

Original Article

Light rail vehicle in Rio de Janeiro: Alternative to public transportation in Brazil?

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ABSTRACT

This case investigated the evolution of public transportation modal light rail vehicle (LRV) in Rio de Janeiro, Brazil, designed to integrate the existent network models in a city with approximately 6.8 million inhabitants, served by metro lines, trains, bus, and port network. Veículo Leve sobre Trilhos (VLT) Carioca was conceived to transport approximately 70,000 passengers per day, inaugurated for the Olympics 2016. It is also the world's second tramway system to abolish entirely catenary overhead line (along with Dubai's LRV), using Alstom's alimentation par le sol ground-level power supply system. LRVs in Rio are not new. First launched in 1859, the former public transportation system was powered by animal traction. Later substituted by electrical tramway network (bondes), main public transportation until 1963, when the entire network was substituted by the controversial bus network, which contributed significantly for traffic congestion and air pollution in crescent scale. In 1898, electrical, catenary-network trams became the main public transportation, until 1963, substituted by bus networks. This single case presents the VLT Carioca project, along with analysis and discussion of the modal transport integration and impact to the current Rio public transportation system. Recommendations for future research complete the present work.

Keywords: Light rail vehicle, Public transportation, Veículo leve sobre trilhos carioca

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INTRODUCTION

This article investigated the light rail vehicle (LRV) system in Rio de Janeiro state, southeastern Brazil, as unit of analysis of the descriptive single case study.^[1]

LRV Rio is hereafter named Veículo Leve Sobre Trilhos (VLT) Carioca (VLT is the acronym for *Veículo Leve sobre Trilhos*, or LRV in Portuguese. *Carioca* is the native from Rio de Janeiro state, which means literally from indigenous language *Tupi Guarani*, *cari* = white, and *oca* = house. Literally "house of white" - referring to the Portuguese settlers, which occupied Brazil from 1500 to 1822 - colonial regime).

Rio de Janeiro state, which capital is Rio de Janeiro City, where the VLT was built, has 6.688 million inhabitants.^[2] The VLT Carioca was designed to transport 70,000 passengers per day, aiming to connect various arrival points in Rio, such as *Terminal*

Rodoviário Novo Rio (Rio interstate bus terminal), *Porto do Rio Janeiro* (Rio de Janeiro Port), and *Aeroporto Santos Dumont* (Santos Dumont Airport), located at the central region. VLT Carioca is part of the *Porto Maravilha Project*, which revamped the Center Rio for World Cup 2014 and Olympics 2016, in Eduardo Paes (Mayor) administration (2009–2017).

As part of the *Porto Maravilha* operation, the neighborhoods of Saúde, Gamboa and Santo Cristo gained new services, without losing their history, reintegrated to the dynamics of the city. VLT Carioca also connects trains, metro, *barcas* (waterway public transportation), bus stations, airport, and cruise lines (port), in a vital area for Rio de Janeiro economy, as well.^[3]

Porto Maravilha project was first conceived to revitalize Rio's central region, from 2010 to 2018 at the cost of BRL 3.5 billion (approximately \$ 2 billion). VLT Carioca is part of the project, also devised to eliminate 60% of bus and 15% of car

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traffic circulating in the central region.^[3] It had a cost BRL 1.2 billion (approximately \$ 400 million), approximately the same investment to reform Maracanã stadium, where the World Cup 2014 final match, and Olympics 2016 were disputed.^[3]

Porto Maravilha Project objectives' are mainly to reorganize and redevelop: (a) Approximately 5 million square meters on center region Rio de Janeiro; (b) 18 km tunnels (including Marcelo Allencar tunnel, with 14 km extension 22 m below the sea level); (c) 17 km of bicycle paths; and (d) 700 km of urban infrastructure networks.^[4]

VLT project started on 2012, to encompass initially two lines and 26 stops, inaugurated between 2016 and 2017, later extended to the third line inaugurated on December 2018. The fleet is composed by 32 Alstom Citadis trams, with capacity for 420 passengers each, and 44 m of length. Each tram is catenary-free, equipped with Alstom's alimentation par le sol (APS) ground-level power supply system. The main features of the VLT Carioca project are: (a) Main public transport modal between the port and central regions; (b) priority in transit; (c) improvement of the pedestrian; (d) vehicle traffic optimization; and (e) interconnection with existing public transportation models.^[4]

In July 2012, the Rio de Janeiro City Mayor, opened up the public bidding process, as per Law 8.666/93 and 8.883/94 on the VLT Carioca project.^[5,6] The bidding was held on April 30, 2013, won by the VLT Carioca consortium, formed initially by Invepar, Odebrecht TransPort, collaborative customer relationship Companhia de concessões rodoviárias (CCR), RioPar, Benito Roggio Transporte (BRT), and Régie Autonome des Transports Parisien (RATP).

