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URBAN MOBILITY – A LRV (*VLT*) PROPOSAL FOR THE CITY OF PETRÓPOLIS

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Abstract. The present paper describes a proposal for constructing a Light Rail Vehicle (LRV) system, called VLT in Portuguese, in the city of Petrópolis, in Brazil, in line with the modern concept of granting urban mobility to intermediate cities. The studied city joins diverse conditions to improve its mobility, such as, its mild climate, forests, and topographical setting, its population, its historical and developing stage, and its cultural heritage, composed at the origin by German immigrants. The project emphasizes low cost plans and simplicity to propose the use of the VLT between the center of the city and all its districts along the ancient and no longer used rail line connecting Rio de Janeiro to northern states, in order to be adjusted to traffic jams that affect all displacements. The historical development of the city is described in its specific aspects, which also justifies the present proposal.

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1. INTRODUCTION

This paper discusses modal division strategies based on sustainable principles adopted by cities with low level of environment footprints. Modal division characterizes the proportion of total trips captured by each corresponding modal transport alternative which should be integrated in a strategic systemic vision defined by the municipality such that people's mobility and accessibility are optimized. The lack of modals must be considered including sidewalks and bicycle lanes, concerned how mature the accessibility is, from low capacity, or somehow primitive systems, up to high capacity transportation infrastructures such as rapid trains, subways or even airplanes. The CO2 emissions ought to be taken into consideration so that the city can be framed in the World Ranking of cleanest cities with the smallest possible environmental footprint contributing to the sustainability of the planet.

The Urban Mobility is a central concept for planning compact cities, for which an integrated smart transportation system and the ideal density to interfere positively in the infrastructure economy, without being detrimental to the efficient circulation and a healthy coexistence of its people, is desirable. The discussion arises in the context of an urban space classified as compact cities.

> "A compact city is a polycentric urban structure with ideal densities of housing, work, and recreation activities where the movement of cars are reduced and public and multimodal transport connecting the various neighborhood centers are privileged. In this sense, urban mobility is a key element for the creation of a truly compact city. The transportation system should be integrated and should contribute positively to the infrastructure economy without being detrimental to the efficient circulation and a healthy coexistence of its people" [9].

The Light Rail Vehicle (LRV), called VLT (*Veículo Leve sobre Trilhos*) in Portuguese, uses electric traction and is considered 100 % clean if electricity generation is also clean. This feature upgrades the system to a more prominent position than BRT – the Bus Rapid Transit modal, and all bus systems that use fossil fuels as energy resource and does not need to occupy exclusive tracks to its circulation.

The VLT can carry between 9,000 and 30,000 passengers/hour/direction with the advantage of coupling 2 to 4 cars simultaneously and can move as trolleybuses in the city. The proposed VLT model is generally called "the pre-metro", based on a system developed in 1974 in Rio de Janeiro, whose methodology was used at the time on the Integrated Planning of Rio de Janeiro Subway [5], in partnership with the Union Internationale des Tramways/Internationaler Permanenter Strassenbahn Verein, the association known nowadays as UITP (International Association of Public Transport), now applied to a real case study: the transport system of the city of Petrópolis, RJ. This low-cost pre-metro cars were developed at the time in order to create an intermediate capacity transport modal between buses and the subway. This last system, the subway, is considered a high capacity modal.

Once the municipality states that priority is put into operating the pre-metro in the city's transportation planning, it is necessary for the municipality to organize, in order to provide technical resources to enable it to digest the financial resources and, otherwise acquire, in the shortest time possible knowledge of urban reality, especially in terms of population mobility, as seen in Figure 1.

Planning should be articulated on two levels of action - macro and micro planning - without ignoring the essential characteristics. Planning should be focused on the core activities and to strengthen the existing team in the constitution of the municipal transport company, which can study alternatives in which the decision-making process does not contribute to substantially expand the physical and financial schedules. A concerned planning on meeting the goals is

being considered.

