pollution Control in Guangdong. US State Department. Washington DC.

²⁵⁴ Wu, Quian Zhao. Chief Engineer. Guangzhou Research Institute for Environmental Protection. 11/24/00 Interview.

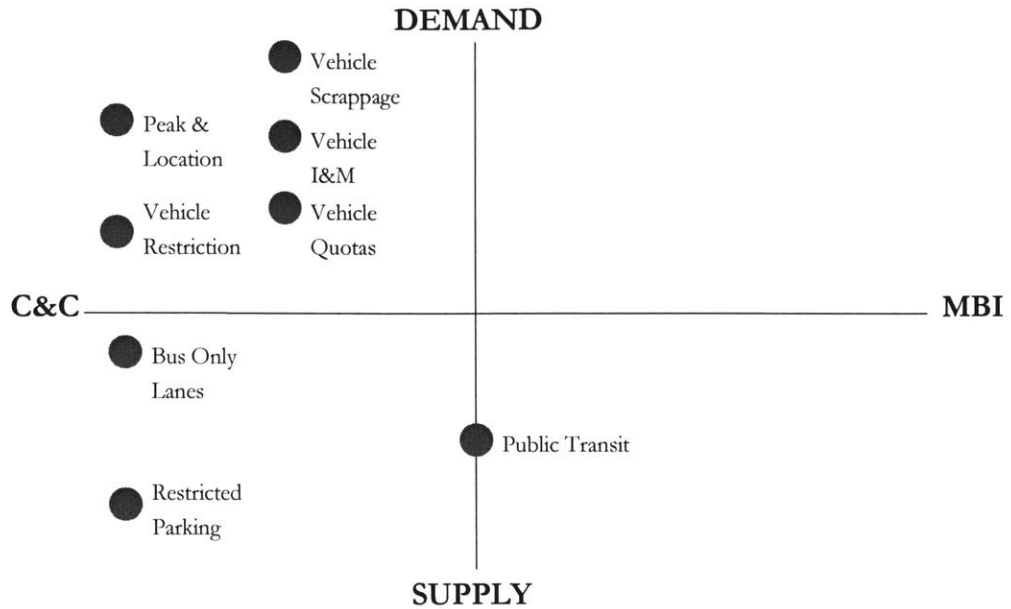
²⁵⁵ Enhe, Hao. (2001) Sustainable Development in Guangzhou. Office of the Leading Group of Guangzhou's Agenda 21. Guangzhou.

TDM. The study commissioned by the mayor outlines some of the policies under preliminary consideration by the GMG. Among those programs and policies which the study recommended for further investigation are the development of a paratranist system of minibuses, ridesharing, and subscription buses; Development of a comprehensive parking management system; Creating restricted travel zones; Alternative work hours, flex-time, and work-at-home initiatives; and Charges, including road pricing, parking pricing, and fuel taxation.

There is growing interest in pricing initiatives, which may be employed as a mechanism to curb demand and create new sources of funding for the municipal transportation departments. These agencies have recognized that revenue-generating policies must be combined with the provision of efficient and low-cost public transportation systems in order to be socially responsible and politically feasible.²⁵⁶ The chart below illustrates the current Guangzhou transportation policy family using the matrix developed in Chapter 4.

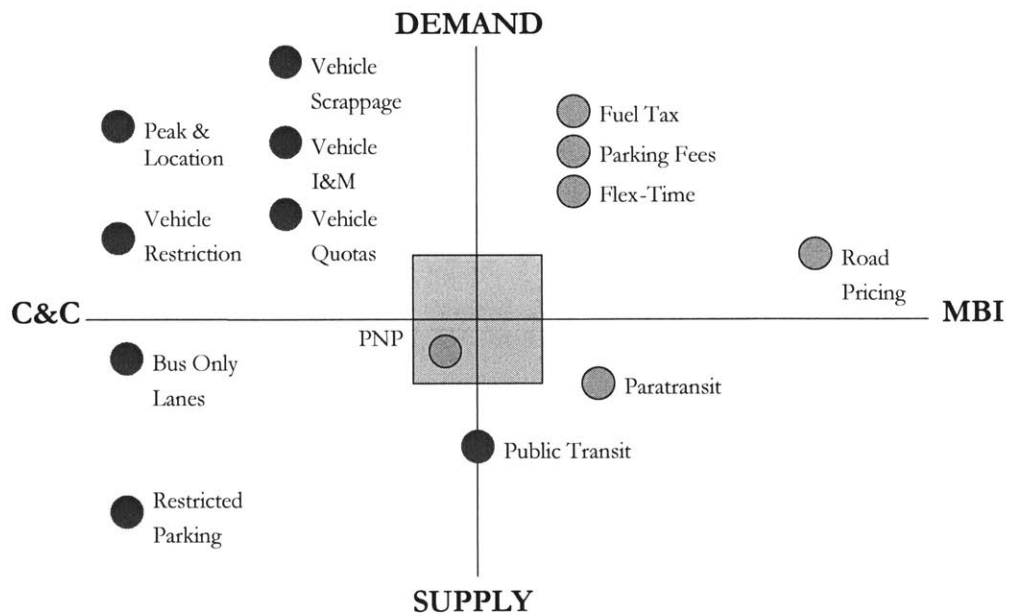
²⁵⁶ Zhou, He-long. (2001) Director, Guangzhou Transport Planning and Research Institute. Interview.

Figure 52: Guangzhou's Current Transportation Policy Matrix



In contrast, by the year 2001 Guangzhou has begun to shift the emphasis away from command and control policies and has begun to consider using market based initiatives to complement its existing policy-suite.

Figure 53: Guangzhou's Emerging Transportation Policy Matrix (2001)

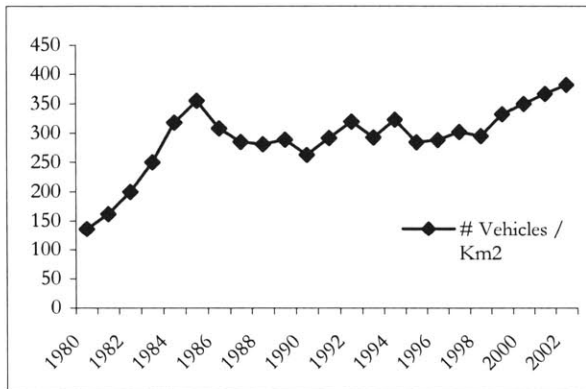


8.7 Guangzhou: Urban Transportation System

8.7.1 Urban Road Network

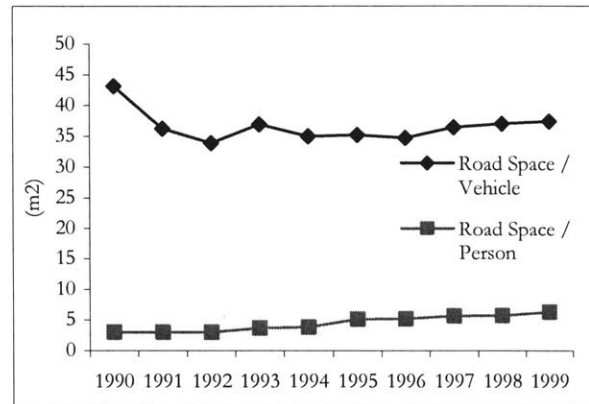
Urban transportation infrastructure in Guangzhou expanded gradually in the years after the national program of “Openness and Reform” began in 1978. After a decade of intense industrialization and rapid motorization, brought on by the economic liberalization policies, the city found itself in dire need of additional urban road capacity. By 1985, the vehicle density per square kilometer of road space exceeded 350 cars.²⁵⁷

Figure 54: Vehicle Density per Km2



[Source: GRIEP]²⁵⁸

Figure 55: Road Space per Capita & Vehicle



[Source: GRIEP]²⁵⁹

From 1990 to 1999, Guangzhou built an extensive new urban road system. During this time, urban road capacity increased substantially, growing at an average annual growth-rate of almost 14%. (See Figure 56 below). Concurrently, the urbanized city core expanded dramatically from 187Km2 in 1990 to 286Km2 in 1999. Guangzhou’s commitment to supplying additional road infrastructure during this administrative expansion is shown by the accompanying rise in the Road Area Ratio (RAR = total road space / total urbanized area) as depicted in Figure 55 below. By 1999, Guangzhou had built 1800km of urban roads including 2 major expressways, 13 arterial trunk roads, and 10 urban “feeder” roads. In spite of this substantial expansion urban road, construction did not match the rising demand; the annual growth rate for vehicles exceeded 25%. Figure 54 above plots the number of vehicles per square kilometer of urban road space, clearly demonstrating that demand outstripped supply. Guangzhou also has a low ratio of road space per capita; at 6.3m2 per capita the city has yet to achieve the its stated objective of reaching the Chinese national average of 7.2m2 per person.²⁶⁰

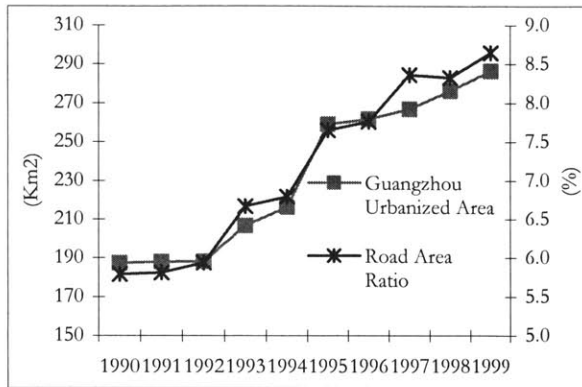
²⁵⁷ GRIEP & Center for Environment Peking University. (2001). *Capacity Development for NOx Pollution Control in Guangzhou*. Beijing

²⁵⁸ Ibid.

²⁵⁹ Ibid.

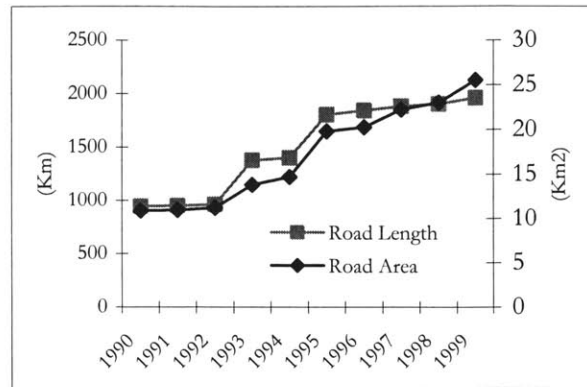
²⁶⁰ Ibid.

Figure 56: Urban Road Length & Area



[Source: GRIEP]²⁶¹

Figure 57: Urbanized Area & % Devoted to Roads



[Source: GRIEP]²⁶²

In 1992, the Guangzhou Municipal Government approached the World Bank to request funding for urban transport infrastructure development, in particular to complete the final sections of the Guangzhou Inner Ring Road, which it had started building. Following an extensive urban transportation study (GUTS) and the publication of the final report, the project was approved. In 1994, the World Bank's provided a USD\$200M loan to the Guangzhou Municipality in order to improve the capacity and efficiency of the transport system in the Guangzhou City center by completing construction on an inner ring road expressway. The total project cost was estimated at USD\$586, with the remainder financed by the municipal government. The Guangzhou City Center Transportation Project (GCCTP) also sought to restructure and reform the public transportation system for greater efficiency and to improve the "market orientation" of the bus system. The World Bank hoped that in so doing it could improve the city's environment by reducing motor vehicle pollution. The Bank also allocated a portion of the loan to help develop local expertise and institutional capacity for transportation management. The following were the major components of the city's largest transportation capacity improvement project:²⁶³

Guangzhou Inner Ring Road: The GIRR component of the project involved the Inner Ring Road construction, land acquisition, and resettlement of project-affected people. In addition to providing funding for the completion of the physical construction of the highway, the Bank provided technical assistance for construction management and environmental monitoring during construction. Additionally, the Bank provided technical and managerial expertise to develop a comprehensive road-maintenance system. The effect of the GIRR land acquisition and road construction on the total urbanized area and road capacity from 1994 to 1996 is evident in Figures 56 and 57 above.

Bus Transport Improvements: Improvements to the quality and financial viability of bus services available in Guangzhou were achieved through a suit of efforts. The Bank sought to introduce competition by facilitating private sector involvement in bus operations. This was accomplished by providing support for institutional reform of public transport, funding the construction of a maintenance depot, and providing needed equipment.

²⁶¹ GRIEP & Center for Environment Peking University. (2001). Capacity Development for NOx Pollution Control in Guangzhou. Beijing

²⁶² Ibid.

²⁶³ Guangzhou City Centre Transport Project. (1997). Project CNPE3614. World Bank. www.worldbank.org

Motor Vehicle Pollution Control: Reduction of the air pollution in the Guangzhou city center was of paramount importance to the Bank. The Bank helped to fund the introduction of unleaded gasoline, a system for the inspection and maintenance of vehicles, an automated motor vehicle pollution monitoring system, and the formation of the Vehicle Emission Research Center. The GCCTP loan also provided assistance for the development of alternative fuels, modification to conventional fuels, and for deployment of instruments to remotely sense highly polluting vehicles. The legacy of this investment was discussed earlier.

Traffic Management and Safety Program: In order to achieve the primary objective of reduced congestion and improved traffic management, the Bank funded efforts to develop a bus lane network, provide footpaths and sidewalks, and segregate bicycle routes. Along with funding for physical works and policy implementation, the Bank provided technical assistance for the design and implementation of a rationalized street network and the creation of a functional hierarchy of roads. For unknown reasons many of these complementary projects were never completed.

Institutional Support: The final component of the GCCTP project was to strengthen the institutional capacity of the Guangzhou municipal government's transportation agencies. The sustainability of the physical, technological, and policy solutions created by the GCCTP would depend on local ability to administer and develop on-going solutions. The Bank's loan provided for assistance in planning, administration, and management of public programs by providing training, research, and consultants. The Bank also prepared an urban transport investment financing strategy and provided support for transportation plans.

8.7.2 *Public Transport*

Passenger Rail

Since 1993, Guangzhou has embarked on an aggressive campaign to promote public transport. A major component of this campaign was the construction of the first phase of the Guangzhou Metro. Line 1 opened in December of 1998, after a five-year construction period, with a maximum capacity of 100,000 people per hour. The city invested 12.7B Yuan (USD \$1.5B) to construct the 18.5 km project through a single purpose corporation, Metro General Corporation. The substantial debt incurred is serviced through new taxes and user fees. Line 2 is currently under construction and will provide an additional 17.8km of metro service.²⁶⁴ Line 3 is in design development but no definitive construction schedule has been set. There is also a limited Light Rail system under consideration to service the "new towns" of Tianhe and Fangcun.²⁶⁵

*Buses*²⁶⁶

Guangzhou has three municipal bus companies and an assortment of privately operated sub-urban bus and minibus operators. However, as congestion levels have increased, there has been a decrease in ridership. Most buses are sub-standard in terms of comfort and convenience; vehicle up-grades are rare due to the low profit margins earned by the operators. Some of the buses are run on priority lanes, but are none are segregated physically from the private-vehicle traffic flow. The mini-buses are primarily rented to drivers on a daily basis. Many are not assigned to any specific routes, and currently there is no legal framework to control their route allocation. Therefore, there is an increasing problem

²⁶⁴ Railway-technology.com. (2001) Net Resources International Ltd. London

²⁶⁵ Guangzhou Urban Transport Study. (1995). MVA Asia Limited. Kuala Lumpur.