VLT Carioca was estimated at BRL 1.157 billion (approximately \$300 million), in which BRL 525 million (approximately \$100 million) were financed by Brazilian Federal Government funds, from the mobility growth acceleration program (*Programa de Aceleração do Crescimento*), and BRL 632 million (approximately \$150 million), through public-private partnership.^[3]

Next, the winner of the public bidding, *Concessionária VLT Carioca S.A.*^[7] which is a public concession for the provision of transport services, aiming at implementation (civil works, systems, and rolling stock), operation and maintenance of the LRV system for 25 years term. The company was constituted to implement the project in 3 years and to operate and main LRV system for 22 years.^[4] *Concessionária VLT Carioca S.A* is a consortium composed by the following Brazilian companies: (a) CCR, 24.4%; (b) Invepar 24.4%; (c) Odebrecht TransPort, 24.4%; (d) Rio Par, 24.4%, and (e) BRT/RATP, 2.25%,^[4] as depicted in Table 1, as follows:

Table 1: VLT carioca consortium

VLT carioca consortium	Percentage
CCR	24.4
Invepar	24.4
Odebrecht Transport	24.4
Rio Par	24.4
BRT/RATP	2.4
Total	100

Source: VLT carioca, 2018. BRT: Benito Roggio Transporte. VLT: Veículo Leve sobre Trilhos, CCR: Collaborative customer relationship, BRT: Benito Roggio Transporte, RATP: Régie Autonome des Transports Parisien, CCR: Collaborative customer relationship

Nevertheless, trams in Rio are not new. Since 19th century, the tramway system was considered an important public transportation network, mainly extinct in the middle of the 20th century, and substituted by the bus network, as described in the background section. Next, the article Methods are presented, as well as case findings and analysis, followed by the discussion section. Finally, recommendations for future research complete this article. The next section provides information about the methods used in this research.

RESEARCH METHODS

The present study is qualitative research, interpretive reasoning, combining multiple methods, such as descriptive single case study,^[1] with extensive archival research, and direct participation, and observation. The unit of analysis is the VLT Carioca (LRV) public transportation network, part of the revitalization project aforementioned as Porto Maravilha Project. This study is limited to the VLT Carioca project.^[4]

This research also is limited by the following: (a) Brazilian Federal Constitution 1988,^[8] which protects the locomotion right within the Brazilian territory, in Art. 5, item XV: "Free locomotion in the national territory in time of peace, and any person, under the law, may enter, stay or leave with their property"^[8] (XV).

The Urban Transport Master Plan for the Metropolitan Region of Rio de Janeiro - Plano Diretor de Transporte Urbano (PDTU),^[9] also limits the research, since all urban projects should be aligned with the norms and principles here established.

The VLT Carioca, as part of the Porto Maravilha Project, abide by Law No. 5.128/2009.^[10]

This work is also restricted to the following municipal decrees: (a) Municipal decree 6065, from April/2016, which

established penalties to the users of VLT Carioca who do not pay spontaneously for the ride, and (b) Decree Rio No. 41627 from May 3, 2016,^[11] which issues the public passenger transport service by means of LRV. The next section presents the Background of LRVs usage in Rio.

BACKGROUND

Tram System in Rio de Janeiro: Offspring

The first tram (bonde) started its operation in 1859, when Rio de Janeiro was the capital of the Brazilian Empire (1822–1888), in the administration of D. Pedro II. The trams were powered by animal traction. The first line connected Largo do Rocio (today Praça Tiradentes) to a place near the current Usina, in Tijuca, in a route of 7-km length. In 1862, steam-powered trams started to operate in Rio. In 1898, catenary electrical powered trams started to work in Rio de Janeiro.^[3,4]

