FGV CIDADES

ANALYSIS OF SHARED STREETS

Task F: Executive Summary

Partners:

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INTRODUCTION

Urban mobility in the city of São Paulo presents a transport system with a marked dominance that is expressed in the concentration of resources and public attention in favor of displacements in private and individual means of transport, to the detriment of active, public and collective modes. The prioritization of individual motorized transport has multiple negative effects, especially with regard to public health and inequality, as it jeopardizes the mobility of low-income people (who are the majority of the population and the main users of public transport) and encourages an environmentally unsustainable model, which in turn affects all citizens by subjecting them to pollution, congestion and road insecurity.

Cities around the world have implemented public policies to encourage active modes and public transport and/or discourage individual motorized modes. With the aim of creating a systematic base of case studies that can support the improvement of existing policies and the formulation of new, more equitable and sustainable public policies (Task B), this project presents analyses of some of these policies, including a study of experiences undertaken in the city of São Paulo.

This study has developed methodologies to measure the impacts of prioritizing individual motorized transport on road safety, atmospheric pollution, greenhouse gas emissions, and congestion, also presenting estimates of the social costs they entail. It is worth noting that there are details of the methods in the respective reports that precede this executive summary, in which the access locations for the scripts and data used are indicated, to make it possible to reproduce, reuse, expand and update the presented calculations (Task C).

Case studies were also carried out in a region of São Paulo, to exemplify the potential demand for transport in the active mode, based on simulations and using models of open innovation, both at the macro level, to assess the potential demand for non-motorized transportation, and at the micro level, to assess the impact of investments in non-motorized transport infrastructure (Task D).

We have also sought to deepen the discussion on the limits and possibilities of improving the management and financing of sidewalks in the city. A broad survey was carried out on the governance of sidewalks, identifying rules, institutions, legal and planning instruments, responsibilities, financing conditions and inspection procedures, management and maintenance, including aspects related to governance and the interfaces between the several actors involved in the management of the active mobility policy in São Paulo.

The various existing funding sources for the improvement of sidewalks in the city were also identified, a process that included the analysis of: the municipal budget; tax instruments (e.g., improvement contribution); urban instruments (transformation axes, Urban Intervention Projects (UIP), urban operations, onerous granting of the right to build, etc.); partnerships with the private sector; and municipal funds (Urban Development Fund – FUNDURB; Municipal Transport Fund, etc.).

On a propositional basis, the project identifies the core components of a sidewalk management program for the city of São Paulo, including its principles and guidelines, main lines of action, available resources and responsible bodies. Last but not least, it includes a simulation exercise in the neighborhood of São Miguel, located in the East Zone of São Paulo, in order to assess the limits and potentialities of applying the improvement contribution to the financing of works to improve the sidewalks in the city (Task E).

This executive summary presents, therefore, an abridgement of the consolidated studies from previous reports and aims to offer, in a succinct and direct way, the main results found. After this brief introduction, this summary presents four sections that correspond, each of them, to the reports that make up the documentation of the project's results, in addition to a conclusion that summarizes the main recommendations for improving and formulating more equitable and sustainable public policies.

1 TASK B: SUMMARY OF PUBLIC POLICIES FOR SHARED STREETS

Task B's report presents the analysis of several public policy instruments for Travel and Complete Streets Demand Management. The objective is to offer inputs that serve the transport policies of the city of São Paulo, oriented to increase the participation of sustainable modes (active and collective), which was discussed in the following steps of this project. In order to achieve that, a first discussion was held about the basic concepts that organize the project, in addition to the analysis of 14 cases in 11 cities with different contexts, including three actions implemented in the city of São Paulo, grouped into: (1) Interventions oriented to travel demand management and the reduction of the use of individual motorized transport; (2) Complete street-oriented interventions and prioritization of active modes; and (3) Interventions aimed at reducing distances. The lessons extracted from the analysis are applicable to sustainable transport policies in the city of São Paulo. The detailed description of each case can be found in the appendix to this document.

