SUSTAINABLE TRANSPORTATION AND LIGHT RAPID TRANSIT IN MACAO

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Abstract

The record high growth in recent years has dramatically changed the way of life in Macao. With more and more private vehicles adding into the originally small and narrow road network, Macao is finding difficulties to cope with the increasing demand for road space and to preserve its environment. As announced in October 2007, the Macao Light Rapid Transit (or LRT) is to be built to provide a more convenient and environmental-friendly way of travel for residents and visitors. Consuming less energy with almost zero emission and low level of noise, the LRT can transport more people in a more sustainable way than the conventional modes of transport, which all relies on limited road space, in Macao. To work with management strategies that will favour public transport, the Macao LRT can help to improve the environment by attracting more car or motorcycle users, therefore cutting down the number of private vehicles on the roads and free up the road space for pedestrians and buses. Through connecting pedestrian walkways at LRT stations, it will help to ensure that most places, especially historical sites, are within walking distances, a culture of walking that Macao can continue to be proud of and a key element to ensure that Macao will have a sustainable transportation system for the continual growth in its economy.

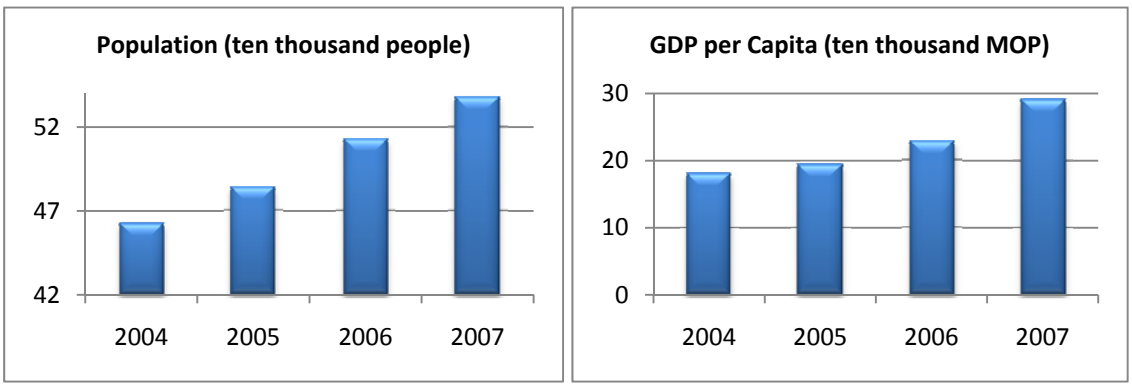
1. Introduction

With more than 400 years of history, Macao has a small land area and a densely populated old town with narrow and busy streets. The recent record growth in economical activities, mainly due to the rapidly expansion of the entertainment and

gaming industries, have brought dramatic changes to the originally calm and peaceful living environment.

At the beginning of 2008, according to the Statistics and Census Services Macau (2008), there are more than 530,000 people living in Macao, excluding the number of visitors which was closed to 27 million in 2007. The average size of a household is about 3.2 persons. The total number of households is about 134,332. 48% of the population do not own cars, and so are most of the visitors. Their main modes of travel are walking and buses.

With a land area of 29 km^2, Macao has one of the highest density of population in the world. The total road length is about 370 km, with close to half of them in Macao peninsula itself. The private vehicle population reached 180,000 in 2007. Half of the private vehicles owned are motorcycles. Figure 1 shows the growth in the economy, population and the number of tourists. The rising economic activities and the income have triggered a rapid increase of number of private vehicles, as shown in Figure 2.



