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FACILITATION OF TRANSPORT AND TRADE IN LATIN AMERICA AND THE CARIBBEAN

The current state of metro and railway systems in Latin America

I. Introduction

The aim of this document is to outline the state of existing or planned metro and railway systems in Latin America. It describes current trends in rail and metro networks and the problems that often arise when implementing new, large and costly infrastructure projects.

The vibrant history of guided transport systems in the region began with the construction of the first rail networks in the nineteenth century and continued as metro systems were introduced in the region's fastest-growing cities in the early twentieth century.

Most of the Latin American cities examined as part of this study have serious structural problems and suffer from environmental pollution due to poor urban and land-use planning and a lack of regulatory procedures.

Buenos Aires pioneered the implementation of the first metro system (underground) in the region, but over the years, such systems have also been built in Mexico City, Caracas, Santiago, São Paulo and Rio de Janeiro.

Decisions relating to the construction of metro systems, which were rolled out in these cities during the 1970s and the start of the 1980s, were subject to the political and economic vagaries of the time. The professionals involved in the construction of the metro systems in Rio de Janeiro and São Paulo recount the competition between the two cities to see which one would finish first, with progress being made faster in some areas than others.

In the late 1980s and early 1990s, other cities with mobility problems started to implement metro systems, such as Lima, Medellín (Colombia), and Monterrey and Guadalajara (Mexico).

More recently, we have seen these systems introduced in cities with high population growth and considerable mobility problems, for example, Valencia and Maracaibo in the Bolivarian Republic of Venezuela, Valparaíso in Chile,

This issue of the *FAL Bulletin* describes how metro and railway systems contribute to sustainable mobility, looking at some of the current challenges and their technical solutions

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Santo Domingo in the Dominican Republic, San Juan in Puerto Rico, and several cities in Brazil, including Recife, Fortaleza, Brasilia and Porto Alegre.

Some cities, unable to implement metro and rail networks owing to financial constraints, opted for bus rapid transit (BRT) systems; this was the case in Curitiba (Brazil) and Bogota (Colombia). These systems enjoyed immediate success and similar models have been put in place in other Latin American cities. Despite this, both cities are currently considering building metro systems.

This has sparked a debate on which system is the best and which is the most expensive to build — with the answers to such questions being heavily influenced by the stakeholders involved in each sector.

As metro networks have thrived, the opposite has been true for railway systems, which have started to decline and lose share in both passenger and cargo services. Fixed installations and existing rolling stock are deteriorating gradually, because of the lack of investment in replacements and the solid expansion of transport by truck and bus.

Lastly, the more developed cities worldwide consider the different alternatives available when planning a new transport system, resulting in well integrated networks made up of different modes of transport, including buses, trams and light railway transport (LRT).

II. Global trends

When designing transport systems for densely populated cities a number of factors that influence quality of life are taken into account, with particular regard for the interests of future generations. These factors include:

Population density in large cities

Major cities in the region attract people from other areas within the same country or from neighbouring countries. They arrive in the hope of a new life, seeking job opportunities and improved well-being for their families.

However, this tends to aggravate the problems faced by growing cities that lack a proper development plan and, as a result, exacerbates structural problems relating to infrastructure and transport.

Demand for environmentally friendly infrastructure and green buildings

On the whole, as part of the efforts to improve the quality of life in cities, new infrastructure is increasingly being set up with a view to reducing pollution.

Water shortages, environmental degradation and frequent extreme events

The problems that could arise in the future as a result of environmental degradation are a major concern in large cities. That degradation is often associated with a lack of planning and frequent extreme events triggered by climate change, such as periods of heavy rainfall, which have revealed poor or inadequate infrastructure in many cities in the region.

Investment in clean, inexpensive technologies

The use of clean technologies, for example, hybrid or electric vehicles, or in relation to power generation, is currently on the rise and it is only a matter of time before they are cheap enough for mass implementation.

Increasing leisure time as a result of new travel patterns and new settlement concepts

Implementing more efficient transport systems, whether metro, rail or BRT, results in shorter travel times and new settlement concepts, such as the formation of satellite cities on the outskirts of major cities with efficient transport systems to connect people with their workplaces.

Faster transportation of export products to ports

Export products are generally transported to ports by truck or train. The technology used for loading, unloading and storage has improved at many ports. However, in some cases, poor road and rail access to ports result in slower delivery times, higher transport costs and lower competitiveness.

