CAF DEVELOPMENT BANK OF LATIN AMERICA

SUSTAINABLE TRANSPORT

THE EXPERIENCE IN CANOAS

SUSTAINABLE TRANSPORT. THE EXPERIENCE IN CANOAS

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01

INTRODUCTION

Public transport in Latin America is facing a series of challenges, including a progressive decrease in service demand, saturated road network, longer and longer travel times, as well as noise and air pollution. All of this is linked to the lack of planning of cities and the mobility of their inhabitants. While important advances in the field of mass transportation systems have been made and there is certain technical unanimity regarding the need to make progress with these systems to foster more efficient mobility and environmentally friendly solutions in cities, their implementation has not achieved the results initially expected.

Many cities are facing a proliferation of regulated and non-regulated transport options and the acquisition of private vehicles (e.g., motorcycles). These are important challenges that hamper the planning and projection of levels of demand, necessary information to evaluate public transport alternatives. This scenario is generating financial problems for private operators and even the systems, in addition to citizen complaints about the services provided, among other issues.

Likewise, cities must make decisions based on technical analyses of the cost-benefits of the different mobilization alternatives for their citizens. Given that today there is an important menu of options in this regard—light rail transit solutions such as trams or subways, overhead cable cars, bus rapid transit (BRT) or preferential bus lanes, etc.—cities should avoid abstract discussions about which of these methods is the best option and concentrate on providing viable solutions, taking into account their unique geographical, financial and social situations, especially, passenger demand.

However, reality has shown that best practices on a global scale, with outstanding examples also in Latin America, are combinations of different public transport modes to mobilize users.

Public transport is a multi-modal solution in essence. In its simplest form, it always combines the pedestrian network with the bus system. Ideally, it also considers infrastructure adapted for bicycles, exclusive or preferential bus lanes and, when the level of demand justifies it, light rail transit networks, trams or subway lines.

The best alternative solely depends on the requirements and realities of each city. There is no single formula that is 100% replicable from one city to another because each territory is unique, with its own people and needs.

Best practices on a global scale are combinations of different public transport modes to mobilize users.

Nevertheless, it is possible and highly advisable to review the best practices of each city, to adopt them and also to learn about unsuccessful experiences so as not to repeat mistakes, in an effort to adapt those best practices to particular urban needs.

In this vein, it is clear that cities must plan their transport system according to their unique geographical, social and economic realities, based on the user needs to move about the city with the aim of providing efficient and environmentally sustainable mobility solutions.

Another consideration is what type of transport does a city want to offer to its users: something that they can pay on their own or one that addresses their needs efficiently and with dignity. It is not a minor dilemma, in that it faces off two parallel concepts: self-sustaining transport and transport as a public service. In effect, experience has demonstrated that they seem to be incompatible.

Self-sustaining transport is based on offering what the users can pay for, that is to say, the quality will depend on their payment capacity. In the case of transport as a public service, the assumption is the opposite: if the resources of the users are not sufficient, the state covers the difference to guarantee the quality it is responsible for, given its definition as a public service.

This should not limit the optimization of resources in the operation of the transport systems. On the other hand, by determining that this operation requires—in general terms—public resources to provide quality service, it is clear that this service competes with others of high social importance (health care, education, residential public services), making it necessary to invest these resources properly and ensure that they are not squandered.

In this context, a new technological operating alternative for operating a public transport for the mobilization of users emerges, based on the propulsion of a rail vehicle driven by an air flow produced by low-pressure air electric fans.

The proposal evaluated by the municipality of Canoas, in the Brazilian state of Rio Grande do Sul, based on the successful experience using Aeromovel technology[1] at the Porto Alegre airport, aims to address the technical, financial and social realities outlined in this document.

This report aims to give proof of the work carried out by Canoas with CAF's support, highlighting the good practices throughout the process, so that they can be adapted and replicated in other Latin American cities.

Along these lines, the document includes a chapter with the project background that summarizes its different aspects and main characteristics; an analysis of the international experiences in this type of transport; and, finally, the Canoas case study's technical, institutional, financial and legal aspects. This document approaches the subject from the perspective of best management practices in the planning of transport systems that could be replicated in other Latin American cities, since they do not depend exclusively on the selection of a technology and, in general, they are not related to the particular geographic and social characteristics of this city.

1. Aeromovel is a technology patented by the Brazilian Coester Group for the mobilization of public transport users. It is based on the features described previously, which involve the automated pneumatic propulsion of rail vehicles, powered by the air flow produced by low-pressure air electric fans. Moving forward, references to Aeromovel should be understood within this context of a patented technology and not as an operating model with a particular company.

02

PROJECT BACKGROUND

Based on the city's socio-economic and financial realities, in search of a sustainable alternative (environmentally and operationally), the municipality of Canoas, a neighboring city of Porto Alegre, in the Brazilian state of Rio Grande do Sul, proposes to implement a transport system based on the propulsion of a vehicle on rails using air flows generated by electric fans.

From a public service perspective adjusted to the characteristics of an efficient and profitable means of a mass public transport, this system is structured based on the following premises:

- Exclusive tracks for vehicle operation.
- Lower infrastructure costs in relation to other modes.
- Capacity greater than fifteen thousand (15,000) passengers per hour per direction.
- Lowest possible impact on property (effort to reduce the need for expropriation or purchases).
- Operating costs largely affordable with the user rate.

Canoas has made progress in the structuring of this system on a greater scale.

- Environmentally sustainable system from the perspective of emissions (100% energetically efficient electric system) and noise and vibration.
- Fully automated and with high safety standards for users.
- A technical design that adapts to the city's geographical reality (with capacity to provide service in areas with steep inclines), through a scheme that is integrated into the city's urban model.
- Ease of construction, through an expandable model that makes it possible to initiate service in high-need zones or areas to later serve other areas of the city as required.
- It should be a mode that is integrated with other modes within a system that allows the interoperability in benefit of the user.

With these premises, Canoas has made progress in the structuring and implementation of this system on a greater scale.

It is recommended that those cities currently evaluating transport solutions familiarize themselves with the process undertaken by Canoas, especially from the perspective of best practices and lessons learned.

It is hoped that this information will be useful not only for these cities, but also for the municipality of Canoas in the review process currently underway and also for potential investors interested in the development of this new transportation system that could break paradigms in Latin America's cities.

03

INTERNATIONAL EXPERIENCES OF SIMILAR MODELS

Public transport based on the propulsion of a vehicle on rails using the air flow produced by electric fans was first implemented in the mid-nineteenth century, in the atmospheric-driven systems, that is to say, using air pressure.

The problems faced by similar systems in the past will be reviewed in this chapter with the aim of assessing whether they have been evaluated and surpassed by current experiences.

At present, there are only two systems functioning with this technology: in the city of Porto Alegre (Brazil) and in Jakarta (Indonesia). Although neither one represents a public mass transportation service, it is possible to affirm that they do fulfill the function for which they were designed, inasmuch as they handle the projected volume of passengers, and they are integrated with other means of transport that form part of the public systems. Even though the international experiences have different service assumptions, in both cases the systems have been considered successful in terms of the implementation of the technology and their operability.

Background about atmospheric railway systems

i. Atmospheric propulsion systems in Europe

In 1843, one of the first atmospheric propulsion railway systems was officially opened. It ran two miles from Dublin to Kingston, in Ireland. The system was used, mainly, to travel short distances. Even though the initial lines required adjustments in technology and, in some cases, ongoing human assistance, the system worked correctly for 11 years.[2] Around 1854, it was replaced progressively by steam locomotives, mainly due to their energy efficiency and lower cost in terms of maintenance.

In general, the implementation of this first short-haul project using air propulsion was considered a success; it could carry considerable loads at a speed of 40 miles per hour, with superior capacity and faster speed than other lines previously built at the time.[3]

Since then, as seen in the reports from the time,[4] the atmospheric railway has offered significant advantages, including:

- Larger savings in comparison with steam locomotives, as the pneumatic system has the capacity to apply force in accordance with the load being carried, which alleviates the general infrastructure costs.
- Lower maintenance costs in comparison with other systems.

2. Dalkey, *The Atmospheric Railway 1843-1854*. Available at: http://www.dalkeyhomepage.ie/atmosphericrailway1843.html.

3. Turnbull, W. (1847). *An essay on the air-pump and atmospheric railway.* London.

4. Pinkus, H. (1840). *The new agrarian system and the pneumatic-atmospheric and gaso-pneumatic railway, common road and canal transit London*. London.

