1 In the scope of a Public Policy [1]

Public transportation falls in the category of public goods, this is to say:

Community requirement – To assure mobility that community requires while performing **daily obligations**, as well as during **leisure time,** via improved recognition of community basic needs.

Community safeguard – To monitor and coordinate measures by which **individual behaviour evolves to solidary community orientated standards**. Regarding transport policy, this is to say that the increasing use of the private car not only works against the present improved awareness of urban environment and public health, but also increases inefficiency in congested areas, working against individual and community interest at the same time.

The safeguard of the public interest often results in a set up of measures that restricts the freedom of the individual user. Penalties or taxation are known actions, but **the most successful concerted actions have been the set up of improved standards of comfort and efficiency by which the private car users become motivated to use public transportation**.

Public transport routes and systems have evolved in cities over the years. Out-of-date acknowledgment is often based on parameters regarding **load**, **economy, comfort** and,

[1] The main target should be to increase general mobility and to reduce dependency of individual transport ownership.

Comfort and efficiency are achieved via:

- Quality of the equipment
- Coverage
- Frequency
- Speed
- Integration with other systems
- Efficiency and comfort of network and interfaces

All these standards are to be enhanced via:

- Facilitation and access to administrative and consume needs at interfaces
- Attraction of civic life events at staion piazzas and atriums
- Beautification

more recently, the raising awareness for **lesser visual impact and more environmental friendliness** (mostly noise and gas releases).[2]

2 Sustainability

The quality of public goods (the category of goods in which public transportation falls) is not only to correspond to the public assets but also to express the commitment of a public policy in the application of those assets.

In the very specific scope of developing economies based on tourism, orientated to foreign/non-regional visitors and propelled by foreign investment, the evaluation can only be more sensitive in the framework and rise of public awareness towards social sustainability.

It is known that when local community is **not directly involved,** or beneficiary of the revenue generated, population **turns rather indifferent**. But in case the community is to experience levels of constrain, i.e. **urban/social stress**, the feeling may easily **evolve to irritation**.[3]

Within social sustainability criteria, the keyword is very likely to be **improvement of urban environment as social counterpart of development.**

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[2] The provision for public transport has been basically supported on three types of networks, either separately or in conjunction with one another. They have been the buses and trolley buses, light railways (trams) and heavier railways. Each system is chosen as best suited for the job it has to do, depending on the number of people to be carried, the distance to travel and the urban geography.

Among all systems, **buses tend to be regarded as the second rate form of transportation**. This regard is mostly based on the acknowledgement that often **out-of-date vehicles are in operation and circulate in already congested streets together with other traffic**.

The fact that by using busses it is possible to assure any emerging transportation need without investing in infrastructures other than the roads, which already exist, made **buses the workhorses in transportation system,** as well as the preferred system for private concessionaries and less committed public policies**.**

[3] It is under this evaluation that former considerations envisaging new transportation systems and strategies for Macau SAR, which were initially specifically addressed to visitors, connecting strategically tourist spots, **could only but be a most unsustainable measure to social environment.** It would also only strengthen corporation business, probably destroy community small business participation in the tourism orientated economy, for which **one can only but support the decision for the quite different approach in the undergoing study, regarding city transportation.**

On the other hand, **Macau SAR tourism can only reach uniqueness value if based on an urban experience**, not if tourists mobility is channelled, exclusive or separated from the urban and communal substance, criteria that very much fall in the **category of appreciation improved standards, of progressively more learned tourists**.

It is much in this understanding that **an efficient urban transportation is by all means a peacemaking infrastructure as a communal counterpart of economic development**.

3 Opportunity

Macau SAR urban tradition largely accounts for the lack of effective overall planning, far more consequence of sectorial opportunities or necessities, most cases supported on private initiative partnerships, while maintaining territorial strategy flexible.

Therefore, it has been more via functional infrastructures and service networks than via comprehensive urban planning, that it has been possible to assure articulation of the city's various fabrics and moments.

If this has been the tradition, as well as a trained capacity, **the prospect of a new transportation network can only generate unique opportunity for regional articulation in the scope of a public urban strategy in the enveloping and comprehensive sense of planning.**

4 Trends and Changes of Behaviour

Many cities are now better places to live and work, and **there has never been more of a demand for a better functional and visual environment for the city** to become a 'delight' to be in and a place to enjoy, rather than an environment torn apart by traffic.[4]

Transportation design, stations as well as equipment, are also considered in a quite different approach. They are not only orientated to efficiency and comfort, but also as an **expression of the many enjoyable and sophisticated aspects of the cosmopolitan life,** for which operators progressively tend to be more receptive favouring imaginative design.

[4] The urban model of Macau SAR is strongly characterized by South European urban models, such as **the existence of an orientating cosmopolitan city centre**, which favours human interaction, and can be particularly stimulating when it comprehends an historical core.

The framework of European cities aspirations by the year 2000 was to retransform cities in regard to their natural aptitude, by making the urban space quieter, safer and more enjoyable, **pedestrian accessible, but also publicly transported, by means that are a delight to use, comfortable, convenient and efficient.**

The known success of the metro in Bilbao, the Meteor Line in Paris or the London Jubilee extension in bringing light down to platform levels has added a totally new delight to a new generation of underground travel.

It is **for this type of counterparts** that **residents are willing to adjust behaviours** and give up older habits, or older priorities, such as to own a private car.

