# Complete Streets

Evaluation of the impacts of its implementation in the City of Lisbon

**Francisco Mendes de Melo Marques**

## Extended Abstract

Thesis of obtain the Master of Science Degree in Civil Engineering

Suprevisors:
Prof. Ana dos Santos Morais de Sá
Prof. Filipe Manuel Mercier Vilaça e Moura

**November 2021**

# Abstract

Many cities today are still too focused on motorized traffic and end up with streets that make life difficult for pedestrians and cyclists. To mitigate the problems associated with this reality, the methodology of urban street design has been progressively changed in order to approach the concept of Complete Streets, which treats pedestrians, cyclists, public transport users and motorists in an equitable way.

This dissertation aims to evaluate the impacts that Complete Street interventions, in terms of sidewalk width, width and number of traffic lanes, type and location of bicycle lanes, parking provision, and traffic signal timing, may have in changing the patterns of use and enjoyment of public space. To this end, we will study the impacts of a hypothetical intervention in Avenida do Brasil in the city of Lisbon, using a microscopic multimodal traffic flow simulation software, and we will evaluate these impacts against the theoretical framework and international best practices/standards.

With the accomplishment of this exercise, it is possible to realize that the CML *Manual do Espaço Público* is adequate in the defense of the Complete Streets ideals, as it establishes criteria and norms that aim to intervene on urban streets in order to allow safe access to all users.

**Keywords:** Complete Streets; Traffic Simulation; Vissim; Complete Streets Implementation; Performance Evaluation

# 1. Introduction

## 1.1. Framework

The Complete Streets concept treats pedestrians, cyclists, public transport users and motorists equally. By promoting equity among the various modes of transport, it aims to improve the quality of life for all users by designing streets that are both safe public spaces and enable sustainable, high-performance transport networks [1].

In the urban context, especially in the more central areas, the street space is often scarce in relation to the multiple functions it has to ensure (accessibility, mobility and social function), observing that the planning has privileged the mobility function, which has compromised the quality of life in cities. To mitigate the problems associated with this reality, the methodology for designing urban streets has been progressively changed in order to approach the concept of the so-called "Complete Streets".

According to Smart Growth America (2003) [2] a complete street is defined as "designed and operated to allow safe access for all users, including pedestrians, bicyclists, motorists, and motorists of all ages and abilities. Complete Streets facilitate crossing the street, pedestrian access to stores, jobs and schools, and bicycling to work". This institution, considered an international benchmark, aims to solve enormous challenges facing urban spaces, such as climate change, the scarcity of affordable housing, the need to promote vibrant local economies, or how to connect people to affordable jobs and services.

It should be noted that while these types of policies like Complete Streets can lead to radical changes in traffic, Complete Streets projects *"are remarkably affordable, some of the projects cost only a few thousand dollars. They cost less to build than a typical urban arterial, but they can still increase bicycle, pedestrian and automobile activity"* [3].

## 1.2. Objective

This dissertation aims to evaluate the impacts that Complete Street interventions, in terms of sidewalk width, width and number of traffic lanes, type and location of bike lanes, parking supply and traffic light timing, may have in changing the patterns of use and enjoyment of public space. To this end, we will study the impacts of a hypothetical intervention in Avenida do Brasil in the city of Lisbon, using a microscopic multimodal traffic flow simulation software, and will evaluate them against the theoretical framework and international best practices/standards.

# 2. State of the Art

## 2.1. Historical Background

After the Second World War, governments at both central and local level had a major goal of providing quick and safe access to anywhere by car. This focus led to society becoming overly dependent on individual transport, not only in rural and suburban areas, but also in urban centers where a public transport network is normally installed. This dependence has led to a rapid increase in motorization rates in many societies around the world, and consequently a decrease in health and quality of life in urban centers.

Only a quarter century later, with a growing awareness of the environmental problems associated with motorized transport, loss of quality of life associated with mobility patterns characterized by heavy reliance on the car, and the decharacterization and impoverishment of the quality of urban centers that are no longer frequented, did the first policy with concepts similar to what we know today as "Complete Streets" (1971, Oregon, USA) emerge, which provided that streets in urban environments, both new and reconstructed, should accommodate the safe movement of bicycles and pedestrians. This policy also served to call for the funding of bicycle and pedestrian facilities by municipalities and public institutions [4].