1.1 Concepts, principles and general guidelines

The project, in general terms, aimed to evaluate measures aimed at sustainable mobility through the promotion of active mobility and public transport and disincentives to the use of individual motorized transport. An important portion of the initiatives studied relies on what is usually called travel demand management (TDM) strategies. This concept proposes that the appropriate combination of a series of actions creates conditions and incentives for people to change their decisions regarding the way they commute and, thus, transform their mobility patterns and adopt more sustainable, efficient and equitable options. Generally, TDM strategies combine economic measures – also called command measures – as well as regulatory, physical and operational measures to promote the desired changes in travel preferences, such as: (1) reducing the use of individual motorized transport (IMT); (2) promoting active modes (mobility on foot and bicycle use); (3) promoting the use of collective public transport (CPT).

The concept of "complete street" is based on the understanding that the thoroughfare (i.e., the street, from one lot to the next, including the sidewalk) is a public space and, therefore, must be designed taking into account the urban context in which it is inserted, aligning mobility needs with social coexistence. In this sense, we propose to balance the needs of different modes of transport, benefiting people of all ages and abilities, in accordance with zoning, the economy and the local natural environment (Santos et al., 2021).

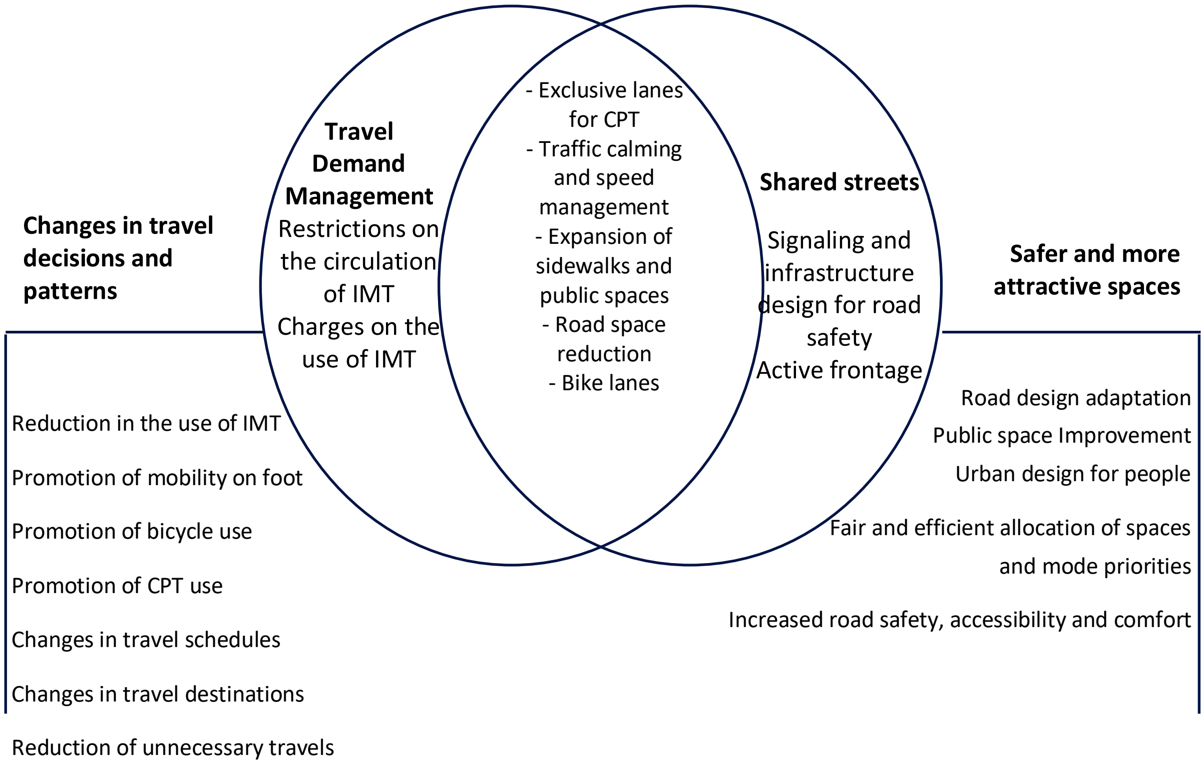
In this report, complete streets are treated as a concept of street that focus primarily on the pedestrian and provides safe, comfortable and convenient access for all people, regardless of their walking abilities and the mode of transport they use. It is important to note that complete streets do not necessarily need to have designated space for each of the transport modes. That is, the configuration of the street must allow its functions within the mobility system to be exercised while offering safety and comfort to the people who use it.

