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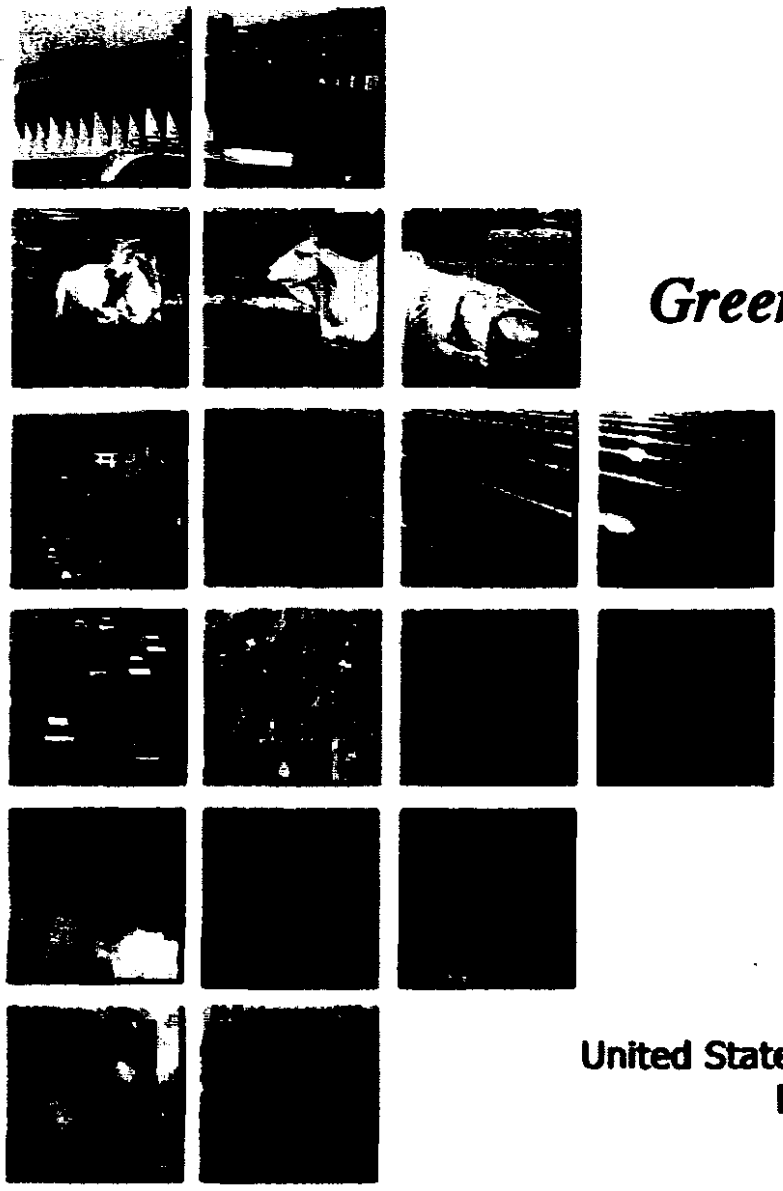
CLIN 7B : Completion of Project site Selection : Demonstration Project Design



Greenhouse Gas Pollution Prevention Project— Climate Change Supplement

A Program of the:
United States Agency for International Development/India Mission

Implemented by:
The Louis Berger Group, Inc.

Global Environment Team

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TABLE OF CONTENTS

Executive Summary 3

Chapter 1 : Introduction and Background for the Project 7
- Transport Sector and Climate Change
- Transport Sector and Health
- GEP-CCS Activities in the Transport Sector

Chapter 2 : Demonstration Project Design Process 12
- Assembling a Project Design Team
- Preliminary Fieldwork
- A Menu of Intervention Options/First Workshop
- Selection of a Demonstration Project Site
- Second Workshop
- Description of Key Milestones in the Design Process
- Criteria for Defining Potential Interventions

Chapter 3 : Demonstration Project Design Criteria 19
- Evolution and Finalization of the Criteria
- Design Criteria and Scope of the Demonstration Project

Chapter 4 : Traffic Management Interventions 22
- Introduction
- Existing Conditions in the Demonstration Project Area
- Traffic and Transport Interventions Selected
- Emissions Reduction Potential
- Costs and Finance
- Implementation

Chapter 5 : Vehicle Technology/Management Interventions: Improved PUC Systems 36
- Introduction
- PUC Certification Process
- Potential Local Air Quality and GHG Benefits
- Proposed Demonstration Project
- Operational Requirements
- Emissions Reduction Potential
- Preliminary Costs/Revenues and Financing
- Implementation

Chapter 6 : Vehicle Technology/Management Interventions : Electric Vehicles 43
- Status and Description of Electric Vehicle Technology
- The Electric Vehicle Component of the Demonstration Project
- Preliminary Costs/Revenues and Financing
- Emissions Reduction Potential
- Implementation

Chapter 7 : Vehicle Technology/Management Interventions : Retrofitting Vehicles with Cleaner Fuel Burning Engines 48
- Intervention Definition
- Operational Requirements
- Emissions Reduction Potential
- Costs and Financing
- Implementation

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List of Figures

Figure 2-1: Demonstration Project Site 15
Figure 4-1: Typical NH 9 Corridor Improvements 26
Figure 4-2: Initial LBG Circulation Concept 28
Figure 4-3: MCH Traffic Separation Scheme 29
Figure 4-4: Typical Bus Stop 30
Figure 4-5: Typical Intersection Reconfiguration Model 33
Figure 4-6: Relationship Between Speed and Emissions 34
Figure 5-1: Upgraded PUC System Features 38
Figure 7-1: Preliminary Retrofit Implementation Schedule 51

List of Tables

Table E-1: Criteria Considered in Project Design 4
Table 1-1: General Health Effects of Vehicular Emissions 8
Table 1-2: Criteria and Weight Factors Used in City Selection 9
Table 1-3: Composite City Selection Ratings 10
Table 2-1: Preliminary Intervention Ideas Menu 13
Table 2-2: Pollutant Concentrations at Various Monitoring Stations 16
Table 3-1: Demonstration Project Intervention Criteria 20
Table 4-1: Existing Morning Peak Hour Volumes Khairathabad to ESI 23
Table 4-2: Approximate Traffic Composition in the NH 9 Corridor 23
Table 4-3: One-Way Versus Two-Way Road Capacities 24
Table 4-4: Improved Signalization Synchronization and Reduced Travel Times 31
Table 4-5: Relative Emissions Reductions from Traffic Management Interventions 34
Table 5-1: City Wide PUC Emissions Reduction Potential 39
Table 5-2: Emission Reduction Potential from a 10-Station PUC System 40
Table 5-3: Break Even Evaluation for PUC Upgrading Options 41
Table 6-1: Relative Operating Costs of Electric Vehicles 45
Table 6-2: Local Emissions Reduction Potential of 3-Wheeler EVs 46
Table 7-1: Emission Benefits from Retrofitting 100 Cars of 1996 Model 49

Annexes

Annex 2A-1 Agenda: First Project Workshop
Annex 2A-2 Agenda: Second Project Workshop
Annex 3A-1 Other Near Term Potential Interventions
Annex 4A-1 Summary of Traffic Surveys for the Demonstration Project
Annex 4A-2 Traffic Management Improvements for the NH 9 Corridor
Annex 4A-3 Model Policy for Control and Administration of Parking
Annex 5A-1 Flow Chart of the New Computerised Emissions Test Center
Annex 5A-2 10 PUC Station Costs and Revenues
Annex 6A-1 Electric Vehicle and Revenues/Profit and Loss
Annex 6A-2 Electric Vehicle Implementation Information
Annex 6A-3 TVS Hybrid Electric Three Wheeler
Annex 7A-1 Emissions Norms for Petrol/Diesel Vehicles

EXECUTIVE SUMMARY

E.1 Background

The Greenhouse Gas Pollution Prevention Project – Climate Change Supplement (GEP-CCS) was initiated in May 2000. Funded by USAID, the project is being implemented in India by the Louis Berger Group Inc. for USAID/India. The main purpose of the project is to provide technical assistance to build capacity and facilitate demonstration projects that result in reduced greenhouse gas (GHG). The project has six different components. The component addressed in this report is the development of a demonstration project for reduced local and GHG emissions from vehicles in a selected city. Other components of the GEP-CCS project focus on reduction of GHG emissions in industries, the utility sector and municipalities (methane emissions from municipal solid waste).

This report is the third in a series of five reports on reduction of GHG emissions from the transport sector to be completed per the transportation component of GEP-CCS.

Selection of Hyderabad as Site for Demonstration Project

The first report in the series entitled *Selection of a City* (May 2001) was prepared by a GEP-CCS partner, the Society of Indian Automobile Manufacturers (SIAM). The purpose of the report was to identify an optimal city with which GEP-CCS could collaborate for designing and obtaining finance to implement the demonstration project. Hyderabad was selected from a list of six potential candidate cities (Bangalore, Chennai, Hyderabad, Kolkata, Mumbai and Pune). Nine criteria were used and weighted to give importance to key factors. For example, the most important criterion (weighted 5) was the ability and willingness of the local government to support such a demonstration project; the second ranked criteria (2 criteria weighted 3 each) were air quality and the availability of alternative fuels. Total scores were adjusted to enable reporting on a scale of 100. Hyderabad was ranked first, with almost 85 points. Mumbai was second, with almost 82 points.

Vehicle Technology Assessment/Emissions Reduction Technologies

The second report in the series entitled *Report on Vehicle Emission Technology Assessment* (VTA) was completed in June 2001[1]. The VTA provided a basis for evaluating vehicle technology, fuel and vehicle management options that could potentially be employed in the demonstration project. The report assessed the type of vehicles in Hyderabad (two & three-wheelers, cars, taxis, buses, etc.) and the emissions per km/person from each. Also, it assessed environmentally sound vehicle technology options, emission levels resulting from using better technology and alternative fuel options (and the relative costs to users), and looked at vehicle management options that would reduce vehicle emissions.

[1] The two reports: a) *Selection of a City*, and b) *Report on Vehicle Emission Technology*, are available from USAID on request.

E.2 This Report: Hyderabad Demonstration Project

The Hyderabad demonstration project is designed to integrate vehicle technologies and traffic management interventions in order to serve as a model for reducing GHG emissions from vehicles and to promote new transportation interventions. The demonstration project will incorporate new applications of existing technologies and transportation management interventions that could be replicated across India.

Over time, USAID suggested that the scope of the demonstration project assignment be refined and limited. USAID re-iterated that the purpose of the TA was to identify a set of options, that is, traffic interventions and technology or vehicle management options, that are or would be available in the short-term, relatively low-cost and that could be managed or implemented by local authorities. *The over-riding project design considerations were the ability of the project to implemented and replicated.* In order to meet these dual goals and to assist project formulation, criteria were developed and applied to ensure that the main factors were considered in the final project design (see Table E-1).

Table E-1: Criteria Considered in Project Design

Criteria	Comments and Implications for Design
Implementation probable within one-two years	Desire for tangible, visible changes in local and GHG emissions reduction in the short-term.
Interventions within the direct control of local implementing authority or private sector agents	Interventions dependent on state or GOI policy or regulatory decisions, such as fuel policy or vehicle retirement, were not included as there is no assurance that policy or regulatory decisions would be approved and permit demonstration within the 1-2 year timeframe.
Relatively low initial capital costs	A key factor for facilitating replication in other municipalities. Major capital-intensive interventions such as mass transit systems, large transportation infrastructure projects, etc., even when supported by donors, are given lower priority as they are not easily replicable - due to short-term resource and capacity constraints of most Indian municipalities. Where possible, interventions with revenue generation potential were prioritized as being more likely to be sustainable and replicable.
Technology and/or fuel availability	The one-two year timeframe dictated that technologies, fuels and other interventions should be available for practical application within this period.
GHG emissions reduction potential	GHG reduction potential was not the priority filter for selecting interventions, as local pollutant reductions are the primary drivers for local decision makers. However, only interventions that have at least an incremental GHG emission reduction potential were considered
Finance potential	Priority interventions were those with a high degree of finance or funding potential (particularly true of Hyderabad).
Consistency with local transport and development plans	Local authorities were deemed more supportive of interventions that reinforced/supported their current transport or development objectives.

Options to be Demonstrated

Many different technologies and alternative fuel types were initially identified and considered. Implementation and replication potential was largely viewed as being achievable to the extent that local authorities have sole or primary discretionary authority to implement interventions (and/or in partnership with the private sector). It was decided to drop alternative fuels from further consideration as the policies and regulations affecting their availability and use lie at the central and state government levels rather than the local government level. This is also true for vehicle management options such as vehicle retirement or bans of certain types of vehicles. Also, a number of technologies such as fuel cells were dropped from further consideration on the grounds of cost, availability and suitability factors.

As the lead agency in Hyderabad responsible for traffic management and planning, the Hyderabad Municipal Commission (MCH) partnered with LBG to design the demonstration project. Mindful of past and projected rapid increase in transport vehicle population numbers, the MCH seeks a series of traffic and transport interventions based on sound international practice. The MCH has been very proactive in facilitating transportation sector improvements in the city and has worked closely with the LBG Team to design traffic and transport management interventions that are practical and implementable given local conditions.

The demonstration project has, through a series of iterations, been refined to a series of traffic management interventions and three readily available and relatively low-cost vehicle technology/management interventions:

Traffic Management Interventions

The traffic management interventions are designed essentially to reduce traffic congestion and to improve traffic flow. The benefits to urban air quality are derived from the lower combustion of fuel per km travelled and the cleaner combustion of fuel. From the first effect, the total pollution load is reduced; from the second, the types of pollution are changed. The net effects are direct reductions in CO2, CO, HC, PM and NOX emissions and indirect reductions of NOX pollution generated by the ultra-violet effect on unburned HC in the atmosphere.

Seven interventions are proposed for demonstration:

- Treatment of road cross-sections - segregation of non-compatible vehicle streams to reduce vehicle conflicts;
- Roadway standardization to ensure consistency in lane number and width;
- Improvements of intersections to improve flow and reduce turning movements;
- Improved pedestrian and driver control (separation of vehicle movements from vulnerable road users);
- Enhanced signing and information devices;
- Improved signalization synchronization to reduce traffic delays and idling at intersections; and
- Improved control of parking to reduce traffic flow conflicts.

Vehicle Technology/Management

Three interventions are proposed:

1. **Improved Emissions Checking Systems** offer significant reductions in vehicle emissions when a good emission check and maintenance system is enforced. This type of innovation is very cost-effective as the preliminary infrastructure is already available. Ten Pollution Under Control (PUC) centres would be upgraded with new equipment such as 4-gas analyzers, computerized and linked to a central database and fitted with video technology to test and keep track of vehicles examined (to help the local government to track polluting vehicles). Preliminary estimates that such a system and maintenance enforcement would reduce CO_2 emissions by approximately 2,363 tons per year.

2. **Electric vehicles** (EV) offer the benefit of zero tail pipe emissions. It is proposed to demonstrate the characteristics and benefits of operating electric 3-wheelers.[2] It is estimated that a petrol driven 3-wheeler operating 80 kilometers per day, 365 days per week with an average of two passengers produces approximately 2,430 tons of CO_2 each year. An electric powered 3-wheeler would produce zero tailpipe CO_2 emissions over that same period. A partnership with several Indian automobile manufacturers in collaboration with SIAM is being facilitated to implement this intervention.

3. **Retrofit of Ambassador cars** in the MCH fleet with new, lower emission-producing engines is seen as the most cost-effective intervention given constraints on government constraints on purchasing new vehicles. Given the large number of Ambassador cars in use by local, state and national government users, the replication potential of this intervention should be considerable. A public-private partnership between the MCH and an Indian auto manufacturer is being facilitated for this purpose. Retrofit of petrol 100 petrol cars with Bharat II stage emissions compliant engines would reduce CO emissions by 5.44 tons per year and HC+Nox emissions by 3.43 tons/year. Retrofit of 100 diesel engine cars would yield reductions of 6.0 tons per year of CO and 2.3 tons per year of HC+NOx. Evaluations of CO_2 reductions have not yet been made as emissions norms for CO_2 have not been established.

E.3 Next Steps

Following agreement on the design of the demonstration project, different sources of potential financing of the demonstration will be approached and assessed and a project document prepared for financing (4th report in the vehicle emissions series).

A set of guidelines for integrating traffic management interventions into urban development plans will then prepared for wide distribution in India. The guidelines will be developed in consultation with various stakeholders and disseminated jointly with USAID. The guidelines (5th report) would be designed to assist other Indian cities to adopt transportation interventions to reduce urban air pollution and GHG emissions.

[2] However, the generation of the electricity to power the vehicles directly or via batteries creates either air pollution (thermal-electric generating plants) or other environmental impacts (hydro-electric generating plants) at/around the generating site. Therefore, life cycle emission dynamics of electric vehicle technology needs further assessment to determine the net benefit or impact on air emissions.

CHAPTER 1: INTRODUCTION AND BACKGROUND FOR THE PROJECT

The Greenhouse Gas Pollution Prevention Project – Climate Change Supplement (GEP-CCS) was initiated in May 2000. The Louis Berger Group, Inc. under USAID/India is implementing GEP-CCS. The overarching goal of the project is to provide technical assistance to diverse Indian stakeholders to facilitate a shift to a less GHG emissions intensive development path. Three main thrusts of the project are: Information Dissemination and Outreach; Technical Assistance for Facilitating Model, Replicable GHG Mitigation Projects; and Institutional Capacity Building. One component of the project focuses on creating a demonstration project for reducing GHG emissions in the transport sector and on building capacity of urban local bodies to incorporate transport related GHG reduction measure into the development planning processes for their cities.

1.1 The Transport Sector and Climate Change

As noted previously, globally, the transport sector is estimated to contribute approximately 25% of total GHG emissions, primarily in the form of CO_2. Of greater significance is that worldwide, energy use is increasing faster in the transport sector than in any other sector and fastest of all in developing countries. From 1980 to 1997, transportation energy use and associated GHG emissions increased over 5% per year in Asia (excluding the former Soviet Union), compared to 1% growth in GHGs from all sectors worldwide (Pew Center, 2001)

Growth of GHG emissions from transport in India is considered to mirror the dramatic growth trend noted above. Support for this assumption is found in the recent and projected trends in vehicle ownership in major cities across India, where the populations of two-wheeler, three-wheeler, autos, transport trucks and buses have doubled, tripled, quadrupled or more over the past 10-15 years. Projected future growth rates in vehicle populations are equally as dramatic. Vehicle population growth in the city of Hyderabad, the location selected for implementing the demonstration project, reflects this trend as will be discussed later.

1.2 Transport Sector and Health

The major pollutants emitted by motor vehicles include CO, NOx, SOx, HC, and suspended particulate matter (SPM). These pollutants have damaging effects on both human health and ecosystem integrity. The human health effects of air pollution vary in the degree of severity, covering a range of minor effects to serious illness, as well as premature death in certain cases. Most of the conventional air pollutants are believed to directly affect the respiratory and cardio-vascular systems. In particular high level of SO_2 and SPM are associated with increased mortality, morbidity & impaired pulmonary function, lead prevents hemoglobin synthesis in red blood cells in bone marrow and impairs lever and kidney function and causes neurological damage.

More than 750,000 people annually in India are estimated to die premature deaths due to increasing air pollution as reported by Center for Science and Environment. In the mid –1990s, health spending amounted to 6% of India's gross domestic product, one of the highest levels in developing nations. A portion of this spending can be attributed to health costs associated with air pollution derived from the transport sector. Table 1-1 below summarizes hazards related to motor vehicle emissions.

Table 1-1: General Health Effects of Vehicular Emissions

Pollutants	Effects on Human Health
CARBON MONOXIDE (CO)	Can affect the cardiovascular system, exacerbating cardiovascular disease symptoms, particularly angina; may also particularly affect fetuses, sickle cell anemia and young children. Can affect the central nervous system, impairing physical co-ordination, vision and judgment, creating nausea & headaches, reducing worker productivity and increasing discomfort.
NITROGEN OXIDES (NOx)	NO_2 can affect the respiratory system. NO and NO_2 where they play a part in photochemical smog formation, may contribute indirectly to increased susceptibility to infections, pulmonary disease, impairment of lung function & eye nose & throat infection.
SULPHUR OXIDES (SOx)	SO_2 can affect lung function
PARTICULATE MATTER (SPM & RPM10)	Fine particulate matter may be toxic or may carry toxic (including carcinogenic) trace substances, and can alter the immune system. Fine particulates can penetrate deep into the respiratory system irritating lung tissue, causing long-term disorders.
LEAD	Can cause brain damage, encephalopathy in children resulting in lower I.Q., death, hyperactivity & reduced ability to concentrate.

Source: Houghton & Hunter (1994) and The Economic Times (1997)

1.3 GEP-CCS Activities Transport Sector

Clearly, a window of opportunity exists to identify possible interventions in the transport sector for reducing local and GHG emissions (and the socioeconomic impacts that arise from them). It is this opportunity that GEP-CCS, through its focus on climate change mitigation demonstration projects, can help Indian stakeholders to capture.

The GEP-CCS urban transportation component is composed of five main activities, each of which builds upon the other:

1. Preparation of a "City Selection" Report;
2. Preparation of a vehicle technology assessment (VTA) report for the selected city;
3. *Design* of a demonstration project for reducing GHG emissions from vehicles;
4. Development of project documentation for seeking finance to implement the demonstration project;
5. Development of transportation guidelines for use by municipalities in shaping transportation management strategies for reducing emissions.

The City Selection Report and the VTA have already been completed. This report describes the demonstration project design. The project documentation report will be the next activity initiated, followed by the transportation management guidelines. Each of these activities is described below:

City Selection Process

As the GEP-CCS transportation component focuses on GHG mitigation strategies in urban environments, a municipal body partner would be needed to collaborate on project design. Most importantly, to maximize the potential that the project, once designed, would be implemented, a city and local partner would need to be chosen carefully.

LBG selected the Society of Indian Automobile Manufacturers (SIAM) as one of its team members for providing technical inputs in the demonstration design process. Under the guidance of LBG, SIAM designed and completed a *"City Selection Report"*. A series of criteria were used to evaluate six cities chosen by SIAM as potentially the most appropriate for the demonstration project. Nine criteria were defined based on SIAM's assumption that these best represent the profile of a city in which the goals of the demonstration project could most successfully be achieved. In addition, each of the criteria was weighted based on its relative import for contributing to project success. Table 1.2 shows the criteria and their ranking:

Table 1-2: Criteria and Weight Factors Used in City Selection

Criteria	Weight Factor
Local government support	5
Air quality	3
Availability of alternative fuel	3
Vehicle population	2
Human population	2
Age of vehicles in fleet	1
Availability of multi-modal transport options	1
Availability of vehicle emissions testing facilities	1
Average bank deposit per capita	1

Note that the highest weight is give to the "local support" criteria. This reflects the critical importance placed on maximizing the demonstration project's implementation potential – the support and proactive contribution of the local municipal partner to GEP-CCS would be critical to achieve this outcome.

SIAM then evaluated each city using a rank scoring system for each of the individual criteria. Table 1-3 below shows the final the composite score for each city.

Table 1-3: - Composite City Selection Ratings

City	Composite Rating
Hyderabad	84.8
Mumbai	81.6
Bangalore	81.3
Pune	74.8
Chennai	70.0
Kolkata	58.3

Hyderabad emerged as the preferred city for partnering on the demonstration project. While Hyderabad was preferable for a number of reasons, perhaps the most important was it's ranking as the most proactive and likely city to actively support the demonstration project process and to lead project implementation efforts. The report is available from USAID upon request.

Dr. P.K. Mohanty, Special Commissioner at the Municipal Commission of Hyderabad (MCH), the lead agency for transport and urban development within the city, was then contacted. Over the ensuing two months, a working collaborative relationship with the MCH was developed and the basic scope of the project was defined. Information sharing began in earnest. In addition, through the MCH, the LBG team was introduced to and held discussions with other key project stakeholders. These included the A.P. Regional Transport Office (RTO), A.P. State Pollution Control Board (APPCB) Hyderabad Police Commissioner's Office (PCO), the A.P. Ministry of Environment and Forests (APMOEF), and the A.P. State Regional Transport Commissioner's office (APSRTC). The Principal Secretary of the A.P. Municipal Administration and Urban Development Ministry has also wholly supported the GEP-CCS/MCH partnership.