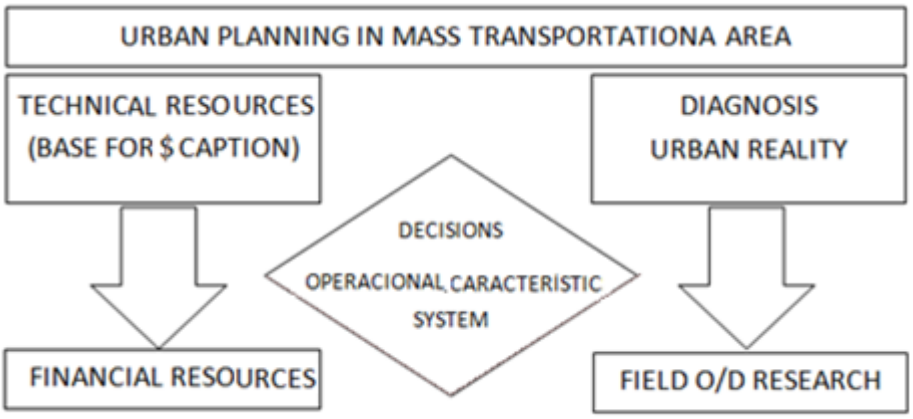

Figure 1: Urban Planning in Mass Transportation Area. Adapted from [5]

The systemic model of financial engineering must satisfy three big groups (Figure 2):

- Group 1 of urban, economic, social and environmental balance as shown in Figure 2: (a) integrated and decentralized system integration of modal distribution in planning the location of stations and stops; (b) provide beneficial characteristics from the urban point of view in order to distribute the most of the operating system in peak times; (c) identify areas of greater and lesser purchasing power, giving the population the greatest possible accessibility to the transport system of the city, so that the ticket cost is consistent with the ability to pay; (d) analyze the use and occupation of land in order to indicate urban voids that may collaborate with distributed demand related to the development of sub-centers; (e) reviewing the types of transport that use clean energy, which can contribute to sustainable development of the municipality; and (f) environmental comfort issues that will ensure the use of the form of transport to attract the user;

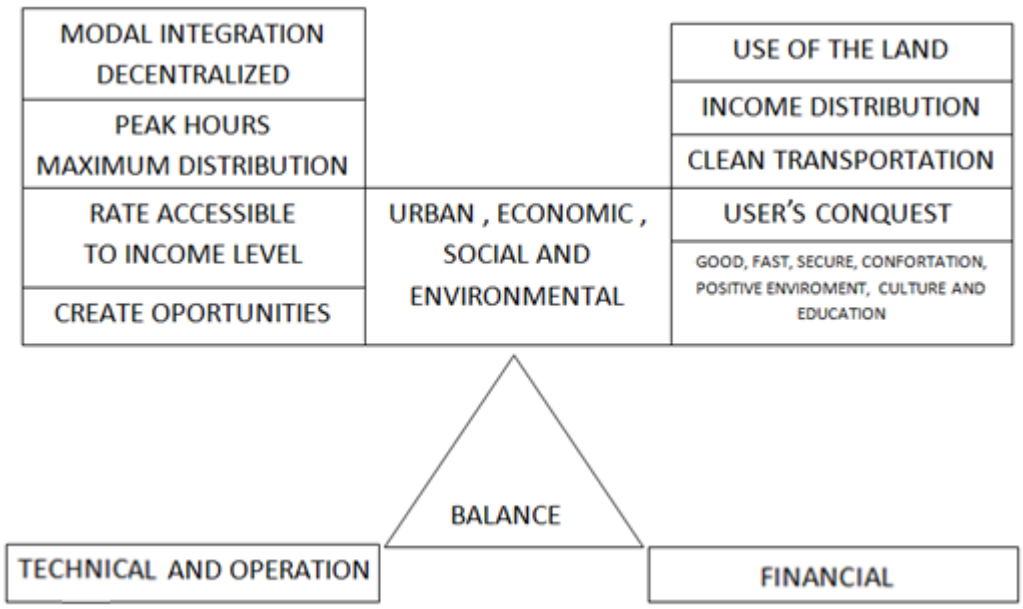

Figure 2: Groups of Balance. Adapted from [6]

- Group 2 of technical and operational balance: (a) investment schedule on labor, equipment and systems; (b) pre-established quality in the previous item guarantees in this way the balance of the system; and (c) calculated flows in order to avoid waiting in extension stations and stop points, or the integration with other modes; and
- Group 3 of financial balance: (a) enable the system financially or through credit lines or modes of PPP - public private partnerships, so zero investment in a given period [7].