²⁶⁶ Gao, Dian Ying. Deputy Director of the Guangzhou Planning Commission. Interview 6/2001.

with inefficient competition (over supply) for the most heavily traveled routes, which has contributed to congestion, pollution, noise and degraded service to outlying neighborhoods.

There was a 90% increase in the number of road-based public transit vehicles (mainly buses) from 1993 to 1996. However due to the simultaneous increase in private vehicle ownership and constrained urban road capacity the travel speed of the public transportation vehicles has been severely degraded. In response to this situation, Guangzhou has developed a series of measures to increase the travel speed of the buses by prioritizing their operation over private vehicles. The measures currently in effect include:²⁶⁷

1. Demarcating of “bus-only” lanes on the major thoroughfares
2. Designating certain roads for public transit vehicles only
3. Designing efficient bus-stops and fare collection booths to maximize through-put
4. Prohibiting private vehicles from operating in certain zones during specific times
5. Physically segregating motorized and non-motorized traffic
6. Banning the entry of non-resident trucks into the city-center during the day

8.8 Institutional Organization & Structure

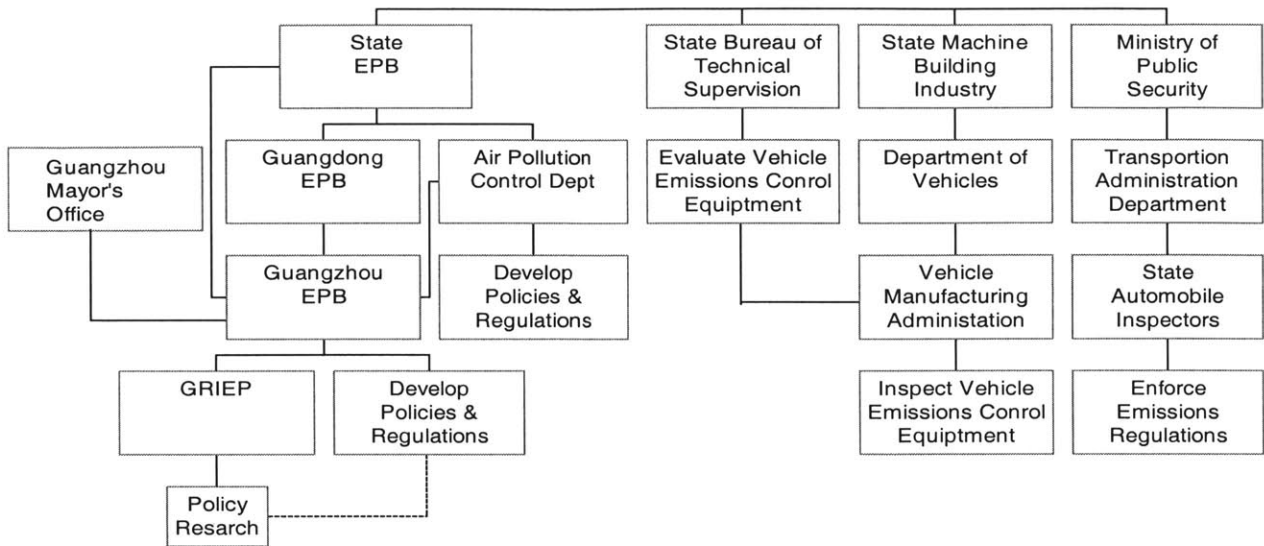
8.8.1 *Guangzhou's Environmental Protection Institutions*

Guangzhou has developed a set of institutions to research and implement policy on the local level. These institutions also interface with the national level environmental protection institutions and enforce national standards. The Guangzhou Environmental Protection Bureau (GEPB) is the primary agency responsible for implementation of local, regional, and national environmental laws. The Guangzhou Research Institute for Environmental Protection is the policy research arm of the GEPB and is subsumed under it administratively. These institutions are under the administrative control of the mayor of Guangzhou, the Guangdong Environmental Protection Bureau (GDEPB), and the State Environmental Protection Authority (SEPA). The enforcement of the inspection and maintenance programs is left to the Traffic Police Bureau, reporting directly to the national Transportation Administration Office under the Ministry of Public Security. The State Environmental Protection Authority also directs policy research and formulation with regards to air pollution.

As is evidenced by the charts below there is a complex web of relationships and division of responsibilities. The difficulty of negotiating this intricate regulatory system is partly to blame for the legislative inaction. In addition, the scarcity of funding available for research at the local level has resulted in the need to find outside sources such as the UNDP, Chinese Universities, and the World Bank. The result is that the research efforts to develop policies are fragmented, and there is a danger of repetitious work being conducted by a number of actors on different levels. Notably absent from the administrative matrix is a feedback loop from the public. This may adversely impact the effectiveness of implementing policy, since there has been no attempt to garner public support or understanding. Although ostensibly all seeking similar policy objectives, the fragmentation of the funding sources, research methodologies, and political power make effective legislation difficult to implement.

²⁶⁷ GRIEP & Center for Environment Peking University. (2001). *Capacity Development for NO_x Pollution Control in Guangzhou*. Beijing

Figure 58: Chinese Environmental Regulation Administration

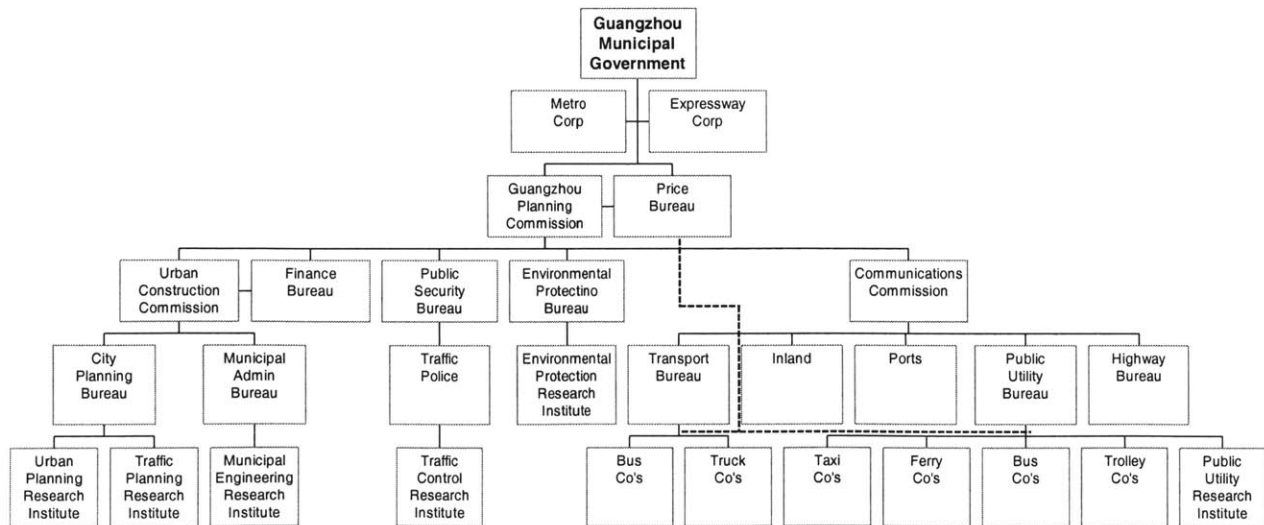


[Sources: US State Dept & GRIEP]

8.8.2 Guangzhou's Municipal Transportation Institutions

Guangzhou's administrative structure is the product of the command economy system, which dominated China since the 1950's. The institutional structure is characterized by a strong vertical orientation, central control, and rigid hierarchy. The organizations within the bureaucracy enjoy some autonomy and are able to generate independent income, but are plagued by a lack of resources and ill-defined boundaries of jurisdiction. The result is a series of administrative fiefdoms that jealously guard their assets and sources of income. This convoluted system is not conducive to integrated policy design, implementation, or enforcement.²⁶⁸

Figure 59: Guangzhou's Current Transport Administration



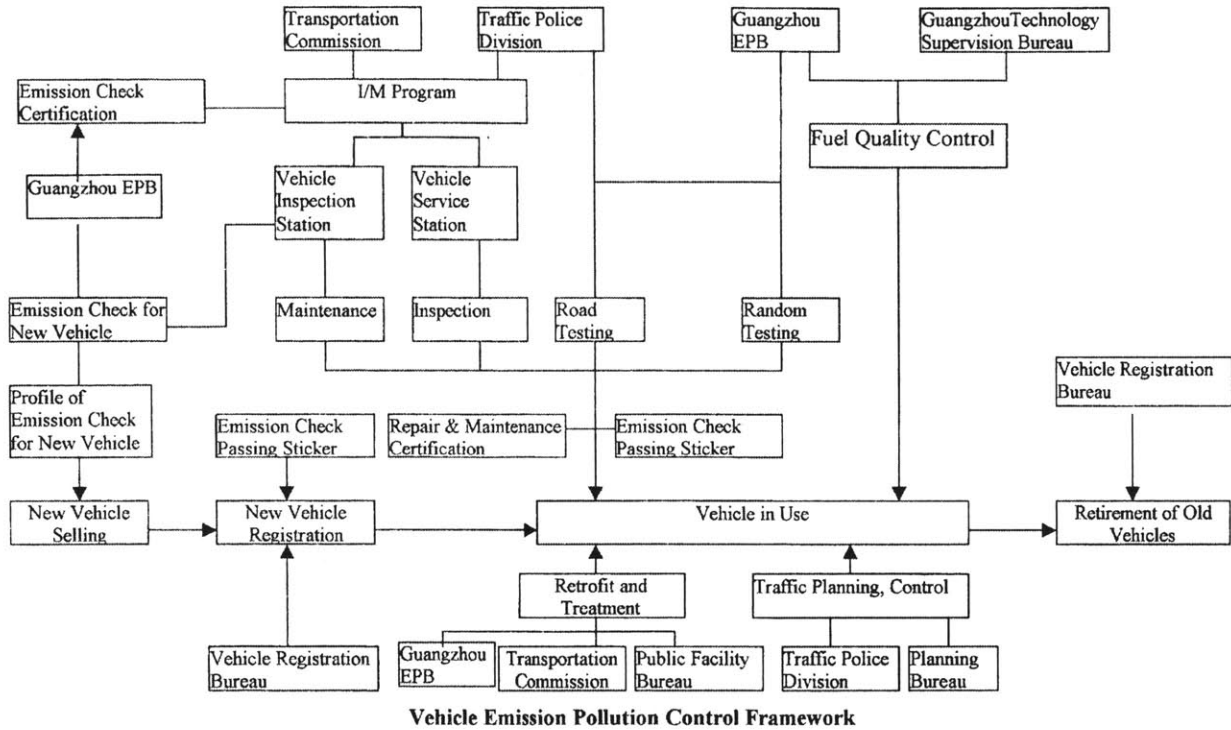
[Source: GUTS]²⁶⁹

²⁶⁸ MVA Asia Limited. (1995). *Guangzhou Urban Transport Study [GUTS]*. Kuala Lumpur.

²⁶⁹ Adapted from MVA Asia Limited. (1995). *Guangzhou Urban Transport Study [GUTS]*. Kuala Lumpur.

The administrative responsibilities of the various entities responsible for vehicle emissions control, within the Guangzhou Municipal Government, are similarly complex, as shown below.

Figure 60: Guangzhou's Emissions Control Administration and Processes



[Source: GEPB]

8.8.3 Transportation Project Financing

Until recently, Guangzhou's primary sources of funding for transportation and telecommunications infrastructure were the municipal budget, direct state investment, and domestic bank loans. In 1994, the Guangzhou municipal government drafted a Transport Development Strategy which set aside Yuan 35B (USD\$4.1B) for transportation investment through 2000. However, from 1991 to 1995 the city contributed 19.3B Yuan (USD\$2.3B) from its coffers, 60% of the total invested. State investment and domestic bank loans accounted for the remaining 40% of the city's infrastructure investment fund. This financial burden strained the city's budget and yet still did not suffice to meet the growing need for new infrastructure. Initially the city sought to supplement these sources of funds with loans from multi-lateral lending agencies such as the World Bank and ADB. The USD\$200M GCCTP loan was Guangzhou's most successful effort to draw in international capital.²⁷⁰

In recent years (1996-2001), however, the World Bank and ADB have increasingly focused on "soft" projects for health, education, and the environment. Concurrently, the PRC government has shifted its attention westward in an attempt to develop more evenly the country's resources. Consequently, many of the "successful" eastern cities such as Guangzhou have been left to fend for themselves financially. Thus, in spite of enviable economic growth, Guangzhou has been faced with shrinking capital resources and limited access to additional tax revenue.²⁷¹ In 1996, Guangzhou published a new

²⁷⁰ Guangzhou's Agenda for the 21st Century. (1996) Leading Office of Guangzhou's Agenda for the 21st century.

²⁷¹ Gao, Dian Ying. Deputy Director of the Guangzhou Planning Commission. Interview 6/2001

strategy for transportation financing in Guangzhou Agenda for the 21st Century. The new strategy seeks to develop a “multi-channel” and “multi-form” investment system. Those projects that are capable for generating revenue are to be funded through multiple channels, including private investors and foreign lenders. The government will thus be able to use its limited investment capacity for only those projects that promote social benefits without corresponding financial returns. In order to help attract foreign investment the city sought to relax restrictive policies related to foreign capital investment in and ownership of transportation infrastructure assets.²⁷²

Because of this initiative, Guangzhou’s transportation projects are established as financially self-sustaining enterprises and must seek funding from private financial institutions. Foreign bank loans, bonds, foreign joint ventures, and user fees are the new vehicles for project finance in Guangzhou. Currently the corporatized municipal bus and ferry operators are able to generate enough revenue to cover operating expenses and depreciation, but they are insufficiently profitable to improve service or invest in major system expansion. Studies on user fee levels to establish full cost recovery have indicated that the necessary charges would be generally affordable. However, further examination of the exact geographic income distribution, demand levels and elasticity would be required to verify feasibility on a case-by-case basis. The percentage of people who would be left without affordable access to public transit must also be determined before implementing substantial rate hikes.²⁷³ Inadequate cost forecasting has resulted in the temporary diversion of city taxes, originally slated for other uses, to finance the Metro system. It has been calculated that the revenue generated from ridership on Lines 1 and 2, when operational, will be sufficient to cover operating expenses and debt service. The city is exploring opportunities to make-up the revenue shortfall needed to construct lines 3 & 4 by redeveloping 26 urban sites as high-tech office parks.²⁷⁴

²⁷² Guangzhou’s Agenda for the 21st Century. (1996) Leading Office of Guangzhou’s Agenda for the 21st century.

²⁷³ MVA Asia Limited. (1995). Guangzhou Urban Transport Study [GUTS]. Kuala Lumpur.

²⁷⁴ Ibid.