## 2.2. Complete Streets: Concept

The concept that streets should be designed for a wide variety of transportation modes is commonly known as Complete Streets. The Complete Streets movement has called on policy makers, urban planners, and transportation engineers to move away from traditional motor vehicle-centric thinking and instead adopt a view of streets as a public resource that should be safe and available to all users.

Smart Growth America defines a complete street as "designed and operated to allow safe access for all users, including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities. Complete streets make it easy to cross the street, walk to stores, and bike to work." The American Planning Association defined them as streets that "accommodate pedestrians, bicyclists, mass transit, and cars, creating multimodal transportation networks" [5]. In this sense they are designed to fit the specific needs of each mode, namely with respect to sidewalks, street furniture, or pedestrian buffer strips; segregated or shared bike lanes; dedicated bus lanes and passenger shelters; and motor vehicle circulation, in general. Almost all of the definitions stress that any street design executed following the idea of Complete Streets must be sensitive to the context and community it is part of. A street may be considered complete without freight loading and unloading areas if it is in a residential neighborhood, or it may be complete without a shelter for public transit users if there are no bus routes. "Complete Streets" are streets that are sensitive to their surroundings and are designed to allow safe and efficient circulation of all modes on them [6].

Complete streets have been shown to offer many benefits for both individual users and the community at large. While each project may be different, complete streets have been shown to increase safety for motorists and other users, primarily by reducing vehicle speeds. They are also able to reduce noise pollution and create more accessible and attractive areas that generally contribute to improved livability and economic activity [7]. By encouraging more active modes of transportation, Complete Streets policies can also encourage healthier lifestyles for their residents [8]. Some interventions on existing Complete Street-type streets have resulted in increases in pedestrian activity and decreases in air pollution [9][10]. Anderson and Searfoss (2015) examined dozens of Complete Streets projects and found that when comparing before and after completion, the vast majority of projects saw decreases in crash rates and increases in trips made on foot, bicycle, and public transportation. These projects also cost much less than the usual rehabilitation projects. Other studies on Complete Streets interventions have seen evidence of increased economic development, reduced crashes, and increased bicycling as a mode of transportation [8][11][12]. In addition, these interventions have been shown to be desired and welcomed by different types of users, including motorists [13].

### 2.2.1. Fundamental Elements of Complete Streets"

Investments in Complete Streets interventions for a community should advance the goals set by its residents or representatives, which generally include providing access to destinations, supporting the local economy, ensuring environmental quality, and improving safety for all travelers. In addition, many communities focus on improving public health and addressing equity, where both have cross-cutting measures to other goals.

In an attempt to enumerate some of these goals several studies, technical reports, and scientific papers have been developed in recent years. The University at Buffalo and Smart Growth America have developed a kind of script to help transportation experts identify and establish performance measures to evaluate Complete Streets interventions. With this information in mind, as well as the literature review conducted as part of this dissertation, we conclude that Complete Streets have different types of objectives and therefore different types of components.

These components follow a common idea of **equity**, as transportation services and infrastructure often impact certain populations and neighborhoods unequally, with important implications for social equity. In evaluating Complete Street-type projects, the distribution of impacts and benefits to traditionally disadvantaged communities, including people of color, older adults, low-income families, and people with disabilities should be analyzed The equity perspective also refers to the possibility of using a scarce resource (the street space) by different types of users [1][3][14]. This broad sense of equity can be further differentiated into a general idea of **public health**, **place** or sense of community and **economy** [15].

**Place** or sense of community refers to the fact that investments in urban planning and transportation infrastructure influence the community's quality of life, and when aware of community context, existing and planned land use and buildings, transportation needs, and the culture of residents, can result in streets that become vibrant public spaces [15]. The **economy** component allows for the evaluation of urban space improvement projects, in general, and public space, in particular, and transportation infrastructure to include metrics that show how the project contributes to economic performance, whether by connecting people to jobs, providing jobs in building and operating public transportation, or increasing the value and attractiveness of land uses [11][12][15]. And the **public health** component allows project-level measures to indicate whether investments in improved public space and transportation infrastructure enable people to lead healthier lifestyles through increased access to physical activity and active forms of transportation, decrease the incidence of serious or fatal injuries, and reduce exposure to pollutants. Still, in order to go into more detail, it is possible to subdivide the concept of public health into three independent areas: the environment, safety, and access [15][16].