Vehicle Technology Assessment Report

A wide range of vehicle technology, alternative fuel and vehicle management options exist for reducing local and GHG emissions from the transport sector. The potential application of such technologies and strategies for selecting among them is largely contingent on many variables, not the least of which are the pollution and pollutant issues being addressed, economics, technology availability, fuel availability and socioeconomics. To ensure that the LBG team and its local and state stakeholders had sufficient information on these two key issues, LBG initiated a *"Vehicle Technology Assessment Report"* (VTA). The VTA contains a wide range of critical information that was to be used for making informed decisions on interventions for the proposed demonstration project:

- Background data on the Hyderabad vehicle population and its emissions characteristics;
- Emissions factors for vehicles and fuels;
- Current emissions estimates for Hyderabad;
- Effects of alternate fuels on emissions reductions;
- Effect of fuel quality, vehicle technology and relocation of vehicles on emissions reductions;
- Effect of inspection and maintenance on emissions reductions
- Background information on alternate fuels and case studies in the use of alternate fuels

CHAPTER 2: DEMONSTRATION PROJECT DESIGN PROCESS

The demonstration project design process began in April 2001. By April 2002, the process was complete. This short review of milestones in the design process is intended to illustrate the basic steps that need to be followed to replicate the process in other contexts.

2.1 Assembling a Project Design Team

LBG assembled a core team to generate and provide technical assistance to the MCH. As the two main components of the project were likely to be related to vehicle technology and traffic management, two experts in these fields were recruited. Mr. David Jarrett, a Senior Transport Specialist from LBG was brought in to provide assistance on traffic management planning. Mr. Will Kirksey from the International Institute for Energy Conservation (IIEC) joined the team to provide inputs on vehicle technology options. As noted previously, LBG also teamed with SIAM. SIAM brought a wealth of capability and information on India specific transport and emissions issues as well as access to its member auto manufacturers and other key Indian transport stakeholders. Several early scoping meetings were held by the team to define preliminary project parameters and goals.

2.2 Preliminary Fieldwork

Subsequent to completion of the VTA, in May 2001, the LBG team conducted two weeks of field evaluations in Hyderabad and held a series of meetings with the MCH and key local and state stakeholders. The work was conducted to assess existing traffic and transportation conditions in Hyderabad, evaluate the range of technical and other supporting data available from the MCH and other stakeholders pertaining to traffic management, meet with a variety of Indian auto manufacturers to assess the state of vehicle technologies they are developing and discuss alternative fuel issues, and in general, to build additional collaboration among key local and state stakeholders. As an outcome of the visit, a basic action plan for moving the demonstration project forward was developed.

2.3 A Menu of Intervention Options and the First Demonstration Project Workshop

Between May and August, the LBG team put forward a "menu" of traffic management, vehicle technology, alternate fuel and vehicle management interventions options for preliminary consideration. The purpose was to identify a range of interventions that could be considered with local stakeholders for inclusion in the demonstration project design. The proposed traffic management options were based on prior field observations and consideration of the MCH's interests and traffic management improvement plans. Technology and fuel options evolved from the VTA but were filtered based on conversations with Indian and international auto manufacturers and alternative fuel experts. The comprehensive list of intervention ideas were first vetted with the MCH and deliberated.

On August 23, 2001, the MCH and LBG team conducted a public workshop entitled, "Demonstration Project for Reducing Emissions from Vehicles in Hyderabad". The event was designed to engage a variety of stakeholders on the preliminary menu of interventions options and to elicit feedback on the demonstration design concepts. Approximately 45 people attended. Mr. A. K. Goyal gave the welcome address. Dr. P. K. Mohanty, Municipal Commissioner; Tishya

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Chatterjee, Secretary of the A. P. Pollution Control Board; Mr. C.L.N. Gandhi, A.P. Road Transport Authority; Mr. Rao, Hyderabad Police Department, and members of the LBG team including Ron Sissem, Will Kirksey, David Jarrett, and Mr. N.V. Iyer who represented SIAM also made presentations. The agenda for the workshop is included in this document as Annex 2A-1. A summary of the types of intervention options presented by the LBG team as a starting point for discussions is included in Table 2-1. All of the participants supported the demonstration concept and provided valuable feedback on issues that warrant consideration when selecting interventions.

Table 2-1: Preliminary Intervention Ideas "Menu"

Intervention Approach	Menu of Options Discussed

Traffic Management
 	
Primary concept behind intervention ideas is to increase transport efficiency to reduce overall travel and resulting emissions
	• Traffic signal systems
	  o Synchronization
	  o Demand response systems
	  o "Green Wave" systems
	• Traffic management
	  o Re-planning intersections
	  o Bus priority systems (dedicated lanes)
	  o One way street systems
	  o Vehicle segregation by lane markings
	  o Segregation by barriers
	  o Signing schemes
	• Pedestrian separation and priorities
	• Road construction
	  o Over passes
	  o Under passes
	  o New Roads
	• New rail construction
	• Measures to control traffic volume
	  o Restrictions on ownership
	  o Restrictions on vehicle usage
	  o Restrictions on licensing
	  o Control on access and parking
	  o User charges
	• Land use planning/redistribution

Vehicle Technology	**Technologies** • Hybrid or fuel cell vehicles • New power systems for 2 and 3-wheelers • Advanced pedal powered vehicles • "Leap ahead" technologies **Alternate Fuels** • Euro II • CNG and LPG • Electricity • Bio-fuel • Inspection and maintenance • Vehicle phase outs through incentives for vehicle replacement and micro-credit for upgrades • Mode shift through expanded bus service and restricted zones for other modes

2.4 Selection of a Demo Project Site

During the workshop and in discussions with the MCH prior to it, recommendations were made that the interventions be focused in a specific, bounded area of the city. The primary rationale being that the interventions should be tangible and enable citizens and stakeholders to clearly recognize that tangible improvements for emissions reductions were taking place. During workshop discussions on this issue, the design team pointed out that the demonstration area should exhibit one or more of the following: 1) a demonstrable level of traffic congestion to which traffic management interventions could be applied to show measurable improvement; 2) a reasonably high level of public transport usage; and 3) a recognized high level of air pollution.

Selecting the Site

Workshop participants recommended four possible sites. These included the Charminar, Abids, Tank Bund and Panjagutta corridor areas. Each of these areas was discussed and a cursory evaluation made. Panjagutta appeared to be the most feasible. Subsequent field observations made by the design team corroborated that this corridor, which centers on National Highway 9 (NH 9), would be good candidate. Not only did the corridor meet the above-noted criteria, but the MCH had already been considering a range of possible roadway and circulation improvements in this area. With technical assistance from the LBG team, the improvements could be tailored to achieve improved local and GHG emissions reductions goals without additional budgetary expenditures. The team also observed that the corridor could be linked with a loop through the Greenlands area as an opportunity to explore progressive roadway reconfiguration ideas.

The demonstration project site is illustrated in Figure 2-1. The selected area includes the main traffic corridor between Khairatabad junction and ESI Hospital via Panjagutta and Ameerpet. It also includes the loop connecting Ameerpet to Panjagutta via Greenlands and Rajiv Statue Junctions. Several months later, it was decided to include Raj Bhavan Road, which links Rajiv Statue Junction with Khairathabad, to the demo area. The main purpose for the addition was to create a potential connection to the new Necklace Road mass rail transit (MRT) now being developed by the city.

The demonstration area hosts a large number of administrative, corporate and commercial complexes as well as densely populated residential areas. The main transport feature is the major arterial, NH 9, which connects Mumbai to the north and Vijayawada in the southeast. The length of NH 9 within the demonstration area is approximately 4.5 km. The NH 9 corridor between Khairatabad and ESI Hospital has seven major junctions including: VV Statue Junction, KCP Junction, Srinagar Colony, Panjagutta, Ameerpet, Sarathi Studio and SR Nagar. The Greenlands loop includes the Greenlands and Rajiv Gandhi Statue junctions.

Details about traffic and circulation conditions within the demonstration area are provided in Chapter 4 – Traffic and Transport Management Interventions.

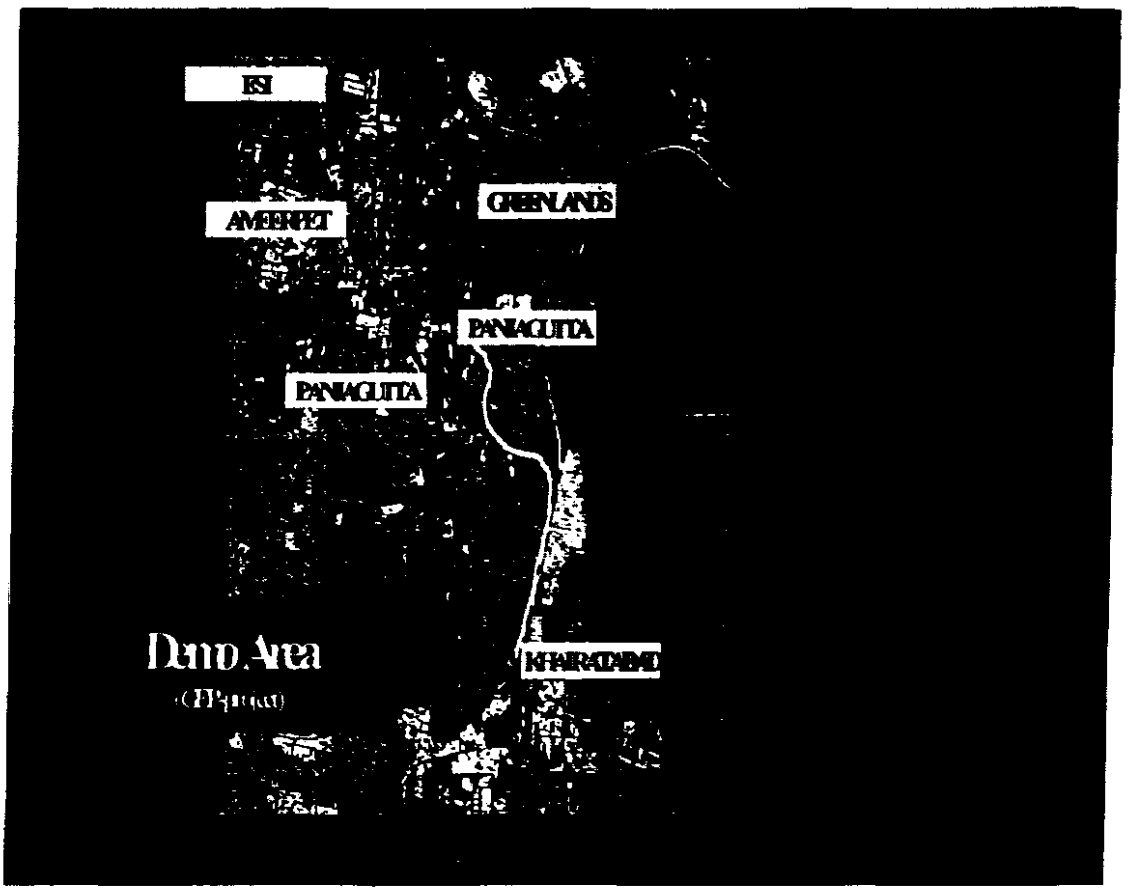


Figure 2.1 – Demonstration Project Site

Emissions Loads in the Demonstration Project Corridor

Comprehensive data on pollution loads in the demonstration corridor of NH 9 and in other areas of the city is being generated over time by the APPCB. The APPCB has set up a series of ambient air quality monitoring stations in the city and has recently completed a study of respiratory drug off-take as a proxy for understanding the relative health impacts of vehicular emissions in target areas of the city. Table 2-2 on the following page depicts shows the ground level concentrations of various pollutants at five monitoring stations. As can be seen, loads at the Panjagutta monitoring station are quite high, especially particulate levels (possibly owing to a high volume of buses and relatively, of transport vehicles). The "PM" figures reflect the relative size of particulate matter measured in microns.

While somewhat difficult to correlate the number of patients reporting to hospitals near the monitoring stations with vehicular emissions causes, data generated by the APPCB indicates that the number of patients reporting to hospitals in the Panjagutta area is at least two times greater than any other area in which monitoring is taking place. In combination with additional data being generated by the APPCB, there is growing evidence that vehicular emissions can be correlated with rising incidences of health problems. One may also assume that the health costs

associated with those problems is rising as well, though no data is available to verify this assumption.

Table 2-2: Pollutant Concentrations at Various Monitoring Stations (micro gr/m^3)

MONITORING LOCATION	NO_x	CO	PM1	PM 2.5	PM 5	PM 10
PARADISE	11.68	48.89	97.41	107.72	112.73	122.63
PANJAGUTTA	12.41	51.96	186.0	205.70	215.3	234.2
ABIDS	12.46	52.16	150.9	166.80	174.6	189.9
CHARMINAR	8.34	34.93	60.41	66.80	69.91	76.05
NEHRU PARK	5.19	21.74	26.23	29.00	30.35	33.02

Source: APPCB

2.5 Subsequent Key Activities

From August 2001 to February 2002, the LBG team and the MCH continued to collaborate to evolve the demonstration project design. The LBG conducted a number of activities for this purpose:

- Discussions and exchange of information on traffic management intervention design ideas and parameters with the MCH;
- Conducted a policy exchange to the U.S. to enable key MCH and state stakeholders to study integrated models of transportation planning and design that could be applied in Hyderabad over the short or longer term;
- Completed a detailed traffic survey in the demonstration project area to generate specific data on traffic volumes, turning movements, delays and average speeds;
- Held discussions and meetings with:
    - Indian and international auto manufacturers and technology providers to develop partnership ideas for electric vehicle (EV) interventions, assess hybrid vehicle potential, and discuss vehicle retrofit concepts;
    - Oil companies and research organizations;
    - GOI interests including the Petroleum Conservation Research Association, Ministry of Non-Conventional Energy Sources, Ministry of Environment and Forests, Central Pollution Control Board, etc.;
    - Bi-lateral/multi-lateral and domestic funding agencies including the World Bank, Asian Development Bank and Global Environment Facility, Clean Cities program of the USEPA, Export Import Bank, ICICI and IDFC to investigate project finance opportunities;
    - State and local stakeholders to keep them updated on progress;
- Consulted with U.S. based experts and institutions including Ford Motor Company, the US EPA, IIEC, and others;
- Made presentations on the demonstration project at multiple workshops and conferences to facilitate outreach and interest.

February Meetings with the MCH and Local Stakeholders

In early February, LBG and USAID held meetings with the MCH and select local stakeholders to consolidate efforts on the demonstration project. A number of key decisions were made:

- The range of traffic management interventions was largely fixed;
- The LBG proposal to provide a conceptual design for maximizing the efficient linkage of existing/proposed MRT stations with the existing road network in the demonstration area was discussed and validated;
- MCH noted their continued interest in retrofitting a number of vehicles in the Municipal Corporation fleet;
- MCH reasserted interest in providing non-monetary incentives to facilitate inclusion of EVs in the project, but is not interested in owning or operating alternative vehicles;
- Commitment was given to fund 50% of a "next generation" bus in partnership with APSRTC.

Following up on earlier discussions, LBG facilitated another meeting between the APSRTC and Ashok Leyland, its bus fleet vehicle provider and servicing agent. The purpose was to investigate specific retrofit/improved fleet maintenance options for reduced emissions. Both parties agreed to move forward to investigate and report on intervention options.

Refinement of Traffic Management and Vehicle Technology Interventions

Between February and April, the MCH began to put more detail to the traffic management interventions. Its ideas were based in part on principles and advice provided by LBG and certainly on its knowledge of existing conditions. In addition, LBG provided specific inputs on parking management policy and MRT station design for improved access and mode shift potential. Once the MCH completed its draft traffic management intervention plan, LBG reviewed and provided comments on it. On the vehicle technology/management side, LBG continued to hold meetings with and discuss finance and implementation issues with stakeholder partners for the interventions that essentially had already been selected.

2.6 Second Workshop on the Demonstration Project

On April 17, LBG and the MCH collaboratively conducted the second workshop on the demonstration project. The purpose of the workshop was to present the final draft set of interventions for the demonstration project and to elicit input from key stakeholders. Approximately 65 participants attended. The agenda is included in this report as **Annex 2A-2.** LBG and SIAM also arranged an exhibition of EVs and a demonstration of an improved Pollution Under Control vehicle emissions checking system during the workshop. Four EV manufacturers exhibited their products, including Mahindra & Mahindra, Reva, Scooters India Limited, and BHEL.

The new Mayor of Hyderabad, Mr. T. Krishna Reddy and the new Municipal Commissioner of Hyderabad, Mrs. Ramachandran, attended the opening session and providing words of thanks and support. The Mayor also had a chance to drive REVA's electric car. Ron Sissem; Mr. CLN Gandhi, Jt. Commissioner from the APRTA; and Dr. Ramani from the APPCB also made presentations during the introductory session to set the context for the workshop.

In the latter two sessions, demonstration design partners made presentations on individual interventions that the overall design team had selected. Mr. Ranadhir Reddy, Additional Commissioner from the MCH and his consultant, Mr. Ragahva Chari provided a full presentation on the proposed traffic management interventions. Atanu Ganguli from SIAM presented the EV components, Mr. Murlikrishanan of SIAM presented on the PUC component, and Mr. Rao of Hindustan Motors presented the preliminary scope of the Ambassador retrofit intervention.

The outcome of the workshop was as anticipated. Participants had a number of questions about individual components of the design and about its cost and implementation schedule. As importantly, the participants were well informed about the project and will be able to brief others in their organizations about it. Members of the press also attended. While no significant changes in the project design are required as a result of participant input, some of the comments will necessitate that the design team consider specific details of particular interventions.

CHAPTER 3: DEMONSTRATION PROJECT DESIGN CRITERIA

As has been noted previously, a plethora of traffic and transport management and vehicle technology and management interventions are available for reducing local and GHG emissions from the transport sector. These vary from relatively low capital/transaction cost ideas to highly capital intensive/high transaction cost ideas. This chapter summarizes how the project team evaluated and finally selected the specific interventions that are included in the final design.

3.1 Evolution and Finalization of Criteria

During preparation of the VTA and during the initial evolution of the project concepts, many of the potential interventions remained "on the table" as possible components for the project. This is reflected in the fact that VTA and the input from the LBG team consultants initially considered a full range of possible interventions. In discussions with key local and state stakeholders during and after the August 2001 workshop, a more refined set of intervention selection criteria began to emerge based on the team's decision, with direct input from USAID, that the overriding priorities for formulating the demonstration project design were its ***implementation and replication potential.***

Implementation implies a high likelihood that interventions will become reality on the ground. Replication potential implies that other municipalities may recognize and act on their potential to implement similar interventions. Both of these factors are critical to maximizing the potential benefits of this demonstration project. On this premise, the project criteria illustrated in **Table 3-1** on the following page were developed and used to guide intervention selection.

3.2 Design Criteria and the Resulting Scope of the Demonstration Project

As would be expected, application of the design criteria substantially narrows the scope of potential interventions with local and GHG emissions reduction benefit considered for inclusion in the project. Some examples are noted in the "comments" column of Table 3-1. Several interventions that are typically considered in comprehensive approaches to emissions reductions as noted previously in Chapter 2 that are not part of the demonstration project are as follows:

Alternative Fuels

Use of alternative fuels such as CNG, LPG, ethanol or other biofuels were generally not considered. Policy decisions to permit their use may not yet be formalized, the fuels may not available in Hyderabad within the specified project implementation timeframe, and/or their development may not be mature enough to ensure fuel availability/viability within the implementation time frame. In the case of LPG, a private company has been planning a project to commercialize LPG as a transportation fuel in Hyderabad. This fact, in combination with the fact that long-term, sustainable supplies of LPG are not certain across India, led to the omission of LPG as an alternate fuel. However, for informational purposes, Annex 3A-1 contains a brief summary of the relative emissions characteristics of CNG, LPG and ethanol as compared to conventional fuels.

Table 3-1: Demonstration Project Intervention Criteria

Criteria	Comments/Implications for Design
Local body and/or private agent(s) defined and willing to take implementation responsibility	Interventions can only be implemented if an implementing authority/agent has or is likely to be defined. GEP-CCS's scope precludes it from acting as an implementing agent.
Interventions can be implemented within one-two years	The desire to create tangible, visible changes for local and GHG emissions reduction in the short-term drove the inclusion of this high priority criterion.
Interventions are largely within the direct control of local implementing authorities or private sector agents	Interventions dependent on state or GOI policy or regulatory decisions such as fuel policy or vehicle management (retirement), were generally not included in the project. There is no assurance that policy or regulatory decisions would be approved within the timeframe needed to ensure concrete outcomes are demonstrated.
Relatively low initial capital and operations and/or maintenance costs	A key factor for facilitating realistic replication potential in other municipalities across India. Major "one-off", capital-intensive interventions such as mass transit systems, large transportation infrastructure projects, etc., even if supported by third party bi/multi-lateral donors, were given lower priority as they are less likely to be replicable across India due to short-term resource and capacity constraints of most Indian municipalities. Where possible, interventions with revenue generation potential were selected, as they are more likely to be sustainable and replicable. Interventions that require approvals or policy actions whose approval was deemed uncertain during the project design or implementation timeframe were not prioritized.
Technology/fuel availability	The implementation timeframe of one-two years dictated that technologies, fuels availability, and other potential interventions be mature enough for practical application within this period.
GHG emissions reduction potential	GHG mitigation potential of interventions was not the priority filter for selecting interventions, as local pollutant reductions are the primary driver for local decision makers. However, only interventions that have at least an incremental GHG emission reduction potential were considered. No specified volume of local or GHG emissions reduction was sought.
Finance potential	Interventions with a higher degree of finance or funding potential were prioritized. This was especially true for interventions to be implemented by the MCH.
Consistency with local transport and development plans	Local authorities were assumed to be more supportive of interventions (implementation potential enhanced) that reinforce/support their current transport or development objectives if such are defined.

Advanced Technologies

Due to technology availability limitations and/or cost, advanced technologies such as fuel cell powered vehicles were not considered.

Mass Transit Systems

While mass transit systems such as high capacity bus systems or rail transit have been demonstrated to be very effective interventions for emissions reductions, the scope of the

demonstration project did not permit their consideration. In addition, it is highly unlikely that such systems would meet several of the design criteria, including implementation timing criteria, replicability or local decision-making control.

Policy or Regulatory Interventions

Policy and regulatory interventions such as vehicle retirement, constraints on vehicle ownership, road use pricing, etc. are largely outside the discretionary authority of local bodies, resting largely with state or GOI bodies. Furthermore, such interventions would not be consistent with the intention to include tangible, visible actions that can be included in a defined project.

CHAPTER 4: TRAFFIC AND TRANSPORT MANAGEMENT INTERVENTIONS

4.1 Introduction

Traffic and transport management can play a significant role in reducing local and GHG emissions. In congested and inefficient traffic conditions, the average speed of all vehicles in the traffic mix declines. As speeds decrease, the efficiency with which hydrocarbon-based fuels are burned generally decreases. Less efficient combustion results in increases in vehicular emissions.

For most types of vehicles and fuels, fuel efficiency is maximized at an optimal speed. In congested, urban traffic conditions in most Indian cities, including Hyderabad on NH 9, average speeds during peak travel hours typically range from 10 kph to 15 kph, well below the range of 40 kph to 50 kph or higher where many Indian vehicles attain more optimum fuel burning efficiency. Interventions that improve traffic flow and average speeds up to the point where optimal fuel efficiency is reached will generally result in reduced local pollutant and GHG emissions.

The primary purpose of the traffic management interventions is to improve flow conditions in order to facilitate improved fuel efficiency and lower emissions. LBG and the MCH have worked collaboratively to identify a range of potential interventions that are appropriate for this purpose given the range of opportunities and constraints for making improvements within the demonstration project area.

4.2 Existing Conditions in the Demonstration Project Area - Causes of Poor Vehicle Flow

Amongst many others, the following are the major causes of congestion in the demonstration area:

- Lack of lane discipline;
- Lack of parking control;
- Poor pedestrian facility provision and control; and
- Lack of channelized intersections;
- Excessive delays at intersections.

