Framework for Designing Regional Planning Architecture for APTS-Enabled Regional Multimodal Public Transportation System

By

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Master of Environment
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Abstract

Unsustainable transportation systems have been the cause of many problems facing urban areas around the world. Lack of regard for sustainable development considerations by those responsible for planning and implementing transportation systems has caused unhealthy air quality, noise pollution, traffic congestion, loss of green spaces and biodiversity, disruption of neighborhoods, equity problems, resource use etc. Many factors could potentially cause unsustainable transportation systems to persist. Transportation planning and decision-making is crucial in determining the structure and operation of transportation systems and hence also its sustainability. This thesis explores the idea of transportation planning institutions with the capability to design and implement sustainable transportation systems and how these institutions can be developed. The Regional Strategic Transportation Planning/CLIOS Process and Regional Planning Architecture Protocol were combined to form a Regional Planning Architecture Strategic Design Framework. To illustrate the use of the framework, it was applied in developing a RPA for planning a sustainable APTS-enabled regional multimodal public transportation system for the rapidly developing Kuala Lumpur Metropolitan Region in Malaysia.

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List of Acronyms

APTA	American Public Transportation Association
APTS	Advanced Public Transportation System
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
ATT	Advanced Transportation Telematics
AVCSS	Advanced Vehicle Control and Safety Systems
AVL	Automated Vehicle Location
CAD	Computer Aided Dispatch
CAT	Chatham Area Transit
CVLB	Commercial Vehicle Licensing Board
DO	District Office
DOE	Department of Environment
EPU	Economic Planning Unit
ETC	Electronic Toll Collection
EU	European Union
FTA	Federal Transit Administration
FTCPD	Federal Town and Country Planning Department
FTDKVPD	Federal Territory Development and Klang Valley Planning Division
GPS	Global Positioning System
GRTA	Georgia Regional Transportation Authority
GVRD	Greater Vancouver Transportation Authority (Translink)
HPU	Highway Planning Unit
IAPG	Interagency Planning Group
ICT	Information and Communications Technologies
IDMS	Integrated Demand Management System
ITS	Intelligent Transportation System
IVI	Intelligent Vehicle Initiative
KL	Kuala Lumpur
KLMR	Kuala Lumpur Metropolitan Region
LA MTA	Los Angeles County Metropolitan Transportation Authority
LRT	Light Rail Transit
MDC	Multimedia Development Corporation
MECM	Ministry of Energy, Communications and Multimedia
MED	Ministry of Entrepreneur Development
MHA	Malaysian Highway Authority
MHLG	Ministry of Housing and Local Government
MOSTE	Ministry of Science, Technology and the Environment
MOT	Ministry of Transport
MOW	Ministry of Works
MPO	Metropolitan Planning Organization
MSC	Multimedia Super Corridor
MTDB	Metropolitan Transit Development Board
NCTD	North County Transit District
NDPC	National Development Planning Committee
NITC	National Information and Technology Council
PJC	Putrajaya Corporation
PPP	Public Private Partnerships
RMP	Royal Malaysian Police

ROA	Regional Operating Architecture
RPA	Regional Planning Architecture
RSA	Regional Service Architecture
RSSB	Rangkaian Segar Sdn. Bhd.
SANDAG	San Diego Association of Governments
SDA	Statutory Development Agencies
SEDC	State Economic Development Corporation
SEPU	State Economic Planning Unit
SPC	State Planning Committee
STCPD	State Town and Country Planning Department
STIF	Syndicat des Transports d'ell de France
TDM	Transportation Demand Management
TfL	Transport of London
TIS	Traveler Information Systems
TOD	Transit-Oriented Development
TSS	Transit Safety and Security
US DOT	United States Department of Transportation
UTA	Utah Transit Authority
VMS	Variable Message Signs
ZVV	Zurcher Verkehrsverbund

1 Introduction

Since the early 1990s, institutional re-design or re-arrangement of organizations is increasingly being considered as one of the many strategies used to increase organizational effectiveness and efficiency in meeting the challenges posed by changes in the organization's external and internal environment; technological change, societal change, regulatory changes etc (Ancona et al., 2004, m2 p.12)[1]. The need for transportation systems to be more 'sustainable' not only from the environmental perspective, but also economic, equity and institutional perspectives have created challenges and opportunities for transportation entities everywhere. This thesis explores the idea of transportation planning institutions with the capability to design and implement sustainable transportation systems. More specifically, the aim of this thesis was to develop a framework for strategic design of institutional 'architectures' that have the capability to plan and implement sustainable transportation systems at a regional scale. The case study of this thesis is the planning of a sustainable APTS-enabled regional multimodal public transportation system for the Kuala Lumpur Metropolitan Region in Malaysia.

1.1 Problem Statement

Unsustainable transportation systems have been the cause of many problems facing urban areas around the world. Lack of regard for sustainable development considerations by those responsible for planning and implementing transportation systems has caused unhealthy air quality, noise pollution, traffic congestion, loss of green spaces and biodiversity, disruption of neighborhoods, equity problems, resource use etc. Many factors could potentially cause unsustainable transportation systems to persist. Transportation planning and decision-making are very crucial in determining the structure and operation of transportation systems and hence its sustainability. The Kuala Lumpur Metropolitan Region (KLMR) is faced with the problem of an unsustainable transportation system; institutional issues are an important cause of the problem's persistence in the area.

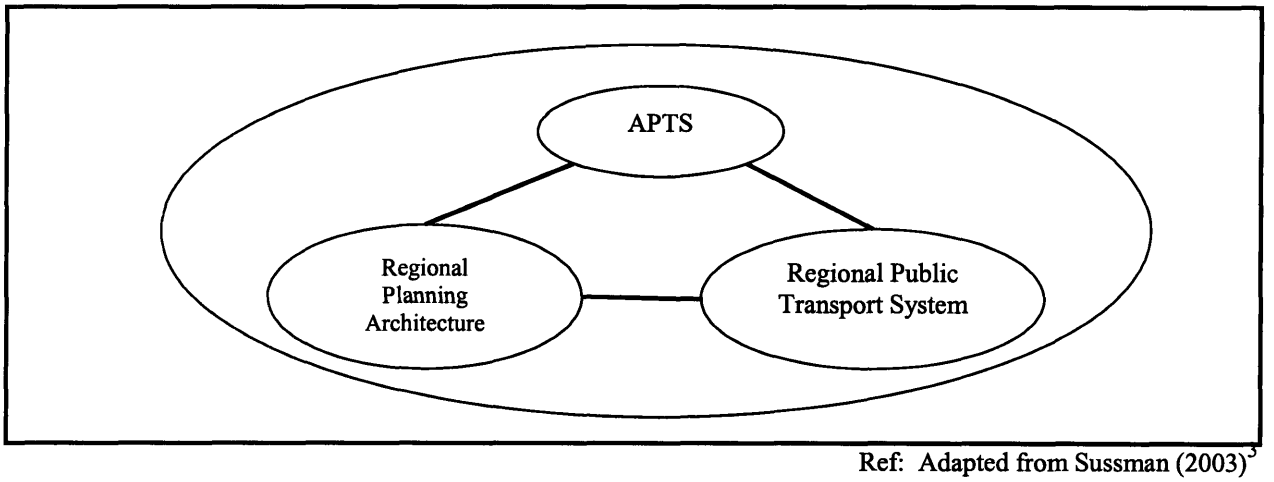
There have been many studies conducted to improve the sustainability of the transportation system KLMR; various structural and local plans have been developed to guide the sustainable development of the area. However, Kamalruddin (2003)[42] suggested that because of the current nature of transportation planning institutions, well studied transportation solutions have usually failed to be implemented fully. Hence, these solutions have usually been remedial and retrofitted. An example is the construction of light rail networks covering only a few areas of the KLMR with many routes to remain heavily congested. Despite the drafting of structural area plans with specific need for transportation facilities and services, surburban areas with new sprawling neighborhoods are still left with poor public transport facilities or none at all. Bad bus service with poor scheduling and problems with congestion, have never been improved but light rail services have been upgraded frequently. Highways cut apart communities and these disproportionately experience more than usual traffic congestion, geohazards, air quality and noise problems.

The Malaysian government had recognized the institutional aspect of the problem and just recently proposed a central body called 'Urban Transportation Authority' with supposedly far reaching powers to ensure that all planning, implementation and monitoring will be under one institution. The Authority plans to integrate the 8-10 ministries and agencies that are currently involved. A special emphasis was given to the quality of service and the use of ITS to improve

the public transportation system (New Straits Times, 27 May 2004)[2]. The question faced by the government now is, how to design the Authority such that it will be able to plan, implement and monitor sustainable transportation systems at a regional level? What aspects make an institution capable of planning and implementing a sustainable regional public transportation system?

1.2 Purpose and Objectives

Sustainable transportation planning requires institutions which have the capability to perform planning of sustainable transportation systems. Sussman (2003)[3] suggested that transportation has three perspectives: institutions, systems and technology. In this thesis, the technology of concern was the Advanced Public Transportation System (APTS). The system was the regional public transportation system. The institution that was focused upon is the transportation planning institutions and organizations, or more specifically what we call the regional planning architecture (RPA).



Ref: Adapted from Sussman (2003)[3]

Figure 1-1: Components of Regional Transportation System Sustainability: APTS, Regional Public Transportation System and Regional Planning Architecture

This thesis argued that because these systems are interdependent, for overall transportation system sustainability, all three aspects should contribute to sustainability. Thus, the objectives of this thesis were:

1. Determine what makes transportation planning institutions capable of planning and implementing sustainable regional transportation systems,
2. Develop a strategic organizational design framework for developing RPA (henceforth called RPA Strategic Design Framework) that is capable of planning and implementing sustainable regional transportation systems,
3. Apply the strategic organizational design framework to the KLMR public transportation system.

1.3 Methodology

This thesis was based on information obtained from journals, reports and books.

1.4 Organization

This thesis is organized into 6 chapters.

Chapter 1: Introduction
This chapter provides the problem statement and objectives of the thesis.

Chapter 2: Institutional Capability for Sustainable Transportation Planning
Sustainable transportation planning requires institutions, which have the capability to perform planning of sustainable transportation systems. This chapter defines the aspects of transportation planning institutions that are capable of planning and implementing sustainable transportation systems, evaluates the most common traditional transportation planning process and describes the need for institutional change.

Chapter 3: Sustainability of Regional Multimodal APTS-enabled Public Transportation System and Institutional Implications
APTS offers an opportunity for efficient integration of different transportation modes – a multimodal system - as well as management of transportation systems at a regional level. This system's sustainability was qualitatively assessed. In this chapter, the need for institutional change brought about by the need for the capability to plan and implement a sustainable APTS-enabled regional multimodal public transportation system is described.

Chapter 4: Framework for Strategic Design of Regional Planning Architectures
Regional strategic transportation planning (RSTP) for an APTS-enabled regional multimodal public transportation system requires changes in the transportation organizations as well as the institutional framework for transportation planning and decision-making. This chapter describes a framework for strategic design of a RPA, henceforth called RPA Strategic Design Framework.

Chapter 5: Application of RPA Strategic Design Framework: Illustrative Case Study of KLMR
The results of the application of the RPA Strategic Design Frameworkto develop an RPA for the planning of a sustainable APTS-enabled regional multimodal public transportation system KLMR is presented.

Chapter 6: Conclusions
The main findings and future areas of research of this study are described. .

2 Institutional Capability for Sustainable Transportation Planning

To develop sustainable transportation systems, we need institutions which have the capability to perform planning of sustainable transportation systems. This chapter defines the aspects of transportation planning institutions that are capable of planning and implementing sustainable transportation systems. The most common traditional transportation planning process is evaluated against a sustainable development-oriented transportation planning process. Based on this comparison, the need for institutional change proposed.

2.1 Sustainable Transportation

The term 'sustainable transportation' stems from the concept of 'sustainable development'. The term, which was first coined in the United Nations World Commission on Environment and Development 1987 Bruntland report called "Our Common Future", puts forth the idea of development that meets the needs of the people today without compromising the ability of future generations to meet their own needs. Sustainable development is the idea of deliberate decision-making in order to direct global development and system evolution towards a more sustainable route. While it provides a very broad goal to the world community now, it nevertheless poses a challenge in the operationalization of the term, i.e. when one tries to implement sustainable development in specific sectors e.g. agriculture, health care, education, transportation etc.

Hall (2002)[4] conducted a comprehensive review of what sustainable transportation is. The review also included the internationnally accepted definition of sustainable transportation suggested by the Center for Transportation Studies (CST) in 1997. The CST had generally defined sustainable transportation on three dimensions: Environment, Economy, and Equity (i.e. social equity). According to CST's definition, sustainable transportation has many dimensions and covers a wide range of transportation issue areas -environment, economy, and social equity. However, Hall argued that there needed to be included in the CST's definition the idea of managing the increasing 'throughput'; in Hall's view, transportation was considered as an enabling mechanism that could bring about consumption at ever increasing rates. Thus, sustainable transportation defined by Hall is as follows:

> "allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;
> is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy;
> limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise;
> AND
> controls the throughput of natural and manmade resources to rates within the carrying capacity of the environment, society and the economy"

Hall's (2002) suggested that the idea of controlling 'throughput' was critical in ensuring decision makers to think about impacts that are outside their areas of influence e.g. land use systems,

economic systems, telecommunication systems. Thus, Hall had developed a list of the principles and challenges of sustainable transportation (Table 2-1).

Table 2-1: Principles and Challenges of Sustainable Transportation

	Environment	Economy	Social Equity	Institutional	
Principles	Precautionary; Preventative; Regenerative; Substitutability; Assimilative Capacity; Avoidance of Irreversibility; Use of Energy; Stewardship; Ability to Recycle	Polluter Pays; Cost Internalization; Affordability; Cost-effectiveness; Economic Well-being	Access & Choice; Equity; Social Well-being; Social Responsibility	Integration; Comprehensive & Long-term Planning; Transparency & Accountability; Goals, Performance and Outcomes; International Co-operation; Technical Innovation	Reduction of Automobile Dependency; Improvement in Efficiency; Protection of Health & Safety; Appropriate Use of Land & Resources; Participation & Education
Challenges	Emissions; Freshwater; Biodiversity; Renewable Energy; Environmental Management	Economic Reform; Globalization of Production & Trade; Financial Restrictions	Access & Affordability; Access, Equity & Choice	New decision-making Processes; Measurement of Progress Through Indicators; Institutional Capability; International Governance; Technological Innovation; Automobile Dependency;	Efficient Transportation; Competition for Resource and Access to Infrastructure; Land Use; Congestion; Maintenance; Education about Sustainable Transportation Issues

Ref: Hall (2002)[4]

The principles and challenges are catergorized under environment, economy, social equity, and institutional. Hall's addition of the 'institutional principles' to the traditional categories of environment, economy and social equity, acknowledged the critical need to include the capability of institutions to plan and manage sustainable transportation systems.

Table 2-2 describes in detail the institutional principles of sustainable transportation systems. The institutional principles could serve as a guiding policy for transportation institutions to plan, develop and implement sustainable transport systems.

Implementing these principles is not without challenges as shown in Table 2-2. Theoretically, successful implementation, or operationalization, of the sustainability principles could most likely lead to the attainment of sustainable transportation system objectives. Hall (2002)[4] suggested that to successfully implement these principles depends upon the:

- Transportation planning and decision-making process
- Operation of existing supply of transportation system
- Design philosophy the transportation modes, i.e. favoring more private or public modes
- Use of the existing transportation sector

From the transportation planning decision-making perspective, Hall suggested that governments will need to develop better data, information, analyses and tools that enable a more comprehensive analysis of impacts, consider indirect and cumulative impacts, consider demand management solutions, and enhance public involvement. Given these new challenges, governments need to respond by increasing their capability in performing planning that would

lead to sustainable transportation systems (VTPI, 2003[5]; Gifford, 2003, p. 160[6]; Littman, 2003[7]). These new capabilities will necessarily lead to institutional and organizational change.

Table 2-2 : Institutional Principles and Challenges of Sustainable Transportation

Principles	
Integration	integrate sustainable transportation requirements into the definition and implementation of all policy-making
Transparecy and accountability	make the decision-making process transparent and accountable
Goals, performance and outcomes	assist the transparency and accountability principle through the use of goals and performance measurement
International co-operation	increase the level of international co-operation
Technological innovation	foster technological innovation that supports the objectives of sustainability through partnerships between government, industry and academic research centers
Comprehensive and long-term planning	ensure that transportation decisions are based on the principles of comprehensive and long-term planning
Reduction of auto dependency	reduce automobile dependency
Improvement in efficiency	explore ways of promoting efficient travel behaviour
Protection of health and safety	design and operate transportation systems in a manner that protects the health and safety of all people
Appropriate use of land and resources	promote the efficient use of land and other natural resources while ensuring the preservation of vital habitats and other requirements for maintaining biodiversity
Participation and education	encourage public involvement in decision-making with the objective of achieving community cohesion and livability
Challenges	
New Decision-making Process	develop tools for better decision-making
Measurement of progress throught development of indicators	develop standards that will be accepted by all parties for evaluating transport performance
Institutional Capability	create institutional capacity to address complex, long-term issues
International Governance	develop consensus on the environmental effects of international trade and globalization, with the goal of enhancing the influence of international institutions to effect change
Technological Innovation	develop and promote the use of new and innovative technologies that reduce the environmental impacts of transportation while meeting the needs of passengers and shippers.
Efficient Transportation	ensure the development of a balanced approach to promoting transportation efficiency;
Competition of Resource and Access to Infrastructure	manage competition for resources and access to infrastructure between personal and freight transportation
Reduction in Automobile Usage	manage automobile usage and encourage the development of a more balanced transportation system
Land Use	initiate smart land use planning to ensure that land use planning becomes closely linked with transportation and environmental planning at the national, regional and local level
Congestion	anticipate congestion and develop a portfolio of mobility options for people and freight
Maintenance	ensure adequate finance is allocated to preserve the existing transportation infrastructure; and
Education about Sustainable Transportation Issues	improve education and awareness of sustainable transportation to make the public more aware of the environmental impacts of their transportation choices

Ref: Hall (2002)[4]

2.2 Elements of an Institution and Capability for Sustainable Transportation Planning

A comprehensive definition of institutions is that it refers to not only organizations, but institutional ideas, orientations as well as mechanisms or processes (Table 2-3).

Table 2-3: Elements of Institution

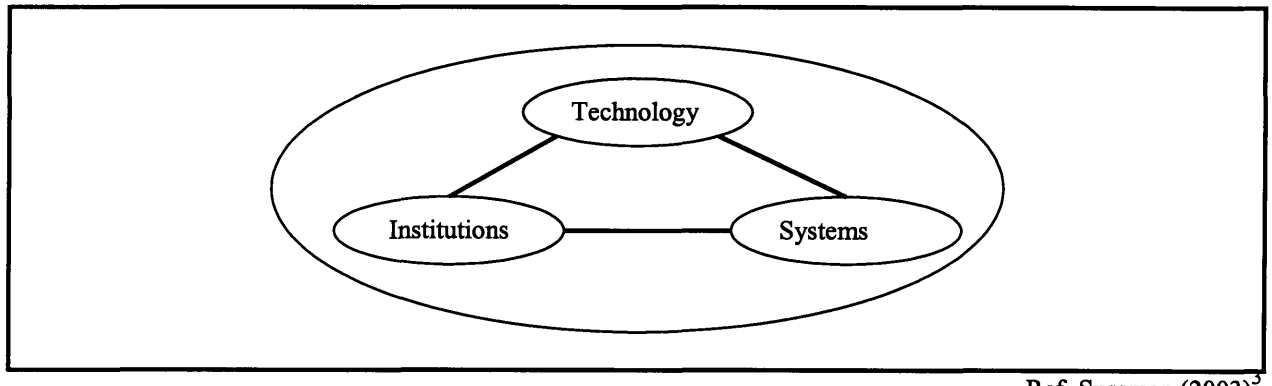
Domain	Elements
Ideas	General expectations of society guiding behavior; values, ideas, principles
Organizations	Structured temporary or permanent organizations with implicit and explicit and implicit internal rules
Orientations	Societal norms, *leitbilder*
Processes or Mechanisms	Administrative, political and social procedures, legal norms

Ref: Adapted from Spangenberg et al. (2002)[10]

The need for transportation planning institutions to consider sustainable transportation aspects has been well documented (Feitelson, 2002[8]; Shiftan, 2003[9]). In the area of research for sustainable development indicators for institutions, institutions generally refer to inter-governmental organizations that are expected to take aspects of sustainable development into their decision-making (Spangenberg et al, 2002)[10]. In the context of this thesis, institutions which are capable of planning and implementing sustainable transportation systems are understood as institutions that are capable to perform sustainable transportation planning. These institutions have organizational ideas, orientation and processes that adhere to sustainable transportation principles. In other words, the term institutions with the capability to perform sustainable transportation planning refer organizations/institutions that make decisions based on processes (i.e. the transportation planning process) which are oriented towards sustainable transportation principles.

2.2.1 Dimensions of Transportation Systems

Figure 2-1 shows that transportation systems have three dimensions: systems, technology and institutions. Systems refer to the concept of flows and stocks of supply and demand on transportation networks. Technology refers to propulsion, fuels, guideways (e.g., roads, railroads), and guidance and control systems. Institutions refer to the pragmatic way that people develop and manage transportation systems within a complex social, political and economic environment.



Ref: Sussman (2003)[3]

Figure 2-1: Dimensions of Transportation Systems

Because these systems are interdependent, for overall transportation system sustainability, all three aspects should contribute to sustainability. In the case of transportation planning institutions, if the transportation planning process leads to sustainable transportation systems, the institution is capable of performing sustainable transportation planning. The outputs of the planning process is a sustainable transportation system. Ideally, to successfully develop an institution capable of producing sustainable transportation systems, performance measure indicators of 'transportation system sustainability' would be useful; such indicators would provide measures of degree of sustainability of the output of an institution. However, research in this area is still actively undertaken. For the purposes of this thesis, Hall (2002)[4] principles of institutional sustainability was used.

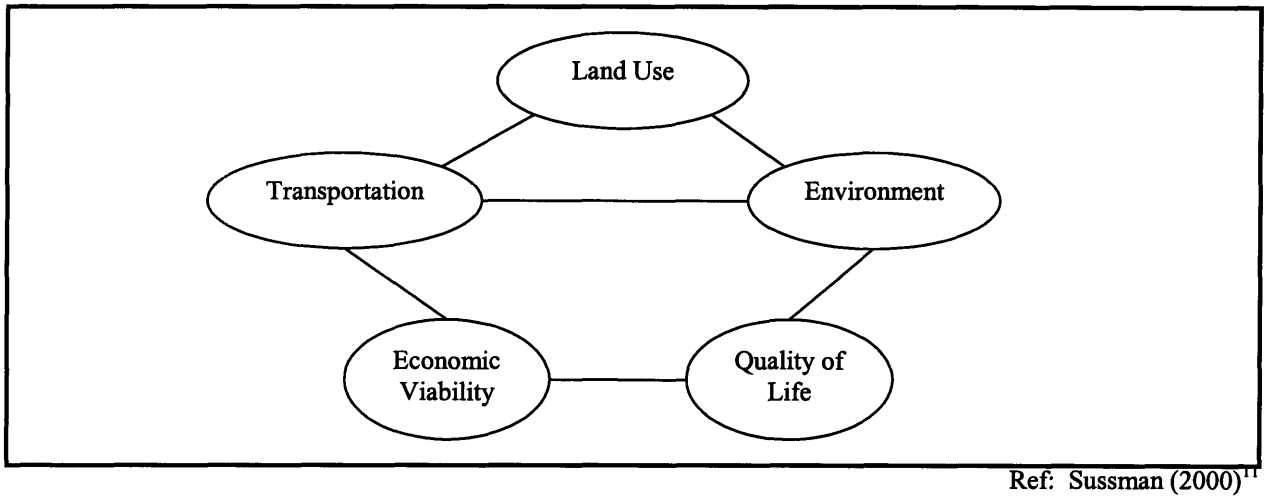
2.3 Traditional vs. Sustainable Transportation Planning

This section describes the main shortcomings of the traditional transportation planning approach and proposes generalized approach to transportation planning considered to adhere to sustainable transportation principles.

2.3.1 Importance of Transportation Planning and Decision-making

The scope of transportation planning and decision-making activity would reside within the institutional subsystem. Nevertheless, because the systems are interdependent, the impacts of transportation planning would be exerted on both the transport system as well as the technology (see Figure 2-1).

In the institutional context, transportation planning is the first step in decision-making about the strategic investments in transportation facilities and system operation. Transportation planning covers a broad spectrum of decisions ranging from setting performance goals and objectives to national transportation systems at one extreme to the prioritization of local projects in a small administrative area (Gifford, 2003)[6]. Not only is transportation planning important in planning for the infrastructure and services that provide mobility and accessibility to an area, it is also important because of the wide ranging impacts it has on land use, environment, economy and quality of life.



Ref: Sussman (2000)[11]

Figure 2-2: Transportation / Land Use /Environment Connection

The transportation system's performance influences many other subsystems in an urban area (Figure 2-2). The transportation / land use / environment connection is very important in an urban area or a megacity. The impact of transportation on the environment and land use in turn influences the level of economic and social activity, which will ultimately influence the community's quality of life (Sussman, 2000[11]; Meyer and Miller, 2001, p. 503[13]; Vuchic, 1999[12]). Thus, transportation planning and decision-making indirectly determines the vision of the community's quality of life. Thus, transportation planning decision-making is important as it is directly responsible for establishing strategic transportation investment and system operations directions for an area as well as indirectly responsible for determining a community vision for the future.

2.3.2 Problems of Traditional Transportation Planning

There much room for development in the current methods used in transportation planning (VTPI, 2004)[14]. Gifford (2003)[6] described the current transportation planning policy of highway and transit policy of the last 50 years in the United States as "fixated on planning, designing and constructing the Interstate Highway system, and then coping with the creative destruction it wrought". The biased policies of the past have made the private vehicle the most widely used transportation mode and had managed to direct the evolution of land uses (e.g. residential, commercial, industrial) into those that are sprawling and surburban in nature. One of the most problematic aspects of traditional transportation planning most often mentioned is the fact that it still uses a narrow perspective when evaluating transportation impacts and solutions. Table 2-4 lists the impacts that are normally considered and often overlooked in traditional transportation planning.

Table 2-4: Impacts Considered in Traditional Transportation Planning

Normally Considered	Financial costs to governments Short-term vehicle operating costs (fuel, tolls, tire wear) Travel time (reduced congestion) Per-mile crash risk Project construction environmental impacts	
Often Overlooked	Downstream congestion impacts Impacts on nonmotorized travel Parking costs Long-term vehicle costs (depreciation, insurance, residential parking) Project construction traffic delays Impacts of generated traffic (latent demand)	Indirect environmental impacts Strategic land use impacts Impacts on transportation options Equity impacts Total per-capita crash risk Impacts on physical activity and public health

Ref: VTPI (2003)[17]

VTPI (2003)[17] lists the problems that came about due to lack of appropriate perspective. The problem had often given rise to solution implementation that shifts the problems or just worsens problems in other areas. Inappropriate scope had also led to the inability to consider more integrated solutions which could provide multiple benefits. The cause of the lack of appropriate scope was ascribed to the fact that some impacts are relatively difficult to quantify (e.g. equity, secondary and tertiary environmental impacts, crash risk). Some impacts are disregarded easily because of deeply engrained institutional culture and strategies (Hall, 2002)[4]. Exclusion of impacts like these tend to underestimate the total costs (which usually include external environmental and social costs) of highway projects and the potential benefits of transit improvements. Thus, the outcome of years of traditional transport planning methods had resulted in economic and social distortions that tend to overvalue private vehicle-oriented improvements and undervalue alternative solutions to transportation problems; these have led to unsustainable transportation systems. Due to the importance of transportation planning and decision-making in determining the shape of transportation systems and the quality of life of the community it serves, a reform of the traditional transportation planning to a process that has a sustainable development orientation has been suggested (Gifford, 2003, p. 160[6]; Littman, 2003[7]).

2.3.3 Aspects of Sustainable Transportation Planning Process

A systems approach has been suggested to be part of the concept of 'sustainable development-oriented planning' (Meyer and Miller, 2001, p. 28[13]; Littman, 2003[7];VTPI, 2004[14]). The system's approach studies whole systems, rather than just examining a system's components independently; this requires comprehensive research methods which is time consuming and data intensive. Meyer and Miller (2001, p. 75)[13] suggested incorporating the following aspects into the traditional transportation planning process to overcome its shortcomings:

1. Setting up of a Future Vision

An establishment of a future vision was stated as one of the aspects of the sustainable transportation planning process. Traditionally, elected political decision makers focus on short term issues which would affect them in their next re-election cycle. To overcome this shortcoming, it is important that transportation planners comprehend the long term and future impacts of present day decisions. In addition, the setting up of a vision of the future would also provide a platform for development of a community vision and the role of various transport solution alternatives in the vision.