- Higher average speed without any need to incur additional expenses.
- Improvements in safety, which reduce collision levels and prevent fires and related problems that occur with the high temperatures of other technologies.

On the other hand, the French capital also invested in air technology with the Paris-St Germain line, which operated from 1847 to 1860, when once again the development of other types of engines progressively replaced it.

Finally, one of the last studies and efforts to implement pneumatic systems took place in the South Devon railway corridor, in England.[5]

Figure 1 - The track with atmospheric propulsion in the center, South Devon railway corridor [6]

Once construction was begun in 1845, the engineers in charge, and Isambard Kingdom Brunel, in particular, saw the possibility of covering a portion of the line route that no other locomotion system could resolve due to the incline. The first routes ran from Exeter to Teignmouth, in 1846. This project was the first to use atmospheric technology in passenger transport.

Although this system worked for some years, technology has lost traction and has been gradually replaced by steam technologies, reason why it was withdrawn in September 1948 from circulation. In any case, experts at the time unanimously agreed that atmospheric propulsion made it possible to build systems with lower installation and maintenance costs, better speed efficiency, and increased safety levels and reduced accident rates. [7]

5. Gill, Thomas (1848) *Address to the proprietors of the South Devon Railway / by the Chairman of the Board of Directors*. London.

6. Wacky Railroads, London. Available at http://www.hows.org.uk/personal/rail/wwr/atmos.htm, 7/24/2017

7. Gill, T. (1848). *Address to the proprietors of the South Devon Railway / by the Chairman of the Board of Directors.* London. p. 32.

The decision to change the technology was based on the fact that in too dry climates some materials tended to fail, like the leather, which was used in the connection valves between plates.

ii. Pilot project in New York: The Beach Pneumatic Transit

Some years later, in New York City, Alfred Ely Beach inaugurated an underground pilot line that ran on pneumatic propulsion.[8] The system, which was installed underground in Broadway, had only one stop and a single car that ran the same roundtrip. It operated from 1870 to 1873. The system was also based on pressurized air that moved the vehicle through tubes. The model was opened to the public, with an initial design that, if completed, would have covered five miles in total, connecting lower Manhattan with Central Park.

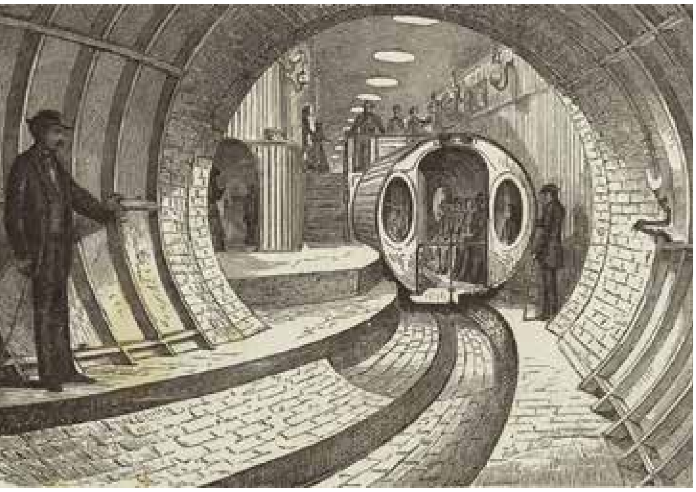

Figure 2 - The Beach Pneumatic Transit - Drawings of the vehicle in movement[9]

In its years of operation, the model became a tourist attraction for citizens, who took it for a single trip and imagined what the subway would be like. Even so, it mobilized around 400,000 people. The project never expanded due to the difficulties in obtaining operation permissions, which left it short of money before getting its real expansion underway.

Based on these case studies, it can be said that the first attempts to implement atmospheric propulsion systems in the 19th century were suspended due to the entry of other types of technologies, which seemed to perform better at the time. This does not cancel out the favorable re-

8. *http://www.nycsubway.org/wiki/Beach_Pneumatic_Transit.* (2012). Available at The Beach Pnemautic Transit: http://www.nycsubway.org/wiki/Beach_Pneumatic_Transit.

9. *http://www.nycsubway.org/wiki/Beach_Pneumatic_Transit*. (2012). Available at The Beach Pnemautic Transit: http://www.nycsubway.org/wiki/Beach_Pneumatic_Transit.

sults of atmospheric systems and some operating advantages in relation to the other modes of transport.

In the following years, at the beginning of the 20th century, the development of the steam engine and, later, electric motors, replaced all the other propulsion alternatives. Even studies and any interest in analyzing other types of technologies that could evolve favorably were abandoned.

As we will see below, the technology based on the operation of automated, pneumatic rail cars was brought back at the end of the 20th century; today, there are services running in two different cities. The technical difficulties that atmospheric propulsion technology faced in the past have been analyzed and resolved over the years, with the entry of new technologies, materials and different mechanisms that have reopened the doors to the operation of air-driven propulsion systems.

After reviewing the origins of the atmospheric train and international experiences during the 19th century, we will continue with the case studies of the two cities with this technology currently in operation: Jakarta and Porto Alegre. We will look at the main advantages of implementing this technology and the favorable results for the community.

Finally, based on the successful results of these two cities, we will analyze some proposals contemplated and developed as models and prototypes in other cities of the world.

Jakarta: An interconnection corridor in a theme park to the city's light rail transit (LRT) system

Although, as indicated previously, Aeromovel's technology, based on the automated operation of pneumatic light vehicles running on rails, is an initiative developed by the Brazilian Coester Group, its first implementation was in an Indonesian theme park, Taman Mini Indonesia Indah, in Jakarta. The first designs of the technology currently in use in this city were made in 1970 by Oskar H. W. Coester, in Brazil.

Figure 3 - Aeromovel in Jakarta, Indonesia

Studies were conducted to open the line that connects the theme park. It is two-miles long with six stations, a 3.2 km circular route and three trains in operation. The first two vehicles have capacity for 104 passengers; the third, which is the vehicle with the highest capacity, can hold 300 passengers: 48 seated and 252 standing.

The model incorporated in Indonesia is part of a series of rides for mobilizing people throughout the park; visitors can also use cable cars and monorails, among other options.

Figure 4 - Jakarta - Indonesia, a theme park where a transport line based on the operation of automated pneumatic vehicles run on rails is located. Source: Google Maps.

This first line in Jakarta has been conceived as the reincarnation of the models developed in the 19th century.[10] The system's greatest benefits include:

10. King, Charles, Vecia, Giacomo. Sintropher (2015) *Innovative Technologies for Light Rail and Tram: A European reference resource. Briefing Paper 8 Additional Fuels.*

- It has been operational since 1989 and, in all this time, there have been no reports of any major operating problems or accidents.

- Efficient load movement: because these vehicles do not have to carry any sources of combustion, nor are they equipped with an engine or transmission, their weight is reduced significantly. This makes them possible to move up to three times more load than conventional models.

- Low maintenance levels given that it has very few moving parts.

- Accident prevention thanks to “air bags:” pockets of pressurized air between trains, which ensures they don’t get too close to one another.

- The structures require less weight, and have to support less material and need less reinforcing.

- Significantly shorter construction times.

This system has mobilized passengers throughout the theme park’s recreational complex since 1989. Altogether, it has carried around 20 million passengers[11] over the past 27 years.

Jakarta is one of the cities with the highest population growth in the world; it currently has nine million people inhabitants. Since 2007, an expansion of the Light Rapid Transit Rail (LRT) using air-propelled technology has been under analysis, overseen by international advisors.

In this case, the analyses contemplate the possibility that the LRT expansion be carried out with technology based on the operation of automated pneumatic vehicles running on rails for public transport throughout the city system. However, the lines built and those that are projected in the short term have been made with electric trains, not using this technology.

11. Atta, Ricardo (2015). *Uma proposta de extensão da linha 4 do metrô do Rio de Janeiro (Barra da Tijuca) pelo sistema Aeromovel [A proposal to extend subway line 4 in Rio de Janeiro (Barra da Tijuca) using the Aeromovel system.]*

In addition to government projects, there are other public-private initiatives in Indonesia that also promote the use of this technology.[12] In the area of Kemayoran, there is a possible project with an investment of USD 7.5 million per kilometer for the construction of 11.5 kilometers, plus a 25-year operation concession.