The “shared streets” are a type of intervention with common objectives aimed at promoting mobility on foot, the use of bicycles, the improvement of the quality of public space and the creation of spaces for coexistence, in addition to the increase of road safety. But the idea behind “shared streets” (a specific type of “complete streets”) is that different modes of transport can share space without implying that one mode prevails over the other.

The manifold roles that thoroughfares play under the concept of shared streets can be categorized according to the variables “movement” and “attractiveness” (Transport for London, 2013). Attractive locations with a large volume of transfers of transport modes and with commercial concentration require measures such as speed reduction, implementation of bicycle lanes, restrictions on private vehicles, etc. in order to allow the use of the streets by the different modes in a safe and comfortable way. Local streets that are not very busy nor very attractive can be shared, for example, after the implementation of different types of pavement.

While TDM uses economic, regulatory, operational and physical instruments to create conditions and incentives that promote changes in people’s decisions regarding the way they commute and, thus, change the travel patterns in the city, complete streets represent the very transformations of spaces, aiming at offering greater attractiveness, safety and health, considering pedestrians a central element of the urban design and the road network (Figure 1).

Figure 1. Relationship between Travel Demand Management and Complete Streets.



Source: Own elaboration.

In this project, we sought, whenever possible, to take advantage of synergies and the potential of complementary actions, either as an object of analysis or as premises. The combination of economic command measures (using the price system for this) with the redesign of streets is a kind of synergy. For example, by taxing vehicles according to their impact on traffic congestion, room must be made for active modes. Thus, we sought solutions that use a combination of instruments to achieve the goal: sustainable and more equal transport for all.

From these concepts and premises, we studied transport policies implemented in São Paulo and in the world. Table 1 systematizes the 14 cases of 11 cities, grouped into: (1) Interventions aimed at managing travel demand and reducing the use of individual motorized transport; (2) Complete street-oriented interventions and prioritization of active modes of transport; and (3) Interventions aimed at reducing distances.

Table 1. Analysis groups for the cases selected.

Case	City	Country	Start	Instruments
Group 1. Interventions aimed at managing travel demand and reducing the use of individual motorized transport				
Rodízio [Vehicle restriction]	São Paulo	Brazil	1997	Fee
Restricción Vehicular	Santiago	Chile	1986	Fee
Congestion charge	London	England	2003	Fee
Pico y Placa & Tasa por congestión	Cali	Colombia	2005	Fee
Área C e Ecopass	Milan	Italy	2008	Fee
Zona Azul [Parking fees for specific areas]	São Paulo	Brazil	1975	Fee
Group 2. Complete streets-oriented interventions and prioritization of active modes of transport				
Street Design Guide	New York	USA	2009	Urban planning and nudge
Metrominuto	Pontevedra	Spain	2011	Tecnology and nudge
Reduced speed area	São Paulo	Brasil	2013	Urban planning and design
Política de espacio público	Bogotá	Colombia	2015	Urban planning and nudge
Superillas	Barcelona	Spain	2016	Urban planning and design
Projeto Cidade da Gente	Fortaleza	Brazil	2017	Urban planning and design
Walkability plan	London	England	2018	Urban planning and design
Group 3. Interventions aimed at reducing travel distances				
15-Minute Paris	Paris	France	2020	Urban planning and design

Source: Own elaboration.