2. Responsive to Varying Scales of Analysis

Large, regional transportation system configurations were almost the only scale that traditional transportation planning efforts concentrated on. Although planning at the regional level would allow for mnay efficiency benefits to accrue (explained in chapter 3), it would not allow for decision makers to obtain information at other scales for example, local or project based scales; levels at which system impacts would also occur and might be overlooked. In addition, the identification of stakeholders (e.g. local governments, interests groups), who would gain or loose from the project, would also not be possible. Therefore, it is beneficial to have the ability to plan and perform analysis at many scales.

3. Broad Scope of Problem Definition

As described earlier in Figure 2-1, transportation affects many other systems; land use, environment, economy, quality of life. Transportation problems as well as their solutions are thus not easy to define. Solutions often require policy action outside of the transportation control and area of influence. One purpose of planning is therefore to explore beyond the simple definition of the problem and examine the total system in which it operates in order to identify the vision, system goals and objectives as well as the impacts (both secondary and tertiary). The physical and organizational characteristics of the problem must be analyzed in order to understand the range of potential problems as well as solutions.

4. Flexibility in Analysis

Transportation planning decision-making is inherently a political process. The outcomes of are often influenced by the opinions of different political constituencies and interest groups. The process comprises of bargaining and searching for concensus among different stakeholders. Thus, an effective planning process must have the ability to incorporate new information for comparative evaluation of alternatives purposes.

5. Evaluation, Feedback and Continuous Monitoring of Performance Measures

The context within which transportation planning process takes place is dynamic. As such, new problems and constraints as well as solutions tend to arise. Thus, transportation planning process should be capable of continually seeking feedback, perform evaluations and monitor its environment to ensure the system operation's performance measures are at its targeted level.

6. Connection to Implementation Process

It was found that implementation process (referred to as programming and budgeting) of final transportation planning decisions often entail dealing with new type of politics and correspondingly a new set of stakeholders and narrow self interests in certain projects or policies. For that reason, it is important that the transportation planning process produce a continually updated plan that consists of programs planned over a multiyear period. Short term plans was suggested to be 1-3 year time frames and outlined in detail. Long term plans should be outlined as well but with less specifics. The outcomes of the implementation should also be included so as to connect implementation with decisions made.

7. Opportunities for public involvement

Transportation planning decision-making is pluralistic in nature. It is essential that opportunities are given to all stakeholders to be involved and be able to influence in the decisions made. Example of stakeholders are local and regional decision makers (e.g. MPOs), professional and technical staff who advise officials, organized interest groups such as business and civic groups, and the public.

Meyer and Miller (2001)[13] suggested that this approach could be applied to develop a more detailed process for specific problem areas for different planning contexts, for example as a sustainable transportation planning process, a subarea planning study or site specific planning. To be effective, they suggested that the approach must reflect the needs and characteristics of the relevant decision-making process. As mentioned in the previous section, Hall (2002)[4] suggested that transportation planners need to develop better data, information, analyses and tools that enable a more comprehensive analysis of impacts, consider indirect and cumulative impacts, consider demand management solutions, and enhance public involvement. The decision-oriented approach suggested by Meyer and Miller (items 1-7) seems to comprise the aspects which would conform to the criteria of for a mechanism for sustainable transportation planning institutions.

2.4 Institutional Capability for Sustainable Transportation Planning and Institutional Change

Decision-making on transportation planning occurs within a transportation planning institutional framework. A transportation planning institution may include: organizations, processes, relationships, constraints and roles (Table 2-5).

Table 2-5: Components of Transportation Planning Institutions

Components	Description
Organizations	Groups of people with specific functions/tasks formed to provide and manage transportation services. Even though these organizations are within one institution, each organization may maintain contradictory mandates
Process	The formal procedure of communications and methods of producing outputs from these organizations that is regularly mandated by other levels of government (e.g. local government level subjected to procedures determined by federal level)
Relationships	The informal personal and group dynamic relationships that make the process work or slow down if desired
Constraints	The political, legal and fiscal limitation and controls that can either give support for preffered outcomes of that can become nearly insurmountable barriers
Roles	The positive and negative roles of specific individuals or groups

Ref: Adapted from Meyer and Miller (2001)[13]

Institutional capability of transportation planning institutions is suggested to refer to the institutional structures for implementation and the skills needed to implement, operate and maintain transportation projects and systems (Meyer and Miller, 2001, p. 603)[13]. Institutional capability is a key factor in successful implementation of transportation plans and programs.

Organizational strategic design theories suggest that institutional components designed approapriately could lead to a more effective and efficient institution to meet its expected goals (Ancona et al, 1999)[1]. Thus, it is suggested that the efficiency and effectiveness of a transportation planning institution to carry out its policies and programs based on sustainable transportation principles is largely determined by how the institutions are designed. There are many planning contexts in which institutional capability issues have become main barriers to project implementation. Most significant ones are associated with intelligent transportation

systems (ITS) regional deployment, coordination of land use and transit service planning and improving business community and transportation management association relationhips for solving local transportation problems associated with rapid urban development. In these cases, institutional re-design or change has been one of the strategies for improving institutional effectiveness and efficiency in meeting its intended goals.

As stated before in section 2.2, institutions that are capable of sustainable transportation planning would be expected to take aspects of sustainable development into their decision-making. The ideas, cultural norms, orientations and processes that the institution's components adhere to is suggested to be those that are in line with those principles of sustainable transportation. Section 2.3 highlighted several aspects of sustainable transportation planning and the design of regional planning architectures for sustainable transportation systems is addressed in chapter 4. Before that, chapter 3 describes the specific changes that are taking place in public transportation system and the need for institutional change in the planning process.

2.5 Chapter 2 Conclusion

Institutional capability is a key factor to successful implementation of transportation plans and programs. This chapter has argued that transportation planning institutions capable of planning and implementing sustainable transportation systems are those that have ideas, cultural norms, orientations and processes which adhere to the institutional principles of sustainable transportation as defined by Hall (2002). Based on these principles, it is suggested that the traditional transportation planning process is in need of a reform. The reform will necessitate institutional re-design or change in order to have the capability to perform sustainable transportation planning.

3 Sustainability of Regional Multimodal APTS-Enabled Public Transportation System and Institutional Implications

Advanced Public Transportation Systems (APTS) offers an opportunity for efficient integration of different transportation modes – multimodal systems - as well as management of transportation systems at a regional level. In this chapter, the sustainability of such a system is qualitatively assessed. This chapter also describes for the need for institutional change brought about by the emerging new paradigm for local public transportation organizations to plan and implement regional multimodal systems.

3.1 Sustainability of APTS-Enabled Regional Multimodal Public Transportation

Intelligent Transportation Systems (ITS) enables efficient management of operations of transport systems by harnessing information and communication technologies (ICT) to enhance transport system efficiency. However, the use of ITS has been suggested by some to be unsustainable as increasing efficiency of transportation systems could simultaneously increase resource throughput, overconsumption and ultimately more wastes which are counterproductive to sustainability goals. Nevertheless, there are studies which suggest that ITS could contribute to sustainable transportation. This depends very much on how it is used and deployed. Public transportation system, theoretically and as suggested by empirical evidence, contributes to sustainable transportation systems. This section argues that the use of ITS, especially APTS, in public transportation system could contribute to sustainable transportation systems.

3.1.1 A Systems View of an ITS Enabled Multimodal Urban Public Transporation

Sussman (2000)[38] suggested two basic components that make up transportation systems: internal and external components (Table 3-1). The internal components of transportation systems include infrastructure; vehicles; control, communications and location systems; system operators. The external components include the government, users of the system, stakeholders, and the supply industry.

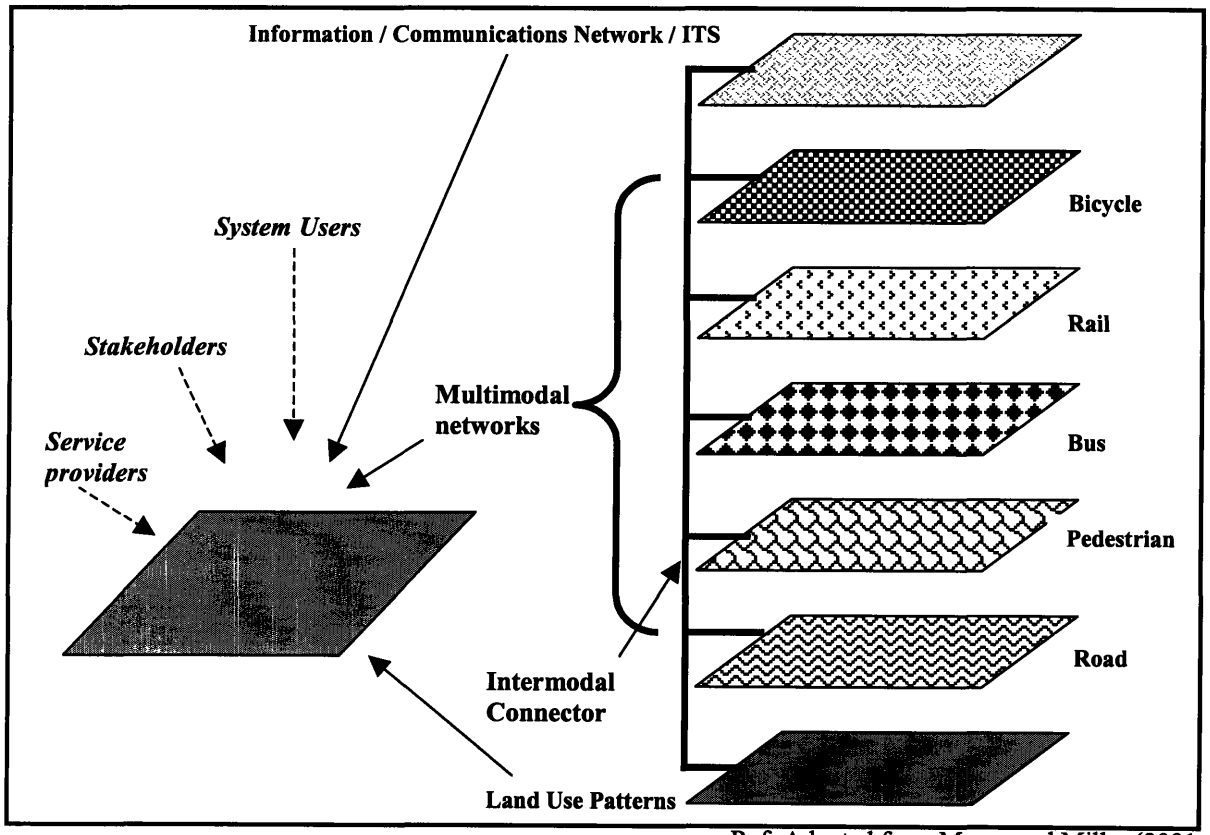
Table 3-1: Basic Components of Transportation Systems

Internal Components		External Components
Infrastructure	Control, communications, and	Environment
Vehicles	location systems	Government
Equipment	Operating plans	The customer
Power Systems	Operators	Stakeholders
Fuel		Financial Community
		Supply Industry
		Competition

Ref: Adapted from Sussman (2000)[38]

These components and systems working together could be assembled into a multimodal transportation system. Figure 3-1 is one view of a multimodal transportation system (Meyer and Miller, 2001, p. 7)[13]. There are many transportation infrastructure and services, available in a metropolitan area that provide opportunities for mobility and accessibility. The multimodal

system is composed of different 'multimodal networks' and 'information/ communications networks' which allow a traveler to move from one place to another. The 'information and communications network' would be where ITS technologies would be used to collect and disseminate traveler information to increase overall multimodal system efficiencies. The 'intermodal connector' gives the ability to transfer from one modal network to another. Important to note here is that metropolitan 'land-use' patterns and the institutional structure (i.e. service providers, stakeholders, system users) which form part of the multimodal system, affects overall performance of the system.



Ref: Adapted from Meyer and Miller (2001, p. 9)

Figure 3-1: Multimodal Transportation System and ITS

3.1.2 Benefits of APTS-Enabled Multimodal Regional Perspectives

The concept of an ITS enabled regional multimodal transportation system can be extended to a public transportation system. Such a system is one which forms part of its 'multimodal network' all modes of public transport, including non-motorized private transport, – road, pedestrian, bus, rail, bicycle – at a regional scale.

The multimodal perspective could contribute to sustainable transport systems primarily because it could increase system effectiveness and efficiency by integrating different transportation modes in providing service and mobililty (Meyer and Miller, 2001, p.29[13]; Hall, 2002[4]).

The regional aspect of the system could contribute to sustainability primarily because it could lead to increased economic well being as well as the environmental management effectiveness of a region. Similar to the multimodal perspective, the regional perspective makes

use of the integrative aspect of sustainability. The benefits of the regional concept are three. First, because there are many subsystems that makes up a transportation system for a metropolitan area and their associated institutions, the regional perspective would be useful institutionally in the determining how these many agencies and groups fit together. Business strategists like Micheal Porter and Rosabeth Kantar have suggested that the fundamental unit of economic competition is the regional or metropolitan scale and not at the national scale. The effectiveness of the competitive unit depends on a transportation system which is efficient at a regional scale. In addition to that, environmental experts have suggested that environmental issues like air and water pollution is need to be managed at a regional scale and not just at the urban scale. Therefore, managing and operating transportation system at a regional scale is highly beneficial as economic and environmental benefits can be accrued (Sussman, 2001)[15].

3.1.3 Sustainability of Public Transportation System

There are two main reasons why public transportation is focused upon in this thesis. First is the theoretical justification that public transportation contributes to sustainability and second is the empirical data that suggests that improving public transportation system efficiency and effectiveness is critical to solve the mobility problems faced by many cities around the world.

Strategy for Sustainable Transportation System

Public transportation system is itself considered as a strategy that could contribute to sustainability. There are a variety of strategies that support sustainable transportation systems (Table 3-2) (Deakin, 2001) [16]. As shown below, these strategies can be categorized mainly as vehicles and fuels, guideways and operations, and demand management. Transit and non-motorized modes are considered as part of the strategy for sustainable transport.

Table 3-2: Strategies for Sustainable Transportation Systems

Strategy	Specific Strategy and Examples
Vehicle / Fuel Technological Changes	▪ Improved efficiency of conventional vehicles (e.g. manufacturer innovations / supplier offerings ▪ Responses to consumer demand ▪ Responses to government regulation and incentives (e.g. CAFÉ standards, R&D partnerships, Taxes, rebates, subsidies) ▪ New vehicle technologies ▪ New fuels
Road/ Vehicle Operations	▪ ITS improvements ▪ Driver education ▪ Improved logistics and fleet management
Demand Management	▪ Modal substitution (rail substitutes for truck, telecommuting, teleshopping, teleconferencing, IT-enhanced routing and scheduling) ▪ Transit, walking incentives (non-motorized modes) ▪ Telecommunications substitutions ▪ Pricing incentives / disincentives (gas taxes increases, vehicle registration / license fee based on fuel efficiency and use, other impacts based on use, subsidies for preferred modes) ▪ Land Use–Transportation Strategies (compact development, mixed use development, higher densities, transit oriented development)

Ref: Adapted from Deakin (2001)

The justification for the sustainability of public transportation system could be illustrated qualitatively from Table 3-3.

Table 3-3: Sustainability of Transit Service Improvements

Public Transport System Service Improvements	*Increases Efficiency*	*Increase Affordability*	*Reduces Auto Dependency*	*Environment*	*Economy*	*Social Equity*	*Institutional*
Additional routes, expanded coverage, increased service frequency and hours of operation	X		X	X			X
Lower fares, increased public subsidies		X	X		X	X	X
Vehicle Trip Reduction[1] programs, and other Transit Demand Management Programs[2] (TDM) that encourage use of alternative modes		X	X		X	X	X
High Occupancy Vehicle (HOV) Priority[3]	X		X	X			X
Comfort improvements, such as better seats and bus shelters	X		X	X			X
Transit Oriented Development (TOD)[4] and Smart Growth[5]	X		X	X			X
Pedestrian and cycling improvements that improve access around transit stops	X		X	X			X
Improved rider information and marketing programs	X		X	X			X
Improved security	X		X	X			X
Services targeting particular travel needs, such as express commuter buses, Special Event Service[6], and various types of Shuttle Services[7].	X	X	X	X	X		X
Accessibility Design[8]	X		X	X			X
Park & Ride facilities[9]	X		X	X			X
Bike and Transit Integration[10] (bike racks on buses, bike routes and Bicycle Parking at transit stops).	X		X	X			X

Ref: Adapted from VTPI (2003)[17]

[1] Vehicle Trip Reduction – programs that provide commuters resources and incentives to reduce their automobile trips e.g. teleworking, ridesharing, parking cash outs and transit allowances.
[2] Travel Demand Management Program - an institutional framework for implementing a set of TDM strategies.
[3] High Occupancy Vehicle (HOV) Priority - strategies that give priority to HOV, e.g. transit buses, vanpools and carpools.
[4] Transit Oriented Development (TOD) - residential and commercial areas designed to maximize access by transit and nonmotorized transportation, and with other features to encourage transit ridership.
[5] Smart Growth - general term for policies that integrate transportation and land use decisions, e.g. by encouraging more development within existing urban areas where additional growth is desirable, and discouraging low-density, automobile dependent development at the urban perimeters.
[6] Special Event Transport Management – encourages the use of alternative travel modes to occasional events that draw large crowds, such as festivals, games and fairs, or when construction projects or disasters create temporary transportation problems.
[7] Shuttle Services - include a variety of transportation services that use small buses or vans to provide public mobility.
[8] Accessibility Design - refers to facility designs that accommodate the widest range of potential users, including people with mobility and visual impairments (disabilities) and other special needs
[9] Park & Ride - consists of parking facilities at transit stations, bus stops and highway onramps, particularly at the urban fringe, to facilitate transit, rideshare use and bicycle parking
[10] Bike and Transit Integration - bicycling integrates well with transit which is most effective for moderate- and long-distance trips on busy corridors, while cycling is effective for shorter-distance trips with multiple stops. Combining transit and cycling can provide a high level of mobility comparable to automobile travel.

The left most column lists typical transit systems improvement e.g. HOV priority, transit oriented development (TOD), improved security and safety, and improve traveler information system (VTPI, 2003)[17]. The ability of the aspects of these transit improvements to contribute to the principles of sustainability (Hall, 2002)[4] is indicated by the information in the columns to the right of the first column. It has to be noted that the information presented here only serves as an illustration and is not comprehensive in describing how the sustainability of transit

improvements could be determined; perhaps 'sustainability indicators of public transport systems' could be developed. Thus, from this table, it is suggested that all these transit improvements could either directly or indirectly contribute to environment, economic, social equity and institutional sustainability as defined by Hall.

Millenium Cities Database for Sustainable Mobility

The critical importance of public transportation as a strategy in sustainable transportation was highlighted by a study called "Millenium Cities Database for Sustainable Mobility" conducted by Vivier (2001)[18]. The group, based in the Institute for Sustainability and Technology Policy (ISTP), University of Murdoch, compiled data on demographics, economics and urban structure, vehicle population, taxis, road networks, parking, public transport networks (supply, use and cost), mobility of individuals, the choice of transport mode and transport system efficiency and its environmental impacts (travel times and costs, energy use, pollution, accidents, etc.); these data were analysed and 66 raw indicators were developed. The sample for the study included 100 cities from developed and developing countries in Western Europe, Eastern Europe, North America, Latin America, Africa, Middle East, Asia, and Oceania.

According to the study, private automobile dependency is increasing in a majority of cities in both developed and developing countries. It is expected that by 2020, demand for urban mobility would have increased by 50%. The study predicts that if nothing is done to curb the use of automobiles, it will absorb all of the biggest part of urban travel demand as well as generate all the congestion and pollution it brings about. The burden of the automobile on the economy, resource use and environment in comparison to public transport was calculated as well (Table 3-4). The study suggested based on the empirical data that the strategies that could lead sustainable mobility are those that would encourage urban forms that are more space saving, more energy efficient and more environmentally-friendly: "zero growth" in automobile traffic, and the development of attractive and efficient public transport. Development of attractive and efficient public transport is considered critical in solving the unsustainable mobility problems plaguing the cities today brought about by unsustainable land use and private automobile dependence. Thus, this information supports the idea that public transportation system could contribute to the sustainability of transportation systems.

Table 3-4: Proportion of Public Transport and Impacts on Journey Cost, Energy Use and Emissions

Region	Density (persons/ hectare)	Proportion of journey by foot, bicycle and public transport	Journey Cost (as % of GDP)	Annual Energy Use (megajoules /person)	Emissions (CO, SO_2, NO_x, COV per person (kg)
USA and Canada	18.5	14%	12.5%	51,500	237
Oceania	15	21%	13.4%	30,500	189
Western Europe	55	50%	8.3&	16,500	88
Central and Eastern Europe	71	72%	14.8%	8,000	89
Asia (affluent cities)	134	62%	5.4%	11,000	31
Asia (other cities)	190	68%	13.6%	6,000	84
Middle East	77	27%	9.2%	15,500	215
Africa	102	67%	21.7%	6,500	148
Latin America	90	64%	14.3%	11,500	118

Ref: Adapted from Vivier (2001)[18]

3.2 Advanced Public Transportation System

The previous section had suggested that public transportation system could contribute to a sustainable transportation system. Now, the APTS is described followed by the potential APTS impacts on sustainability.

Advanced Public Transportation Systems (APTS) refer to the application of ITS technologies to improve the reliability, safety, efficiency, and productivity of public transportation system (FTA ,2003)[32]. According to the Federal Transit Administration's (FTA) (2000)[19], APTS is defined as:

> "...a collection of technologies that increase the efficiency and safety of public transportation systems and offer users greater access to information on system operations. The goal of APTS technologies is to provide public transportation decision-makers more information to make effective decisions on systems and operations and to increase travelers' convenience and ridership."

Thus, FTA's goal for using APTS is to increase travelers' convenience and ridership by increasing the efficiency and safety of transit systems as well access to information on systems and operations. It is assumed that the goal for increasing traveler's convenience is equivalent to increasing reliability and increasing ridership would mean increasing productivity. A brief overview of ITS and APTS are provided in the next few sections to illustrate how APTS could potentially increase system public transport system efficiencies.

3.2.1 Overview of ITS

3.2.1.1 Definition of ITS

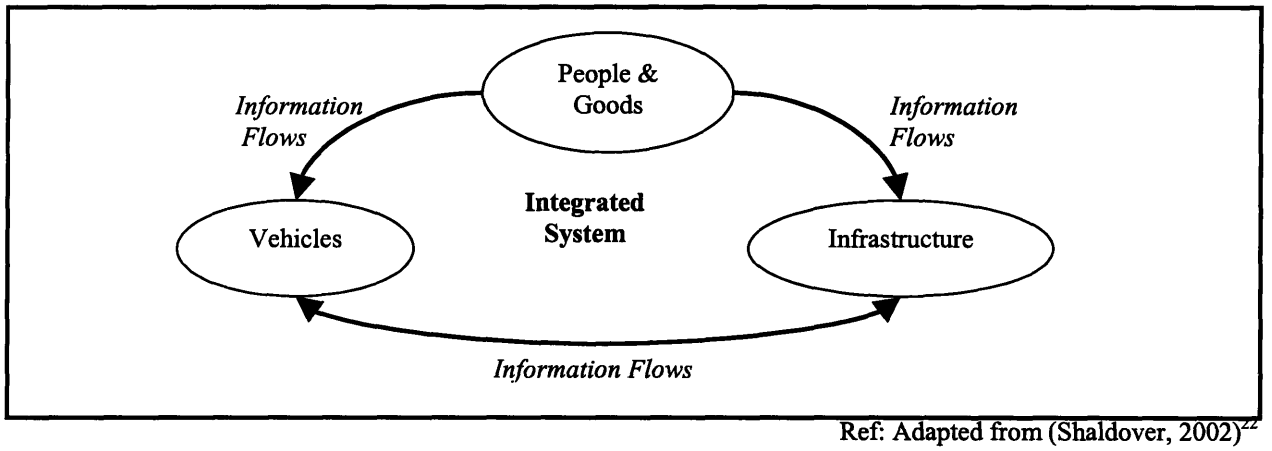
There are many terms that have been used to describe ITS, e.g. 'road transport informatics' by the Japanese and Advanced Transportation Telematics (ATT) by the Europeans (McQueen, 1999 p. 20)[20]. Nevertheless, ITS could be best described as (Sussman, 2002[21]; McQueen, 1999 p. 20[20]):

> "The application of technologies in communications, control, electronics, and computer hardware and software to improve surface transportation system performance"
>
> "The application of information and communications technologies to the planning and operations of transportation systems"

ITS is the use of technologies to support transport system management functions which are planning and operations. The new capabilities in transport system management enabled by ITS has the potential to change transportation as we know it today. By what mechanism does ITS improve transport management system?

3.2.1.2 Information-Oriented Transportation Paradigm

An information- oriented paradigm could explain how ITS works. Figure 3-2 shows an 'Information-Oriented Transportation' paradigm.



Ref: Adapted from (Shaldover, 2002)[22]

Figure 3-2 : Information-Oriented Transportation System Paradigm

Shaldover (2002)[22] stressed the fact that the significance of ITS is not the impact of a new technology, but its ability to integrate the transportation system. The figure explains how ITS works as an integrator: the transportation system was broken down as 'infrastructure', 'vehicles', and the 'people and goods' (i.e. users) being moved through the system. Information, via information and communications technologies, could bind these elements into an integrated system. The paradigm asserted that with easy and inexpensive information flows among these elements, the system is more likely to be optimized and operate as a system. Such an integrated system is expected to be effective and efficient in meeting its goals.

There are four main concepts that are critical in understanding ITS (Francois, 2000)[23]:

1. There are items of information, if collected and disseminated in a timely manner, can positively affect transport system functions and safety.
2. Information collected and used in ITS can be beneficial to one or all of the "stakeholders" – goods and people - in the system.
3. ITS can only be truly effective nationally when the many components of ITS are deployed in a unifying framework; system architectures serves as an organizing tool for integrating ITS system components
4. ITS development and deployment needs expertise in many areas – electronics, civil engineering, human factors, information management, GPS technologies, public-private sector policy development and management pratice and finance.

3.2.1.3 The 'ITS-4' Technologies

The innovation in ITS is that vehicle and infrastructure systems are viewed as one system rather than independent system components and Shaldover's paradigm had illustrated that. Information and communication technologies were mentioned as the key element that binds the two components together. What are the technologies used in ITS? Sussman (2000, p. 319)[38] called these 'ITS-4' technologies (Table 3-5). It is composed of technological capabilities to sense, communicate, process and use information.

Table 3-5: ITS-4 Technologies

Technological Capabilities	Description
Sense	Ability to sense presence and identity of vehicles or freight loads in real-time on the infrastructure through roadside devices of GPS.
Communicate	Ability to communicate or transmit large amounts of information more reliably and less expensively.
Process	Ability to process large amounts of information through advanced information technology.
Use	Ability to use this information appropriately and in real-time to achieve improved transportation network operations. Algorithms and mathematical methods are used to develop strategies for network control and optimization.

Ref: Adapted from Sussman (2000)[38]

These technological capabilities are designed into 'user services'.

3.2.1.4 Main User Services

ITS represents a broad systemic approach to transportation (Sussman, 2000)[38]; the system is usually described as built on three main technological subsystems – ATMS, ATIS and AVCS (Shaldover 2002[22], Sussman, 2000[38]). Throughout the years, the main ITS user services (Table 3-6) have been assembled to meet transportation needs in a variety of different environments – commercial freight transport, public transport and rural transport systems. APTS is a user service that combines the three main user services for the purposes of collecting and disseminating traveler information and technologies to improve system operations, including fare collection, intra-modal and inter-modal transfers, scheduling, headway control.

Table 3-6: ITS Main User Services

Main User Services	Description
ATMS Advanced Traffic Management Systems	ATMS provides the overall network management. The system collects data about real-time operation of network, traffic light control, congestion ameliorating strategies and incident management. Normally viewed as infrastructure-centered, an ATMS get much of their data from users through wireless phone systems. The latest data collection technique is the use of probed vehicles and communications.
ATIS Advanced Traveler Information Systems	ATIS supplies 'travel condition' information to travelers before or during trips. Usually viewed as vehicle-centered, an ATIS receives a large amount of data from infrastructure-based sensing. ATIS will not attain full value until fully integrated with ATMS, allowing system managers to incorporate ATIS data into operations decision-making.
AVCSS Advanced Vehicle Control and Safety Systems	AVCSS (or sometimes referred to as AVCSS - Advanced Vehicle Control Systems) offers a new level of control and safety technology applied to vehicles and infrastructure. Often thought of as entirely vehicle-centered, AVCSS is often ignored in the more conventional infrastructure centered ITS capabilities. These systems' value increases greatly from infrastructure-based data to address capabilities in intersection collision warnings, land departure warnings, low-friction road surfaces and fully automated driving.