In addition to the above, the right-of-way (ROW) for the main roads varies. For example, the ROW on NH 9 varies from 14 meters to 24 meters. This irregularity invites unorganized lane changes and poor lane discipline, especially considering that the full ROW in many locations is not fully paved. Bus stops are also not placed in optimal locations (i.e. where road width is narrower) causing buses to stop in through lanes of traffic and causing backups. A number of "pinch points" on the roadways also exist where narrow bridges or where buildings of important cultural value encroach onto the standard ROW. These types of problems are particularly acute on NH 9 and in the Greenlands area. Conditions on Raj Bhavan Road are generally better with less traffic volume and roadway demand.

Also typical for most major urban areas in India, parking management is poor or non-existent. Vehicles of all types, including non-motorized carts and vendor stands, park in random locations at road margins, often blocking through traffic or infringing on pedestrian flows. The result is

substantial "side friction" encountered by through traffic, which causes slowing and stoppage, especially for vehicles traveling in the left lanes of four-lane roads. This problem also exists at bus stops where paratransit vehicles (usually 3-wheelers) park within the bus stop zone, forcing buses to stop for passengers within the left lane of a roadway.

Traffic Volumes and Congestion

The demonstration area certainly meets the criteria for having a demonstrated level of congestion and high traffic volume. Table 4-1 shows morning peak hour traffic flows on the main segments of NH 9. Based on standard road performance standards, the volumes shown would warrant eight lanes to deliver "C" level of service (on a scale of A to F, with A being free-flow conditions and F being gridlock conditions).

Table 4-1: Existing Morning Peak Hour Volumes Khairatabad to ESI

Road Segment	Vehicles Per Hour (Morning Peak)
Khairtabad – KCP	9800
KCP – Panjagutta	7000
Panjagutta – Srinagar Colony	7800
Srinagar Colony - Ameerpet	7850
Ameerpet – Sarathy Studio	7300
Sarathy Studio – SR Nagar	9300

Source: MCH and LBG traffic surveys

Currently, the width of NH 9 varies from five lanes to eight lanes. However, there are several bottlenecks of two to three lanes in width that also facilitate congested flow conditions.

Traffic Composition

The types of vehicles moving through the corridor during the morning peak hour are generally as shown in percentage terms and in absolute numbers in Table 4-2.

Table 4-2: Approximate Traffic Composition in the NH 9 Corridor

Vehicle Types	Percentage of Total	Numbers of Vehicles
Cars	10	950
2-Wheelers	42	5000
Buses	6	335
Auto rickshaws (3-Wheeler)	32	1348
Good Carriers	8	780
Others	2	20

Source: MCH and LBG Traffic Surveys

The above information was generated through a detailed traffic survey conducted by LBG and MCH. Delay evaluations, link counts and intersection turning counts were made as a basis for generating inputs for design alternatives. Details of these counts are included in Annex 4A-1.

4.3 Traffic and Transport Management Intervention Options for Improved Vehicle Speeds

LBG and the MCH conducted a visual reconnaissance of the demonstration project area in August of 2001 and evaluated existing traffic data for the area. The problems noted above were verified and a general survey of traffic conditions was conducted. To initiate the traffic management intervention process, LBG's transport management expert initially proposed three main principles as a starting point for LBG and MCH collaboration which were felt to be appropriate for the demonstration project area.

Reduction of Conflicts by the Creation of One-Way Roads

The creation of one-way roads can achieve considerable increases in traffic efficiency. On links, it is found that a pair of roads previously operating as two 4-lane roads in two directions, which are changed to operate as a pair of 4-lane one-way roads will experience an increase in efficiency[3]. At intersections, the creation of a one-way road will reduce the number of turns dramatically. Thus if a standard 4 way intersection has one of its roads changed to a one-way operation the movements reduce from 12 to 7 (a dramatic reduction of more than 40% in conflicting movements). The new one-way roads may then be reorganized so that the road space will be operated at maximum efficiency. Table 4-3 shows the how capacities of one-way versus two-street systems differ.

Table 4-3: One-Way Versus Two-Way Road Capacities

Configuration	Theoretical Capacity
2-Way/2 Lanes	2 x 1,100 = 2,200 ➔ ← 2 x 1,100 = 2,200 **Total = 4,400**
1 Way/4 Lanes	4 x 1,300 = 5,200 ➔ ← 4 x 1,300 = 5,200 **Total = 5,200**

Source: LBG

Segregation of Non-Compatible Vehicle Streams

The typical urban traffic stream shows a mixture of vehicles of different types. Large, heavy goods vehicles mix with small light cars and auto rickshaws. The vehicles operate at varying speeds and for different purposes. Some are making short distance trips; others long distance. All of these differences create a situation in which there is conflict of movement in the traffic

[3] This is shown by a simple capacity assessment. A two-way 4-lane road has a capacity of 2 x 1,100 pcu/hr in each direction = 2,200 pcu/hr in each direction. So two 2-lane roads have a combined capacity of 4,400 pcu/hr in each direction. A 4-lane, one-way road has a capacity of 4 x 1,300 pcu/hr or a total capacity of 5,200 pcu/hr in each direction.

stream. The segregation of vehicles by type or purpose can lead to great efficiencies in the overall operations.

Separation of Vehicular Movements from Vulnerable Road Users

The traffic operations in an urban area have to be sympathetic to both motorized users and non-motorized. Primarily the latter includes pedestrian and cyclists, both of whom are classified as vulnerable road users (VRUs). If the provisions for these users are not provided for properly, there will be delays caused to traffic due to random crossings of the highway and danger to VRUs. This should be resolved by the creation of a policy followed by properly designed and prioritized crossings.

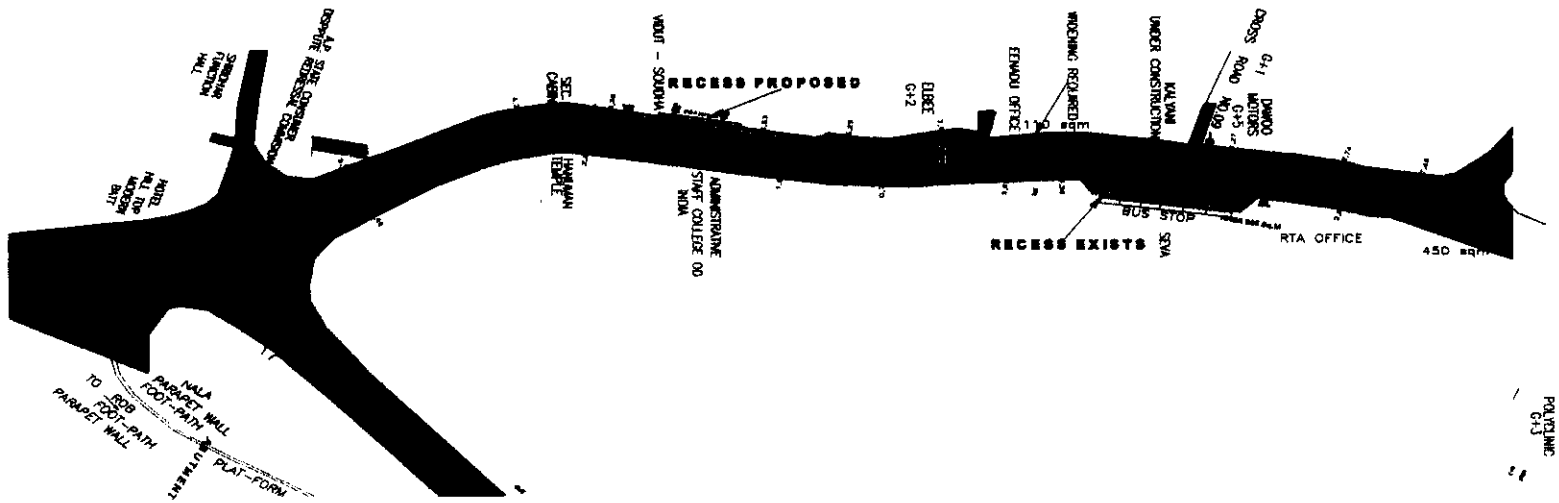
These concepts, along with parking controls, creation of "clean vehicle" zones, bus priority lanes, standardization of roadways to international/Indian standards, and intersection improvements to improve efficiency were the basic components of the initial design concept framework that directed the subsequent intervention selection process.

4.4 Evolution of Design Interventions

Over time, MCH, with LBG input, evolved a basic set of general intervention ideas largely based on the initial principles proposed. These are as follows:

- Segregation of non-compatible vehicle streams;
- Synchronization of traffic signals to reduce intersection delays;
- Junction improvements to reduce turning conflicts;
- Reductions of side friction through:
    - Provision of paratransit parking
    - Rationalization of bus stops with bus bays
    - Provision and enforcement of 2-wheeler and 3-wheeler parking
    - Encouragement of off-street parking
- Standardization of the road ROW, especially on NH 9 to create a uniform carriageway wherever possible;
- Separation of vulnerable road users (pedestrians) by suitable pedestrian crossings;
- Signage and signal timing facilities to direct traffic flow and fuel efficiency

These design interventions have been incorporated into an NH 9 corridor traffic management improvement plan by the MCH. For presentation purposes, the NH 9 corridor has been broken up into eight segments that are illustrated in a set of eight "sheets". For illustrative purposes **Figure 4-1** shows one of these segments. A number of the "typical" types of traffic management improvements proposed for the NH 9 corridor in general are shown in the figure, many of which are noted as "proposed". Design improvements for each of the remaining segments of the highway are illustrated on their respective segment sheets in Annex 4A-2.



Source : MCH

Figure 4-1: Typical NH 9 Corridor Improvements (Sheet 1 of 8)

The following text summarizes each of the types of interventions proposed in the NH 9 corridor. It is anticipated that many, if not all of these interventions, would be replicated within the Greenlands loop in a subsequent phase of the project.

Roadway Circulation Changes/Vehicle Segregation

Traffic segregation has been proposed to improve traffic flow. Segregation entails grouping vehicles of similar use and behavior and putting them into separate streams to reduce conflicts between them. Lacking adequate segregation, traffic of all types weaves across the available road space, looking for the path of least resistance. In Indian conditions, vehicles are generally grouped into three types: non-motorized vehicles (i.e. cycle rickshaws and bicycles), private and commercial vehicles (cars, transport vehicles and often 2-wheelers), and public transit and paratransit vehicles such as buses and 3-wheelers).

Initial LBG Circulation Reconfiguration Proposal

As noted previously, LBG initially proposed a fairly progressive circulation concept for the demonstration project area. The proposed design sought to effectively increase roadway capacity and reduce turning conflicts at intersections. It also included a priority bus lanes element. Several benefits, including promoting a potential mode shift to buses (with the motivation being more rapid transport times) and promoting a shift to "clean" vehicles (which would have been allowed to utilize the dedicated lanes) were intended to result from the reorganization plan. Figure 4-2 illustrates the circulation components that were proposed.

This system incorporated with-flow and contra-flow bus lanes on NH 9 (and incorporated a physical division allowing boarding and alighting provisions). This approach gave substantial benefits in terms of timesavings and reduced the conflicts at intersections by some 40% to 50%. However, it also required adjustments to some road infrastructure (such as drainage and lighting) and while the MCH was intrigued with the principles, after some study, ultimately it was felt that such a substantial change was too progressive to ensure its implementation. Furthermore, the plan would have required improvements in storm drainage and lighting and median modifications whose cost would have been difficult for the MCH to absorb.

MCH Segregation Proposal

Using some of the above noted design principles; the MCH opted for a much less proactive approach to segregation focused on NH 9. This scheme is shown Figure 4-3 on the following page. The MCH retains the existing two-way system and the intersections as they stand at present. The main changes have been to the way in which the road cross sections are treated. The current behaviour of the traffic in the demonstration area manifests itself in virtually total lack of lane discipline. Traffic of all types weaves across the available road space along the minimum resistance path. This causes danger, reduces road capacity and creates unstable flow conditions. Paratransit vehicles, mostly 3-Wheelers and buses utilize the left lane while cars and 2-Wheelers, would utilize the right lane as they are less likely to make frequent curbside stops.

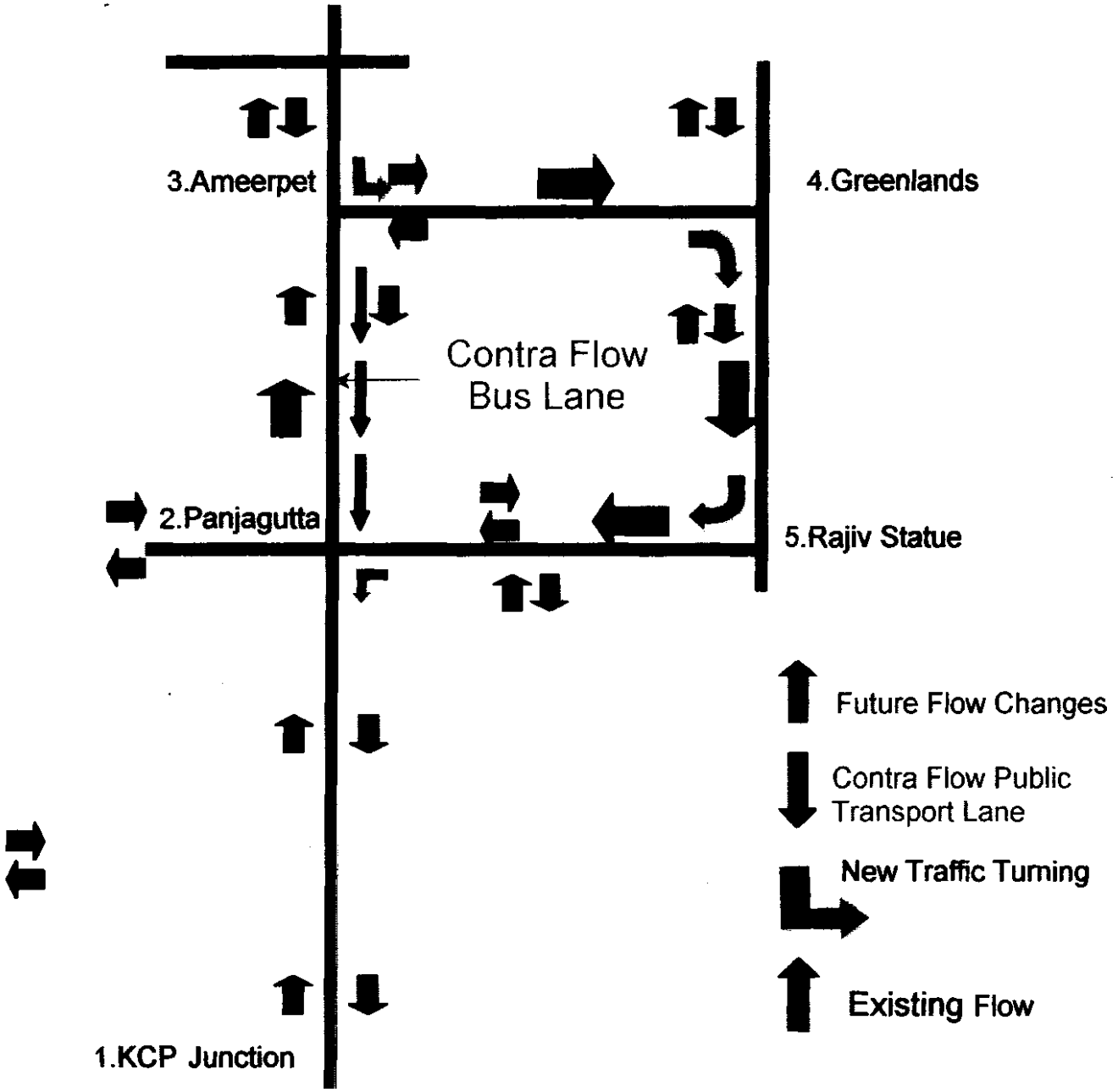
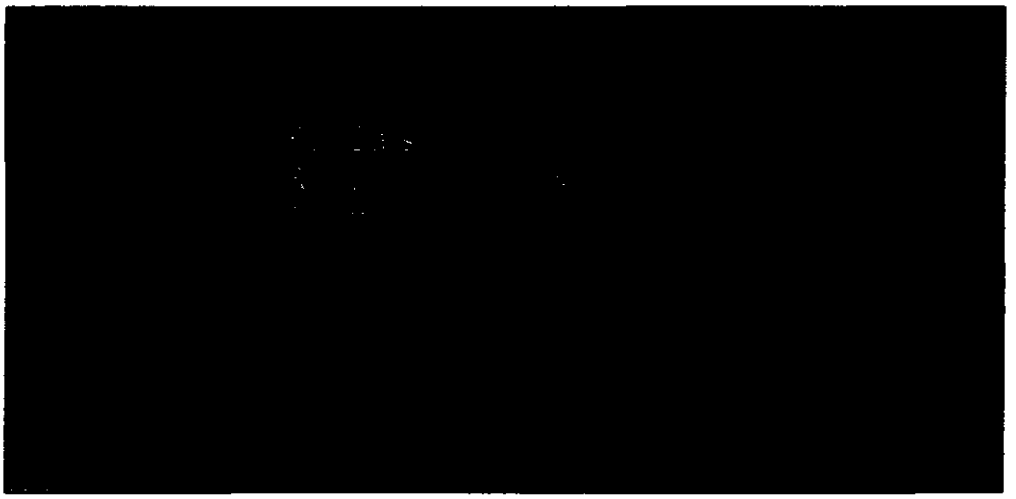


Figure 4-2 - Initial LBG Circulation Concept

Figure 4-3: MCH Traffic Segregation Scheme



The delineation of the lanes would be made by using strong paint lines on the surface. This, together with lane markings is the cheapest method of segregating traffic. The MCH also proposes an extensive signing system that will instruct drivers entering the corridor to utilize the appropriate lane. This scheme will require strict enforcement by police to ensure that the correct vehicles use the prescribed lanes. If this is not enforced, the same 'free-for-all', which exists at present, will prevail and all advantages will be lost.

Improved Bus Stop/Bay Design and Parking Management and For Reduced Side Friction

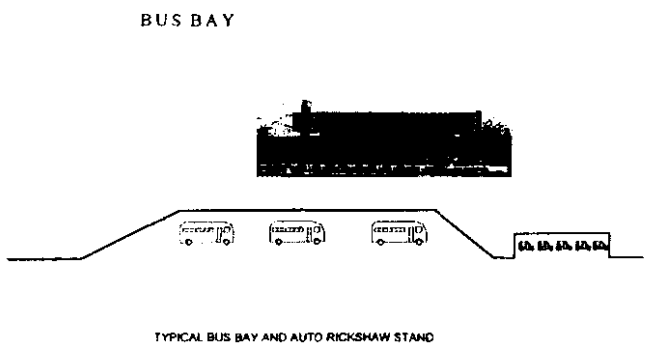
Bus Stop Design and Location

Currently, there are 16 bus stops located on the NH 9 corridor within the demonstration project area. Several of these have been determined to be too close to each other based on international headway (optimal distance between vehicles) standards or located where road ROW is narrow. Bus drivers are thus inclined to pass buses stopped in front of them by merging into the right lane, creating interruptions in traffic flow. Further, several bus stops are located where the NH 9 ROW is narrow. Other stops are located at the existing curbside. Buses stopping at these types of locations often occupy a portion of the left lane, forcing following vehicles to merge into the right lane. Again, significant disruptions in flow result.

The overall improvement plan for bus stops is to relocate three existing stops, create recessed bus bays at four existing stops that are not recessed, establish one or two new recessed stops, improve existing recessed bays and to install signing at all stops to better manage bus behavior. Figure 4-4 shows a "typical" section of an improved bus bay. By utilizing deeper bays located at wider portions of NH 9, buses can stop for passengers without interfering with the flow of traffic in the left lane. Buses will then be able to merge back into the left lane. This will also reduce

traffic/bus passenger conflicts that occur when passengers de-board within the roadway. Please refer to Annex 4A-2 for locations of existing and proposed bus stops.

Figure 4-4 – Typical Bus Stop



Parking Management

Parking management interventions are of two major types. In general, several locations within underutilized margins of NH 9 ROW lying outside the designated four lanes of traffic will be dedicated to regulated 2-wheeler and 3-wheeler and auto parking. Further, on street parking outside of these locations will be restricted to encourage off-street parking. About 13 new parking bays will be located in the NH 9 corridor within the demonstration project area where only two exist today. This approach will further serve to reduce side friction by removing vehicles that currently park within the existing road ROW and whose movements into and out of the traffic flow often cause conflicts. The proposed new parking areas are illustrated on the various NH 9 segments illustrated in Annex 4A-2.

Comprehensive Parking Management Policy

Parking management in the demonstration area, throughout Hyderabad, and in Indian urban areas is such a critical issue that LBG has proposed a model, comprehensive parking management policy to the MCH for consideration as a broader intervention. The full text of the model policy is included as Annex 4A-3. Generally, the policy identifies objectives, responsibilities of local authorities and strategies for effective parking management including: parking supply and demand, types of parking, short-term versus long-term parking, other forms of space provision, parking prohibition, signs and marking, enforcement and penalties, and tariff setting.

Standardizing the NH 9 Right-of-Way

Currently, pavement widths, ROW width, width of travel lanes, etc., within the demonstration area, especially in the NH 9 corridor, are not consistent. These inconsistencies in travel conditions result in traffic delays as drivers slow to avoid unpaved areas or merge between lanes to respond to side friction and other obstacles. In addition, without standardized travel lanes, it

becomes difficult to clearly define travel ways to which regulatory measures for vehicles, parking areas and behavior, etc. can be applied.

The proposed design of the NH 9 corridor calls for standardizing the width of travel lanes so that four lanes (two in each direction) of consistent width are created. Several sections of the NH 9 corridor have recently been widened. However, some of the widened sections still remain unpaved. In some locations, new paving is required to ensure two 3.5-meter wide lanes in both directions, which is consistent with international standards.

Signal Synchronization

Signal synchronization is a strategy used to reduce delays at intersections by linking signals so they are timed to appear green as vehicles approach from the previous signal. The purpose is to improve average vehicle speeds by reducing the frequency and duration for which vehicles must stop at subsequent traffic signals. There are four main intersections in the demonstration area of which one is a roundabout and three controlled by signals. LBG and the MCH have exchanged information on potential synchronization schemes. The best possibilities for implementing such schemes appear to be between intersections in the NH 9 corridor and between the Greenlands and the Ameerpet intersections.

The MCH has conducted a study on improving synchronization within the NH 9 corridor between the Khairatabad intersection at the southern terminus and ESI at the northern terminus of the corridor. Table 4-4 shows two examples of how improved synchronization can reduce travel times within the corridor. As can be seen, travel times are significantly reduced in both directions (42% and 64%, respectively). Reduced travel times equate to improved speed and reduced emissions.

Table 4-4: Improved Signal Synchronization and Reduced Travel Times

Delay in Seconds – Morning Peak Hour			Delay in Seconds – Evening Peak Hour		
Khairatabad to ESI			ESI to Khairatabad		
Signal#	Before	After	Signal	Before	After
102	57	45	712	92	83
202	38	17	603	34	13
302	109	25	507	67	36
401	0	54	403	0	12
502	47	11	307	89	44
601	49	54	208	47	21
703	90	66	108	50	33
Reduced Delay: 3.8 Minutes			Reduced Delay: 2.3 Minutes		

Source: MCH

The MCH has noted that signals in the city are set manually. An electronically controlled and cabled system between lights does not exist. The timing of lights has and can continue to be tampered with by untrained city employees. Furthermore, it is generally necessary to change the timings to respond to changing traffic conditions (i.e. peak versus non-peak conditions). In the former case, traffic police will need to be specially trained not to randomly reset signals at individual intersections. In the second case, it may be necessary train traffic police to change signal timings manually to optimize synchronization at different traffic flow periods. LBG did

explore the MCH's desire to install a cable, computer controlled synchronization system in the corridor. MCH expressed an interest in the future, but felt incremental efforts to improve the manual synchronization system would suffice over the short term.