Also much of the criticism gathered locally by this undergoing public consultation regarding a new transportation system for Macau SAR, is to be evaluated in the category of **common scepticism driven by older habits,** which falls in a specific category of social phenomena, and is to be verified via available data on similar transformations that ended up to generate community participation and turned out quite successful.

5 The Future of city centre

In older cities, which boast restrictions due to pre-existing conditions, namely in centres, attempts to alleviate road congestion through building more roads or widening roads have long ceased, partly because land value is too high but mostly because of strong public and professional opposition. Traffic engineers nowadays tend to accept that **widening roads only brings more traffic in**.

However, it has not been so easy to accept the closing of roads, or the reducing of space for vehicle circulation on streets, with the unshakable belief that 'traffic must have somewhere to go', but after all, **all it took was a change of behaviour with the reassurance of far more attractive alternatives and counterparts.**

The present experience is that the city centre can be pedestrian-only about 1 km square, and still quite manageable, when directly accessed from periphery by underground transportation and locally served by bus-trams and taxis, with scheduled pick ups and deliveries.

The expectation for the city centres is to have them **compact, efficient and ideally to have everything within walking distance.** Roads are to carry only essential traffic and **to eliminate vehicular pollution as first priority.**

Onstreet parking in the centre is to be limited to short period passenger pick-ups only. Pavements are to be more spacious and less constrained giving priority to more

environmental, **cleaner, safer and more attractive** planning. Service vehicles are to be encouraged to make deliveries only at off-peak periods. Residential parking spaces are to have priority before commuter parking.

As much as cybernetics generate new ways of interaction, technology is most unlikely to make city centres obsolete. It is common awareness that **city centres fall exactly in a specific scope where humans favour to interact materially** instead of virtually.

City centres will continue to be where business is, and face to face contact remains a deciding factor in human interaction. Together with an existing historical core the city centre envelope many qualities of urban life, which cannot be found elsewhere.

City centres will always be a preferable place to be and live but only if its environment is to evolve to improvement rather than to diminishment.

Among other factors **for city centres to survive it is necessary to house more people in the core area**[5] **with a sustainable demography.** Residents may give life to the city centre out of office hours and go to work within walking distances.

If more people would dwell in the city centre, the same transport infrastructures that **gives efficient access to commuters to their working places**, could well be **the same infrastructure that gives city centre dwellers the possibility to have efficient access to environmental decompression.** (The kind of resource a city centre is less strong in, by definition).

Future city centres are now to be planned for a much greater mix of uses in opposition to the past trend of rather specialized uses.

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[5] The contemporary demographic segment that corresponds to this population is the 'dinkies' (those with dual income and no kids), who prefer the buzz of the city rather than the peace of the suburb and tend to develop partly sophisticated, partly alternative living styles.

They are dwellers who favour a stimulating surrounding and also the possibility of carefree means to escape to leisure facilities or natural surroundings. For them a private car may not be a priority, as long as other forms of mobility are assured.

This is a demographic segment that only needs solidarity incentive policies, such as easy access to purchase small older apartments in the centre, incentives that may easily trigger their motivation and energy, and generate a potential task force in urban renovation.

Urban Renovation falls in the category of public goods, even when released to private concessionaries in substitution to the public sector.

In this understanding it is possible **to make both sides of the pendulous equation of demographic mobility** between city centre dwellers and suburb dwellers **more even**[6], balancing commuting fluxes and making uses and carrying capacity more efficient**.**[7]

These are **trends** in social behaviour **that may directly and favourably influence mass transportation fluxes as well as to shape new strategies in transportation**.

Therefore one can only but to admit that any envisaged automated transportation system for Macau SAR could favour from a very early stage an express line that could link the whole territory from the Gong Bei Border Gate to the island of Coloane, as a **potential basis capable to generate potential new trends in urban behaviour, demography, as well as the nature of the transportation strategy itself.**

[6] While envisaging possible new trends in flux equations, **temporary demography** (tourists) may be relevant in terms of carrying capacity but not in terms of behaviour.

As much as tourists move in quite preconfigured geography, in most cases rather unchangeable, activities seldom run on restricted schedules and are more likely to occur during off peak periods.

[7] The **development of other centres in the metropolitan area** may also encourage the reduction and multidirectional distribution of fluxes as a consequence of the autonomy and multifunctionality of other centres, provisioning for daily life necessities, housing, job opportunities, health and educational facilities as well as consume goods.

6 Relevant Changes [8]

Relevant changes in public transportation emerged largely from the acknowledged necessity to define different criteria regarding the articulation of the centre and the peripheries. These transformations gave new rise for the **heavy rail**[9] and **light rail**[10] systems, connecting the outskirts directly to the city core, instead of making room for a functional city core periphery to interface with the suburban transportation system as by older trends.

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[8] **The evaluation** is that, if the centre is to be equipped with multi-storeyed car park around it, which was at the beginning considered as crucial for the city centre survival, this ends up to generate heavy use concentrated on the inner ring road system. This hasn't in any way reduced the use of the private car and has even demanded for heavier infrastructures to facilitate the commuter traffic, which was taking land and setting up **fortresses of traffic flow and road infrastructure** around the city centres.