Ref: Adapted from Shaldover (2002)[22];Sussman (2000)[38]

3.2.2 Advanced Public Transportation System Services

As mentioned previously, the term APTS user service refers to a combination of several groups ITS main subsystems, namely -- ATMS, ATIS and AVCSS. State-of-the-art ITS technologies listed here is only for the United States and was was obtained from the 'Transit ITS Impacts Matrix' website (US DOT, 2003)[24]; the website is maintained by the APTS Advisory Group, FTA, ITS America, and the American Public Transportation Association (APTA). This site has been intended to provide a one stop resource for transit planners and operations personnel to access and share dynamic and updated information on the benefits and costs of ITS for transit. Figure 3-3 is a taxonomy of transit technologies according to the 'Transit ITS Impact Matrix'.

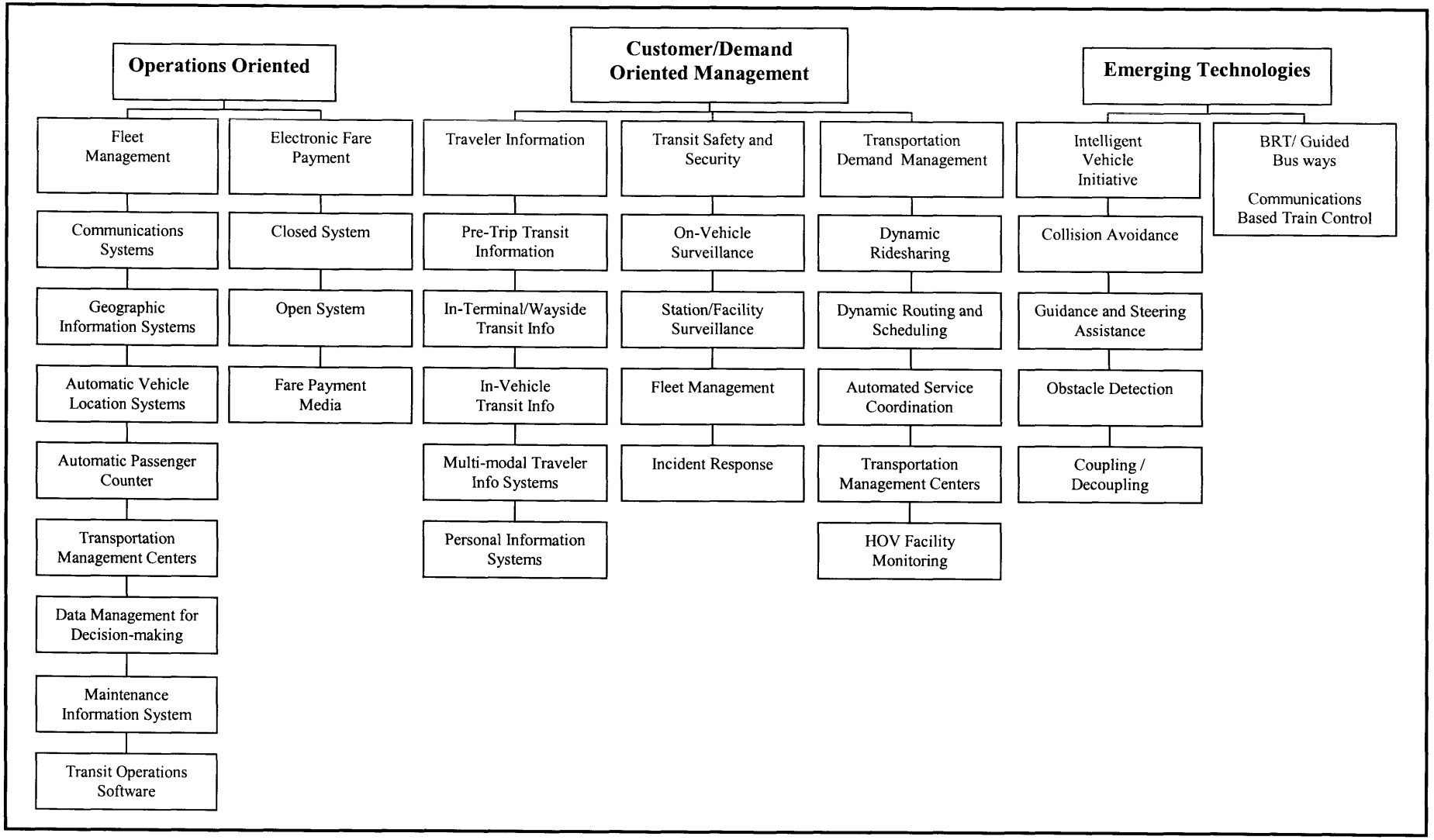
There are three main categories of technologies and services – 'Operations Oriented', 'Customer/Demand Oriented', 'Emerging Technologies'. These three main categories of technologies and services are further categorized into more specific services e.g. fleet management and transport demand management. Table 3-7 describes these APTS services in more detail.

Table 3-7: Advanced Public Transportation Services / Technologies

Service / Technology	Description
Fleet Management System	Application of technologies such as computer software, communications systems, and vehicle location technologies for more effective planning, scheduling, and operations of transit vehicle fleets. Operations software and AVL technologies have been very successfully deployed.
Electronic Fare Payment System	Provides an electronic means of collecting and processing fares. Customers use a magnetic stripe card, smart card, or credit card instead of tokens or cash to pay for transit trips.
Traveler Information System	Transportation information provided to travelers prior to and during a trip. Includes static and/or real-time information provided at home, at work, at transit stops, in transit vehicles, and for several modes. Information is provided via multiple devices/media. Pre-trip information is widely used.
Transit Safety and Security	Systems and technologies that deal with transit customer and operator safety and security. Technologies include silent alarms, covert microphones, and surveillance cameras installed in vehicles.
Transportation Demand Management System	Programs designed to reduce demand for transportation through various means such as ridesharing and other forms of transit. Systems and technologies dealing with the management of transportation demand.
Intelligent Vehicle Initiative	Intelligent Vehicle Initiative (IVI) applications to transit. The goal of IVI is to improve the safety and efficiency of transportation by reducing the probability of motor vehicle accidents through the use of vehicle control technologies.
BRT/Guided Busways	New paradigm of ITS applications: off vehicle payment, rapid boarding, guidance for berthing, lane width control, and/or route divergences. Coupling of vehicles for line haul segments of route. Electronic coupling, electric propulsion, and energy storage potential.
Communications Based Train Control	Train control system that uses continuous bidirectional communications between trains and wayside computers. Vehicle movement control is based on vehicle location computations from radio reflective, radar, geopositioning, or other airborne media. Does not require track circuits for its operation.

(Ref: US DOT, 2003[24]; US DOT, 1996[25])

Figure 3-3: Transit ITS Services / Technologies Taxonomy



Ref: US DOT (2003)[24]

3.2.3 Illustrative example of Fleet Management APTS System

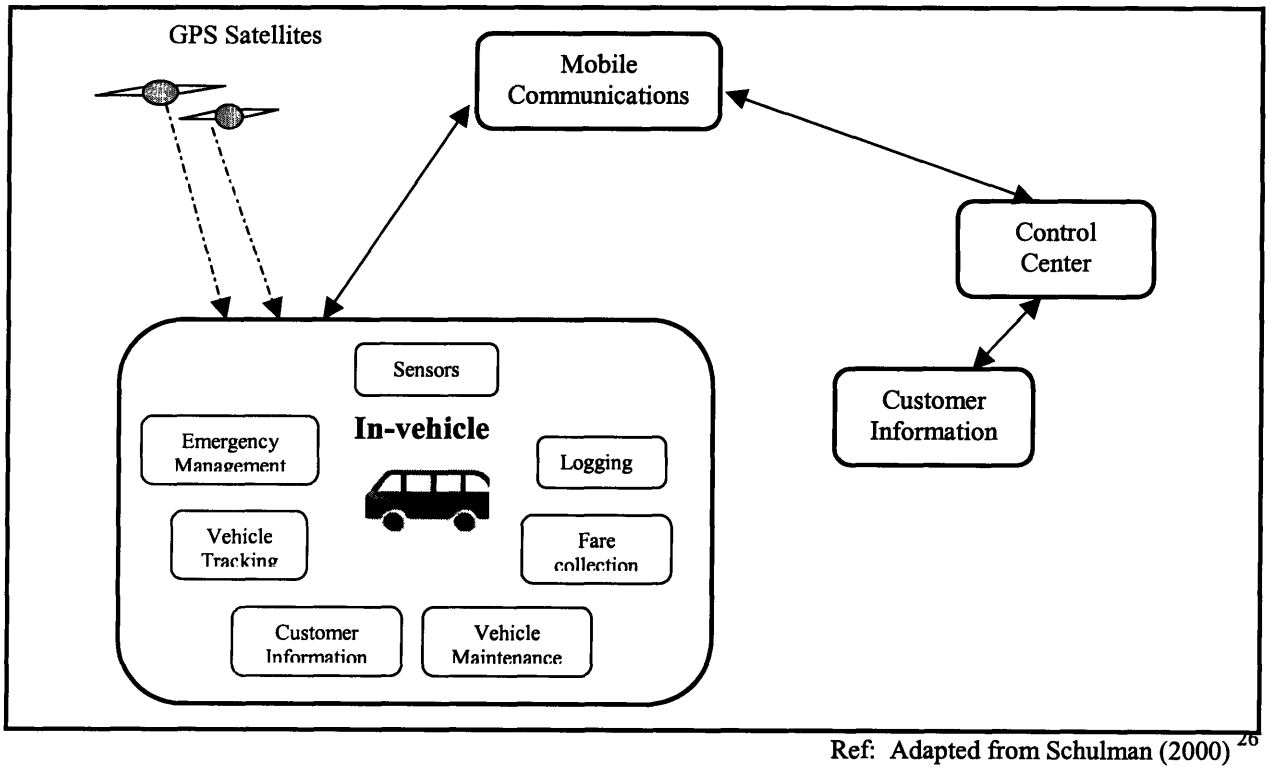
This section serves to illustrate how APTS could increase system efficiency. The fleet management system is focused upon. The fleet management system improves the efficiency, reliability and safety of transit systems, thus making them more attractive to users, transit operators and the local government areas that they serve.

System Implementation Objectives

The objectives of these system implementation include: schedule adherence, safety and security, performance monitoring, public information, improved communications, improved fleet management and productivity, and improved management systems.

System Architecture and Functionality

The basic system architecture of fleet management systems are the same even though there are design and functionality variations. There are three main elements of the architecture – in vehicle, mobile communications backbone, and control center as shown in Figure 3-4 (Schulman, 2000)[26]:



Ref: Adapted from Schulman (2000) [26]

Figure 3-4: Simple Schematic of Data Flows in Fleet Management Components and Subcomponent

In-Vehicle

The 'in-vehicle' component is the mobile-end of the system. It allows for the determination of real-time location of vehicle, interface between operator and system, and the communication between the vehicle and the control center. It may also have components that collect data which would provide enhanced functionality of the system. Real-time data like vehicle location and

arrival times can be transmitted to passengers for e.g. at bus stops, terminals or internet websites. The subcomponents of the in-vehicle component are shown in the figure and their functions are in Table 3-8.

Table 3-8: Functionality of In-vehicle System Component

In-vehicle Systems	Function
Logging	- On-board recording of vehicle information - Information, time and location correlation
Fare Collection	- On-board revenue - Smart cards
Vehicle Maintenance	- Mechanical systems - Electrical systems - Fuel systems
Customer Information	- Kioks - Arrival times -Voice annunciations - Internet - Destinations signs - Advertising signs - Pagers
Vehicle Tracking	- Schedule adherence - Priority movement - Route adherence
Emergency Management	- Covert audio monitoring - Silent alarm reporting - Vehicle tracking - Video surveillance
Sensors	- Collision avoidance - Lift - Door opening - Automatic Passenger Counters

Ref: Adapted from Schulman (2000) [26]

Mobile Communications Backbone

The mobile communication system allows for two-way voice and data communication between the vehicle and the control center. The basic components of the mobile subsystem are the fixed end equipment, the remote transmission sites and the in-vehicle radio. The radio communication system determines the process for installation of a fleet management system; radio systems usually operate in the 450 to 900 MHz range. Such systems may include private or shared or public radio networks; may be analog or digital; single site, multisite, or simulcast; and have conventional (untrunked), trunked, or pseudo-trunked channels.

Control Center

The control center (or dispatch center) is the fixed end of the system. This is where operational management decisions regarding the system are made. It is also the location where data from the in-vehicle systems are aggregated and transmitted to other agencies. Some control centers provide direct access to incoming data to emergency units (e.g. transit police, local police), maintenance unit, management, general public. Table 3-9 shows an example of the operation service units that could use the dynamic data from the control center via a Computer-Aided Dispatch (CAD) and Automatic Vehicle Location (AVL) system.

Table 3-9: Control Center Operation Service Units and Functions Using Dynamic Data

Operation Service Units	Function	Operation Service Units	Function
Operations	- Schedule adherence - Route deviation - Incident management	Maintenance	- Breakdowns - Routine service
Scheduling	- Time points - Schedules	Customer Information	- Arrival times - Schedule adherence - Wayside signs
Marketing	- Service reliability - Service interruption - Passenger counts	Service Planning	- Schedule adherence - Passenger counts
Finance	- Fare revenue - Passenger counts		

Ref: Adapted from Schulman (2000) [26]

Benefits and Costs of Fleet Management Systems

The efficiencies resulting from fleet management system implementation described above have been reported around the United States. The 'ITS Benefits and Cost Update 2003' (US DOT, 2003)[27] reports the benefits and costs of ITS systems in the United States and around the world. Table 3-10 lists of the benefits of Fleet Management Systems.

Table 3-10: Examples of Benefits and Costs of AVL/CAD Fleet Management System

Benefits	
Productivity	Analysis of travel times suggested that Kansas City, Missouri that used an AVL/CAD system reduced up to 10% of the vehicles required for some bus routes with no reduction in customer service.
Mobility	The Denver, Colorado, Regional Transport Department implemented its AVL system to improve bus service, and succeeded in decreasing passenger late arrivals by 21%.
Customer Satisfaction	The GPS-based vehicle location system in Denver, Colorado, rated very well with Regional Transportation District dispatchers. Operators and dispatchers were able to communicate more quickly and efficiently. Almost 80% of dispatchers found the system "easy" or "very easy" to use, and about 50% of operators and street supervisors experienced the same.
Costs	
System Cost	Capital cost: approx $10.4 million Annual O&M cost: approx $1.9 million The AVL system installed by the Denver, Colorado, Regional Transport Department on its 1,355 vehicle fleet is GPS-based. The capital cost includes system software, dispatch center hardware, in-vehicle hardware, field communication equipment, initial training, and planning and implementation.

Ref: US DOT (2003)[27]

In general, the major benefits of fleet management systems reported include (Schulman, 2000)[26]:

- Improved customer service in terms of reliability, improved safety and security and improved bus status information;
- Improved operational efficiency in terms of increased flexibility of assignments, faster response to emergency situations, improved efficiency in tracking on-time performance and increased capability in handling complaints;
- Increased ridership.

Due to the nature of the system which has many components, it was suggested that in order to maximize the system capabilities, careful planning and integration of the total range of functionality anticipated in the system is needed; this becomes particulary important if the budgetary funds available require the total system functionality to be implemented over time in phases. Failure to plan for such implementation will result redundant technology, unnecessary expenses and system integration complexity.

3.2.4 Sustainability of APTS-Enabled Public Transportation System

The use of intelligent transportation systems (ITS) to increase the efficiency of private vehicles was suggested to be unsustainable as more throughput of vehicles as well as latent demand would be generated. Thus, ITS's ability to increase efficiency of transportation systems could simultaneously increase resource throughput, over consumption and ultimately more wastes which are counterproductive to sustainability goals (Hall and Sussman, 2003[28]; Kanninen, 1996[29]; Meyer and Miller, 2001, p. 29[13]). However there are studies which suggest that ITS-generated information could contribute to sustainable transportation (Jordan and Horan, undated)[30]. It is stressed here that ITS is only a technology and it is the manner in which it is applied which makes its impact positive or negative (Sussman, 2000).

It was shown previously in Table 3-2 how public transportation system could contribute to sustainability. APTS could increase the efficiency of public transport systems and simultaneously contribute to sustainability. The degree of how much more 'sustainable' an APTS-enabled public transportation system is unknown and is beyond the scope of this thesis. The manner in which APTS technologies and services could increase the efficiency of public transport system is shown below. Table 3-11 qualitatively examines how APTS can increase the efficiency and effectiveness of public transportation system. The left most column lists public transport improvements and the immediate column to the right indicate whether the improvement contribute to sustainability as indicated in Table 3-2. The next 8 columns that follow list the APTS technologies and user services as defined by US DOT (2003)[24]. The check marks indicate whether the public transport improvement contributes to sustainability and/or whether an APTS technology or service could assist, either directly or indirectly, in increasing the efficiency of the improvement. For example, the efficiency and effectiveness of adding routes, expanded coverage and increasing service frequency and hours of operation would be increased by APTS technologies and services like the fleet management systems, electronic fare payment, traveler information service, transit safety and security, transportation demand management and BRT systems. From the qualitative information in Tables 3-2 and 3-11, it is suggested that APTS-enabled public transportation could contribute to sustainable transportation.

Table 3-11: Public Transport System Service Improvements and APTS Technologies and User Service

Public Transport System Service Improvements	*Contribute to Sustainability?*	*APTS Technologies and Services*							
		Fleet Management System	*Electronic Fare Payment System*	*Traveler Information System*	*Transit Safety and Security*	*Transportation Demand Management System*	*Intelligent Vehicle Initiative*	*BRT/Guided Busways*	*Communications Based Train Control*
Additional routes, expanded coverage, increased service frequency and hours of operation	X	X	X	X	X	X		X	
Lower fares, increased public subsidies	X		X			X			
Vehicle Trip Reduction programs, and other Transit Demand Management Programs (TDM) that encourage use of alternative modes	X			X		X			
High Occupancy Vehicle (HOV) Priority	X	X	X	X		X			
Comfort improvements, such as better seats and bus shelters	X								
Transit Oriented Development (TOD) and Smart Growth	X			X		X			
Pedestrian and cycling improvements that improve access around transit stops	X			X					
Improved rider information and marketing programs	X			X					
Improved security	X				X				
Services targeting particular travel needs, such as express commuter buses, Special Event Service, and various types of Shuttle Services.	X	X	X			X			
Accessibility Design	X								
Park & Ride facilities	X			X					
Bike and Transit Integration[10] (bike racks on buses, bike routes and Bicycle Parking at transit stops).	X			X					

Ref: US DOT (2003)[24] and VTPI (2003)[5]

3.2.5 APTS Opportunities for Multimodal Integration

APTS-enabled public transportation system improvements could contribute to sustainable transportation systems. The FTA's strategic plan for public transport has goals which could be considered in line with sustainable transportation systems. APTS has been suggested to be a prime enabler of these goals (Kushner, 2000)[31] as shown in Table 3-12. APTS could contribute to public transport goals like safety, customer orientation, positive image of public transport.

Of interest in this thesis is the ability of APTS to integrate different modes of transportation systems (e.g. rail, bus, taxis). There are many benefits and efficiencies that could arise as a result of such integration. The next chapter describes in more detail the concept of multimodalism in transportation systems and the planning implications.

Table 3-12: FTA Strategic Vision Strategies

		APTS Technologies									
Goals	**Description**	*AVL*	*ATMS Integratuion*	*GIS*	*In-Vehicle Annunciation*	*APC*	*Automated Iteneraries*	*VMS*	*Interactuive Kioks*	*Signal Priority*	*Electronic Fare Collection*
Safety and Security	To provide a secure and safe environment that includes operationally safe equipment and facilities, as well as personal security and property protection.	X		X							
Customer Oriented	To focus on customer-based needs for current and future markets and provide responsive, affordable, convenient, and accessible public transportation services.	X	X	X	X	X	X	X	X	X	X
Adapt to Change	Foster industry adaptability to enable the industry to respond to changes in transportation patterns, technologies and needs	X	X			X				X	
Multimodal	To encourage collaboration among those who use, provide, regulate, fund and/or benefit from transportation to promote choices among transportation modes.	X	X				X			X	X
Quality Organization	To be responsible to employee needs and empower its employees to be productive contributors to the FTA mission.	X									
Highest level of Service	To improve the delivery of transit service and mobility for the public through a proactive role in providing technical assistance and support to transportation providers.	X	X	X	X	X	X	X	X		X
Links to Community	To promote a coordinated planning process that involves the needs of the community through livable communities and improves personal mobility.	X		X		X				X	
Positive Image	To clearly demonstrate the benefits that public transportation brings to our communities and to raise the consciousness of the public toward the role of FTA as a major partner in public transportation.	X	X		X		X	X	X		X

Ref: FTA (2003)[32]

3.2.6 Summary of Sustainability of APTS-enabled Public Transport System

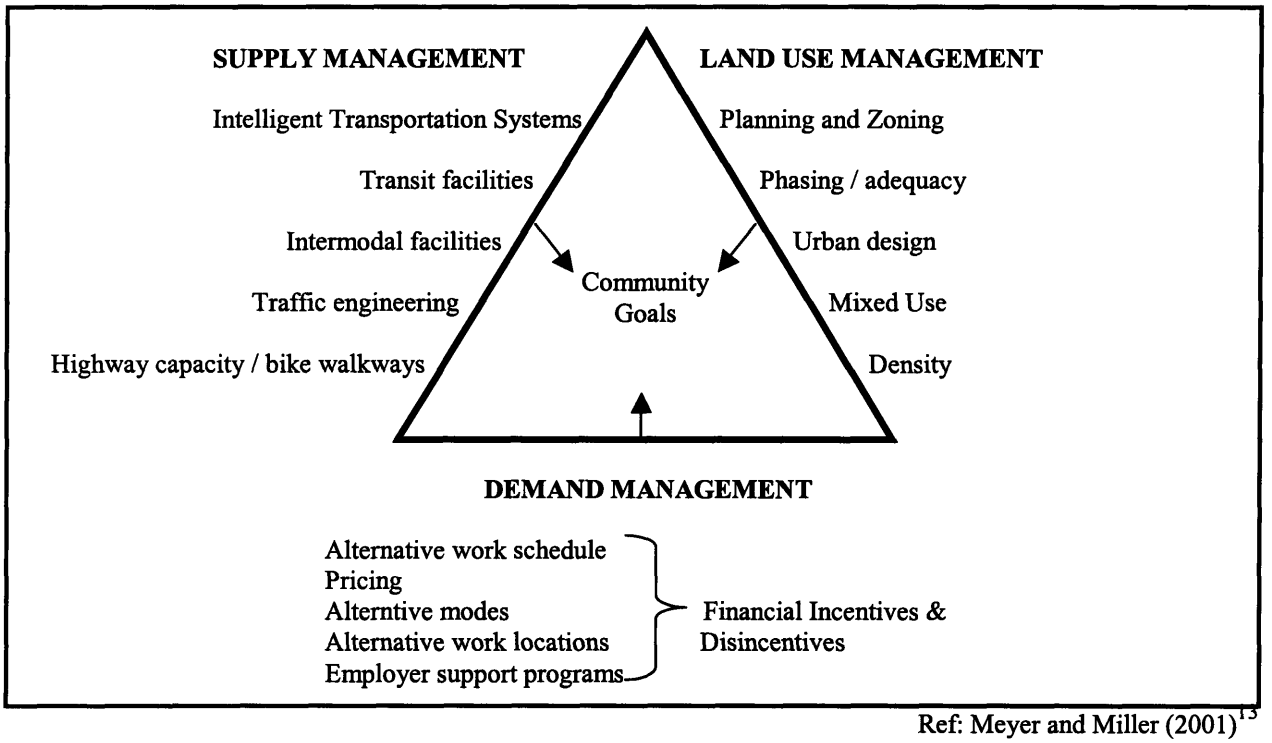
This section described qualitatively how APTS-enabled public transportation systems could potentially contribute to sustainable transport systems. In addition to APTS contributing to sustainability, APTS also can provide opportunities for regional and multimodal integration of transportation systems which could further increase system efficiency and ultimately increase the sustainability of transport systems. Chapter 4 describes the planning implications of a multimodal and regional APTS-enabled public transportation system and argues for the need of a regional planning architecture.

3.3 Planning Implications of Multimodal and Regional Perspectives

Meyer and Miller (2001)[13] described multimodal transportation planning as:

> "The process of defining problems, identifying alternatives, evaluating potential solutions and selecting preferred actions that meet community goals in a manner that includes all feasible transportation modes"

The efficient functioning of a multimodal transport system rests upon a coordinated transportation program more so than a unimodal system. Figure 3-5 shows the components of a multimodal transportation program. The coordinated strategy for managing and planning multimodal transportation system consists of three components – supply management, demand management and land-use management. The keyword to the strategy is management. This is crucial because transportation systems already exist and the decisions like what infrastructure to build; what operational improvements to make; what development patterns are compatible; how to provide institutional and funding structure; for example, are all system management decisions. Many agencies have adopted this perspective. For example, the Maryland DOT mobility planning studies have adopted this perspective in identifying measures for solving transportation problems. These measures include pricing of parking, traffic operations improvements, public transit and highway capacity expansion, and land use strategies. Other agencies which have adopted such perspective are the MPO in Albany, New York and Denver. Because of the broad perspective this approach takes on identifying problems and solutions, it is expected to be the "future" of transportation strategies.



Ref: Meyer and Miller (2001)[15]

Figure 3-5: Components of a Multimodal Transportation Program

The concept of multimodal planning can be focused on solely public transportation. Solutions can be developed from the public transport supply perspective, demand perspective as well as land use perspective. However, as the next section illustrates, developing a multimodal regional APTS-enabled public transportation coordinated program is not an easy task and accomplishing such tasks necessitate organizational and institutional change. The next section describes the institutional change that is underway in public transportation organizations in Europe and United States instigated by a variety of factors. These changes involve the way they plan and operate public transportation systems.

3.4 Multimodalism, APTS and Need for Strategic Institutional Change

Because of the changing context of the environment in which public transportation systems operate, there is a mission or paradigm shift in public transport institutions to move towards providing multimodal services through the "Mobility Management Paradigm". The emerging new mission has slowly in the past 2 -3 years led to changes in the way a large segment of the public transportation industry reorganize their organizational structure, management nad institutional arrangements. This section describes why these changes have occurred, what these changes have entailed and how public transportation institutions have responded to the change. The information presented are from United States and European Union experiences.

3.4.1 Changing Context of Public Transportation

The previous sections have described multimodal transportation planning as having a direct cause-effect relationship. For example, agencies can select various strategies in demand, supply and/or land use management to affect system performance. In actuality, travel behavior and

travel patterns on transport networks are affected by many factors outside the control of planners and government agencies. For instance, overall levels of travel reflect the state of the economy i.e when the economy is booming, more travel is generated (Meyer and Miller, 2001, p. 13). Understanding how these factors drive changes in the transportation planning process over time is very important in setting a strategic vision for the future.

3.4.1.1 Causal Factors of Declining Public Transportation Use

Meyer and Miller (2001, p. 15) suggested that the root causes of overdepency on of private vehicles over public transport could be one or more of the following: more trips/capita made by women; increasing number of single person households; increasing population and employment in the suburban area (vs. central city); increasing auto ownership by women; increasing person miles traveled; increasing person trip travel; and vehicle costs. Although many factors have such an influence, the following have been most relevant to the public transportation system institution in the United States (TCRP, 2000[33]; TCRP, 2003)[34]:

1. **The Vitality of Urban Areas**
   The quality of life and economic vitality of urban areas are more and more threatened by unabated expansion of urban development (i.e. sprawling), rising congestion across cities and suburbs, the ever increasing cost and declining performance of a wide range of public services, and the increasing unwillingness to increasing public investment for addressing these problems under traditional programs.
2. **Socioeconomic Trends that Diminish the Role and Relevance of Public Transport**
   Socioeconomic trends tend to diminish the importance of traditional public transportation services. Some of them are listed below (Meyer and Miller, 2001, p. 19):
   - Rise of the service economy which diffuses travel patterns;
   - Increasingly flexible work schedules, which requires multiple trips over longer distances and periods of the day. Trip chaining is difficult to do with public transportation;
   - Rising real income in many segments of the population, which increases vehicle ownership and use;
   - Increases in single parent, single adult and two worker households, which reduces the usefulness of tradition transit service
   - Suburbanization and the accompanying low densities in population and employment, which greatly reduces the attractiveness of of public transportation in rapidly developing areas;
   - Slow introduction of new technologies into the public transport industry, which limits fundamental change and improved market adaptability and responsiveness.
3. **The "Enabling Environment": Fragmented Responsibilities, Regulatory Contraints, and Conflicting Policies and Goals**
   The "enabling environment" in surface transportation is replete with fragmented responsibilities, as well as regulatory constraints, conflicting policies and goals, and restrictive "stove piped" funding mechanisms that often limit the ability of organizations to adapt quickly and frustrate efforts to enhance responsiveness to changing travel markets and conditions.
4. **Organizational Dynamics and Culture**
   The organizational dynamics and culture of local public transport organizations historically have presented a barrier to change and are reinforced by long-standing policies, programs,

and regulartory frameworks, as well as deeply engrained change-resistant perspectives and attitudes on the part of many industry managers and labor force.