1.2 Case studies of policies implemented in São Paulo and around the world

Based on the analysis of the cases, it is possible to list several actions to be adopted by the public authorities to ensure that the implementation of an instrument aimed at prioritizing active and collective modes of displacement is successful:

1. Use the price system, creating fees for modes of transport that generate negative externalities and offering subsidies to modes that generate positive externalities.
2. Adopt strategic communication that is appropriate to the context, engaging the population, especially in the case of unpopular measures.
3. Link transport policy to the public health and climate change mitigation agenda for policy prioritization.
4. Conduct temporary tests and experiments for evaluating the measure and helping in the elaboration of the communication strategy.

5. Institutionalize the policy in administrative (boards, departments, planning pieces, etc.) or legal (laws) terms.
6. Align processes and visions in order to reduce the fragmentation of responsibility for the public space and its governance.
7. Use nudges/incentives to change individuals' behavior.
8. Define clearly and institutionalize the destination of the funds raised.
9. Continually review and adjust public policy.

The analyzed cases presented several strategies that communicate and, in some cases, open spaces for dialogue on actions aimed at promoting sustainable transport. In the report, for each of the cases studied, communication strategies identified in the launch and implementation phases were listed (and sometimes illustrated). For analysis purposes, the strategies were categorized into five major groups: campaigns, press, events, participatory processes and access to information. The table below shows an overview and, in the sequence, analytical observations will be presented.

Figure 2. Communication strategies adopted during the launch and implementation periods of the policy.

CASES	CAMPAIGNS				PRESS		EVENTS		PARTICIPATORY PROCESSES		ACCESS TO INFORMATION
	TV and/or radio campaign	Social media campaign	Correspondence	Opinion poll survey	Press articles	Government chief executive as spokesperson	Debates, lectures and other expository events	Tactical urbanism	Public consultation	Participatory workshops	Official website
Group 1 - Interventions aimed at managing travel demand and reducing the use of individual motorized transport											
Rodízio (1997)	•			•	•						•
Restricción Vehicular (1986)		•		•	•						•
Congestion charge (2003)	•	•	•	•	•	•	•		•		•
Pico y Placa e Tasa por congestión (2005)		•			•						•
Área C and Ecopass (2008)	•	•	•		•	•	•		•		•
Zona Azul (1997)					•						•
Group 2 - Interventions aimed at complete streets and prioritization of active modes of transport											
Street Design Guide (2009)					•		•				•
Metrominuto (2011)					•						•
Reduced Speed Areas (2013)					•			•		•	•
Política de espacio público (2015)											•
Superillas (2016)		•			•	•	•	•	•	•	•
Projeto Cidade da Gente (2017)		•		•	•	•	•	•	•	•	•
Walkability (2018)					•						•
Group 3 - Interventions aimed at reducing travel distances											
15-minute Paris		•			•	•		•	•		•

Source: Own elaboration.

The communication strategies observed in the cases illustrate how it is possible to resort to different actions, depending on the nature and objectives of the policy, the level of maturity of the public debate on the subject, prior knowledge about the population's disposition or opposition to the measure and the degree of prior engagement of the population with the proposed measures. Despite the need to elaborate the communication plan according to the context, it is possible to observe a pattern in the strategies adopted according to the category of cases.

Advertising campaigns, usually on TV, radio, billboards and banners, may have two approaches. One of them is **informative**, aiming at clarifying the changes, how the measure works and practical issues that impact the daily lives of the population, in addition to placing the topic on the public agenda. The other approach focuses on raising **awareness and engagement** (convincing), with catchphrases that explain the importance of changing the population's behavior and its potential impact. This type of campaign also includes a call to action, calling on the audience to do something. Examples are seen in the cases of Rodízio in São Paulo and Congestion Charge in London: "You collaborate a few hours and the traffic improves every day" and "If you could see London's air, you'd want to clean it too", respectively. Mass advertising campaigns are especially relevant before the implementation of unpopular measures, as in the case of policies that implement demand management instruments (group 1).