For the known demographic fluxes, this concern doesn't seem to have direct application in Macau SAR territory, much as a result of the known characteristics of concentration and confinement. However two major **factors of increasing complexity, may configure situations that may correspond to what present trends recommend to avoid or to change**:

1 **The level of urbanization is reaching a continuum but is not equally distributed**. Specialization is likely to occur. (In aspects other than entertainment, concentration/specialization is to be avoided as a generating factor of simultaneous unidirectional fluxes).

2 **The regional interfaces,** namely the boarder gates, the maritime terminals and the future bridge to Hong Kong **will generate more road use.** Under present restrictions is not the expected number of vehicles entering, but rather the traffic it generates to feed these interfaces.

In the scope of **'retrofitted measures',** such as little availability of parking spaces at transport interfaces, or the high use cost of parking space, they are all rather unpopular measures. However social behaviour may well adjust to new standards via attractive public transportation, may motivate changes in habits, namely the use of the private car.

Examples of strategically **retrofitted measures** is the deliberate omission of "**park and ride"** facilities at stations, in order to reduce the traffic generated by them and to encourage passengers to reach stations on foot or by other feeder systems, or to be simply dropped or picked, either by:

"**kiss and ride"** (a lift from a friend or a relative or a taxi service)

"pooling systems" (either **"car polling"**, when friends or family arrange their schedules in order to share the same car, or **"van polling"**, used by corporations to serve fellow workers living in the same building area or run by some residential conglomerates as part of the common facilities for the residents.

[9] **The heavy rail** aims to serve periphery and outskirts fast, only with a few stops to city centre; crosses the city underground, stops are normally at interfaces, interconnects other **feeder system networks**, relies on **interface strategy** and encourages peripheral satellite centre development. Heavy rail requires heavy infrastructure and is essential in larger scales of complexity.

[10] **The light rail** can serve periphery relatively fast, as well as circulate in the city centre. It can work as a feeder system as well as a stand alone system, depending only on adequate infrastructure or line requirements to cope with different hierarchies of performance.

Today's available hardware resembles an improved tram, comfortably accesses and smoothly motioned, which can **run safely at reduced speed among pedestrians** as well as at higher speeds, underground or in channelled tracks, to reach periphery fast.

The light train system were initially adapted to intermediate complexity, to assure automated and pollution free city circulation, while avoiding heavy and expensive underground tunnelled circulation and stations. Light trains cover the total transportation network of cities as complex as Melbourne (3 488 750 inhabitants), Strasbourg (450,000 inhabitants) or Portland (235,000 inhabitants).

7 The New Metro (heavy rail)

The underground train (occasionally aerial but originally envisaged as the **metro**politan transportation of the future) was in its first generation considered the visionary urban mass transportation in terms of efficiency and carrying capacity.

The evolution was that while roads were being freed of mass transportation systems, they became room for the transportation of the private car of the urban elites.

Later, by means of urban demographic explosion and the democratization of the private car, transportation returned to crowd the streets. (by means of the private car, as well as complementary demand of public transportation).

Present 2nd generation [11] of underground transportation had to deal with new strategies of mobility regarding accuracy, reach, efficiency, carrying capacity, safety and a whole new level of hierarchy of services in urban networks, very much targeting a change of habits, namely the commuter use of the private car.

The difference is that **the new demand on Metro network coverage density is not to be the same as in the 1st generation**. Not only stations could no longer be as close to each other as before (trains and platforms were to accommodate more units and too many stations reduce efficiency) but also station design became rather complex due to improved means of escape in order to evacuate platforms in four minutes and provide ventilation systems which can get rid of smoke rapidly, (now essential requirements that have considerable impact in space requirements, even at surface level). Therefore new underground rail, targets mostly the express type, necessarily belongs to a certain hierarchy of transportation ands is to be integrated with other systems (either existing or to develop).

For the quite lofty spaces underground mass automated rail requires, any large scale urban renovation operation is nowadays **an opportunity not to miss** to comprehend public transport interfaces, which are difficult, if not impossible, to accommodate in condensed city areas where ground is not so commonly available.

8 The New Tram (light rail)

Present trend very much recognizes the construction of **light rail routes**, with units that carry in average 200 passengers, as the **way of restructuring cities targeting**

[11] Known city transformations from 1st generation to 2nd generation are:

- Stations platforms of existing lines had to be extended and some platforms became so close to each other that can almost be interconnected, i.e. Lisbon).
- Some stations in existing lines have been deactivated for being so close to each other (i.e. New York).
- New lines of the metropolitan express type had to be built, which directly connect periphery and reach city centre accurately and fast, in order to meet designated standards of efficiency, while others lines remain in use as feeder systems and local distributors (i.e Paris, Madrid and London).

efficiency, environmental sustainability and little impact in cityscape. It became one of **the success stories of public transport in recent years,** as alternatives to bus routes, and are now known to be running in over 100 cities worldwide, being most of those cities in Europe.

Efficiency is monitored nowadays by devices that can show to drivers if units are running on time, to passengers when will next train approach the stop with 'real-time' information boards at stops, *transponders* may turn traffic lights in their favour at junctions and *pulse scheduling*[12], together with appropriate design, can coordinate the network in order to enhance interface efficiency, to minimise waiting time for passengers changing. Criteria known as *seamless interchange* for comfort and efficiency in public transportation.

Light Rail allows the same city coverage as busses, stops are placed normally every 300-400 metre intervals, or within a range of 5 minutes walk. It gives answer to many population expectations in the scope of comfort, freedom of movements, safety, reliability, public hygiene, and has actually been reducing traffic, namely the use of the private car in city.