5. **The Quality of Customer Experience**
   The quality of customer experience has not entirely emerged as a major focus in providing services as it has in many other service and commercial enterprises like intermodal freight (e.g. Maersk and SeaLand/CSX), U.S. Postal Service, Federal Express, UPS, and the European transit agencies (e.g. London, Zurich). Performance measurements have been dominated by operational, output based measures.
6. **The Digital Economy and Information Age**
   Local public transportation organizations historically have been slow in deploying state-of-the-art information and other emerging technologies that have become more commonplace and in actuality are increasingly expected by customers in most other markets and industries.

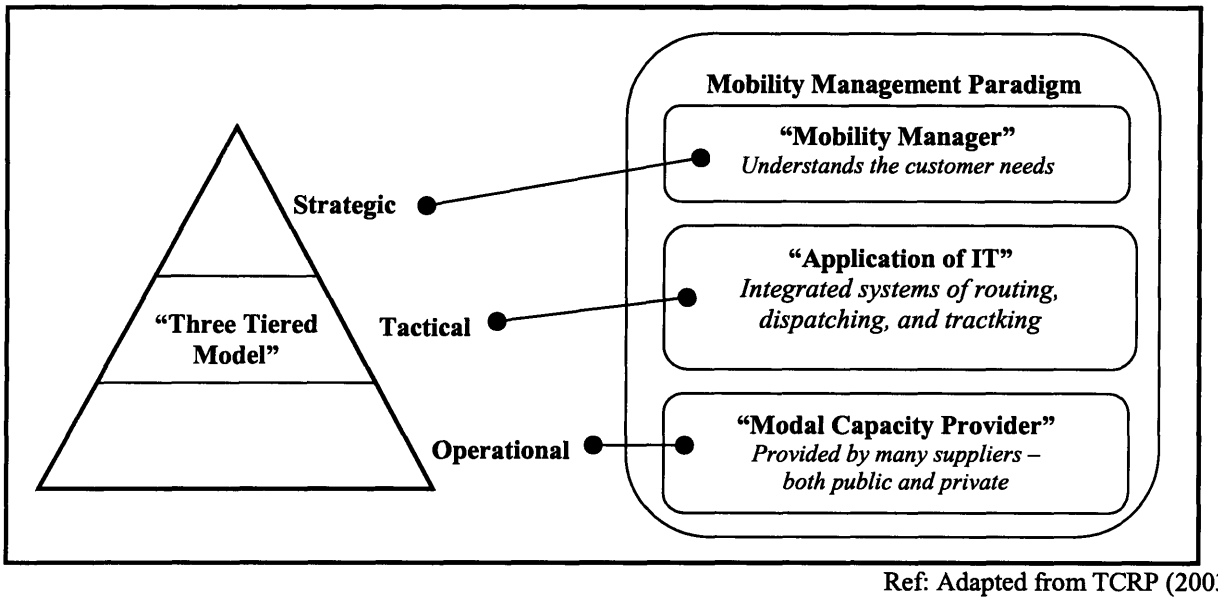
These trends have been suggested to be the major driving forces of change which have led to a widespread mission shifts in local public transportation organizations across the United States.

3.4.2 "Mobility Management Paradigm", Information Technology and Organizational Structure Change of Transportation Organizations

A TCRP (2003)[34] report entitled "Emerging New Paradigms A Guide to Fundamental Change in Local Public Transportation Organization" synthesized years of research on the organizational and institutional changes that has been taking place in the local public transport organizations in the United States and European Union. The emerging new paradigm reflects the changes that have taken place in other industries, both public and private, like intermodal freight (e.g. Maersk and SeaLand CSX), package delivery (e.g. U.S. Postal Service, Federal Express, United Parcel Service), and airlines industry (Delta and United Airlines). The theme of the change is refered to as "Mobility Management Paradigm". This paradigm is one which:

> "...elevates customer-driven mobility management to the level of strategic importance, retains and strengthens functions that support the mobility management mission, and delegates remaining functions to partners with clear expectations for more accountability to customers."

The fundamental organizational structure that has emerged as a result of adoption of this paradigm has been termed "Three-Tiered Model". The organizational model acknowledges that there are fundamentally three functions of management structures governing public transport services' -- 'strategic', 'tactical', and 'operational' functions and approapriate design of these functions could lead to higher organizational effectiveness. Figure 3-6 illustrates this idea.



Ref: Adapted from TCRP (2003)[34]

Figure 3-6"Three–Tiered Model" and "Mobility Management Paradigm"

In essence, there are three main elements of the new emerging paradigm:

Mobility Manager
The strategic goal of the organization is to focus on enhancing mobility and increasing the quality of customer's experience. It is in the strategic interest of the agencies to become "Mobility Managers" whose main responsibility is to provide customers with information and ease of access to a range of services (i.e regional public transport service depicted in Figure 4-1) that can serve individual travel needs through a region and has the capacity to monitor and evaluate the quality of customer's experience. This function was suggested to be strategic in nature and would form an "umbrella" or "oversight" organization.

Application of IT
This new capacity is enabled by the "Application of information technology (IT)" which is capable of continuous tracking and serving customer needs, customer experiences, and operation of the network. This function was suggested to be tactical in nature.

Modal Capacity Provider
The network capacity denoted by the "Modal Capacity Provider" is made available by many suppliers, both private and public, through various partnering arrangements. This function would more operational in nature.

It follows that the changes that needs to occur to implement the new "Mobility Management Paradigm" necessitates change along six main dimensions (TCRP, 2003)[34]:

- "Mission shift
  Shifting core mission from just providing capacity through asset ownership to having a broader responsibility for "managing mobility" and managing a wide range of assets (e.g. multimodal network).

- Obsession for the customer
  Measures of performance and success should focus more on the quality of the customer experience.
- Collaboration
  Fundamental strategy has to become one that is of collaboration across modes, organizations, and jurisdictions.
- Integration
  In addition, to achieve collaboration, integration of assets, services and business functions has to occur.
- Information Technology
  To collaborate and integrate, state-of-the-art information technologies, primarily APTS, is needed to create effective links between customers and partners.
- Organizational Structure Change
  Formation of new business units, redesign and relocation of traditional functions, development of new professional skills and competencies, and reengineering of traditional business process will need to occur as a result of the need to implement the new mission, increased focus on customers, new partnerships, and the requirements of new technologies."

3.4.2.1 APTS as Enabler of Collaboration and Integration and Implementation Issues

The application of information technology is critical in enabling and implementing collaborative activities and integration to occur between key functions and business processes. As mentioned before, APTS, which uses information and communications technologies, provides opportunities for regional and multimodal integration of transportation systems which could lead to greater system efficiency and sustainability of transport systems. APTS technologies and user services such as common scheduling, real-time, regional, web based service and operations information for on-street users; and the regionwide standard electronic fare systems are a major part of the "enabling" mechanisms that make public transportation oganizations able to adopt and implement the new paradigm. More specically, APTS could allow for:

- Implementing the "Mobility Management Paradigm";
- Accurate and sophisticated performance measures of service quality and efficiency;
- Connecting continuously in real time to partners in service design and delivery, and
- Understanding and monitoring customer needs and levels of satisfaction with services offered.

APTS are forcing fundamental changes in the structure of organizations as well as institutional arrangements (Sussman, 2002)[15].

It is important to understand the institutional issues that are major barriers to ITS/APTS deployment. This is because of the nature of the system implementation which requires effective data and communication lines to be established between many different private and public entities. The US DOT conducted a survey on the status of APTS technologies deployment in the United States (US DOT, 2001)[35]. Worth highlighting is the fact that the report noted that APTS alone without other private mode use restraints cannot achieve its intended benefits. There were also lessons to be learned about implementations issues regarding APTS. From the system perspective, there is the difficulty in getting systems to work together. The more APTS systems

elements and agency implements, the more difficult integration becomes. Some transit agencies are still hesitant about deploying APTS technologies because of costs, lack of awareness of benefits of APTS, resistance to change or absence of personal knowledge about APTS. In addition, APTS technologies have the reputation of being difficult to implement although technologies have become more user friendly. Often technologies are proprietary from vendor to vendor and can be hard to operate and maintain for a transit agency with little advanced technology experience. The US DOT also outlined several cross cutting institutional issues and lessons to be learned for ITS deployment which is applicable to APTS and its integration into other ITS systems:

- ***Cost of APTS systems***
  Cost of APTS implementations remains the greatest barrier to widespread deployment.
- ***Awareness and perception of ITS technologies and benefits***
  Explicit public and private sector awareness and support for ITS must be obtained. Failure to do so means a lack of financial resources and other support for ITS projects.
- ***Long-term operations and maintenance***
  ITS projects are not like most typical capital and infrastructure projects in that they have operations at their core, implying the need for financial support over the years. The cost of a project's operation and maintenance must be identified in the project planning stage, and the impacts of these costs addressed.
- ***Regional deployment perspective***
  The implementation of a regional perspective for ITS deployment is one of the most important strategies for success. A regional perspective means that stakeholders view projects from the standpoint of other project participants in their region as well as from their own. Such a perspective, which fosters a more cohesive and integrated project vision for all involved, is critical in facilitating development of ITS products and services.
- ***Human resources management for ITS operations***
  Public agencies may not have the staff needed to develop, install, and operate ITS. The staff may also lack the expert capability required. Shortage of ITS professionals also may lead to capable public sector staff being lured to the private sector. These conditions will occur when a public sector agency has limited resources to hire and train staff, and to provide salaries and benefits comparable to the private sector.
- ***Multi-organizational relationship***
  The establishment of strong working relationships will continue to be a challenge to the ITS community. Managers of public agencies must be willing to give up some of their autonomy and develop a regional perspective when establishing coalitions with other public agencies. Cultural differences between public and private sector entities must be overcome for collaborations to take place.
- ***Explicit ownership and use of resources***
  These issues include who owns the data generated, whether there should be a charge for the data, how this information will be shared among the partners, and to whom the information will be released.
- ***Flexible procurement process***
  The lack of flexibility in the procurement process and the public sector's aversion to taking risks contribute to this problem. Changes to legislation, policies, or procedures may be necessary to allow the parties flexibility to use the most appropriate procurement method, as determined by project needs. Failure to be flexible in the procurement process means that

acquisition procedures used for construction projects are the only tools available for procurement of advanced technologies.

- ***Intellectual property rights for private sector involvement***
  The proper assignment of intellectual property rights presents a continual challenge to ITS projects. Applications of ITS raise vexing new questions regarding patentable inventions, copyrights, and trade secrets, as well as compilations of data derived from the operation of ITS technologies. These issues must be addressed early in the life of an ITS project to promote the involvement of private sector representatives.
- ***Privacy protection strategies***
  Users of ITS applications must be informed of data collected and how they will be stored and used. Users may not accept data for non-traffic management purposes or for identification of individual travel patterns. Agencies must develop strategies to inform their customers about the collection and use of data and to protect their privacy.
- ***Liability***
  Even though liability concerns has not been a major issue to date; however, as with the area of privacy, these concerns may increasingly grow with time.

It is important that these barriers be taken into consideration when planning for the deployment of APTS. Appropriately deployed, scarce public transport resources can be better defined, separated and focused into those that are strategic and operational in nature which leads to greater organizational effectiveness in implementing its missions.

3.4.2.2 Organizational Change

The recent wide acceptance of the "Mobility Management Paradigm" by a large number of transportation organizations has intiated changes in organizational structure and capacity. Most evident is the shift in the view that operational performance is of paramount strategic interest to something which views customer's experience as a strategic mission, a view that has been largely neglected. At the core of the organizational change relevant to the new paradigm is the distinction that has to be made between:

1. Organizational capacity and systems needed for planning for execution of long term strategic interests and missions;
2. Organizational capacity and systems needed for operations management on a daily basis

The emerging model now is the creation of "regional umbrella" organization that coordinates and oversees the provision of public transport services. However, this model is not entirely new in the United States. These types of agencies have existed in Chicago and New York; the structures and arrangements that they have allow them to exercise a range of strategic, coordinating and management functions that steer investment and delivery of traditional transit services in a multi-jurisdictional environment. What is different from the "umbrella" organization model and the one suggested by the TCRP (2003)[34] report is the call for diminishing the role of the public agencies as sole owner of assets (e.g. infrastructure and equipment) and employers of operating personnel. Most importantly, the new model emphasizes the strategic responsibilities of the public agency for service integration, resource allocation, and overall performance of the system and respective service providers. Strategic direction remains a

public sector responsibility and modal and geographical operational responsibility can be exercised through public private partnerships (PPP).

3.4.3 Examples of Strategic and Operational Roles and Responsibilties of "Three-Tiered Models"

As described previously, the "Three-Tiered Model" emphasizes the separation of roles and responsibilities which are strategic and operational in nature to successfully implement the "Mobility Management Paradigm". This section illustrates by use of examples the roles and responsibilities of the local public transportation organizations which have undergone organizational changes (TCRP, 2003)[34]. The TransLink and GRTA form two main examples:

Greater Vancouver Transportation Authority (TransLink)

TransLink was created in 1998 to function as the coordinator of a formally defined Regional Transportation Network. TransLink has the responsibility to plan, finance, operate, and manage transportation in coordination with the region's growth and economic development plans. Through a series of operating subsidiaries, public and private partners, and contractors, TransLink is responsible for planning regional strategies for:

- Public transport operated by four wholly owned subsidiary organizations and private contractors;
- Roads and bridges on a 2,100-mile Major Road Network in partnership with municipalities;
- Air quality management and emission standards in cooperation with the Greater Vancouver Regional District the regional planning agency;
- Transportation demand management through alternative programs and partnerships with private business and industry; and
- Intelligent transportation systems (ITS) planning and deployment through a subsidiary corporation.

The overall structure of the new formed TransLink organization, its multimodal mission, the arrangements through which it executes its mission, and the separation of regional strategic responsibility from operating responsibility reflect the themes and principles of the emerging new paradigm.

Georgia Regional Transportation Authority (GRTA)

The GRTA was formed in 1999 in reaction to air quality and transportation planning problems in the Atlanta region. GRTA's authority is statewide but is directly applied to jurisdictions that are under federal nonattainment status for air quality. Responsibilities of the GRTA lie in four specific areas:

- Implement public transportation services and capital improvements within the region,
- Withhold state grants from local jurisdictions whose plans fail to adhere to regional goals and plans,
- Approve transportation improvement programs and regional plans, and
- Enjoin state and federal transportation funding for developments of regional impact.

In concept, the institutional changes brought by the formation of the GRTA and TransLink have many similarities. First, the changes have strengthened the regional strategic planning and transportation management function as separate from the operation of different systems and services. There is also a much closer link created between transportation investment decision-making and regional land use and development plans. There are also fundamental differences in

the in governance and financing. In terms of governance, TransLink's members consists of local elected officials appointed by the regional planning agency (GVRD). GRTA's members on the other hand is appointed by the governor of Georgia.In terms of funding sources, TransLink obtain exlcusive regional funding sources (including fuel taxes, residential and commercial property taxes, residential electric utility fees, sales taxes applied to parking, and fees from emission testing). The GRTA has substantial bonding authority (which is currently challenged in court), but no independent regional revenue source. GRTA also negotiates fee-for-service funding agreements with local jurisdictions desiring service.

There are many other examples of transportation organizations that have undergone the aforementioned structural changes (Table 3-13). These changes are not as major as the ones seen in TransLink and GRTA, but they indicate a move towards such changes. The table describes briefly the roles and responsibilities of local public transport organizations that have been restructured to become strategic planners in the United States and the European Union (EU). The organizational changes that have taken place are similar; strategic responsibilities of the "umbrella" local public transportation organization are primarily for service integration, resource allocation, and overall performance of the system and respective service providers. Nevertheless, the TCRP (2003) report described that these changes are still evolving as organizations are testing what functions and activities should be performed by what groups to best serve customer needs and the new paradigm for managing mobility from a multimodal perspective. Table 3-14 is an example of the selected functions and activities that will be consolidated under the formation of an 'umbrella' public agency which will consist of the San Diego MTDB, NCTD and SANDAG. The objective of the consolidation of functions is to streamline and quicken the rate of transportation planning and investment in a more coordinated, multimodal and collaborative way. The review will make a distinction between which functions will be moved to the 'umbrella' agency as a matter of strategic importance and which should remain in the surviving transit operating agencies.

Table 3-13: Examples of Local Public Transportation Organizations as Strategic Planners in United States and European Union

Country	Public Transport Organization as Strategic Planners	Example of Roles and Responsibilities
United States	Chatham Area Transit (CAT), Savannahm Georgia	- Regional and strategic responsibility for all surface transportation services
	ValleyRide, Boise, Idaho	- Integration of operations of multiple services and providers - Planning focusing on programming, technology and land use coordination - Market development and community outreach focusing on customer concerns - Centralized human resources and finances
	Utah Transit Authority (UTA), Salt Lake City, Utah	- Have regional in scope and strategic in nature functions which is separated from operations planning and asset maintenance i.e. general manager, board coordination, organizational development, strategic think tank, chief performance officer, regional public relations and marketing, capital planning and programming, legal, audit, civil rights, financial management and services, comptroller, information technology, customer service, central maintenance and purchasing, human resources, training and security.
	Metropolitan Transit Development Board (MTDB) and the Consolidated Agency (SANDAG[1] and NCTD[2]), San Diego, California	- Decides on regional and strategic transit and transporation issues - Serves as an oversight and management organization focused on service integration with a customer orientation - Transit service and operation responsibilities have been delegated to purely operating agencies and contractors - Consolidates planning and programming functions as well as major construction project
	Los Angeles County Metropolitan Transportation Authority (LA MTA), Los Angeles, California.	- Clearly divided 'corporate business units' from 'service sector units' - "Tier One" interregional service operations, including Metro Rail, Metro Rapid (BRT), Rapid Bus, and Express Bus operations - Budget and capital planning - Collective bargaining agreements - Fare policy and service standards - Performance monitoring and tracking of all programs - ITS - Communications and community relations for corporate bus and rail service actions - Government relations - Construction management - Finance
European Union	Syndicat des Transports d'ell de France (STIF), Paris, France.	- Plan includes multimodal strategies to reduce auto traffic and increase use of transit and non-motorized modes (i.e. bicycles, walking) - Determine pricing policy for transit systems - Develop incentive based performance measurements to improve quality of service
	Transport of London (TfL), London, United Kingdom	- Local car sharing policies to reduce auto ownership - Bus signal prioritization - Congestion-based roadway pricing
	Zurcher Verkehrsverbund (ZVV), Zurich, Switzerland	- Advertisement for 12 month mobility pass for rail, bus, ship, tram and autos - Local car sharing system
	Regional agency, Bremen, Germany	- Car sharing system for transit users using the "Bremer Card"

[1] SANDAG – San Diego Association of Governments; an MPO
[2] NCTD – North County Transit District

Ref: TCRP (2003)[34]

Table 3-14: Selected Functions and Activities Reviewed for Potential Consolidation

Function /Activity	
Customer Relations and Marketing	***Human Resources***
Market Research	Hiring
Marketing	Evaluation
Advertising	Training / Professional Development
Business Development	Grievance
Outreach and Public Information	
Graphics and Production	***Multimodal Operations***
	Services Contract Management
Finance and Administration	Taxicab Regulation
Budget Development	Operations Coordination and Policies
Grant Management	Bus Stops, Shelters, Facilities
Pass Sales / Cash Handling	
Procurement	***Information Technology***
	Software Management
Legal and Compliance	Fiber Optics
Counsel	Radio Communications Systems
Legislative Support	Fare and Customer Information Technologies
Risk Management and Insurance	
Contract Compliance	***Engineering and Construction***
Internal Audit	Engineering
Security	Construction
	Construction Oversight / Management
	Real Estate / Property Management
	Other Non-Operating Functions

Ref: TCRP (2003)[34]

A similar review is undertaken by the UTA in Salt Lake City. Separate modal and geographic operating units are being formed to increase responsiveness of services and operations to customers and increase efficiencies. Managers of these units will have significant autonomy and authority to plan and manage operations but the strategic and corporate support functions will remain in a much smaller UTA 'umbrella' agency to make certain issues of regional strategic importance are managed from a regionwide perspective.

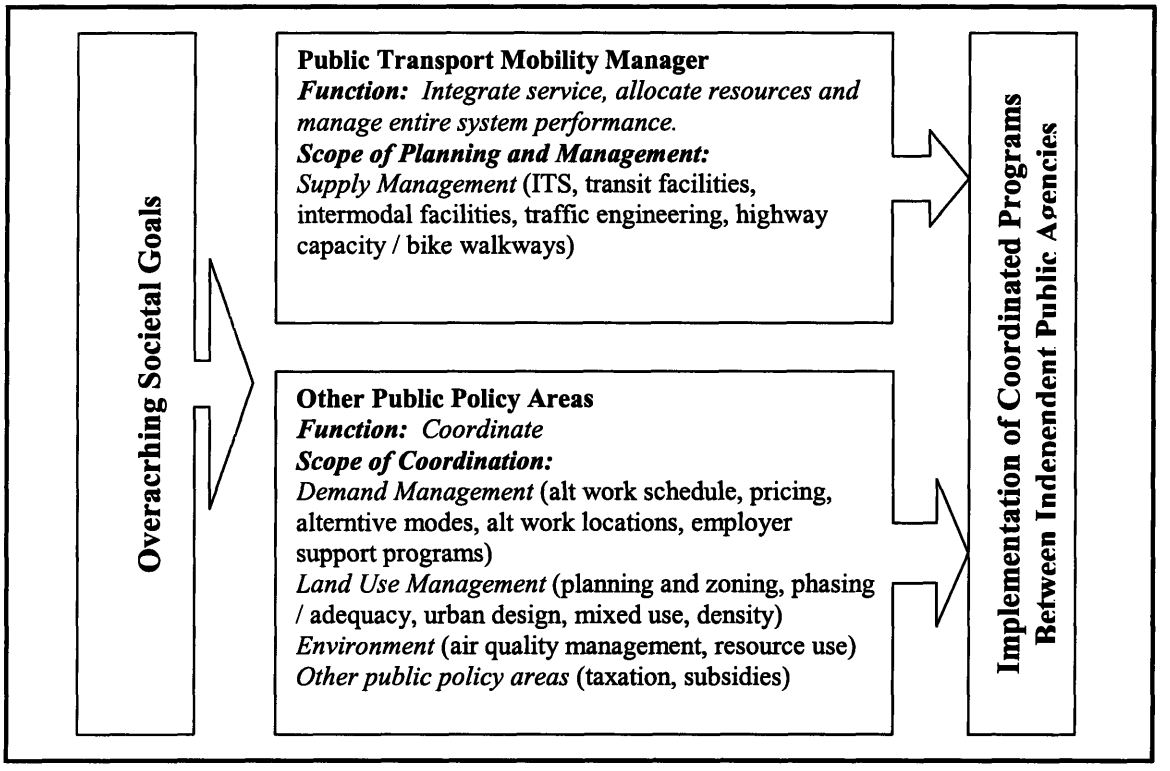
3.5 Institutional Change and Elements for Strategic Planning for Sustainable APTS-enabled Multimodal Regional Public Transportation System

As mentioned previously, the new organizational model emphasizes the strategic responsibilities of the public agency for:

- service integration,
- resource allocation, and
- overall performance of the system and respective service providers.

In addition to these areas of responsibilities which are within the control and influence of the transportation organization, there must also be some responsibilities to coordinate with other agencies that are responsible for systems that transportation systems have impacts on; land use, economy, environment etc (Figure 2-2). From a strategic perspective, it was suggested that the success of the new organizational structure and mission will be restricted unless the mobility management mission and practices can be aligned and integrated with the actions and policies that shape travel demand and management of the overall transportation network (TCRP, 2003).

This idea is supported by the need for a coordinated strategy for managing and planning multimodal transportation system which consists of three components – supply management, demand management and land-use management (Meyer and Miller, 2001)[13]. Figure 3-7 describes how strategic planning for mobility management can be integrated with broader policies and programs.



Ref: Adapted from TCRP (2003)[34]

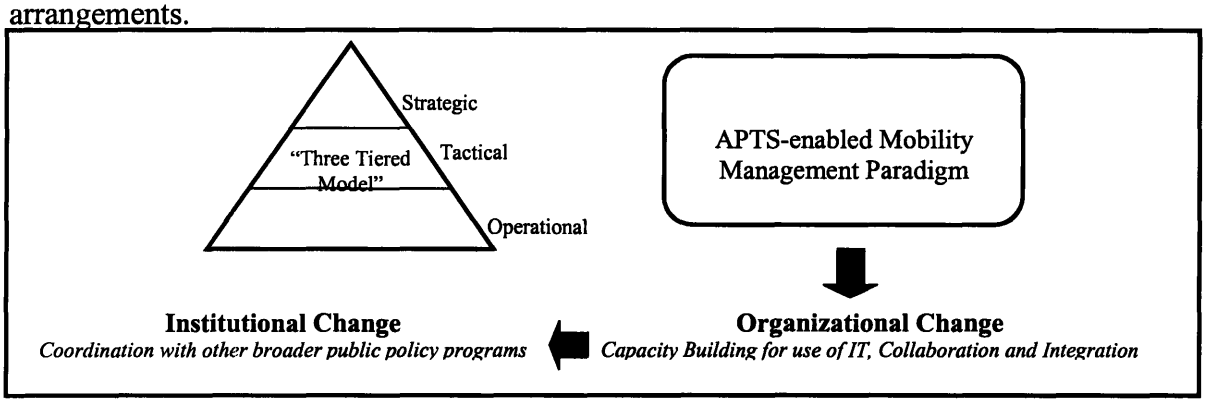
Figure 3-7: Integrating Public Transport Mobility Management with Broader Policy Goals and Programs

As shown in the Figure 3-7, there need to be linkages between organizations that are responsible for public transportation mobility management and other independent organizations, policies and programs in (represented in arrows). The two big arrows in the middle of the figure represent the two main functions that transportation organizations should take responsibilities in. In one type of function (top box arrow), the organization has control and influence and thus has the responsibility for strategic planning of investment and management of transportation system supply (e.g. transit facilities, ITS). In another type of function (bottom box arrow), the organization has no direct control and influence but has the responsibility to coordinate with other independent organization's public policy program areas in for example land use management, demand management, environmental management. The responsibility would be to ensure that transportation planning and decisions are coordinated with other program areas to support an overall societal goal.

Two linkages are assumed to exist (as represented by the vertical bars)

1. Common goal for community and society (e.g. sustainable transportation) such that there are shared goals and objectives around which to collaborate and build partnerships.
2. A high degree of overlap among elected leaders who have policy making responsibilities in seemingly independent issue areas, organizations and agencies making available more opportunities for mutual support and reinforcement.

As shown in Figure 3-8, there will need to be changes in organizational structure and capacity as a consequence of of adopted a new mission of "mobility management", increased customer focus, new partnerships, and the requirements of APTS. In addition, for the successful implementation of the new paradigm, there also needs to be changes in the institutional arrangements.



Ref: Adapted from TCRP (2003)[34]

Figure 3-8: "Mobility Management Paradigm" Driving Organizational and Institutional Change

The elements that transportation organizations need to take into account while planning could be suggested as in Table 3-15.

Table 3-15: Organizational and Institutional Elements for Strategic Planning for APTS-enabled Mobility Management

Organizational Level Elements	Institutional Level Elements
Multimodal Transportation Supply Management	***Demand Management***
Customer Relations and Marketing	e.g. alternative work schedule, pricing, alternative modes, alternative work locations, employer support programs
Planning and Development	
System Integration	
Finance and Administration	***Land Use Management***
Legal and Compliance	e.g. planning and zoning, phasing / adequacy, urban design, mixed use, density
Human Resources	
Multimodal Operations	***Environment Management***
Information Technology	e.g. air quality management, resource use
Engineering and Construction	***Other public policy areas***
Other Non-Operating Functions	e.g. taxation, subsidies

These elements have been divided into two categories based upon the function that transportation organizations have to assume: (1) Organizational, (2) Institutional. This is done due to the importance of ensuring a broad scope in the planning process to meet the desired societal goals

which are in tandem with transportation goals. These elements are not meant to be exhaustive and are only meant as a broad list of elements that should be included in planning a sustainable multimodal public transportation system. Due to the importance of transportation planning and decision-making in determining a community vision for the future and of establishing strategic transportation investment and system operations directions for an area, it is suggested that the specific elements of strategic transportation planning be more closely evaluated to as to ensure the strategic objectives of a public transportation system (i.e. increase customer focus and efficiency) are met and the organizational as well as institutional structure is strategically structured appropriately to effectively and efficiently implement the strategies needed to meet the objectives.