The **environment** parameters focus on minimizing environmental impacts that may influence public health [9][17]. The **safety** component aims to ensure that people can travel safely to their destinations, which with Complete Streets projects, means prioritizing safety for everyone who uses sidewalks, rides bicycles or public transportation, and drives cars or trucks [16]. And finally, **access** parameters try to ensure effective transportation systems that allow people to access their destinations safely and reliably by foot, bicycle, public transportation, car, or truck, creating multi-modal, integrated, and comprehensive transportation networks [15][17][18].

In the scope of this master's thesis, and with the use of modeling, a study will be conducted only incorporating this indicator "Access" and its essential parameters. And to assist the reader's precept, a summary table has been prepared with the recommended parameters to be taken into consideration, as well as their measures and metrics that help quantify how people relate to the concept of “Complete Streets”.

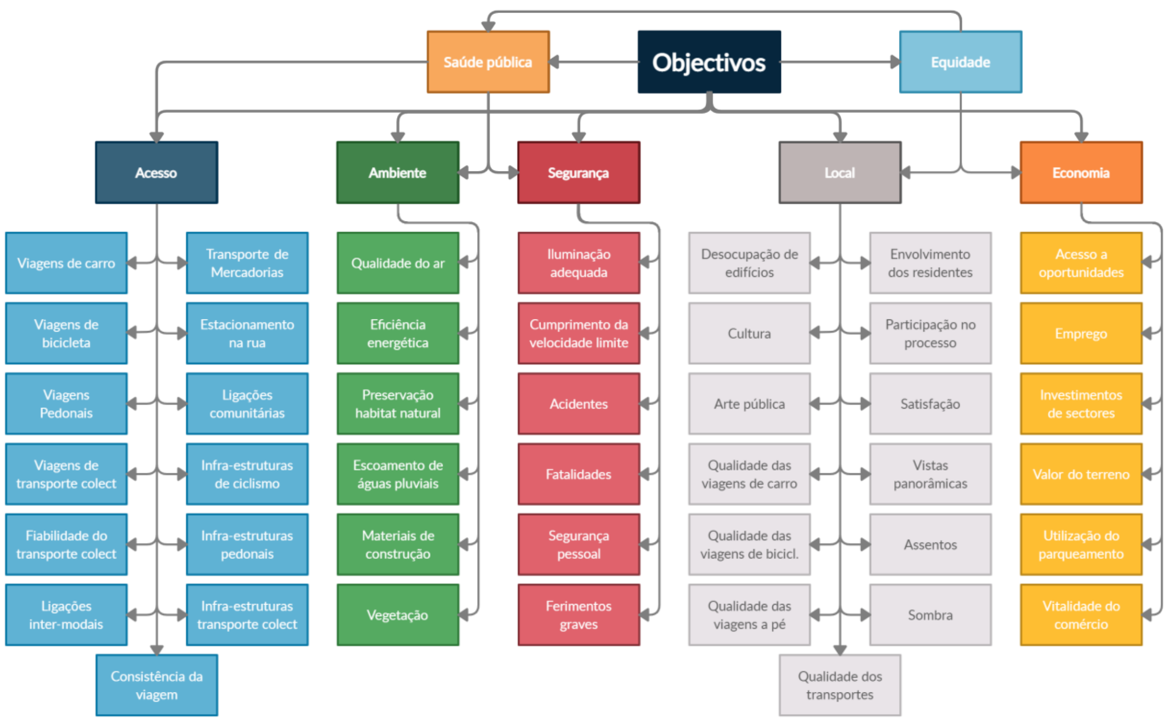


**FIGURE 1 - KEY ELEMENTS OF "COMPLETE STREETS**

# 3. Methods

To study the impact of interventions in terms of sidewalk width, width and number of traffic lanes, type and location of bike lanes, parking supply and traffic light timing, in changing the patterns of use and enjoyment of public space, in this case in Avenida do Brasil, we used PTV Vissim, a multimodal microscopic traffic flow simulation software developed by PTV AG (PTV Planung Transport Verkehr).

## 3.1. Characterization of the Case Study

The case study chosen to assess the impacts of interventions in terms of sidewalk width, width and number of traffic lanes, type and location of bicycle lanes, parking provision, and traffic light timing on changing patterns of use and enjoyment of public space, under the Complete Streets concept, was Avenida do Brasil.