It is common to carry out opinion polls to guide the campaign strategy, as occurred in São Paulo (Rodízio) and London (Congestion Charge). This is because mass media advertising campaigns are in general very expensive. Therefore, it is important to ensure that the aired/published ads are as assertive as possible, considering that we can say the same thing in many ways, but not all ways will generate the desired impact on the audience. This effectiveness check is carried out via surveys to hear the opinion of a sample of the target audience on the campaign materials, thus ensuring that the message is clear and meets the communication objectives.

Participatory processes, in addition to collecting contributions from society, were used as a first step in the population's communication and engagement strategy. It is essential to understand the perceptions and concepts of the public that will be impacted by the measures and mass communication strategies in order to adapt the language and present arguments capable of gaining popular support, in addition to optimizing the production of materials with assertive messages. In London (in the case of the Congestion Charge), in Paris (specifically for the removal of parking spaces under the 15-Minute Paris program), and in Milan, public consultations were carried out. In these three cases, the public opinion was divided, and the political cost of taking the decision was high. So, the public consultation was a way for the government to share the decision with the citizens, or even to overcome political barriers/opposition through the voice of the population. A good example is the case of Milan, where the Milano si Mueve association started a petition that led to a referendum in which it was revealed that 79% of the population were in favor of increasing vehicle restrictions in the city center.

In the case of the Metrominuto program, in Pontevedra, we observed actions aimed at generating behavioral change to encourage more people to walk. The nudges, based on behavioral science, encourage desirable choices through effective communication with the population, without restricting individuals' freedom of choice. Nudge actions are generally cheap, simple and often present in the decision-making environment/context. In turn, mass communication campaigns for behavioral change tend to be more expensive and more complex and outside the decision-making context. The innovation of nudge actions lies in identifying cognitive barriers and overcoming them, stimulating beneficial behaviors for the individual and the community. With the motto, "On foot you live longer", the Metrominuto program did not imply operational changes and focused on overcoming information barriers (related to possible routes, estimated time, health and environmental gains, among others) that made it difficult for citizens to visualize the mode on foot as a real and suitable option for their travels.

Another key strategy for communicating measures that affect – or have the potential to affect – the population is media engagement. Media outlets have the power to bring information to a large number of people, based on information and backed by their credibility. The relationship with journalists must be fostered strategically and carefully, since the press can help to engage the population or rather dividing opinions. To avoid noise in communication, it is possible to hold workshops with journalists to inform them about mobility policies before announcing them to the public. Two other mechanisms, which are more commonly adopted, are the announcement of the measure in press conferences and the use of the government chief executive as a spokesperson, demonstrating the relevance of such a policy in the government agenda. A recent and emblematic case is that of mayor Anne Hidalgo, who took advantage of the debates during the electoral period to guide the media and involve the population in the 15-Minute Paris program.

Events such as tactical urbanism interventions, held in Barcelona, São Paulo and Fortaleza, also promote engagement. By tactical urbanism we mean temporary actions of street transformation with light materials (paint, flower pots, markers, etc.) that facilitate dialogue with the surrounding community and are excellent ways of communicating definitive interventions, as they can be easily viewed by the population. Street actions and urban interventions are excellent resources to attract press attention and give more visibility to the theme in an organic way (without paying for media space).

More personalized communication strategies can also be used, depending on the reality of the city and as a complement to mass communication actions. Some cases employed a direct and individualized approach with citizens as a strategy, as in London, in the case of the Congestion Charge, in which correspondence was sent to drivers, or in Milan, where letters were sent to families with information about the damage that the pollution causes to health.

Make available reliable and up-to-date information on official channels, such as city hall websites, is a fundamental communication strategy. All cases analyzed provide information on government websites. The population needs to know where to find correct and up-to-date information and how to proceed in case of doubts. In the case of London, a telephone line was created for the population to call and dispel their doubts.