9 Case Study: Guangzhou, PRC (Recommendations)

9.1 Basis for Recommendations

Using the conceptual framework developed in this study, and the evaluation criteria previously explained, we seek to draw some conclusions and draft recommendations for the city of Guangzhou. We will endeavor to make feasible recommendations that complement and support existing efforts, and are in tune with the goals of the Guangzhou Municipal Government. We will evaluate *combinations of policies and technologies* that may serve to increase mobility in Guangzhou. The analysis that follows will highlight the tradeoffs between the various solutions, and thus foster more informed decision-making. Our choice of recommendations are based on a number of considerations, chiefly:

1. Extensive interviews with GMG officials, who helped us to determine the level of political support for policies and desired development trajectory for the city.
2. The objectives stated in the *Guangzhou Local Agenda for the 21st Century* (1996).
3. The objectives stated in *Capacity Development for NO_x Pollution Control in Guangzhou* (2001).
4. The objectives stated in *General Development Scenarios during 1995-2010 in Guangzhou* (1999).
5. The objectives and recommendations found in *Guangzhou Urban Transport Study* (1995).

These documents, and related interviews, have revealed consistent themes that define the specific challenges the city hopes to overcome and identify those solutions that are most likely to find the requisite political support within the GMG. Specifically the following objectives have been reiterated repeatedly:

1. Guangzhou seeks to develop a comprehensive urban transportation system with public transit at its core.
2. Guangzhou has recognized the need to supplement infrastructure development with policies to regulate demand for private vehicle transport.
3. Guangzhou seeks to control the vehicle fleet growth and composition.
4. Guangzhou is faced with chronic capital constraints that have inhibited it from achieving its investment goals.
5. Guangzhou has recognized the cost effectiveness of using market-based initiatives and private capital to achieve these goals.

We have constructed a rough but comprehensive sketch of the conditions in Bogotá, Singapore, and Guangzhou. We have identified the institutional, regulatory, and technological capacities of Guangzhou. We have demonstrated the validity of TDM as a policy framework that is viable and cost effective. Finally, we will examine three specific strategies that have been implemented in Singapore and/or Bogotá with relative success. We will attempt to glean those elements that have the greatest chance for transference and relevance to Guangzhou. The question remains how are these elements to be modified and synthesized in order to generate effective results. The strategies and programs that will be recommended for adoption and adaptation have been selected based on the criteria that defined sustainable transportation in Chapter 2.

These recommendations are not seeking to define the *only* path towards achieving the aims heretofore stated, but rather the least-cost approach. Hence, the problems that the city currently faces may be solved by a number of strategies (a dramatic increase in road supply might be one strategy), however, the benefit derived will come at a price which is higher than optimal. The cost of addressing

Guangzhou's congestion and pollution problem using a supply-side approach would be enormous. The required massive capital investment, environmental disruption, and socio-economic dislocation would far outweigh the gains achieved. It is our estimation that the solutions recommended below offer similar benefits at lower relative costs. There are, however, disadvantages to this approach. In general, the more innovative policies may require a more fundamental change in the capacity, authority, and governance of the agencies that are responsible for implementation. This institutional barrier can be very significant. Some innovative policies may also rely on social norms that are not inherently accepted in Guangzhou, such as the polluter-pays. In the final analysis, if the hurdles of implementation are not overcome, even the best crafted most equitable policies will fail.

9.2 Comparative Challenges

The differences between Guangzhou and Singapore are apparent; one may indeed question the relevance of the comparison. Nearly all the major criteria for comparison and evaluation are divergent for these two cities. The size of their population, its growth rate, income levels, administrative boundaries, and levels of contamination are very different. The pollutant types (NO_x, SO₂, and TSP) and sources are similar, but their levels are very different. The rate at which these pollutants are being added to the air shed is quite different too. This discrepancy is due primarily to the technological deficiency of the Guangzhou vehicle fleet, and with time the rate of emissions per vehicle, it is presumed, will level off. There are three primary justifications for the comparison:

- 1) The autocratic system in Singapore has managed to stimulate enviable economic growth while maintaining autonomous control and protecting the environment.
- 2) The municipal government of Guangzhou regards Singapore as the "ultimate" urban model and wants to emulate it.²⁷⁵
- 3) The issue of developmental time-line also needs to be considered, as the initial industrialization of China's East Coast is transformed into post-industrial economy the relevance of comparing these systems may grow.

Thus, the challenges these urban systems face share some similarities, the context in which these challenges are confronted is quite different, as is their relative level of success in dealing with the problems.

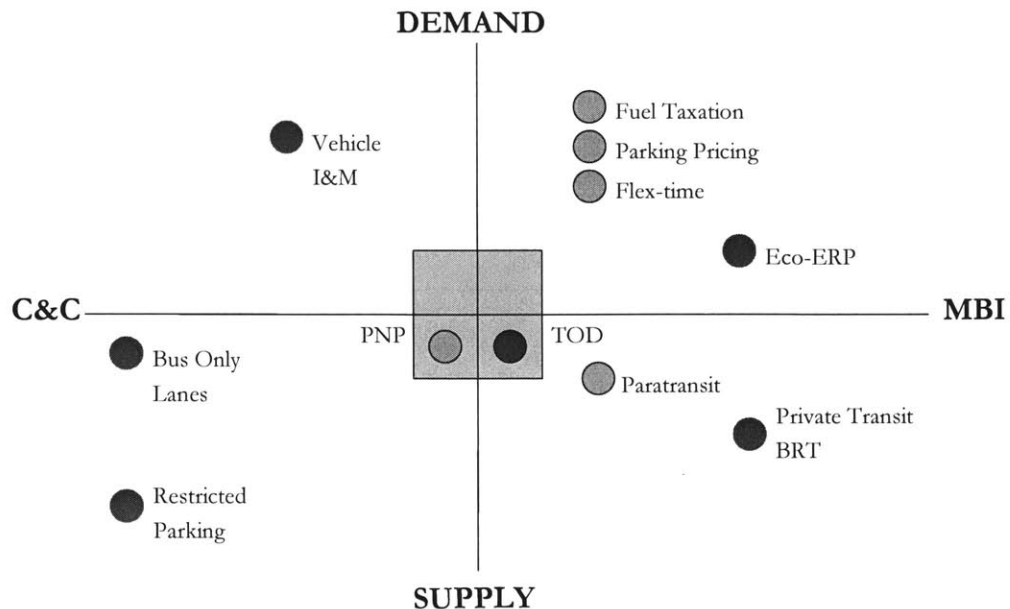
9.3 Core Recommendations

The framework of policies that are recommended herein is illustrated below. Importantly, the use of market-based initiatives should eliminate, in the end, the need for some of the existing command and control regulations. The process by which certain regulations may be phased out in lieu of these innovative market approaches will be discussed later. Interestingly, our conclusions and recommendations are very much in line with the recommendations made by the World Bank in 1995. The Guangzhou Urban Transport Study identified a preferred approach based on the development of various growth scenarios and economic forecasts. The essential components of the GUTS recommendations were an extensive bus-priority system, segregated bicycle routes, expansion of the Metro, and motor vehicle demand management.²⁷⁶ We have arrived at similar recommendations, and hope to define some useful implementation strategies that will allow Guangzhou to apply these recommendations.

²⁷⁵ Gao, Dian Ying, Deputy Director of the Guangzhou Planning Commission. Interview 6/2001.

²⁷⁶ Guangzhou Urban Transport Study. (1995). MVA Asia Limited. Kuala Lumpur.

Figure 61: Guangzhou's Recommended Policy Matrix



The four primary recommendations arising from this study were presented to the municipal government of Guangzhou during the concluding meeting of the AGS Future Cities group in December of 2001, they are:

- (a) Integration of land-use and transportation planning into a comprehensive: **Transit Oriented Development strategy.**
- (b) Development of an efficient, privately operated **Bus Rapid Transit System**
- (c) Employment of **Electronic Road Pricing** to curtail demand for travel in the CBD's and thereby reduces congestion and pollution.
- (d) A recommendation that the city consider a process of **Institutional Review, Reform, and Integration** at the local level to consolidate and clarify responsibilities relating to land-use planning, transportation planning, traffic management, and enforcement.

9.4 Bus Rapid Transit

As Guangzhou comes to terms with its undeniable need to provide adequate public transport to a burgeoning urban population it is faced with a number of options, namely:

1. Expansion of the existing conventional bus system
2. Development of a Bus Rapid Transit system
3. Construction of Light Rail Transit
4. Expansion of the Mass Rapid Transit (Metro) system

While light rail is growing in popularity in developed cities around the world, the high construction and operating costs make it financially unsustainable for most developing cities. Likewise, an extensive expansion of the MRT system is unlikely to be an economical option. Bus Rapid Transit can serve as a low cost alternative to LRT systems, or at minimum, as a stepping-stone that can precede fixed guideway investments. Expansion of the existing uncoordinated bus system is unlikely to yield benefits and

would likely contribute to additional congestion. In Guangzhou, given the public funding constraints private capital must be employed efficiently and profitably to serve the mobility needs of the city. Due to a limited ability to pay and the difficulty associated with acquiring new rights-of-way, it is our recommendation that Guangzhou develop a BRT feeder system.

9.4.1 Recommendation Drivers

- Even if Guangzhou were able to construct substantial new urban roads, the anticipated rate of motorization would outpace the growth in supply. The future demand for travel into and through the city center can only be satisfied by public transit. Therefore, an efficient system of public transit to serve the city center is vital and preferred.
- The existing system of municipal buses and privately operated mini-buses suffers from a lack of coordination, insufficient modal segregation, inefficient competition, and poor service quality.
- The BRT feeder system envisioned would complement the existing transit services, and would not seek to fully replace any of the existing modes.
- Many of the elements used by BRT systems are adaptable to LRT (right-of-way, stations, signaling, and information systems), thus the initial investment is not lost if and when conversion becomes economical.
- BRT systems can be built incrementally allowing expansion (and contraction) of service as demand changes or funds become available. This flexibility allows for greater responsiveness to the market and avoids long-term capital commitments in uncertain environments.

9.4.2 Operational Goals²⁷⁷

- Increase capacity and quality of bus service to achieve a target of 55% of motorized trips.
- Achieve and maintain an average travel speed of 18Km/h.
- To reduce air pollution (TSP, CO, and NO_x).
- To be financially self-sufficient.

9.4.3 Essential Components²⁷⁸

Bus Rapid Transit is not characterized by any particular technology, facility improvement, or service configuration. BRT systems around the world would employ a host of varying technologies, facilities, and operations. BRT is differentiated from traditional bus systems by the integration of advanced technologies with a comprehensive operational plan and innovative customer interfaces. The integration of these elements can result in a mass transit system that is more comfortable, faster, safer, and more secure than a traditional bus system. The recommended BRT system, borrowed largely from Bogotá, would have the following basic characteristics:

Vehicles

- Use of high-capacity (articulated or double-articulated) vehicles.
- Use of low polluting vehicles (CNG, LPG, hybrid, or electric) vehicles.

Facilities

- Deployed only along the major thoroughfares.
- Physically segregated lanes from the existing traffic flow at grade using curbs.
- Use of some “bus-only” streets

²⁷⁷ Guangzhou Urban Transport Study. (1995). MVA Asia Limited. Kuala Lumpur

²⁷⁸ Kang, Alice. (2000). Bus Rapid Transit: An Integrated and Flexible Package of Service. Booz Allen & Hamilton, Inc. Virginia.

- ❑ Use of high-capacity loading stations.
- ❑ Increased distance between loading station to facilitate higher travel speed.

Information Systems

- ❑ GPS based vehicle tracking to allow real-time traveler information up-dates.
- ❑ Prioritized signal control to allow even distribution of vehicles along route and preferential treatment at mixed-roadway intersections.
- ❑ Real-time dispatching information relayed to operators and passengers.

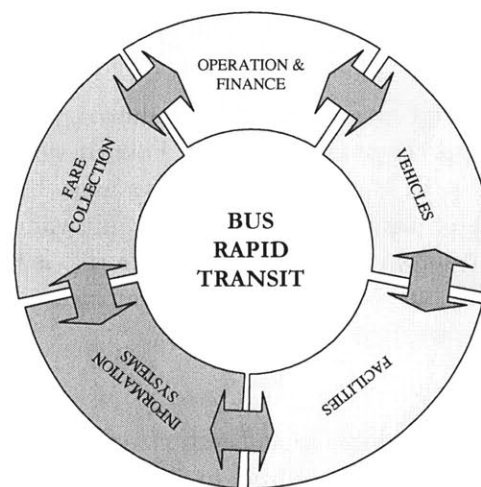
Fare Collection

- ❑ Flat one-time payment allowing transfers to other transit modes.
- ❑ Electronic pre-paid ticketing.
- ❑ Cash-less, anonymous, electronic “smart” cards.

Operation & Finance

- ❑ Privately financed concession-based, ownership and operation.
- ❑ Remuneration of operators would be tied to number of kilometers traveled and quality of service, to avoid price wars and degradation of service outlying routes.
- ❑ Fares would be collected and distributed by the GMG, not the operators.
- ❑ Defined and fixed route structure.
- ❑ Coordinated and predicable arrival and departure schedules.
- ❑ Integrate timetables with other transit modes to allow facilitate transfers between MRT, rail, and existing bus services.

Figure 62: Elements of an Integrated BRT System



[Source: Kang]²⁷⁹

²⁷⁹ Adapted from: Kang, Alice. (2000). Bus Rapid Transit: An Integrated and Flexible Package of Service. Booz Allen & Hamilton, Inc. Virginia.

9.4.4 Implementation Strategy²⁸⁰

Project Development

In order to be effective, private sector investment in transportation systems must be complemented by a well functioning government that performs its core duties diligently. When this precondition is not met, the advantages of private sector participation may evaporate. In order to reduce public expenditures, improve the quality of service, and achieve a financially sustainable system the municipal government should confine its involvement to the following tasks:

1. Determining the project development process.
2. Define the role for the private sector in procurement and operations.
3. Identify the role for the BRT within the integrated public transportation context.
4. Provide strategic planning of the route structure, station locations, and corridor development.
5. Assess environmental impact.
6. Confirm acceptability of tariff structure
7. Provide assistance (subsidies) to the economically disadvantaged.
8. Provide land, right-of-way, and permits.

Financing & Procurement

The interests of both the private and public sector must be aligned to yield tangible benefits. The guidelines set forth by the government will determine the extent of the role played by the private sector with regard to investment and technological expertise. There is a range of procurement strategies available to the Guangzhou Municipal Government (GMG) for developing a privately operated BRT system.

- Initial public sector design, development, funding, and operation followed by a concession for commercial operation.
- Public sector development of the basic infrastructure followed by private supply of the equipment (vehicles, control systems etc.) and commercial operation.
- Public sector financing coupled with private sector Design-Build-Operate-Maintain (DBOM).
- Private sector development using Build-Operate-Transfer, Build-Transfer-Operate, or Build-Own-Operate-Transfer strategies.

In light of Guangzhou's need to alleviate its chronic capital shortfall, the recommended strategy would be to employ a fully privatized procurement system such as BOT, BTO, or BOOT.

To reap the full benefits of private sector participation the GMG must carefully craft a competitive tender that details the desired operational and performance standards, but avoids precluding creative solutions. For example, the level of emissions allowed by Vehicle Mile Traveled (VMT) might be specified, but the government ought to avoid designing the technology to achieve this level. By specifying a low emissions rate per VMT the government would preclude diesel-fueled buses, but would leave the choice between CNG, LPG, hybrid, or electric vehicle to the competitors. Other performance criteria or operational requirements might include:

- Minimum frequency of service per stop
- Minimum level of passenger amenities

²⁸⁰ Adapted from: Fox, Halcrow. (2000). Mass Rapid Transit in Developing Countries. World Bank Urban Transport Review. Department for International Development. London.