Avenida do Brasil is located in the parish of Alvalade (municipality of Lisbon) and is considered a level 3 secondary distributor in the Municipal Master Plan of the Camara Municipal of Lisbon. And was chosen for the study of impacts of the implementation of the Complete Streets concept, because it has great importance for the crossing of local inhabitants as well as from other parishes and municipalities, has high traffic volume especially at peak hours (more than 1000 vehicles per hour) and has problems such as frequent traffic jams, poor implementation of bicycle paths and sidewalks reduced in much of its length. Being then the Avenida do Brasil a 3rd grade secondary distributor, it has to comply with these fundamental parameters (among others):

- Sidewalks with a width of no less than 2.25m and a minimum width free of any obstacle of no less than 1.80m; Cycle tracks with a width between 1.20m [minimum] and 1.50m [recommended] (for one-way) and between 2.40m [minimum] and 2.60m [recommended] (for two-way).
- Avoid curbside bus stops, as this encourages high speeds and consumes pedestrian space, and ensure 1.20m or more between the shelter and the facades.

## 3.2. Model Validation

In order to assess the model's conformity with reality, the GEH formula (proposed by **G**eoffrey **E**. **H**avers) was used to validate the model created. For this purpose, in July 2021, 15-minute manual traffic counts (light vehicles, heavy vehicles/merchandise and buses) (later extrapolated to 60 minutes) were performed at all intersections of Avenida do Brasil, on weekdays between 8 AM and 9 AM. Then, the volumes counted for light and heavy vehicles/merchandise were converted into volumes for vehicle inputs, and for buses, we used the times from the Carris bus route tables operating on Avenida do Brasil. With regard to bicycles, we used counts performed by CERIS (IST research unit), carried out at the intersections of Campo grande - Av. Brasil, Av. Brasil - Av. Roma, Av. Roma - Av. Igreja, and Av. Igreja - Av. Rio de Janeiro, during the period between 8 AM and 9 AM on weekdays.

In statistical analysis, the "rule of three" states that if a given event did not occur in a sample with n subjects, the interval from 0 to 3/n is a 95% confidence interval for the rate of occurrences in the population. When n is greater than 30, this is a good approximation of more sensitive test results. Subsequently, counters were introduced in the proper directions and traffic movements, at all intersections of the modeled network except at its extremities (connection of Av. do Brasil to Campo Grande and to Rotunda do Relógio), 30 simulations were performed in order to achieve representative results (# Estimated Vehicles) and confronted these values with the manual counts of motorized traffic (# Observed Vehicles), using the GEH formula (see table below).

TABLE 1 - GEH STATISTIC RESULTS FOR MOTORIZED TRAFFIC

| Percurso | Ponto B Murtas (baixo) | | | | | | Ponto C Roma | | | | | | Ponto D Murtas (cima) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W | NE | ND | E | SE | SD | WE | W | NE | ND | E | ED | W | WD | EE | E |
| nº Veículos (Estimado) | 542 | 25 | 18 | 314 | 564 | 241 | 104 | 376 | 146 | 200 | 374 | 526 | 482 | 172 | 142 | 424 |
| nº Veículos (Observado) | 550 | 25 | 20 | 405 | 515 | 225 | 135 | 485 | 150 | 220 | 430 | 635 | 730 | 275 | 235 | 725 |
| **fórmula GEH** | 0,3 | 0,0 | 0,5 | 4,8 | 2,1 | 1,0 | 2,8 | 5,3 | 0,3 | 1,4 | 2,8 | 4,5 | 10,1 | 6,9 | 6,8 | 12,6 |

| Percurso | Ponto E Rio Janeiro | | | | | | Ponto F Reinaldo Ferreira | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WE | W | NE | ND | E | ED | WE | W | WD | E | ED | EE | ND | SE | SD |
| nº Veículos (Estimado) | 110 | 408 | 255 | 85 | 243 | 172 | 121 | 590 | 54 | 268 | 57 | 54 | 39 | 19 | 64 |
| nº Veículos (Observado) | 135 | 515 | 320 | 95 | 355 | 275 | 150 | 545 | 60 | 290 | 75 | 70 | 40 | 20 | 65 |
| **fórmula GEH** | 2,3 | 5,0 | 3,8 | 1,1 | 6,5 | 6,9 | 2,5 | 1,9 | 0,8 | 1,3 | 2,2 | 2,0 | 0,2 | 0,2 | 0,1 |

For base case traffic modeling work, according to Markus Friedrich, a GEH value below 3.6 is considered an optimal match between modeled and observed hourly volumes, between 3.6 and 5.8 is good, and below 8.5 is satisfactory [19]. And given that most of the values obtained through the GEH formula are below 8.5, it can be said with confidence that this model adequately represents the reality of the case study.