Depending on complexity **they can be combined in different levels of interdependency.** [13]

9 New possibilities of light rails and distributive networks

In the scale and scope of distributive transportation, urban renovation operations regard the **Light Rail**[10], the improved tram type, to be a most successful solution in order to correspond to environmental criteria in public transportation requirements, at levels of efficiency and comfort [14] never experienced before, most pleasant to use when naturally or imaginative blended into the cityscape.

Most models available can operate on an exclusive right of way, as well as in mixed traffic or even among pedestrians.[15] This is to say that the same model can operate in urban circuits assuring safety requirements in close circulation with pedestrians, as well as to circulate

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[12] Units are timed to arrive at an interchange point the same time as other units are about to leave in other directions.

[13] They can be supported by other feeder systems which may cover areas less favourable to the set up of road infrastructure such as low density areas or extremely constrained urban fabrics.

They may also feed other more express regional networks, which cross the city underground interfacing efficiently the crucial and busy points of the network.

[14] Nnowadays equipped with wide doors and integral low-floor, ensure easy accessibility for the disabled and prams at 25cm from road level (virtually at pavement height).

[15] The steel structure of the frame has been pulled up to the sidewalls of the tram to make them streamline and protect the passengers in case of collisions along the side of the vehicle.

efficiently on express ways at higher speed. (Bombardier is a well known make. Light rail department based in Vienna)

Brussels,Belgium

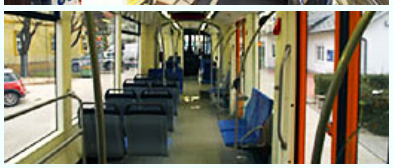

Eskisehir,Turkey


Geneva, Switzerland


Graz, Austria


Linz, Austria


Lodz,Poland

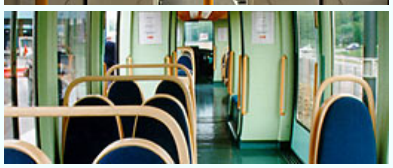



Marseille, France


Milan, Italy


Porto, Portugal


Strasbourg, France




Strasbourg

Bordeaux

Automated systems are however dependent on a rail and aerial infrastructure. This is the drawback of such systems but also the incentive that propels research to make automated motion lighter and more manoeuvrable.

In this aspect recent improvements have been made, namely the designated Guided Light Transit (GLT) system (different from the VAL system now in operation in Singapore, which is geared for automatic operation and requires vertical guide-rails)

GLT system[16] operating in Nancy, known to have had some difficulties at the beginning, is the effort for a cost-efficient solution with minimum road infrastructure bridging the gap between road and rail.

[16] The modular, bi-direction Translohr now in operation on the Val de Marne Busway, guided along a shallow central rail, varies in length from 18 to 39 meters; it can carry from 2,000 to 5,000 passengers per hour and direction, depending on the number of articulated modules chosen. The main benefit is its rail and road bi-modality: it can be operated on a segregated electrified lane with a single central guiding rail, or operated as a road vehicle on tires, driven independently and powered by a diesel-electric system or under its own battery to return to the depot or negotiate wireless stretches or tunnels. The manufacturer also states that the vehicle is low floor throughout, has a narrow turning circle, can negotiate gradients up to 13 percent, and costs half as much to build than a conventional tramway.

Clermont-Ferrand, France

Padova, Italy

L'Aquila, Italy

Sakai, Japan

Mestre-Venise, Italy

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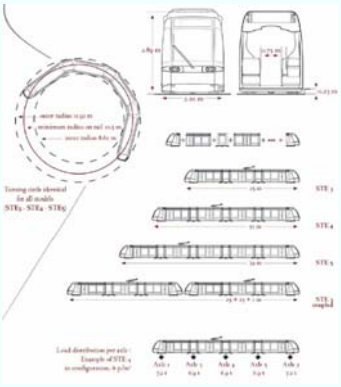
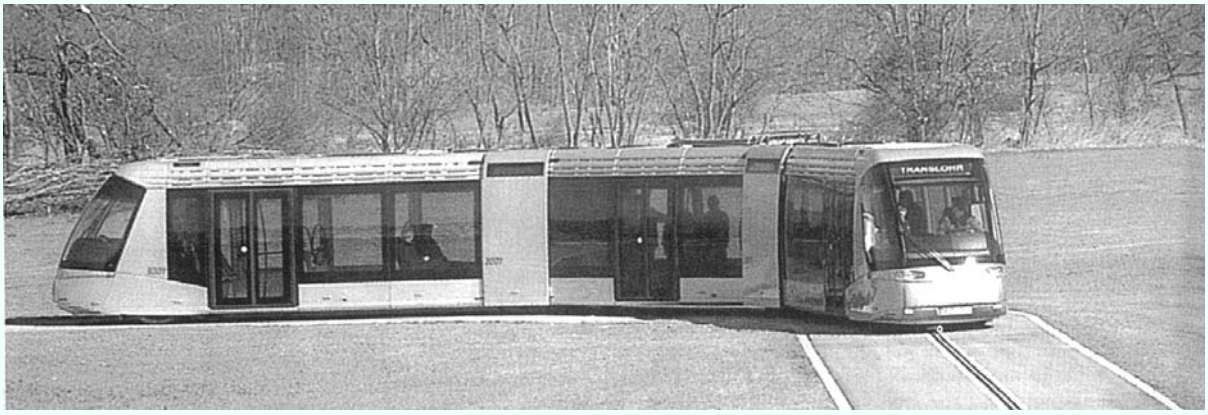
Although GLTs are Rubber Tyred Vehicles, roads lightly structured still have to be reconstructed in order to meet necessary road surface specifications as the vehicles are relatively heavy and guidance forces them to run over the same part of the road surface all the time.