Although there is no detailed information on this proposal, it is evident that there is a corporate interest in increasing the capacity of this technology in the city, based on the main benefits previously mentioned in terms of capital investment, favorable environmental efficiency ratings and the system's overall reliability.

Porto Alegre: The transport system as a connection to the airport and its conception as a pilot project

Even though there first was a private line in Porto Alegre for testing and demonstrations in 1983, the model was not fully in operation until a couple of years ago.

In the pilot project in 1983, the Ministry of Transport and the State Government awarded a contract for the implementation of the pilot line, with an investment equivalent to USD 2.7 million for the construction of 1,025 meters of elevated rails[13] to connect two stations using a single articulated vehicle with a nominal capacity for 300 passengers. But, after work had begun on Loureiro Da Silva Ave-

12. See PPP Indonesia at http://www.pppindonesia.co.id/

13. The history of Aeromovel. http://www.pucrs.br/aeromovel/historico.php

Figure 5 - Aeromovel technology operating in Porto Alegre, Brazil[14]

nue, and due to a change in the administration of the Transport Ministry, the funds for the project were not released and it was put on hold. The solution opted for was to shorten the pilot line to 650 meters, financed exclusively with private funds. In 1986, a new contract was signed through the Ministry of Science and Technology with the purpose of completing the first line, but once again there were some problems due to the contractual design and the absence of clauses for the adjustment of values, which significantly reduced the project scope. This time, the private contractor abandoned the project.

This system was completed in 2013, after two years of design and construction, in time for the 2014 World Cup hosted in Brazil. The line crosses a satellite service of one kilometer, which connects Terminal 1 at the Salgado Filho International Airport with a station close to the city's train system.

The total investment in the system was USD 11.7 million, financed with resources from the Federal Government, and the trains—with a capacity for 300 passengers—mobilize approximately 3,100 passengers per day.[15] The system was developed as part of a series of ambitious urban projects designed to implement mobility, sports and urbanism solutions during the World Cup.[16]

14. International Conference on Automated People Movers and Automated Transit Systems, and William J. Sproule. (2016). Innovation in a Rapidly Urbanizing World: *Proceedings of the 15th International Conference, April 17-20, 2016*. Toronto: http://ascelibrary.org/doi/book/10.1061/9780784479797

15. Sintropher Project and King, Charles, Vecia, Giacomo et al. (2015). *Innovative Technologies for Light Rail and Tram: A European reference resource. Briefing Paper 8 – Additional Fuels. London.*

16. Misoczky de Oliveira, C., & Misoczky, M. C. (October-December, 2016). Urban entrepreneurialism in FIFA World Cup host cities: the case of Porto Alegre. Organizações & Sociedade, October-December, 624-645. *Organizações & Sociedade*, p. 624-645.

This project was conceived as an urban business initiative for Porto Alegre, which needed to promote an image of a modern, developed and efficient city through high-impact proposals, like the construction and the opening of the system at the airport. At present, the system is operational and transporting passengers to and from the airport.

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Among the project's best practices, the following stand out:

- Environmental impact: significantly diminishes contaminating emissions levels, with a high reduction of noise pollution.
- Infrastructure flexibility: infrastructure with a capacity for adaptation, making it possible to build it independently of any existing highway and adjust to the situation of the territory and the specific context.
- National production and design: in the case of Porto Alegre, there is a high favorable opinion of the system. As a completely national product and design, the project has generated a sense of belonging in the city, improving the image and the capacity to create innovative and productive solutions on a national level.
- Security and promotion of the use of the service: reduces travel on foot between the stations of Trensurb and the airport, as well as the need to arrive at the airport by individual public transport, like taxis, fostering the use of public transport in general. Also, it is inclusive, guarantees passenger safety and promotes a reduction in costs associated with mobilization to and from the airport because fares are integrated with the metropolitan system.
- Low-cost implementation model for developing cities: thanks to its similar operation to urban elevated metro and underground systems, it enjoys a positive perception among citizens as a

Figure 6 - Structure of the Airport Line.[18]

viable mass public transport model for developing cities that do not have the budget to invest in metro system infrastructure and high-cost operation.

- More accessible financial option: it opens the door to analyze a different, financially viable option for cities with average budgetary power and high-capacity mobility needs.

- IT monitoring and control systems: the implementation of control software allows monitoring of speed, brakes and door opening with real-time information on the system operation and access from wireless devices like cell phones and tablets.[17]

- Ample service hours: the service operates continuously seven days a week, from 5:00am to 11:20pm.

- Fare integrated to the city's train system.

17. Ribeiro, A. (June 13, 2014). *Blog: Portoalegre Aeromovel controlled by Elipse Mobile.* Available at Ellipse Software: https://www.elipse.com.br/en/mobile/elipse-mobile-e-aplicado-no-aeromovel-de-porto-alegre/

18. International Conference on Automated People Movers and Automated Transit Systems, and William J. Sproule (2016). Innovation in a Rapidly Urbanizing World: *Proceedings of the 15th International Conference, April 17-20, 2016*. Toronto: <http://ascelibrary.org/doi/book/10.1061/9780784479797>

Other cities

Based on the results discussed in the two previous sections, there are cities other than Canoas developing feasibility studies for the implementation of technologies based on the operation of automated pneumatic vehicles on rails, and generating models and prototypes for the implementation of this technology.

In California, a private project led by Flight Rail Corporation[19] has constructed a working prototype of an elevated high-speed rail system propelled by air pressure within a sealed power tube underneath the train.

Figure 7: Vectorr TM Prototype, Mendocino County, California.[20]

19. *Our technology is superior* (2016). Available at Flight Rail Corporation: http://www.flightrail.com/

20. (http://www.flightrail.com/our-prototype.html, 2017)

The high-speed train is designed to operate at speeds of 200mph and to climb inclines as steep as 10 degrees, more than three times steeper than a conventional train can climb.

The prototype was built at 1/6 scale and is operating on a 638-meter elevated rail in Mendocino, California. The train is classified as a green system, which minimizes visual, noise and air pollution, reduces the environmental impact and the need for tunneling and underground infrastructure.

Although progress has been achieved in terms of the prototype's automatization and control functions, and general additions and improvements have been made, based on the compiled information, there are still no plans to build a full-scale model or put it into operation as a mass public transport system.

That said, it is an interesting example study to demonstrate the technology's progress and the system's advantages, and how its reach could continue to grow on a global scale.

21. *Aeromovel representatives' visit to Rionegro, Colombia.* (2016). Available at the Mayor's Office of Rionegro: https://www.rionegro.gov.co/node/2014

In the case of Colombia, the Mayor's Office of Rionegro-Antioquia has been studying the alternative since mid-2016,[21] considering that the level of investment in the project is relatively low in comparison with the necessary investment to move ahead with a metro project, BRT, tram or similar technologies.

The municipality is in the process of legally establishing a project management entity in charge of addressing mobility problems and working jointly with the government of Antioquia, the Mayor's Office of Medellín and Civil Aeronautics, among others.

Projections indicate that the fully installed system could mobilize approximately 50,000 passengers[22] per day, given the large influx of people traveling to and from the Jose Maria Cordoba International Airport located in the city.

The project, which is still in the analysis and structuring stage, calls for the construction of an 18-kilometer rail with 16 stations, including, in the final stage, a connection with the airport terminal, the second busiest in Colombia in terms of passenger traffic.

22. *Aeromovel representatives' visit to Rionegro, Colombia.* (2016). Available at the Mayor's Office of Rionegro: https://www.rionegro.gov.co/node/2014

The municipality is in the process of legally establishing a project management entity.

04

THE CASE OF CANOAS

LESSONS LEARNED
AND BEST PRACTICES

Institutional aspects

i. Public sector actors who played a key role in this process

The implementation of a mass public transport system involves the participation of different state agencies, given the crossover into several working areas of the municipal administration. A project of this scope touches on many issues. The main ones are land-use planning, environment, public finances and treasury, public space and, of course, mobility and transport.

The work of the leaders of the entities responsible for these issues is essential, but not sufficient. Without the political will of the highest municipal authority, it is unlikely that a project of this complexity will be successful. That said, it will require of an implementation time much greater than in those cases where there is a direct and active leadership of this kind.