Actions do not always aim to reach all population. It is also very important to think about communication strategies that mobilize specific audiences, as in the case of the New York Street Design Guide, in which events were held (debates and lectures) aiming at engaging key actors in public space projects, such as architecture offices, construction companies and design departments within the city hall itself. Additionally, engaging influencers such as journalists, academics, experts on the subject, and influencers who speak to target audiences can help reach the public through the endorsement of the message by people the audience trusts.

Defining which strategy is the best to be adopted will depend on the nature and purpose of the measure, the target audience, the messages to be communicated, the available resources, the map of actors and favorable and contrary political positions, the space and conditions in the public debate on the topic and the motivation behind the measure (for example, public health, environmental objectives, road safety, among others). A careful analysis of the context is essential to design an adequate communication strategy, as what works in one location may not be viable in another. In this sense, having a repertoire of possibilities helps to find the best path for promotion, engagement and persuasion in a given context.

1.3 Task B Conclusions

Task B's report brought together sustainable transport policies with the aim of inspiring the city of São Paulo in its own transport policies, based on an approach that combines travel demand management strategies and complete streets. The scope of measures that can be adopted is quite wide and covers several solutions. The potential synergies and complementarities, resulting from the combination of modal migration with infrastructure reconfiguration interventions that focus on people, public spaces, safety and the city's habitability, open up a diverse and comprehensive range of possibilities for action by the public authorities.

In order to reach their true potential, several of these actions have some degree of interdependence with others, which makes the integral planning, implementation and management processes more critical. For this reason, the measures evaluated and developed in this study are more focused on interventions in the streets network to prioritize active mobility and discourage the use of IMT. For this, they need to be understood not as isolated actions, but as part of a broader and more articulated strategy. To achieve these objectives, public administration can use a series of instruments, such as:

1. Taxation: congestion charges, contamination charges, street parking charges, etc.
2. Urban design: traffic calming measures, expansion of sidewalks, implementation of sidewalks, bike lanes, exclusive lanes for buses, etc.
3. Urban planning: mixed-use zoning (residential and commercial), densification along transport axes, etc.
4. Nudges: advertising campaigns, correspondence with information sent directly to citizens, discounts for behavior changes, etc.
5. Technology: bus apps, apps with best bike routes, modal integration platforms, etc.

The cases analyzed in the previous section show how these experiences are, indirectly, the result of fundamental state capacities for the implementation of truly comprehensive and intersectoral strategies, such as:

1. Inspection: ability to enforce the provisions of public policy, as in cases of vehicle restriction, urban tolls, parking areas with fees.
2. Monitoring: ability to monitor the progress of public policy, allowing its effectiveness to be assessed, such as the use of GPS on buses to monitor their frequency.
3. Governance: ability to manage different teams (including those from other bodies and different organizations) for the pursuit of public policy.
4. Communication: ability to inform and/or convince the target audience and stakeholders about the validity of the public policy.
5. Social participation: ability to engage and involve the target audience of the public policy in its formulation, implementation and evaluation.
6. Financing: ability to raise funds, whether public or private, to invest in the public policy.

2 TASK C: SPACE SHARING AND NEGATIVE EXTERNALITIES IN THE CITY OF SÃO PAULO

Task C report presents the methodological description, advances, results on estimates of street space distribution by mode of transport, as well as the methodology and estimates (based on available information) of negative externalities in 4 dimensions: emissions of CO2e; congestion time; traffic accidents and health impacts resulting from excessive emissions of fine particulate matter (PM2.5). For each dimension we also suggested methods for monetization and estimation of the respective monetary costs associated with these externalities. After this brief introduction, the main results are described below.

2.1 Street space

The distribution of street space between different modes in the city of São Paulo is extremely uneven, with individual motorized transport (IMT) being prioritized with the allocation of 60.8% of the area to this mode, which is equivalent to more than 9 times the 6.5% area occupied by collective motorized public transport (CPT), 20 times the space dedicated exclusively to buses (2.9%) and three times the area dedicated to sidewalks with a width above the minimum for pedestrian circulation (17.1%).