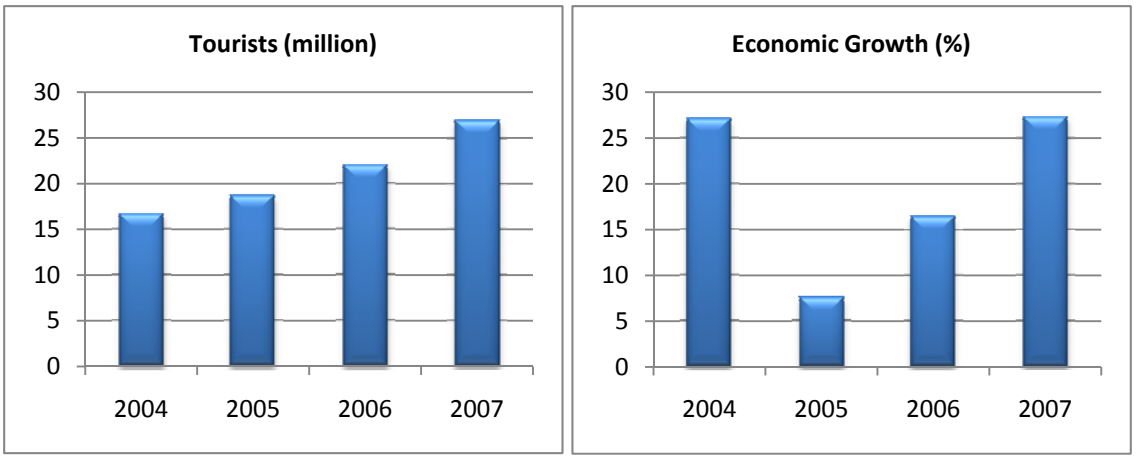


Figure 1. Some of the Key Statistics of Recent Years in Macao

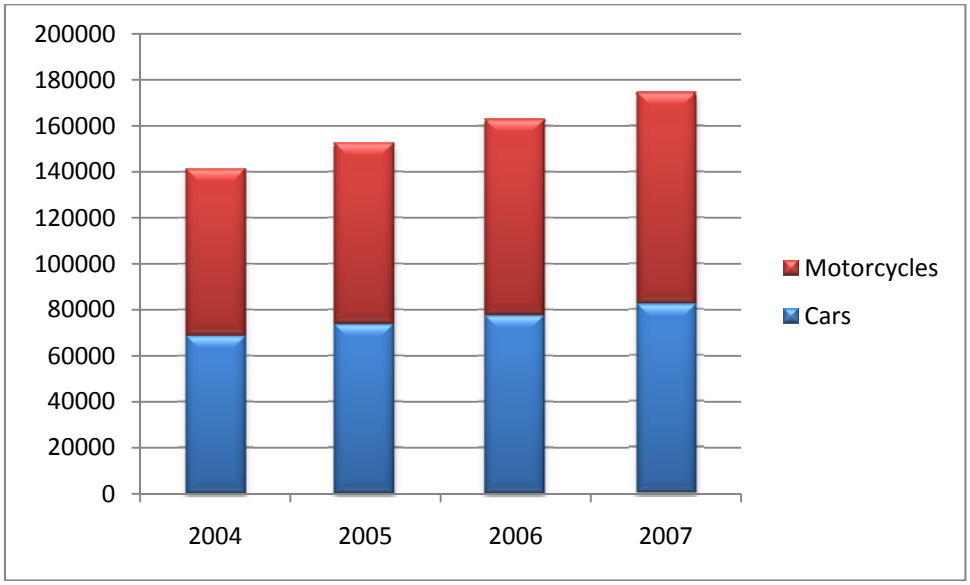


Figure 2. Growth in Private Vehicles

Considering the dense and small urban area in Macao, and its high private vehicle ownership due to the high economic growth and lack of an efficient public transportation system, if the trend continues, the living environment in Macao may not be able to sustain the development in its economy. It's already reported from various studies that this has become a major concern. For example, more than 60% of the respondents expressed that the traffic conditions would worsen in the next three years in a study by Yeung and Choi (2007). In a study by Chen (2007), the

main concerns due to traffic congestion are worsening air quality, longer commuting time, reduction in productivity, delay in emergency rescue and damaging the living environment.

This shows that transportation and the environment are well recognised as an important aspect of people's daily life in Macao. In order to harmonise the effects of economic expansion and the livelihood of people, a sustainable transportation policy and system is much needed. In this paper, the Macao Light Rapid Transit System is presented and its relationship with achieving a sustainable urban development in Macao is discussed.

2. The Green Link of Macao – the Macao Light Rapid Transit System

Considering the small area of Macao and its highly concentrated population, the light rapid transit with its high level of service and reliability can become the main mode of transportation for residents and visitors. The service area of the Macao LRT can be greatly enlarged through integration with the network of pedestrian walkways, and buses. This is in addition to the carparks situated near LRT stations, which together can help to attract more people taking transit, instead of driving, while serving the travel needs of the vast majority. By doing so, the LRT is likely to become the "green link" of Macao, as it can help to keep Macao moving, while the environment quality can be improved at the same time.