## 3.3. Transforming Av. Brasil into a "Complete Street"

In the scope of this master's thesis, the main focus of the evaluation and implementation will be the Access component, which comprises a large part of the parameters associated with the Complete Streets concept. And with the Access parameters in mind, the *Global Street Design Guide* (International Consortium) and the *Manual do Espaço Público* (Lisbon) were consulted, in order to create a summary table that facilitates the evaluation of the streets and the reader's perception. From now on, only the values from the *Manual do Espaço Público* (Lisbon) will be taken into consideration, since it is possible to verify that many of the minimum parameters and some of the recommended ones are already recommended in this manual of good practices of street design, which also has more specificities on the same topics and adds other topics to be evaluated.

In order to evaluate the street conditions, the most relevant sections of Avenida do Brasil were identified, and then cross-sectional profiles of these sections were made in AutoCad. With the cross-sections of the most relevant sections already drawn, it was possible to assess the concordance with the parameters present in the CML *Manual do Espaço Público*.

### 3.3.1. Elaboration of Solutions

After evaluating the most relevant sections, with the idea of gaining more free space on sidewalks, the once recourse to coexistence of bike lanes on sidewalks, it was understood that it could not continue in practice. That said, and given that Avenida do Brasil only has two traffic lanes in each direction, we came up with the idea of placing the bike lanes in shared lanes in BUS lanes, so that we wouldn't have to give up at least one traffic lane of road traffic. It is recognized that this solution is not the best in the perspective of cyclists' safety. And with this conception in mind, successive incremental changes were made to the streets:

- replacement of the rightmost traffic lane, along the entire length of Avenida do Brasil, with a dedicated BUS lane, in the Campo Grande - Aeroporto direction;
- all BUS stops in cutout, are now directly in the traffic lane;
- the intersection of Rua Eng. Manuel Rocha and Rua Reinaldo Ferreira was joined, and the resulting intersection is now fully signalized;
- slow-down lanes have been introduced, along Avenida do Brasil, at all signalized left-turn intersections;
- the traffic lights at the Fausto Guedes Teixeira Street intersection were also removed and left turns were prohibited;
- the rightmost traffic lane along the entire length of Avenida do Brasil was replaced by a dedicated BUS lane, in the direction Aeroporto - Campo Grande;
- the intersection of Rua Eng. Manuel Rocha and Rua Reinaldo Ferreira was reorganized and slow-down lanes were introduced for left turns at this intersection;
- dedicated bike lanes were removed and shared bike lanes were created in the BUS lanes;
- refuges were created in the crosswalks that cross Avenida do Brasil, whenever there was sufficient width in the street;
- and adjusted the signal cycles accordingly.

To aid the reader's perception, a table was prepared with a summary of the recommended and minimum parameters to be checked, as well as their assessment separated into four groups: meets the recommended - green; meets only the minimum - yellow; does not meet the minimum - red; no element for assessment - gray.

**TABLE 2 - SUMMARY TABLE WITH THE COMPARISON OF THE CURRENT SITUATION WITH THE PROPOSAL**

| | | | Situação Atual | | | | | | | | | | | | | | Proposta | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
| Rodovia | Largura mínima | das vias | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | das faixas BUS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Passeios | Espaço de circulação pedonal | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Canal de | ifraestruturas | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | equipamentos | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | estacionamento oblíquo/perpendicular | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Percurso pedonal acessível (livre de obstáculos) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ciclovias | Percurso pedonal acessível (livre de obstáculos) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Pista | unidireccional | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | bidireccional | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Faixa de protecção a | objectos | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | muros ou fachadas | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Estacionamentos | Longitudinal | largura do lugar (com 5m de comprimento) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Oblíquo a 60º | largura do lugar | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | profundidade (avanço sobre o passeio possível) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | profundidade (avanço sobre o passeio inviável) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Largura da via de acesso | 1 via de trânsito | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 2 ou mais vias de trânsito | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Transporte Público | Percurso pedonal acessível (livre de obstáculos) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Distância entre a paragem e o lancil | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Distância entre a paragem e fachadas | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# 4. Analysis and Discussion of Results

As can be seen, in the current situation of Avenida do Brasil, in a large part of its length, nearly one third of the parameters assessed do not meet the minimum requirements suggested by the CML *Manual do Espaço Público*. The most impaired themes are the Sidewalks (pedestrian circulation spaces and paths), the Bicycle paths and the Public Transport (boarding and alighting area).