Public institutions must not only be solid for the project structuring and tender, but also self-critical and capable of reform to meet the needs of the new model.

Just as important as establishing clear rules and strict obligations for private-sector service providers is a strong and capable institutional body—from the legal, technical, and financial points of view—that can act as controller, planner, and manager of the sys-

Canoas implemented a scheme of institutional coordination.

tem. While private operators may have important legal and contractual responsibilities, the ultimate responsibility for providing the service lies with the public sector.

In this sense, the task of having a transport system does not culminate in the structuring or award of construction and operation contracts; on the contrary, this is the least complex stage. Various international experiences show that well-formulated contracts can fail due to lack of control and institutional capacity to manage them.

In the case of Canoas, Treasury Secretariat's leadership has been unquestionable and a good example of high managerial coordination from public institutions. However, it must be complemented with a transformation process undertaken by the transportation authority focused on the administration of operation contracts and, especially, the capacity to adapt them to the changing conditions of the surroundings in this type of project.

ii. Levels of institutional coordination

Canoas implemented a scheme of institutional coordination through a multidisciplinary team that formed a management committee for system implementation. This team was responsible for all planning and project execution activities. It was formed by the following entities:

It is a positive coordination scheme insofar as it brings together the main project managers and limits decisions to a specialized committee with decision-making capacity.

However, it is considered that this body should be complemented with at least two other coordinating bodies. The first one, of a political nature, led by the mayor, enables decision-making when the municipal authorities cannot reach an agreement, as well as streamline decisions and permits needed for project development. Also, this body must serve as a space for accountability to the highest municipal authority.

The second coordinating body suggested is a broader space than the management committee, where other entities can participate, such as those responsible for land-use planning, the environment, the industry and others with a close relationship to the project. In this regard, the heads of the competent entities can inform the management committee of any progress made in areas of their competence and serve as a liaison with the heads of their entities so that they make any pertinent decisions.

Financial aspects

i. Public-private partnerships to finance the project

Given the financial situation of Canoas, like in the vast majority of Latin American cities, where public resources for project development are limited, the city opted for a scheme that combines public and private funds to develop its mass transport system.

The adoption of a public-private partnership model, which is gaining more and more acceptance in the face of the financial reality described above, is not the only innovative and novel aspect of this project. The financing scheme adopted by Canoas was formulated so that it could be deployed under one of the following alternatives: (i) phased execution, to take advantage of the available resources, so the project can move forward by contracting some of the infrastructure through public works and, in parallel, structuring the concession model without halting the release of public resources, or (II) integral approach, through a concession model that includes all works, operation and maintenance to decrease risks of integration between private and public investments, reducing the need for public resources throughout project development.

Furthermore, this financial structuring approach has made it possible to incorporate a multilateral development bank (in this case, CAF) in the review of the financial projections and technical aspects of the project.

The first of the two alternatives (phased execution) entails contracting the first stage entirely (100%) with resources originating from credits granted by the Brazilian government-owned bank Caixa Econômica Federal, with a counterpart financed by CAF.

It would include the contracting of civil works and the public service networks for the construction of the 4.6-km section connecting the Guajuviras district with Trensurb's Mathias Velho station, which includes nine stations.

This phase would also include the hiring of Aeromovel Brasil S. A. (ABSA) as a technological adviser, selected from among other alternatives, as indicated in the preceding chapters, including the executive projects of civil works, inspection, and management.

The following phases would be built by a private concessionaire, which would also be responsible for operating the city's entire transportation system (including the city buses) for a 40-year period.

These phases would be financed by the concessionaire, which would receive the revenue generated from the public transport fares without requiring any additional public resources. The concessionaire will be selected under the criterion of the lowest technical fare in its bid proposal, which will also ensure an optimization of the fares charged users.

This scheme of breaking down the project into phases given the immediate availability of resources is different from a traditional model, in which these resources are incorporated to the concession with partial payments from public funds, supplemented by private resources (in this case, fares collected from users).

In the second alternative (execution through an integral concession), the private concessionaire would be responsible for the entire project (except works related to public service networks already executed through public works). This would include all tasks related to construction, operation and maintenance, which would also be funded by the concessionaire.

In this scheme, the private concessionaire will be responsible for the repayment of the loan from Caixa Econômica Federal. Like in the phased-execution scheme, the private operator would receive payments based on user fares. Since, unlike in the phased-execution alternative, all financing would be assumed by the private investor, the repayment term for these investments would be extended from 40 years to 50 years.

In the case of both alternatives, the municipality would work with CAF in the search of private financing alternatives, through green funds that would ensure more competitive technical fares in the bid proposals.

Below is a summary of the main financial variables used to calculate each one of these alternatives. The differences between them are related to the amount of the private investor must finance in each case.

Total demand of the system (Aeromovel + bus):	85,000 passengers
Estimated annual increase in demand:	2.5%
Real IRR:	9.61%
NPV:	BRL 516,313,571.15
Contract value:	BRL 10,729,797,770.28
Annual operational cost of the bus service (year 1 of full operation):	BRL 21,478,573.51
Annual operational cost of elevated rail service (year 1 of full operation):	BRL 15,049,945.08
Total value of the works for the operation of vehicles on elevated rail:	BRL 1,005,965,016.56
Total amount of investment - CAPEX:	BRL 1,170,365,904.57

Fare:	Current fare adjusted annually based on the Extended National Consumer Price Index (IPCA, for its initials in Portuguese)
Average exchange rate USD – BRL in 2016:	3.4528

ii. Components of the financial model-Level of physical and financial sustainability (management model, financing, fare-related risks)

Another important aspect to take into consideration when structuring the financial model is to ensure that it includes the project's total costs and revenue without underestimating the former or overestimating the latter.

To this extent, the municipality of Canoas has carefully reviewed the operating costs (especially considering that the system is based on a new technology). This assessment reflects the operational reality of the current bus system and the operating technology of automated pneumatic vehicles on rails to and from the Porto Alegre airport.

The same care has been taken when estimating infrastructure construction and maintenance costs, for which the municipality also has pre-existing information that ensures a solid foundation for their inclusion in the financial model.

In terms of revenues, the estimate of demand growth (3% per year, which is equivalent to the rate of natural increase) is also a conservative calculation, which is highly advisable given experiences of other cities where projects failed due to overly optimistic demand projections.

Also, the scheme of competition based on a lower technical fare compensates the more conservative estimate because those bidding on the concession can calculate their own estimates based on higher projections—at their own risk—and assess the possibility of submitting a lower bid.

In this sense, the definition of the fare adjustments (which should be included as a contractual rule to ensure legal certainty to investors) also responds to a realistic projection aligned with the principle of safeguarding users.

In effect, the model contemplates a base fare equal to current bus fares, which are increased once a year (in July) in accordance with the Consumer Price Index (CPI) from the previous year. The concessionaire's high level of investment in the construction phase, as well as for the operation of the system, is also taken into consideration. But this level of investment is considered to be fundable by commercial banks, leveraged by the project's viability and the already mentioned possibility of accessing green funds or other financing schemes that make the project more attractive for private investors.

Finally, this careful analysis of costs and realistic revenue projections can be complemented by including in the model all costs related to the project's management, presentation, oversight and monitoring in a way that these components pertaining to the public sphere rely only on project resources.

iii. Comparison with other modes

The technical chapter mentioned that a comparison of different transport modes is a critical component of making objective decisions focusing on user benefits when selecting technology. However, the comparison should not be limited just to decisions regarding service quality and mobilization efficiency, it should be complemented by financial analyses to determine whether the optimal technological choice is actually viable and can be funded from the perspective of the city's budgetary and social reality.

In the case of Canoas, the management board clearly defined a line of social policy for this analysis: the project should not increase user fares, however, it should improve service in terms of quality, reliability, comfort, reduced travel times, integration with Trensurb and the bus system, while being affordable for the city.

A comparison of different transport modes is a critical component of making objective decisions focusing on user benefits when selecting technology.

Under these assumptions, automated, pneumatic propulsion rail vehicles were identified as the best choice, not only because this option could fulfill the defined objectives (even in terms of mobilization capacity based on vehicle adaptations described in earlier chapters), but also because it presented advantages over other modes thanks to the system's design: low energy consumption costs; possibility of automating vehicle operation thereby eliminating the need for drivers; and, low system maintenance (vehicle and facilities) and infrastructure construction costs (pillars and stations).