This supply distribution contrasts with the modal split of travel demand, as identified in the OD2017 survey carried out by RMSP. Public transport travels, despite constituting the largest portion, with 34.5% of total travels, have the lowest dedicated space in the road space (6.5%). Travels made exclusively on foot, that is, without considering walks to access public transport, are 32.4% of the daily total, but the area for pedestrian circulation with minimum accessibility conditions is only 17.1%, while IMT travels account for 33% and occupy 60.8% of street space. Taking as a basis the ratio between the street space used by each mode and the respective number of daily travels, at one extreme we find **travels in individual motor vehicles** (cars, motorcycles, taxis, private and school buses), which **accounts for 13.6 m^2/daily travel. At the other extreme is the street space used by public transport, with an indicator 6 times smaller: 2.3 m^2/travel** (or, when only the area of exclusive bus lanes is considered, 0.7 m^2/travel).

If only the area of sidewalks with minimum accessibility conditions is considered, the indicator attests that pedestrians have 4.3 m^2/travel available. These numbers indicate the current lack of priority for public transport, which, despite being able to transport more people per square meter and, therefore, being more efficient than the car in terms of space use, has much less area reserved for it in the street. The greater use of public space by cars becomes an implicit subsidy to private individual transport, given that there are no fees or additional contributions for road use. In other words, the entire cost of road maintenance ends up being paid by all taxpayers, except in the case of app drivers, who pay for the use of the road.

Table 2. Total values (ha) and percentages of the area of the street space component in the MSP

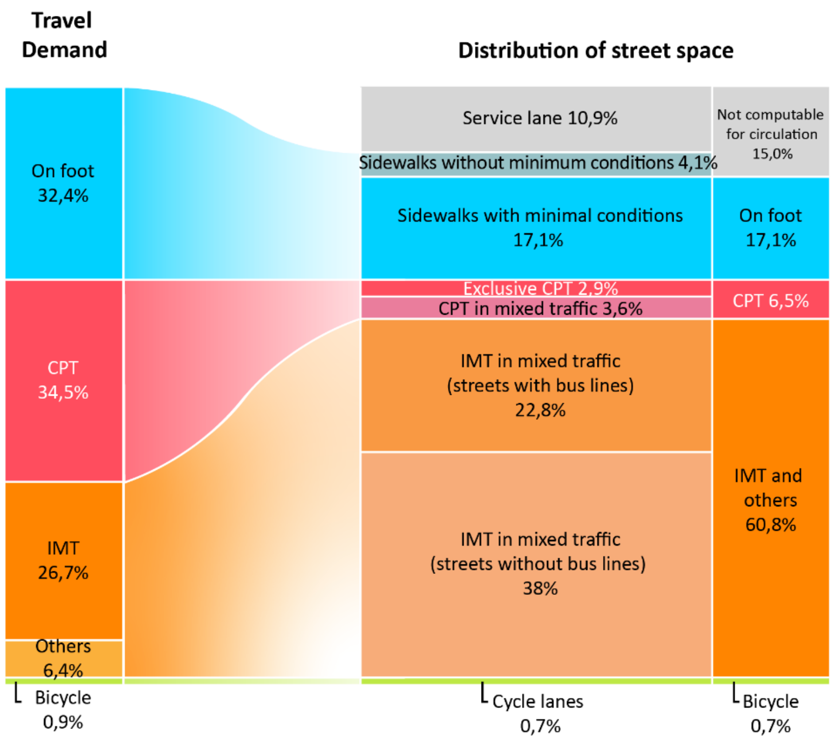
Street component by type of use			Distribution per Component		Disaggregated Distribution	
			Area	%	Area	%
Sidewalks	Service lane		6,210.60	*32.1%*	2,108.6	*10.9%*
	Without minimum conditions for pedestrian circulation				797.1	*4.1%*
	With minimum conditions for pedestrian circulation				3,304.9	*17.1%*
Bus lanes (exclusive use of CPT)			561.7	*2.9%*	561.7	*2.9%*
Mixed traffic	Streets with bus lines	CPT use	5,093.80	*26.3%*	687.7	*3.6%*
		IMT use			4,406.1	*22.8%*
	Roads without bus lines (exclusive use of IMT)		7,348.50	*38.0%*	7,348.5	*38.0%*
Cycle lanes and tracks (exclusive use of bicycles)			128.5	*0.7%*	128.5	*0.7%*
Total			19,343.10	*100.0%*	19,343.1	*100.0%*