Easing pressure on road networks

By improving the services on offer, guided transport systems, such as metro and rail networks, can capture demand from other modes of transport, such as cars and trucks, which eases the pressure on road networks. Fewer internal combustion engines mean lower hydrocarbon, carbon dioxide and nitrogen oxide emissions.

III. Metro systems

There are several large metro networks currently operating in Latin America, primarily in the most densely populated cities. Metro systems have recently been implemented or are about to be built in a number of cities that did not have one. This process takes longer in some cases than in others, depending on the difficulties encountered during the implementation phase and the economic situation in each country. Panama City, Bogota and Quito are examples of cities that are at different stages of implementing new metro projects.

In Santiago, Lima, Buenos Aires and some cities in Brazil, work is currently under way to expand existing

networks that are already in operation, while Monterrey, Santo Domingo and Medellín are studying the feasibility of extending their networks.

Examples of lines that were inaugurated recently are line 12 in Mexico City, line 4 in São Paulo and line 2 in Santo Domingo, which uses the latest technology.

The technological innovations that are being incorporated into the new lines include:

- Tunnels constructed using tunnel boring machines (TBM) or the new Austrian tunnelling method (NATM)
- Tracks with double elastic fastening
- Contact lines: overhead power cables/third rail
- Communications-based train control (CBTC) signalling systems
- Automated driving
- Operational control posts
- State-of-the-art rolling stock
- Air conditioning at stations
- Passenger information
- Platform screen doors

1. Cities with metro systems in Latin America and the Carribean

The current state of the metro systems in each country (see map 1) is outlined below.

Argentina is about to celebrate the 100th anniversary of the Buenos Aires metro, which is under concession. The network has suffered in recent years owing to a process of disinvestment. Inappropriate public policies on subsidies adopted by the government have led to the degradation of the network's infrastructure. The task of improving this service by carrying out the necessary investments in restoring rolling stock and adding more trains now lies in the hands of the Buenos Aires city government, which was recently transferred the service concession by the national government.

New sections are being added for passenger services on lines B, H and A to accommodate new train formations. And, although public works to extend line E to Retiro are ahead of schedule, electro-mechanical equipment must be bought in order to bring that line into operation and ease congestion on line C in the city centre.

Map 1
CITIES WITH METRO SYSTEMS IN LATIN AMERICA

Source: Prepared by the author.

Brazil is the country with the highest number of cities with metro systems. São Paulo and Rio de Janeiro operate traditional networks, while some inland cities have started operating branch lines of the Brazilian company of urban trains (CBTU) in urban areas, which are similar to metro systems. The following cities are among those that have implemented or are in the process of implementing a metro system:

- **Fortaleza** currently has the south and west lines in operation, with studies being carried out to expand the network.
- **Recife** is currently operating two lines.
- **Belo Horizonte** has one line in operation and two in the pipeline.
- **Brasilia** has had two lines in operation since 2001.
- **Salvador** will have two new lines in operation from 2014, probably under a build-operate-transfer (BOT) agreement.
- **Curitiba** is considering building its first line.
- **Porto Alegre** has one line in operation.
- **São Paulo** has five lines, one of which is the first operated with driverless trains in Latin America and is part of the system operated by the Paulista metropolitan trains company (CPTM).
- **Rio de Janeiro** currently has two lines in operation and is planning to incorporate new lines.

Chile has metro systems in two cities:

- **Santiago** has the **Santiago Metro** system which has been extended in recent years. Line 4 was added to the network and existing lines 1, 2 and 5 were extended. Determined efforts are being made to upgrade the technology used in an attempt to provide a better service at rush hour. The construction of lines 3 and 6 is currently under way and the level of technology used will place the company at the cutting edge worldwide.
- **Valparaíso** has the **Valparaíso Metro** system, known as **Merval**, and is currently adding extra trains to improve services.

Peru has resumed the **Lima electric train** project and stage one is already operational. Stage two is being built and should begin operating in 2014. There are also plans to add other stages to the project to improve the transport network.

Ecuador carried out studies to build its first metro line in **Quito** and construction started in 2013.

Colombia has one system in operation and another in the engineering phase.