When comparing all these elements under the service assumptions defined above, the structuring team concluded that the operation of a mass public transport mode based on automated air-propelled vehicles on rails would be the most efficient mobilization option—among those that were financially viable—as shown in the table below:

Implementation Comparison (cost/km)

Mode	Estimates BRL Mn/Km	Evaluation for Canoas
BRT	15 to 30	Unfeasible: need to widen gauge
Tramway	40 to 60	Unfeasible: need to widen gauge
Subway	250 to 500	Economically unfeasible
Monorail	150 to 300	Economically unfeasible
Aeromovel	35 to 60	Feasible

Source: Technical Criteria for Urban Mobility Project Evaluations. National Transport and Urban Mobility Secretariat – SEMOB. Ministry of Urban Affairs. November 2014.

Specifically, the above analysis ruled out the possibility of using modes like a metro or monorail because their financial cost was too high. In addition, the BRT and the tramway were not feasible as gauge widening was not viable for urban and financial reasons (cost of associated property purchases and expropriation).

In terms of operating costs, the main project figures are presented below:

Bus operating costs (initial 36 months):

Conventional bus:	4.97 BRL/Km
Bus rapid transit:	3.98 BRL/Km

Low-floor bus:	5.76 BRL/Km
Monthly operating cost:	BRL 4,945,925

Rail vehicles' operating cost:

Monthly operating cost:	BRL 1,254,162.09
Monthly cost per passenger:	BRL 0.459
Cost per vehicle/kilometer:	BRL 3.95
Average exchange rate USD-BRL in 2016:	3.4528

The tables below show the main results of the operation and maintenance costs (stated in Brazilian Reais - BRL- for the Canoas project) of the principal system mode based on pneumatic vehicle propulsion:

Total annual O&M cost

Equipment	2,787,089	18.27%
Employees	5,959,615	39.06%
Energy	6,512,268	42.68%
Total:	**15,258,972**	**100%**

Annual O&M employee costs

Administrative employees	581,160	9.75%
Operation employees	1,983,600	33.28%
Maintenance employees	3,394,855	56.96%
Total:	**5,959,615**	**100%**

Vehicle/hour O&M costs

Equipment	21.15	18.27%
Employees	45.23	39.06%
Energy	49.43	42.68%
Total:	**115.81**	**100%**

Vehicle/Km O&M costs

Equipment	0.72	18.27%
Employees	1.54	39.06%
Energy	1.68	42.68%
Total:	**3.95**	**100.00%**

Total O&M costs per passenger

Equipment	0.084	18.27%
Employees	0.179	39.06%
Energy	0.196	42.68%
Total:	**0.459**	**100%**

O&M costs per day *365 days*

Equipment	7,636	18.27%
Employees	16,328	39.06%
Energy	17,842	42.68%
Total:	**41,805**	**100%**

O&M costs per month *365 days*

Equipment	229,076	18.27%
Employees	489,831	39.06%
Energy	535,255	42.68%
Total:	**1,254,162**	**100%**

Based on these figures, it can be asserted that operation and maintenance costs are up to ten times less than metro costs, up to seven times lower than tramway costs, and up to three times lower than BRT diesel systems.

iv. Risk allocation[23]

The risk allocation scheme for the project, in general, and the concession contract, in particular, is critical to ensure the transport system's viability and sustainability.

In the case of Canoas, using the approach of dividing the construction phase into two operation types (the first one is 100% public and the second one involving a public-private participation model), during the initial construction stage, under a public works model, the main risks have been allocated to a public entity, whereas during the concession stage, the majority of the risks have been allocated to a private entity (the same applies to execution under an integral concession model).

Risk distribution is particularly important in public service contracts because the state (in this case, the municipality) cannot delegate its obligations pertaining to this matter. Even if investors should have a clear idea about how the project will be executed, this may not contemplate lower user service levels, rendering the risk allocation challenge even bigger in this type of project.

As to the overall project risks, there are five main aspects:

- Technological, particularly in the operation of a mode that has never been used for large-scale mass passenger public transport systems. There are two components for mitigating this risk: the experience from operating the Porto Alegre airport line applied to this project and a comparison with other modes to determine that this is the best and most viable alternative for the citizens of Canoas.

23. Based on the project in the draft contract delivered by the municipality of Canoas

- Competition. This being an innovative project, there is a risk that no bidder or very few bidders would participate. The way to mitigate this risk is establishing an attractive financial model for investors, encouraging the participation of multilateral banks to strengthen and promote the project, and establishing transparent participation rules to attract the highest number of interested parties possible.

- Operation. This is a typical risk of any transport system. It can be mitigated by imposing clear operating rules and obligations on the party responsible for the system's operation, and by implementing an adequate monitoring scheme with the public agency responsible for the service.

- Technological dependence on few suppliers. Based on the selected operation scheme and the encouraged involvement of national industry (i.e., Brazilian manufacturers), there is a risk of concentration. However, it is possible to mitigate this risk by requiring that the concessionaire guarantee service provision (the concessionaire must decide upon the risk mitigation mechanisms to avoid this risk) under technology and knowledge transfer obligations.

- Demand. This is also a typical risk in any transport system. It can be mitigated by proper risk allocation under the contract. Adjusting supply to demand should not be left exclusively in the concessionaire's hands as this could decrease service quality if service frequency and comfort are reduced; therefore, this scheme should seek formulas that would enable risk sharing.

This section presents the foreseen concession risks. The proposed draft contract, under a public tender scheme, establishes the structure pertaining to risk and the revisions to the contract under the principle of assigning to the concessionaire the risks it is best prepared to manage.

Under these assumptions, the draft contract includes guarantees for the concessionaire against any of the following potential events:

- Unilateral contract amendments involving changes to minimum service provision requirements imposed by grantor.

- Tax changes.

- Extraordinary service cost variations vis-à-vis the bid preparation stage.

- Illegal actions or omissions by grantor or grantor representatives.

- Demand variation in a percentage equal to or higher than the 10% estimated in the parameters used for concession modeling.

However, these potential situations will not trigger an automatic revision of the contractual balance. The contract shall only be reviewed when the impact of these variations on the project cash flow decreases the internal rate of return declared by the concessionaire in its bid.

Similarly, when these events (e.g., a reduction in costs or an increase in demand) trigger a positive variation in IRR, a review of the contract may be carried out in favor of grantor. In addition, the contract includes a clause that establishes the automatic reinstatement of the contractual economic equation in the event of a variation in demand (probably the most critical [risk] because of its financial implications).

The main concessionaire-specific risks include:

- Failing to obtain the economic return estimated in its bid for reasons different from those foreseen to trigger contract review and described in the list below.

- Demand variation different from the variation foreseen in the contract review clause.

- Bid errors or omissions.
- Destruction, robbery, theft or loss of concession property.
- User safety maintenance.
- Negotiating a collective bargaining agreement.
- Interruption or lack of supply of materials or services by subcontractors or employees.
- Exchange rate variation equal to or lower than 10% of the rate on the bid submission date.
- Existence of civil, administrative, environmental, tax and criminal liability declarations regarding events that may occur during the service provision term.
- Legal costs originating from convictions or litigation due to legal actions initiated by third parties.
- Financing risks.
- Risks inherent in the possible failure of the national industry (i.e., participating Brazilian manufacturers) to offer goods and supplies necessary for service provision.
- Reduction in the residual value of property involving the concession.
- Reduction or non-realization of alternative, supplementary or accessory income from projects associated to service provision.
- Non-realization of alternative or supplementary income foreseen by concessionaire.

- Delays caused by the city's traffic flow.
- Economic inefficiencies or losses arising from problems attributable to the concessionaire's operational organization and/or service scheduling.

Along these lines, by executing the contract, the concessionaire expressly states that it is aware of the nature and scope of the risks assumed and that it has integrated these risks into its bid price proposal.

Environmental sustainability and climate change mitigation

The environmental impact analysis was also considered as part of technology selection variables. In this case, electric motors that do not produce contaminating gases, pollution, noise or visual contamination was the solution of choice.

Compared to the current bus operation system, this reduction will be significant[24] as a result of the replacement of the fleet running on fossil fuels, and also of the environmental conditions required for the remaining vehicles to operate on the integrated transport system.