Since 2002, a number of studies have been carried out to identify the best alternative to build the LRT system. Accompanied with each stage of studies, public consultation was carried out to collect feedbacks to improve the system design. In October 2007, it was announced that the Phase 1 Macao LRT system is to go ahead (GIT, 2008). The SAR Government also establishes the "Transportation Infrastructure Office (GIT)" in November 2007. GIT is responsible to plan, coordinate and monitor the LRT development in Macao and also to study alternative operation and management schemes in the future.

In order to overcome the constraint due to insufficient land resources in Macao, the Phase 1 LRT alignment was determined in a way to satisfy the needs to connect the major entry-exit points at the Macao Peninsula and the Taipa Island, the distribution of residents and working population, the tourist demand, as well as considering external environment and engineering feasibility. The phase 1 LRT is about 20 km in length, starting from the Barrier Gate and ending at the Taipa Maritime Terminal, passing through the densely populated North District, Macao Maritime Terminal, tourist attractions, the downtown area, COTAI and airport, the LRT is to connect Macao with its two islands. The system is planned to operate 19 hours per day, 3 minutes headway during peak periods and 3 to 6 minutes headway during off-peak periods. The operation will utilize dual train set (i.e. 4 carriages), with a peak capacity of 8,000 passengers per hour per direction. These operation parameters can be varied depending on the actual demand to suit the needs for travel.

Figure 3. The Phase 1 LRT route alignment (the 2006 Optimised Version)

The LRT will help to raise capacity for more tourists in Macao, to promote the integration with the Pearl River Delta area, and also to respond to the rapidly increasing demand for more and better public transportation services due to the

rapid growth of the society and economy. The LRT can also help to attract more private transportation users to switch to public transportation, and to realize the policy goal of giving priority to public transport and establishing it as the mode of choice in Macao. When this happens, the pressure on road capacity would reduce and the traffic can be flowing smoothly. This in turns can help to improve the environment in terms of improved air quality, reduced noise levels, and less delays on roads. Many road users, including taxi and bus passengers, would also be benefited. The society and economy of Macau can then be developing in a sustainable way.

The Phase I Macao LRT System

With a total length of about 20 km, the Phase I Macao LRT will join the Macao peninsula and the Taipa island via the Sai Wan Bridge, connecting major entry/exit points, residential, commercial districts and tourist attractions.

On the Macao peninsula, the track length is around 9 km, with 12 stations, and the journey time is estimated at 18 minutes.

After the Sai Wan Bridge, the total track length on the Taipa island (including the COTAI area) is about 8 km, with 11 stations and an estimated journey time of 16 minutes.

To connect to areas that are not directly served by the Phase I LRT system, passengers can use the public transport transfer facilities at LRT stations and to reach their destinations using other modes of public transportation.

The length of train consisting of two carriages is about 30 meters, with a passenger capacity (at 4 persons per m^2) of around 200. With a planned 3 minute headway during peaks, the peak capacity of a dual train per hour per direction is about 8000 people, although the service frequency can be adjusted according to demand to optimise the level of service during actual operations.

The project cost is estimated at 2006 price level at around MOP 4.2 billion, consisting of MOP 1.5 billion for the Infrastructure and 2.7 billion for the system and rolling stock.

The pillars of the track are to be located at the medians and not to occupy the road space as much as possible. The void areas at the stations and the pillars can be used as green space. Transfer facilities with other public modes (bus and taxi) will be provided at major stations. Of the 23 stations, 11 of them are adjacent to public car parks.

The service, as is the inherent characteristics of the LRT itself, will be safe, reliable and on-time, environmentally friendly with low (or zero) pollution and low noise levels.

The needs of passengers are the focus of design inside the carriages and stations, features such as barrier-free design, with special consideration for senior and handicap persons, handrail escalators, lifts and guided-path titles, will be common in all elements. Carriages will be spacious and comfortable. The landscape design will harmonize with the surroundings, especially historical places such as UNESCO sites, with pillars of the track not to occupy the road space as much as possible. Green

design, such as natural light and natural breeze, needs to be used extensively at stations, to cut down the energy consumption. Automated half-height platform screen doors need to be installed at all stations to provide the greatest safety standards to passengers. At major stations, transfer facilities with other public modes of transportation need to be provided, with ample space, facilities, amenities and information guidance. Effective and reliable evacuation systems need to be thoroughly planned and put in place along all tracks and stations.