- **Medellín** was the first city to implement a metro service, which is renowned for its high professional standards. The system has incorporated feeders at route starting points, such as the Metrocable, and a feasibility study is being carried out on incorporating new tram feeder lines.
- **Bogota** is currently preparing a study and engineering blueprints for building the Bogota Metro, following the success of its BRT Transmilenio transport system.

Panama began the construction of its first metro line a couple of years ago and it should be ready for inauguration in 2014.

The Bolivarian Republic of Venezuela has three cities with metro systems:

- **Caracas** has three lines in operation, one of which connects to Los Teques Metro and is being integrated into the bus network.
- **Valencia** is operating only the first section of line 1, which measures 4.7 km. The second and third sections of this line have yet to be built and there are plans to build another line.
- **Maracaibo** is operating only the first section of line 1, which measures 6.5 km. The remaining sections have yet to be built and there are plans to build another line.

Mexico has three cities that operate metro systems:

- **Mexico City** currently operates 12 lines. In addition to being the most compact network in the region, it is one of the systems that transports the largest number of passengers. It is also unique in that, thanks to its layout, its lines are bidirectional during peak hours.
- **Guadalajara** has a light train system with two lines in operation and is planning to build a third.
- **Monterrey** has only two lines in operation and is studying the possibility of building a third.

The Dominican Republic has the Santo Domingo Metro, which is one of the newest networks in the region and the largest in Central America and the Caribbean. Most of line 1 runs along a viaduct and a large section of line 2 is underground. Studies to lay a third line are under way.

Puerto Rico has the San Juan urban train network, which has only one line and is integrated with the bus service. It is unique in that it is operated and maintained by the company that built it.

IV. Light metros

Light metro networks have a major impact on sustainable development in metropolitan areas. They give structure to a territory, promote and shape growth within their area of influence and highlight strategic points in a city. They provide both the drive and framework for generating and supporting economic activities and services.

Building a new light metro system means reintroducing urban rail transport, which disappeared in many cities

in the 1960s when tram networks were dismantled. The advantages of planning, building and implementing environmentally friendly systems with a lower urban impact have been discussed at great length. This has led to the widely accepted, global trend of building light metros. Today, light metros have become a symbol of modernity and have helped to improve the quality of life and of the urban environment in consolidated inner city areas.

Light metros (or modern trams) are highly reliable and efficient. They offer sustainable mobility, make urban and suburban areas more attractive and can be adapted to the ever-changing mobility patterns in different cities. They offer a transport solution that is in line with current lifestyle trends in expanding cities and offers an alternative to increasing collective and private motor transport, which leads to a rise in traffic congestion and pollution and affects the quality of life of the population.

These systems offer forward-looking industrial designs and models adapted to each city's current needs. Another key point is that they can be integrated seamlessly into existing transport networks without the need for complex, expensive infrastructure works.

Many European cities are making progress in implementing light metros. Several Latin American cities, where it is not feasible to make substantial investments in new metro systems, are studying the feasibility of implementing light metros.

V. Rail systems

Interestingly, a number of rail networks are starting up again after coming to an almost complete standstill in many countries several years ago.

Today, many countries are aware that to make the regional products they export more competitive, they must improve the cost structure of inland transport and resuming rail services justifies investment plans.

Suburban rail networks are essential for passenger transport in major cities because they operate as a feeder service for metro lines, helping to reduce car use for long journeys and the environmental impact caused by private transport. What is more, most cities do not have the physical space available to expand road networks, but they do still have sections of unused railway tracks, except in some cases where land has been appropriated.

Plans are under way in **Argentina** to modernize the Belgrano rail freight network, as well as the busiest branch lines of the suburban and intercity rail passenger service.

Investments have been made to improve safety on suburban rail networks following several fatal accidents. To that end, tracks are being improved and modernized, new trains purchased from China are being incorporated into the network and signalling systems are being made safer. There are plans to upgrade these systems in the coming years.

At present, the tracks of the Belgrano railway used for transporting freight are being upgraded. Work to improve tracks between Buenos Aires and Rosario and Buenos Aires and Mar del Plata should start soon and new trains will be added on the San Martin, Mitre, Sarmiento and Roca railway lines. Safety improvements are being made to the signalling systems on several lines including Mitre and Sarmiento.

In terms of private projects, work is also under way to build the Bioceánico central rail corridor.