In the proposed scenario, with the creation of bike lanes shared in BUS lanes, it was possible to extend the sidewalks to widths equal or greater than those recommended by the *Manual do Espaço Público*, increasing the safety and comfort of pedestrians and cyclists. Regarding individual transport, even if the number of individual motorized transport traffic lanes was reduced by half, with changes in traffic light cycle times and the creation or expansion of slowdown lanes, the traffic volume is not much reduced and, in general, travel times are lower than the current situation of Avenida do Brasil (as shown in Table 3).

TABLE 3 - COMPARISON TABLE OF THE CURRENT SITUATION WITH THE PROPOSAL

| Percurso | Situação Atual | | Proposta | | Variação | |
|---|---|---|---|---|---|---|
| | nº Veículos | Tempo (min) | nº Veículos | Tempo (min) | Volume | Tempo |
| 01: Aeroporto - Campo Grande | 365 | 4,06 | 400 | 3,49 | 9,59% | -13,92% |
| 02: Aeroporto - Roma | 88 | 3,09 | 99 | 2,66 | 12,50% | -13,98% |
| 03: Aeroporto - Rio Janeiro | 148 | 2,10 | 175 | 1,71 | 18,24% | -18,90% |
| 04: Aeroporto - Murtas | 166 | 2,27 | 164 | 1,67 | -1,20% | -26,22% |
| 05: Murtas - Campo Grande | 188 | 6,00 | 303 | 5,00 | 61,17% | -16,59% |
| 06: Murtas - Roma | 276 | 7,03 | 413 | 3,95 | 49,64% | -43,86% |
| 07: Murtas - Rio Janeiro | 56 | 7,60 | 87 | 4,79 | 55,36% | -36,98% |
| 08: Murtas - Aeroporto | 56 | 9,60 | 68 | 5,70 | 21,43% | -40,57% |
| 09: Roma - Rio Janeiro | 105 | 2,24 | 112 | 1,68 | 6,67% | -25,01% |
| 10: Roma - Aeroporto | 78 | 3,42 | 88 | 2,28 | 12,82% | -33,50% |
| 11: Roma - Murtas | 95 | 2,02 | 95 | 1,76 | 0,00% | -13,18% |
| 12: Roma - Campo Grande | 253 | 2,42 | 239 | 1,60 | -5,53% | -33,99% |
| 13: Rio Janeiro - Aeroporto | 58 | 3,16 | 66 | 1,85 | 13,79% | -41,45% |
| 14: Rio Janeiro - Murtas | 53 | 3,54 | 96 | 2,53 | 81,13% | -28,62% |
| 15: Rio Janeiro - Campo Grande | 158 | 5,31 | 218 | 3,97 | 37,97% | -25,37% |
| 16: Rio Janeiro - Roma | 39 | 4,15 | 62 | 3,28 | 58,97% | -21,09% |
| 17: Campo Grande - Roma | 304 | 2,09 | 294 | 0,88 | -3,29% | -57,63% |
| 18: Campo Grande - Rio Janeiro | 80 | 3,26 | 67 | 2,22 | -16,25% | -31,92% |
| 19: Campo Grande - Aeroporto | 102 | 5,17 | 82 | 4,15 | -19,61% | -19,73% |
| 20: Campo Grande - Murtas | 48 | 2,71 | 53 | 1,89 | 10,42% | -30,43% |

# 5. Conclusions and Future Works

By performing this exercise, in this case for Avenida do Brasil, it is possible to realize, using modeling and simulation in Vissim, that the CML *Manual do Espaço Público* is adequate in the defense of the Complete Streets ideals, as it establishes criteria and norms that aim to intervene on urban streets in order to allow safe access for all users, including pedestrians, cyclists, drivers and car drivers of all ages and abilities. It is also possible to verify and confirm that no major investments or drastic changes to the existing infrastructure (nor interventions on the street buildings) are necessary to promote safe and comfortable access for all users.