- ❑ Minimum passenger capacity per vehicle
- ❑ Minimum accident disruption down-time
- ❑ Minimum vehicle maintenance schedule
- ❑ Minimum level of planned future investment in vehicles, loading areas, and depots
- ❑ Real-time availability of passenger information
- ❑ Lowest fare rate / tariff structure
- ❑ Minimum length of concession

9.4.5 Potential Obstacles

Fare rates that insure profitability may not be affordable to some demographic groups. Should this situation arise it is recommended that direct subsidies be given to the economically disadvantaged to allow them access to the BRT system. Direct, transparent subsidies are nearly always preferable to hidden subsidies to operators.

Existing bus operators, along the major routes, may voice objections to the new system. Existing private operators should be invited to compete for the new system. Those that are constrained by lack of capital might be encouraged to sell shares to foreign or domestic partners to form joint ventures. Alternately they may opt to sell their assets and knowledge to a competitor. Additionally, the system should be phased in gradually to allow the systematic divestiture of existing assets by the current operators.

*Legal barriers to foreign investment resulting from the haphazard application of Chinese law.*²⁸¹ Potential foreign investors are confronted with an array of vague, contradictory and arbitrarily applied laws. China's rapidly modernizing and expanding economy essentially dictates this legal reality. The shifting sands of the global economy propagate the use of flexible interpretative law in China. Soon after the opening of the Chinese market, the need to import Western law doctrines became apparent to the Socialist regimes. The importation of legal norms, however, has not been effectively translated into local administration and implementation of these norms. In China today reliance on personal contacts or '*guanxi*' is the real guide and guarantee for foreign investors. In Western terms, there is no true rule-of-law in China.

- ❑ *China's Joint Venture Law:* China's Joint Venture law is meant to be centrally dictated and universal, in reality, the weak legal structure allows for very diverse and diffuse administration of laws. The official JV law does not restrict either the type or amount of foreign investment in China. In practice, the Ministry of Foreign Trade institutes a 49% cap for all foreign investment in Chinese joint ventures. While lacking formal legal backing, this cap is enforced.
- ❑ *Implementation of day-to-day law in China is unsystematic and preferential.* Legal norms are enforced by local officials in an instrumental and parochial manner rather than universally and indiscriminately. Often these local officials simply lack knowledge of the laws, and lack the ability to distinguish between policy and law. Since there is no effective recourse against sporadic and inconsistent enforcement, the practice is perpetuated.
- ❑ *BRT systems suffer from "second-class" stigma among many political decision-makers.*²⁸² The very disadvantages of fixed guide-way transit, high capital cost and permanence are often

²⁸¹ Rice, Michelle. (1999). Establishing A Joint Venture in The People's Republic of China. New England International & Comparative Law Annual. Boston.

²⁸² He-long, Zhou. Director Guangzhou Transportation Planning Research Institute. Interview 6/2001.

viewed as positive indicators of development and confidence by politicians. LRT and Metro transit systems are considered the hallmarks of an advanced city, and there may be a reluctance to develop lower cost substitutes. Efficient rail-based mass transit systems are also considered prerequisites for enticing foreign investment. As Guangzhou seeks to compete on the global stage, the lure of flashy, albeit unsustainable, mega-projects may interfere with the city's ability to meet its mobility needs.

9.5 Environmental Electronic Road Pricing (Eco-ERP) ²⁸³

Guangzhou's latest master plan, the 10th Five-Year Plan, features a polynuclear city planning strategy. The Guangzhou Urban Planning Group has devised a strategy in which the old city center, currently congested and polluted, will be de-emphasized. This new development strategy calls for the creation of four or five major city centers each with a high-tech based CBD center. Within this context, a limited ERP scheme is recommended to reduce congestion and pollution in these city centers.

The average cost of car ownership is estimated to be \$3000 per year²⁸⁴; the vast majority of Guangzhou's population is not yet able to afford private vehicles. The alternative that is accessible at this income level is a motorcycle. The question then is, will it be possible to discourage the purchasing of any form of privately owned transport before income levels rise to the projected 2010 levels, when car ownership becomes feasible for large numbers of people. The answer is, of course, only if adequate alternatives are available. Comprehensive and efficient systems of public transportation must be available to support the demand offset by limiting or discouraging private vehicle ownership. Re-injecting revenues generated through electronic tolling into mass transit systems would increase the efficiency of the system, and provide additional access to mobility to the economically disadvantaged. A secondary effect of a clear correlation between the source of the revenues and their expenditure would be to bolster public support for such efforts.

9.5.1 Recommendation Drivers

- At current projected rates of motorization and income growth, by 2010, Guangzhou will develop a level of motorization similar to a typical southern European city. Without aggressive demand management measures, the city will be mired in a perpetual state of gridlock.
- Guangzhou currently places temporal restrictions on access to the city center and certain corridors for trucks, motorcycles, and bicycles. While these restriction are relatively easy to enforce they are not efficient mechanisms, and do not generate income.
- Congestion pricing, facilitated by an ERP system, has proven to be one of the most effective and cost efficient measure available to reduce congestion and air pollution.
- Implementation of ERP during the nascent stages of motorization will result in a progressive taxation effect, as only the wealthiest citizens own vehicles. The revenues generated, if used properly, will benefit the great majority who relies on public transportation.
- Early implementation will also facilitate political approval and public acceptance. The government will have the opportunity to demonstrate substantial gains (reduced congestion, improved public transit) before a large percentage of the population will be affected.
- ERP technology is sufficiently advanced to allow for very fine-tuning at little or no additional cost. Thus, vehicle emissions factor, length of trip, and duration of trip may all be used to adjust the

²⁸³ The term "Eco-ERP" and the basic concept behind it were adapted from a series of e-mails I exchanged with Jack Opiola of Hyder Consulting (Hong Kong). Some form of this basic idea was briefly considered for the second Hong Kong ERP study. Detailed information was not publicly available, and so I continued to develop this idea on my own.

²⁸⁴ Litman, Todd. (2001). TDM On-Line Encyclopedia. Victoria Transport Policy Institute. Victoria, BC.

costs to alter behavior and consumption patterns in the unforeseeable future. The flexibility and adaptability of the technology leaves these options open for the future.

- Past experiences with congestion pricing and ERP have proven to be profitable. The city is in dire need of innovative revenue generating mechanisms.
- The PRC's political and legal systems are more conducive to congestion pricing implementation than most developing countries.

9.5.2 Operational Goals

- Reduce congestion in the existing and new city centers in order to achieve and maintain an average vehicle travel speed between 25Km/h and 30Km/h.
- Reduce vehicular emissions resulting from congestion to levels accepted by the WHO and comparable to OECD cities.
- Use market forces to change the vehicle fleet characteristics to include a higher percentage of low-emissions vehicles (LEV).
- Develop and maintain a stable source of alternate income for Guangzhou's transportation planning and enforcement agencies.

9.5.3 Essential Components²⁸⁵

Electronic Road Pricing works on the principle that motorists who contribute to congestion and pollution should pay for their impact on the city. The marginal effect of one more vehicle on a road may not be significant when the utilized capacity is low. However, as the road reaches full capacity the marginal impact of one more vehicle results in significant reduction of overall travel speed. As demonstrated earlier, reduced travel speeds also exacerbate the emission of pollutants by lowering combustion temperature. When motorists are charged a toll to approximate the level of inconvenience they cause and corresponding environmental damage, they will choose to drive only when the benefits they derive outweigh the full cost of driving. This is an equitable and transparent way to account for the full-cost of private vehicle use. (I.e. those who contribute more towards congestion will pay more.) By charging for the use of congested roads, ERP allows for more efficient use of the urban road network. It functions by diverting traffic from the heavily used roads to the less used ones. It also diverts traffic from the peak hours to the less congested times. Lastly, it reduces traffic when motorists switch to other modes of transport.

Traditional ERP toll rate-determining variables such as vehicle size may not be applicable to Guangzhou's existing vehicle fleet, which are predominantly motorcycles. Environmental weighting of the relative environmental impact of a vehicle is an efficient method to encourage purchasing of cleaner vehicles. Environmental ERP, or Eco-ERP, complements the traditional congestion-relieving properties of road pricing with a system based on the environmental rating (according to an emissions profile) of a vehicle or "Eco-points". An environmental factor is determined for each class of vehicle and then multiplied by the ERP charge for the designated zone and time of day.²⁸⁶ A factor for road space use could also be used to discourage particularly large vehicles (trucks) from entering the CBD during the specific times. Many flexible-tolling strategies will give the municipality a set of tools that it can use to achieve a wide range of objectives. The recommended Eco-ERP system, synthesized from Singapore's ERP system and a Wilbur-Smith study for Hong Kong has the following major components:

²⁸⁵ Gomez-Ibanez. (1995). Road Pricing for Congestion Management: A Survey of International Practice. National Academy Press. Washington DC.

²⁸⁶ See reference #282.

Pricing Scheme

- Cordon Pricing Scheme: Under a cordon-pricing scheme, a well-defined area is tolled when vehicles enter or exit the cordoned area. Additionally, major thoroughfares through the cordon may be tolled to capture the costs associated with vehicles that remain within the congested zone during the tolling period.

In-Vehicle Technology

- Given the sophistication and complexity of the proposed tolling strategy, a greater reliance on complex in-vehicle technology will be required. While it would theoretically be possible to implement an ALS-like system in Guangzhou, a manual tolling system would preclude the time and emissions based sensitivity.
- Vehicles should be equipped with electronic-tags (transponders), which can communicate with the roadside gantry allowing the basic vehicle characteristics to be quickly processed to determine the toll level. (I.e. vehicle type, Eco-point rating, previous violations etc.)
- A read-only tag affixed or integral to the license plate would be used for motorcycles. More sophisticated read-write transponder could be made available for car and trucks.
- The motorcycle tags would contain the vehicle characteristics and would alert the driver when entering a tolled-zone, but would not be able to employ anonymous “smart-card” technology unless integrated into the vehicle design. The motorcycle tags could either debit a prepaid account or allow for monthly billing to the owner.
- The read-write transponders would allow the use of anonymous smart cards that could be refilled at banks, post offices, and other institutions.
- The smart-card transponder could also alert the driver of the amount tolled, and remaining balance, monthly activity, and time spent in congested zones, unlike the motorcycle tags.
- The important advantage to the smart card transponder is that it allows protection of the user’s identity, which is not possible with the passive read-only tags.
- The read-write transponder is forward compatible with emerging technologies providing real-time traveler information including traffic conditions, weather, and navigation. These applications may be developed and deployed in the future.

Roadside Communications²⁸⁷

- Roadside microwave systems using Dedicated Short-Range Communication (DSRC) allow for two-way communication between the vehicle and the gantry, which is essential for the smart card transponders.
- The recommended system for Guangzhou relies on a passive system whereby only the roadside gantry actively transmits a signal. This signal is then modified by the vehicle tag and retransmitted back to the gantry. Although less technologically sophisticated than an Active system, the large motorcycle fleet necessitates this compromise.
- Microwave based systems do not require large gantries or disruption of the road service. Gantry’s can be mounted on existing telephone and electric poles, or on simple overhead steel structures.

Vehicle Detection & Classification

- The gantry-based transponder would collect, at minimum, the following information: vehicle type, size, time of entry, and Eco-point rating.

²⁸⁷ ISO TC204 Committee of Japan. (2001). DSRC: Vehicles and Roads Start a Dialogue to fulfil the Dreams of the 21st Century. Tokyo.

- ❑ Effective enforcement will require a robust system to identify vehicles not equipped with transponders, empty cash-cards, illegally modified systems, or misclassified vehicles.
- ❑ A number of technologies are available to assist in enforcement. Digital video and still cameras have proven highly effective at capturing license plate images at speeds up to 120km/h. Images may be read manually or scanned by increasingly sophisticated computers.
- ❑ Pulse-mode microwave systems can perform random checks that verify vehicle size, account balance, vehicle ID numbers, and systems that have been tampered with.

Accounting & Payment Technology

- ❑ The transponders should be designed to allow either pre-payment by cash-card or post-payment by billing. Such a dual accounting system will avoid unnecessary enforcement costs when a user has simply forgotten to refill his smart card.
- ❑ The read-only tags on motorcycles will be charged to an existing account, although it too may be pre-paid or billed. Users should have the option of opening an ERP account, which would be debited as used. If there were insufficient funds available, an automatic bill would be generated to the vehicle owner.

Figure 63: Components of an Eco-ERP System



9.5.4 Implementation Strategy

Project Development

In order to be effective private-sector investment in such complex technological systems must be complemented by a well functioning government that performs its core duties diligently. When this condition is not met, the private sector may be reluctant to participate. The municipal government should confine its involvement to the following tasks:

1. Determining the project development process.
2. Define the role for the private sector in design, deployment, and operations.
3. Provide strategic planning of the cordoned areas, gantry locations, and tolled thoroughfares.
4. Assess potential environmental impact of reduced congestion.
5. Confirm acceptability of toll structure and strategy.
6. Provide assistance (subsidies) to the economically disadvantaged.
7. Provide needed permits, regulatory support, and legal guarantees.

Procurement & Financing Strategy

The Guangzhou municipal government has a unique opportunity to design a revenue generating system whose initial capital requirement would be financed partially or entirely by private enterprises. Therefore, the use of a public-private partnership or wholly private development of the Eco-ERP system is recommended. By granting a private developer a long-term concession to build, operate, and maintain the ERP system, and to collect revenues from it, the GMG may be able to offset the entire initial capital investment.²⁸⁸ At the conclusion of the concession period, the GMG would have a new source of funding and will be able to competitively bid the operations and maintenance functions to the private sector. Due to the sophisticated technology that the ERP systems require, the Guangzhou may turn to the leading technology suppliers for a source of vendor financing.

A precedent for this type of private-public cooperation has been set by TransCore and the city of Yibin. TransCore, a multinational firm that develops technologies to manage ground transportation systems, entered into an alliance with NeoSource Intel-Tech Ltd., to deploy wireless communication windshield stickers for vehicle registration in Chengdu province. For the initial rollout, the Chengdu provincial government has required that electronic ID numbers be assigned to all vehicles in Yibin City. The roadside Automatic Vehicle Identification (AVI) system will make wireless microwave inquiries of passing vehicles. Within 1/10th of a second, the windshield stickers provide vehicle registration information, vehicle emissions status, tax payment status, annual vehicle examination status, and a complete traffic record. The information gathered by the AVI management system will be used primarily by the Sichuan Provincial Public Security Bureau. The public security bureau hopes to dramatically improve reduce theft and improve public safety.²⁸⁹ A similar system could be easily adapted for electronic toll collection in Guangzhou.