Driven by economic growth and in preparation for the 2014 World Cup and 2016 Olympic Games, **Brazil** has implemented a number of rail infrastructure projects. An example is the high-speed train from Rio de Janeiro to São Paulo, an intercity passenger service which will be a boon to travellers once it is up and running since the air shuttle service between the two cities is often saturated at peak times.

Of the 10 busiest freight rail networks in the region, 6 are operated by companies in Brazil. Every year, they transport around 475 million tons across a 30,000 km rail network. In Brazil, there is a lot of scope for expanding rail transport because there is demand and travelling inland involves covering vast distances.

The Plurinational State of Bolivia is considering possible routes for the Bioceánico central rail corridor, which would connect its two railway networks, the 2,274 km Andina network and 1,423 km Occidental network. This project would link ports along the Pacific coast in Chile and/or Peru with the port in Santos, Brazil, located on the Atlantic coast.

In **Chile,** several initiatives have been put forward in recent years to create a suburban rail network on the outskirts of Santiago. Some of these projects sought to emulate the successful road concessions model for rail transport. However, the high cost of investment led to the failure of some of the processes launched in the early 2000s, such as the invitation to tender for the Melipilla rail service concession. A consistently sound train service is provided by the rail company to Rancagua and new trains are currently being added to the network to improve the quality of the service.

The Santiago-Melipilla Metrotren project was launched recently and could be up and running in 2016. It is expected to transport 30 million passengers per year and connect the communities of Maipú, Padre Hurtado, Malloco, Talagante, El Monte and Melipilla.

Lastly, Chile and Argentina support the construction of the Bioceánico central rail corridor, a private initiative for the freight market.

Colombia is investing in its rail infrastructure, which will help to lower the current cost of sending goods by road. Works are also being carried out on the following sections of the rail network: between La Dorada and Chiriguaná; Puerto Berrío and Cabañas; Bogota and Belencito; La Caro and Zipaquirá; Bogota and Facatativá; and the Capulco Port branch line. A feasibility study is under way to build the Canal Seco branch line, which would link the ports on the Atlantic and Pacific coasts in the north of the country.

Ecuador's national rail company has launched a railway system recovery plan which aims to modernize railway tracks and stations. This will improve the operational efficiency of the railway system's tourist and heritage services and contribute to the socioeconomic development of the country, by increasing socially responsible production activities that promote tourism and an appreciation of the country's history and heritage.

The recovery plan is extremely important for transport as it connects the north of the country to the south along the Pacific coast. It will measure approximately 500 km and will improve connections between the most popular tourist attractions in Ecuador.

Governments in **Central America**, firm in their conviction that infrastructure and transport are vital to the economy, the mobility of people and goods, and businesses, are setting their sights on infrastructure and transport-related projects. The main projects under way include the Guatemala Interoceanic Corridor and the Mexico-Panama rail project.

A railway recovery process is currently under way in **Guatemala** and different alternatives are being considered for passenger and freight transport. One option that is being looked at is a passenger rail service in Guatemala City. As for freight transport, no solution has yet been found to the controversy surrounding a historical rail concession that was subsequently rescinded by the Guatemalan State.

In **Mexico**, the present government's plan for the five-year period 2013-2018 is to set up three new passenger trains. It hopes to call for tenders in 2014, which would lead to investments of MXN$ 95 billion, equivalent to more than US$ 7 billion. The following projects are included under this plan:

- A high-speed train connecting Mexico City and Querétaro, requiring an investment of US$ 4.5 billion to build a 583 km line.
- A train connecting Matamoros and Brownsville, covering 30 km and providing access to the United States.
- The Mexico City–to-Toluca project.
- A transpeninsular connection between Yucatán and Quintana Roo.

In **Panama**, it was recently announced that a proposal to create a rail link from Panama to Mexico is being revived.

Paraguay is reviewing recovery plans, which will need strong political support.

Peru is studying the possibility of linking up to a Bioceánico central rail corridor across Bolivia. This would link the ports of Ilo and Arequipa in Peru with the port of Santos in Brazil and could also be used for tourism.

The Bolivarian Republic of Venezuela launched a national plan for rail development a few years ago, though construction has been held back by the country's topography and the cost of works.

Uruguay has started a process of restructuring its railway system and recently announced that it would invest in restoring the rail network.