3. A Sustainable Transportation System for Macao

Transportation planning is normally governed by a set of transportation policy, as a general rule, and this is especially true for Macao. For the benefits of Macao's long term development, such transportation policy needs to be formulated to provide a sustainable transportation system, to satisfy the travel demand at various stage and scale of development. A sustainable transportation policy is one that is aimed at minimising consumption of natural resources and negative impacts to the environment, while serving the needs for travel. Under such policy, the emphasis should not be the over expansion of the road infrastructure to suit the growing need of private vehicles, but rather to provide the most suitable form of transportation to optimise the needs for infrastructure and the preservation of the environment quality. Though road infrastructure will still need to be maintained and improved, public transport, especially rapid transit, is normally the most ideal form of transportation for sustainability.

In Macao, special consideration needs to be concentrated in preserving its valuable historical places and its limited green spaces, while introducing new transit systems

that can be developed and operated harmoniously. This is in addition to the constraints such as small urban spaces, narrow streets, dense and uncontrolled development, which have been coexisting with the well-preserved heritage sites. For such already congested areas, roads and private transportation are clearly not an affordable or sustainable solution for the problems of transportation. On the contrary, with proper transportation planning, these constraints can become advantages, for example, a network of well-designed pedestrian walkway system, connected to LRT stations with short walking distances, will be an ideal way of serving the travel needs of the population living at the old towns of Macao.

The transportation policy governing the long term and sustainable development of Macao has been defined in 2007 (Secretary for Transport and Public Works, 2007). The key element of the policy is to give priorities to public transportation and to establish it as the choice mode for travel (公交優先). As shown in Figure 4, the LRT will be the core transportation mode responsible for the daily transportation needs of residents and visitors, while it'll be connected through interfacing facilities to a network of pedestrian walkways and bus services. It is envisaged that the initial phases of LRT will run in the coastal areas of Macao, while the later phases may go through the inner areas nearer to the old town. In the long run, the LRT may be connected to the railway system in the Pearl River Delta through transfer stations. This policy is supported by results from various studies that provide evidences of relatively high (25%) proportion of the daily trips made via walking and about 40% using buses (Yeung and Choi, 2007).

Taxis will continue its role of providing door-to-door premium services, although they will also be interfacing with LRT at stations. The Transportation Infrastructure Office,

or GIT is specially tasked to spearhead the development and modernisation of the road infrastructure, and to develop the LRT as the core mode of transportation to solve the mid to long term internal transportation needs of Macao. The objective is to provide a comfortable, highly efficient and modern transportation system to serve the residents and tourists.

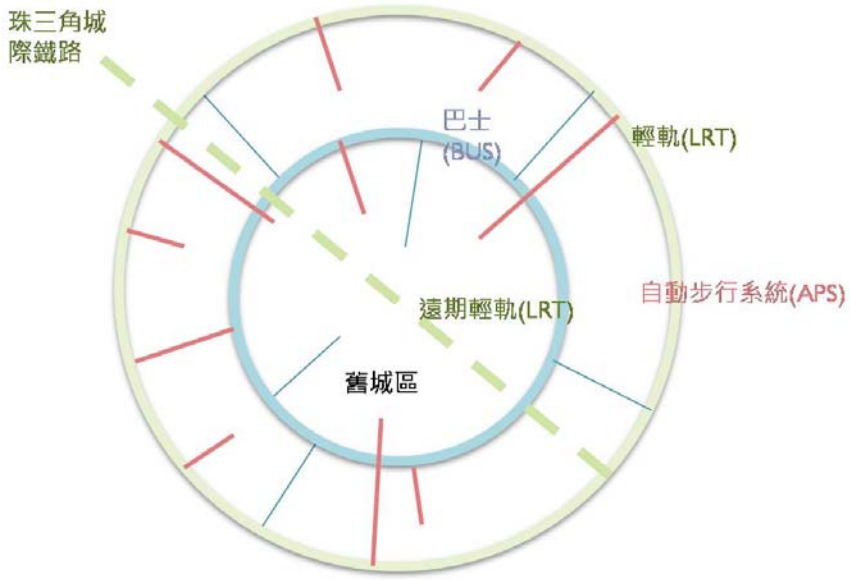


Figure 4. LRT as the Core Mode of Transportation in Macao

Various studies (Yeung and Choi, 2006, and Chan, 2007) conducted surveys to investigate the acceptance of LRT and reported acceptance rates of 74% and 76% respectively, while air quality, followed by traffic congestion, are cited as the major reasons for their support. Chan (2007) also reported that if priced competitively close to 73% of private vehicle users would consider switching to take LRT. This shows that there are a wide support of LRT and if it can be built and operate successfully the above mentioned policy goals can be achieved. The improvement in air quality and traffic congestion can be expected if the switching as reported in various studies does occur.