The technology selected for the structural axis has the following features and advantages:

24. According to the report "WRI Brasil Cidades Sustentáveis. (2016). *Inventario de Poluentes Atmosféricos do Transporte Coletivo Urbano por Ónibus em Canoas* – RS," produced by WRI in June 2016, the system will reduce CO_2, NO_x and particulate matter emissions by about 32%, 40% and 50%, respectively, compared to current levels of pollution caused by the transport system.

- It is a zero-emission, fully electric system that uses energy efficiently as lines and/or catenaries need not be electrified; power is only required to energize the motors that generate low-pressure air (at some stations).
- The air-propelled vehicles do not require traction on rails or on-board motors, which make them very light; as a result, the required support infrastructure is equally light and streamlined.
- Operation is fully automated; no driver needed. It is a safe system developed under aviation regulatory standards.
- It does not produce noise or vibrations.
- It is a modular construction that can be implemented quickly.
- It does not require large areas for yards and shops.

Technical aspects

i. Choosing the best alternative for user mobilization – Mode selection based on mobilization needs

The municipality of Canoas conducted a demand study (2016) to identify citizens' transport needs and requirements, and establish the most efficient alternatives for the mobilization of public transport users.

Even though this is a basic decision, it should not be made lightly. It is important to establish citizens' needs before defining what mobilization modes will be implemented. Along these lines, any public transport policy should be supported by demand studies as up to date as possible.

In these studies, different technologies for user mobilization were compared not in a theoretical manner but considering the reality of mobilization in Canoas. In addition to evaluating the alternative selected in the end for user mobilization along the structural axis, i.e., a system consisting of a vehicle propelled on rails using an air flow produced by electric industrial fans, this comparison also assessed the possibility for this structural axis to be a high capacity metro or bus system, even including private vehicles, as shown in the figure below:

Comparison with other transport means

Aeromovel 15,800 kg 300 passengers 53 kg/pass (goal for Canoas)	**NYC Subway** 38,000 kg 240 passengers 158 kg/pass
New VW Gol 1.0 934 kg 5 passengers 187 kg/pass	**Bus BRT** 32,000 kg 270 passengers 119 kg/pass

The technology choice also addressed the public space and geographical reality in Canoas. Aspects like inclines, land availability, implementation time-frame, among others were taken into account in the comparison of the different transport modes.

As a result, the decision to adopt a rail system using air-propelled vehicles resulted from a technical analysis based on demand studies and was made comparing different alternatives, considering the main advantages this mode offers users.

Based on the successful experience in Porto Alegre, the Aeromovel vehicle was redesigned into a more comfortable and safe cabin.

Safety was also included in the system's design, selected as the mobilization mode for users along the structural axis of the transport system in Canoas.

Along these lines, based on the successful experience in Porto Alegre, the Aeromovel vehicle was redesigned into a more comfortable and safe cabin, keeping the initial advantages that positioned it as a safe vehicle in case of collision with a close to zero probability of derailment.

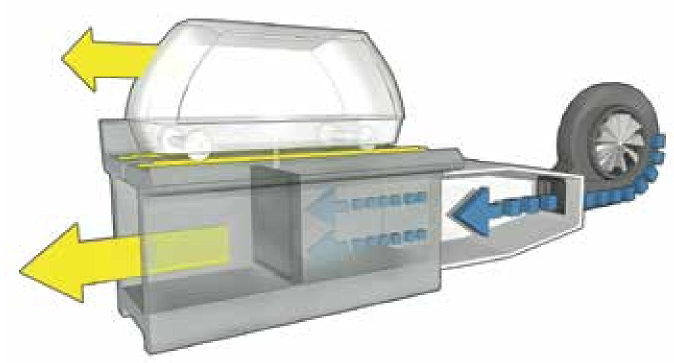
This major safety condition was a cornerstone of the design and was complemented by other salient aspects. As we have just seen above, the financial model of this mode of operation, integrated into a system that includes other transport modes, was assessed to be viable without requiring an increase in current user fares.

The above has been enhanced by a context of specific advantages for users in terms of environmental benefits, reduced travel times, service regularity and punctuality (as it is a segregated transport system that does not need to coexist with private cars or buses) and more comfort (HVAC-equipped rail cabins, with Internet service and multiple entry points—each vehicle has four doors on either side—so passengers can get on and off quickly).

ii. Features of the technology selected for the operation of the Canoas transport system structural axis

The figures below show the technology used for the automated pneumatic propulsion of rail vehicles through an air flow produced by low-pressure air electric industrial fans, which will be the structural axis of the Canoas' transport system:

Functional concept



This technology has a lower energy cost than other modes thanks to the light vehicle weight, the use of stationary electric motors and the fact that traction and braking are not contained in the vehicles but on the track, which provides the system with the full benefits of low-friction.

Propulsion

Pressure levels

Aeromovel system: (0.2 atm - maximum / 0.07 atm - mean)

Systolic blood pressure (0.16 atm / 120 mmHg)

Car tires (2.5 atm / 36psi)

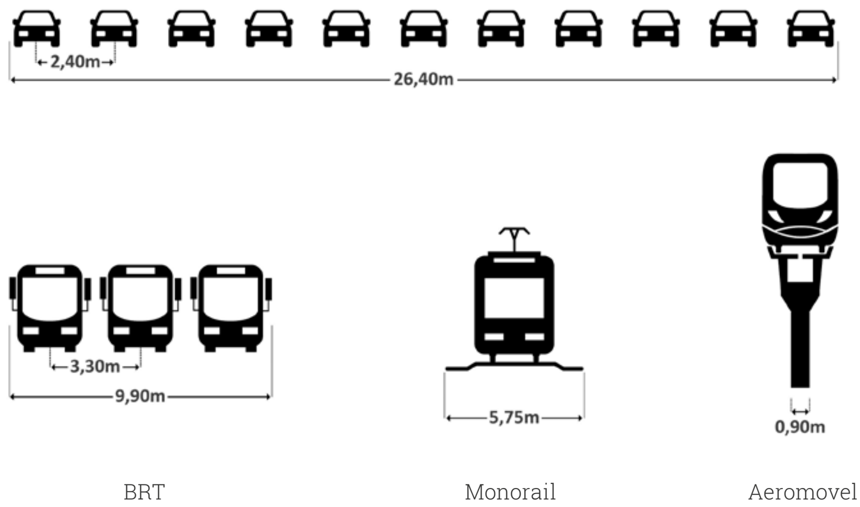
Sparkling wine (6 atm)

Pneumatic circuits (10 atm)

Hydraulic circuits (200 atm)

The vehicle is driven by low-pressure air, which enables efficient energy consumption.

Comparison among transport modes



Similarly, this technology has a low impact on the urban structure as the segregated elevated track overcomes the curves and inclines required for operation, using the available public spaces, especially the existing separators on roads and highways, which limits the need for expropriation.

iii. Project phases

Another important topic in this process is related to the decision to develop the project under a phased execution model as described in the section on financial aspects. These phases can be organized as a mixed format including public works and concession or as an integral, 100% concession model. The three designed phases are the following:

The first phase will connect the Guajuviras neighborhood to Trensurb's Mathias Velho station, including nine stations along a total of 5.9 km. This line will run along 17 de Abril Avenue and Boqueirão Street.

The second phase will connect Mathias Velho station with Mathias Velho district along Rio Grande do Sul Avenue. This 5.5-km phase will include seven stations.

The last phase (6.5km) will connect Ramiro Barcelos station (between Ramiro Barcelos and Farroupilha Avenues) with downtown, with ten stations. The route will run along Farroupilha Avenue, Boqueirão Street, Inconfidência Avenue, Victor Barreto Avenue (crossing BR-116) over to the city's downtown area.

The structural axis will include 25 stations in total along an approximately 18-km route.

iv. Productive chains involving national industry

La municipalidad de Canoas definió como uno de sus principios de The municipality of Canoas defined the inclusion of national (and regional) industry (manufacturers) in the selected transport solution as one of its core principles. This is a formidable asset, not only as an economic driver, but also as a door to access project allies.

In fact, one of the main needs of transport projects is that citizens learn about them and develop a sense of appropriation. Different formulas exist to attain this goal, comprising from effective communication to the participation of civil society in structuring discussions.