According to the methodology used in the work, in planning it is necessary to consider the levels of major activities and their interrelationship - macro, as well as micro planning that will act as feedbacks from the macro planning. The macro planning considers the entire city and its current lines and future flows. This is a schedule for all the phases of the execution of a system that aims, when demand justifies it, the implementation of underground or surface metro.

The remaining of the paper is divided in four sections. Section II describes the land and its foundations, specially the contribution of the German immigrants; Section III discusses the proposed VLT; Section IV sketches some conclusions; and Section V presents the bibliography.

2. THE GERMAN INFLUENCE

The city of Petrópolis is situated in the vicinity of Rio de Janeiro about 70 km from the State Capital. According to the Brazilian Institute of Geography and Statistics (IBGE) [4], in 2015 the urban population comprised 95 % of the 298,000 inhabitants. The region is entirely mountainous, making its climate quite different than the one that prevails in Rio de Janeiro, especially during the nights and along summer time. Given a lasting rainy season, along the time the forests and the rains have formed rivers that have determined flat areas later occupied by the settlers, not only in the central areas but also in all districts of the municipality, while the numerous picks and wild forests have been mostly preserved. According to [4], the population occupies about 30 % of its vast territory, most of which is characterized by the Atlantic Forest in protected areas known as Area of Environmental Protection – APA (in Portuguese: Area de Proteção Ambiental) of Petrópolis. The downtown area is highly dominant, but in the other districts there are people that, for various reasons, are imposed to come every day to the center such as work, purchases, affairs in general, and schooling, since in the less populated districts the schools only offer basic education, and any kind of more advanced instruction requires the displacement to the central area.

During the imperial period experienced in Brazil (1822-1889), the second emperor, D. Pedro II, has built a summer palace in Petrópolis, which has become an independent city in March 16, 1843. In addition, according to [1], at the time, Petrópolis has received in 1845, more than one thousand German immigrants brought from Europe in thirteen ships, its first settlers, most of them engaged in the palace construction, especially on wood work. In their memory, the city has built an obelisk in the center of town containing about 300 family names of the first German settlers. With the advent of the two world wars, half a century later, and the number of Brazilians that decided as volunteers to participate in the wars, against the official interests of the country, the Federal Government has created barriers to the dissemination of the German language, including especially its taught and its oral expression, imposing to transgressors a jail sentence. With such measures, despite the significant number of inhabitants carrying today a German family name, the language is hardly spoken, although the taught of the language is nowadays freely offered.

After the advent of the Republic, in 1889, Rio de Janeiro remained the capital city of the country, and Petrópolis became the summer resort of all presidents, up to 1960, when the capital

was moved to Brasilia. The same might be said about the wealthier inhabitants of Rio de Janeiro which used to maintain two houses, one in Rio and another for summer occupation in Petrópolis.

On the cultural front, we might presume that the German settlers have left or stimulated a number of traditions, such as the world famous choir Canarinhos de Petrópolis, constituted by young boys, and created in 1924. Another cultural activity is the *Festa do Colono* or Bauern Fest (in German), i.e., the settlers festival, that has been happening in July in the last 30 years, when an estimated total of over 300,000 people, from all over, drink beer, eat German appetizers, and listen to German choirs, some brought from the south of Brazil, where the German influence was more predominant. During the last century, Petrópolis, continuously known as imperial town became an industrial city, preponderant on beer and textiles production. At the present time, Petrópolis retains a number of fine social indicators, perhaps leading indicators in the State of Rio de Janeiro, such as high living conditions, good safety, touristic city, and a proper refugee for the inclement summer temperatures that are experienced in Rio. However, the ancient urban plan of Petrópolis has concentrated the population in its center and left the traditional narrow streets surrounded by mountains imposing today heavy traffic congestions and lack of proper parking spaces.