Intersection Improvements

The traffic movements at the intersections within the demonstration project area are a major cause of delay, danger and confusion. The original circulation concept of one-way streets and contra flow lanes proposed by LBG provided a system of circulation that substantially reduced conflicts, dropping conflicting turns by some 45%. Without using a one-way street system, the current proposed intersection configurations will not enable such a substantial drop in conflicting movements. It is essential with this retained system to provide very specific and guided turning paths.

To facilitate improved intersection capacity and performance under the MCH proposed circulation system, LBG reviewed the intersection configurations of four of the intersections in the demonstration project area and made recommendations to the MCH. The recommendations focused on the following:

a) All lanes should be of standard width (3.5 meters) according to international norms;
b) There is full pedestrian separation with crossings protected with pedestrian refuges;
c) Conflicting turns at the four way intersections are regulated by signal phasing allowing pedestrian movements to take place in safety;
d) All movements are guided completely to prevent illegal and dangerous turns;
e) The wide-open spaces within the intersections are reduced so as to permit good directional guidance and to allow the incorporation of landscaped areas to 'soften' the urban spaces. Some intersections have features added to provide foci for traffic movements.

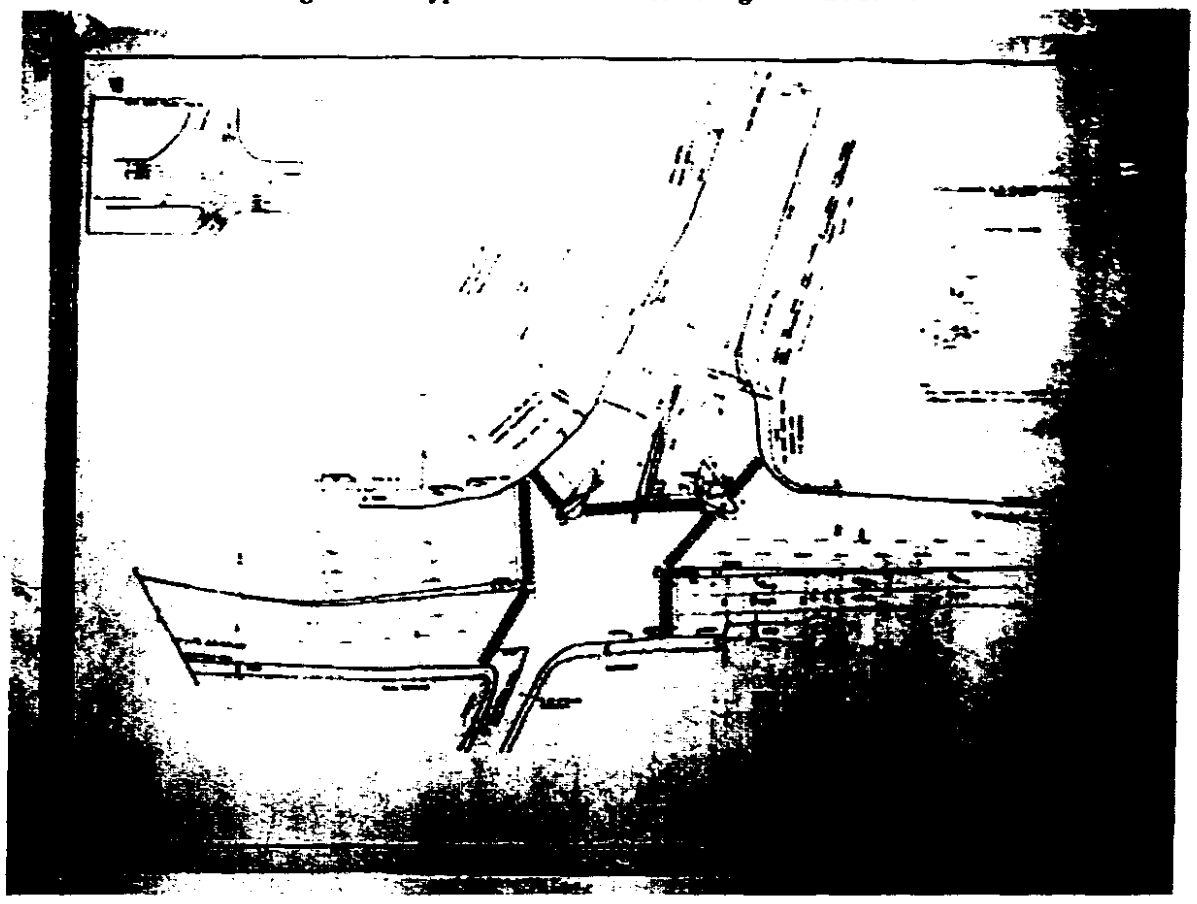
The MCH had already begun a series of intersection design concepts for the intersections within the demonstration project area as well as in a number of other locations throughout the city. Using LBG recommendations and its own evaluations, intersections within the demonstration area have been reconfigured, with actual physical modifications to follow during the implementation stage of the project. Figure 4-5 illustrates "typical" intersection improvements that would take place. These generally include lane reconfigurations, turning lanes, ensuring medians and islands are properly placed or removed as necessary, etc.

Signage

If the segregation, parking, and other interventions noted above are to be effective, a comprehensive signage plan is required. The MCH has developed a comprehensive signing plan for the demonstration area. A number of the signage locations can be seen in Annex 4A-2. Large overhead signs would be placed at the entry points to the corridor to direct the segregated use of lanes. In addition, parking and a host of other signage would be included.

The MCH has elicited bids from a variety of transportation hardware providers for signage improvements. LBG has also been in contact with 3M-Birla for this purpose. It is anticipated that per existing local regulations, a contractor may be retained to construct and install signs in exchange for advertising space within the corridor.

Figure 4-5: Typical Intersection Reconfiguration Model



4.5 Emissions Reduction Potential

As was noted in the introduction to this chapter, the traffic management interventions are designed to improve vehicular flow within the corridor and by so doing improve fuel efficiency. In addition, by improving average speeds, the amount of time a vehicle operates through the corridor is reduced, adding to fuel savings and emissions reductions.

Quantification of emissions reductions from traffic management interventions is a complex task. The conceptual approach is to calculate an emissions baseline by determining the average speeds of all vehicles on a given road segment under existing conditions and applying emissions factors to each type of vehicle traveling that segment (considering engine type, type of fuel being utilized, etc.) at that average speed. After implementing the interventions, the same process would be followed but the average speed would have increased, necessitating the use of new emission factors for that speed. The difference in the baseline emissions and the post-project emissions would show a reduction in total emissions.

Based on interviews with a number of institutes, SIAM, auto manufacturers and others, it was determined by the project team that today in India, emissions factors of the type needed have not been developed. It is worth noting that USAID is funding a research project at the University of Ohio whose outcomes will be a set of emissions factors that can be applied for the purposes noted. These should be available in the summer of 2002 and may be used retroactively to refine emissions estimates made in this project.

Traffic studies conducted by LBG and the MCH indicate that existing average speeds in the NH 9 corridor are approximately 15 kph during peak hours. It is estimated that the interventions could result in an average speed increase of from 5 kph to 10 kph. MCH is planning to conduct post-project traffic surveys to determine the actual speed increases. It must be remembered however, that the NH 9 corridor is far from being a closed system. Any number of variables, such as an increase in vehicle population, local or regional development, other roadway improvement or capacity improvement projects in other parts of the city, etc., could directly affect the volume of traffic moving through the corridor.

Table 4-5 shows the estimated local pollutant reductions from implementing the traffic management interventions in the NH 9 corridor. Studies in France indicate that in congested conditions where traffic speeds are similar to those in Hyderabad during peak hours, CO_2 emissions for cars are approximately 520.7 grams/kilometer. In free flow conditions at approximately 35 kph, CO_2 emissions decline to 189.5 grams/kilometer. A similar relationship is expected in Hyderabad. Speed/emissions relationships are also illustrated in Figure 4-6 for local pollutants. Again, CO_2 emissions would decline in proportion to reductions in local emissions.

Table 4-5: Relative Emissions Reductions from Traffic Management Interventions in tons/day

15-20	1.450	.230	.040
20-25	1.440	.220	.040
Total	2.890	.460	.080

Source: MCH and LBG

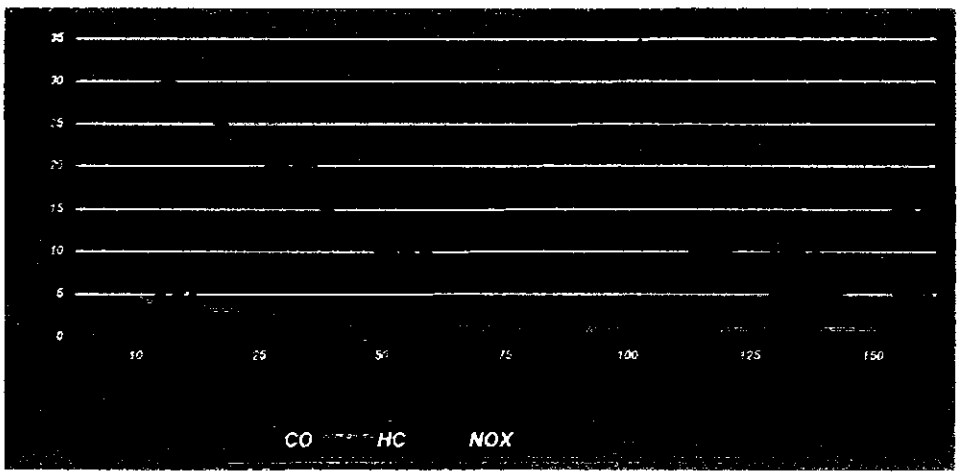


Figure 4-5: Relationship Between Speeds and Emissions

4.6 Costs and Finance

The MCH has worked out initial cost estimates for materials and hardware required to implement the interventions within the NH 9 corridor. The overall estimated cost is between Rs5,00,000 to Rs6,00,000 or approximately $100,000 to $120,000. Included in this estimate are:

- Roadway widening
- Zebra crossing delineations for pedestrians
- Signboards
- Pavement markings (paint)
- New bus bay construction
- Overhead directional signage

Of these, the overhead directional signage constitutes about 50-60% of the total estimate. Therefore, it will be important to develop a public-private partnership to bring this cost down. Additional costs, which have not yet been calculated, will be incurred for traffic signalization synchronization improvements.

Funds for these improvements would come from a cost-sharing partnership between the MCH and the National Highways Department. The Department is responsible for paving and other "in roadway" improvements for national highways. The MCH has already allocated a capital improvements budget for various roadway and transport improvements within the city, including a number that had been contemplated within the demonstration project area. Therefore, it will not require funding above that already available to implement the interventions and representatives of the MCH do not feel there will be a problem in accessing existing funds for this purpose.

4.7 Implementation

The MCH, in partnership with the National Highways Department, will be the lead implementing agency. The MCH has the manpower and operational ability to implement the interventions.

Initially, the MCH planned to make improvements in two phases. The first phase would have included the NH 9 corridor and the Greenlands loop. A second phase would have extended to Raj Bhavan Road. However, over time, the phasing plan has changed. Phase one is now the NH 9 corridor. A phase two encompassing the Greenlands loop is anticipated. Given the much lower traffic volumes on Raj Bhavan Road, the MCH is not planning to extend the interventions to this road at the present time. The MCH anticipates that phase one improvements can begin within three to six months. Phase two improvements would likely be initiated within six to nine months. However, timing of the second phase may be contingent on the completion of phase one improvements and on the relative results thereof. Improvements would likely be made in the following order:

- Paint markings for lane segregation and zebra crossings
- Bus stop locations fixed/construction and paving
- Roadway pavement widening
- Auto rickshaw parking
- Car parking
- Pedestrian footpath treatment
- Signboard erection
- Junction improvements
- Signalization synchronization
- Overhead signboard

CHAPTER 5: VEHICLE TECHNOLOGY AND MANAGEMENT INTERVENTIONS: IMPROVED POLLUTION UNDER CONTROL SYSTEMS

5.1 Introduction

The performance of any vehicle deteriorates gradually over time but regular inspection and maintenance can improve performance and keep emissions under control.

India already operates an inspection and maintenance program called "Pollution under Control" (or PUC). The process involves vehicle emission testing and certification when standards are met. The process is a low investment and high return intervention. A number of authorities in Andhra Pradesh and Hyderabad, as well as GOI officials have developed policy statements supporting the expanded use of the PUC system as a major tool for reducing vehicular emissions. As is well known, the existing PUC checking system has not, for the most part, operated effectively or thoroughly. This proposed intervention calls for piloting upgraded PUC centers where critical shortcomings of the existing PUC system are overcome. However, the political and policy will must exist to enact stringent enforcement actions to support the effectiveness of any PUC system. With an improved emissions checking system, a greater number of vehicles will be maintained to reduce emissions and improve fuel efficiency.

SIAM has recently conducted inspection and maintenance camps in several Indian cities including Delhi, Mumbai, Bangalore and Hyderabad. Data collected during the camps showed that by improved maintenance, substantial reductions in CO, HC and CO2 emissions could be achieved. For example, in Delhi, CO2 would be reduced by a total of approximately 56,000 tons/year.

5.2 PUC Certification and Process

Under the PUC certification program, vehicles are checked with the engine idling (for gasoline engines), and with the engine revving in neutral (for diesel engines). When emissions are within the prescribed limit, a PUC certificate is issued for the vehicle, otherwise it would go for repair in order to enable the vehicle to meet the stipulated emission level.

The present process for the PUC check is as follows:

- The vehicle reports for PUC certification at an authorized emission test center;
- The engine is started/ warmed up (if not already so) and a test probe inserted in the tail pipe;
- When the engine is running smoothly, the results are observed on the analyzer;
- When results are not within the stipulated range, minor adjustments are made to the carburetor by the tester; if there are no major problems, the emission values are brought within acceptable limits;
- A PUC certificate and windscreen sticker are generated and handed to the owner.

The PUC system is simple and effective but its potential is not realized because of:

- Malpractice due to human intervention;
- Inadequate procedures due to lack of proper training;
- No audit by independent authority;
- No tracking system or follow up of vehicles failing to meet norms.

5.3 Potential Local Air Quality Benefit and Reduced GHG Emissions

With assistance from the Oak Ridge National Laboratory of the USA, SIAM conducted an I&M program in November/December 1999 with participation by all 2-wheeler manufacturers along with the Indian Oil Company, ATMA, PCRA and TERI in Delhi. The objective of the program was to form a public-private partnership, generate test data and implement an I&M program. Camps were held at 12 locations and 66,000 2-wheelers checked.

All the vehicles were tested for tail pipe emissions and some were also subjected to fuel efficiency, opacity and mass-emission tests. Most vehicles were 1 to 15 years old. Approximately 7% of tested vehicles did not meet the requisite standards but did meet them after maintenance. Under idle, I&M lowered HC emissions by some 40% and CO emissions by about 3% and raised fuel efficiency by 10-20%. On fuel savings alone, if such testing and maintenance were carried out on the entire Delhi fleet, fuel consumption would be reduced by 24 million liters per year and CO2 emissions would be reduced by 56,000 tons/year.

An analysis was also conducted by the Automotive Research Association of India on a total of 34 vehicles including 2-wheelers, 3-wheelers and passenger cars of various ages, whereby simple, inexpensive maintenance such as cleaning, tuning, and adjusting the carburetor and ignition systems achieved a 60% reduction in HC and CO emissions, and a 20% improvement in fuel consumption.

5.4 Proposed Demonstration Project

It is proposed to establish ten computerized PUC emission test centers within and near the demonstration area to overcome deficiencies of the present system and enable:

- Networking of the computerized system to enable tracking of vehicles and identify defaulters (presently only 30% of vehicles undergo a periodic emission check);
- Facilitate regular communication with vehicle owners;
- Facilitate compilation, sorting and retrieval of collected data for analysis and policy formulation.

Improved emissions checking through upgrading existing PUC centers is low-cost, easily implementable and replicable, and would form part of an I&M program to ensure that tail-pipe emissions remain within the specified limits during vehicle operations. Figure 5-1 on the following page shows the basic components of an upgraded PUC center.

5.5 Operational Requirements of Upgraded Computerized Test Centers

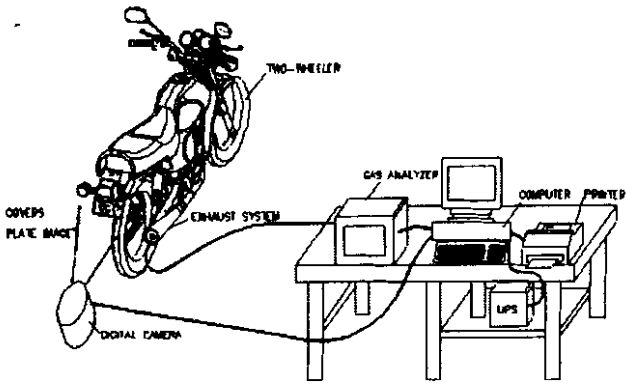
Equipment:

a. **Gas analyzer:**[4]
   - Upgrade existing equipment to convert from analog to digital signal
   - Set up new four-gas analyzer for petrol vehicles (with a lambda sensor to check new passenger cars with closed loop 3-way catalyst)
   - Opacity meter with temp probe and RPM meter (for diesel vehicles)

b. **Computer** with suitable software and **printer**

c. **Camera** (a digital web camera to photograph registration of the vehicle)

[4] The checking procedure may need modification to enable computerization of the checking process and to minimize erroneous results.



Computerized PUC Emissions Test Center Schematic

Computerized Test Certificate

View of Emission Test Center in Delhi

Checking Process:

A flow chart explaining the emission check process for an upgraded PUC center is given in Annex 5A-1.

Infrastructure:

a. **A cubicle** of suitable size for placing computer system and analyzer with sufficient space for the operator,
b. **Enough space** for maneuvering the vehicle outside the cubicle,
c. **A mounting for the web camera** outside the cubicle - to photo vehicle rear registration number plates.

Personnel would be trained to operate the computerized system, by the equipment manufacturer. The equipment would be calibrated and maintained regularly.

A team of Transport Department officials should assess the results of the audit and necessary steps should be taken to continuously improve the system in order to minimize non-conformity of emission checking.

5.6 Emission Reduction Potential in Hyderabad

Data from an extensive study done by the SIAM on vehicles in Hyderabad and other cities showed that through simple I&M procedures, local pollutants and GHG emissions could be reduced by significant amounts. There were approximately 1.1 million vehicles registered in Hyderabad in 2001. The composition of the vehicle fleet in 1999 (as per Ministry of Road Transport in Hyderabad for all except buses and per the AP Transport Department for buses) was 757,676 2-wheelers, 43,945 3-wheelers, 83,782 cars, 18,067 taxis and 5,996 buses.

Table 5-1 below shows reductions in tons per day resulting from an effective, city-wide PUC system where all vehicles in the city are tested per existing emissions checking regulations. The figures are based on several assumptions: 1) fuel efficiency improvement by doing minor maintenance is about 20% as defined in the VTA, so CO2 reduction is 20%; 2) approximately 20% of all vehicles tested fail and require maintenance; 3) the emissions load factor for each category of vehicle as defined in tons/day the VTA is multiplied by .2 x .2 = .4 to arrive at the emissions reductions shown. For example, the VTA notes the total CO2 emissions reduction for 2-wheelers could be up to 39 tons/day (total emissions from 2-wheelers = 969 tons/day or 969 x .4 = 39)

Table 5-1: Citywide PUC Emissions Reduction Potential in Hyderabad (tons/day)

	2-Wheeler	3-Wheeler	Car	Taxi	Buses
CO	.512	.109	.46	.128	.044
HC	.360	.074	.007	.024	.007
NOx	.007	.003	.006	.011	.073
CO2	3.87	.091	.082	1.29	.970

Source: SIAM

[5] The checking procedure may need modification to enable computerization of the checking process and to minimize erroneous results.

Table 5-2 below illustrates the relative emissions reductions that could accrue to implementation of the 10-station upgraded PUC system being proposed as part of the demonstration project. The assumptions are that 10% of the vehicles in Hyderabad are tested and 20% fail and require maintenance. Emission factors from the VTA were utilized for the reduction calculations.

Table 5-2: Emission Reduction Potential from 10-Station PUC System (tons/year)

	2-Wheeler	3-Wheeler	Car	Taxi	Buses	**Totals**
CO	153.6	32.4	13.8	38.4	13.2	**251.4**
HC	108.0	21.6	2.1	7.2	2.4	**141.3**
NOx	2.26	.855	1.87	3.312	22.1	**30.4**
CO2	1162.8	332.5	770	387.60	291.6	**2362.8**

Source: SIAM

Computerization of Diesel Emission Checking System

Following the development of the emission checking system for petrol engines, equipment manufacturers are working with SIAM to design and implement computerized emissions checking for diesel vehicles. It has been suggested that the equipment manufacturers would formulate the specifications and test procedure for computerized diesel emission checking and give their recommendation to test agencies and the government. The SIAM is presently conducting trials on the computerized Diesel emission checking system and with selected equipment manufacturers.

5.7 Preliminary Costs/Revenues and Financing

Costs and Revenues

Preliminary costs for upgrading an existing PUC center system for gasoline vehicle, excluding networking and other ancillary costs are as follows (**also see Annex 5A-2**):

Cost per System (Rs.)

New system with 4-gas analyzer 335,500
New system with 2-gas analyzer 210,500
Emission test system computerization 85,500

To set up a total of 10 PUC centers in the demonstration area (5 new centers with 4-gas analyzers and 5 existing centers upgraded with computerized equipment) is estimated to cost approximately Rs. 2,105,000 (approximately US$ 45,000).

Assuming the investment carried out by the emission test center owner is through a bank loan, an estimate done by SIAM shows that the owner of the center will be able to break even if the numbers of vehicles shown in Table 5-3 below are checked per day under each of the three PUC upgrade options noted above:

The above break-even estimates have been calculated taking into consideration all the operating costs of PUC centers as detailed in Annex 5A-2. SIAM is currently conducting a more in depth

cost and revenue generation analysis. The figures noted and those in the relevant Annex could change.

Table 5-3: Break Even Evaluation for PUC Upgrading Options

Break Even Period	New system with 4 gas analyzer	New system with 2 gas analyzer	Present system with computerization
3 Years	32 vehicles/day	24 vehicles/day	16 vehicles/day
5 Years	24 vehicles/day	19 vehicles/day	15 vehicles/day

Source: SIAM

Financing/Funding

LBG has been facilitating discussions on funding for this intervention. GEP-CCS's GOI partner, ICICI, has expressed a concrete interest in financing the 10 new/upgraded PUC centers. Commercial finance may be available to facilitate private sector implementation and operation of a system or individual centers. Grant funds may be available to a non-commercial entity for the same purpose.

Several discussions have been held with ICICI and SIAM on a financing framework. ICICI is interested in identifying a credit worthy, reputable implementing entity. As SIAM is such an organization and has taken a lead role in developing a PUC strategy for India, SIAM may be the logical partner and has recently expressed interest in playing the project promoter role. SIAM is now communicating with ICICI on the modalities of putting together a formal proposal for the project. Should alternative partners need to be identified, ICICI, LBG and SIAM will collaborate to identify such partners and structure a finance and implementation package.

SIAM has stated its willingness to provide technical support for system implementation and operation to whomsoever becomes the implementation entity.

5.8 Implementation

Implementation of this intervention will require the participation of several key stakeholders including the A.P. Road Transport Commissioner's office, SIAM, financial institutions, owners of emission test centers and equipment manufacturers to computerize the existing systems or set up new systems. SIAM has agreed to provide technical assistance to support the implementation.

A meeting among these stakeholders has already taken place. It was agreed that the RTC office would play the key role, that SIAM would likely manage funding or a grant that might be available to implement the demonstration project and that the owners of emissions test centers, represented by the Emission Testers Association (ETA) would be engaged as probable partners.

Several general steps in the implementation process are envisioned:

- Formation of Management Team (in process);
- Meeting with owners of emission test centers, equipment manufacturers, and financial institutions (one meeting to date);

- Identifying test centers for computerization and the set up of new centers (preliminary identification by the ETA completed);
- Determine cost and financial implications of the whole exercise (preliminary estimates being formulated by SIAM);
- Secure financing or funding;
- Set up centralized data control computer systems;
- Transport Department issues appropriate notification to reach an understanding with emission test center owners for computerization within a specified period; and
- Devise an audit system of emission test centers and audit by an independent agency reporting to the Transport Department.