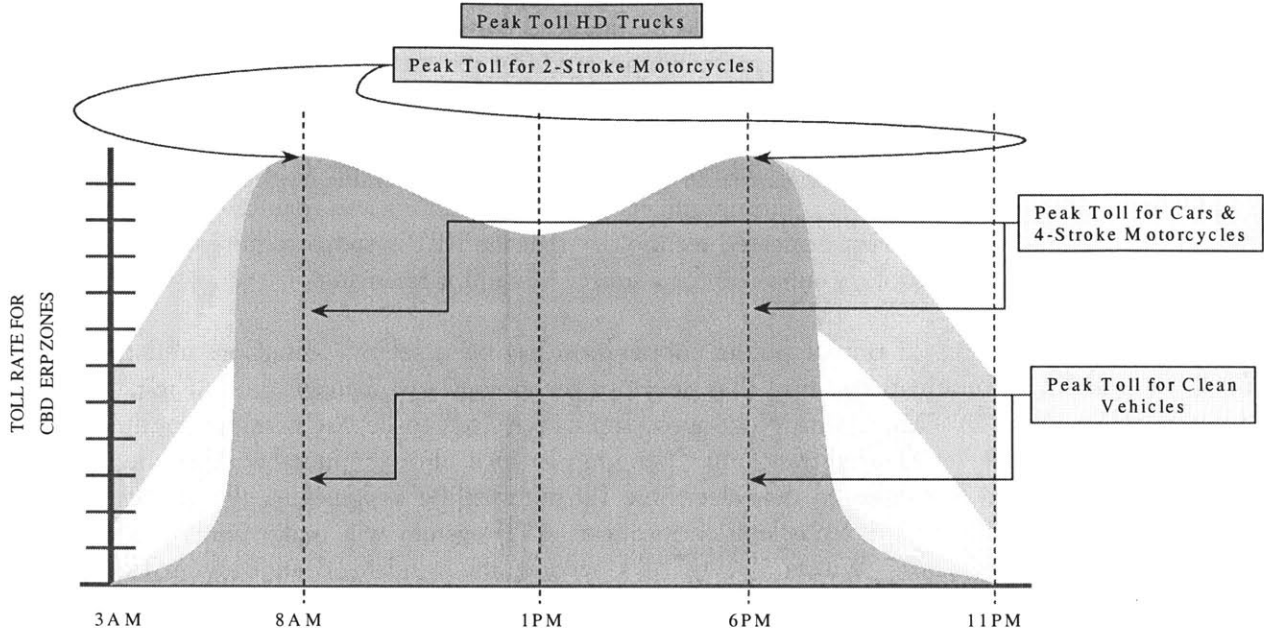
Tolling Strategies

Two tolling strategies will be described, the first is based on defining “families” of vehicles and applying stratified tolls to these categories depending on the time of day. Vehicles are classified into four pricing categories: heavy-duty trucks, 2-stroke-motorcycles, cars and 4-stroke motorcycles, and clean vehicles. The chart below illustrates a possible tolling structure that aims to reduce overall traffic in the CBD, particularly during the morning and evening rush hours. Evening delivery of goods by heavy-duty truck is encouraged by maintaining a high toll rate throughout the day, followed by precipitous decline between the evening and morning peaks. By allowing a toll-free window from 11pm to 3am, this strategy clearly aims to consolidate all the heavy-duty traffic into the middle of the night. Deliveries made at this time will be less disruptive to passenger traffic, and additionally Ozone creation will be eliminated due to a lack of sunlight.

²⁸⁸ It is unclear if it is legal for private enterprises to toll the public in China. If there are legal barriers to direct toll collection, a special purpose entity could be formed by the GMG to administer the tolls and remunerate the private investors.

²⁸⁹ Gregorski, Tim. (2000) *A Look Back at the Year in ITS*. In: *ITS World*: November-December 2000 Scranton Gillette Communications Vol.5 Num.6

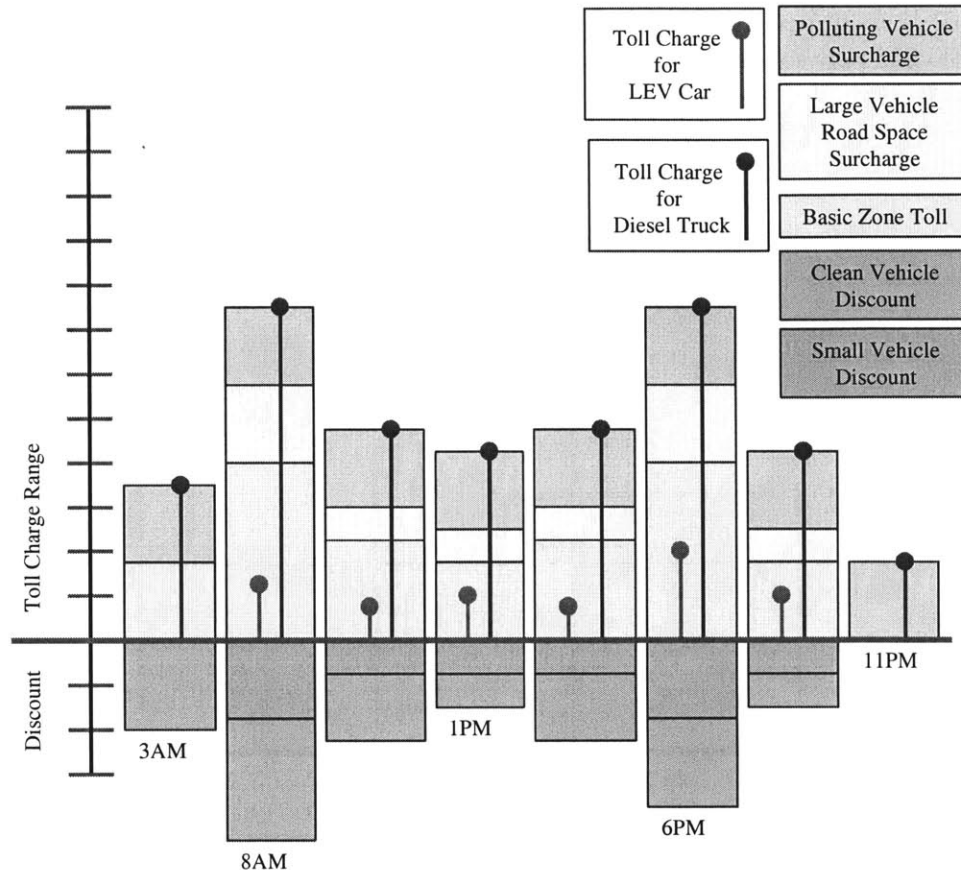
Figure 64: Eco-ERP Tolling Strategy #1



2-Stroke motorcycles are the highest per capita polluters in Guangzhou's vehicle fleet. However, these inexpensive vehicles have played an important role in the growth of the service sector and their outright elimination, as is currently suggested, may have severe socioeconomic ramifications. The growing restrictions that Guangzhou has placed on the use of bicycles further exacerbate this effect, as they are the primary substitute for motorcycles. Consequently, encouraging a shift to less polluting 4-stroke motorcycles may be the best possible solution for the city. This tolling strategy reduces the toll rate for 4-stroke motorcycles to reflect a reduced environmental impact. Since the difference in purchase price between the two varieties is relatively small, it is expected that a relative increase in the ownership-cost of a 2-stroke vehicle will have a strong impact on demand.

Clean vehicles such as Low Emission Vehicles (LEV), Gasoline-Electric hybrid, and Zero Emission Vehicles (ZEV) are tolled at very heavily discounted rates throughout the day and night. Initially, the city may opt to forgo all tolling for clean vehicles. A complete removal of tolls from these vehicles could be employed as an indirect subsidy to the clean technology market, since the cost of road-space use would not be recouped from the user. This could be an innovative approach by the government to preempt resistance from the local automobile manufacturers. Lowering the relative cost of ownership for these new technologies may help to promote the development of local production of clean technologies including Hybrid cars and electric scooters.

Figure 65: Eco-ERP Tolling Strategy #2



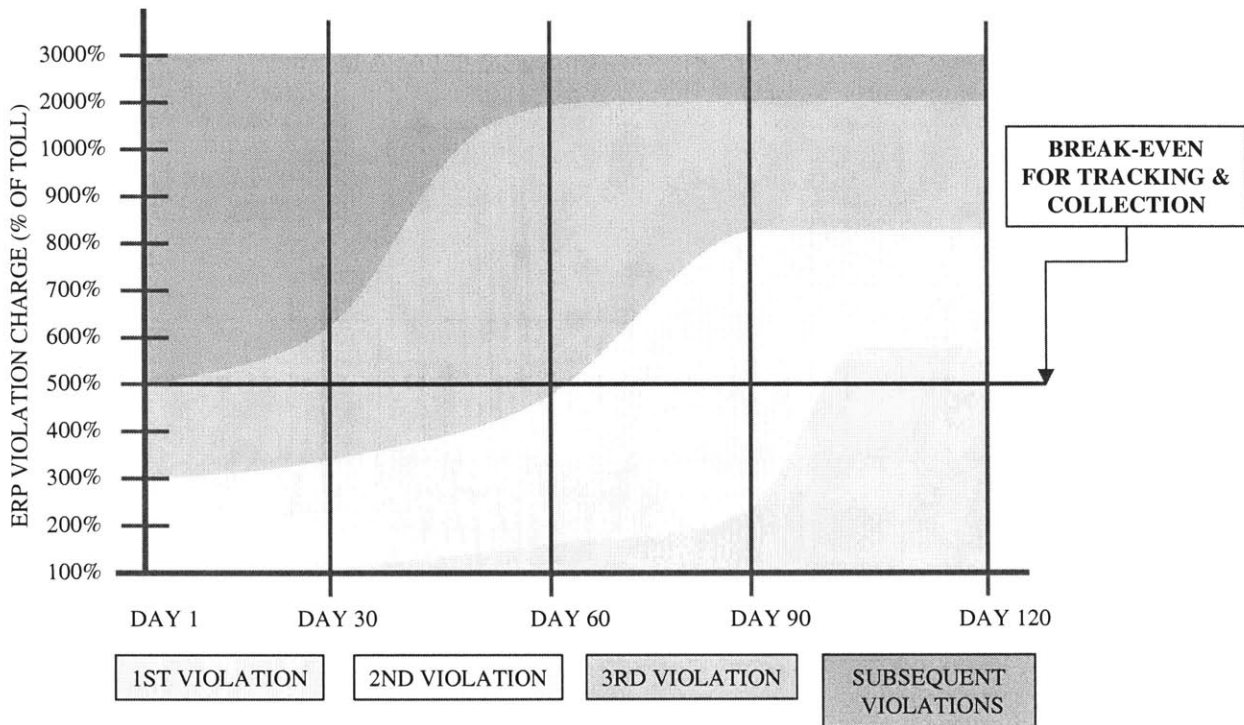
The second tolling strategy is based on a graduated structure that avoids arbitrarily grouping vehicles into family in spite of differences in size and emissions. Each vehicle, regardless of classification would be evaluated on two measures: size and emissions. Large vehicles, be they buses, light trucks, or heavy trucks would be required to pay a “large vehicle surcharge” to account for the cost of additional road-space. Likewise small vehicle such as 2-seat cars and motorcycles might receive a discount from the base toll rate. The emissions factor of vehicles would also be tested and evaluated on a semi-annual basis as part of the existing inspection and maintenance program. A rating for emissions levels would be made independent of the vehicle type. More polluting vehicles (diesel trucks, 2-stroke motorcycles, and old cars) would be subject to a pollution surcharge. Cleaner vehicles would receive a corresponding discount.

Enforcement Strategy

The problem of developing an efficient and effective enforcement of the tolling regime in Guangzhou must be addressed. The Guangzhou Public Security Bureau (GZPSB) will be hard-pressed to track and ticket every non-compliant user in each ERP cordon due to financial constraints. The violation charge strategy depicted below is an initial attempt at devising a system by which users will be naturally enticed to comply, as the potential threat of very severe fines is high. Secondly, should a user opt to violate the regulations of the CBD, the cost of the violation will be sufficiently high to warrant the effort and finance the costs associated with identifying, tracking, and billing him. The underlying motive is not to punish those who have accidentally become non-compliant. Rather it is to identify

and isolate the most egregious delays in payment and repeat offenders. By concentrating on the worst examples, the GZPSB will be able to clearly illustrate that voluntary compliance is worthwhile. In so doing, the goal is to virtually eliminate intentional offences. The high fine structure imposed by Singapore (USD \$25 per violation) was effective in this regard.

Figure 66: Eco-ERP Enforcement Strategy



*Revenue Use Strategy*²⁹⁰

Revenues derived from the ERP must first payback the private investors or technology providers for capital costs plus an adequate return. This return on investment (ROI) should be pre-determined. The ROI of the private consortium may be negotiated as Net Present Value target, an allowable rate-of-return, or a set period for private toll collection by the investors.

The manner in which the government plans to allocate revenues from ERP will determine, in large part, the socioeconomic and political feasibility of the system. In general, once the system has been transferred from the private developers to government ownership the revenues should remain within the transport sector. Road use charges should not act as pure taxes, but rather as instruments to finance transport sector investment and services. There are three primary recommended uses for these revenues: Direct subsidies for economically disadvantaged citizens, non-revenue-generating transportation infrastructure investment, and improvements to mass transit systems. In Guangzhou, in order to implement this scheme effectively and with minimal impact on commuters' lives the development of a comprehensive, efficient, and affordable system of public transportation must be a priority. The revenues derived from congestion pricing should be used primarily for this purpose. Linking ERP to improved public transport services would go a long way toward improving public

²⁹⁰ Adapted from: Santos. (1999). *Road Pricing on the Basis of Congestion Costs: Consistent Results from Two UK Towns*. Cambridge UK.

sentiment towards these charges. Other uses for revenue could include developing non-motorized transport facilities and providing transit subsidies to the poorest city residents.

9.5.5 Potential Obstacles

Demand transference. The problem of *demand transference* to the outlying areas and roads must be carefully studied and modeled to assure that the matrix connecting the city centers does not become overloaded.

Demand creation. The program if successful may result in a new modal split, as more people opt not to use private vehicles. This newly created demand for public transport can push the existing public transit systems beyond their carrying capacity.

Insufficient toll revenue. The relatively low-income levels may make a self-sustaining revenue based model impossible in the near-term. Further analysis including extensive demand forecasting, willingness to pay, and ability-to-pay must be conducted to determine the initial financial viability.

*Political and public opposition*²⁹¹

It is important to understand that the introduction of the demand management programs (the ALS and ERP) in Singapore was incredibly unpopular. Public reaction to the policies ranged from anger to disappointment. The public believed the policies were infringements on property rights, mobility, and a general nuisance. The political structure of Singapore's government enabled the suppression of this dissent and implementation of policies without regard for public support. There were efforts made, after implementation, to address these grievances through information dissemination, but there was no feedback mechanism to deter or influence the policy makers. It is easy to imagine that resistance to such policies in the US, for instance, might be much more vocal. Due to the representative nature of the policy-making bodies in the US, such policies might never be considered publicly let alone instituted. The political dynamics in Guangzhou are similar to Singapore in some respects. As such, we might expect the government of Guangzhou to have less difficulty in implementing unpopular programs.