3. THE VLT SYSTEM

The development of the proposed VLT capacitated transportation system appears economical in its construction and operation, and welcome by the people and public authorities, in order to make the transport to the center of town, and to avoid the usual traffic jams and lack of parking spaces. Notice again that the area of Petrópolis is enormous, especially in downtown area, which concentrates about 30 % of the entire population, but its occupied area is basically restricted to the flat areas carved by the rivers along the centuries and estimated in 25 % of the whole municipality.

Besides the downtown center, the entire municipality is split in five districts, according to Figure 3 (Center, Cascatinha, Itaipava, Pedro do Rio, and Posse), and the proposed VLT would cross all of them. The districts follow about a similar description, mountainous but protected areas having flat spaces, normally associated to river banks, where the much less dense population inhabit. However, as mentioned before, these populations are highly dependent of the center of the city where all administrative and political facts do really happen. Transportation to the downtown center is the problem at stake in terms of time, cost, and comfort.

The proposed VLT line will partially assume the railway line implanted by English constructors in 1850, which operated for more than 50 years, connecting Rio de Janeiro to Vitória and Belo Horizonte in the north of the country. The project plans immediately to recycle 27 underutilized wagons that are available in Rio de Janeiro. Those wagons made part of a project implemented in the capital city of the state of Rio de Janeiro in the 80's, in Metro-Rio Line 2, which circulated between 1982 to 1987 when they were removed from circulation because of the increased demand. They are still technologically updated for the lower levels of demand noticed today in Petrópolis.

Shown in Figure 4, these trains are still useful for 5 to 30 years. Similar wagons still operate in smaller towns (e.g. Brussels) where speeds range between 50 and 80 km/h, curves are up to 90 degrees, go up steep roads up to 4 %. Additionally, they have the advantage of having flexible load capacity due to the possibility of remaining coupled from one to four cars in its locomotive, depending on demand fluctuations, as happen at peak times.

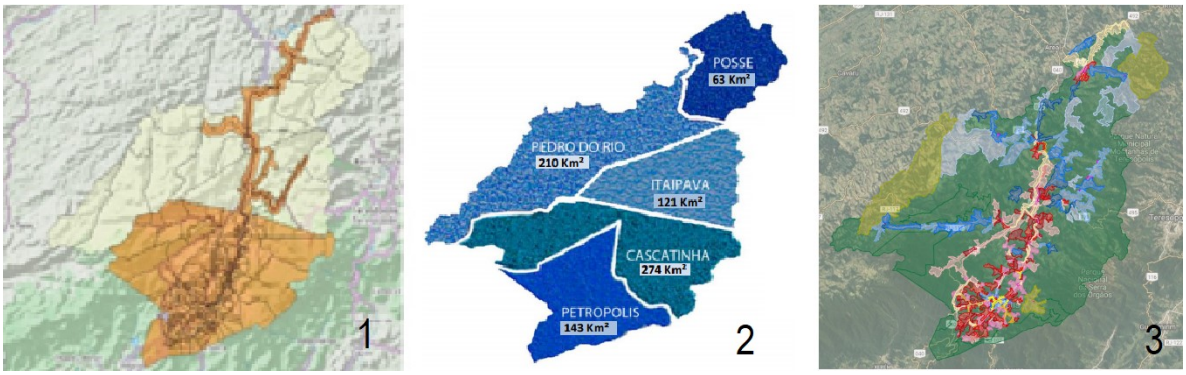

Figure 3: Petrópolis Geographic divisions: (1) IBGE sense, (2) District divisions and (3) city Zoning [8]