Implementation timing will be dependent on all of the above factors. However, preliminary estimates for beginning the upgrade process are from six to eight months.

CHAPTER 6: VEHICLE TECHNOLOGY AND MANAGEMENT INTERVENTIONS: ELECTRIC VEHICLES

From start of the Project, LBG has considered the demonstration of electric powered vehicles (EVs). After assessing a number of different options, it is proposed to demonstrate 3-wheeler EVs in Hyderabad.

6.1 Status and Description of Electric Vehicle Technology

The Government of India has shown keen interest in promoting EVs in the country, for example, see the report: "*Auto Fuel Policy*" by the Expert Committee headed by Dr. Mashelkar, Director of Council of Scientific and Industrial Research. A key comment is as follows:

> *"The Committee recommends providing financial and fiscal incentives both to manufacturers and users, of EVs, in order to make these vehicles competitive."*

As a new generation product, EVs need support in order to facilitate their adoption and commercial viability. Several state governments, including Andhra Pradesh, have provided financial benefits in terms of exemptions/reduction of duties and taxes for this purpose. The EV manufacturers have suggested incentive measures such as subsidies to EV owners (as the capital cost of an EV is higher than a conventional vehicle), reduction or elimination of sales and registration taxes, reservation of certain routes for or promoting registration of EVs, and preferential tariff rates for electricity charging stations. These measures would reduce capital costs and/or operating costs and improve the attractiveness of EV technology for private users.

Electric vehicles utilize energy in storage batteries as the prime mover, along with an electric motor, controller and reduction gear-box as necessary. They are fitted with an on-board charger or can be charged at a battery charging station. Charging takes some 8-12 hours. When fully charged, an EV can travel about 80-125 km. For recharging, batteries are connected to an external electric supply through a battery charger that converts AC to DC power. Charging can be undertaken at a charging station or via an inbuilt or separately owned battery charger. To reduce vehicle down time, depleted batteries can also be replaced by a stack of charged batteries. Battery leasing schemes are evolving based on this concept. EVs in all other respects are similar to conventional vehicles in operation.

Features of EVs include the following:

- Range of approximately 80-125km per charge satisfies the 5 to 45km average daily travel distances of most Indians;
- Zero tail pipe emissions since not burning any type of fuel;
- Reduced noise (approximately 50% of conventional internal combustion engines);
- Very low maintenance cost (because there are far fewer moving parts);
- Ease of operation (no clutch or gear shift);
- Full torque even at near zero speed;
- Regenerative charging system prolongs the battery life, by harnessing the energy released during deceleration/breaking

Improvements in battery life, power to weight ratio, reducing battery charging time, and range of operation would enhance the acceptability and use of EVs. Attractive product pricing; the availability of charging stations at convenient locations; training of dealers, maintenance and charging personnel; and offering superior service and customer assistance are important for the same reason.

LBG has held numerous discussions with Bajaj, Mahindra & Mahindra, TVS, Scooters India Ltd, BHEL and REVA, all manufacturers of EV products. All have expressed an interest in the demonstration project and the potential of partnering to utilize their vehicles in Hyderabad. Today M&M and Bajaj have partnerships with US Technology providers who have provided operational and control technologies. With indigenous R&D capacity, Indian manufacturers are in a position to commercialize the various EV models developed (e.g., 3-wheelers, cars and mini buses). EV products are being operated in Delhi, Lucknow, Mumbai, Bangalore and some other cities.

It should be noted that the TVS company also has produced a prototype hybrid 3-wheeler. While the technology looks attractive, this technology was not included as an intervention because of remaining uncertainty about when it will mature to the point of having concrete demonstration potential on a significant level. Annex 3A-1 and 6A-3 contain background information about hybrids and about the TVS prototype, respectively.

6.2 The Electric Vehicle Component of the Demonstration Project

The intervention is the introduction, with the assistance of the SIAM, of a number of electric 3-wheelers to Hyderabad. The purpose is to demonstrate their functionality, environment benefit, and compatibility with existing vehicles as a means to promote increased private ownership. Other EV products may be considered as part of the intervention in the near future. Key features of this intervention include the following:

- About 100-500 3-wheelers would be supplied by existing manufacturers (Bajaj, Mahindra & Mahindra and Scooters India Ltd at present) provided adequate financing arrangements can be developed;
- Private owners would purchase and operate the EVs on a commercial basis;
- MCH would make EV charging sites within and/or adjacent to the demonstration area available on a concession basis;
- One or more fixed routes will be identified to provide linkages between existing and proposed bus stops, institutions or commercial areas in or adjacent to the demonstration area, and one or more MRT stations in the project area; [6]
- The EVs would be marketed by manufactures in combination with SIAM through a marketing program developed by the manufacturers;
- The manufacturers would provide local technical support to vehicle owners.

[6] The purpose is to facilitate a modal shift to the MRT by making access to it more efficient. In addition, positive incentives for public use of electric 3-wheelers will be built into the MRT station design by giving such vehicles priority access to prime embarkation and disembarkation areas.

6.3 Preliminary Costs/Revenues and Financing

Costs and Revenues

The potential revenue for an operator of an EV 3-wheeler is estimated below, based on capital, operating and maintenance costs. Capital costs of EVs are estimated to vary between 1.5 and 3 times the cost of a comparable fossil fuel driven vehicle according to SIAM and inputs from its members. Operating costs obtained from various EV manufacturers are shown in Table 6.1 below. While data on revenue generation potential is not widely available, Mahindra & Mahindra estimated that revenue from its 3-wheeler vehicle with a capacity of seven people would be approximately Rs.7000/month when the owner is also the driver, Rs.4000/month when a driver is hired. Annex 6A-1 contains detailed a detailed profit and loss account produced by Mahindra & Mahindra for its EV 3-wheeler product. Also included is a profit and loss account for the operation of a battery charging station estimates.

Table 6-1: Relative Operating Costs of Electric Vehicles Per Seat (Rupees)

Manufacturer	Type of Vehicle	Cost/Km
Scooters India Ltd.	3-W	1.50
Bajaj	3-W	.75
Mahindra & Mahindra	3-W (8-10 passenger)	.50
BHEL	Bus	.50
Reva	Car	.50

Preliminary Finance Options

Several sources of finance are being explored. First, a number of EV manufacturers have their own finance programs. In collaboration with LBG, SIAM has been facilitating conversations with these manufacturers on possible finance packages. Second, discussions have been held with two domestic Indian financial institutions that have expressed an interest in looking at finance programs for an EV market. Third, LBG has discussed the EV demonstration with the World Bank (WB), Asian Development Bank (ADB), and the Global Environment Facility (GEF). While the project does not look like a "fit" for the WB or ADB, LBG will be facilitating further discussions with the GEF. GEF operates a sustainable transport funding program that supports measures, including alternate technologies or fuels, where such interventions can have a significant impact on GHG emissions reductions and where the costs of technologies will drop significantly with economies of scale.

As noted in the Introduction, the fourth of the five elements of the GEP-CCS transportation component is the development of finance documentation for the demonstration project. Hence, LBG's next major thrust will be to team with the finance stakeholders noted above, especially SIAM and relevant EV manufacturers, to develop integrated finance options for bringing EVs to Hyderabad.

6.4 Emissions Reduction Potential

While it is recognized that EVs do result in air emissions, their potential for contributing to improved *local ambient air quality* within Hyderabad is substantial. Assessment of the emissions generated by an EV is complex and largely beyond the scope of this study. Nevertheless, a brief review of the issue is warranted. The volume of emissions generated to produce electrical energy for EVs is dependent on many variables. Of prime importance is the type of fuel used in a thermal power plant (i.e., coal, oil, natural gas, nuclear), as the fuel type is a major factor in the character and volume of emissions generated. The ratio of fossil fuel supplied electricity to renewable energy supply that is sent to the electricity grid (i.e. electricity from hydro plants) is also important. Issues of energy efficiency, transmission and distribution losses, battery charging efficiency, etc., further complicate such an assessment.

Two related studies give some insight into potential emissions reductions from EVs relative to conventional vehicles. According to the EPRI (Electronic Power Research Institute), electric cars are considered to be 97% cleaner than gasoline powered cars, even taking into account the emissions from the power plants that generate the electricity to recharge the batteries (as per a paper by M&M). Similarly the Bajaj Company has estimated a reduction of over 56% in CO2 when a 2-stroke 2-wheeler is replaced by an electric 2-wheeler. Other estimates quoted by Bajaj have shown that if a 2-stroke petrol driven 3-wheeler is replaced by an EV 3-wheeler, a reduction of 23% in CO2 emissions is possible. The difference in estimates between EPRI and Bajaj owe to the differing types of vehicles addressed and to what remains as an inexact methodology for estimating reductions.

Table 6-2 indicates the relative *local* ambient air quality benefits that could accrue by replacing petrol driven two-seat EV 3-wheelers with EV 3-wheelers.

Table 6-2 *Local* Emissions Reduction Potential of 3-Wheeler EVs*

Emission Reduction Per Year through Replacement of One Petrol 3-Wheeler				
CO	HC	CO2	SO2	NOX
292.5 kg	19.6 kg	2,438 kg	.58 kg	7.58 kg
Emissions Reduction per Year through Replacement of 500 Petrol 3-Wheelers				
CO	HC	CO2	SO2	NOX
292.6 tons	58.4 tons	1,220.0 tons	.28 tons	3.8 tons

Source: VTA and LBG

Emissions factors in grams/person/day are taken from the VTA and are based on 1999 data. Each vehicle is assumed to carry two passengers, consistent with existing 3-wheeler occupancy rates in Hyderabad. All vehicles are assumed to travel 80 km/day, consistent with existing daily averages in Hyderabad and operate 365 days per year. Table 6-2 *does not* reflect emissions from electricity generation at its source, which is assumed to be outside the Hyderabad/Secunderabad urban area.

6.5 Implementation

Development of a detailed specific implementation plan will require inputs from and coordination between the participating EV manufacturers, SIAM, the MCH, and other stakeholders. A number of basic issues that must be addressed in an implementation program are summarized below:

1. Formation of a task force composed of SIAM, EV manufacturers and potential financial institutions, as well as LBG to formulate precise financial needs assessment and a detailed project report based on infrastructure, EV products to be incorporated into the project, potential battery leasing schemes and analysis of potential subsidies or concessions available at the local, state or GOI level;

2. EV Marketing and Sales Plan

To be developed and implemented by the participating EV manufacturers

3. Establishment of battery charging facilities

The MCH has indicated that it will facilitate locating one or more battery charging stations in or adjacent to the demonstration project area. Based on the total number of EVs to be introduced in Hyderabad and the likely areas in which they would be operated, one or more additional stations may be necessary. LBG is currently in discussions with MCH about possible locations, but input from the EV manufacturers will be needed in this regard. Annex 6A-2 contains a schematic of a "typical" support structure for a battery charging station as supplied by M&M.

4. Development of product maintenance facilities and training of personnel

Local support for the EV products would be provided by dealers assigned by the particular EV product manufacturer. In the case of M&M, it is tentatively envisioned that a standard local support facility would consist of a Supervisor / Owner, Testing Technician, Electrician and Mechanic.

Training of local support facility staff will be necessary. Annex 6A-2 also contains a basic schematic of the basic components for a training program as envisioned by M&M for its product service program.

LBG will be working collaboratively with SIAM and other potential participating EV manufacturers over the next two months to develop a comprehensive implementation plan that includes benchmark dates.

CHAPTER 7: VEHICLE TECHNOLOGY AND MANAGEMENT INTERVENTIONS: RETROFITTING AMBASSADORS WITH CLEANER FUEL BURNING ENGINES

As has been discussed earlier in this document, the terms of reference for the demonstration project reflected USAID's interest in converting vehicle fleets to cleaner burning fuels as one of the possible interventions. As has also been noted, alternative fuels have not been considered as an intervention for a number of reasons. However, LBG has maintained the fleet conversion concept under conditions that meet the overall demonstration project criteria.

7.1 Intervention Definition

This intervention proposes the conversion of a portion of the fleet of vehicles owned and operated by the MCH to cleaner fuel burning engines. More precisely, a number of the MCH's fleet of Ambassador cars fitted with pre 2000 emission compliant engines would have their engines replaced (retrofitted) with cleaner fuel burning Euro I or better yet, Euro II compliant engines. An investigation would also be made into working with the state government on a retrofit program. Presently Euro I fuel is available in Hyderabad. Euro II is likely to be available in early 2003. Emission reductions would accrue as the difference between the current baseline emissions generated by older, less efficient "dirtier" fuel burning engines and those generated by the newer, more efficient and cleaner fuel burning engines.

This intervention is consistent with the fundamental project criteria. Most importantly, it is likely to be implementable by the MCH. Review and approval of the plan may be necessary from the Regional Transport Authority (RTA). Preliminary discussions with the RTA indicate that the intervention should be permissible as long as it meets criteria contained in the Vehicle Code. From an economic standpoint, the MCH is under direction not to purchase new vehicles for its fleet. As the fleet ages, it becomes more and more costly to maintain old vehicles. Retrofitting is an option for improving the functional and emission performance of vehicles that is viable at a cost substantially below that of the new vehicles. And given the very large number of Ambassadors in he MCH fleet and the fleets of municipal, state and Government of India agencies /ministries, the potential for larger scale replicability could be significant.

The present plan of retrofit had the preliminary concurrence of the prior MCH Commissioner.

7.2 Operational Requirements and Process

To implement this intervention, LBG is facilitating a public-private partnership between Hindustan Motors (HM) and the MCH. HM has initiated an Ambassador car retrofit program to service the needs of individuals and institutional owners of Ambassadors for which there is benefit in retrofitting with improved engines. LBG has held meetings with HM to identify retrofit options, costs and technical issues and has also vetted and had received a positive response from the MCH for looking at this option in more detail.

The main steps in the retrofit process are as follows: o

1. HM and MCH would collaboratively review MCH's existing Ambassador fleet. LBG has already forwarded a profile of the fleet to HM. The purpose is to identify candidate vehicles

2. For retrofitting, body condition and compliance with basic structural fitness requirements are the primary criteria for selecting retrofit candidates; the model year of production of vehicle shall also need to be considered along with. HM would provide this service free of charge.

3. The MCH has maintenance facilities for its existing fleet. There is a possibility that the cost of retrofitting could be reduced if the MCH facilities and labor can be used for the work. HM would work with the MCH to evaluate these facilities for adequacy and gaps in terms of technology or human capacity to carry out the program. HM would provide a service team for its evaluation and use its own "dealer assessment" criteria as a basis for the evaluation. Training and equipment needs and well as capacity-building needs would be identified. The downside of an MCH program lies in the fact that the liability for the performance of retrofitted vehicles would lie with MCH – warrantees applied by registered HM dealers would not be valid.

4. HM and the MCH would identify a target number of vehicles and develop a scope of work and budget for the retrofit program. If MCH is not able to finance a demonstration, LBG would work with the MCH and HM in the subsequent financing phase of the demonstration project to identify finance opportunities and partners.

5. MCH would need to facilitate any required approvals from the Regional Transport Authority. As was noted, the RTA has acknowledged that a retrofit program can be undertaken on a minimum ten-vehicle fleet per existing Vehicle Code standards. The technical configuration for the retrofitting program has already been approved by Automotive Research Association of India (ARAI).

6. If the MCH facilities and capability is sufficient, HM would provide technical assistance to MCH mechanics and supervise the retrofit process to ensure it is technically sound. If not, HM would organize its local dealers to perform the work.

7.3 Emissions Reduction Potential

The emission norms from year 1991 to Bharat Stage II (BS II) Petrol/Diesel driven cars are given in Annex 7A-1. Using these norms, Table 7-1 below includes estimates of emission benefits by retrofitting 100 petrol or diesel vehicles of 1996 vintage with BSII compliant engines. It is assumed that each vehicle covers 10,000 kilometers per year and emissions are at the mean value of specification.

Table 7-1: Emission Benefits in Tons/Year and Percent Reduction by Retrofitting 100 cars of 1996 Model with BSII Compliant Engines

Fuel Type	Emission Types							
	CO		HC+NOx		PM		CO2	
	Tons/Yr.	%	Tons/Yr.	%	Tons/Yr.	%	Tons/Yr.	%
Petrol	5.44	83	3.43	93	NA[2]	NA[2]	NA[1]	NA[1]
Diesel	6.00	85	2.3	76	NA[2]	NA[2]	NA[1]	NA[1]

[1]CO2 emissions are not specified so the benefits could not be estimated. However reduction in emissions means better fuel combustion, hence better fuel economy with a concomitant thereby proportionate benefit in CO2 emissions.
[2]There was no PM regulation in 1996 However PM reductions can be expected to be substantial

The above figures are a good indicator of emission benefits. However, the actual benefits will depend on the types of engines that would be replaced with new Euro I or II engines. It should be noted that CO2 emissions norms have not been defined in India or in many other parts of the world. Extrapolation of CO2 emissions reductions from other emission figures is a complex modeling task. LBG will be working to provide a broad estimate as the project moves forward.

7.4 Costs and Finance

The primary costs for this program are related to purchase of new engines and associated components/parts. To retrofit with Euro II engines, the engine and parts costs come to approximately Rs. 77,000 per vehicle. For Euro I engines and associated parts, the cost is approximately Rs. 105,000 per vehicle. Ancillary parts and labor needs could raise either or both of these figures by approximately Rs. 3000 to Rs. 5000 on a vehicle-by-vehicle basis. A fee of approximately Rs. 10,000 per vehicle is normally assessed by dealers that would perform the retrofit if the MCH were not able to do so. HM has supplied a cost schedule for various retrofit options that can be used as the basis for evaluating finance needs and formulating a proposal for this intervention.

Based on preliminary evaluation, HM believes that the retrofit of an Ambassador, using assumptions about types of engines and ancillary costs, will have a payback period of approximately 48 months. HM is currently working more on detail cost and payback projections, but these can only be fully refined once a survey of the Ambassador fleet is completed and a specific retrofit program is designed.

While the MCH has expressed preliminary interest in financing a pilot retrofit program, funding is not certain. LBG will be working with HM and the MCH to identify finance needs once cost estimates are finalized. LBG would help facilitate preparation of financial documentation needed to approach appropriate financial institutions in order to fill gaps in finance needs.

7.5 Implementation

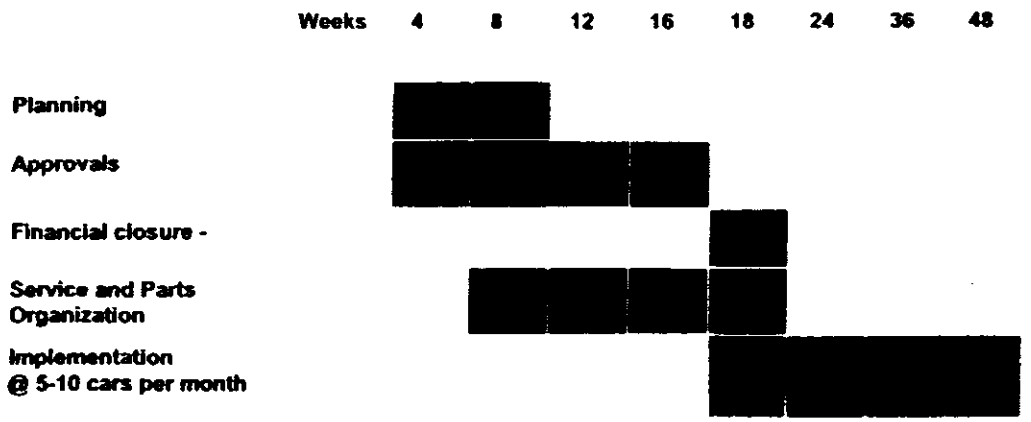
As explained above, HM and MCH would work together to implement the retrofit program as per following steps.

- Set up working group composed of HM, the MCH, and RTA
- Develop a Memorandum Of Understanding for the terms of cooperation
- Assess fleet conditions
- Assess conditions at MCH workshops and capabilities of MCH mechanics; and estimate inputs required for them to take up Retrofit job in terms of Training, Tooling & equipment needs.
- Decide retrofit options to be implemented. There are a variety of choices of engine types to be utilized. The determination of which is appropriate is contingent on a variety of factors including the vintage of vehicle to be retrofitted, fuel type used (Euro I or II), and several other factors, including cost;
- Decide the extent of refurbishing/inclusion of ancillary items like seat belts or other components would be included;
- Conduct detailed project cost estimates;
- Obtain project approvals;
- Obtain clearance by all regulatory agencies;

- Facilitate financial closure;
- Set up project implementation review team;
- Hold a project kickoff function;
- Conduct the retrofit process;
- Have retrofitted vehicles certified and approved.

Figure 7-1 below is a tentative implementation schedule for this intervention. The schedule is dependent on a number of factors including length of time required for approvals and to obtain financial closure.