Using the Vissim software, a model reproducing the current state of Avenida do Brasil was created and validated using the GEH statistical formula, comparing the values estimated in Vissim with the traffic volumes from manual counts performed at each intersection of Avenida do Brasil. Once the model was validated, the current conditions of Avenida do Brasil were evaluated, the most relevant sections of the street were identified, and then cross-sectional profiles were made in AutoCad. With the profiles drawn, it was possible to assess the agreement with the parameters present in the CML *Manual do Espaço Público* and, after the diagnosis was made, it was found that there was a clear need for a Complete Streets intervention to rebalance the use of the available space among the various modes of transport, with an important need for intervention for active modes (especially pedestrian) and the improvement of design solutions for public transport. With the idea of gaining more free space on sidewalks, the once recourse to the coexistence of bike lanes on sidewalks, it was understood that it could not continue in practice. That said, and given that Avenida do Brasil has only two traffic lanes in each direction, we came up with the idea of placing the bike lanes in shared lanes in BUS lanes, so that we wouldn't have to give up at least one traffic lane of road traffic. After all recommended changes were implemented, we drew the respective cross-sectional profiles, and again checked the agreement with the parameters present in the CML *Manual do Espaço Público*.

In the current situation of Avenida do Brasil, in a large part of its length, nearly one third of the parameters evaluated do not meet the minimum requirements suggested by the Manual of Public Space, but in the proposed scenario, with the creation of bike lanes shared in BUS lanes, it was possible to extend the sidewalks to widths equal to or greater than the recommended in most sections evaluated, thus increasing the safety and comfort of pedestrians and cyclists. As far as individual transport is concerned, even though the number of individual motorized transport traffic lanes has been reduced by half, with the proposed traffic light cycles and the creation or expansion of slowdown lanes, the volume of traffic has hardly been reduced and, in general, travel times are lower than the current situation on Avenida do Brasil. However, it should be remembered that although the results presented are representative of reality, using microscopic multimodal traffic flow simulation software such as Vissim, the quality and representativeness of the results is always subject to the experience and expertise of the software user and the behavior of the simulated dynamic entities is not always the most perceptible and consistent. Adding to this the fact that the manual traffic counts were performed during the Covid-19 pandemic, and even extrapolating to pre-pandemic values, it is expected that the results obtained through modeling and simulation in Vissim may differ from reality if the proposed changes were performed on the existing street.

In the context of this dissertation, we evaluated the impacts on Avenida do Brasil in changing the patterns of use and enjoyment of public space produced by the recommended interventions in terms of sidewalk width, width and number of traffic lanes, type and location of bike lanes, parking supply and traffic light times. However, the Avenida do Brasil, for ensuring a proximity distribution, as well as the routing of traffic flows to higher level roads, and also for being a major axis of road circulation in the parish of Alvalade, presents itself as an interesting case study to complement the evaluation of the study done in this dissertation with a more comprehensive evaluation, which also includes the neighboring streets or even at an integrated level of the Alvalade neighborhood. We consider that an evaluation involving the roads delimited by the 2ª Circular, Avenida Gago Coutinho, Avenida Estados Unidos da América and Campo Grande would be a good suggestion, since the proposed changes in Avenida do Brasil will certainly have a strong influence on the volume of traffic on these roads, as well as in possible congestion and constraints on them.