3.6 Chapter 3 Conclusion

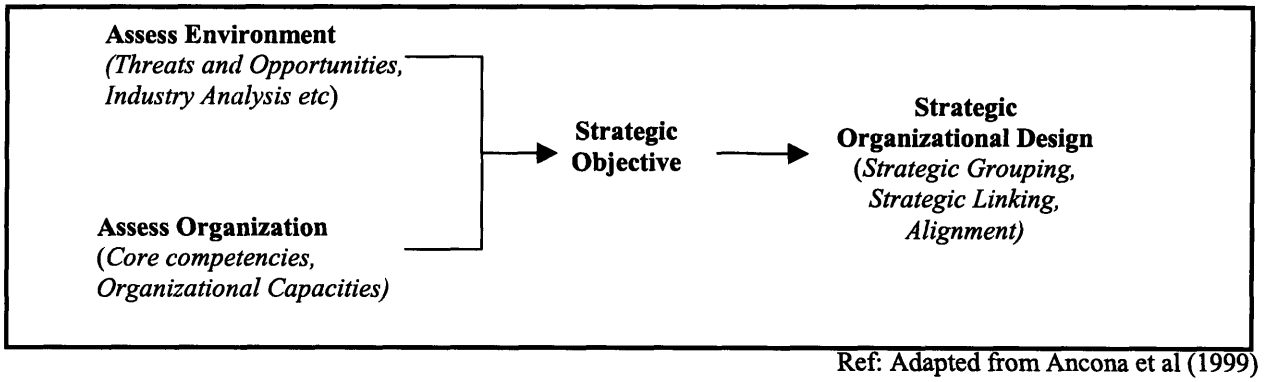
This chapter showed qualitatively that the implementation of an APTS regional multimodal public transport system could contribute to sustainable transportation system. The emerging new paradigm of "mobility management" which has been brought about by changes in the context in which public transport system operate requires agencies to build capacity in collaboration, integration and use of ITS and APTS. Capacity building in such areas necessitates organizational change and consequently institutional change for strategic planning and operations of public transportation systems.

4 Regional Planning Architecture Strategic Design Framework

Regional strategic transportation planning (RSTP) for a sustainable APTS-enabled regional multimodal public transportation system requires changes in the transportation organization as well as the institutional framework for transportation planning and decision-making. Combining the RSTP/CLIOS process and Regional Planning Architecture (RPA) protocol, this chapter describes a framework for strategic designing of a RPA that is efficient and effective in planning and implementing sustainable regional transportation systems.

4.1 Process for Strategic Organizational Design

Strategic organizational design describes the idea of systems intentionally constructed or 'architectured' to achieve a certain strategic goals. The strategic design perspective stresses the efficiency and effectiveness of the organization. 'Efficiency' entails achieving strategic goals with the least possible resources and 'effectiveness' involves ensuring that goals are met to the standard necessary for the organization to succeed. The key assumption of the strategic design perspective is that an organization is most effective and efficient when its strategy fits the conditions of its environment and when the organizational components are aligned with the strategy and with each other. The process which leads to the the strategic design of an organization is depicted in Figure 4-1 (Ancona et al, 1999)[1].



Ref: Adapted from Ancona et al (1999)

Figure 4-1: Process in Strategic Organizational Design

The process of strategic organizational design could be divided into two major stages:

Stage 1: Determining Strategic Objective

This involves assessment of the 'environment' and the 'organization'. It is assumed that the term 'environment' used in this context refers to institutional systems external to the organization (or institution) that is concerned with. The term 'organization' on the other hand would refer to intra-organizational issues.

Stage 2: Determining Strategic Design

This stage's objective is to design organizational structures that would perform effectively and efficiently to have the determined strategic objective. It consists of the following steps:

Linking Strategy and Organization
Determining what activities the organization must carry out to achieve success in its strategies and how the organization's capabilities might effect the strategies

Strategic Grouping
Deciding how the activities identified in stage 2 are to be allocated into jobs, departments, divisions, and other units, and how people are assigned to each.

Strategic Linking
Making sure that people, jobs and departments etc. are coordinated effectively with each other.

Alignment
Ensuring that the different elements and processes in the organization work together to carry out the strategies.

Determining fit
Make certain that the organizational design meets the requirements of its external environment.

In the realm of transportation planning, designing a strategic transportation institutional structure based on the assessment of the external and internal environment which includes the physical systems in addition to the institutional systems would be highly beneficial. The CLIOS/RSTP process and the RPA Protocol are suggested to be methods that could be combined into one framework to achieve the results of such assessments for strategic organizational design of an RPA. The overarching objective of the combined framework for RPA design is to develop a RPA that is efficient and effective in planning and implementing sustainable regional transportation systems.

4.2 Regional Strategic Transportation Planning as a CLIOS and the Regional Planning Architecture

Sussman and Sgouridis (2004)[36] had adapted the generalized CLIOS process to be a specialized framework for regional strategic transportation planning (RSTP). This section introduces the RSTP/CLIOS Process and the RPA.

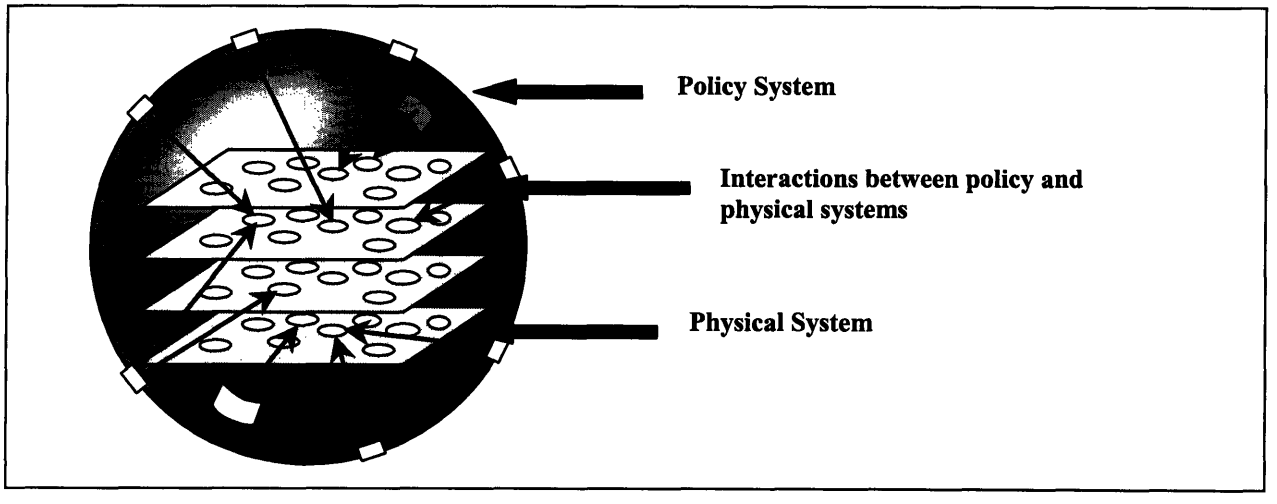
4.2.1 Transportation System as CLIOS and "Nested Complexity"

The CLIOS Process was developed to understand the characteristics of a category of complex socio-technical systems and is suggested to be a useful tool for policy design and implementation (Dodder et al, 2004)[37]. Applications of the framework in the telecommunications, energy distribution, transportation and military areas are currently underway (Sussman and Sgouridis, 2004)[36]. Sussman (2000, p.7[38]) described the transportation as a CLIOS - Complex, Large, Integrated Open System:

> *"Complex:* A system is complex when it is composed of a group of related subsystems, for which the degree and nature of the relationships are imperfectly known. It displays emergent behavior that is hard to predict, even when subsystem behavior is easily predictable. The various subsystems have varying time scales (e.g. land use changes vs.

operating decisions). System behavior in the long-term and short-term may be distinctly different and small changes in inputs or parameters may produce large changes in system behavior.
Large: A system is large when it has impacts that are large in magnitude and frequently last for a long time and covers a large geographical area.
Integrated: A system is integrated when its subsystems are closely coupled through feedback loops.
Open: A system is open when other systems – social, economic, political, environmental - are explicitly included in the scope of analysis."

The key feature of a CLIOS is that it exhibits "nested complexity": a complex physical system, embedded within a perhaps "messier" policy or institutional system. "Nested complexity" is a phenomenon when the physical system is influenced or managed by a policy system, whether deliberately or not. Figure 4-2 illustrates the "nested complexity" concept.

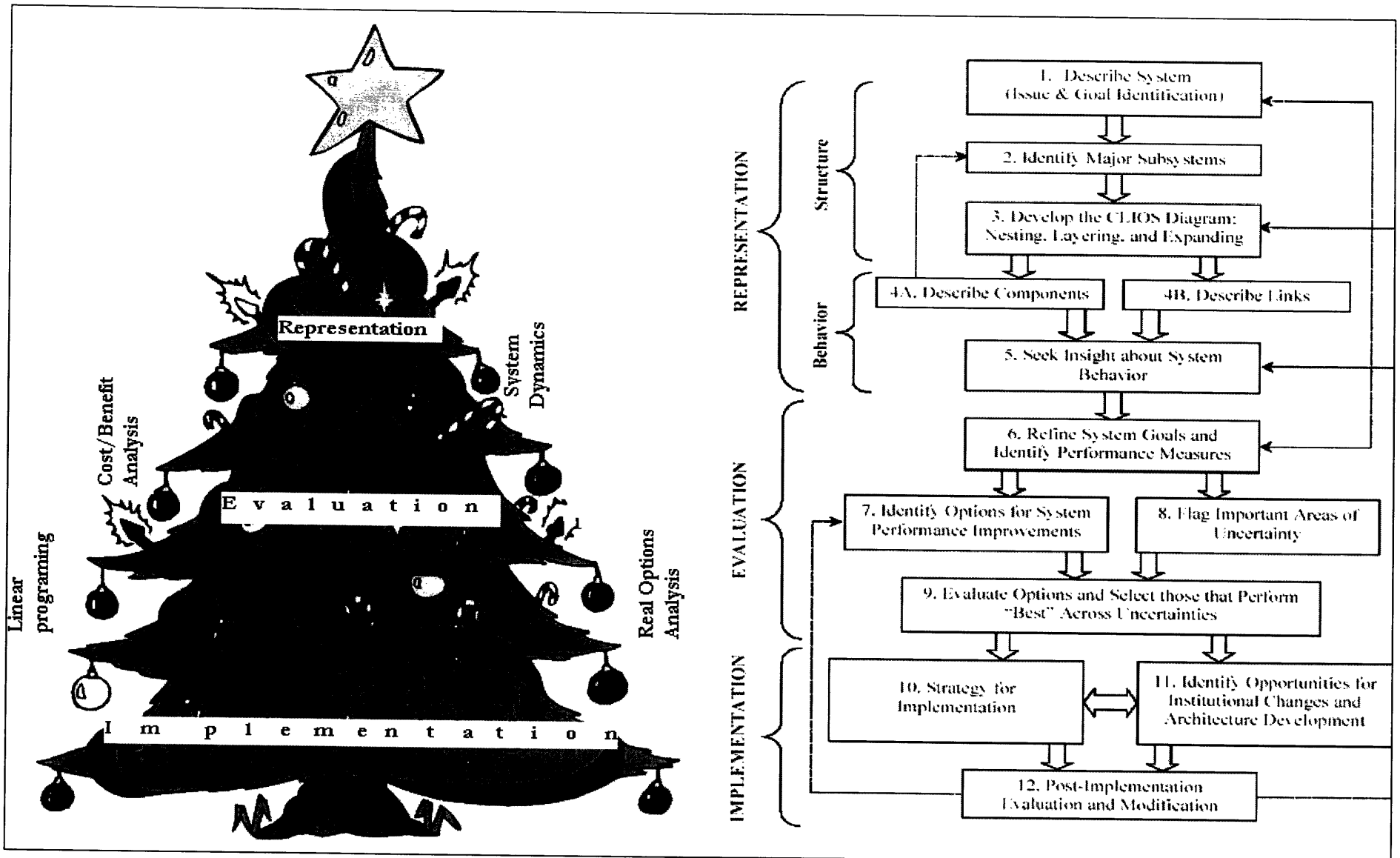


Ref: Adapted from Dodder et al. (2004)[37]

Figure 4-2: "Nested Complexity" CLIOS Concept

As a CLIOS, the transportation system is composed of a complex physical system (shown here arranged in layers) embedded within a policy system (shown as the sphere). The 'layers' of the physical system can be represented by engineering and economic models. The policy system can be represented by the organizational and institutional network of policy makers, firms, political and social stakeholders. The policy system acts upon the physical systems, and vice versa, giving rise to the emergent behavior of the CLIOS.

The CLIOS process has three main stages of analysis, which are iterative, as shown in Figure 4-3: (1) Representation, (2) Design and Evaluation, and (3) Implementation.



Ref: Sussman and Sgouridis (2004) [36]

Figure 4-3 : The Christmas Tree Analogy and the CLIOS Process

The CLIOS Process was described as being akin to a Christmas Tree; the three meta-process (i.e. representation, design and evaluation, and implementation) makes up the tree and the ornaments hanging are equivalent to the sub-processes or methods that could be employed to meet the purpose of the meta-process (Figure 4-3). Various technical, economic and social based processes and tools can be used in the CLIOS process e.g. total quality management, systems engineering, tradeoffs analysis, scenario analysis, sensitivity analysis, stakeholder analysis, SWOT analysis (Dodder et al, 2004[37]; Sussman and Sgouridis, 2004[36]; Harrison and McConnell, 2003[39]).

Representation
The purpose of this stage is to produce the system's diagrammatic and text descriptions in terms of its structure and behavior as well as critical issues and goals.

Design and Evaluation
The purpose of this stage is to evaluate options designed for physical system performance improvements. The tools employed in this stage should allow for the identification of system perrformance measures, the identification and design of physical performance improvement options, and the evaluation of options and uncertainties.

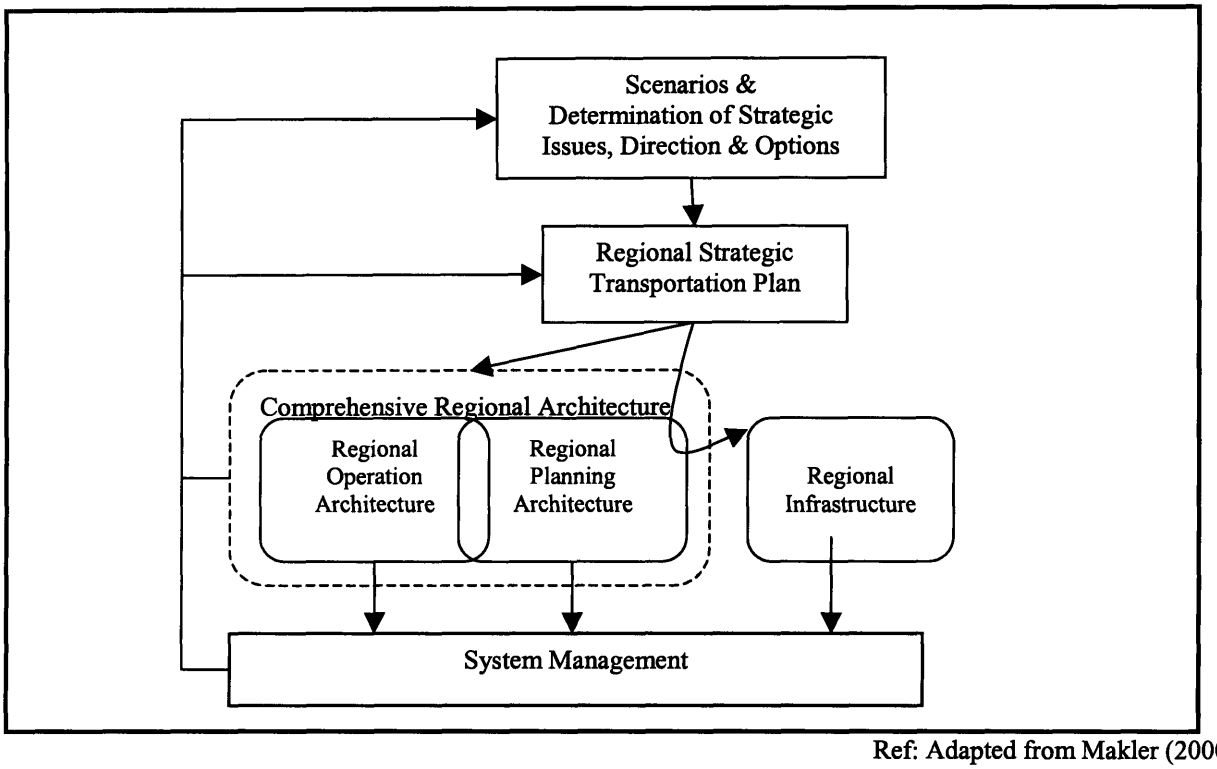
Implementation
The role of this stage is to implement improvements to the system including modification of the institutional system. The methods employed in this stage should allow for the development of implementation strategy for options, the creation and evaluation of institutional performance improvement options and the post-implementation evaluation.

4.2.2 Regional Strategic Transportation Planning as a CLIOS

Research on developing a broad systems framework for regional strategic transportation planning (RSTP) process is currently being conducted at MIT. The pre-cursor to the RSTP as a CLIOS is the RSTP process.

4.2.2.1 Regional Strategic Transportation Planning Process

The RSTP process, formerly known as ReS/SITE (Regional Strategies for the Sustainable Intermodal Transportation Enterprise), is shown in Figure 4-4.



Ref: Adapted from Makler (2000)[41]

Figure 4-4: RSTP Framework with Differentiated ROA, RPA and RI Elements

The RSTP has several important aspects:

Outputs of RSTP: Regional Architectures and Regional Infrastructure

The standard output of transportation planning is physical infrastructure plans or "lines on maps"; these could be referred to as regional infrastructure (RI) (Sussman and Sgouridis, 2004)[36]. The distinctiveness of the RSTP is that it uses the concept of regional architectures (RA) in addition to the standard RI plans for increasing the efficiency of transportation systems. RA represents the institutional component of a regional transportation system and serves to describe how a region's institutions must relate to one another to provide transportation infrastructure and services (Conklin and Sussman, 2000)[40] .

The concept of RA was further refined by making a distinction between planning and operations (or service) architectures. Makler (2000)[41], in his thesis entitled 'Regional Architectures and Environmentally Based Transportation Planning: An Institutional Analysis of Planning in the Mexico City Metropolitan Area', developed the concept of a 'Comprehensive Regional Architecture' (CRA); it included the RPA and regional operating architecture[1] (ROA). He stressed that the CRA and RI critically support the deployment of transportation services – one from a physical perspective and the other from an institutional perspective. Makler (2000)[41] also suggested a link between RPA and RI to stress the concept that the deployment of RI is actually a function of RPA's capability to develop and implement it.

[1] Formerly known as regional service architecture (Makler, 2000)

Scenario Development and Strategic Issues, Directions and Options
Diverse scenarios of the future and the determination of strategic issues, directions and options from multiple perspectives (e.g. economy, environment, society, regional and local transportation needs) are inputs into the RSTP. The reason for this is to encourage the development of plans and services that are robust with respect to a set of possible outcomes.

Feedback loops
The RSTP framework incorporates feedback loops between the CRA and System Management with the planning cycle (i.e the RSTP).

System Management
System management is the short-term version of the RSTP and this activity makes sure that the transport system in its current state operates as effectively as possible and works towards achieving the region's short and long range transportation and economic goals.

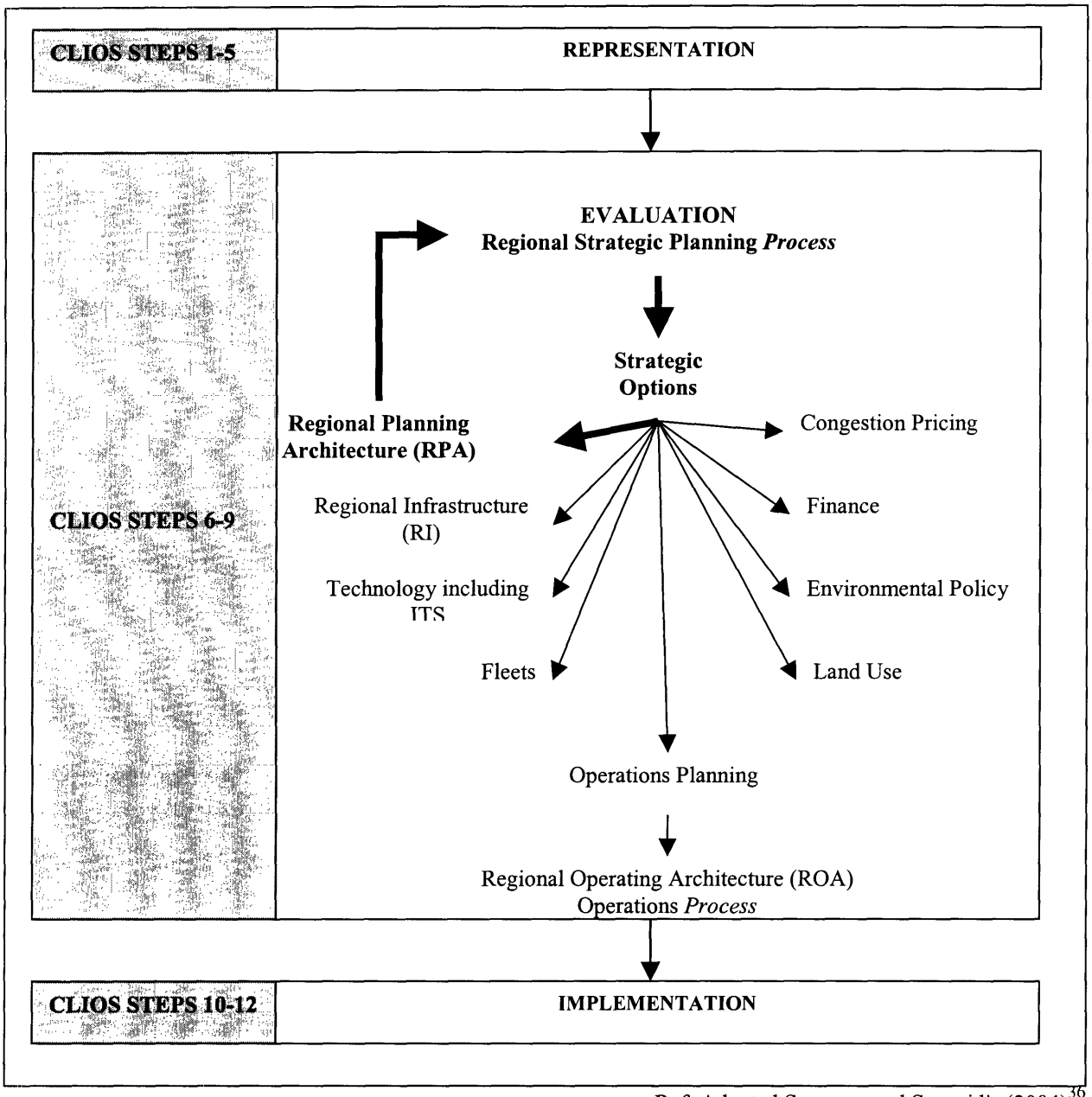
4.2.2.2 Regional Strategic Transportation Planning as a CLIOS

The RSTP process described previously was improved by Sussman and Sgouridis (2004)[36] using the CLIOS process. This new framework, henceforth called the RSTP/CLIOS Process in thesis, is shown in Figure 4-5. The RSTP/CLIOS Process is divided into three major stages. The corresponding CLIOS process steps are noted in the shaded box to the left of the figure:

RSTP/CLIOS Representation
The RSTP/CLIOS process begins with the representation stage, which consists of the following CLIOS steps 1-5:

Step 1: Describe system: issue and goal identification
Step 2: Identify major subsystems
Step 3: Develop the CLIOS Diagram: nesting, layering, and expanding
Step 4: (A) Describe components (B) describe links
Step 5: Seek insight about system behavior

The overaching goal of the RSTP was suggested by Sussman and Sgouridis (2004)[36] to be: "a regional transportation plan should ensure adequate, efficiently operated, robust, and a secure transportation network that maximizes total societal benefits within a sustainable framework". This is important to highlight as the RSTP is inherently driven by motives for developing sustainable transportation systems as described in Chapter 2 of this thesis. As for the total system representation, Sussman and Sgouridis (2004)[36] suggested that the representation phase create a "representation and experimentation platform where the existing infrastructure, organizational structure, and impacts on economy, land use and the environment are represented".



Ref: Adapted Sussman and Sgouridis (2004)[36]

Figure 4-5: RSTP/CLIOS Process and Regional Planning Architecture

RSTP/CLIOS Design and Evaluation

The RSTP process described in section 4.2.2.1 is initiated in this stage. CLIOS steps 6-9 are the methods employed for this stage:

Step 6: Identify performance measures and refine system goals
Step 7: Identify options for system performance improvements
Step 8: Flag important areas of uncertainty
Step 9: Evaluate options and select robust ones that perform best across uncertainties

The outputs of CLIOS steps 6-9 are highlighted in Figure 4-5. These steps generate various types of strategic options to improve system performance including regional architectures (i.e. RI, RPA and ROA), fleet technology, environmental policy, operations planning, congestion pricing, land use etc. (Sussman and Sgouridis, 2004)[36].

RSTP/CLIOS Implementation
The implementation stage of the RSTP/CLIOS process is the same as the CLIOS process where the institutional system, among other systems, is modified to achieve effective and effcient implementation based on the strategic options chosen in the RSTP/CLIOS design and evaluation stage.

4.2.3 Comparison to Aspects of Sustainable Transportation Planning

A transportation planning process that could lead to the planning of sustainable transportation systems was described as having the following aspects (section 2.3.3) and these are compared to the RSTP/CLIOS process described by Sussman and Sgouridis (2004)[36]:

Setting up of a Future Vision
The RSTP/CLIOS framework establishes a future context by developing scenarios in step 9.

Responsive to Varying Scales of Analysis
The RSTP/CLIOS framework acknowledges different time scales of analysis as well as implementation issues in the representation and design and evaluation stages. For example, the acknowledgement of the ROA and RPA, which have different planning time scales, are evidence of this aspect.

Broad Scope of Problem Definition
The respresentation stage demands a broad and comprehensive systems definition of the problem and issues faced in an area.

Flexibility in Analysis
Methods employed in steps 8 and 9 (e.g. real options analysis, scenario analysis) take into account the uncertainties inherent in the systems and have parameters which could be altered easily given different circumstances.

Evaluation, Feedback and Continuous Monitoring of Performance Measures
The RSTP/CLIOS process stresses upon these aspects in all the three main stages.

Connection to Implementation Process
The implementation stage is explicitly connected to the planning process in the design and evaluation stage.

Opportunities for public involvement
Public participation is an integral part of scenario analysis as well as determination of critical issues and goals of the system.

Thus, given that the RSTP/CLIOS process incorporates the sub processes identified as those, which could contribute to a transportation planning process, it could be suggested that the RSTP/CLIOS process could lead to the planning and development of a sustainable transportation systems.

4.2.4 Need for Methods for RPA Development in RSTP/CLIOS Process

The previous section suggested that the RSTP/CLIOS process could lead to sustainable transportation planning. It follows that for the sustainable transportation plan to come to fruition, the RSTP/CLIOS process must be implemented by a transportation planning institution or within the context of this thesis, a regional architecture with the capability to effectively and efficiently implement sustainable transportation planning. The CRA, which is composed of an RPA and ROA, is suggested to provide a competitive advantage as it leads to "stable, clear cut organizational environment that is more effective and allows clear cut working relationships with the private sector" (Sussman and Sgouridis, 2004)[36]. Thus, the interest of this thesis is how to develop a RPA which could conduct sustainable transportation planning; more specifically, the RSTP/CLIOS process.