On the other side, they are far more manoeuvrable (and equally in all allowed modular combination) around horizontal curves, and also able to climb steeper gradients while respecting environmental and community noise standards.

The multi-articulated vehicles boast a rather state-of-the-art design concept with wide panoramic windows, allowing unobstructed views of the cityscape, and meet high comfort standards for passengers with 100 per cent low-floors.

Nancy[17]



[17] Tram-on-Tires – Nancy, France

In 1998, the Greater Nancy Urban Community (CUGN) of France ordered 25 Tram-on-Tires units from Bombardier Transportation, with the objective of equipping its segregated-lane transit system and expect to brighten the City of Nancy with innovative, modern and environmentally-friendly new features in exchange of its existing trolleybus network

The rubber-tired GLT, features automatic guidance via a single rail imbedded in the roadway, requires fewer infrastructure works than traditional trams, and can run off track and on battery to return to the depot or negotiate catenaryless stretches or tunnels.

10 Revolutionary systems.

As much as street automated mass transportation improvements made accomplishments regarding city environmental sustainability, comfort, efficiency and safety, two main targets are still the experimental frontier for lesser dependency and economy, namely street infrastructure:

1. The suppression of street catenaries for power supply [18]
2. The suppression of street rails, or guides. [19]

Ansaldo-Breda Stream

The most complex system, but with the potential to replace inferred visually disruptive overhead. Uses a magnetic pick-up to collect power, from a flexible conductor in a 300mm x 600mmm trench.

Cost high
flexibility medium
capacity medium
status Trieste trial

Renault/Matra Civis

Uses painted lines on the roadway seen by a computer recognition system to steer the bus. Propulsion said to be by operator choice, although double overhead is more realistic than a battery or diesel option.

Cost medium
flexibility high
capacity high
status prototype building Lyon and Rouen trial

Cegelec AEG

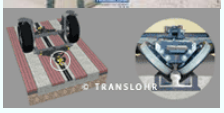
Promoted (unsuccessfully) for Liverpool, the 'MRT' uses buried cables that guide the bus by induction. Conventional trolleybus overhead supplies the tractive force.

Cost high
flexibility high
capacity medium
Status project only

Bombardier GLT

The most tram-like device, but with rubber tires. Utilizing conventional rapid transit overhead but a guiding and current returning buried mono rail, this bus has also been proposed with trolleybus overhead

Cost low
flexibility low
capacity high
status trial built



Translohr

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[18] The suppression of Catenaries for power supply has been implemented by Ansaldo with a system called STREAM, a technical sophistication of the underground traction power supply, being tested in Trieste. The electric propulsion comes from battery or by collecting power from the track. Current collection is made by electromagnetic activation of an electric contact line embedded in the roadway and supplying power, which has been adapted for urban purposes as the contact line is under voltage only beneath the vehicle. (very much like a Scalextric model)

[19] The suppression of ground guiding and railing is now being successfully developed by Matra Civis in conjunction with Renault with optically guided dual mode vehicles being tested in Lyon and Rouen, France.

11 Evaluating present vehicle circulation in Macau SAR

First thing one is to acknowledge is that circulation in Macau has gradually evolved to almost exclusively channelled type, which is:

11.1 In order to cope with traffic and parking needs, traditional roads have become mostly single way in Macau peninsula. Destinations can therefore only be reached along specific circuits with little, if any, alternative.

This is to say that **the freedom of movements of a private car user to opt for an itinerary is rather limited and not too different of the itineraries of the buses in circulation.** The advantage of the private car is only, comfort and schedule freedom, via exclusive means.

11.2 On the other hand, since road circulation in Macau is already of the channelled type and optimized along designated corridors, especially in older areas, **if public transportation was to become bound to a preconfigured rail/catenary network, but also automated and pollution free, qualitative advantages were to be achieved and dependence of preconfigured itineraries wouldn't result in any cumulative restriction.**

11.3 Present acknowledgement is also that existing public transportation system, solely supported on buses which run on very short interval schedules on specific traffic corridors, congestion **ends up configuring city bus convoys, in no way smaller than conventional light trains**.

Therefore, it seems to be in the scope of **present heavy city bus use,** acknowledged as out-of-date by present standards of efficiency, security and environmental criteria, although making efforts to renovate obsolete material), but still **without hierarchy strategy targeting efficiency** (comprehending in the same line rather inefficiently local distribution with stops within 300-400m reach, as well as long distances with the same interval of stops), **what urges to assure by new standards of service in public transportation.**

12 Hierarchies and interfaces (see point 3 for reference on opportunities that may missed in non concerted planning,)

While comprehending a new system of transportation for Macau SAR it is necessarily to articulate a hierarchy of transportation services (given or envisaged), which have different requirements, performances and use equipment with different specifications. (see for reference attached tables).

Metro specification requirements are nowadays difficult to set in practice with the functioning of a distributive network (see point 8).