Figure 7-1: Preliminary Retrofit Implementation Schedule



ANNEX 2A-1

Agenda: First Project Workshop – *Reducing Air Emissions from Vehicles*

Annex 2A-1

Agenda: First Project Workshop - *Reducing Air Emissions from Vehicles*

A DEMONSTRATION PROJECT BEING IMPLEMENTED IN HYDERABAD BY THE GREEN HOUSE GAS POLLUTION PREVENTION PROJECT (GEP-CCS) UNDER USAID/INDIA IN COOPERATION WITH THE HYDERABAD MUNICIPAL CORPORATION

KICK-OFF WORKSHOP PROGRAM

August 13th 2001, 9:45 am - Hotel Viceroy, Hyderabad

SESSION I:	**INTRODUCTION TO THE VEHICLE EMISSIONS DEMONSTRATION PROJECT AND CURRENT TRANSPORTATION/EMISSIONS ISSUES IN HYDERABAD**
0945 - 1000 am:	**Registration**
1000 - 1010 am:	**Welcome Address** Mr. A. K. Goyal, Principal Secretary, A.P. Municipal Administration and Development Dept., Hyderabad
1010 - 1020 am:	**USAID Initiatives in Hyderabad** Mr. Sandeep Tandon and Mr. N. Bhattacharjee, USAID Office of Environment, Energy, and Enterprise
1020 - 1030 am:	**Reducing Vehicle Emissions in Hyderabad – Linkages with the Green House Gas Pollution Prevention Project (GEP-CCS)** Mr. Ron Sissem, Chief-of-Party, GEP-CCS
1030 - 1040 am:	**City of Hyderabad Initiatives in Transportation and Urban Planning for Environmental and Economic Benefits** Dr. P K Mohanty, Municipal Commissioner & Special Officer, Hyderabad
1040 - 1050 am:	**Briefing on the Current Traffic Situation in Hyderabad** **Mr. Dinakar Prasad, Dy. Commissioner of Police, Hyderabad**

1050 - 1100 am:	**Briefing on Transportation Management in Hyderabad** Mr. C.L.N Gandhi, Jt. Transport Commissioner, AP
1100 - 1115 am:	**TEA BREAK**
SESSION II:	**DEMONSTRATION PROJECT BACKGROUND AND CONCEPTUAL DESIGN ELEMENTS – THE GEP-CCS DEMO PROJECT TEAM**
1115 - 1120 am:	**Introduction to LBG Demo Project Design Team and Activities**
1120 - 1140 am:	**City Selection Process and Vehicle Technology Assessment** Mr. N.V. Iyer, Executive Director, SIAM
1140 - 1200 pm:	**Demo Project Design: Vehicle Technology Interventions and Emissions Reductions** Mr. William Kirksey, International Institute for Energy Conservation
1200 - 1220 pm:	**Demo Project Design: Traffic Management Interventions and Emissions Reduction** Mr. David Jarrett, Senior Transportation Engineer, The Louis Berger Group, Inc.
SESSION III:	**PARTICIPANT DISCUSSION / INPUTS TO THE DEMONSTRATION PROJECT DESIGN**
1220 - 1320 pm:	Facilitator – Mr. Ron Sissem
1320 - 1330 pm:	Next Steps in the Demo Design Process
1330 - 1430 pm:	**LUNCH**
	END

ANNEX 2A-2

Agenda: Second Project Workshop - *The MCH/GEP-CCS Demonstration Project for Reducing Air Emissions from Vehicles*

Annex 2A-2

Agenda : Second Project Workshop – The Workshop on the MCH/GEP-CCS Demonstration Project for Reducing Air Emissions from Vehicles

April 17th 2002, 9:30 am – 1:30 pm – Kakatiya Hotel, Hyderabad

AGENDA

SESSION I:	**INTRODUCTION TO THE DEMONSTRATION PROJECT AND CURRENT TRANSPORTATION/EMISSIONS ISSUES IN HYDERABAD**
0930 - 1000 am:	**Registration**
1000 - 1005 am:	**Welcome Address** Mr. A.K. Goyal, Principal Secretary, AP Municipal Administration and Development Department
1010 - 1020 am:	**Workshop Goals and Overview of Project Design Purpose, Process, Partnerships and Outcomes** Mr. Ron Sissem, Chief-of-Party, GEP-CCS
1020 - 1030 am:	**City of Hyderabad Initiatives in Transportation and Urban Planning** Mrs. Chitra.Ramchandran , Municipal Commissioner & Special Officer, Hyderabad/Mr. Ranadhir Reddy, Additional Commissioner
1030 – 1040 am:	**USAID Initiatives in Hyderabad** Mr. SandeepTandon , Project Management Specialist, USAID Office of Environment, Energy, and Enterprise.
1040 - 1050 am:	**Vehicle Emissions in Hyderabad and the Demonstration Project Area** – *Emission Levels and Health Impacts* Mr. Tishya Chatterjee, Member Secretary, AP Pollution Control Board
1050 - 1100 am:	**Regulatory and Management Interventions for Emissions Reduction** – *Regional Transport Authority Initiatives* Mr. C.L.N Gandhi, Jt. Transport Commissioner, AP

1100 – 1115 am:	**Comments on Enforcement Issues** Mr. Krishna Rao, Hyderabad Police Commissioner
1115 – 1130 am:	**TEA BREAK**
SESSION II: 1130 am – 1:30 pm	**DEMONSTRATION PROJECT DESIGN COMPONENTS, BENEFITS AND IMPLEMENTATION ACTIONS**
	Definition of the Demo Project, methodology/boundaries, assumptions, and components **Mr. Ron Sissem, Chief-of-Party, GEP-CCS**
Part A	**Traffic Management**
1130 am – 1210 pm	**Summary of Traffic Management Interventions Proposed the Demo Project** Mr. Ranadhir Reddy, Additional Commissioner, MCH/Dr. S. Raghava Chari – Traffic Consultant to MCH
PART B	**Vehicle Management and Technology Interventions**
12:20 pm – 1:00 pm	**Emissions Checking System Intervention** SIAM Representative Mr. Murlikrishnan
	Overview of Electric Vehicles and SIAM EV Demonstration Intervention Mr. Atanu Ganguly, SIAM
	Vehicle Retrofit Interventions Mr. Shankar Rao, General Manager, Quality Assurance and Product Service, Hindustan Motors Representative
SESSION III: 1:15 – 1:30	**DISCUSSION / NEXT STEPS**
1330 - 1430 pm:	**LUNCH**
	End/EV Demonstration

ANNEX 3A-1

Other Near Term Potential Interventions

Annex 3A-1

Other Near Term Potential Options

As noted in Chapter 3, advanced technologies and alternate fuels that did not meet the general intervention criteria were not included in the demonstration project design. However, for informational purposes, one technology and two alternate fuels that are emerging and may be available to local decision makers as options for reducing vehicular emissions are worth noting. Each is briefly described below along with its relative emissions reduction potential.

Hybrid Vehicles

Hybrid vehicle technology is emerging in India. Hybrid vehicles have already been commercialized in several developed countries. A hybrid vehicle is driven by a combination of an internal combustion engine and electricity stored in batteries. This system can overcome the inherent limitation of a storage battery in terms of limited operating range. At the same time, the engine can operate at a more optimum level, thereby increasing fuel efficiency and lowering emissions. While emissions data on various Hybrid vehicles varies, emission reduction in the range of 20-50% is generally reported. The internal combustion engine can be powered by one of several types of fuels, including conventional/clean fuels.

Technology Overview

Hybrid technology enables either the battery or internal combustion engine to take up the drive load depending upon vehicle speed or load. Two general operating systems are being applied in India , as below:

System 1:
The battery is used to start the engine, but at low speed a switch is made to the internal combustion engine. Electric power assists when peak power is required. The internal combustion engine operates in an optimally efficient mode and is used to charge the batteries also. At low speed (in city traffic), a hybrid can operate on battery power. At higher speed, for cruising, the internal combustion engine as constant speed internal combustion engines, yielding higher efficiency.

System 2:
The internal combustion engine operates at optimal, constant speed and is used to drive a generator, which powers a motor to propel the vehicle. Depending upon power requirements, power is taken either from the engine or from the batteries. Batteries are charged by the engine and can also be charged from mains during overnight parking.

Benefits

Hybrid electric vehicles have many beneficial characteristics: lower emissions, easy to drive as there is no clutch or gear shift, regenerative braking can be used to charge batteries, full torque is

available even at zero speed and fuel efficiency is high as the engine operates at optimum level. In addition, hybrid electric vehicles exhibit lower noise and vibration characteristics compared to traditional technology vehicles.

Status in India

Hybrid vehicles have been under development in India only since the year 2000. However, competitively priced hybrid vehicles produced by Honda and Toyota have been introduced internationally. A hybrid bus made by the Transteq Company in the US is being commercialized and is in use. As part of a visit of officials from the MCH and Andhra Pradesh State government to the US, LBG organized a visit to the Transteq Company. Discussions were held with the company officials to determine if the vehicle could be demonstrated in India. However, its high capital cost precluded such a demonstration.

Ashok Leyland is conducting trials on a prototype hybrid electric bus using a diesel engine. The vehicle is fitted with a downsized 50 KW diesel engine (against 80 KW output Engine for conventional Bus) and 60 storage batteries. To date, a series of tests have been completed, but many more are required. This product may not be commercially available for several more years. Therefore, it was not considered for the demonstration project.

TVS is testing a prototype 3-wheeler hybrid with the assistance of two technology partners from the US, including the Owens Corning and Solectria Corporation. TVS has noted that this product may be commercially available within the next one to two years.

Emission Reduction Potential

The following table summarizes emission reduction potential provided in related literature for various types of hybrid vehicle technologies and companies

Emission Reduction Potential of Hybrid Technologies

Vehicle	Emission Reduction as per Tests/ Estimates
Hino Motors (Japan) HEV 310 HP 55 Seater	NOx – 34%, CO – 10 to 15%, Smoke Density – 50%[1]
Nissan HEV	Overall emissions reduction of 30%[2]
HEV Transit Bus Tested in New York	Overall emissions reduction of 30-35%[3]
Ashok Leyland HEV Prototype Bus	Projected at 20-30% overall
TVS 3-Wheeler Prototype	HC+NOx – 82%, CO – 42%, CO2 – 28%

[1] Hino Motors, Japan
[2] 13th Electric Vehicles Symposium-Oct. 1996
[3] Vehicle Development through New York State consortium

Future Scenario

While hybrid vehicles look promising, their future in India will depend upon how the products develop and perform, their price, Government policies and infrastructure availability. While discussions with TVS have already been held on the potential to link this technology with the demonstration project, as of today, some uncertainty remains over the timeframe in which the technology is likely to be demonstrable in a tangible way.

CNG/LPG As Alternative Fuels

CNG is available in the Krishna Godavari basin of Andhra Pradesh. The Gas Authority of India Ltd. (GAIL), along with HPCL and the A.P. Government, is setting up a joint venture company for distribution of natural gas (for use in residential, commercial and in automotive sector-CNG), auto-LPG and piped gas in Hyderabad and other cities in Andhra Pradesh. To date, CNG is not available in Hyderabad. In the Spring of 2001, the A.P. State Government had announced that CNG would be available in Hyderabad by the end of 2001. However, as of Spring 2002, the requisite infrastructure to bring CNG to Hyderabad had not been constructed. As of today, it is uncertain when CNG may be available. The experience in Delhi with conversion to CNG has been cause for hesitation by other municipalities to initiate similar programs.

LPG is also being pursued by the central government for use in automobiles and the oil companies have already started setting up LPG dispensing units in individual locations throughout India. GAIL is setting up a 600 km LPG pipeline from Visakhapatnam to Hyderabad. Recently, a private sector company has also revealed plans to put up two LPG dispensing stations in Hyderabad. LPG looks to be a more concrete alternate fuel possibility in the short-term. However, some uncertainty remains over its availability in sufficient volume to support its widespread use in the transport sector.

While there are several plans in place for establishing infrastructure for dispensing of CNG/LPG the actual availability of these fuels will be dependent on a number of as of yet uncertain fuel policy, economic and technical issues.

Emission Reduction Potential

To provide some understanding of the relative emissions reduction potential of CNG and LPG, emissions for various vehicles is summarized in the following table:

Emission Reduction Potential Using CNG/LNG as Alternate Fuel

Vehicle Type	Present Fuel	Alternate fuel	Emission Reduction (%)				
			CO	*HC*	*NOX*	*PM*	*CO2*
3W	Petrol	CNG	70	63	20		42
Cars	Petrol	CNG	93[1]	24[1]	18[2]		16[2]
Bus	Diesel	CNG	16	17	42	98	19[3]
Taxi	Diesel	CNG	(76)	(196)	53	83	15
2W	Petrol	LPG	48	(15)	(15)		7
3W	Petrol	LPG	40	50	-	-	15
Cars	Petrol	LPG	17	14	(33)	-	30
Taxi	Diesel	LPG	(695)	(15)	51	80	15

Source: [1]As per Indra Prastha Gas Ltd, [2]As per World Bank, [3]As per Brooklyn Union Gas.
(Figures in brackets indicate and increase in emissions)

Annex 4A-1

Summary of Traffic Surveys for the Demonstration Project

The surveys for delays to vehicles were carried out at 5 intersections and a total of 16 approaches. The vehicle fleet was divided into 7 categories and almost 10,000 observations were recorded at the 16 approaches. The data was summarized and a further analysis was undertaken by the project team. The data will be used in three ways namely:

a) Intersection Approach Delays. The data is grouped by individual intersections and approaches. Some intersections (notably Somajiguda) have very little delays (between 5 and 13 seconds); others (notably Panjagutta) have significant delays (mostly in excess of 80 seconds). The largest delay experienced by traffic in the area occurs at the northbound approach to Panjagutta intersection where the average delay is 85 seconds.

b) Through Routing Delays. In this assessment, the analyst can identify the cumulative delays which vehicles occur as they pass through the group of intersections forming the demonstration study area. As examples of this, two routes have been selected as follows. A vehicle traveling from Khairatabad to High School intersection on the national highway would experience delays at the approaches to the intersections at KCP (36"), Panjagutta (85") and Ameerpet (45") amounting to 2¾ minutes in total. The second example takes a vehicle traveling between the Airport and High School Intersection and would experience an intersection approach delay of over 1½ minutes.

c) Vehicle Type Delays. Average delays by vehicle type indicate that HGVs stand out as being considerably more subject to delay than other vehicles. On average, HGVs wait for 70 seconds at each of the approaches compared with say, 43 seconds for a car. The overall average delay to all vehicles at all approaches is about 52 seconds.

LINK COUNT SURVEYS

The objectives of the link counts were to establish the details of the mix of traffic in the are according to each of the links in the selected network. There were counts taken at six locations and the direction of travel at each was counted separately

It is interesting to note that in almost all cases, the flows in the morning peak period are not as large as those in the off peak period. The exception is the road between Ameerpet and Greenlands. Aside from this link, it is not unusual to find the off peak flows between 50% and 100% higher than the 'peak' period.

Typical 12 hour flows on the national highway are 74,900 vehicles per day (vpd) south of Panjagutta, rising to 86,415 vpd between Panjagutta and Ameerpet and dropping back again to 73,500 north of Ameerpet. On the national highway there is a predominance of southbound traffic being about 55% of the total traffic in the corridor.

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On the loop roads, traffic is similar and slightly higher than on the national highway. Between Ameerpet and Greenlands, flows are relatively low with 34,000 vpd. South of Greenlands intersection however, the flows amount to 94,700 vpd over 12 hours. On the southern leg of the loop between Somajiguda and Panjagutta flows are measured at 61,500 vpd. Typical hourly volumes on these five main links are shown in Table 1 below.

Table 1. Flows and Capacities on Main Network Links

Link	Peak Hour Flows (Pcus/hr)	Number of Lanes	Theoretical Capacity (Pcus/hr)	Volume/Capacity Ratio
Kcp-P	4,800	4	4,800	1.00
P-A	4,400	6	7,200	0.60
A-G	1,300	2	2,000	0.65
G-S	5,300	6	7,200	0.74
S-P	3,000	4	4,800	0.63

The values for V/C ratio appear to show that there are no major difficulties in this network. However, the main challenge in any urban area is to resolve congestion caused by intersections. Link volumes seldom cause the congestion and this is indeed the case in this area.

INTERSECTION TURNING COUNT SURVEYS

These surveys concentrate upon obtaining data pertaining to how vehicles move through the five main intersections in the Demonstration Project area. The information was collected for the same seven vehicle types as for the link counts and for two 2-hour periods (07.00 to 09.00 and 10.00 to 12.00). The surveys contractor summarised the data for each time period and also provided values for turns in pcus/hr.

The data will be used to provide concepts for revised intersection design both for the existing conditions and for future conditions after the new traffic circulation systems have been put in place. In the example provided the analyst may see the main flows moving through the Ameerpet intersection during the 2 hours period between 07.00 and 09.00. Some interesting points to note are:

- The approach volumes from the west are numerically very small but make quite a large difference to the efficiency of the intersection. It may be best to eliminate these movements or at least remove the through and right turns from this approach.
- By far the most prominent movements are the through movements from north to south (1,400 pcus/hr) and vice versa (1,200 pcus/hr). The significance of this is that with a 2½ minute cycle time (=24 green phases) there is a need to get almost 60 vehicles through the junction in both directions on the green time available.
- The second most important movement is the turn between the north and the east (High School to Greenlands). In the morning this amounts to 500 pcus/hr and rises to 600 pcus/hr in the off peak time. The reverse turn (a right turn) from Greenlands to High School is also significant and of similar volume.
- Other movements are relatively minor and could be accommodated with revised layouts.

ANNEX 4A-2

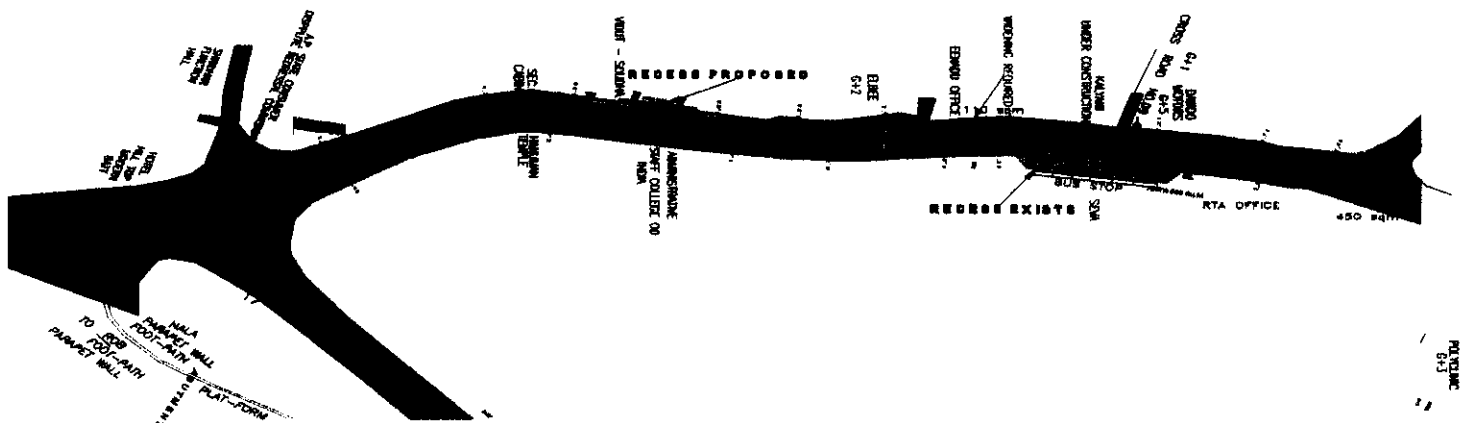
Traffic Management Improvements for the NH 9 Corridor

Annex 4A-2

Traffic Management Improvements for the NH 9 Corridor

The eight figures on the following pages each represent a segment of the NH 9 corridor from Khairathabad to ESI. Each illustrates the types of improvements that are planned within the respective road segment.

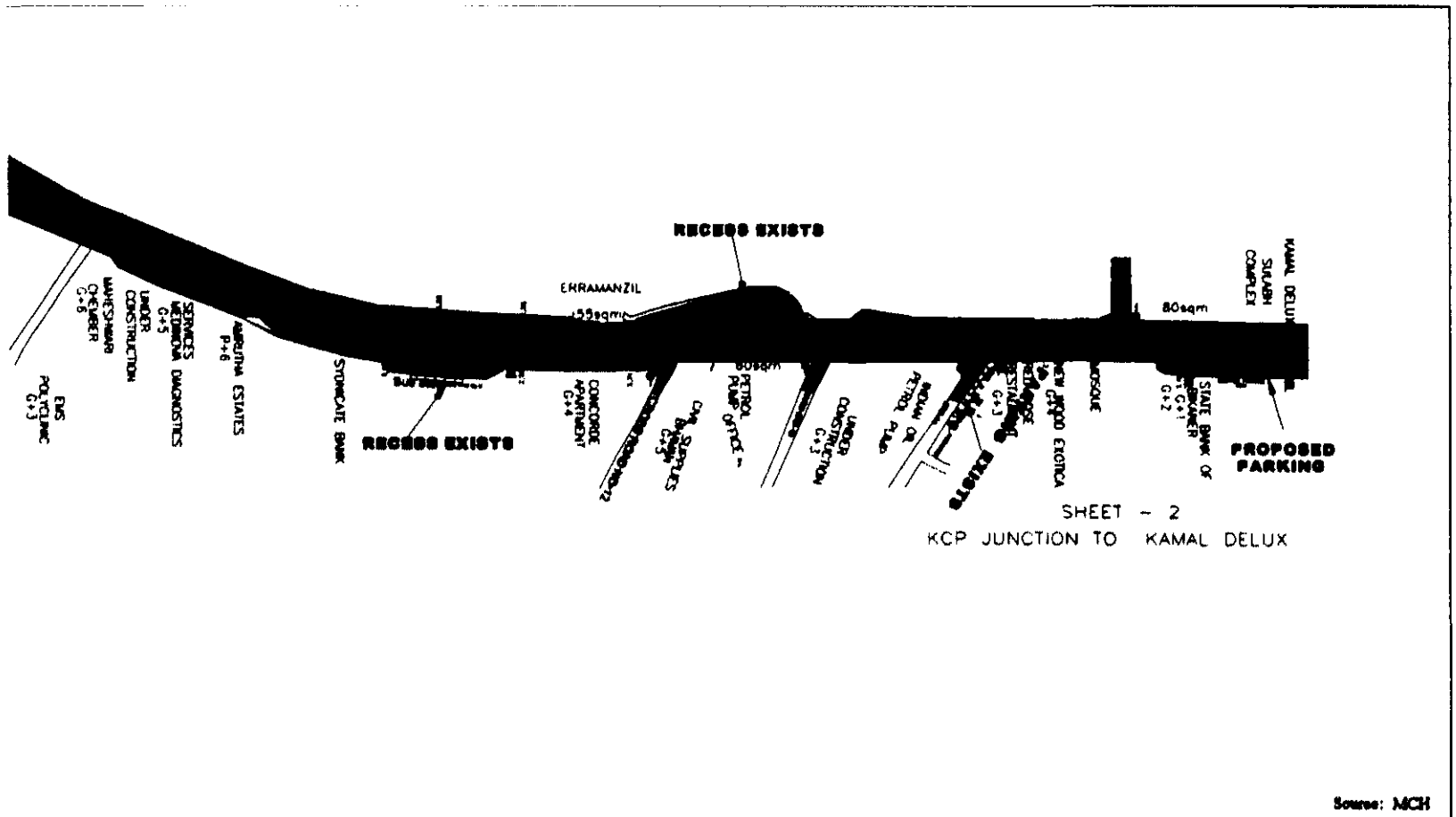
Red marking on the edge of a corridor indicates that road widening is needed. Dark red cross hatched areas at the edge of the roadway indicates that pavement is required. Other improvements are noted as "proposed". Some of the fine detail is lost in these graphics. The MCH can be consulted for further details.