The old trams were extinguished by the left-wing and controversial Governor Carlos Lacerda, who substituted the non-polluting transportation system by the polluting, fossil fuel powered, bus network, in 1963. The state decree No. 1507, from January 19, 1963, established that the bus should become the only vehicle admissible in the collective transportation system. On May 21, the *bondes* (trams) were dismantled in the Southern Zone of Rio, and ultimately in the entire region. The Santa Teresa tram was the only one line preserved, to work as a living museum of this important aspect of the form Rio de Janeiro passenger transportation history.^[3]

VLT in Rio de Janeiro: 21th Century

The decision of dismantling the tramway system proved to be disastrous. The network was a non-polluting, cheap transportation service, in comparison to the polluting, fossil fuel, bus system transportation. Traffic in Rio de Janeiro started a long path into chaos, which persists, since the city has grown in unexpected and non-planned proportions.

In 1975, however, Rio de Janeiro State Government started to build the Metro lines, inaugurating the first line in May 1979, including a new modal to the City.

Along with the choice of Brazil Rio de Janeiro to host both World Cup 2014 and Rio de Janeiro state, to host the Olympics 2016, a golden era of urban investments was capitalized under mayor Eduardo Paes administration, the offspring of the VLT Carioca Project.^[3]

RESULTS

VLT Carioca: Civil Construction

The civil construction of the VLT Carioca started on September 2014, by Santo Cristo neighborhood, where the rails are

common to both lines 1 and 2. The civil works took place in parallel with other major transformations in the region (from Project Maravilha), built in parallel, such as (a) demolition of the Elevado da Perimetral; (b) construction of 8 km of road tunnels; (c) conversion of a section of Rio Branco Avenue into a public walkway, and (d) construction of the Museum of tomorrow.^[3]

The excavation in the region also revealed important aspects or the Rio de Janeiro’s ancient history: it was discovered an old slave trading post, at the Center Region of Valongo, classified by Unesco as a World Heritage of Mankind.^[3]

Testing of traffic on line 1 started in October 2015. At the end of February 2016, the first test was carried through Av. Rio Branco, with the VLT taking the road from the Bus Station to Cinelândia. Line 2 tests began in the second semester 2016.^[3,4]

Finally, the inauguration of VLT Carioca took place on June 5, 2016, between Santos Dumont and Museums stop, just two months before the Olympics 2016 start. On December 2, 2017, the inauguration of the Praia Formosa stop, the final section of both lines 1 and 2.

Lines Extension

The aforementioned Projeto Porto Maravilha then encompassed the creation of a new modal of public transportation, the VLT, designed to interconnect Santos Dumont Airport to the *Rodoviária Novo Rio* (interstate bus station), cruise lines, ports, and Metro.^[3,4] The Masterplan encompasses three lines, according to Figure 1, as follows:

Line 1 was inaugurated for the Olympics on June 5, 2016, connecting Santos Dumont Airport to Novo Rio interstate bus station. It performs 6.4 km, with 20 stops, with access to subway lines 1 and 2, the *Providencia* cable car and the Padre Henrique *Otte* bus terminal, as well as the airport, the bus station, and the Pier *Mauá* cruise terminal.^[3,4]



Figure 1: Veículo Leve sobre Trilhos carioca lines (VLT) 1, 2, and 3. Source: VLT Rio, 2018

Line 2 connects Praça XV to the Novo Rio Interstate bus station. It is comprised 12 stops, with access to the waterways, boat terminal of Praça XV, along with lines one and two of Metro, and trains of SuperVia.^[3,4]

Line 3 was designed to connect Santos Dumont Airport to Central do Brasil, Center train hub, on a 4-km extension. Line three has 10 stops and interconnects lines one and two. In total, the three lines encompass 15.4 km extension.^[3,4]

LRVs: Alstom Citadis 402

The French company Alstom provided 32 modern trams to the VLT Carioca, in which five were built, at La Rochelle, France, later exported to Rio on July 2015, and the remaining 27 were built at Taubaté, São Paulo state at Alstom's facility, as part of the agreement between the VLT Consortium and the French company.^[12]

The model adopted for the project was the *Citadis 402*.^[12] Each tram is 44-m long, 3.82 m height, 2.65m wide, with a nominal passenger capacity of 415 passengers, average speed of 15 km/h and maximum speed of 50 km/h, bi-directional with air conditioning system, working on a



Figure 2: Alstom citadis 402. Source: Author's picture



Figure 3: Santos dumont airport terminal. Airport at the bottom. Source: Author's picture

standard gauge (1445 mm gauge), and with eight doors on each side (16 in total). Alstom Citadis 402 is depicted in Figure 2, as follows:

Figure 3 depicts the final tram stop at the Santos Dumont Airport, as follows:

VLT Power Supply System

VLT Carioca is a catenary-free system, that is, no overhead lines are installed along the lines. Only Dubai LRV has the same characteristics. Alstom has devised two power supply systems to *Citadis 402* trams: (a) APS ground-level power supply system, which encompasses 80% of each route and (b) on-board supercapacitor-based energy storage, along with 20% of the lines. Both power supply systems were developed by Alstom.^[12]

One of the advantages to the APS power supply system is that it helps to preserve Rio de Janeiro's historic heritage, since there are no visible overhead lines, contrasting with historical buildings and landscape. The APS system uses a third rail feeding system, which is the same used in Rio de Janeiro Metro.^[12] APS uses 11-m segments set into the track bed between the guiding rails to supply current to vehicles:

These segments automatically switch on and off according to whether a tram is passing over them, thereby eradicating any risk to other road users. This safety principle was certified by several competent bodies all over the world.^{[12](p.1)}

Figure 4 depicts the APS ground-level power supply system, as follows:

Tram Stops

VLT Carioca stops, due to the historical heritage of the central region (Rio de Janeiro remained the Republic capital until 1961), tram stops were designed to provide minimum visual impact in the landscape.^[3] In the next section, the case analysis is presented followed by discussion and recommendations for future research.

CASE ANALYSIS

VLT Carioca: Sound Alternative to Passenger Transportation?

Originally, VLT Carioca was designed to improve the quality of transportation within the central region, revitalizing the adjacent areas of Porto Maravilha Project, as previously mentioned. The outcome proved to be very effective. Prefeitura do Rio de Janeiro registered a reduction of 60% of bus and 15% of car traffic circulation in the central region.^[3]

In comparison between VLT Carioca and Metro Rio (subway), there are 32 compositions with 180 cars and transports, carrying

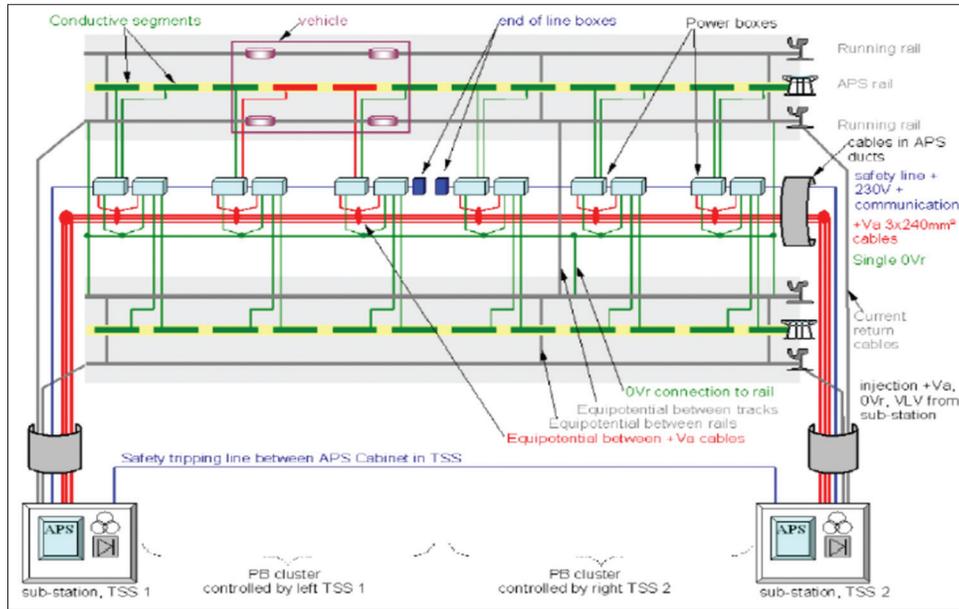


Figure 4: Alimentation par le sol ground-level power supply system. Source: Alstom, 2018. Reprinted under permission

Table 2: Comparison between VLT and metro

Feature	VLT carioca	Metro Rio (subway)
Passenger capacity	70,000 per day	850,000 per day
Number of compositions	32	32
gauge	Standard (1435 mm)	Irish (1600 mm)
Number of trains	32	180
Line extension	15,6 km	57 km
Speed	15 km/h	80 km/h