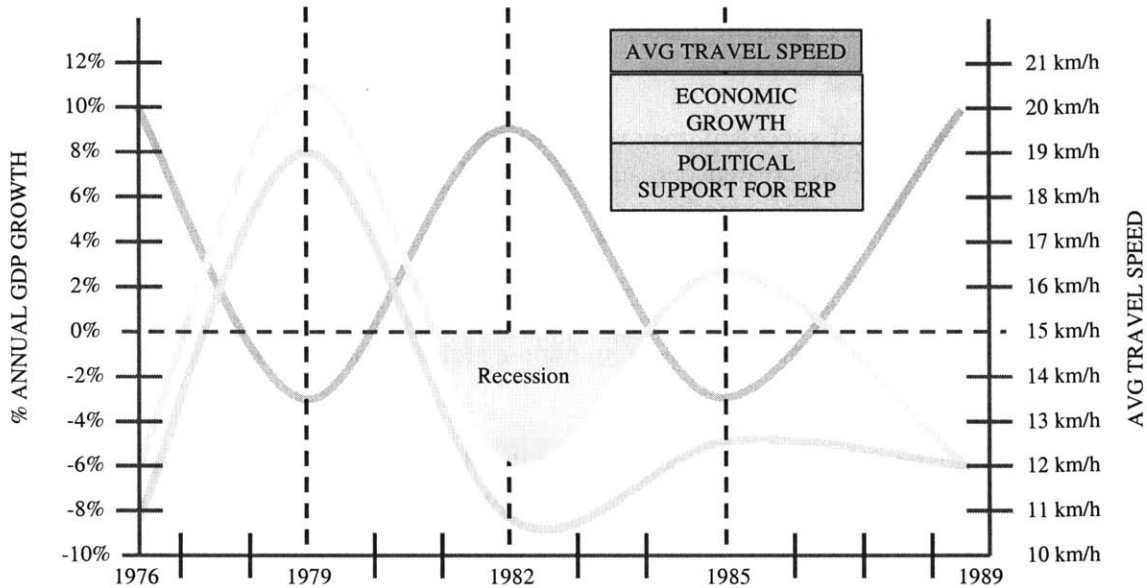
Nonetheless, the difficulty of obtaining political and social support is the most serious obstacle in the way of ERP implementation. To date the only urban-ERP system ever put into use is Singapore's. Numerous cities and countries have conducted feasibility studies, but efforts have run-afraid in the face of intense political resistance. The political opposition to congestion pricing is driven by: privacy concerns, equity-impact concerns, automobile manufactures, and a fear of innovation.

- *Political resistance.* An examination of the Hong Kong ERP case study demonstrates a strong correlation between political support for pricing and general economic health. As the graph below shows proponents of ERP found that as the economy expanded and income levels increased the level of congestion worsened. Correspondingly, support for congestion pricing increased. As support gathered, the government commissioned a detailed study. However by the time the study was completed the economy was in recession. The lower economic activity reduced disposable income and demand for travel dropped. As demand dropped the average travel speed increased. Confronted with less income, a pessimistic economic forecast and improved travel conditions the public and political support for congestion pricing vanished. This dynamic may not yet be applicable

²⁹¹ Gomez-Ibanez. (1995). *Road Pricing for Congestion Management: A Survey of International Practice*. National Academy Press. Washington DC.

to Guangzhou, but the city would do well to understand it and anticipate similar effects in the not too distant future.²⁹²

Figure 67: Political Support for ERP in Hong Kong



- *Privacy concerns* are now largely allayed as the stored-value smart card allows anonymous tolling.
- *Equity-impacts* in developing cities is not a real concern. The tolled population represents the wealthiest segment (there are no poor drivers).
- *Automobile manufacturers* pose a serious threat to implementation in Guangzhou unless they can be preempted of their opposition. One strategy for establishing a collaborative partnership would be to allow certain vehicles to drive toll-free (hybrid, electric, LEVs).
- *A fear of innovation* is driven by the lack of knowledge, understanding, and trust on the part of citizens. People often do not understand the reasoning or benefits of pricing, they do not trust the institutions in power, and they are leery of the technology involved. The primary vehicle to overcome each of these obstacles is information. Governments must make a determined effort to openly publicize their intentions and plans, explain reasoning and technologies, and seek public consensus for innovation. When these concerns have not been addressed forthrightly, resistance has coalesced and the initiative has been stymied.
- *Lack of advanced information infrastructure.* An effective ERP enforcement strategy requires a complete national, up-to-date, accessible vehicle registration database, which can be accessed automatically. This system is not always available in developing cities. On-the-spot fines for violators may be the only enforcement policy possible. This solution has serious implications for Guangzhou in that

²⁹² Yam, Kong. Director Hyder Consulting. Hong Kong. 6/2001 Interview.

road space is required to deal with offenders, there is the possibility of corruption, and a large number of offenders may induce congestion at the control points. Induced congestion may be so great that the benefits of the ERP scheme are eroded.

9.6 Transit Oriented Development

The spatial distribution and density of land use activities influences demand and opportunities for mass transit development. Likewise, the development of mass transit corridors, in this case BRT corridors, influences the characteristics of land use in their vicinity. The realization that there is an important correlation between land-use planning and transportation planning is an important one that the Guangzhou municipal government is now beginning to face. The Guangzhou Urban Planning Group has acknowledged that transportation-based land use planning is a vital component of effective travel demand management systems and necessary for the encouragement of optimal mode mobility decisions.²⁹³ Development of an integrated BRT system in Guangzhou will provide a structural axis to guide the city's anticipated growth into the near future. However, the experiences of other municipalities offer a note of caution in this regard. Where bus corridors have been characterized by heavy traffic flows, poor quality vehicles, high emission and noise the result have been discouraging. On the other hand, the successful examples in Bogotá and Curitiba demonstrate that an efficient and integrated BRT system can promote dense land use, improve accessibility, and reduce demand for private vehicle use.²⁹⁴

9.6.1 Recommendation Drivers

- ❑ Intensive mixed-use development will be vital to the long-term financial viability of mass transit corridors in Guangzhou.
- ❑ TOD concession, leases, and land sales provide a unique opportunity to generate much needed revenue for the GMG.
- ❑ New development along transit lines will enhance economic activity and increase the local tax base.
- ❑ As the level of motorization in Guangzhou increases dramatically, the need for coordinated land-use planning becomes even more pressing. As more people have access to private vehicles, development patterns will likely become diffused if unregulated.
- ❑ Uncoordinated lower-density development patterns can lead to increased costs for roadway investment, increased total land use, increases environmental impact, reduced green space, and higher per capita utility costs.²⁹⁵

9.6.2 Goals

- ❑ Transit oriented developments represent opportunities for more intensive development and less sprawl resulting in reduced auto congestion, reduced air pollution, and lower infrastructure costs.
- ❑ Increase accessibility to affordable, low cost transportation.
- ❑ Increased ridership and revenue for the BRT system to support a financially self-sustaining mass transit system.
- ❑ Increased government revenues.

²⁹³ Mr. Liu, Director of the Guangzhou Urban Planning Research Institute. Interview June 2001.

²⁹⁴ Fox, Halcrow. (2000). *Mass Rapid Transit in Developing Countries*. World Bank Urban Transport Review. Department for International Development. London.

²⁹⁵ Litman, Todd. (2001). *Land Use Impact Costs of Transportation*. Victoria Transport Policy Institute. Victoria. Canada.

9.6.3 Implementation Strategy²⁹⁶

Multiple strategies must be employed to help assure that a transit-oriented development policy achieves the desired results. These strategies should be based on the premise that urban planners must do more than just passively expect efficient development along transit corridors. Planners must assess the market demand for development, actively encourage developers to participate in transit-oriented development, promote private development through public investment, and uncover innovative opportunities to partner with the private development community. The primary tools at the disposal of government planning agencies are: market analysis, financial incentives, funding sources, regulations, and direct public action.

Assessing Market Potential

A first important step in implementing TOD is to assess the market for financially viable development by evaluating the potential demand for residential and commercial development long planned transit corridors. “Market analysis for TOD involves understanding the multiple levels of the economy and the real estate market. A comprehensive market analysis process involves the review and assessment of market factors at various levels within the regional market. Such an analysis provides a general idea of the types of development that could be located successfully within the transit corridor area. The information gathered from a market analysis should be incorporated into an action plan or market strategy for promoting TOD.”²⁹⁷ A wide range of factors determines the potential market for transit-oriented development. Each location along a corridor will respond to different strategies and have different influences. According to Scandola (2001), the following guidelines should be followed by municipal agencies to aid in the assessment of development opportunities:

- ❑ Define TOD objectives concisely.
- ❑ Understand government responsibilities for TOD.
- ❑ Determine realistic expectations for each corridor and location.
- ❑ Understand that developers make real estate decisions based on market forces.
- ❑ Demonstrate a public commitment to private investors.
- ❑ Understand that the primary determinant of market potential is location.

Providing Financial Incentives

A number of financial incentives have been used to fund transit-oriented development projects around the world. Many of these tools innovatively pool public resources for funding projects that benefit communities. The following are a list of some of these incentives and their legislative status.

- ❑ Tax Increment Financing: Captures the additional property taxes generated by private development projects to finance the up-front public development costs. These funds could provide the necessary amenities to help spur development in targeted locations.
- ❑ Tax Incentive Zones for Transit: Tax breaks for mixed-use developments in targeted locations, such as areas around transit stations and along transit corridors. Fostering development in these areas would provide access to transit to a greater number of people, thereby reducing the need for automotive use.

²⁹⁶ Adapted from: Scandola, John. (2001) Transit Oriented Development in the Central Puget Sound Region. Washington State.

²⁹⁷ Scandola, John. (2001). *Market Context for Assessing Development Potential*. TOD in the Central Puget Sound Area. Washington State.

Pursuing Funding Sources

Pursuing various funding sources that will support development activity and leverage private investment is an important component of a TOD implementation strategy. “There is no single source of funds designed to facilitate transit-oriented development. The sources of capital funding available are the same as those used for regular municipal infrastructure development. The funding challenge is to use these resources in such a way as to maximize the potential development opportunities in a station area.”²⁹⁸

- ❑ A number of different funding sources may be required as part of a comprehensive and targeted funding strategy.
- ❑ “A targeted funding strategy will allow jurisdictions to link funding for infrastructure with the likely beneficiaries of the proposed improvement. This allows jurisdictions to extend their limited resources and lets them benefit from the increased value created by the public investment.”²⁹⁹
- ❑ Aside from taxation, co-development, and leasing sites around stations, transit systems can also raise some revenue by leasing space on vehicles and around stations for advertisements.

Improving the Regulatory Environment

Governments must create a permitting and regulatory environment that encourages rather than discourages transit-oriented development. Public policy has a powerful impact on the timing, magnitude, and nature of transit-oriented developments. Regulation that may be used to support development along transit corridors include:

Modify zoning and development regulations: When modifying regulations, it is important to consider market forces. Stringent land use regulations can discourage positive development activity, while very broad regulations may result development that is not desirable.

- ❑ In order to facilitate a closer proximity between residences and workplaces the land and housing markets should be deregulated.
- ❑ Designation of urban growth areas.
- ❑ Use of aggressive mixed-use zoning.
- ❑ Establishment of rigorous standards for density and design

Simplify the Permit Review Process: Extensive delays and uncertainty in the permitting process can be a significant deterrent to private development. “The permit review process plays a large role in both the time and level of certainty in getting development approval. Facilitating the permit process can provide a powerful incentive for TOD.”³⁰⁰ Some methods to streamline the permit review include:

- ❑ Remove or consolidate steps in the permitting process.
- ❑ Ensure that the applicable regulations are well organized and easily accessible.
- ❑ In anticipation of development proposals, the government may begin processing some of the permit steps.
- ❑ Allow for flexibility in the permit process.

²⁹⁸ Scandola, John. (2001). Transit Oriented Development in the Central Puget Sound Region. Washington State.

²⁹⁹ Ibid.

³⁰⁰ Scandola, John. (2001). Transit Oriented Development in the Central Puget Sound Region. Washington State.

Public Sector Initiatives

Proactive measures from the public sector are necessary to stimulate private sector involvement in TOD. “Transit agencies and local governments need to be more entrepreneurial, to seek and utilize regulatory tools and flexibility, to provide incentives or financing where appropriate, and to vigorously pursue and follow through with opportunities to work with the private sector. Opportunities to leverage public investments in station areas can maximize the potential for private investment.”³⁰¹

Some recommended public sector initiatives include: establishing development incentives, providing necessary public facilities and infrastructure, assembling land, helping to secure financing, and participation in joint development projects.

Establish Development Incentives: Depending on the economics of a given site developers may require fiscal incentive to commit capital. Incentives can be given in the form of bonuses for providing certain amenities, expediting the permitting procedures, providing direct payment for public improvements, or reducing tax rates for certain developments.

Provide Public Facilities and Infrastructure: Public infrastructure investment demonstrates a long-term commitment to a development plan and can spur increased private investment. Some of the public improvements along transit corridors could include green spaces, improved pedestrian facilities, or new drainage systems.

Assemble and Package Land for Development: One of the more powerful tools at the disposal of municipal governments is the ability to secure and package economically viable land parcels along the transit axis to promote TOD. Once secured, the parcels may be leased or sold to private investors.

Securing Project Financing: TOD, especially in blighted neighborhoods, can be stimulated by risk sharing and aggressive financial participation by the government. Underwriting the land costs is one means of risk sharing. In return, governments may require participation in project development or a stake in the equity generated. Alternately, a government agency might exchange a percentage of future revenues for accepting below-market rents from a project developer.

Joint Developments: Through cooperation of the private and public sectors in planning, designing, and constructing projects it is possible to maximize the contributions of and benefits to each sector. By employing joint development, transit investments and commercial/residential developments can be integrated to create value and public benefit. Joint development allows that the public to share in the value enhancements generated by the public investments through the management, sale, or lease of land or air rights near transit facilities.

³⁰¹ Ibid.

9.7 Institutional Reform

Successful implementation of sustainable urban transportation policy is dependent in large part on effective and efficient institutional dynamics and organization. While there is no single institutional arrangement that can be transposed on all locations, there are certain common characteristics shared by both highly effective and very deficient organizational structures. Guangzhou's administrative structure is the product of the command economy system, which dominated China since the 1950's. The institutional structure is characterized by a strong vertical orientation and rigid hierarchy, but a fragmentation of responsibilities and jurisdictions. The sub-organizations within the bureaucracy enjoy some autonomy and are able to generate limited independent income, but are plagued by a lack of resources and ill-defined boundaries of jurisdiction. The result is a series of administrative fiefdoms that jealously guard their assets and sources of funding. Consequently, the degree to which one arm of this bureaucracy is able to draw upon the resources of another is limited, and the incentive for collaboration and integration is absent. Thus, the municipal government's ability to implement and enforce integrated policies is severely restricted.³⁰² Accordingly, the development and deployment of comprehensive and capital intensive initiatives such as Bus Rapid Transit, Eco-ERP, and Transit Oriented Development is less likely.

In an attempt to define the criteria by which public organizations may be evaluated, we will employ a matrix to define the basic elements of these organizations and evaluate their operations. The chart below demonstrates some of the essential characteristics of government agencies as they evolve from traditional organizations to modern high-performing institutions. Guangzhou's municipal transportation bureaucracy has some traditional and transitional characteristics, as previously discussed.