However, the introduction of a **Metro system can alleviate distributive network use, assure more efficiency in the longer distances, but is to be strategically concerted with other feeder systems via interface coordination**. [20]

[20] Taking an airport as an example of a rather uniform density of circulation and complexity, much like an urban continuum, far end gates are now reached directly with a shuttle rail, but gates are to be comfortably accessed by conveyers (moving pavements). Conveyers are less busy since there is the shuttle rail for longer distances, and shuttle rails are very efficient as long as they reach destination with minimum number of stops. **Efficiency is met by best performance in each hierarchy**.

Prospective Macau SAR Automated Rail Network

	Regarding the 4 different alternatives the equation probably main criteria are: 1. **Demography criteria**, as circuits develop along areas mostly residential 2. Technical feasibility and **ground mechanics** regarding tunnel construction, whether to be made at open air drench or underground drilled.
	**Solutions A and B** is possibly feasible and less expensive if using **open air drench constructive methods**. However, served areas appear to be busy but only because they are used as traffic corridors. They are **not so densely populated nor has an efficient radius of influence** as half of its sector is mostly mountain. The A and B alignments **will probably continue to be complemented by ground transports which may result a bit redundant** in these areas regarding transportation coverage.
	**Solution C** has the advantage, **not only to run through more densely populated zones and closer to the city centre, but also zones of very difficult access by other conventional transports.** Solution C is also the alignment that **mostly depends on rock drilling** but also **less susceptible to be conditioned by complex existing building foundations**. Access to station platforms for this alignment will probably **have to make use of private property**. Is **probably the most expensive solution but also most achieving** providing it will be well articulated with other surface transport feeder systems which will more easily operate and serve other less ground constrained zones.
	**Solution D** has part of the practical advantages of solutions A and B but not the achievements of solution C. **The weakest point of this solution is probably the feasibility of the diagonal segment which runs cross wards an alluvial sediment valley under existing construction.**

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Taipa Island Network

Lesser strengths of the proposed network in Taipa island are:

- **Airport station should be either on an express line to city centre or on the most distributive line** (blue). The reason is that individual travellers carry language and local transportation should preferably reduce line transferring to minimum while carrying language.
- **The mountain tunnel of the Airport Line is a rather heavy and expensive infrastructure for only rail use** and not attractive enough to combine other utility with this configuration.
- **Macau stadium, University of Macau and Macau Science and Technology University, should be served by the network** as they are attended by large number of users either on a daily basis or on pitch hours.

Presented Solution

If the possibility of a tunnel to run a rail through the mountain is to be considered, **it favours the opportunity to improve the access from Ponte da Amizade to COTAI,** while ducting road and rail traffic together.

Therefore:

- The continuation of the Macau-Taipa line (blue) to the Airport and to the Airport Maritime Terminal would **allow overall city direct access to Airport along one same line.**
- As by the herewith proposed alternative configuration A, the airport line wouldn't need a mountain tunnel. However, such infrastructure, in a crossed position, if to accommodate rail and road traffic would, on a shorter tunnel distance, have a great advantage to **flow traffic from Ponte da Amizade directly to COTAI without compulsory contouring the mountain along the Airport or through Taipa centre.**
- This tunnel would make possible a loop line (red line) that could serve **Macau Stadium, Taipa Norte, University of Macau and Macau Science and Technology University,** transferring to Nacau-Taipa Line (blue) at Stadium and Macau Science and Technology University.
- The extension of this line could serve in future the leisure facilities in Coloane Island [21]

Suggested alternative A

[21] Coloane rail line could be the visionary public strategy to assure absolute non dependency of the private car.
Basic priority would be not to need the private car to go to work.
Visionary priority would be not to need the private car during leisure time.

	• Another possible future strategy could be **to favour Taipa island more autonomously connected and animated by a rather own life style.** This is to say less dependent from Macau peninsula as today is. **Local circulation would be assured by an island line**, articulated but not integrated with Macau-Taipa line, or connections between Macau and Taipa will loose efficiency. In this approach, **Macau-Taipa line would evolve more favourably to an express line.** • As by the herewith proposed alternative configuration B, the distributive local circulation would better liaise the new entertainment developments, as well as leisure and sports. • The extension to a future Coloane Line is better articulated if connected to Macau-Taipa Line but not as an extension of the same line as it serves different peaks and schedules.
Suggested alternative B	

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Conclusions

- Urban railed automated transportation systems may assure different levels of performance, correspond either to the LRT-Light Rail Transit or the HRT-Heavy Rail Transit. Each of them report to specific different hierarchies of circulation and rely on infrastructures of different complexity.

- Any point in a city served by efficient transportation should be within 400m, or 5 mins walk from a public transportation stop.

- Automated **Heavy Rail Transit (HRT)** is to perform mostly in the transportation hierarchy of higher efficiency (longer distances) and **to be articulated or complemented by other feeder systems**.

- Automated **Light Rail Transit (LRT) can perform in the distributive transportation hierarchy as well as in the hierarchy of higher efficiency** with the same hardware, providing the expected carrying capacity does not exceed aprox. 350 people per service and relying on line infrastructure for higher speed (underground, aerial or exclusively channelled).

- In Macau SAR, an **efficient distributive transportation system may be rather a first priority** as by present acknowledgement. Distributive networks definitely require less investment and can be faster accomplished in the short term.