Source: CCR, 2017. VLT: Veiculo Leve sobre Trilhos

approximately 600,000 passengers per day,^[7] according to Table 2, as follows:

The Metro Rio, as depicted in Table 1, transports almost 10 times more passengers than VLT, and has 6 times more trains than VLT. However, Metro Rio does not reach the port areas, covered by VLT, 4 times longer, and 6 times faster than VLT. Both systems are interconnected. Our analysis indicated that both systems are complementary and non-excluding. However, the VLT may not be indicated for passengers in a rush, given its slowness.^[4]

Regarding pollution, according to the Ministry of the Environment, the National Council on Environment (*Conselho Nacional sobre o Meio Ambiente*, in Portuguese), through Resolution N^o. 1, from January 23, 1986,^[13] established the minimum requirements to pollution in urban environments, in which VLT Carioca proved to be the less polluting of all models of public transportation, overcoming Metro and trains, since VLT Carioca is the most silent modal of public transport, and does not emit air pollution, such as carbon monoxide, such as produced by buses.^[4]

DISCUSSION

Despite the fact of VLT Carioca be considered a slow modal of transportation (the average speed is 15 km/h, large number of stops, with short extension between them, what extends the travel time, and the experience proved to be a success).

There are no ticket collectors along the trams, similar to European model collecting services. The tickets are sold in special counter machines, distributed along the stations, and are similar to credit cards that can be filled with credits. Bank cards, such as debit or credit are accepting for payments, as well as currency. It took some time to the native population to get used with the collecting system since it was possible to travel without paying. To solve this issue, City Mayor issued, on April 2016, the Law Municipal Decree 6065, which established penalties to the users of VLT Carioca who do not pay spontaneously for free ride, from BRL 70 to 170 (approximately \$20–\$45 - in case of reincidence). Since ticket costs BRL 3.80 (approximately \$1), penalties vary from 18 to 48 times the ticket fares.^[11]

Curiously, the Carioca VLT is the only worldwide to adopt a concessionaire motorcycle driver to blaze the VLT trail. It is also usual to see people standing and walking on VLT tracks, taking pictures, and other curious behaviors. The City Mayor, along with VLT Concessionaire developed educational campaigns to avoid accidents of all sorts. Furthermore, to prevent tickets evasion, local clerks supervise each tram composition, double checking tickets validity as well as non-payments, applying fees, if necessary, counting on the municipal guard enforcement support.



Figure 5: Collision between bus and Veículo Leve sobre Trilhos.
Source: Extra, 2016

Nevertheless, accidents do happen. Almost 1 month after the inauguration, on July 27, 2016, at 9 PM, a VLT and a bus crashed each other, near Santos Dumont Airport, at Aterro do Flamengo, Center Rio,^[14] as shown in Figure 5.

VLT Carioca is fully convergent with the Urban Transport Master Plan for the Metropolitan Region of Rio de Janeiro - PDTU,^[9] one of the limiting factors that limit this research. One consequence of the implementation of the VLT Carioca was the aggravation of the number of people circulating within the Center of Rio de Janeiro. On the one hand, revitalization of the port area aggravated this problem. On the other hand, the convergent and interconnect new modal of public transportation brought commodity and alternative to users of the public system, since the number of VLT passengers is restricted to the current supply.

In the future, new studies should be performing, to adjust the adequacy of the increasing demand to future service supply. The solution to this puzzle is constant monitoring of the operation and behavior of the post-deployment demand, as well as the real territory occupation, in turn, facilitating the analysis of the public demand studies.

VLT Carioca also reduced of the number of private vehicles the streets of the Center, better capture of the demand of the train system, subway, and waterways, sound alternative to the former bus and metro dependence, on major points in the Central region. In addition, it meets the proposed increase sustainability by reducing air pollution and, therefore, optimizing the public transportation system.

Finally, from 19 to 21 Century, VLT Carioca proved to be a reliable alternative to promote the migration from individual motorization o collective one, presenting a sound convergent solution to the current public transportation system, to be adopted in other neighborhoods, with the purpose of returning the Center of Rio de Janeiro to the people, and preserving the historical heritage from City of Rio de Janeiro.

Future research is encouraged on service demand, to better serve the carioca population. Further case visitation is also encouraged, to monitor the quality of the services, offered to the overall Carioca population, as a sound alternative to public transportation in Brazil.

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