A project, however, is strengthened by the participation of stakeholders other than users. Along these lines, the inclusion of the national-regional industry is a best practice that needs to be analyzed and replicated in other transport projects. In this case, this incorporation was grounded in three important innovations:

The first and most obvious innovation was the evaluation of Aeromovel's technology (of Brazilian origin) as an option for a mass public transport

One of the main needs of transport projects is that citizens learn about them and develop a sense of appropriation.

alternative, which in itself represents an opportunity for Brazilian industry to develop a high-capacity project based on a prior assessment of different alternatives that identified the best one in in terms of cost-benefits.

The second innovation was the adaptation of this technology to Canoas' reality, which, in principle, is a key aspect for the success of any transport system. It is not the municipality that needs to adapt to technology. It is technology that needs to respond to the municipality's mobilization needs. In this regard, several regional companies were called to adapt their vehicles and other components to meet Canoas' reality and transport needs.

The third innovation was the response to this invitation, which translated into a 90% national industry component, i.e., the productive chain associated with the transport operation will be conformed by national industries, most of which originate from or are based in the region. This incorporation, however, will not involve higher costs or investment. On the contrary, it will create local jobs and decrease costs given that production will take place in the same area where this technology will operate.

National companies have been agile in joining the productive chain. Marco Polo and Randon have designed the body and chassis of the vehicle, respectively, tailored to the specific demand and needs of the operating system.

Siemens, in turn, has designed the electric, electronic and communications system, ensuring reliability and availability, while Somax has developed the air fans for the pneumatic propulsion system required for operation and IAT-PADROLL designed the units for the insulation of system rails.

Development today – Productive chain:


Marco Polo

v. Analysis

Another technical aspect that has been considered a priority and a basis for structuring has been full satisfaction of mobilization needs.

The municipality did more than define the operating conditions for a transport system that would use lines running along the main axes of transport demand: it designed a system to cover the entire city of Canoas from an operational perspective.

Therefore, the operation of the main (backbone) axes was structured under a user mobilization scheme based on rail vehicles moved by automated pneumatic propulsion through an air flow produced by low-pressure air electric fans and to enhance the existing transport modes (particularly Trensurb) would also be enhanced, especially considering that the project includes a whole new struc-

This redefinition was also intended to make the life of users easier

ture for the bus transport system so that these main axes are supplemented by a bus service plan meeting user needs.

This redefinition was also intended to make the life of users easier: it was proposed that travel routes be as similar as possible to the current routes, as they are already very well known by citizens. This would smooth the transition to the new scheme.

Under this redesign proposal, bus transport operation would go down from 155 bus lines (including those integrated to Trensurb and urban trains), traveling 33.7 thousand kilometers a day, to 91 lines that would travel 23.6 thousand kilometers, optimizing the fleet and avoiding route redundancy.

Current configuration:

Canoas bus transport system

This image shows the inefficiency of the current system, where services overlap, causing unnecessary circulation and operation costs. This generates long travel times, increased waiting times, system irregularity and lack of punctuality.

Redesign proposal:

Canoas bus transport system

95,836 equivalent passengers/day
18 vehicles (Aer)
26 stations (Aer)
90 buses
91 lines

Bus lines

Trensurb

Aeromovil

Under these assumptions, it was defined that the structural axis would operate on elevated rails that would connect Guajuviras and Mathias Velho districts, including connections to the city downtown area under a phased execution scheme, while the rest of the city would be served by an operational scheme defined contractually as part of the same project.

These modes (Trensurb, rail transport and buses) would compete among them, but would work under a single operational design that would make them complement each other and enhance user benefits. With this in mind, full fare integration between these modes has been included as part of the design.

Finally, a system was devised for the selected technology to transport up to 15,800 passengers per hour per direction, with operation costs up to ten times lower than the metro, seven times lower than the tramway and three times lower than the diesel-powered BTR.

vi. Urban integration – Management efficiency applied to the use of space/urban planning

As stated above, technology selection included urban impact and project implementation timeframe assessments. In both aspects, the selected technology presented significant advantages over the other analyzed transport modes.

In fact, implementing an elevated solution supported by pillars decreases urban impact, particularly by reducing almost to nil the interference with the built city, especially when considering that, as vehicles are light and do not generate significant vibration, the pillars on which the system is erected do not need to be especially large.

Nevertheless, this minimally invasive elevation feature represents an immense advantage as almost no land acquisition is required. This, in turn, eliminates the need for purchases and expropriation that would apply to other surface technologies or heavier infrastructure technologies that interfere with mixed traffic.

This is positive not only from an overall urban perspective, but also because it will not have a negative visual or noise impact on the property adjacent to the urban rail transport lines.

Canoas, through this transport system project, has incorporated STOD as a development model for the city.

Another advantage of the selected technology for the municipality of Canoas is that it dodges real estate speculation in the vicinity of the elevated guideway and fosters orderly and sustainable densification in the surrounding area, pursuant to the municipality's territorial organization mandates.

It is important to highlight that project structuring falls under a sustainable transit-oriented development (STOD) concept, going beyond the concept of dedicated transport structures. This means that the project structure includes urban and transport planning, along with the objective to find a scheme that would enable the building of an efficient and sustainable city from an economic, social and environmental perspective.

Canoas, through this transport system project, with its structural axis based on Aeromovel's technology, has incorporated STOD as a development model for the city. Along these lines, as described in this report, the project seeks not only to solve the issue of mobility and transport, but also uses national technology and companies under an environmental sustainability scheme built upon a transport mode that generates a low emission of pollutants.

This transport system will interconnect the most densely populated areas in the city, like the Mathias Velho and Guajuviras districts, fully substituting an elevated structural axis for the current bus transport mode and replacing the entire current fleet with an electric one. This low-energy, greenhouse gas (GHG)-free transport system will also reduce traffic congestion.

Based on the above, Canoas urban planning has anticipated Integration Macrozones defined around the transport system structural axis in an area of influence of 500 meters on each side of the axis. In this area, a Priced Building Permit has been created as an urban instrument consisting of a concession so that owners can build be-

Canoas will control urban development and increase municipal tax collection.

yond the limit defined by urban planning against the payment of a financial contribution to the city.

By defining this instrument and its application, Canoas will control urban development and increase municipal tax collection to make the transport system project economically viable.

In addition, around the structural axis area, real estate projects included in the Integration Macrozone will receive incentives for actions promoting the mitigation of GHG emissions and resilience to climate change, based on sustainability criteria defined by the local government.

In summary, this system design responds to criteria that exceed a simple transport scheme; the incorporation of STOD criteria assumes an open-minded vision of urban planning that will help achieve sustainable development effectively in social, economic and environmental spheres, as described in detail in this document.

Legal aspects

i. Call for tender documents and contract

The participation rules and the conditions for service provision are clearly defined by the following essential aspects contained in the base tender documents:

Contract purpose: it covers the delegation of service management, including components of (i) infrastructure construction and maintenance; (ii) carriage of passengers using automated pneumatic propulsion rail vehicles and buses; and (iii) construction and operation of terminals.

Tender: it is a public call for bids consisting of two stages: a shortlisting stage, where bidder capabilities are checked, and a qualification stage, selecting the lowest bid price proposal.

Sole purpose: the contract must be performed by a company specially incorporated, having a single subject-matter. This is an important guarantee vis-à-vis the special destination of resources to the concession.

User rights: the existence of specific provisions in this matter is highlighted, particularly efficiency as a right that users can demand.

Economic balance: clear rules about the causes of contract unbalance are laid down, along with unobstructed and clear mechanisms for reinstating the contractual economic equation.

Automatic fare update: it provides legal and financial investment security.

Integrated system: the operation on rails of automated pneumatic vehicles as a structural axis of a system, which will also include bus transport routes to supplement it, has been defined clearly and accurately. The complementarity and competition-free message is essential for contract planning, management and supervision.

Side business: rules regarding the possibility of conducting business at stations are clear, based on profit-sharing and they expressly state that this is a risk run by the concessionaire.

Suppliers: all suppliers must be certified by a technology expert. In addition, the three main suppliers must also be certified by the mayor's office. This provides the system with technological security and trustworthiness.

Bicycle lanes: to establish bicycles as a system component fosters a multimodal approach and is in line with the project's environmentally friendly stance.