- At the same time **Heavier Rail Transit network is to be set up**, but more **targeted to the scope of higher efficiency**. Infrastructures will take longer to accomplish, but by the time HRT is in operation, it will **provide for the growing demand of higher efficiency** at the same time that **releases the increased urban stress that is still to be expected in future on distributive transportation networks** as a result of demographic growth and demand.

- **The quality and efficiency of interfaces play major roles**, and necessary spaces are to be agreed within urban strategies. Undergoing major and heavy interventions, such as Tap Siac Square and Lisboa Hotel, should not miss the opportunity of integration in the transport interface strategy at an early stage.

- **An automated mass transportation system is always an opportunity for new urban planning articulation.**

- A new transportation strategy is **also an opportunity to incentive and to generate new behaviours and life styles among the population**, as well as a motivation to change sustainably other not so good older habits.

- In tourism orientated cities, strongly characterized by an urban experience, there is no social sustainable approach to urban transportation if based on a strategy which gives priority to tourism over local inhabitants. The sustainable approach is **to favour a humanly resourced city rather than a tourist resort city,** even if the main resource turns out to be the hosting industry.

- Impact in urban public transportation regarding tourism is to be monitored in terms of carrying capacity as well as in terms of level of appreciation.

- Level of appreciation is to meet agreed standards that regard tourists as well as local population, as **sound criteria for sustainable public infrastructure in the scope of a tourist orientated economical framework.**

- For the tourist value of any urban destination, **stimulating planning and public infrastructures also play major roles.**

- **Visionary planning** should consider two types of allowance for growth:

  1. **Capacity**, space, size, scale, such as circulation spaces and length of stations.

  2. **Level of complexity**. The possibility to evolve to a different network configuration in order to cope with higher levels of complexity and standards of efficiency. [22]

Urgent measures are:

1. To stimulated **lesser use of the private car.**
2. To banish **obsolete hardware under circulation.**
3. To minimize the use of **polluting public transportation veihicles.**
4. To improve **mobility and comfort.**

[22] Spare allowance regarding efficiency does not only regard capacity but also articulation in order to cope with a hierarchy of specialization of the transport lines, such as the ability to cover longer distances in a shorter time and with less number of spots, and the ability of an efficient local distribution. This is to say that some lines may be extended to become express regional, and other lines may be extended to assure better local distribution. If overall coverage is to be obtained via the extension of a local distribution line, the service will gain more coverage but will loose performance and efficiency due to too many stops.

Performance and Application Comparative Chart I [23]

COMPARATIVE PLANS OF TRANSPORT SYSTEMS (metres 10 0 20 40 / feet 0 10 50 100)	COMPARATIVE SECTIONS TWO-WAY OPERATION (metres 0 5 10 / feet 0 5 10 20 30)	TURNING RADII	ECONOMIC DISTANCE BETWEEN STOPS	PASSENGER OR VEHICLE CAPACITY PER HOUR ONE WAY	AVERAGE SPEED
MINIRAIL (Intamin)		24 m 80'	600 m ·5 mile	4-5,000	50 km/hr 30 mph.
ARTICULATED THREE-CAR TRAM		15-30 m 50-100'	400-800 m 1200 '	10-20,000	32- 50 km/hr 20-30 mph.
GUIDED LIGHT TRANSIT (Bombardier)		12 m. 40'	4-500 m 1200'	10,000	32-50 km /hr 20-30 mph.
VAL SYSTEM (Matra)		40 m 120'	1-2 km. 1·7 mile	10-30,000	35 km /hr 21 mph
SHUTTLE TRANSIT (Otis)		18-90 m 60-300'	500 m ·5 mile	3-8,000	40 km/hr 25mph
SKYTRAIN		35 m 120'	1-2 km. 1·7 mile	7,500	47 km /hr. 29 mph.
MONORAIL (Alweg- Hitachi)		46 m. 150'	1-2 km. 1 mile	10-30,000	40 km/hr. 25 mph.
GUIDEWAY TRANSIT Adtranz)		22 m 72 '	1-2 km ·7 mile	8,000	30 km / hr 20mph
UNDERGROUND METRO		101m. 330'	1-3 km. ·5-2 mile	20-40,00	32-50 km/hr. 20-30 mph

[23] Future Transport in Cities, , *by Brian Richards, Spon Press*

Performance and Application Comparative Chart I I [24]

COMPARATIVE PLANS OF TRANSPORT SYSTEMS (metres / feet)	COMPARATIVE SECTIONS TWO-WAY OPERATION (metres / feet)	TURNING RADII	ECONOMIC DISTANCE BETWEEN STOPS	PASSENGER OR VEHICLE CAPACITY PER HOUR ONE WAY	AVERAGE SPEED
PEDESTRIANS				10,15,000	4.8 km /hr. 3 mph
BICYCLES				2-5,000	16 km /hr. 10 mph
MOVING PAVEMENT		straight	100-400m.	6,000	2.5 km/hr 1.5 mph
ACCELERATING MOVING PAVEMENT (Accel-liner)		straight & curved	100-400 m.	6,000	7.5 km/hr 4.5 mph
PRIVATE CAR ON SURFACE STREET				700-900 v.p.hr.	13-24 km / hr 8-15 mph
MINIBUS		6 m 20'	400-500 m 500 yd.	120 vph. 3,600	10-15 km/hr 6-30 mphr
DOUBLE DECK BUS ON CITY STREET		21m 70"	3-400 m. 500 yd.	120 vph. 7,200	13-24 km / hr. 8-15 mph.
EXPRESS BUS ON SEPARATE LANE		20m	1610 m.	1,450 vphr.	88.5 km/hr.
GUIDED BUS ON SEPARATE LANES		20 m 70'		120 vph. 10,000	100 km /hr. 62 mph