VI. Studies and engineering

There is a direct link between project engineering and investment projects for a country's infrastructure. The infrastructure and competitiveness of a country are also closely correlated, as shown by the model used by the World Economic Forum.

Poor planning and short-sighted public policies that lack a vision beyond the current term of government lead to insufficient investment in transport infrastructure

projects. Furthermore, incomplete studies and engineering blueprints delay project execution and have an negative impact when it comes to negotiating funding with multilateral credit institutions and private banks.

The purpose of project engineering is to define, design, build and implement transport infrastructure projects. The participation of project engineers is concentrated principally at the definition and implementation phases, and to a much lesser extent, the operational stage. Investment projects are always multidisciplinary, involving several engineering disciplines at each phase or stage of a project, to varying degrees depending on the nature of the project.

Four factors are taken into account when analysing national competitiveness in different sectors: the conditions of demand, the external context, complementary and related industries, and the strategy, structure and type of competition between businesses in the sector. Government action can affect these factors both positively and negatively and the government's role and influence in project engineering is also analysed.

The following steps must be taken to ensure a project's success:

1. Conceptual engineering

- Studies of demand
- On-site socioenvironmental studies
- Topography studies
- Cadastral surveys to identify possible expropriations
- Geotechnical studies
- Identification of sources of financing

2. Basic engineering

- Public works
- Railway tracks
- Electro-mechanical equipment
- Rolling stock

3. Detailed engineering

- Public works
- Railway tracks
- Electro-mechanical equipment
- Rolling stock

4. Calls to tender

- For the construction of public works and rails
- For the supply of electro-mechanical equipment
- For the supply of rolling stock

The duration and structure of each of these processes must be planned and outlined in Gantt and PERT charts. This is because each phase in the construction process takes a different length of time and certain activities are critical.

Without a good project plan specifying the time frames for construction and the delivery of equipment, these processes might not occur in a timely fashion. In the region, there have been cases where trains have been received before works have been finished. In other cases, equipment has not arrived until long after works have been completed owing to purchase-related delays. The failure to define such time frames can lead to additional costs that tend not to be measured, but which can increase the overall cost of the project considerably.

VII. Types of contract

In practice, there are a number of contract modalities for these projects, some of which may be more appropriate than others, depending on the structure of financing or the operational modalities that best suit the principal.

The most common types of contract that principals use include:

Contracts for each component

- Construction of public works
- Construction of rail tracks
- Provision of electro-mechanical equipment
- Provision of rolling stock

Turnkey contracts

- A single contract for construction and supply

Inspection contracts

- A single contract or contracts for each area of specialization

Other types of agreement to be considered are public-private partnerships (used for line 4 of the São Paulo metro) and build-operate-transfer (BOT) agreements (the preferred option in Puerto Rico). Private participation may take the form of financial contributions, but if this model is to be successful, the fares charged for using the service when it is operational must ensure that any investments can be recouped.

VIII. Specialized inspections

Contracts, whether public, private or mixed, must be managed by a competent and efficient principal who should fulfil his or her role properly. Public contracts should be managed by professional, independent public companies that are held accountable for their actions and are duly audited. The administration of private and mixed initiatives depends on proper contract design and effective oversight capacity.

The success of the contract lies in the State's or manager's ability to define policies and regulate projects.

Engineering companies with sound professional experience must be chosen to ensure proper oversight. The right criteria must be set for selecting companies and assessing professionals.

One of the processes involved in assessing engineering, construction and the supply of equipment is the certification of materials and equipment. This means ensuring that prototypes that cannot guarantee safety in the event of equipment failures will not be used in the metro and rail service. One clear example of this was the validation of the bogies used by the trains provided by CAF for the Santiago Metro, which were subject to a number of test protocols before they were accepted for use in the regular passenger service.

Lastly, all systems must be assessed on the basis of their reliability, availability and maintainability (RAM), in accordance with the EN 50126 standard. This certification seeks primarily to detect and mitigate any risks which could affect the operational continuity of the metro and rail service.