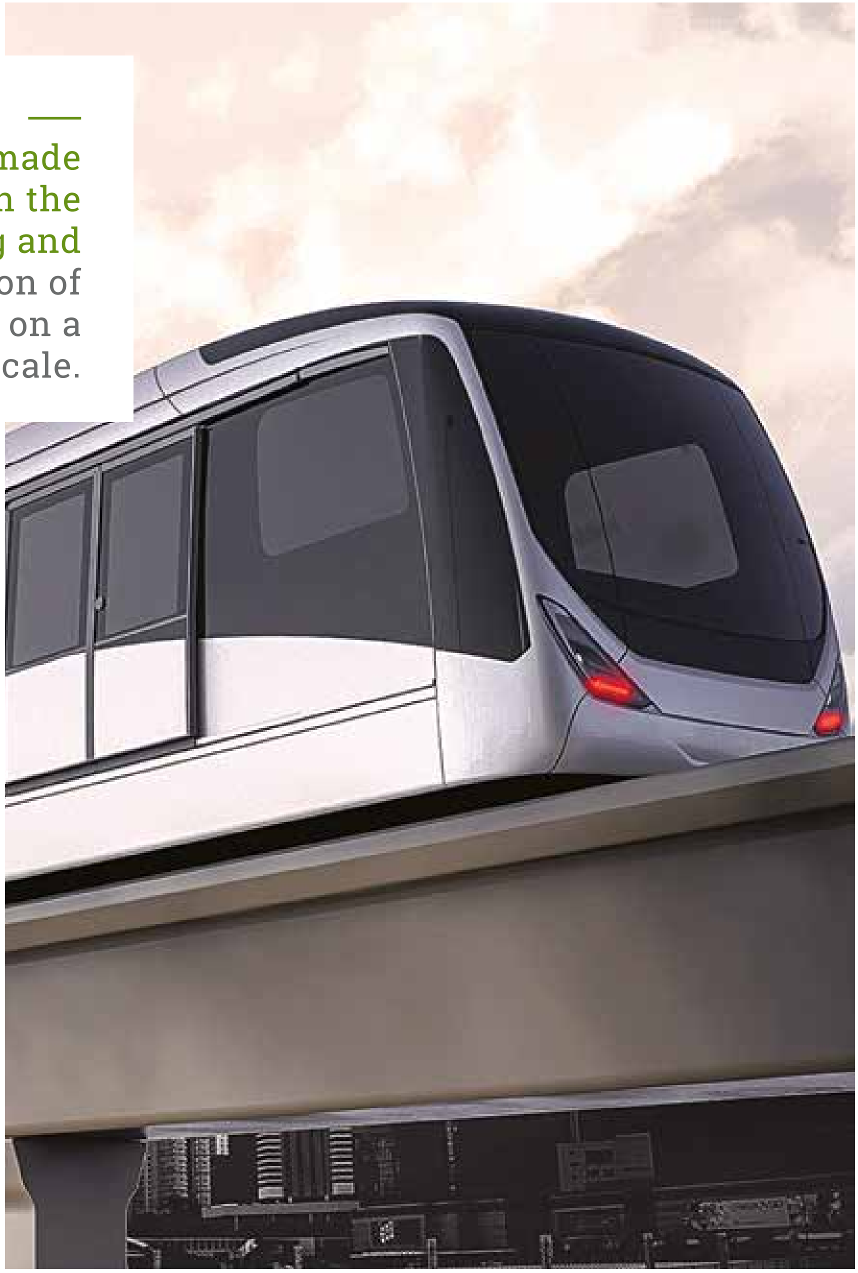
System coverage: the operational design includes full city coverage (serving 317,000 passengers).

Participation requirements: these are defined it terms of project needs and not stakeholder requirements, which is key to avoid proposals by bidders technically or financially unqualified to implement such a project as ambitious as the Canoas' transport system.

Compensation model and risk allocation scheme: compensation is a mechanism not just to repay concessionaire's investments, but also to respond to allocated risks. Consistency between these two aspects is key to business fairness and defines stakeholder participation. Along these lines, the draft contract clearly determines that the financial model presented by the concessionaire should consider risk compensation.

Transparency rules: in addition to provisions in the bidding documents and without prejudice to these provisions being expanded, the local government has adopted a series of actions to promote the project and present it to national industry and potential investors. These types of actions generate a critical transparency atmosphere that should also be supplemented with other series of actions, including explanatory rounds (at public hearings) of process documents, especially on key issues such as infrastructure construction, transport system operation, risk allocation scheme, compensation, among others.

Canoas has made progress in the structuring and implementation of this system on a greater scale.



ii. ii. Recommendations by CAF to Canoas local government to strengthen the structuring process

CAF proposed a series of actions and measures to strengthen the documentation of the process. The main aspects presented for local government's consideration are summarized below:[25]

Recommendation	Purpose goal	Area
Create the role of user advocate	This is a role for somebody who—with good judgement and technical skills—can defend the rights of users and act as a voice that represents them before transport authorities and the service grantor.	Technical – Draft contract
Service quality measures—flexibility of routes and service timetables	Documents should define that initial service planning be flexible and that it needs to adjust to demand needs.	Technical – Draft contract

25. What is presented in this paragraph is just a summary including the recommended aspects: the document presented to the municipality developed these concepts and contract clauses or changes to the tender conditions applicable to the concessionaire selection process for these aspects to be actually implemented.

Recommendation	Purpose goal	Area
Operation manual	The idea is to have a manual that is part of the contract, incorporated as an annex thereto, providing operation guidelines and minimum parameters for correct transport system operation.	Technical – Draft contract
Service levels manual	This manual should be added as a contract annex to guarantee transport service quality and offer a set of transport system indicators.	Technical – Draft contract
Operation control center	Establish the obligation for the concessionaire to create a replicate, mirror or any other scheme for the grantor to monitor and take control of operation in case of emergencies or serious breach by concessionaire.	Technical – Draft contract
Origin-destination matrix	Lay down the obligation to share all information used by concessionaire to schedule operation, including an update of origin-destination city matrices at least every two years.	Technical – Draft contract

Recommendation	Purpose goal	Area
Fare update to share efficiencies	Bearing in mind that this is a long-term contract, provisions should be included setting forth that, if efficiencies are generated during operation, these can be transferred to users.	Financial – Draft contract
Business alternatives to user fares	It is deemed advisable to expressly regulate that the municipality of Canoas, based on technical studies, can adjust the user fare to incorporate the positive effect of business modalities or alternatives implemented on system use that can improve service levels.	Financial – Draft contract
Payment formulas for the removal of used fleet vehicles	In order to provide security to investors and avoid the possibility of their including in bid price proposals the cost of undepreciated fleet vehicles upon concession end, the inclusion of a financial payment formula was proposed for the removal of these fleet vehicles.	Financial – Draft contract
Financial closure	In order to guarantee the soundness of the proposal and have available a means to act in time in case of default on operation financing, the inclusion of rules related to implementing financial closure by the concessionaire was proposed.	Financial – Draft contract

Recommendation	Purpose goal	Area
Control over system resources	Contractually oblige the concessionaire to guarantee that grantor can regain control of concession resources in case of emergency or serious fault by concessionaire. In this regard, contractor must undertake to accept that all management contracts governing concession resources (trusts, bank accounts, etc.) should enable takeover by grantor without the need for concessionaire's authorization.	Financial – Draft contract
Process rules focused on transparency	Notify the embassies of the countries of origin and any potential interested parties identified directly of the initiation of the process. Setting up an online and virtual data room including full project information. Holding public and open specialty hearings. Presenting the project to the community, trade unions, universities, think tanks and state oversight agencies.	Legal – Tender documents

Recommendation	Purpose goal	Area
Strengthen bids with technical and financial support	Enhance project soundness and the capacity to complete project execution with the obligation that both technical and financial experts support the bid and guarantee suitable implementation in case of tender award.	Legal – Tender documents
Rules for the entry of rolling stock	It is advisable to have clear rules governing the entry of rolling stock into service, setting forth that the concessionaire is required to guarantee this entry to meet mobilization needs and that rolling stock entry needs to be subject to grantor's approval.	Legal – Draft contract
Rules governing concession takeover	A proposal was made to supplement the contract rules currently incorporated to the draft contract so that lenders (banks) or insurers can act in case of default by concessionaire.	Legal – Draft contract

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