[24] Future Transport in Cities, *by Brian Richards, Spon Press*

Specification and Cost Comparative Chart I [25]

MODE	DESCRIPTION	CAPACITY	CAPITAL COST
Bus 	Rubber-tire vehicles which operate in mixed travel lanes or in dedicated bus lanes. Major air quality benefits will occur if area transit fleets substitute clean fuel buses for diesel buses.	85 persons per vehicle	$300,000 per bus United States General Accounting Office
Bus Rapid Transit 	A BRT system combines intelligent transportation systems technology, encompassing a variety of approaches including exclusive busways or HOV lanes with other vehicles, and improving bus service on arterial streets. photo courtesy of Lane Transit District (Newland & Co.)	40-80 persons per vehicle	$13.5-$55 million per mile United States General Accounting Office
Electric Trolley Bus 	Electric Trolleys are trolley buses with electronic propulsion. Electric trolley buses receive power from an overhead wire.	80 persons per vehicle	$6-$10 million per mile American Public Transportation Association
Guided Bus 	Similar to Bus Rapid Transit technology, except vehicles are retrofitted with lateral guide wheels and run on a fixed guideway system. Technology can be adapted to fit any bus size or propulsion type.	40-80 persons per vehicle	$10-$40 million per mile American Public Transportation Association
Monorail 	Single rail serving as a track for passenger or freight vehicles. In most cases, rail is elevated, but monorails can also run at grade, below grade or in subway tunnels. Vehicles are either suspended from or straddle a narrow guideway. Monorail vehicles are wider than the guideway that supports them.	45-55 persons per vehicle	$40-$80 million per mile Friends of the Monorail
Stream Bus 	Rubber-tire vehicles similar in appearance to buses. Operates on an underground traction power supply. Stream vehicles are electric and can disconnect from the guideway.	40-80 persons per vehicle	$10-$25 million per mile American Public Transportation Association
Light-Rail Transit 	Primarily at-grade rail mode with electrically powered vehicles receiving current from overhead wires. LRT can operate with other traffic along existing roadways or can be grade separated.	170 persons per vehicle	$12-$118 million per mile United States General Accounting Office
Heavy-Rail Transit 	Grade separated, electrically powered vehicles receiving power from an electrified third rail.	170–300 persons per vehicle	$50-$120 million per mile Federal Transit Administration

Capital Cost information provided in the table above is approximate and for general comparison purposes only. Actual cost to construct will vary upon final design characteristics and route location.

[25] The Briefing Book, The Northwest Connectivity Study, *by the Georgia Regional Transportation Authority*

Specification and Cost Comparative Chart II [26]

MODE	DESCRIPTION	CAPACITY	CAPITAL COST
Commuter Rail 	Powered by diesel locomotives instead of electricity. Commuter Rail usually follows existing freight rail corridors and travel intercity.	120 persons per vehicle	$5-$100 million per mile Federal Railroad Administration
Magnetic Levitation (MAGLEV) 	MAGLEV technology is based on magnetic levitation and propulsion. The guideway can either be elevated or at grade. Magnets fitted to the vehicle react with magnetic rails attached to the underside of the guideway. Levitation magnets attract the vehicle from below toward the guideway, while the guidance magnets hold the vehicle on course laterally. The train is propelled magnetically through a propulsion system located in the guideway. photo courtesy of General Atomics, San Diego, CA	50-60 persons per car/ 4-car train	$40-$100 million per mile Federal Railroad Administration
Automated Guideway Transit 	No driver-AGT can include steel-wheel, steel-rail or rubber-tire vehicles, which operate under automated control under an exclusive guideway grade separated from vehicular traffic. AGT may use conventional or alternative propulsion. photo courtesy of Miami Dade Transit Agency	80-90 persons per vehicle	$60-$100 million per mile Federal Transit Administration
Personal Rapid Transit 	Small, personalized cars that provide service on-demand, non-stop transport, use existing technologies in their design, and are computer controlled versus manually operated. The cars travel non-stop from the station where passengers board, directly to the destination station, by-passing all other stations. Because PRT takes passengers directly to their destination station, it operates on demand, i.e., the cars don't run on schedules but, instead, are waiting at the stations for their passengers to arrive. On-demand non-stop service makes the system more efficient and provides convenient travel at any time of the day. photo courtesy of Prof. Jon Bell, Presbyterian College, Clinton, SC	4-8 persons per vehicle	Not Known
Vanpool 	A vanpool is a group of seven to 15 commuters who choose to ride to and from work together in a van. One member of the group volunteers to drive and the others share in the cost of operating the vanpool.	7-15 persons per vehicle	Varies
Jitney Cab 	A rideshare practice that involves the use of private cars that serve as public transportation.	5 maximum persons per vehicle	Varies
Carpool 	Carpooling is a rideshare practice in which private cars are used to commute passengers to and from work.	5 maximum persons per vehicle	Varies

Capital Cost information provided in the table above is approximate and for general comparison purposes only. Actual cost to construct will vary upon final design characteristics and route location.

[26] The Briefing Book, The Northwest Connectivity Study, *by the Georgia Regional Transportation Authority*