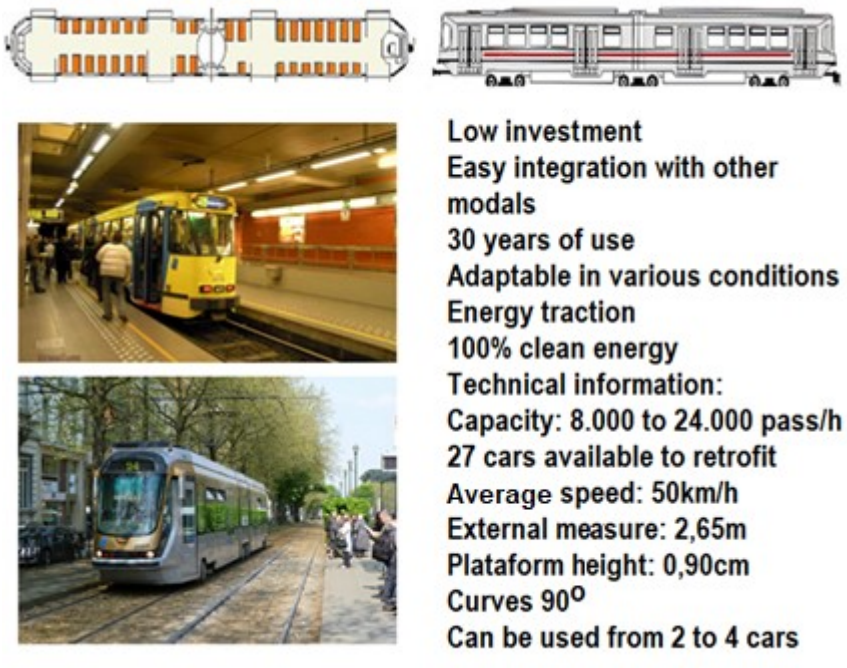

Figure 4: The VLT Car plants and elevation and its characteristics. Picture of Brussels cars; old fashion and modernized in 2000 [2, 10]

These cars are parked in Metro-Rio technical garage, seen at the picture taken from the Rio de Janeiro Municipal administration building, in Figure 5. Although needing minor mechanical revisions, the cost of acquisition and renovation of these machines is around 1/3 of the purchase price of newer equipment, a perfect case of retrofit design, giving the opportunity to develop bike integration.

The car design was specifically developed as a cheaper choice for integration and accessibility for lower classes in the city of Rio de Janeiro and years later were equipped with air conditioning, rated as unessential in Petrópolis.

Figure 5: Pre-metro parking, in Metro Rio Garage - Picture taken in 2017

The VLT system is a potential smart green infrastructure to be integrated in wider transportation system composed by other public transportation modals, such as buses and bicycle network, connecting the new bus station located in the highway BR 040 – the main entrance to the city, from Rio de Janeiro, all the way to Pedro do Rio, on the city limit, Belo Horizonte direction.

> "Social sustainability is a broad and challenging concept. Part of its focus is to give the various groups of society equal opportunities for access to the public space and also to move around the city. Equality is insinuated when people walk and ride bicycles in combination with public transportation." [3].

Other specific objectives were achieved in the city of Petrópolis, in October, 2018 the local University UCP – Universidade Católica de Petrópolis organized a public seminar discussion that served as a tool for legitimating the community involvement and various sectors in the project implementation for a real "Smart City". The discussion of an urban mobility and smart systemic view of public transport as a structural axis of sustainable development of municipalities through this case study in the city of Petrópolis-RJ could contribute to a wider debate. After this event the project to develop the VLT in Petrópolis got more force and it was decided to develop a prototype project area of five kilometers within the next years, before extending the project to all districts of Petrópolis.

4. CONCLUSIONS

This article has described the VLT system proposed for Petrópolis – RJ. The idea is to improve the access to the center of the city, avoiding the increasing congestion and the lack of parking spaces. The proposed system is economical in its construction and in its operations, reducing costs for the users in general. The proposed system shall be operational at least for the next 30 years, or even later, since the population of all districts grow at a limited pace.

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