4.3 The Regional Planning Architecture Protocol

Previously, the RSTP/CLIOS process was suggested as a regional transportation planning process that could lead to the development of sustainable transportation systems. The transportation institution that would implement this process has to be designed in such a way that it could meet the strategic objective of the institution effectively and efficiently. The RPA Protocol was demonstrated by Makler (2000)[41] to be very effective in analyzing institutional architectures and proposing improved institutional arrangements. The following steps were suggested:

> Step 1: Identifying the Organizations
> An inventory of the existing organizations with various responsibilities is generated. Public, private, and non-governmental sectors are to be identified.
>
> Step 2: Characterizing the Organizations
> Organizations are to be characterized on a geographic scale, according to its accountability to the body politic and management philosophy.
>
> Step 3: Characterizing the Linkages
> Information and control flows among organizations are defined as are decision-making hierarchies. This allows the assessment of the capacity of the collective organizations in the region.
>
> Step 4: Prescribing New Institutional Needs for Planning Architecture
> Assessing the collective capacity of the organizations, new institutional needs (e.g. new organization, institutional change etc.) are prescribed.

Makler suggested that this protocol allows for descriptive analysis of transportation planning and decision-making in a metropolitan area and allows for the understanding of institutional relationships in order to propose changes to the current arrangements and lines of

communications and responsibility. It is important to highlight Makler's point that existing regional planning architectures are seldom dictated by the set of plans determined by specific legal legislation like ISTEA and as such suggest that legal mandates for institutional frameworks are not necessarily optimal arrangements. The RPA protocol strongly suggests that institutional innovation is a critical element of RSTP.

4.4 Process for Strategic Organizational Design of Regional Planning Architecture

The process of strategic designing of organizations to meet strategic goals effectively and efficiently was introduced in 4.1. The process required firstly, the determination of strategic objective of the organization or institution, and secondly, the determination of the strategic design. The RSTP/CLIOS process and the RPA protocol can be combined to form a framework for strategic organizational design for regional planning architecture as shown in Figure 4-6:

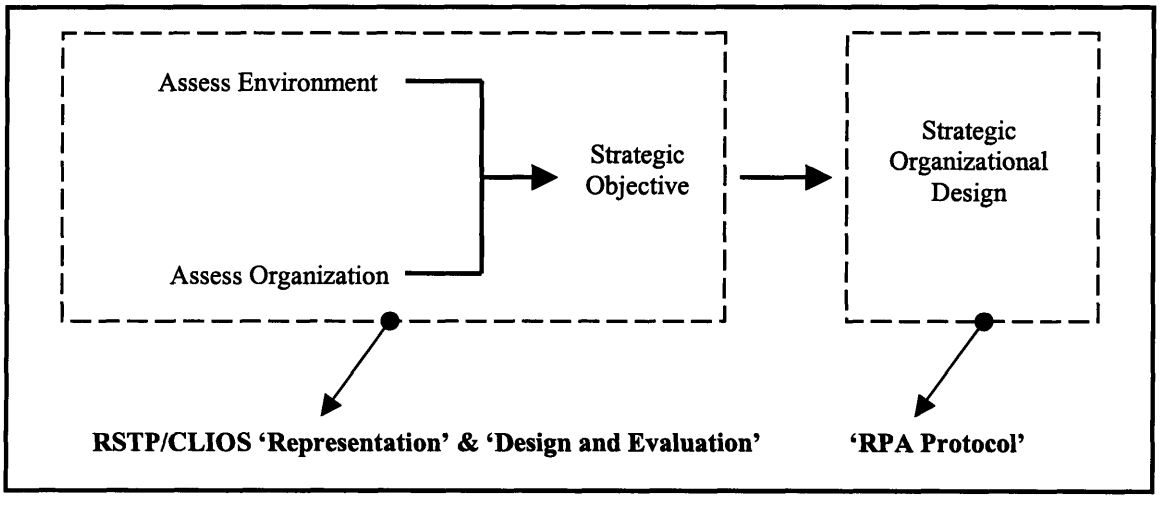


Figure 4-6: Strategic Organizational Design Process for Regional Planning Architecture

It is suggested that the RSTP/CLIOS Process and RPA protocol could be adapted to serve and improve the outputs of the two main stages of strategic organizational design process (section 4.1).

Determination of Strategic Objective Using 'RSTP/CLIOS Process'

The following 9 steps of the RSTP/CLIOS Process (Figure 4-5) are assumed important to determining the strategic objective of the RPA:

Step 1: Describe system: issue and goal identification
Step 2: Identify major subsystems
Step 3: Develop the CLIOS Diagram: nesting, layering, and expanding
Step 4: (A) Describe components (B) describe links
Step 5: Seek insight about system behavior
Step 6: Identify performance measures and refine system goals
Step 7: Identify options for system performance improvements
Step 8: Flag important areas of uncertainty
Step 9: Evaluate options and select robust ones that perform best across uncertainties

As shown above, the first nine steps in the CLIOS process (i.e. representation and design and evaluation steps) are incorporated into the overall strategic design process for RPA. Because of the systematic identification of the issues and goals by the CLIOS process, it is suggested that the regional strategic transportation plan will be much more comprehensive and its strategic policies and goals more robust. Consequently, it is assumed that the RPA will be more effective and efficient in implementing the RSTP.

Determinantion of Strategic Organizational Design Using 'RPA Protocol'
The following 4 steps from Makler's RPA Protocol are shown below:

Step 1: Identifying the Organizations
Step 2: Characterizing the Organizations
Step 3: Characterizing the Linkages
Step 4: Prescribing New Institutional Needs for Planning Architecture

It is suggested that both the RSTP/CLIOS process and RPA protocol could be combined into a framework for developing an effective and efficient RPA. Figure 4-7 depicts a simplified diagram of this process. As shown, the three main RSTP/CLIOS processes – representation, design and evaluation and implemention - are preserved. The outputs of the processes are noted on the shaded boxes on the right of the figure. The two main stages of strategic organizational design process are superimposed on this figure as well (in dotted lines). The only difference between this framework and that developed by Sussman and Sgouridis (2004)[36] is the making explicit the process for developing the RPA which would implement the RSTP/CLIOS Process. The framework also preserves and highlights that the RPA has to be continually updated for every RSTP planning cycle. An area of research that could be pursued is the determination of methods and tools that could best accomplish the purpose of each of the steps in the RPA design framework.

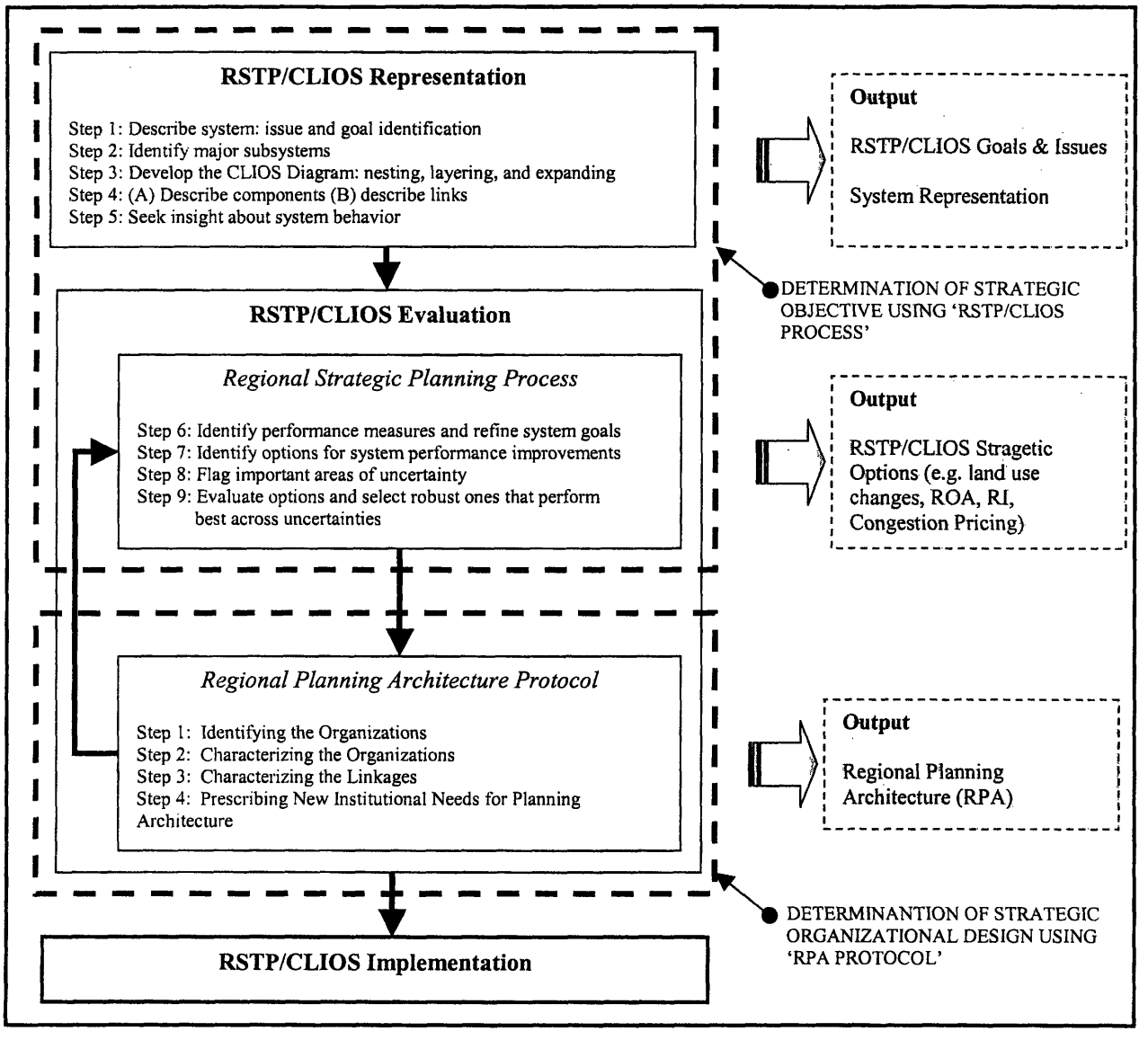


Figure 4-7: Framework for Strategic Design of Regional Planning Architecture

4.5 Chapter 4 Conclusion

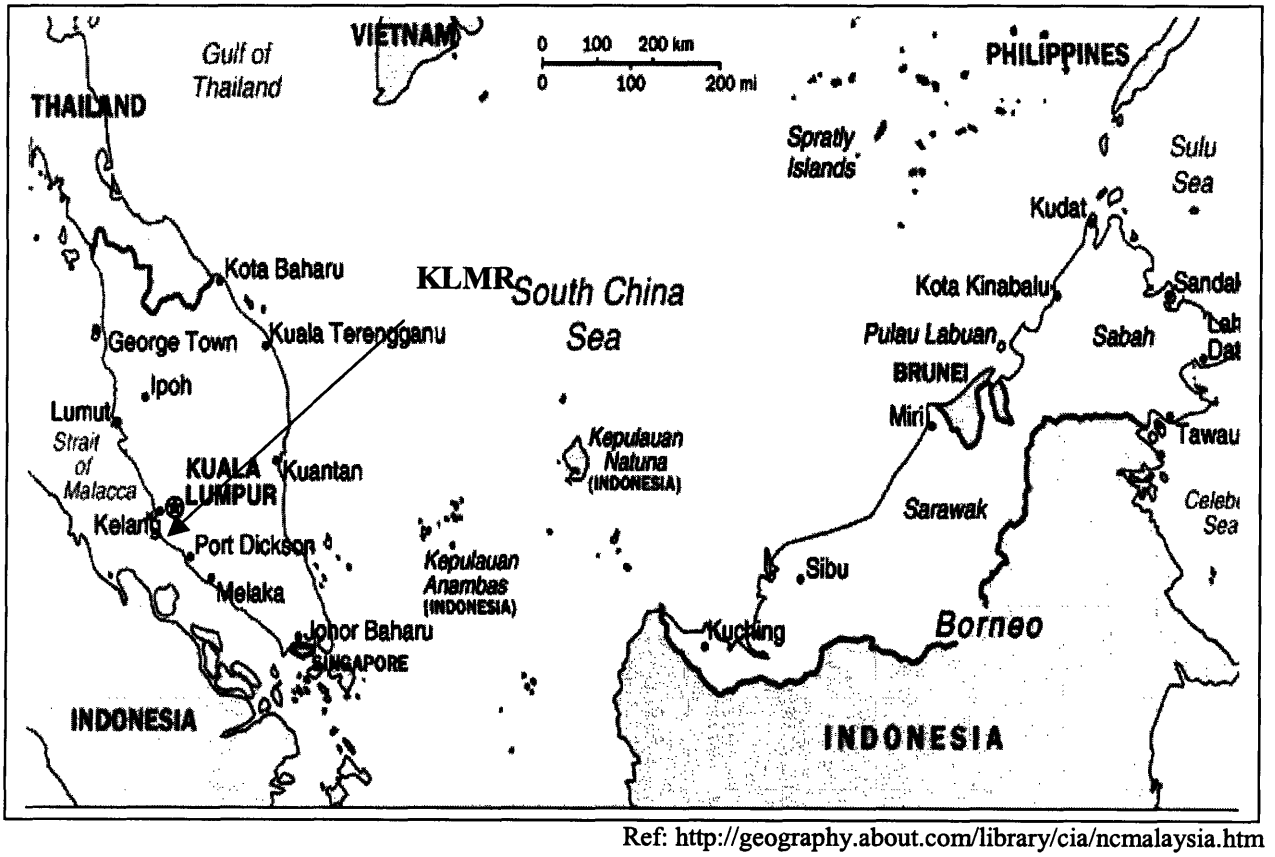
Designing strategic institutions requires an assessment framework. This chapter had examined the possibility of the RSTP/CLIOS process and the RPA protocol to form a framework for designing effective and efficient regional planning architectures that have the capability to plan and implement sustainable transportation systems.

5 Application of RPA Strategic Design Framework: Illustrative Case Study of KLMR

Chapter 4 developed a framework for strategic design of RPA by combining the RSTP/CLIOS process and the RPA protocol. This framework is applied to develop an RPA for an APTS-enabled regional multimodal public transportation system in the Kuala Lumpur Metropolitan Region (KLMR). Because of the limited amount of information available at this point, this case study is illustrative and is by no means a comprehensive strategic design for an RPA.

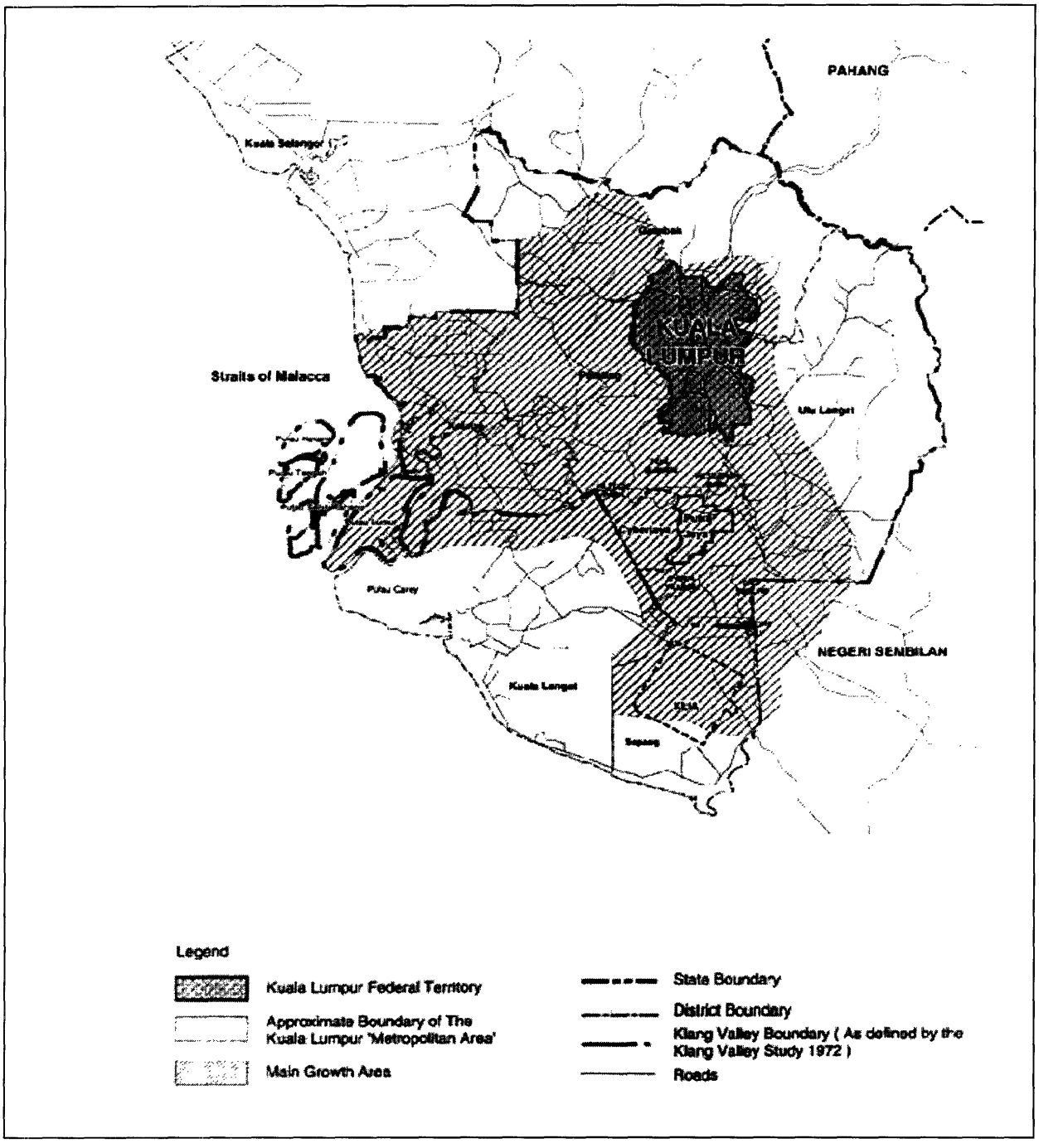
5.1 Brief Background on KLMR

The KLMR is situated in west coast of Peninsular Malaysia in the South East Asian region (Figure 5-1).



Ref: http://geography.about.com/library/cia/ncmalaysia.htm

Figure 5-1: Map of Malaysia and Location of Kuala Lumpur Metropolitan Region



Ref: CHKL (2003)[44]

Figure 5-2: Kuala Lumpur Metropolitan Area

KLMR covers an area of about 4,000 square kilometers and has expanded the originally planned 1972 Klang Valley Region (CHKL, 2003)[44]. 61% of the region is urban and rapid land development activities are taking place (Kamalruddin, 2003)[42]. KLMR comprises a complete range of urban functions with Kuala Lumpur (KL) city as the nucleas of the total area (Table 5-2).

Table 5-1: Function of KLMR and KL Urban Areas, Land Area and Population Growth

Area	Function	Land Area and Population
Kuala Lumpur	Regional Headquarters National and Transnational Companies Regional Offices International and Regional Commercial and Financial Services Specialised and high-end retail services, High- end Hotels and Restaurants and Entertainment Services Specialised Producer and Consumer Services Specialised Education and Training Services National Cultural Institutions including religious institutions, meseums, art galleries, libraries etc Specialised and High Technology Manufacturing Activities	Area: 243 sq km Population: 1991: 1,262,000 2000: 1,423,900 2020: 2,200,000
Kuala Lumpur Metropolitan Region	Federal, State and Local Administration National and International Transportation Nodes Major National and International Transportation Nodes Storage, Warehousing Facilities, Wholesale and Retail Campus Based Educational Institution Space Intensive Recreational Facilities Professional Services, Wide Range of Manufacturing Activities	Area: 4,000 sq km Population: 1991: 3,370,750 2000: 4,207,200 2020: 7,001,700

Ref: CHKL (2003)[44]

As a metropolitan region, KLMR's zone covers multiple jurisdictions (Lee and Rivasplata, 2001)[43]; the region comprises the entities of Federal Territory of Kuala Lumpur and eight local authorities of the State of Selangor (CHKL, 2003)[44]. It is the most socio-economically developed region in Malaysia but unfortunately, unsustainable practices are already widespread in the area. The cause and perpetuation of the problem is complex, with many physical and institutional subsystems dynamically interacting giving rise to these unsustainable conditions. Strategic multisectoral sustainable development oriented policies, which have been adopted, may assist in solving these problems, but as this chapter illustrates, the institutional mechanisms and orientation for implementation needs to be reassessed and redesigned. The remaining section explores this idea with a focus on the public transportation system in KLMR.

5.2 Application of RPA Strategic Design Framework

Chapter 4 described the RPA strategic design framework that was developed by combining the RSTP/CLIOS process and the RPA Protocol. The RPA framework is divided into two main stages (Figure 4-7):

Determination of Strategic Objective Using 'RSTP/CLIOS Process'

Step 1: Describe system: issue and goal identification
Step 2: Identify major subsystems
Step 3: Develop the CLIOS Diagram: nesting, layering, and expanding
Step 4: (A) Describe components (B) describe links
Step 5: Seek insight about system behavior
Step 6: Identify performance measures and refine system goals
Step 7: Identify options for system performance improvements
Step 8: Flag important areas of uncertainty
Step 9: Evaluate options and select robust ones that perform best across uncertainties

Determination of Strategic Organizational Design Using 'RPA Protocol'

Step 1: Identifying the Organizations
Step 2: Characterizing the Organizations
Step 3: Characterizing the Linkages
Step 4: Prescribing New Institutional Needs for Planning Architecture

5.2.1 Determination of Strategic Objective Using 'RSTP/CLIOS Process'

RSTP/CLIOS Step 1: System Description: Issue and Goal Identification

Methodology:
Dodder et al (2004)[37] described important CLIOS characteristics as those related the temporal and geographic scale of the system, core technologies and systems, natural physical conditions that impact or are impacted by the system, key economic and market issues, important social or political issues or controversies related to the system, and persistent or irresolvable problems. The issue areas identified in section 3.4.1 were used as guidance.

Results:
The overarching goal of this step is to define the problem relevant to stakeholders (Dodder et al (2004). Therefore, the policy and management question that this process is addressing is the unsustainability of the transportation system and its associated secondary and tertiary impacts on environment, economy, equity, institutional systems in KLMR. Thus, the system description step has a bias for describing the issues most relevant to public transportation planning process and factors which influence it.

CLIOS Preliminary Checklist of Issues for Passenger Transportation System

The salient aspects of KLMR in relation to transportation system are characterized below.

1. *Vision for Sustainable City*
   Guided by "Vision 2020" and the Local Agenda 21 policy, KLMR and KL city, the nucleas of the region, aspires to develop into a sustainable city by the year 2020. Its development strategy is to sustain rapid economic growth mainly through export oriented secondary and tertiary sectors. To achieve the vision, much investment has been done and will continue developing the area's infrastructure, environment, city management, and cultural, social and community facilities (CHKL, 2003)[44]. Important to note is the intensive public investment in ICT infrastructure (e.g. the Multimedia Supercorridor "MSC").
2. *Sprawled Urban Development and Density of Residential and Employment*
   Despite efforts to develop in a sustainable manner, rapid and haphazard land consumption has taken place in a sprawling manner in the KLMR. In 1995, 61% of the land use is urban compared to 17% in 1985 (Kamalruddin, 2003)[42]. Administrative centers have relocated to the Putrajaya suburbs. Urban development has focused in Kuala Lumpur and has extended outward from KL to Klang forming ribbon development along major urban expressways. Suburbanization of residential and commercial activities occur along roads and isolated from urban rail networks. Many industrial areas in Selangor are slowly being abandoned enabling more commercial and business areas to flourish (Gakenheimer, 2003)[45].

KL exhibits a very low residential density in comparison to other Asian cities. There is however a relatively high ratio of residents to jobs in the central business district (Gakenheimer, 2003)[45].

3. *Traffic Congestion, Unbalanced Mode Use, and Transportation Policies*
   Sprawled land use has encouraged auto dependency in KLMR. Since the 1970's, strong growth in car fleet as compared to low road network growth (due to difficulty in building roads in an urban setting) had resulted in rising vehicle-density ratio – 71 vehicles per road km in 1999 (Gakenheimer, 2003)[45]. There is ever increasing car and motorcycle ownership and is currently at 300 cars per 1000 people in 2000 and 175 motorcycles per 1000 people (unknown year). The high car and motorcycle ownership could be attributed to relatively inexpensive taxes, tolls, low parking costs, the national car policy which encourages car ownership and strong bias for highway use and expansion and lack of government commitment for developing public transportation sector. Other contributing factors could be the increasing dominance of the services sector in KLMR, which tend to diminish public transportation use; low housing and employment densities; increased percentage of women in the workforce; latent demand generated by ICT infrastructure; increasing income levels etc.

   The modal share of private transport (both cars and motorcycles) is 80% and public mode share is a modest 20% (1997 data). Trends indicate that public mode share is declining. Problems with public transport much relate to the service quality – route duplications, unreliable service frequency, overcrowding during peak hours, poor bus condition.

   Modal share of non-motorized transports is very low as pedestrian and bicycle networks are not fully developed. In addition, the hot and humid weather prevents users from walking comfortably in an urban area.
4. *Environmental pollution and degradation*
   Because of sprawled land use, increasing income levels, high motorization rates, and traffic congestion, KLMR suffers from air pollution (due to the bowl like topography which traps and accumulate pollutants), noise pollution, loss in economic productivity, lost of recreational green spaces, flash floods, island heat effects, landslides and worsening of various safety and quality of life parameters. Haphazard transport facilities development has left communities separated, dissected by highways and unsightly infrastructures like elevated highways and pedestrian brigdes.
5. *Inadequate mechanism and role allocation for transportation planning*
   Many of the environmental problems that have been attributed to unsustainability of transportation system has been primarily the inadequate institutional mechanisms for transportation planning and lack of clear assignment of roles and responsibilities.
6. *Weak institutional conformity to policies and plans and overlapping administration in land use systems*
   Weak regard for regional policies and its spatial proposals, and overlapping land administration practices contribute to sprawled land use.
7. *Lack of coordinated land use and transportation planning*
   Lack of integrated land use and transportation planning has also contributed to the unsustainbility of KLMR.

<u>Other Issues Relevant for RSTP</u>

8. *Strong Economic Growth in Services Sector and Percapita Incomes*

In 2003, Malaysia had a relatively strong GDP of 4.9%. The KLMR contributes about 1/3 of the country's GDP – USD 6.752 billion (2000 data). The percapita income is at USD10,300. KL's economy is mainly based on tertiary services, primarily finance. 75% of employment in the area is in finance followed by government. Employment in the manufacturing sector is declining.

9. *Increasing Rates of Population Growth*
   At present, the population density of both KL and KLMR is very low, at 11 persons per hectare. The population in the area is expected to grow at the annual rate of between 2% - 8% and is projected to reach the "megacity" status by year 2020 with a population of 7 million. Surburbanization is suggested to occur by an out-migration of residents from the KL city area into the suburban KLMR; out-migration is suggested to be due to expensive housing. An increase in the population in the KL area is also expected. This is mainly due to the in-migration of people from other parts of the country and outside the country (i.e. immigrants from Indonesia and Bangladesh).
10. *Privatization and Deregulation as Government Strategy to Increase Productivity*
    Since the 1980s, in an effort to increase sector productivity and decrease government financing, privatization and deregulation of telecommunications, power generation and supply, infrastructure, transportation and education services had taken place.
11. *Advanced infrastructure for ICT*
    Effective usage of ICT is considered by the government as one of the crucial factors that will facilitate the efforts to increase economic productivity and competitiveness. The area is expected to have a high-capacity global telecommunications and logistics infrastructure that is built upon the the MSC's 2.5-10 gigabit digital optical fibre backbone.
12. *Squatter housing and social problems*
    Influx of people into the KL city area has also caused problems with squatter houses and associated equity issues (Bunnell and Barter, 2002)[46]e.g. inadequate public transport networks serving low income and squatter residents. A lot social issues related to immigrants are also present.
13. *Increased Women in Workforce*
    The number of women joining the workforce is increasing (Gakenheimer, 2003)[45].

Critical Issues and Goals

The overarching goal of the KLMR is to develop into a sustainable city; it is assumed that a sustainable city should be supported by sustainable transportation systems. The problem that the RSTP/CLIOS process is addressing is the unsustainability of the transportation system. The KLMR has problems with traffic congestion and auto dependency at a regional scale. This problem has been primarily been caused by sprawling land use and institutional policies and mechanisms which are unsustainable. This had caused environmental degradation and pollution, economic productivity issues as well social and equity problems. Thus, based on this overview of the KLMR, the goals and issues relative to the problem at hand are suggested as follows.

- Increase ridership of public transport and non-motorized transportation modes to relieve traffic congestion and improve environmental quality. In the long run, this goal would encourage more dense transit oriented land development. Human health and quality of life are the key drivers for this goal.

- Impose restraint or TDM measure to slow down increasing rates of private vehicle (both cars and motorcycles) ownership and use.
- Means to increase public transport ridership and TDM measures could take advantage of the advanced ICT infrastructure in KLMR to implement APTS systems.
- Improve transportation and land use decision-making such that they plan and develop sustainable transportation systems.