Figure 68: The Evolution of Municipal Transportation Agencies: Guangzhou

| | TRADITIONAL (Public-Oriented) | MIXED (Transitional) | MODERN (High-Performing) |
|-----------------------------------|---|---|--|
| Regulatory Context | Regulation of multitude of processes. Operation of some regulated activities | Performance impeded by conflicting roles and responsibilities | Regulation of key outcomes and oversight only. Facilitation of private provision of services |
| Structural Characteristics | Large with many operations performed by public forces | Smaller size w/ increased outsourcing of functions | Focus on management of private contractors and monitoring results. |
| Core Services | Focus on technical and functional areas, not long-term strategy or integration. | Expected performance not clearly defined or highly valued | Commercial focus with strategic plan and transparent / efficient selection and monitoring of service providers |
| Financing Mechanisms | Dependence on government assigned funds. | Budgetary requests supported by performance-based evaluation. | Funds from stable mix of government and private sources. |

[Source: B&A&H]³⁰³

³⁰² MVA Asia Limited (1995). *Guangzhou Urban Transport Study (GUTS)*. Kuala Lumpur.

³⁰³ Adapted from: Booz-Allen & Hamilton (2001). *Recent Developments in Organizational Transformation*. Washington DC.

Contrastingly, in Singapore the LTA has the overarching responsibility for all aspect of policy formulation, implementation, monitoring, enforcement and infrastructure development.

Figure 69: The Evolution of Municipal Transportation Agencies: Singapore

| | TRADITIONAL (Public-Oriented) | MIXED (Transitional) | MODERN (High-Performing) |
|-----------------------------------|---|---|--|
| Regulatory Context | Regulation of multitude of processes. Operation of some regulated activities | | Robust regulations in place, highly integrated and enforced transport and land-use policies. |
| Structural Characteristics | Large with many operations performed by public forces | Small (70p) highly skilled work force, well developed mission | Focus on management of private contractors and monitoring results. |
| Core Services | Focus on technical and functional areas, not long-term strategy or integration. | | Transparent public tenders in place according to WTO guidelines |
| Financing Mechanisms | Dependence on government assigned funds. | Budgetary requests supported by performance-based evaluation. | LTA bonds, public-private partnerships, advanced tolling system for revenue |

[Source: BA&H]³⁰⁴

Important internal and external actors must have a sense of urgency perhaps even crisis in order to instigate major reforms within an organization. Thus, if in spite of some severe shortcomings, the current system is functioning and there are no major foreseeable crises, the entrenched bureaucracy will resist any attempt to streamline or consolidate. Resistance may be met as a result of two important factors: such transformations will almost assuredly require cutting jobs, and the perceived risk of changing the status quo allocation of power will threaten the established fiefdoms. Two primary questions then remain:

- 1) What are the specific disadvantages to remaining within the transitional framework that *drive* the need for transformation (i.e. create a crisis)?
- 2) How does an agency facilitate and expedite the transformation process, so that it may operate according to the “Best Practice” model for a modern transportation institution?

9.7.1 Recommendation Drivers³⁰⁵

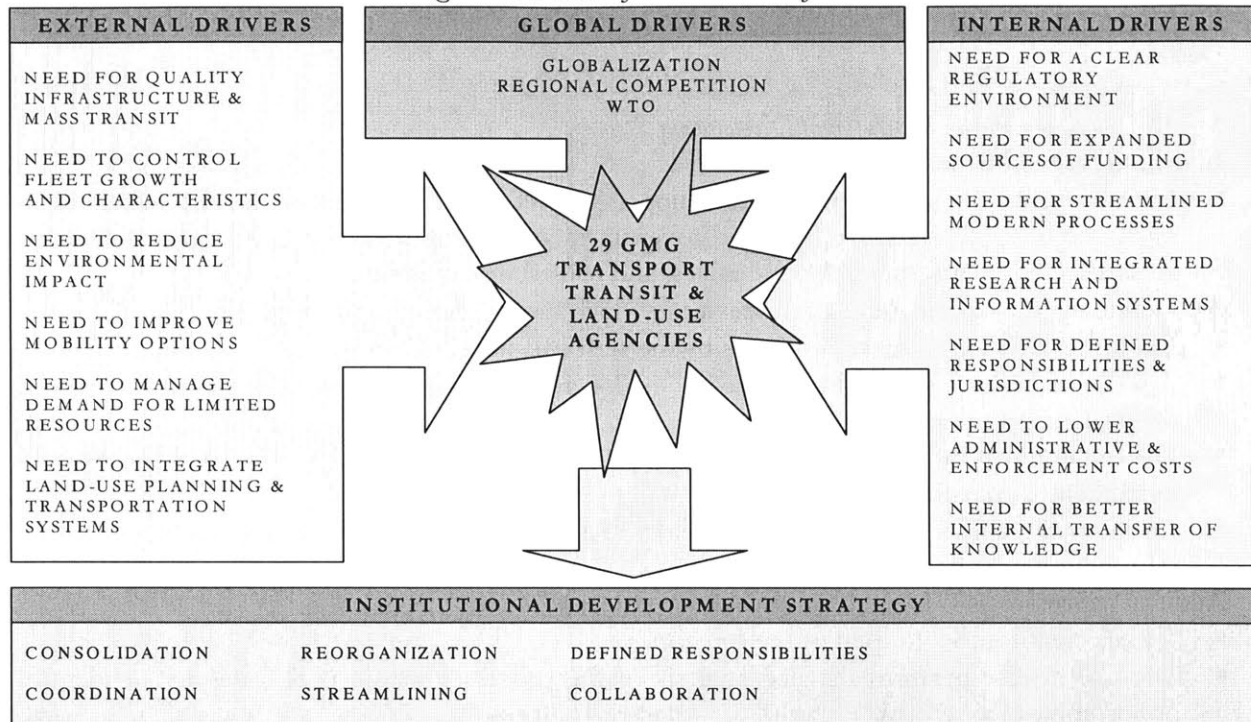
The three primary sources of “drivers” for our recommendation to implement an institutional development strategy are internal, external, and global. Internal drivers are defined as forces that originate from within the organization as it struggles to achieve its objectives. The external drivers are those pressures, which are exerted on the organization from the context in which it operates namely the pressing need to develop a sustainable and integrated transportation and land-use system. Global drivers are the macro-economic forces that are redefining the roles of cities and governments the

³⁰⁴ Ibid.

³⁰⁵ Adapted from: Recent Developments in Organizational Transformation. (2001) Booz-Allen & Hamilton. Washington DC.

world over. All three converge to exert tremendous pressure on municipal government agencies, and in this example, transportation departments in particular.

Figure 70: Drivers of Institutional Reform



[Source: BA&H]³⁰⁶

9.7.2 Primary Recommendation

Institutional structure and organization clearly impact the effectiveness with which an agency can perform its duties. The deeply fragmented structure of Guangzhou’s urban planning and transportation agencies’ organization may require substantial transformation in order to operate effectively. However, we must be careful not to generalize too broadly or to oversimplify the political realities that have created the system. Our primary recommendation, therefore, is for Guangzhou to begin a process of examination, analysis, and dialogue to discover its own unique, optimal organizational structure. The process by which this endeavor may be embarked upon is the development of an *Institutional Development Strategy (IDS)*³⁰⁷. Some specific institutional reform recommendations will follow at the end of this chapter, but these have been synthesized from general “Best Practices” and have not been evaluated by the GMG for applicability or feasibility.

9.7.3 Goals of an Institutional Development Strategy³⁰⁸

- Building internal consensus is vital to the process, without it the protective fiefdoms will hinder the process in an attempt to protect their “turf”.
- Defining an achievable vision with a realistic time horizon is essential. This vision must be clearly articulated and transmitted throughout the hierarchy in order to promote the evolution of the organization.

³⁰⁶ Ibid.

³⁰⁷ Adapted from: Recent Developments in Organizational Transformation. (2001) Booz-Allen & Hamilton. Washington DC.

³⁰⁸ Ibid.

- Elimination of unnecessary processes: Rather than seek the most efficient way for government bodies to administer the operation of a ‘privatizable’ function, the emphasis must be on the removal of that process from the jurisdiction of the government. This is inherently difficult as it involves the voluntary surrender of influence, funding, and personnel.
- Developing results that are reinforcing so that gains are multiplied as more is achieved over longer periods.

9.7.4 Steps to developing an Institutional Development Strategy³⁰⁹

- Initial internal assessment
 - Initiate a series of workshops with all major stakeholders in the organization. The stakeholders might include representative from the government agencies, private bus operators, residents of areas affected by transportation initiatives, and real-estate developers.
 - Define the major categories of processes in which the organization participates.
 - Internal evaluation of these processes by the staff and stakeholders.
 - A sense of urgency should be fostered by highlighting the major drivers, the global forces, and the probable result of inaction.
 - Presentation of “Best Practices” scenarios to demonstrate potential outcomes of a successfully implemented transformation.
 - An internal analysis of the strengths, weaknesses, opportunities, and threats (obstacles) to the reformation process from the participants.
- Audit of processes
 - Assign “task forces” to each of the categories.
 - The task forces perform detailed analysis of the processes within each category to identify opportunities for reform.
 - Compile an audit report with the important findings and suggested courses of action.
 - Conduct post-audit meetings to develop alternative solutions that meet resistance from stakeholder representatives.
- Recommendations for reform
 - Develop a detailed time-sensitive implementation plan for the solutions identified.
 - Identify specific persons or groups that will be responsible for the various tasks.
 - Publish a final report synthesizing the audit findings, solutions, and a specific timetable for reform

9.7.5 Organizational Transformation³¹⁰

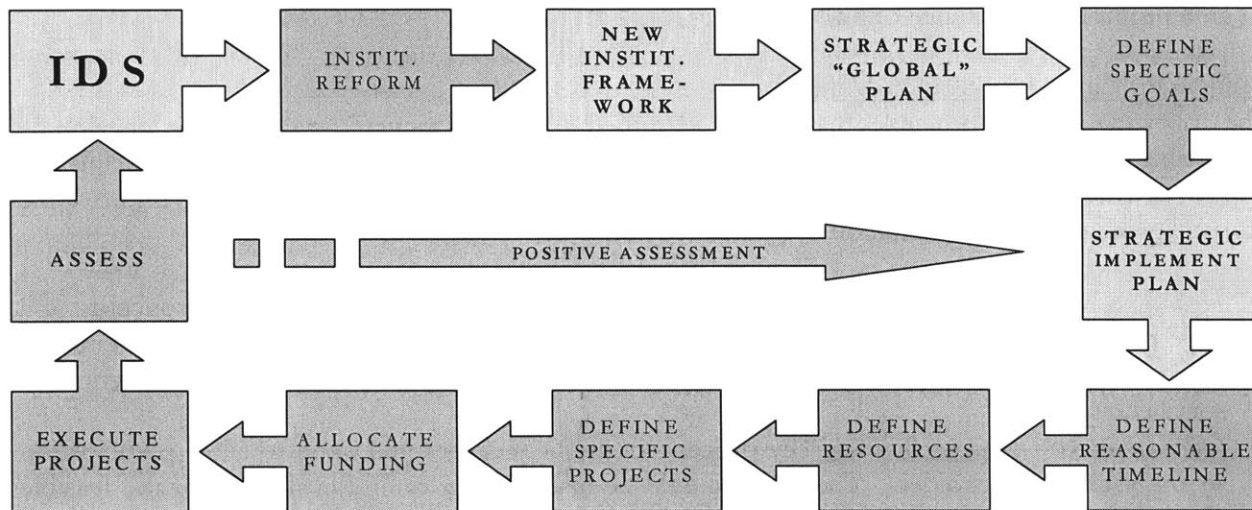
Following the implementation of the IDS process, a number of institutional reforms are to be expected. These reforms should result in a new framework that will facilitate strategic planning within the GMG transportation bureaucracy. The strategies, goals, and eventual projects that flow out of the new framework should be defined by a cohesive vision and contribute towards its realization. A strategic “global” transportation policy plan should be formalized which includes land use development, level of service objectives, resource constraints, and a prioritized plan for public investment. The strategic plan should clearly define the mission of the municipal government agencies with regard to transportation policy and identify specific attainable performance and operational goals. Once these goals have been defined, an implementation plan should follow.

³⁰⁹ Ibid.

³¹⁰ Adapted from: MVA Asia Limited (1995). *The Guangzhou Urban Transport Study (GUTS)*. Kuala Lumpur.

The implementation plan should identify a reasonable timetable for accomplishing its objectives, quantify the available resources, and prioritize projects based on their relative effectiveness to realize the desired goals. Funding allocation for the most important and promising projects would be followed by project execution. Following project execution, the entire process should be reexamined and an assessment must be made as to the effectiveness of the reforms. A positive assessment of the changes would lead naturally back to the implementation plan, where a new set of projects would be identified, funding allocated etc. However, if the assessment identified shortcoming, errors, or omissions the IDS process might be revisited. Again, the stakeholders would have the opportunity to contribute to the evolving process of organizational transformation.

Figure 71: Organizational Transformation Process



9.7.6 Recommended Institutional Reforms³¹¹

Responsibilities and Accountability

- ❑ The GMG should divest itself of commercial responsibilities and focus on the task of strategic planning, policy development, implementation, and oversight.
- ❑ The GMG should also focus on defining the parameters in which the commercialized activities of the private sector take place (for instance, by setting performance standards, developing strategic plans, and developing effective regulatory systems).
- ❑ Accountability should be fostered using a performance management and evaluation framework and positive incentives for internal staff.
- ❑ An emphasis on transparency should be encouraged, as it is often a necessary precursor to private investment.

Regulatory Regimes

- ❑ A regulatory body should be formed to oversee the process and coordinate the public transit system. In order to avoid a conflict of interest, this body should not participate in the operation of transit systems. Rather it should provide the context in which the appropriate combination of commercial freedom, social obligations, and reasonable rates of return may be defined for private investors.

³¹¹ Some recommendations have been adapted from *The Guangzhou Urban Transport Study*. (1995). MVA Asia Limited. Kuala Lumpur.

- ❑ Constraints to efficiency and productivity within the regulatory context should be identified and prioritized for reform. Reform should be undertaken with the input of both governmental and public stakeholder groups.
- ❑ Construction and maintenance of roadways, bridges, and transit systems should be performed in the private sector, using private funding when possible. When private financing is not viable, the government should employ competitive tenders to ensure an efficient use of public funds.

Integration and Coordination

- ❑ Land-use planning, transportation planning, infrastructure development, and public sector investment planning should be pursued in an integrated manner.
- ❑ Information technology should be employed rigorously to reduce costs, improve customer service, and promote transference of knowledge.

Guiding Principles for Decision Making³¹²

The following guiding principles have been identified as “Best Practice” examples for developing sustainable urban transportation policy in OECD countries. Adoption of similar guiding principles by the GMG would contribute to further effectiveness, help to yield informed decisions, and improve the probability of actual implementation of innovative policies.