# Bibliographic References


1. Directorate-General for Mobility and Transport (European Commission) (2004), *Reclaiming city streets for people: Chaos or quality of life?*, European Commission; at https://ec.europa.eu/environment/pubs/pdf/streets_people.pdf
2. Smart Growth America, *What are Complete Streets?*, https://smartgrowthamerica.org/program/national-complete-streets-coalition/publications/what-are-complete-streets/, consultado em Outubro de 2021
3. Geoff Anderson and Laura Searfoss (2015), *Safer Streets, Stronger Economies: Complete Streets project outcomes from across the country*, Smart Growth America; at https://smartgrowthamerica.org/wp-content/uploads/2016/08/safer-streets-stronger-economies.pdf
4. Oregon Department of Transportation (2021), *Oregon Pedestrian and Bicycle Bill (ORS 366.514) Screening Process*, Oregon Department of Transportation; at https://www.oregon.gov/odot/RPTD/RPTD%20Document%20Library/Bike-Bill-Screening-Flow-Chart.pdf
5. Barbara McCann and Suzanne Rynne (2010), *Complete Streets: Best Policy and Implementation Practices, Planning Advisory Service Report Number 559*, American Planning Association; at https://planning-org-uploaded-media.s3.amazonaws.com/publication/online/PAS-Report-559.pdf
6. Babb A, Watkins KE. (2016), *Complete Streets Policies and Public Transit*, Transportation Research Record; at https://doi.org/10.3141/2543-02
7. Litman T (2015), *Evaluating Complete Streets: The Value of Designing Roads for Diverse Modes, Users and Activities*, Victoria Transport Policy Institute; at https://www.vtpi.org/compstr.pdf
8. National Complete Streets Coalition (2015), *The Best Complete Streets Policies of 2014*, Smart Growth America; at https://la.streetsblog.org/wp-content/uploads/sites/2/2015/02/best-complete-streets-policies-of-2014.pdf
9. Shi Shu, David C. Quiros, Rui Wang, Yifang Zhu (2014), *Changes of street use and on-road air quality before and after complete street retrofit: An exploratory case study in Santa Monica, California*, Transportation Research Part D: Transport and Environment, Volume 32 , Pages 387-396, ISSN 1361-9209; at https://doi.org/10.1016/j.trd.2014.08.024
10. Moreland-Russell (2013), *Diffusion of Complete Streets Policies Across US Communities*, Journal of Public Health Management and Practice; at https://doi.org/10.1097/PHH.0b013e3182849ec2
11. Victoria Perk, Martin Catalá, Maximilian Mantius, Katrina Corcoran (2015), *Capturing the Benefits of Complete Streets*, University of South Florida; at https://rosap.ntl.bts.gov/view/dot/29663
12. Chia-Yuan Yua, Minjie Xub, Samuel D. Townec, Sara Imana (2018), *Assessing the economic benefits and resilience of complete streets in Orlando, FL: A natural experimental design approach*, University of Central Florida; at https://doi.org/10.1016/j.jth.2017.11.005
13. Marc Schlossberg, John Rowell, Dave Amos, Kelly Sanford (2014), *Rethinking Streets: An Evidence-Based Guide to 25 Complete Street Transformations*, Sustainable Cities Institute, University of Oregon; at http://www.rethinkingstreets.com/download.html

14. James A. Lenker, Jordana Maisel, Molly E. Ranahan (2016), *Measuring the Impact of Complete Streets Projects: Preliminary Field Testing*, University at Buffalo; at https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Transportation/16-19-Measuring-Impact-of-Complete-Streets-Projects.pdf
15. Stefanie Seskin, Hanna A Kite, Laura Searfoss (2015), *Evaluating Complete Streets Projects: A guide for practitioners*, Smart Growth America; at https://smartgrowthamerica.org/wp-content/uploads/2016/08/evaluating-complete-streets-projects.pdf
16. Molly E. Ranahan, James A. Lenker, Jordana L. Maisel (2014), *Evaluating the Impact of Complete Streets Initiatives*, University at Buffalo (IDEA); at http://idea.ap.buffalo.edu/idea/wp-content/uploads/sites/110/2019/07/IDeACenter_GoBike_CompleteStreets_web.pdf
17. Yifang Zhu, Rui Wang, Shi Shu, Nancy McGuckin (2016), *Effects of Complete Streets on Travel Behavior and Exposure to Vehicular Emissions*, University of California, Los Angeles; at https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/11-312.pdf
18. Bernice Liu, Alireza Shams, Jonathan Howard, Serena E. Alexander, Alexandre Hughes, Anurag Pande (2020), *Assessing Complete Street Strategies Using Microscopic Traffic Simulation Models*, Mineta Transportation Institute; at https://transweb.sjsu.edu/sites/default/files/1712-Pande-Assessing-Complete-Street-Strategies.pdf
19. Markus Friedrich, Eric Pestel, Christian Schiller, Robert Simon (2019), *Scalable GEH: A Quality Measure for Comparing Observed and Modeled Single Values in a Travel Demand Model Validation*, Institute for Road and Transport Science, University of Stuttgart; at https://doi.org/10.1177/0361198119838849