IX. Impact on construction and supply

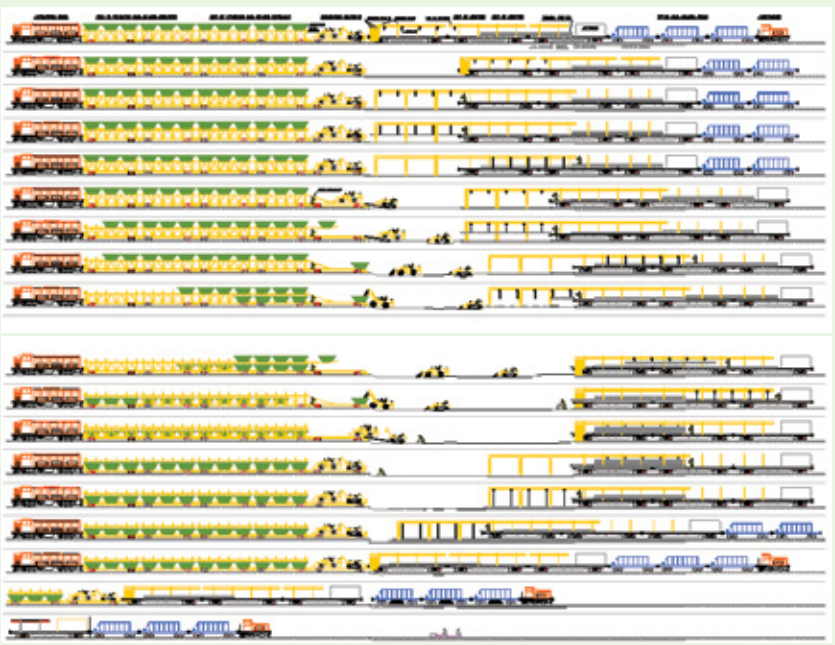
The need for good preliminary studies and engineering blueprints has already been discussed. Indeed, they are crucial when construction companies and equipment suppliers are quoting a price for the work required by principals.

- Contractors and suppliers are unable to give a definitive quote without a complete study and engineering blueprints.
- The uncertainty faced on a daily basis by the majority of those with budget responsibilities in construction companies results in higher costs.
- Principals who do not define the project properly run the risk of having to accept what the builder or supplier decides.

In most cases, engineers must use their imagination and skill to complete complex jobs by the deadline agreed and in keeping with safety standards, without spending more than was budgeted for and achieving the profits expected.

Diagram 1 shows an example of a methodology that was developed to meet the standards set out above in relation to a specific project. This methodology had the essential support of a group of skilled professionals whose vision led to its success. The diagram sets out the train formation and the different steps involved in the process of modernizing line B of the Buenos Aires underground, taken on by Metrovías in 1995 under the Buenos Aires metro network concession contract. Using this methodology, an average of 54 m of track infrastructure, and up to 72 m where the physical conditions allowed, was repaired in a net working time of approximately 4 hours and 30 minutes per night.

Diagram 1
WORKING METHODOLOGY FOR MODERNIZING THE TRACKS OF LINE B OF THE BUENOS AIRES METRO, 1996-1997



Source: Prepared by the author.

X. Final reflections

The need to improve transport systems in Latin America behoves the relevant stakeholders involved to develop policies that aim to reduce travel times. The key to achieving this is designing systems that give priority to intermodality for the transport of passengers and freight and making guided transport systems (metro and rail networks) the backbone of sustainable transport.

This calls for political resolve and a broad consensus between the different sectors in all countries.

The first step is to create a master plan for the development of transport, which must take into account the results from studies on travel patterns. An analysis must also be conducted into the ways in which different modes of transport, either existing or in the pipeline, can be integrated in order to improve and optimize urban mobility.

The plan must take into consideration public policies and be organized into phases (short and long-term) for planning, designing, financing, operating and maintaining the system. Groups of trained experts must be charged with seeing the different phases and stages of the project through successfully.

Important decisions must be taken in relation to financing for such projects, which normally comes from several sources (for example, public funds, multilateral credit organizations and suppliers). Similarly, it is important to consider carefully the type of contract adopted when implementing a new investment plan. Failure to do so could result in the doubling or even tripling of the amounts covered under the contract, which would then have to be financed directly.

In short, good planning is absolutely essential and must be executed with the utmost professionalism in order to ensure that the best use is made of the resources, which are always difficult to secure. Poor management, unnecessary bureaucracy and political whims can lead to the squandering of project funds and very little of the progress needed being made towards concrete improvements to transport systems.