- ❑ *Holistic*: The decision making process must be holistic, it should incorporate a the concerns of a wide range of stakeholders including the private sector, government agencies, and private citizens. The process must also account for the impact of decisions on the economy, environment, and social equity.
- ❑ *Collaborative & Consensus Building*: The process should be inclusive and open to allow participation by the various stakeholders. Decisions should be made after a careful evaluation of the feasible alternatives has confirmed that the chosen approach is most appropriate.
- ❑ *Flexible & Adaptable*: The process must be able to respond to a continually changing context and to unforeseen events. In the midst of Guangzhou’s turbulent economic expansion it is vital that the rigidity of rules is minimized, and that an environment that fosters a dynamic approach is promoted.
- ❑ *Informed & Transparent*: Participants in the decision making process must understand the process in its entirety. It is also important that each participant knows his role, and understands the analysis that is conducted to support policy decisions. The climate should support the flow of information between the stakeholders and decision-makers so that all impacts are carefully considered.

³¹² Adapted from: *Institutional Framework for Implementing Sustainable Urban Travel Policies*. (2000). US DOT. Washington DC.

10 Lessons Learned

Developing mega-cities cannot focus solely on the supply of additional infrastructure to address problem of urban mobility; they must also manage the demand side of the equation.

There is little doubt that developing cities must build an adequate supply of road space to enable the efficient internal movement of cars and trucks. However, even when the road supply is supplemented with extensive public transportation there is little hope of reaching a balance between supply and demand. This disequilibrium is caused by the increasing rate of motorization, which is a function of both population and economic growth, and by the effects of latent demand, which quickly subvert the aim of increased road supply. In mega-cities in particular, there can be no single solution to address the bottleneck.

In the past, many developing cities were leery of putting any restrictions on automobile use, but as we have demonstrated, these fears were unfounded. In Bogota and Singapore, the use of various restrictive measures to curtail automobile use has been accompanied by economic growth, not stagnation. In fact, public transit orientation and the provision of good pedestrian and bicycle infrastructure may be one key to future economic competitiveness. As these “global” cities compete to attract high-paying service sector jobs and highly skilled labor, the environmental condition of the city becomes increasingly important.

In Singapore, we have seen that when road capacity is scarce it may be treated as a valuable resource to be rationed and not a physical constraint to development. Furthermore, we have seen that road pricing schemes such as Singapore’s ALS and ERP are highly effective at controlling congestion and thereby reducing the environmental impact of car use. The pricing mechanism is most effective when it is highly sensitive to the current traffic conditions. Road pricing can also be an innovative source of revenue for cash strapped municipal governments. However, as our example in Honk Kong demonstrated road pricing is also difficult to implement. Significant political pressures prevent many governments from enacting it. This backlash against pricing from the public may be co-opted by careful redistribution of revenues back into public transport. This is the case in Singapore’s where restrictive car ownership (VQS) and car use (ALS & ERP) policies have been complemented by continued investment in its world-class public transport system. All the revenues generated by these policies are plowed back into increasing the efficiency, comfort, and accessibility of the public transport system. It is important that road pricing strategies are employed as early as possible to avoid potentiality regressive effects and to prevent the emergence of a car-dependant culture.

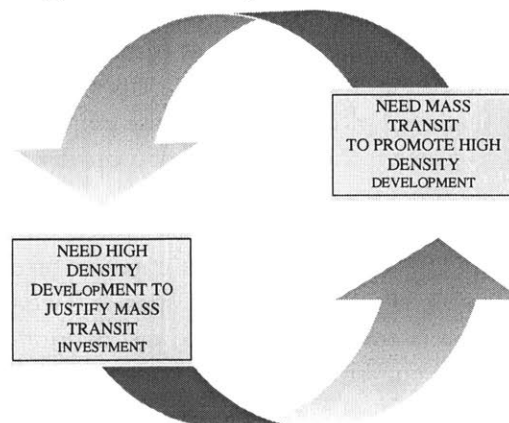
In Bogota, car use restrictions to reduce congestion were employed through a command and control policy, the Pico y Placa regulation. The successful implementation of this measure was in large part due to the overwhelmingly inequitable allocation of road space. Twenty percent of the population used of 95% of the road space, therefore the benefits to the vast majority of the city’s citizens in terms of increased travel speed and reduced emissions, enabled the city to garner sufficient public support for a highly restrictive measure. In general, we may deduce that lower motorization rates will enable developing mega-cities greater leeway in implementing effective TDM policies.

Developing mega-cities must employ a broad mixture of demand-management programs, public transport improvements, and land-use policies *simultaneously* in order to significantly improve mobility.

Singapore pursues an aggressive policy of Transit Oriented Development and high-density development to reduce latent demand. By locating business, shops, and homes in dense clusters around the major rail and bus lines, Singapore has managed to alter the trip distribution considerably thereby reducing the socioeconomic impact of road pricing. . The advantages of integrating land-use planning and transportation planning cannot be overstated. A well-integrated land-use policy can facilitate lower car use and help to ensure that mass transit systems are profitable, without undo socioeconomic costs. Singapore has been particularly successful in this regard.

Bogota's TransMilenio Bus Rapid Transit (BRT) is a prime example of supplementing car use restrictions with heavy investment in alternate transport options. For many developing cities, where fiscal constraints prevent the construction of an underground subway or light rail transit (LRT) system, BRT becomes a politically and economically desirable solution. BRT systems using exclusive right of way, high-capacity vehicles, and electronic ticketing systems can serve as an excellent low-cost alternative to LRT. Furthermore, the transferability of the right-of-way and the guidance, ticketing, and information technologies means that when LRT becomes financially feasible the investments made in BRT are not lost. The development of segregated BRT routes along the major thoroughfares offers developing cities a unique opportunity to provide an high level of service while building demand for a possible future investment in LRT. This dynamic 'demand building' can help municipalities to avoid a vexing dilemma typically faced by planners when designing mass transit for newly developing corridors. High quality, high-capacity mass transit is required to promote the dense development patterns that reduce congestion and provide accessibility, but mass transit systems (particularly rail) require large concentrated markets to be viable. The future fixed guide-way investment can thus be made with a lower market risk, as the initial BRT system would provide the testing grounds for adequate demand levels to warrant the expenditure.³¹³

Figure 72: The Transport Planner's Dilemma

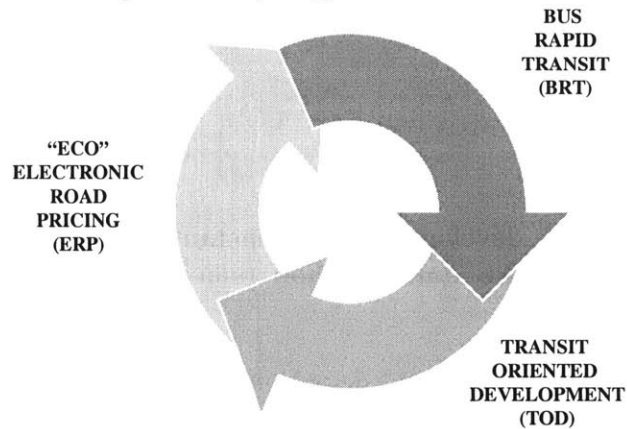


³¹³ Kang, Alice. (2000). *Bus Rapid Transit: An Integrated and Flexible Package of Service*. Booz Allen & Hamilton. Virginia.

Our recommendations to the city of Guangzhou are the product of a similar tripartite approach to the mobility problems faced by the city. Each component (demand management, public transport investment, and land-use planning) contributes to the effectiveness of the other elements in an integrated manner. Together these pieces work synergistically to achieve greater sustainability.

Eco-ERP reduces travel demand, which lowers congestion, but also provides the city with a new source of income. The reduction in travel demand facilitates the reduction in road supply that is required for segregated bus lanes and the income can be used to help fund and administer the BRT system. The BRT system, in turn, encourages development along the major corridors thus supporting the TOD land-use strategy (see above). Finally, a comprehensive TOD strategy reduces demand for private vehicle use thereby complementing the congestion alleviation of the ERP system and encouraging BRT use. Finally, higher BRT patronage leads to greater profitability that reduces the financial burdens on the city.

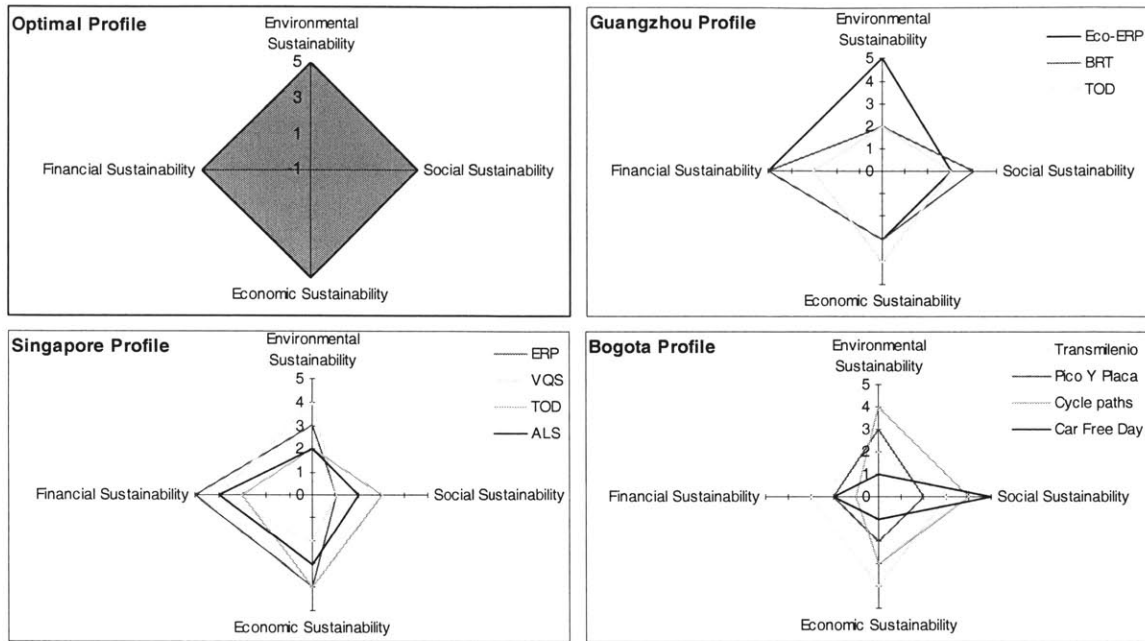
Figure 73: Reinforcing Recommendations



This 'closed loop' approach builds advantages through the interactions of policies and seeks to balance the environmental, economic, and social aspects of sustainability. Combinations of policies can be "mapped" to demonstrate their aggregated effect on the four essential criteria of sustainability. As demonstrated by Figure 74 below, by combining a varied array of transportation policies one can begin to optimize the overall system toward greater holistic sustainability. In making our choices for recommendations to Guangzhou, we sought to achieve a balance between the aspect of sustainability. While Singapore transportation policy mix leans heavily toward the financial criteria, it does so at the expense of socioeconomic costs (mainly the effects of the VQS limitation on car ownership). Contrastingly, Bogota stresses a high component of social equity, but has done so at considerable cost to the city financially. The conclusions drawn by this study prompted our decision to employ a mix of policies that nearly optimizes the total sustainability profile. Eco-ERP satisfies the financial component, TOD the economic, and BRT addresses the socioeconomic dimension.

Our recommendations do not pretend to identify the only set of policies that can contribute to comprehensive sustainability. Nor would the implementation of these policies be enough to guarantee sustainable development. Rather, this study and the recommendations we have made seek to enhance the understanding of the urban mobility dilemma in such a way as to improve the ability of policy and decision makers to make reasoned and informed choices.

Figure 74: Integrated Urban Transport Policy Profiles

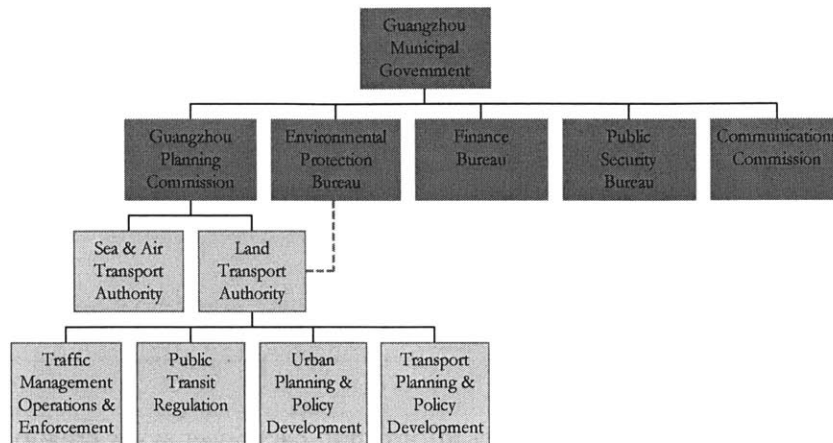


Developing mega-cities must develop adequate institutional capacity in order to design, implement, and enforce effective transportation policies and manage sustainable urban transportation systems.

While numerous innovative policies and regulations have been articulated in this study, an inability to effectively implement these policies can stymie the best ideas. Innovative policies often require unconventional implementation strategies. When these strategies require a very sophisticated institutional structure, extensive training, or the use of specialized technology, the result can be a failure in execution and not conception. Thus, the applicability of any given policy or regulation in a specific city must be considered in light of the existing institutional constraints with regard to implementation and enforcement. In this study we have sought to demonstrate that more effective coordination of a municipal government's processes and better-defined administrative responsibilities can be achieved by consolidating the government's transportation and city-planning institutions.

Singapore's LTA may serve as a potential model for institutional reform in developing cities. As is the case in Singapore, the transportation and land-use planning agencies can be merged to form an integrated urban planning and transportation bureau. While Bogotá's institutions are still characterized by highly fragmented and hierarchical structures typically found in developing cities, the recent reorganization of DAMA is a positive first step in this direction. The chart below (Figure 75) illustrates a simplified theoretical organizational structure that the municipal government of Guangzhou may want to consider.

Figure 75: A Potential Organizational Structure for Guangzhou's Transport Agencies



Organizational structure is but one component of institutional capacity. Transportation departments throughout the world are woefully under-funded and under-trained. As such they should actively develop and support innovative financing arrangements to achieve their objectives. Collaboration with and support of the private sector will provide new avenues for funding projects. With regard to the poorly the trained and paid transportation officials, it is increasingly important that government agencies, academia, and the private sector collaborate closely, as we have done in this study. Together these stakeholders and advisors may be able to define new strategies and to modify existing solutions to suit each particular cultural, technological, and institutional setting. Governments will also find that reducing headcount in bloated bureaucracies will enable them to hire fewer but better qualified and higher paid professionals to lead them on the path to greater economic competitiveness, environmental sustainability.

Final Thoughts

In 2000, the city of Guangzhou officially recognized the need to supplement infrastructure development with policies to curtail demand for private vehicle transport. This paper has sought to demonstrate that there are significant opportunities to learn from the experiences of Singapore, Bogota, and elsewhere when developing transportation policies and programs in Guangzhou. If Guangzhou seeks to develop a truly sustainable urban transport system that leads to improved air quality, reduced congestion, and greater economic activity it must approach the problem in a multi-dimensional manner. There will be no single cure-all policy for this seemingly intractable situation. The recommendations made herein must complement a host of other initiatives to create a sustainable and comprehensive transport system. The effectiveness of these three programs will inevitably be impacted by a myriad of variables and complex interrelationships. However, only in the context of integrated land use planning, the institution of effective traffic management, an emphasis on public transportation and the construction of an efficient road network will the recommendations proposed here achieve their desired results.

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