Given the system description above, these critical goals and issues were also suggested by Barter (1999)[47] who recommended these policy goals for large, dense, middle-income cities like Kuala Lumpur and KLMR. It is suggested, based on the present and future opportunities and challenges in KLMR, that the identified system goals be met using an APTS-enabled regional multimodal public transportation system. As described previously in Chapter 4, this type of system, planned and implemented effectively and efficiently, could potentially increase the sustainability of transportation systems.

RSTP/CLIOS Step 2: Identify major subsystems

Methodology:
In this step, major subsystems – technical, natural, economic, social, and political – that comprise the CLIOS are determined. The linkages between subsystems are also determined to outline the general structure of the CLIOS.

Results:
The following were the issue areas identified in step 1:

1. Vision of Sustainable City
2. Land Use
3. Transport
4. Environment
5. Institutions for Transportation
6. Institutions for Land Use
7. Economy
8. Population
9. ICT
10. Privatization
11. Housing
12. Workforce Composition

Further categorization of these subsystems into major and minor subsystems reveals the following:

Major Subsystems Categories	Technical	Natural	Social	Economic	Political / Institutional
Major Subsystem	Transport	Land Use Environment	Population	Economy	Vision of Sustainable City Institutions for Transportation Institutions for Land Use
Minor Subsystem	ICT		Housing Workforce Composition		

The minor subsystem is catergorized based on the important of the overall system in contributing to the unsustainability of the transportation system. They are also included in this step as they could assist in the solutions which will be focused upon in the subsequent steps.

Major Subsystems Diagram

The CLIOS diagram for major subsystem is shown below in Figure 5-3.

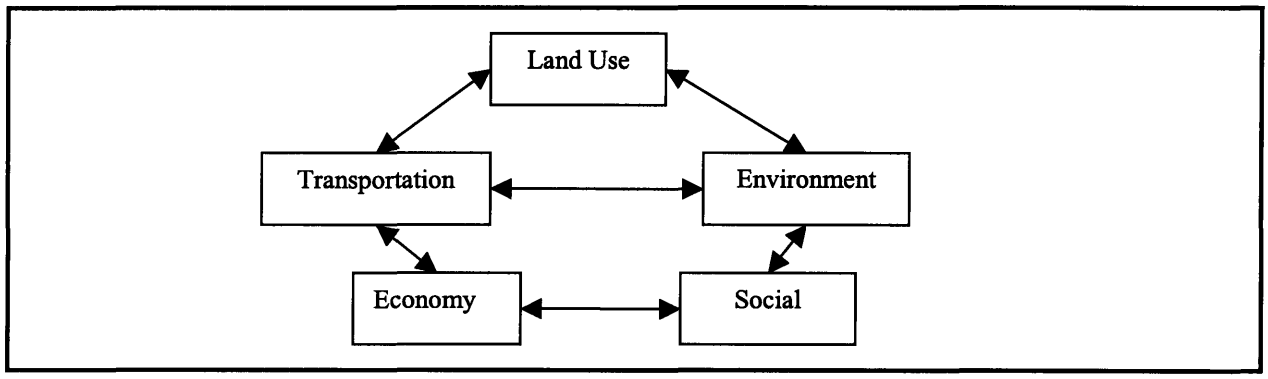


Figure 5-3:CLIOS Major Subsystem Diagram

The RSTP/CLIOS diagram suggests that the unsustainability of transportation in KLMR has many physical and institutional components and the interactions between them are complex giving rise to secondary and tertiary impacts. All these subsystems interact with one another to give rise to the sustainability – 3Es - of the system as defined by Hall (2002)[4]. In reality, the actual interactions of these systems are more complex; each major subsystem is disaggregated e.g. transportation system can be divided into public and private transport networks, planning institutions, operating contractors etc.

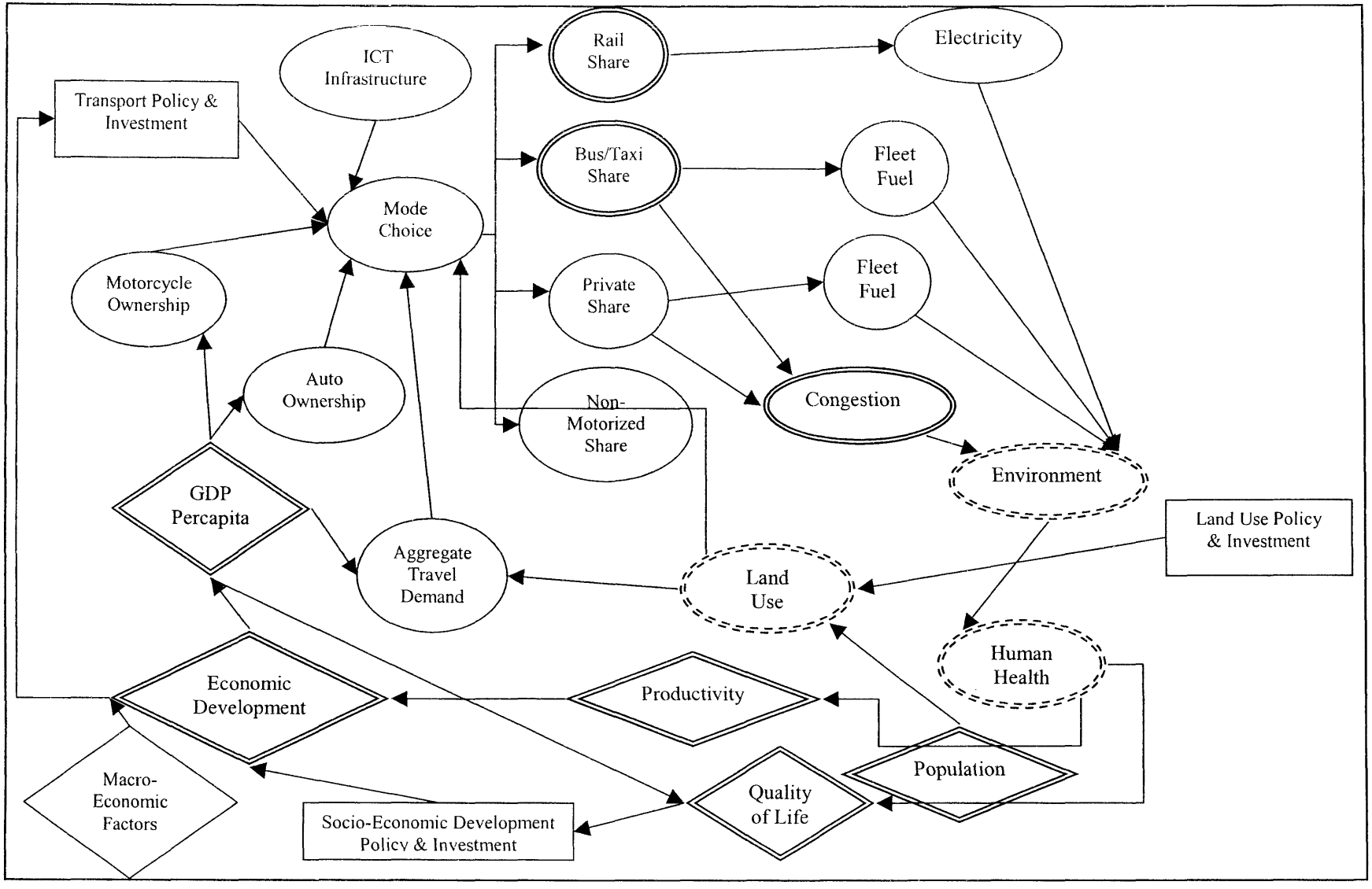
RSTP/CLIOS Steps 3, 4, and 5: Develop the CLIOS Diagram: nesting, layering, and expanding; (A) Describe components (B) Describe links; Seek insight about system behavior

Methodology:
In steps 3, 4 and 5, the CLIOS diagram (Figure 5-3) is further developed to represent the physical and institutional layers as well as the behavior of the system as shown in Figure 3-3.

Results:

Passanger Transportation RSTP/CLIOS Systems Diagram

The result of the RSTP/CLIOS diagram is shown in Figure 5-4. This figure has been adapted to fit the KLMR situation from the passenger transportation system developed by by Dodder et al (2004)[37]; 'non-motorized mode' - includes pedestrian and bicycling facilities; 'ICT infrastructure' - information and communication platforms for APTS; 'Motorcycle Ownership'- make up a big private mode share, were added. The important revelation of this final structure representation was that it revealed the "nested complexity" of institutional and physical components of the system as well as its behavior. The policy and institutional components are designated by the shaded squares and the other components are respresented by circles. The diamonds represent major common drivers.



Ref: Adapted from Dodder et al (2004)[37]

Figure 5-4: CLIOS Passanger Transportation Subsystem

Passenger Transportation System Behavior

As shown in the figure, the following can be suggested as to some selected the behavior of the system:

- 'Mode Choice', be it private or public, is directly influenced by transportation investment and policy. Transportation investment and policy indirectly influence congestion levels as well as emissions to the environment, which could then indirectly influence mode choice, productivity and economic development.
- 'Land Use' could directly be influenced by land use policy. Land use policies could indirectly influence travel demand, mode choice, environment, congestion and ultimately productivity and economy.
- 'Economic development' could be directly influenced by economic policy and investment. Economic policy and investment could indirectly influence GDP percapita and transportation investment and consequently mode choice, auto ownership, travel demand and ultimately the environment.
- 'Environment' could influence human health and and ultimately influence productivity, economic development and quality of life.

There are many other emergent behavior of the system than those mentioned above. The ones mentioned above illustrate more of the policy secondary and tertiary impacts on the passenger transportation system. A dynamic systems model of the entire system would reveal measurable behavioral traits.

An interesting research question in this system representation within the context of this thesis is how much influence do strategic policies in transportation, land use and socioeconomic development have on improving the sustainability of the KLMR passenger transportation system. Another level of complex research question, which would explore the realm of organizational behavioral sciences, is how different institutional architectures (i.e. in terms of composition of organizations in the institution, the political intricacies, presence of formal institutional linkages etc.) that develop and implement these policies influence the sustainability of the system.

RSTP/CLIOS Steps 6, 7, 8, and 9: Identify performance measures and refine system goals; Identify options for system performance improvements; Flag important areas of uncertainty; Evaluate options and select robust ones that perform best across uncertainties

Methodology:

In steps 6, 7, 8 and 9, opportunities for improving both the physical and the institutional system are identified. These options for system improvement are then tested for robustness. The needs for organizational and institutional changes that may be necessary to implement these physical system strategies are then identified.

Results:

The steps in the design and evaluation phase need modeling and quantitative analysis. Because of the lack of data and this case study is only illustrative, the following results are suggested.

Performance Measures

The performance of the system is defined as what degree of sustainability of the transportation system has. In this case, it is the performance of the institution to plan and implement sustainable transportation systems. As mentioned in Chapter 2, there are no performance indicators developed yet and is still an active area of research. For the purpose of this thesis, an alternative is to qualitatively assess the performance of the transportation planning process to plan and implement sustainable transportation systems. Hall (2002)[4] principles of sustainability from the environmental, economic, equity and institutional aspects could be used (Table 2-3).

Physical Improvement Options and Evaluation of Options and Uncertainties

In Chapter 3, an APTS-enabled regional multimodal public transporation system was qualitatively determined to potentially be able to contribute to sustainable transportation system. Therefore, it is suggested that a similar matrix, as shown in the table below, be used to assess various improvement options.

Options to Increase Public Transport Use	***Increases Efficiency***	***Increase Affordability***	***Reduces Auto Dependency***	***Environment***	***Economy***	***Social Equity***	***Institutional***
Option 1							
Option 2							
Option 3							
....							

A scenario analysis could also be conducted to assess the various option's robustness across many different uncertainties in the KLMR e.g. economic, environmental, social, political conditions.

Options to Increase Public Transport Use	***Increases Efficiency***	***Increase Affordability***	***Reduces Auto Dependency***	***Environment***	***Economy***	***Social Equity***	***Institutional***
Option 1 – Scenario A							
Option 1 – Scenario B							
Option 1 – Scenario C							
Option 2 – Scenario A							
Option 2 – Scenario B							
Option 2 – Scenario C							
....							

Summary of Results RSTP/CLIOS Steps 1-9

The RSTP/CLIOS process from steps 1-9 has characterized the system in terms of structure and behavaior. It has also identified critical issues and goals for KLMR to realize its vision for becoming a sustainable city supported by a sustainable transportation system. It was illustrated how the RSTP/CLIOS process could assess the robustness of various options to handle the problem of unsustainable transportation system in KLMR. Because of lack of data and models to test these options and given the physical and institutional conditions that the transportation system operates in which is similar to the conditions in the United States and Europe (section 4.4.1), it is suggested that an APTS-enabled regional multimodal public transportation system should be implemented in the region.

In comparison to the RSTP process, RSTP/CLIOS process is suggested to be more comprehensive. The systematic identification of the issues and goals by the CLIOS process reveals many issues that are not easily linked to the transportation system like squatter problems, regional goals, social composition, institutional dynamics and culture etc. As a result, the RSTP is much more comprehensive and robust because of the insights it has on the conditions of KLMR which could be quantitatively measured by a RSTP/CLIOS based systems diagram (which was not done here sure to lack of data and models). It is therefore assumed that the RPA will be more effective and efficient in implementing the RSTP/CLIOS process and the resulting RSTP.

5.2.2 Determination of Strategic Organizational Design Using 'RPA Protocol'

In this stage, the organizational structure and functions are designed to meet the strategic objective identified in the RSTP/CLIOS, which is to plan for the implementation of an APTS-enabled regional multimodal public transportation system.

RPA Protocol Steps 1 and 2: Identifying and Characterizing the Organizations

Methodology:
An inventory of the existing organizations with various responsibilities is generated. Public, private, and non-governmental sectors are to be identified. Organizations are to be characterized on a geographic scale, according to its accountability to the body politic and management philosophy.

Results:
The organizations that would be directly or indirectly involved in implementation of the regional multimodal system are as shown in Appendix 1. There is lack of information on the organizational dynamics and culture of the organizations in KLMR. The characterization of organizations is only in terms of their functions (Zakaria, 2003)[48]. From the list in Appendix 1, the organizations with different responsibilities are noted as follows: formal strategic planning - P; informal strategic planning – NP; implementation – I; coordination body – C; operator – O; advisory – A; User - U.

Table 5-2: Roles of Organizations in KLMR Potentially Involved in RSTP for an APTS Regional Multimodal Public Transport System

Organization	Roles and Responsibilities	*Scope of Strategic Planning Responsibility*				
		Land Use	**Transport**	**Environment**	**Economy**	***Social***
FEDERAL LEVEL						
Prime Minister's Department	Economic Planning Unit (EPU)	P	P	P	P	*P*
	Federal Territory Development and Klang Valley Planning Division (FTDKVPD)	C	C	C	C	*C*
Ministry of Works (MOW)	Malaysian Highway Authority (MHA)		I/NP			
	Highway Planning Unit (HPU)		P			
Ministry of Transport (MOT)	Road Transport Department		I			
	Department of Railways		I/P			
	Railways Asset Corporation					
Ministry of Entrepreneur Development (MED)	Commercial Vehicle Licensing Board		I/P			
Ministry of Energy, Communications and Multimedia (MECM)					P	
Ministry of Science, Technology and the Environment (MOSTE)	Department of Environment			I/P		
Putrajaya Corperation (PJC)			I/P			
National Information Technology Council (NITC)					P	
Ministry of Housing and Local Government (MHLG)		I/ C				
Multimedia Commissions (MC)					C	
Federal Town and Country Planning Department (FTCPD)		P				
REGIONAL						
Statutory Development Agencies (SDA)		I	I	I	I	*I*
Multimedia Development Corperation (MDC)		I	I	I	I	*I*
STATE						
District Office (DO)						
State Planning Committee (SPC)		C	C	C	C	*C*
State Town and Country Planning Department (STCPD)		NP				
State Economic Planning Unit (SEPU)		P	P	P	P	*P*
State Economic Development Corporation (SEDC)		I	I	I	I	*I*
LOCAL						
Royal Malaysian Police (RMP)			I			
Local Authority • MPPJ	Public Works Department		I/P			

• MPSJ • MPSA • MPK • MPKJ • MPS • District Council of Sepang • District Council of Hulu Langat	Town and Country Planning Department	I/NP				
Kuala Lumpur City Hall	City Economic Planning Unit	I/P	I/P	I/P	I/P	*I/P*
	Urban Transport Department		I/P			
	Public Works and Traffic Management Department		I/P			
	Enforcement Directorate		I			
PRIVATE						
Standard Agencies and R&D Agencies	SIRIM Bhd.				I	
	MIMOS Bhd.				I	
Bus companies	Intrakota Konsolidate Bhd. , Park May Bhd.		O			
Rail companies	Syarikat Prasarana Nasional Bhd., KL Monorail Sdn. Bhd., Keretapi Tanah Melayu Berhad, ERL Sdn. Bhd.		O			
Concessionaires	PLUS, KESAS, ELITE, LITRAK etc.		O			
Professional Organizations	Institution of Engineers					
	Road Engineering Assoc. Malaysia, ITS Technical Committee		A		A	
	Chartered Institute of Transport		A			
	Institute of Highways and Transportation		A			
	PIKOM				*A*	
Land Developers		O				
Investors		O	O			
Business owners					O	
Consultants		A	A	A	A	*A*
PUBLIC						
	Users and consumers	U	U	U	U	*U*
HUMAN RESOURCE	Labor					

Table 5-2 lists the organizations that may be involved in public transportation system planning. These organizations are suggested to be involved in the process, either directly or indirectly. The labeling of their roles, as formal strategic planning, informal strategic planning, implementation, coordination body, operator, and advisory, indicates their influence over the transportation planning process. For example, the role of the Economic Planning Unit (EPU) is as a formal planner for all sectors – land use, transport, environment, economy and social. Whereas, the Federal Territory Development and Klang Valley Planning Division (FTDKVPD) is just a coordinator and it has no formal planning authority. It is suspected that the more sectors that the organizations have formal planning authority over, the more powerful that organization is. Some of these organizations are suggested to be those having roles for planning for socio-economic development at the Federal, Regional and State levels.

RPA Protocol Step 3: Characterizing the Linkages

Methodology:

Information and control flows among organizations are defined, as are decision-making hierarchies. This allows the assessment of the capacity of the collective organizations in the region.

Results:

There is lack of data on the institutional mechanisms of how transportation strategic planning works. The planning decision-making structure for transportation planning was thus inferred from the legislative and political regional planning decision-making drafted from 1989, shown in Appendix 2 (Zakaria, 2003)[48]. The results presented here are inferred from secondary sources. Figure 5-5 is diagrammatic description of the organizational composition and linkages that might exist among the stakeholders in KLMR identified in Table 5-2. This illustration is not a complete representation as there is not enough information to verify the composition and linkages that exists for the KLMR. This is supported by Gakenheimer (2003)[45] who indicated that the transportation planning mechanism and institutional framework in KLMR is anything but clear.

Organizations and Categories of Sectoral Planning

The organizations in Table 5-2 have been categorized into groups according to their involvement in the planning and development of policies in the respective sectors. The purpose of this categorization is to delineate which organizations are involved or influenced, either directly or indirectly, in the planning process. With the information available, the following are the categories of sectoral planning (which may also include policy development responsibilities): 'Socio-Economic', 'Transport', 'Environment', 'Land Use', and 'Transport and Land Use'. For example, the Ministry of Works (MOW), Ministry of Transport (MOT) and Ministry of Entreprenuer Development (MED) are involved or influenced, either directly or indirectly, by transportation investments and policy. Another example is the Federal and State Town and Country Planning Department (FTCPD and STCPD) which are involved in land use planning. The Ministry of Housing and Local Government (MHLG) are involved in policies of the local governments, which are very critical in determining the implementation outcome of land use and transportation plans.

For future research purposes, it is suggested that a comprehensive inventory of organizations that are involved or influenced, either directly or indirectly, in the planning process for public transportation system be conducted. This may include in-depth examination of the actual planning process that takes place in KLMR. Interviews with key stakeholders like the EPU, State Economic Planning Units would provide useful information.

Institutional and Organizational Linkages

Apart from illustrating the composition of organizations in the KLMR, which may be involved in transportation planning, Figure 5-5 also illustrates the linkages between the organizations. It is suggested that there exists a complex web of organizational and institutional linkages in KLMR with regard to public transportation planning. The linkage types are suggested to be as follows (see labels):

- 'A' : Consumer – Government (e.g. Users in KL and Federal EPU)
- 'B' : Government – Government_Intra-sectoral (e.g. Fed and State Economic Planning Units)
- 'C' : Government – Government_Inter-sectoral (e.g. Ministry of Environment and Ministries directly involved in Transport planning – MOW, MOT and MED)
- 'D' : Government – Private (e.g. Ministries directly involved in Transport planning and

Private Bus and Rail Companies)

- 'E' : Private – Private (e.g. Bus companies and Rail Companies)
- 'F' : Private – Consumer (e.g. Bus companies and users in KL area)

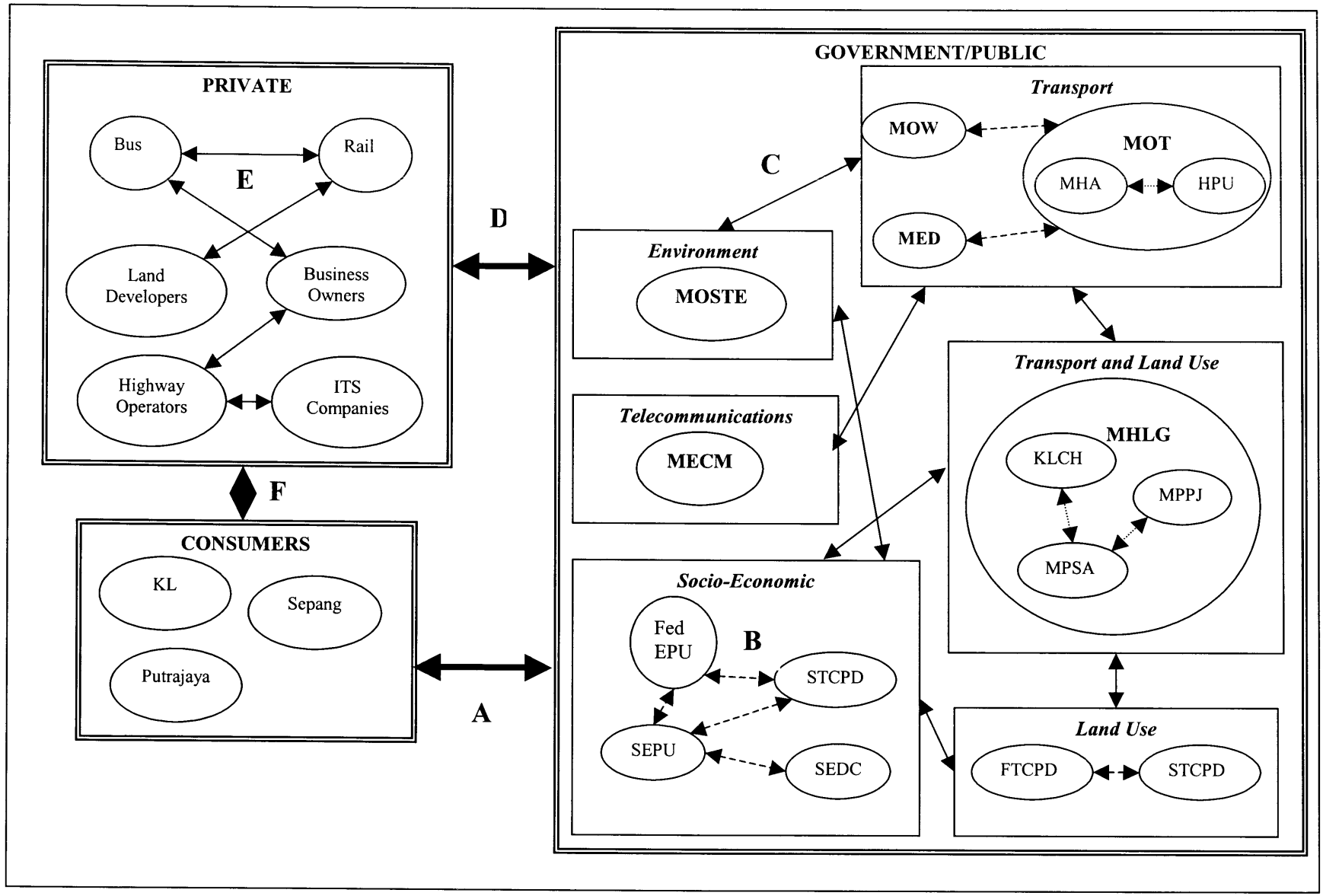


Figure 5-5: Possible Organizational Composition and Interactions in KLMR for Public Transportation System Planning

It is important to highlight 'Government-Government' complexities – i.e. the 'intrasectoral' and 'intersectoral' linkages. 'Intrasectoral' linkages can be further subdivided into inter-organizational and intra-organizational linkages. For example, for the 'Transport' Government – Government_Intra-sectoral linkages, there are inter-organizational linkage between the MOT and MOW. The intra-organizational linkage is within the Ministry of Works between the Highway Planing Unit (HPU) and the Malaysian Highway Administration (MHA).

The 'Intersectoral' linkages are referred in this thesis as institutional linkages. Groups of organizations directly responsible for a sector is assumed to be one institution which operates under similar sectoral policies; for example the MOW, MOT and MED would be under one institution directlt responsible for 'Transport' planning. Therefore, the linkages between the 'Transport' and 'Environment' are considered as institutional.

Labor relations are not addressed here as there is not enough information, but should be addressed in future research projects.

The following are the major linkages that are assessed:

'Transport' Linkages

As shown in Table 5-3, the responsibilities for planning of different modes are spread out among different existing ministries (Zakaria, 2003)[48]. Based on available information, the "business model" of the bus, rail and taxi based public transportation system management in KLMR is as follows:

- National transportation policies is determined by the Ministry of Transport.
- Strategic planning is conducted by Economic Planning Unit (EPU) assumed at the regional and national level. It is assumed that implementation (budgeting) activities are conducted as well. Local authorites conduct planning more at the local level.
- Fare, route control and licensing are managed by the Ministry of Entreprenuer Development through the Commercial Vehicle Lisencing Board.
- Implementation of the strategic plans is done by the Ministry of Transport.
- Construction, maintanence and operations are delegated to the private sector as well as local authorities. Privatization of the public transportation in KLMR is complete and all assets are constructed, owned and operated by the private sector until recently.
- Planning for parking is not done at all by any organization. Enforcement and control are done by the local authorities.
- Planning for pedestrian and non-motorized transport is assumed by the EPU. Enforcement and control are done by the local authorities.

Table 5-3: Functions of Transportation Institutions in KLMR

Institutions	Infrastructure		Private Vehicles	Public Transport	Traffic Rules Enforcement	Pedestrian Facilities	Parking Spaces
	Road	Railway	Car and Motorcycle	Bus and taxis			
Economic Planning Unit (EPU)	Investment Planning	Investment Planning	Planning	Planning		Planning	
Federal Territory Development and Klang Valley Planning Division (FTDKVPD)	Coordination	Coordination		Coordination			
Ministry of Transport		Licensing Supervising	Driving License Registration Vehicle Inspection	Driving License Vehicle Inspection	Traffic safety		
Ministry of Works	Planning Design Construction Maintenance						
Ministry of Entrepreneur Development				License Route Fare control			
Royal Malaysian Police					Traffic control Enforcement		Control Enforcement
Local Government including City Hall of Kuala Lumpur	Planning Design Construction Maintenance	Coordination		Planning Bus/Taxi stop construction Bus terminals Bus lanes	Traffic control Enforcement One-way control	Planning Design Construction Maintenance	Control Enforcement
Private Sector	Construction Maintenance Operation	Construction Maintenance Operation		Operation			

The transportation management model seen here is one that where the role of strategic planning is assumed by the public sector and operational role is filled by both the private and public sectors. This phenomenon is exemplary of the "Three Tiered Model" suggested by the TCRP (2003)[34] for effective and efficient multimodal public transportation planning and operations. In theory, the existence of such a model should give rise to a natural capability of the organizations to adopt and implement the "Mobility Management Paradigm" (Section 4.4.2). In addition, the opportunities present in KLMR for APTS deployment given the advanced ICT infrastructure would increase the capability for implementation of the paradigm. However, this is not the case. The responsibilities for strategic planning, despite being assumed by just the EPU and local

authorities, the prevailing public transportation system is not integrated across different modes and operate independently of each other. This could be the result of many factors:

1. No Shared Vision
   There might be a lack of a shared vision and mission between different public transport agencies for regional multimodal public transportation system. There might be a lack of intra-organizational linkages, which would allow such a shared vision to be formed. It is recommended that there be horizontal and vertical integration of ministries and agencies to ensure integrated planning to take place.
2. Lack of Concern with Customers
   Lack of appreciation of public transport user or customer experience. The government's national car policy and economic incentives favoring private modes are indicative of this aspect.
3. Inability to Collaborate between Private Entities
   There is probably inability of private entities to collaborate and integrate assets. The inability may be due to private economic interests, cultural issues etc. One example which may illustrate this is the difficulty faced by the government to integrate the electronic toll collection systems, which are owned by several private entities in the Klang Valley (Lin, 2003)[49]. It is recommended that the private sector incentives for integration exercises be examined further.