SHEET - 1
FROM V.V STATUE TO KCP JUNCTION

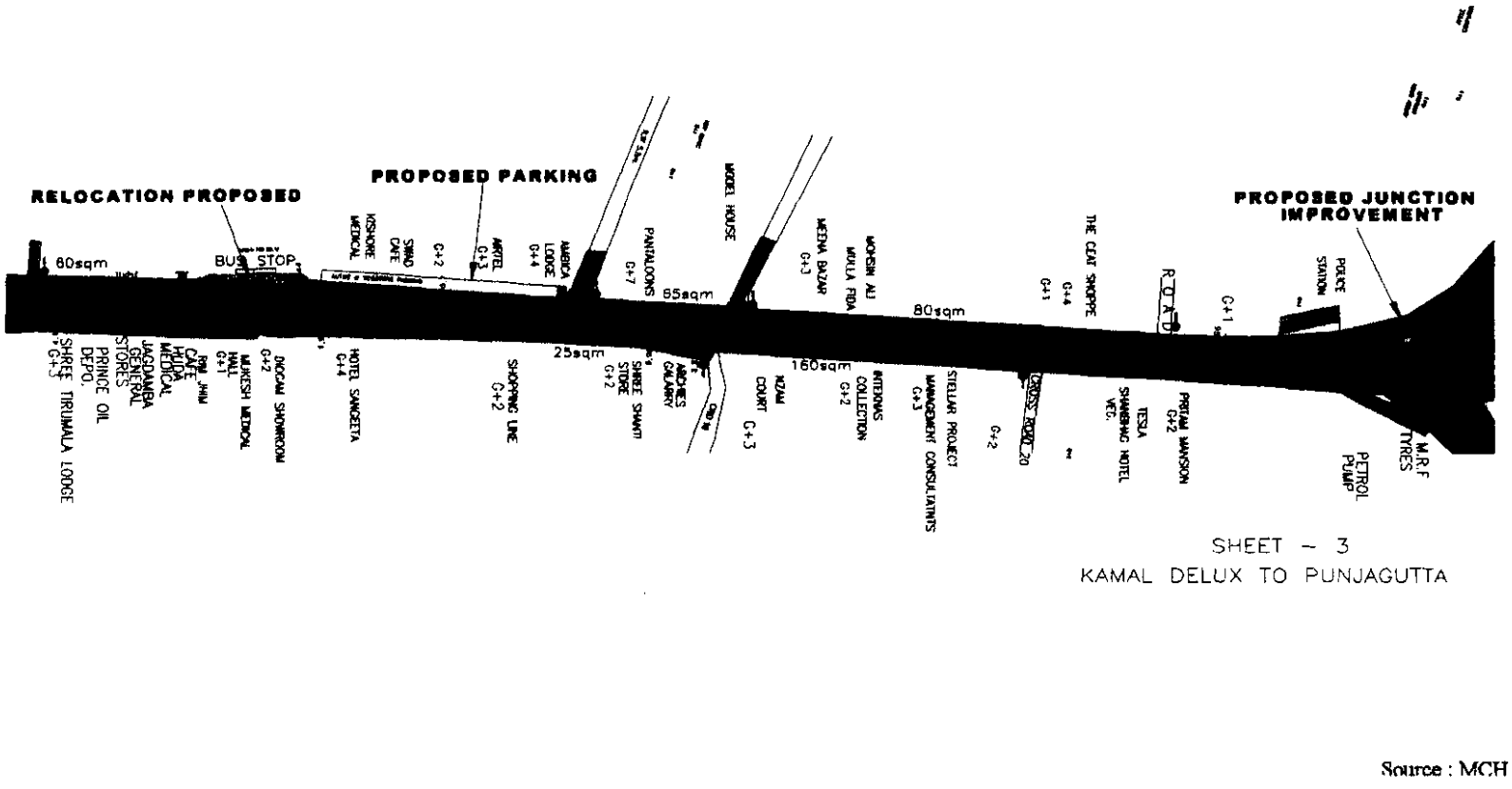
Source : MCH

NH 9 Segment 1 : V.V. STATUE TO KCP JUNCTION



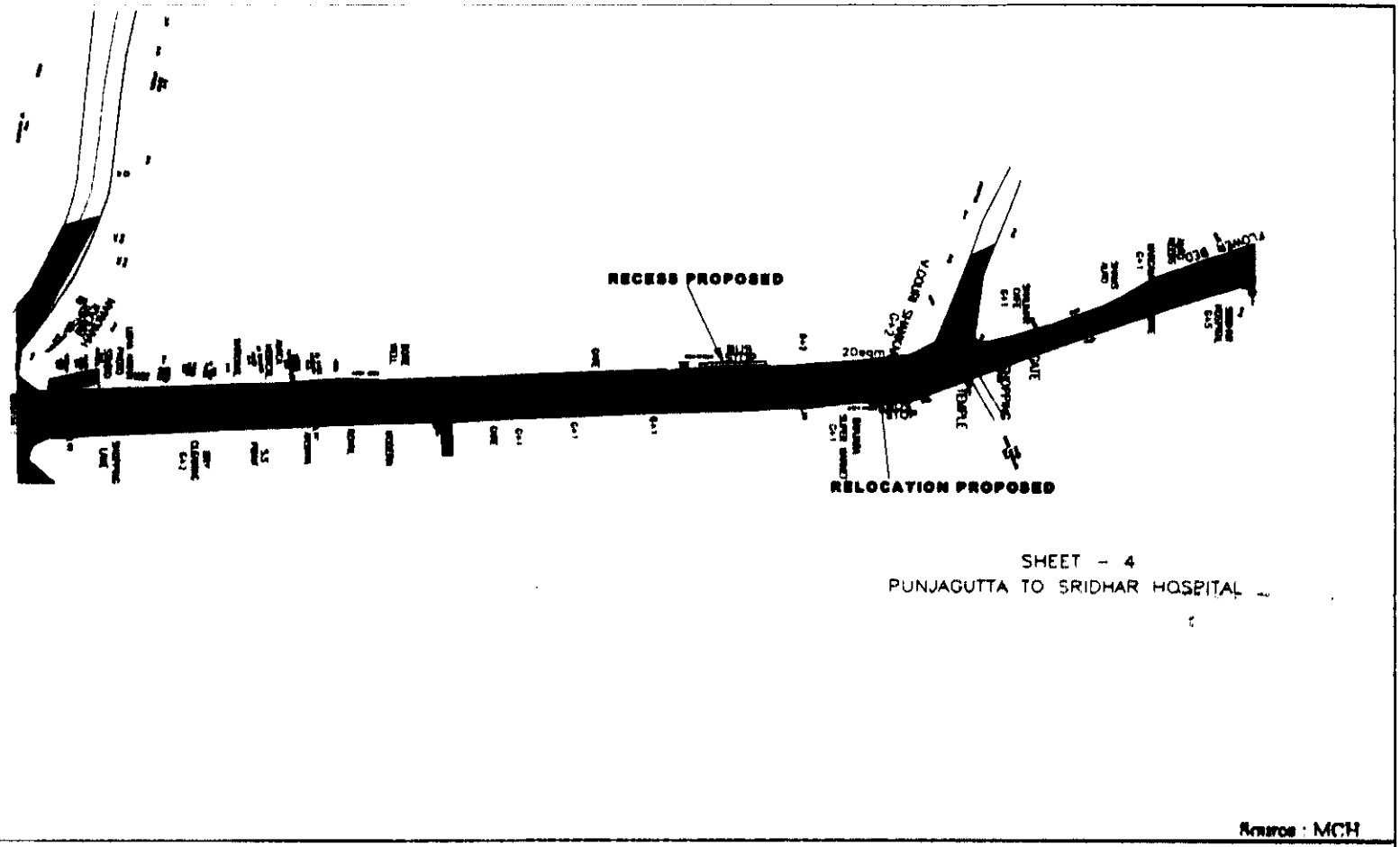
Source: MCH

NH 9 Segment 2 : KCP JUNCTION TO KAMAL DELUX



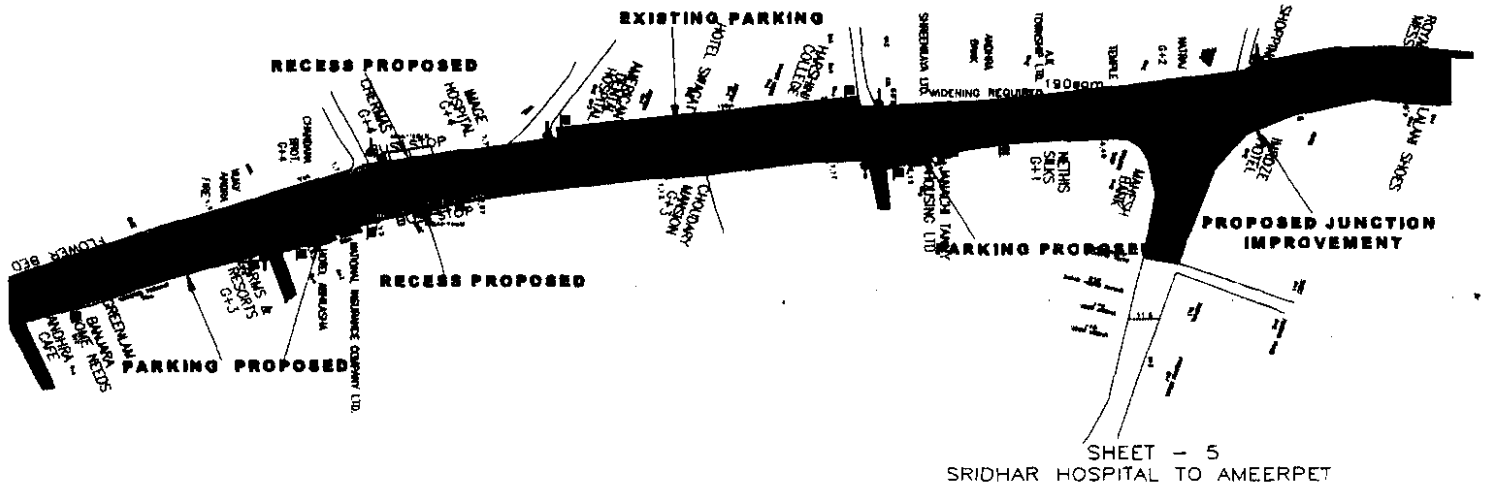
Source : MCH

NH 9 Segment 3: KAMAL DELUX TO PUNJAGUTTA



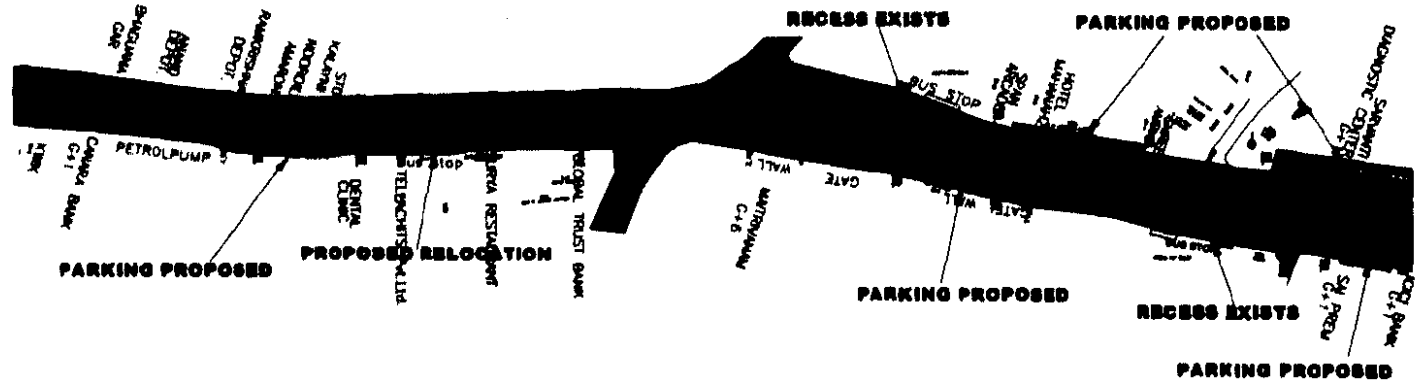
Source : MCH

NH 9 Segment 4: PUNJAGUTTA TO SRIDHAR HOSPITAL



Source : MCH

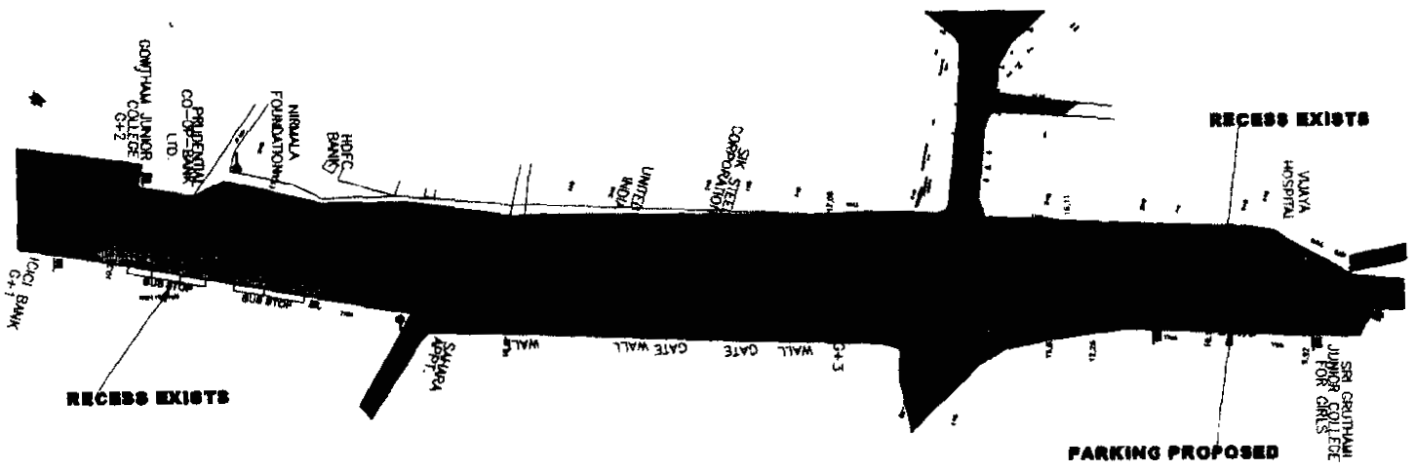
NH 9 Segment 5 : SRIDHAR HOSPITAL TO AMEERPET



SHEET - 6
AMEERPET TO ICICI BANK

Source : MCH

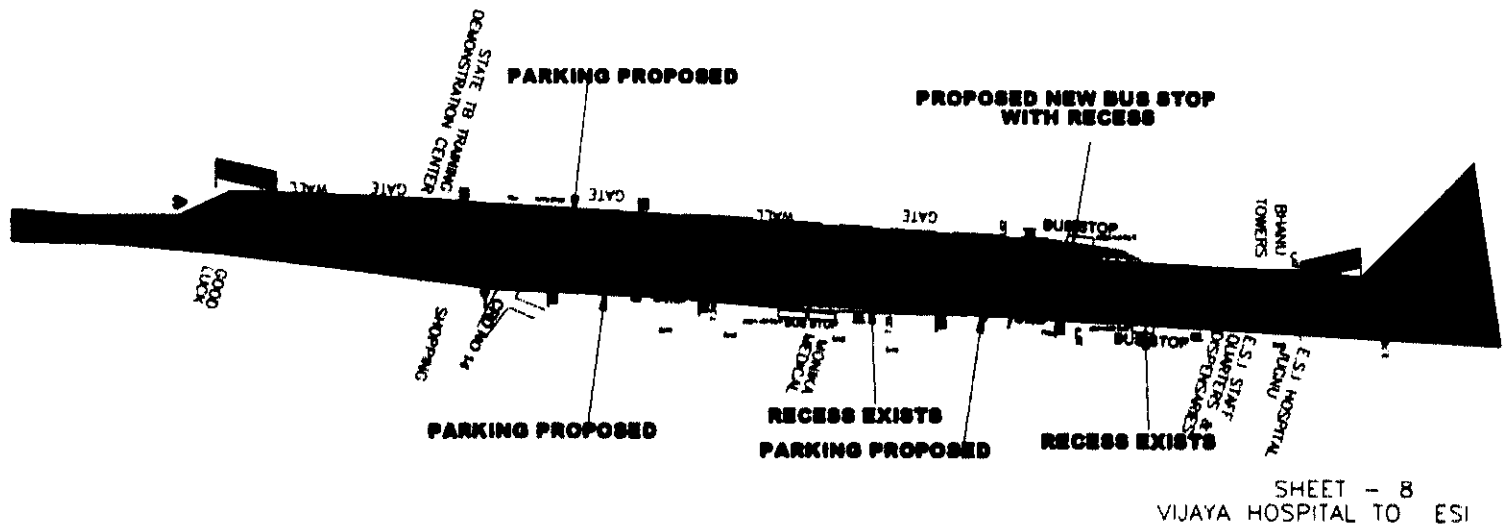
NH 9 Segment 6 : AMEERPET TO ICICI BANK



SHEET – 7
ICICI BANK TO VIJAYA HOSPITAL

Source : MCH

NH 9 Segment 7 : ICICI BANK TO VIJAYA HOSPITAL



Source : MCH

NH 9 Segment 8 : VIJAYA HOSPITAL TO ESI

ANNEX 4A-3

Model Policy for Control and Administration of Parking

Annex 4A-3

Model Policy for Control and Administration of Parking

OBJECTIVES

This consultative document is produced by the Municipality of the City of Hyderabad in order to begin the process of providing a parking[7] control By-law. It will be the subject of a consultation process in which public opinion will be canvassed and the policy refined as a result of this consultation.

Whereas, mobility is a pre-requisite of development and in urban areas this mobility often means travel by car or taxi (or rickshaw in the case of Hyderabad) with ensuing congestion. It is too easy to say "ban the car/rickshaw" in order to resolve the congestion issue. But this prohibition will also constrain development if there is no alternative provided.

Whereas, the uncontrolled use of vehicles in cities is a major cause of congestion and danger. The problem also extends to stationary vehicles, which may also contribute to congestion coupled with a large use of available space especially in the urban centres. This use of space for parking is not only inefficient it is also poor economics in terms of land management. The normal manner of regulating and controlling the use of such land and activities is via a parking policy. These policies are common practise in most urban areas. Conventionally, the following are the main purposes for enacting such policies:

a) The Reduction of Congestion. Parking of vehicles on main roads will reduce the road width available for moving vehicles resulting in loss of capacity and delays. This is an economic disbenefit due to time losses, wear and tear on vehicles and additional fuel burning[8].

b) The Improvement of Safety. Badly parked vehicles are a major cause of dangerous manoeuvres from vehicles and injuries to pedestrians result due to the interruption of their sight lines.

c) The Improvement of Access for Emergency Vehicles. One of the duties of any municipality is to provide for emergency vehicle services (Fire, Police, Ambulances for example). If these vehicles are not able to perform their duties because their accesses are obstructed by badly parked vehicles, destruction of property or the escalation of the severity of accidents due to delayed medical help could be the result.

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[7] *In this document, the word 'Parking' is used to mean the act of leaving a vehicle unattended either on-street or off-street. It makes a distinction between 'parking' and 'waiting' in which latter case, the driver remains by his vehicle ready to move it if needs arise. There is also a distinction made with 'loading and unloading' in which delivery vehicles may be permitted to wait whilst performing the loading duties.*

[8] *For this reason as well, it is of interest to this GHG project since more efficient vehicle operations will reduce fuel consumption and hence exhaust emissions.*

d) The Improvement of Public Transport Operations. It is clear that public transport will be affected along with other road users if vehicles are not properly parked. In fact, due to their lesser ability to manoeuvre, public transport vehicles are usually affected for more than cars.

e) The Reduction of Expenditure on Footpath Repair. The parking of vehicles on footpaths causes damage to these surfaces since they are constructed primarily for light weights. The heavy loads from cars and especially from trucks will cause large amounts of damage necessitating large capital outlays to maintain.

f) The Production of a Cleaner Environment. Smoother traffic flows reduce fuel consumption and hence GHG emissions. In addition, there is an adverse visual impact of haphazard parking.

In consideration of these factors and in the interests of all members of the public, therefore the Municipality of the City of Hyderabad has enacted this policy to control the use and parking of motor vehicles within the city limits.

RESPONSIBILITIES

1. The responsibility for carrying out the policy and its management will be divided between the Local Authority and the Police. The general public will also be required to adopt its own responsibilities in ensuring that the rules laid down in the policy are obeyed. The primary division of responsibilities between the Local Authority and the Police are laid down below in clauses 2 and 3.

RESPONSIBILITIES OF THE LOCAL AUTHORITY

2. In this context the Local Authority is the Municipality of the City of Hyderabad (now referred to as "The City'). The City as a representative of the people is empowered to enact such rules and regulations as it see fit to protect the safety and the quality of life of its residents. As a result therefore the city will undertake the responsibility in this connection for the following aspects:

2.1 Establishment of Standards. The City has provided standards to govern the size of parking bays for cars, auto-rickshaws and Heavy Goods Vehicles (HGV) both on-street and off-street. All areas designated for such parking use will be laid out in accordance with these standards unless special circumstances prevail. The standards are also written to control the provision of private parking within the curtilage of new and old buildings and developments.

2.2 Placement of Parking Spaces. The City will designate areas on and off the street. These areas will designate where the parking of vehicles is permitted and where parking is prohibited. Spaces and prohibitions will be clearly and visibly marked in a consistent manner. The markings will be a combination of on-lane painted information, kerbside pain markings and pole-mounted signs.

2.3 Bus Stop Locations. The City will identify (with due consultation) the correct location for bus stops and will so designate the space accordingly. The parking of vehicles in these spaces will be prohibited.

2.4 Pedestrian Crossings. The City will identify the locations for pedestrian crossings and will designate areas adjacent to these crossings where parking is prohibited at all times.

2.5 Off-Street Car Parks. The City will control off-street parking and will enact a coordinated pricing policy for the proper control of these spaces. Spaces will be designated for overnight HGV parking which will be lit and supervised if necessary.

2.6 Specifically Designated Bays. The City will designate a series of parking bays, which will be identified for specific use. These specific uses include: Disabled Persons, Doctors, Diplomats, Residents and their uses and regulations will be described further in clauses 15 to 18 below.

2.7 Taxi and Auto Rickshaw Ranks. The City will identify the most appropriate locations for waiting areas for Taxis, Rickshaws and Auto Rickshaws. These will be placed in locations convenient to major uses such as Hospitals, Rail and Bus Stations, Government Buildings and Sports Facilities. The City may from time to time designate such areas to be designated for preferred vehicles such as those which have converted to operate with clean fuels.

RESPONSIBILITIES OF THE POLICE AUTHORITY

3. In this context the Police authority is the Municipal Police Department of the City of Hyderabad. The Police are charged with maintaining public order and as such the enforcement of laws and regulations pertaining to traffic is within their domain. As a result, the Police will be responsible for enforcing the regulations concerned with parking in the city. The following more specific tasks will be within the domain of the Police.

3.1 Patrolling Parking Areas. There must be a noticeable presence on the street of those responsible for law enforcement. In fact (see clause X below) many of the duties can be delegated to trained personnel (e.g. Traffic Wardens) acting on behalf of the Police without the need to use trained Police Officers.

3.2 Ensuring that Parking Spaces are correctly used. In the initial stages of the new parking control scheme, there will need to be a period of education and the Police will take a leading role in this activity. At first the Police will adopt a role of assistance and will instruct people where to park and where not to park. Once the scheme is well established their role will be one of regulation and more direct action to dissuade wrongful parking.

3.3 Removal of Obstructions. Where there is unacceptable parking, the Police will be responsible for removal of vehicles obstructing the highway or the footpath.

3.4 Issuing and Collecting Summonses. The Police are the only authority empowered to issue summons for transgressing the regulations. Where parking privileges are exceeded, the Police will issue a summons in accordance with the City By-laws and will enforce the procedures to collect the appropriate fines (see also clause 23 below).

PARKING SUPPLY AND DEMAND

4. The control of parking is a powerful tool for managing the demand for travel. This is especially important in the City central area and regional commercial centers such as Panjagutta/Ameerpet. The parking activity is the destination end of a trip and control of this may be in two main ways. If either or both of these aspects are changed so will the numbers of trips into the denser commercial centers.

   4.1 Price. The City will establish the fees to be paid for parking. These charges will vary according to location, time of stay and time of day. The charges will be adjusted to deter parking at certain times such as peak periods making the prices 'preventative' except for essential journeys.

   4.2 Space Numbers. The actual numbers of spaces will clearly control the number of vehicles that may physically park in an area. As the supply is altered so will the number of vehicles able to access to the area under parking policy control.

5. The City will establish a series of 'Controlled Parking Zones' in the various commercial centres in the City. Within these centres, the City will provide a specific set of regulations within its overall policy for parking provision and regulation. The rules for each individual centre will employ the basic approach established by this By-law.

TYPES OF PARKING

6. The parking provision will vary according to the needs of the residents and the commercial operations. The provision will be divided according to the rules established by the City and will include provision for the types of parking described below in Clauses 7 to 14.

SHORT TERM v LONG TERM PARKING

7. A major differentiation within the parking policy is made to distinguish between the length of time of parking and its associated location. The City has adopted a policy of specifying Short Term Parking as being up to 2 hours in duration, with Long Term Parking being any duration in excess of this time.

8. The City has further decided that short-term parking shall take place on the street and long term parking shall take place off the street.

On-street, short-term spaces will be designated in accordance with the standard dimensions of parking bays and will be located at the kerbside so as to be convenient to shopping and other major traffic attractors. Use of the spaces will be controlled by means of payment systems which themselves will be used to control the time of parking. The City has considered the use of a number of different systems for this pricing control and will identify and install the most appropriate for each separate circumstance. The methods so far considered have included the following techniques[9] and, in the present experimental project has adopted a permit system pending further use.

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[9] ***The options for such control systems will be specified to comply with the most efficient for each set of circumstances. In the analysis of which is the best system, the City has taken into account, the cost of provision of equipment (e.g. Parking Meters, Pay & Display Machines or Permits). It is also to be noted***

a) Parking Metres – these are available from many commercial sources using a simple clockwork and microchip mechanism. They require regular maintenance and the cash needs to be collected on a daily basis. They can be environmentally obtrusive and are not cheap to obtain and install. They are also more difficult to adjust in space terms if the locations change since each meter is specific to a single space.

b) Pay and Display Machines – like metres, these machines are available from many commercial sources using a microchip mechanism. They use little electricity and can be supplied by mains electricity or by solar panels. They require less maintenance than metres and the cash needs to be collected regularly but not on a daily basis. There is a need for fewer machines since one ticket dispenser can control many spaces. As a result, if spaces are altered there is no need to re-organise the ticket dispenser itself.

c) Area-wide Permits – these systems do not require any metres on the street or kerbside. The basis of this system is that individuals will purchase a permit to park in a specific area (e.g. Panjagutta/Ameerpet) and will them be permitted to park in the designated spaces for up to the allotted time. The advantage of this method is its low cost (no actual roadside machines are required) and its high degree of flexibility. At a time of experimentation and development of an idea, this system will be used initially and may be replaced as time passes.

9. Areas for off-street, long-term parking will be identified and designated by the City. These areas will include at-grade parking lots and multi-storey car park structures. Payment control at these spaces will be by automatic or semi-automatic means with the fees graduated on a sliding scale according to the time spent in the space.