As the core transportation mode in Macao's sustainable transportation system, the LRT serves its purposes through a number of endogenous and exogenous characteristics.

3.1. The LRT and sustainability – the endogenous way

As mentioned in the previous section, the LRT will be designed and built with full consideration in how to work harmoniously with its environment, namely the people's living space, the natural environment, and the historical sites. Through public consultations and the LRT studies themselves, such demand have been made known and will be captured in the detailed design of the LRT infrastructure, and the selection of systems and rolling stocks. Specifically, the LRT system will need to adopt a series of "green" design, for example, stations that consume less energy and maximises green elements, such as trees. For the passengers, half-height platform screen doors, escalators and lifts, guided path, are to be provided to enhance the safety and to serve the seniors and people with disabilities. Infrastructure will be specifically designed to minimise the impacts due to noise, though low comparing to the background traffic noise, and views and landscapes. For historical sites, especially the UNESCO heritage sites, special consideration will be given to make sure that there will not be any conflicts to the existing landscape and views, although the LRT with its pedestrian walkways will be placed near the sites to provide convenient access and to reduce the needs to access these sites through other undesired motorised means.

3.2. The LRT and sustainability – the exogenous way

Once the LRT is built, together with an efficient operation, private transportation users and some bus users are likely to be attracted to switch to LRT, as indicated in Chan (2007) and discussed before. The switching of motorised modes to LRT will have positive impacts to the environment. This is because there will be less people using private motorised modes to commute to work, to school or other purposes. For others who do not switch their travelling modes, the roads will be less congested for them, and this will certainly help to cut down the emission and noise, and consumption of fuel, when they drive. From the perspectives of long term transportation management, the needs of owning cars or motorcycles may become less compelling as compared to now, because LRT can provide a safe and reliable, and may be faster, way to reach many people's destination. If this happens, it will help to relieve the pressure on road infrastructure and carparks, more spaces can then be converted for parks and green spaces. New developments can also be linked to LRT as the most direct way of access, cutting down the need to provide direct bus services, as it is now.

The challenges in reaching this target is to make sure that at the design stage the infrastructure are properly designed and scaled to meet the requirements. For example, the system with the endogenous characteristics as mentioned above must be built carefully and successfully. The LRT operations need to be really safe, reliable and efficient, for it to become the choice mode for the majority of residents and visitors. The integration with other modes and facilities must be well planned and synchronised to provide the greatest comfort and convenience to people who may use them. There should also be better knowledge on the demand for the LRT service, including those genuine, or captive, public transportation users, and those who switch from other motorised modes. With such knowledge, the infrastructure

and the operations can then be better scaled to provide the right capacities to meet the demand. With all these considerations met, one can expect that the future scenario of travel within Macao will be very much different from now. Many streets will become better for walking, and LRT will serve the need to travel long distances, even bus rides will be more comfortable and reliable when there are less traffic on the road. And this is truly the manifestation of the more salient aspects of what a sustainable transportation will be in Macao.

4. Conclusions

While the record high growth in recent years has dramatically changed the way of life in Macao, it is finding difficulties to cope with the increasing demand for road space and to preserve its living environment. The Macao Light Rapid Transit (or LRT) to be built to provide a more convenient and environmental-friendly way of travel for residents and visitors has been introduced in this paper. Consuming less energy with almost zero emission and low level of noise, the LRT can transport more people in a more sustainable way than the conventional modes of transport, which all relies on limited road space, in Macao. Past studies have reported that the mode share of walking and public buses is about 65%.

A sustainable transportation policy of giving priorities to public transportation and to promote it as the choice mode of travel has been defined. More specifically, LRT will become the core mode of travel, connected to a network of pedestrian walkway system, and integrated with buses and taxis. This is in recognition of Macao's unique characteristics and the constraints it faces.

To work with management strategies that will favour public transport, the Macao LRT can help to improve the environment by attracting more car or motorcycle users, therefore cutting down the number of private vehicles on the roads and free up the road space for pedestrians and buses. Through connecting pedestrian walkways at LRT stations, it will help to ensure that most places, especially historical sites, are within walking distances, a culture of walking that Macao can continue to be proud of and a key element to ensure that Macao will have a sustainable transportation system for the continual growth in its economy.

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