'Land Use' Linkages

It is suspected that there are ineffective linkages at the intra-organizational level. It was suggested that there is a very weak regard for regional plans and policies by implementing organizations, which are usually local government agencies. There is also overlapping land administration practices that could contribute to sprawled land use and its influence on the unsustainability of the public transportation system. In addition, there is also lack of implementation power by local agencies whose authority is overpowered by state agencies. There is also lack of implementation authority by Federal planning agency as the state can override plans and policies especially in land matters. It is suggested that vertical integration or a further examination of the influence of power and culture of the land use planning organization take place to resolve these issues.

Institutional Linkages

As explained in Chapter 2, there might be a lack of sustainable transportation orientation process of the strategic planning organization at the institutional level. It is assumed that the EPU, through the InterAgency Planning Group, which is a committee of different ministries with responsibilities in the area of socio-economic, land, and environmental planning and development (Table 5-4), would be able to ensure a coordinated planning and development of a sustainable transportation system in KLMR.

Table 5-4: Organizations Responsible for Strategic Transportation Planning Functions

Organization
Socio-Economic
Prime Minister's Department *Economic Planning Unit (EPU)*
Putrajaya Corperation (PJC)
State Economic Planning Unit (SEPU)
Transport
Ministry of Works (MOW) - *Malaysian Highway Authority (MHA) – no formal planning authority* - *Highway Planning Unit (HPU)*
Ministry of Transport (MOT) - *Road Transport Department* - *Department of Railways* - *Railways Asset Corporation*
Ministry of Entrepreneur Development (MED) - *Commercial Vehicle Licensing Board*
Environment
Ministry of Science, Technology and the Environment (MOSTE) - *Department of Environment*
Land Use
Federal Town and Country Planning Department (FTCPD)
State Town and Country Planning Department (STCPD) – no formal planning authority
Transport and Land Use
Local Authority (MPPJ, MPSJ, MPSA, MPK, MPKJ, MPS, District Council of Sepang, District Council of Hulu Langat) - *Public Works Department* - *Town and Country Planning Department (TCPD) – no formal planning authority*
Kuala Lumpur City Hall - *City Economic Planning Unit* - *Urban Transport Department* - *Public Works and Traffic Management Department* - *Enforcement Directorate*

There might be formal linkages established but as the current situation reveals, no sustainable regional multimodal integrated system exists and thus EPU's function could be assumed as ineffective and thus it could be implied that the transportation planning institution is not capable of performing sustainable transportation planning. It is recommended that future research to examine the intricacies of these complex linkages. Research activities would focus on determining the existence and the effectiveness of the organizational and institutional lingkages that would provide the information needed for strategic design. As noted by Makler (2000)[41], exsiting institutional linkages are not apparent from information provided in the institution's formal regulations and administrative laws.

RPA Protocol_Step 4: Prescribing New Institutional Needs for Planning Architecture

Methodology:

Assessing the collective capacity of the organizations, new institutional needs are prescribed e.g. new organizations and institutional change.

Results:
Based from secondary sources and observation of the current unsustainability of public transportation system, changes need to be made as to the current linkages among the organizations involved in public transportation planning to move towards an institution which can plan for sustainable transportation systems, which in this case is the APTS-enabled regional multimodal public transportation system.

Thus, based on the assessments and using the strategic planning elements identified in Table 3-15 for planning of multimodal public transportation, the following functions of the organizations that make up the RPA for an APTS-enabled regional multimodal public transportation strategic planning are suggested (Table 5-5).

Table 5-5: Planning Elements, Organizations and Institutions in KLMR's Regional Planning Architecture

Organizational Level Strategic Planning Elements	**Organization**
Multimodal Public Transportation Supply Management Customer Relations and Marketing Planning and Development System Integration Finance and Administration Legal and Compliance Human Resources Multimodal Operations Information Technology Engineering and Construction Other Non-Operating Functions	Ministry of Transport Ministry of Works Ministry of Entrepreneur Development (Commercial Vehicle Licensing Board) Local Authorities from KLMR region (City and Urban Transport Dept., Public Works and Traffic Management Dept)
Institutional Level Strategic Planning Elements	
Demand Management e.g. alternative work schedule, pricing, alternative modes, alternative work locations, employer support programs	Private and public sector (employers, government departments, businesses)
Land Use Management e.g. planning and zoning, phasing / adequacy, urban design, mixed use, density	State and Federal Town and Country Planning Department Private sector (real estate developers, banks, businesses)
Environment Management e.g. air quality management, resource use	Department of Environment
Other public policy areas e.g. taxation, subsidies	State (SEPU) and Federal Economic Planning Department (EPU)

The corresponding flow chart of the RPA suggested in shown in Figure 5-6.

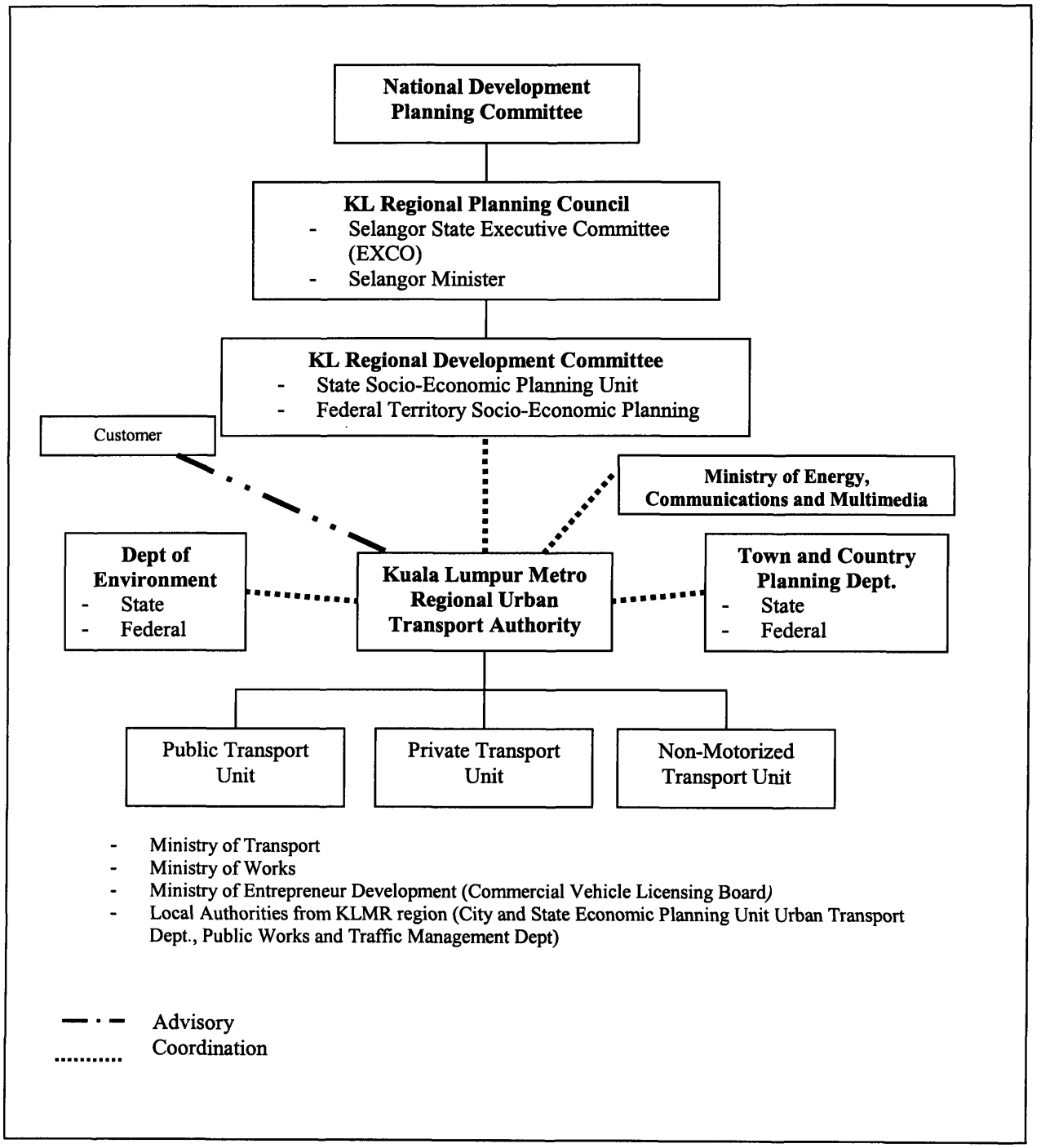


Figure 5-6: Proposed Regional Planning Architecture for an APTS-enabled Regional Multimodal Public Transportation System

The KLMR RPA for public transportation planning is adapted from the legislative and political regional planning and decision-making system drafted for the Klang Valley region in 1989 (see Appendix 2) (Zakaria, 2003)[48]. This is because information on the actual procedures of how transportation planning occurs in the KLMR is unavailable or non-existent. The follow are aspects of the organizations, institutions and processes in the RPA worth highlighting:

1. **Formation of new 'umbrella' urban transport organization**
   There is a formation of an 'umbrella' organization - Kuala Lumpur Metro Regional Urban Transport Authority which is responsible for regional multimodal transportation planning for KLMR. It will be responsible for strategic planning all modes in the region and assume the role of mobility manager. Given the current situation with ineffective private sector financing of KL's public transportation system projects, it is also recommended at this point that asset still be owned by the government. The composition of the authority is suggested to be a horizontal integration of the following agencies and ministries:
   - Ministry of Transport
   - Ministry of Works
   - Ministry of Entrepreneur Development (Commercial Vehicle Licensing Board)
   - Local Authorities from KLMR region (City and Urban Transport Dept., Public Works and Traffic Management Dept)

2. **Private Sector as Service Operators**
   The current operators of consists of private entities. It is suggested that they remain as service providers but with their service performance monitored by the new authority. This ensures that the public transport users' interests for high quality service and reasonable costs are guarded. The remaining local authorities which function as service providers should delegate their responsibilities to the private sector. Means and ways to encourage private sector operators to become asset owners, but with accountability to the transport authority should be further investigated as privatization could increase system efficiencies as well as reduce public financing of public transport systems.

3. **Coordinated Strategic Planning**
   In order to be a transportation planning institution that is capable of sustainable transportation planning, it is recommended that strategic planning be coordinated with public agencies, which are responsible for land use and environmental matters:
   - Private and public sector (real estate developers, banks, government departments, businesses)
   - State and Federal Town and Country Planning Department
   - State and Federal Department of Environment
   - State (SEPU) and Federal Economic Planning Department (EPU)
   - Ministry of Energy, Communications and Multimedia

   Private and public sector relationships should be encouraged towards developing a more transit oriented land use and communities. Incentives for private sector participations should be provided (e.g. tax relief, preferred government company).

   As for the public agencies which have problems of implementation of economic and land development plans, the decisions made by the two levels of government organization (i.e.

state and federal) has to be coordinated (hence placing them into one box as shown in Figure 5-6).

4. **Regional Planning Agencies**
   Because of problems of implementation and planning power in land use matters between the Federal and state, it is recommended that the planning be taken at a regional level. The regional concept could be the unifying element of the different jurisdictions of different agencies responsible for transportation as well as other public policy areas (i.e. environment, land development, socio-economy). These regional agencies – KL Regional Development Committee and KL Regional Development Council - whose actions and plans are to be in coordination with those of the National Development Planning Committee (which is the most powerful planning entity in the government) would ensure that these plans have a higher chance for obtaining funds. In addition, the influence of political biases is lessened by the elimination of the linkage between the planning agencies and State EXCO and minister (as shown in Appendix 2).

5.3 Chapter 5 Conclusion

The RPA Strategic Design Frameworkdeveloped in Chapter 4 was applied to the KLMR. The framework, which combines the RSTP/CLIOS process was found to be useful for systematic and comprehensive determination of the strategic objectives of the system studied. The information from the RSTP/CLIOS process is suggested to provide the critical information needed for strategic designing of the RPA for a sustainable APTS-enabled public transportation system. However, because of the limited amount of information available, the RPA developed in this thesis is only illustrative and serve as preliminary data for future efforts to develop RPA for the area.

6 Conclusions

This thesis explored the idea of how to design regional planning architecture with the capability of designing and implementing sustainable transportation systems. The main conclusions of this thesis are as follows:

1. **Planning for Sustainable Transportation System**
   Because these transportation systems have technology, institution and systems subsystems and are interdependent, it is suggested that sustainable transportation systems should have all three aspects capable of contributing to the overall sustainability of the transportation system. Institutional change was argued to be one of the strategies to increase the effectiveness and efficiency of transportation planning institutions to plan and implement sustainable transportation systems.

2. **Aspects of Sustainable Transportation Planning Process**
   Based primarily on institutional principles of sustainability, the aspects of sustainable transportation planning process was suggested as the following: establishment of a future context; responsive to different scales of analysis; broad problem definition scope; flexibility in analysis; evaluation, feedback and continuous monitoring of performance measures; related to implementation; and opportunities for public involvement.

3. **Sustainability of APTS-Enabled Regional Multimodal Public Transportation System**
   The APTS-enabled regional multimodal public transportation system was qualitatively determined to be sustainable using the principles of sustainability developed by Hall (2002). Institutional and organizational changes were argued to be one of the strategies for planning and implementation of sustainable transportation systems.

4. **RSTP/CLIOS Process and Development of Sustainable Transportation Systems**
   The RSTP/CLIOS process was determined to be able to develop sustainable transportation systems by using the aspects of sustainable transportation planning process.

5. **RPA Strategic Design Framework**
   The combination of the RSTP/CLIOS process and RPA Protocol into one framework was found to be a systematic and comprehensive method in determining the strategic objectives and strategic organizational design of an RPA.

6. **RPA for KLMR's APTS-Enabled Regional Multimodal Public Transportation System**
   An illustrative case study was conducted to apply the RPA design framework. Because of limited data, this case is illustrative and could only serve as preliminary results.

6.1 Future Research Areas

The following are potential future research areas:

1. **Methods and Tools for RPA Strategic Design Framework**
   The methods and tools that could be used to accomplish the purpose of each step of the RPA Strategic Design Framework (i.e. the combined RSTP/CLIOS process and RPA protocol) needs to be identified. Because of the complexity of the socio-technical system, it is suggested that these tools and methods would include not just those that are quantitative in nature (e.g. engineering and economic sciences), but also those that are qualitative in nature (e.g. organizational behavior, psychological sciences).

2. **Sustainable Transportation System Performance Indicators**
   As mentioned in Chapter 2, defining sustainable transportation performance indicators is still an active area of research. It would be useful to have these indicators provide guidance as to the institutional aspects of transportation planning institutions. For example, a question that could be explored is what influence do different types of RPAs (i.e. in terms of different composition, grouping, linkages etc) have on the sustainability of transportation systems.

3. **Understanding the Cultural, Political and Strategic Perspectives of the KLMR Transportation Planning Institution**
   As noted by Makler (2000)[41], exsiting institutional linkages are not usually apparent from information provided in institution's formal regulations and administrative laws. The composition and linkages that is assumed to exist in KLMR had been inferred from secondary sources. It is recommended that future research to examine the intricacies of these complex linkages for the KLMR area be conducted. Research activities would focus conducting detailed interviews exploring and verifying the cultural, political and strategic perspectives of these organizational and institutional structures, which would be highly beneficial for strategic designing purposes (Ancona et al, 1999)[1].

Appendix 1: Roles and Responsibilities of Organizations in KLMR

Organization	***Roles and Responsibilities***
FEDERAL LEVEL	
Prime Minister's Dept.	*Economic Planning Unit (EPU)* *Strategic economic planning for the country; creates 5 and 10 year planning horizons and sets tone for the entire country transportation planning as well. Has budgetary authority. National Development Planning Committee (NDPC) is the most politically power body for development planning. The Interagency Planning Group (IAPG) coordinates national level plans; IAPG consists of the Public Services Department, the treasury, Central Bank, Implementation and Coordination Unit and the Administrative and Modernization Unit. All organizations-NDPC, IAPG, EPU- has formal planning authority. EPU's [2]Infrastructure and Utilities Section plans, evaluates and identifies the major transportation projects including urban transport development and makes the major investment decisions.* *Federal Territory Development and Klang Valley Planning Division (FTDKVPD)* *Coordinates development plans in the Klang Valley. Coordinates road and rail transport development planning for the KLMA.*
Ministry of Works (MOW)	*Malaysian Highway Authority (MHA)* • *Collects traffic data from all toll roads – traffic volume, accident and others* • *Supervise and execute design, construction and maintenance of highways as stipulated by the government* • *Enter into contracts with private entities* • *Collects tolls* • *Regulate use of roads* • *Set rules on use of highways* • *Set rules on types of vehicles allowed* • *Control of traffic and any upgrades of highway* • *Provide advice to operations of privatized toll roads, except those which may have been approved by other agencies* *Highway Planning Unit (HPU)* *Undertakes planning does annual traffic counts at various stations on federal roads analyzes accident records on federal roads gathered by the National Police and the National Traffic Safety Council.*
Ministry of Transport (MOT)	*Road Transport Department* ▪ *Updates the revenue collection system.* ▪ *Registers and license drivers of motor vehicles.* ▪ *Ensures that motor vehicles are roadworthy.* ▪ *Focuses on road safety issues and reduces the rate of road accidents.* ▪ *Maintains records of information pertaining to motor vehicles and drivers.* *Department of Railways*

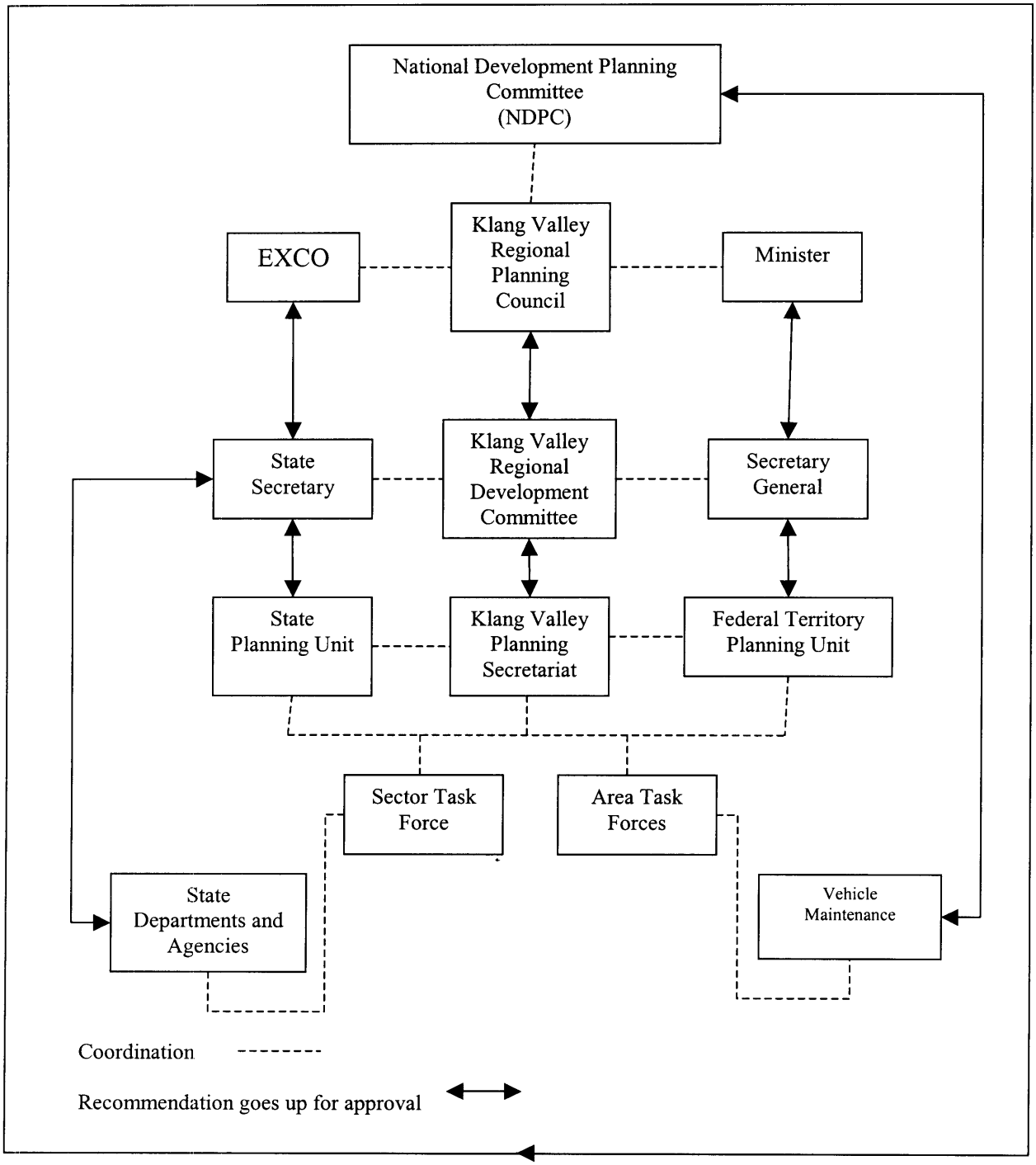
[2] EPU's organization comprises of 17 sections and two main divisions – the Macro Planning Division and the Sectoral Planning Division. The Infrastructure and Utilities Section is under the Sectoral Planning Division.

	▪ *Controls fares and tariffs by examining all proposals for change in the structure and rates of fares, tariffs or charges submitted by any railway company.* ▪ *Formulates regulations and prescribes minimum standards.* ▪ *Ensures compliance of safety standards.* ▪ *Enforces regulations (issuance, suspension and withdrawal of railways licenses, etc.).* ▪ *Studies proposals for new railway schemes and make recommendations for the approval of the Minister.* ▪ *Determines the performance standards of the services of the railway company through statistical formats and reports.* *Railways Asset Corporation* ▪ *Administers and manages lands, properties and rights for railway services.* ▪ *Develops infrastructure facilities for railway services.*
Ministry of Entrepreneur Development (MED)	*Commercial Vehicle Licensing Board* ▪ *Processes and issue and licenses of all classes of commercial vehicles in Peninsular Malaysia (including condition of licenses)* ▪ *Determines the terms and conditions attached to all cases of commercial vehicle licenses issued (fares, operation area, passenger capacity or type of goods, maximum load weight).* ▪ *Formulates policies, roles and regulations pertaining to licensing of commercial vehicles, and monitor their impact on the efficiency of the road transport industry.*
Ministry of Energy, Communications and Multimedia (MECM)	• *Regulator for IT and broadcasting industries* • *Overseas the application and development of IT projects in MSC*
Ministry of Science, Technology and the Environment (MOSTE)	*Department of Environment* ▪ *Implements the Environmental Quality Act 1974.* ▪ *Enforces the Environmental Impact Assessment requirement*
Putrajaya Corperation (PJC)	*Develops the ITS project in Putrajaya*
National Information Technology Council (NITC)	*Authority on IT development at the national level*
Ministry of Housing and Local Government (MHLG)	*Federal Town and Country Planning Department (FTCPD)* • *Coordinates urban planning and gives advice to urban planning matters to the Federal Government and various relevant ministries.* ▪ *Prepares development plans as and when requested by Federal Government departments.* ▪ *Provide assistance to local authorities in preparation of development plans.* ▪ *Promotion of urban planning and upgrading of urban planning standards.* ▪ *Provides training for increasing the skills and knowledge of planners.*
Multimedia Communications and Multimedia Commissions (MCMC)	*Regulates the networked communications and multimedia industries, including radio frequencies.*
REGIONAL LEVEL	
Statutory Development Agencies (SDA)	*Undertakes development projects for areas under their control which is outside the jurisdiction of local authorities.*
Multimedia Development Corperation (MDC)	• *Responsible for ITS in Cyberjaya* • *Overseeing development of MSC with fiscal authority, reports directly to the federal government*
STATE LEVEL	
District Office (DO)	*Office of the district officer*
State Planning Committee	▪ *Primary means for enforcing state authority*

(SPC)	▪ *Coordinates all planning activities within the state.* ▪ *Promote in the State, within the national policies, the conservation, use and development of land in the state.* ▪ *Advises the State on matters related to the conservation, use and development of land in the state.* ▪ *Undertakes assists and encourage the collection, maintenance, and publication of statistics, bulletins and monographs relating to town and country planning.*
State Town and Country Planning Department (STCPD)	▪ *Advises the Government and the SPC on urban planning.* ▪ *Acts as urban planners Local Authorities.*
State Economic Planning Unit (SEPU)	▪ *Oversees the preparation of development plans for the state and local authorities.*
State Economic Development Corporation (SEDC)	• *Develops vacant areas left out of state development plans. Not a planning agency*
LOCAL LEVEL	
Royal Malaysian Police (RMP)	*Maintains law and order.*
Local Authority • MPPJ • MPSJ • MPSA • MPK • MPKJ • MPS • District Council of Sepang • District Council of Hulu Langat	*Public Works Department* ▪ *Plans, develops and manages traffic and road improvements* ▪ *Determines location of roads, bus stops, bus terminals, and other amenities.* *Town and Country Planning Department* ▪ *Regulates, controls and plans development and use of all lands and buildings* ▪ *Undertakes activities to promote the advancement of land use planning and its methodology.* ▪ *Prepares and implements structure and local plans within their jurisdiction*
Local Authority Kuala Lumpur City Hall	*City Economic Planning Unit* ▪ *Formulates policies and strategies on the Socio-Economic Development of the Federal Territory of Kuala Lumpur.* ▪ *Coordinates and monitors development projects* ▪ *Manages all data and information on the development of Kuala Lumpur.* ▪ *Ensures that infra-structure development and public facilities are planned and implemented to promote urban economic activities such as property development, business, transport, finance tourism and others.* ▪ *Ensures an integrated development of the industrial sector which will contribute to the urban economic growth* *Urban Transport Department* ▪ *Coordinate and manage the implementation of the Monorail project and Light Rapid Transit (LRT) System in Kuala Lumpur and areas connected with it.* ▪ *Plans and conducts research on the development of an urban transportation system that covers public and highway transportation system.* ▪ *Designs and implements urban transportation projects financed by the government though City Hall Kuala Lumpur (bus/taxi stops, terminals for city buses and inter-town express buses and taxis)* ▪ *Coordinates and manages public transport facilities and services financed by the government through City Hall Kuala Lumpur.* *Public Works and Traffic Management Department* ▪ *Plans, designs and implements road projects in the Federal Territory.* ▪ *Coordinates with private agencies in the planning and development of road system and traffic management in Kuala Lumpur City.* ▪ *Improves on road designs and to increase road capacity to cater to the needs of the increasing traffic volume.* ▪ *Plans and implements traffic management schemes to improve traffic flow.*

	▪ *Maintains road networks to specific standards for the safety and comfort of road users.* ▪ *Minimizes road accidents.* ▪ *Contribute towards a healthy environment, improve public transportation and promote pedestrian traffic.* *Enforcement Directorate* • *Manage metered parking areas (privatized concept) and manual parking areas.* • *Controls and enforce traffic rules and regulations.* • *Conducts operations to eradicate illegal activities such as illegal car/motorcycle attendants.*
PRIVATE	
Standard Agencies and R&D Agencies	*SIRIM Bhd.* *Creation of industrial standards* *MIMOS Bhd.* *R&D in information technology for ITS*
Bus companies	*Intrakota Konsolidate Bhd. , Park May Bhd.*
Rail companies	*Syarikat Prasarana Nasional Bhd., KL Monorail Sdn. Bhd., Keretapi Tanah Melayu Berhad, ERL Sdn. Bhd.*
Concessionaires	*PLUS, KESAS, ELITE, LITRAK etc.*
Professional Organizations	*Institution of Engineers* *Promotion of engineering profession* *Road Engineering Assoc. Malaysia, ITS Technical Committee* *Promotion of road engineering and ITS* *Chartered Institute of Transport* *Promotion of the transportation sector* *Institute of Highways and Transportation* *Promotion of the road and transport sectors* *PIKOM* *Promotion of computer industries*
Land Developers	
Investors	
Business owners	
Consultants	
PUBLIC	*Users and consumers*
HUMAN RESOURCE	*Labor*

Appendix 2: Legislative and Political Administrative Planning and Decision-Making Structure



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