OTHER FORMS OF SPACE PROVISION

10. In addition to designation of spaces for short term usage at the kerbside, the City will identify and allocate a number of spaces for other purposes.

11. Spaces will be allocated at the appropriate locations for the use by Diplomatic cars bearing an approved CD sticker.

12. Resident Permits will be allocated to those persons who apply to the City offices and who are able to substantiate that they are a resident of the area for which they are applying for a permit. Although all bona fide residents may obtain a permit, the City does not necessarily guarantee that a space will be provided for every permit issued.

13. Disabled Spaces will be allocated at certain convenient locations. These spaces will be properly designated and will have lane markings and pole mounted signs. Their use will be restricted to persons who have been allocated a permit and who display a 'disabled sticker' on their vehicle's windscreen.

PROHIBITION OF PARKING

14. The City will, from time to time, designate some areas where parking is prohibited. These prohibitions may be permanent or they may be on a time specific basis (e.g. during the business day). Typical zones where parking will be prohibited are listed below:

a) Bus Only Lanes – properly designated lanes for public transport vehicles will be provided by the City on some main arteries. These lanes will be clearly marked as such and parking will be prohibited either totally or for specific hours of the day.
b) School Entrance Zones – the entrances and exits from schools will be marked at the kerbside and parking will be prohibited during school hours.
c) Pedestrian Crossing Zones – either side of pedestrian crossings areas will be designated where parking will be prohibited at all times.
d) Suspended Bays – from time to time, the City will have the need to suspend a parking bay and will post a note to this effect. The reasons for this suspension could be for example, for unusual loading say for a furniture moving or for construction. Persons wishing to have a bay suspended will be required to apply to the City for such suspensions and may be required to pay a fee.

SIGNS AND MARKINGS

15. The City will be responsible for providing clear signing to identify the type of parking control. The designations will be by a combination of on-lane markings and pole mounted signs. A convention has been established by the City and comprises the following types of markings.

a) On-lane markings to designate times of parking. These will be by the use of yellow lines painted in or near the gutter. Single yellow lines designate stretches of road where parking is prohibited during the business day (for example 07.00 to 19.00) after which parking is permitted. Double yellow lines designate areas where parking will be prohibited for 24 hours.
b) On-kerb markings to designate loading and unloading times. These are typically by lines drawn on the top of the kerb and will designate during which hours it is possible to undertake deliveries or collections.
c) Post-mounted signs to designate the regulations applying to various restrictions. These signs will specify times when parking is permitted or prohibited, days when restrictions apply and the users who are legitimately permitted to use the bays.

ENFORCEMENT AND PENALTIES

16. The Parking Policy has been enacted by the Council of the City and has come into law according to By-law [redacted] This By-law empowers the Police to enforce the regulations contained within the clauses and the Police will exercise their powers to

enforce these rules. Primarily, this enforcement is a twofold process. Firstly the Police will ensure that the parking spaces are sued correctly by monitoring (see clause 21 below) the use of the spaces throughout the day. Secondly, the Police will issue summonses to persons who violate the regulations and who will be considered to be illegally parked.

17. The Police and the City will train and employ persons as Parking Wardens who will monitor the space usage on behalf of the Police. They will be instructed to issue parking violation notices and to record the reason for the violation and the time and location. These violation notices will then be acted upon by the Police who may issue a summons to the owner of the vehicle incurring the violation.

18. When a violation is recorded, and if the vehicle is parked such that a serious violation occurs the Parking Warden will consult the Police who may then decide to immobilize the vehicle, thereby forcing the driver to incur a more severe penalty or the Police may authorise the vehicle to be towed away.

19. The costs of penalties will be set such that early payment will incur less of a fine than if a payment were to be delayed.

TARIFF SETTING

20. The setting of tariffs for parking has been calculated in order to cover the costs of administration and operation of the system. The costs paid by motorists for parking are determined from estimates of turnover and usage and will be adjusted at the end of each year according to revenue received and expenditures incurred. It is not a policy of the City administration to penalise motorists to the point where the price for parking exceeds the costs of the control.

PUBLICITY AND FURTHER CONSULTATION

21. The City has produced a number of leaflets describing the policy and its details. These are available for public use and can be obtained at the offices of the City Administration at [redacted]. The general public are encouraged to consult these leaflets and to respond with their views.

COMPLAINTS

22. With this Parking Policy, the City is embarking on a new strategy to provide service and organization to the people of Hyderabad. The City invites all residents and visitors to express any complaints about this policy and its operation to the address provided below.

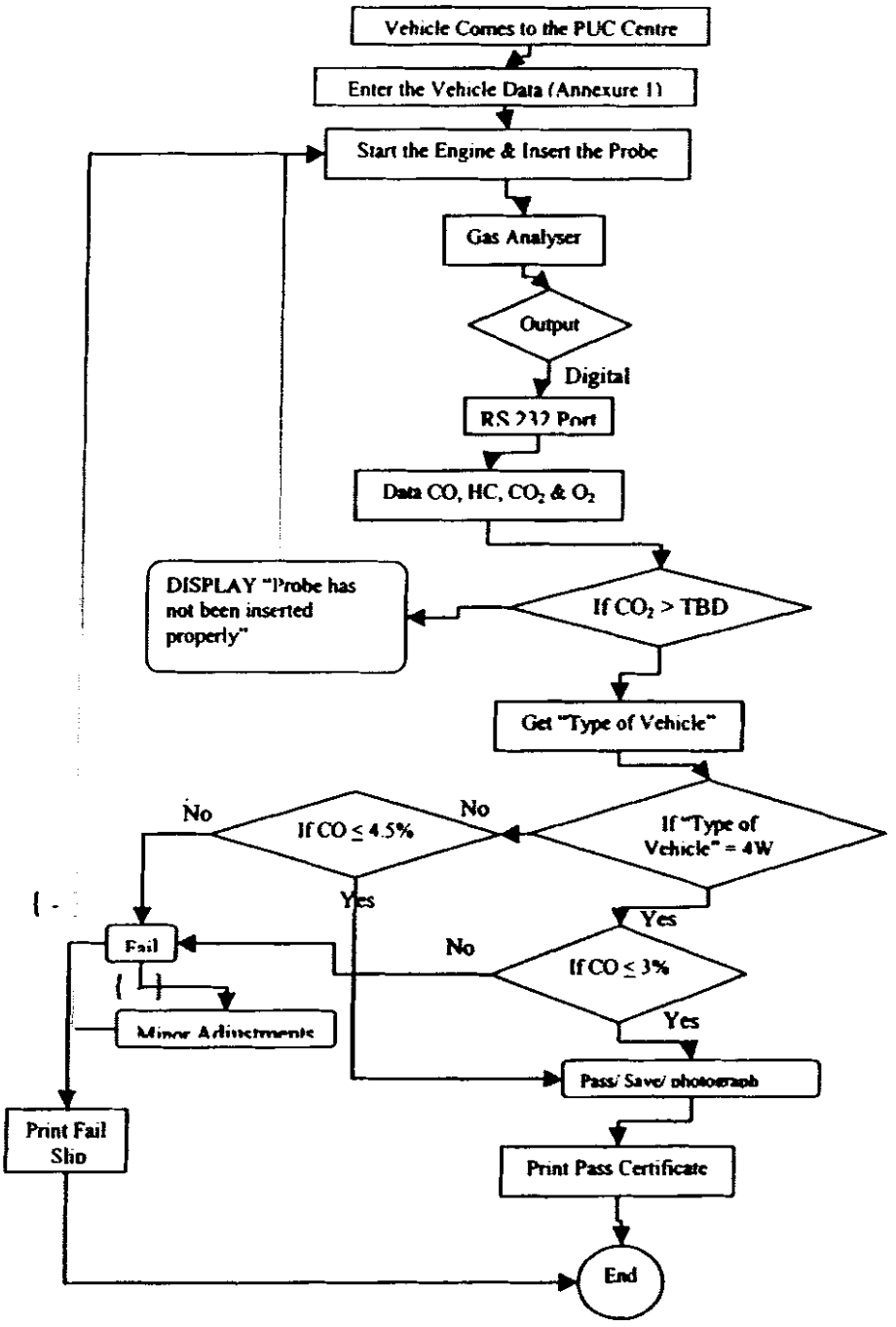
Signed this day _____

ANNEX 5A-1

Flow Chart for New Computerized Emission Test Center

Annex 5A-1

Flow Chart for New Computerized Emission Test Center



Annex 6A-1

Electric Vehicle Costs and Revenues/Profit and Loss

Economics of the Mahindra & Mahindra 3-Wheeler (7 Seats)

Owner's economics :	earnings Rs.4,000 (on 2 shifts/145 kms. Basis) per month
Owner driven :	earnings Rs.7,000 per month
Dealer's economics :	IRR 35 to 45%

Charging economics

- without batteries leasing	:	IRR 30%
- with batteries leasing	:	IRR 50 to 55%

Owner Economics

- Cost of vehicle (with 2 sets of battery):
- Warehouse net dealer price 2,46,144
- On road price 3,57,000
- (inclusive of all taxes, duties, octroi)
- On road vehicle price with charger 3,81,000
- Monthly revenue (on 10 vehicles): 2,60,000
  @ Rs.1,000 per day per vehicle

Monthly expenses: (In Rs.)

a. Electricity charges (15 units x 2 x 10 x Rs.7.2 x 26 days)	56,000
b. Drivers wages (Rs.3,000 x 10):	30,000
c. Maintenance (Rs.500 x 10):	5,000
d. Rent :	10,000
e. Manpower:	7,000
f. Emi for 4 years scheme (Rs.11000x10):	1,10,000
Total monthly expenses:	**Rs. 2,18,000**
Monthly net income:	**Rs. 42,000**

Compared to the cost of gasoline, charging the Bijlee is very reasonable. When recharging an electric vehicle overnight, as most EV users do, it costs about = Rs.150/- a charge that will run 80-90 kms. or 50 ps. per person, per kilometer.

Profit and Loss Account for a M&M Battery Charging Facility *(In Lacs)*

	Year 01	Year 02	Year 03	Year 04	Year 05
Charging Income	17.55	17.55	17.55	17.55	17.55
Battery rental income	-	-	-	-	-
Total	17.55	17.55	17.55	17.55	17.55
Expenses					
Rentals	1.50	1.50	1.50	1.50	1.50
Salaries	1.20	1.20	1.20	1.20	1.20
Administration Cost	0.30	0.30	0.30	0.30	0.30
Power Cost	10.53	10.53	10.53	10.53	10.53
Maintenance Cost	0.23	0.23	0.23	0.23	0.23
Consumables for charging	0.47	0.47	0.47	0.47	0.47
Total	14.23	14.23	14.23	14.23	14.23
Profit Before Deducting Income Taxes	3.32	3.32	3.32	3.32	3.32
Depreciation on battery and charger	0.59	0.59	0.59	0.59	0.59
Profit Before Income Tax	2.73	2.73	2.73	2.73	2.73
Profit Before Tax	2.73	2.73	2.73	2.73	2.73
Tax	0.73	0.87	0.97	1.05	1.10
39%					
Profit After Tax	2.00	1.86	1.76	1.68	1.63
Tax Workings					
Tax Block	5.69				
Opening Balance	5.69	4.26	3.20	2.40	1.80
Tax depreciation	1.42	1.07	0.80	0.60	0.45
Closing balance	4.26	3.20	2.40	1.80	1.35
Outflows					
Capital Expenditure	-	-	-	-	-
Battery Cost	-	-	-	-	-
Electric Installation cost & other fixed assets	0.38	-	-	-	-
Battery storage racks	0.25	-	-	-	-
Trolleys for loading / unloading	0.06	-	-	-	-
Chargers cost - initial 25 chargers	5.00	-	-	-	-
Office rental deposit	3.00	-	-	-	-
Total	8.69	-	-	-	-
Inflows					
Operating cash flows	2.59	2.45	2.35	2.27	2.21
Salvage Value					3.00
Total	2.59	2.45	2.35	2.27	5.21
Net cash flows	(6.10)	2.45	2.35	2.27	5.21
IRR	**30%**				
Capital Employed	8.69				
Return on Capital Employed	**31%**				

Source: Mahindra & Mahindra

ANNEX 6A-2

Electric Vehicle Implementation and Information

Annex 6A-2

Electric Vehicle Implementation Information

Mahindra & Mahindra Proposed Training Support for Dealers/ Drivers, Owners & Mechanisms

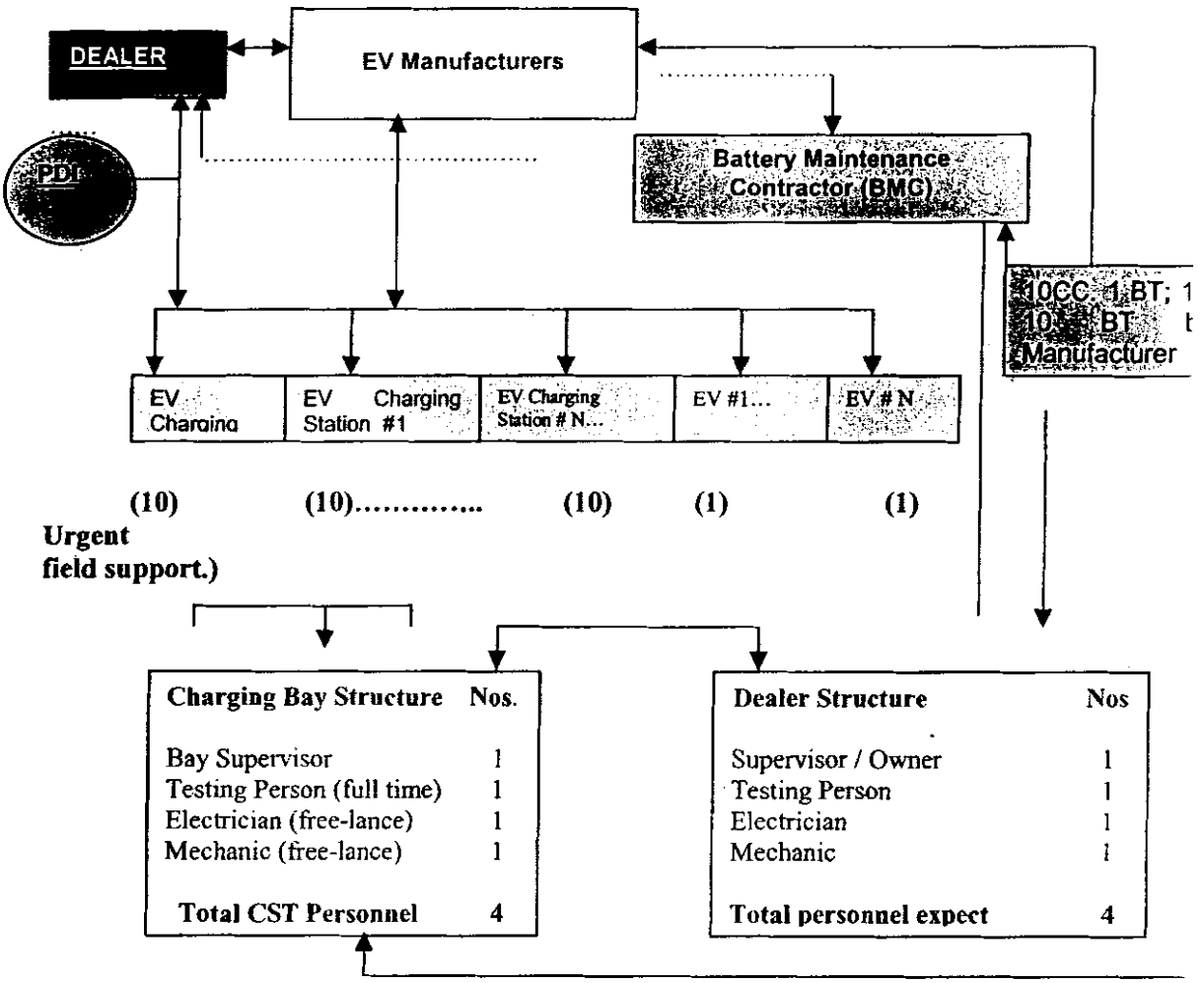
A comprehensive training program is required to be implemented among the users and service providers so as to run the system effectively.

Schedules	By	Training Dates	Training Period
(A) Training to the Company's people. (Training to the trainers.)			
Elec Engg.	C/Wrk	**Phase – I**	5 Day W/S
Mech. Engg.	Wrk		5 Day W/S
Battery Management	E		3 Day W/S
Drive Training	H.O Stf		3 Day W/S
(B) Training for the Dealer			
(1) Elec. Training for Dealer	C/H.O		3 Day WS.
(2) Mech. Training for Dealer	H.O Stf.		5 Day WS.
(3) Battery Management Training for Dealer	H.O.Stf.	**Phase – II A**	
(4) Driver Training for Dealer	H.O. Stf.		5 Day WS.
(C) Training for the Field Person			
Field Level Training for Mechanics		**Phase – IIB**	5 Day W/S
Field Level Training for Electricians			5 Day W/S

Source: Mahindra & Mahindra

Support Structure for Battery Charging Stations / EV

PDI-Internal



Charging Bay Structure	Nos.
Bay Supervisor	1
Testing Person (full time)	1
Electrician (free-lance)	1
Mechanic (free-lance)	1
Total CST Personnel	**4**

Dealer Structure	Nos
Supervisor / Owner	1
Testing Person	1
Electrician	1
Mechanic	1
Total personnel expect	**4**

- The above will be minimum "statutory" requirement per dealer.
- As more vehicles enter the market, the dealer would have to expand the structure
- Above is suitable up to 100 vehicles

Source: Mahindra & Mahindra

ANNEX 6A-3

TVS Hybrid Electric Three-Wheeler

Annex 6A-3

The TVS Hybrid Electric Three-Wheeler

BACKGROUND

The Indian Automotive Industry has been seeking answers to meet the impending stringent Government regulations on emission and develop new innovations to lead the way in establishing future standards in environment friendliness. The TVS Hybrid Electric Three-Wheeler meets Bharat II emission norms while combining the best benefits of fuel efficient IC engines as well as the latest electric powertrain technologies.

The TVS Hybrid Electric Three-Wheeler is an environment friendly, fuel-efficient alternative to the current auto rickshaws for Indian cities. Once commercialized, it will serve as an ideal city commuter capable of carrying three to four passengers with flexible luggage room.

Salient Features

Affordability – the hybrid electric three-wheeler vehicle has been developed with a target of low initial investment as well as low running costs.

- Initial price target of about Rs. 1,00,000/-.
- The fuel economy target is greater than 35 kmpl under Indian drive cycle.
- The vehicle will be a charge sustaining parallel hybrid propulsion system ensuring no additional battery recharging costs.

Seating Capacity: This vehicle will be able to seat three / four passengers including driver with flexible luggage room.

Light weight: The total payload weight will not exceed 300 Kg. The unladen weight of the vehicle excluding traction batteries will be about 310 Kg.

Ergonomics: The vehicle has a steering wheel in place of a handle bar used in current autorickshaws. The problem of driver fatigue is eliminated to a very large extent with a steering wheel.

Aesthetics: The production vehicle will have good fit and finish as well as an areodynamic styling.

NVH: The vehicle has lower Noise, Vibration, and Harshness compared to the present day auto rickshaws ensuring that not only emission norms but also future noise regulations are met.

Fuel tank: capacity of 7 litres, ensures longer time between refuelling.

Drive System: To ensure that the propulsion system is charge sustaining, the following features are incorporated:

- Electric start and very low speed switchover to IC engine.
- Electric power-assist when vehicle demands peak power.
- Under normal operation, IC engine operates in a near-optimal mode to drive the vehicle and charge the batteries.

Maximum speed the vehicle can attain on level ground at full load is 65 km/h, while the normal operating speed in the city will be between 5 and 45 km/h..

Technology: TVS has brought together and integrated suitable technologies, both local and international, to ensure a state-of-the-art manufacturing platform.

Body Panels: The vehicle will be manufactured using affordable, light weight composite materials to control costs and weight, ensuring optimum fuel efficiency is achieved without compromise to passenger safety. TVS have collaborated with Owens Corning, a US multinational, to design and develop a composite body that is 35% lighter than with conventional materials. The vehicle is designed to have contemporary styling and a streamlined body with superior impact and collision strength, dent & corrosion resistance.

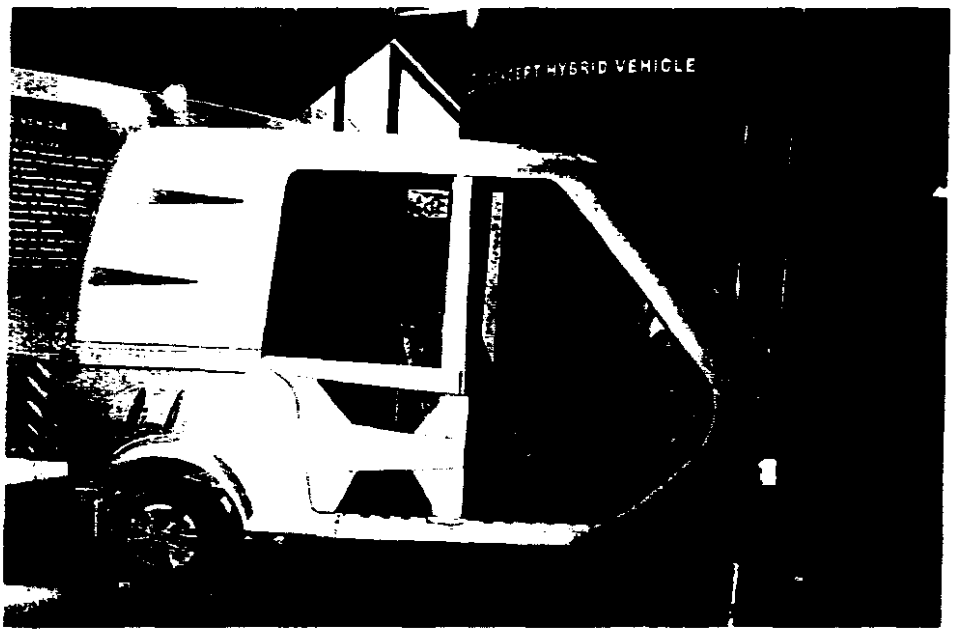
Suspension: A good suspension that is effective under poor quality Indian urban roads, better than the suspension in the existing auto-rickshaws is designed for this vehicle. In addition, the vehicle has adequate road clearance to handle potholes.

Engine: The engine has been developed in-house using current technology with low exhaust emissions and will be compliant with Bharat II emission norms

Batteries: Three maintenance free Lead acid batteries manufactured by an Indian supplier are used as the energy storage system due to economic reasons.

Summary

A concept prototype of the hybrid three-wheeler was showcased at the 6th Auto Expo at New Delhi in January 2002 and drew very large crowds. The unique combination of environment friendliness, ergonomics, advanced technologies and competitive price, positions the hybrid electric three wheeler as superior alternative to any other offering in its category.



ANNEX 7A-1

Emissions Norms for Petrol/Diesel Vehicles

Annex 7A-1

Emissions Norms for Petrol/Diesel Vehicles

Emissions (gms/km) – Petrol Cars				
YEAR	CO	HC	HC+NOX	REMARKS
1991	4.3-27	2.0-2.9	NA	
1996	0.68-12.4	NA	3.0-4.36	
1998	0.34-6.2	NA	1.5-2.0	W/catalytic converter
2000	2.72	NA	0.97	India Stage I norms
B.S II	2.20	NA	0.5	Up to 6 seater & GVW up to 2.5 tons
B.S II	2.2-5.0	NA	0.5-0.7	More than 6 seater & GVW up to 3.5 tons

Emissions (gms/km) - Diesel Vehicles/Cars					
YEAR	CO	HC	HC+NOX	PM	
1992	17.3-32.6	2.7-3.7	NA	NA	Light duty vehicle
1996	5.0-9.0	NA	2.0-4.0		
2000	2.72-6.90		0.97-1.70	0.14-0.25	
B.S II	1.0	NA	0.7	0.08	Cars up to 6 seater and GVW up to 2.5 tons.
B.S II	1.0-1.5	NA	07-1.2	0.08-0.17	Cars more than 6 seater & GVW up to 3.5 tons