Source: Own elaboration, based on data from polygons of sidewalks, bicycle paths and exclusive bus lanes provided by Geosampa, polygons of roads provided by SMUL, routes of bus lines provided by SPTrans and location of bus lanes provided by CEM

The space allocated for sidewalks, in addition to being scarce, also presents a distribution that reinforces social inequalities in the city. **In particular, the 10% with the highest income have more than half of the sidewalks with a width above the minimum desirable, of 2.50 m, practically double that of the poorest 70%.**

In a simulation, we could imagine what would happen if we increased the bus space from 2.19 m to 3.5 m on all streets with mixed traffic that do not yet have segregation. Making this simplistic calculation, we concluded that it would be necessary to add 412 ha of space to the bus, which **represents a loss of less than 10% in the area currently occupied by other motorized vehicles.** That is, space should not be the major limitation for the increase of segregated roads. With regard to space, it does not seem extremely complex to implement bus segregation throughout the transport network. In addition to the budget issue, which adds to the difficulty of execution in the case of exclusive bus lanes, there is the challenge of inspecting such lanes. An effective inspection would imply the monitoring of the street. The financial cost of this monitoring (essentially, implementing radars) is usually more than offset by the revenue from fines, so we are not talking about financial difficulties to implement real-time monitoring. The difficulty is political: in addition to restricting space for cars, fines are wildly unpopular.

Figure 3. Comparison between travel demand and road supply distributions by mode.



Source: Own elaboration, based on data from polygons of sidewalks, bicycle paths and exclusive bus lanes provided by Geosampa, polygons of roads provided by SMUL, routes of bus lines provided by SPTrans and location of bus lanes provided by CEM

Regarding the policy for active modes, what the numbers point out is that the space allocated to sidewalks does not present the same disparity as observed for buses. The problem here is the inadequacy of the sidewalks, which does not appear in the space division data estimated in this research. **We have 12,000 km of sidewalks below the minimum width,** with an average width of 65 cm when we remove the service lane **and another 6,700 km of roads below the desirable standard** (excluding the service lane, this group would have between 1 .2 m and 1.8 m; therefore, the median width would be 1.5 m). Thus, unlike what we found for buses, the space required in order to have quality sidewalks is significant. **We need 4 times more sidewalk space (to ensure they are a desirable size) than we need to ensure segregation of buses throughout their network.**

The implementation of an integral network of sidewalks with desirable width certainly implies a considerable reduction in parking space. The average width of streets without mixed traffic is 5.4 m. If we consider that the average width of the portion of the sidewalk dedicated to pedestrians, in cases where it is below the minimum, is 0.65 m, we would need to add 1.15 m to each sidewalk, that is, 2.3 m in total, leaving 3.1 m for vehicles. It's doable, but it means that this street should be one-way, or rather shared, and certainly with no parking space. This is probably the main battle when it comes to space distribution.

2.2 Externalities

In addition to the subsidized use of public space by individual motorized transport, discussed above, this mode is the main generator of negative externalities, such as traffic congestion, deaths and injuries in traffic, morbidity and mortality caused by poor air quality, as well as emissions of greenhouse gases. Just as the data associated with the consumption of space on the road system indicate a disproportionality in the relationship between people transported and the use of space when comparing private individual modes with collective modes of transport, **estimates of the car's contribution to negative social externalities (congestion, road insecurity and atmospheric pollutants) and environmental (emissions related to the effects of global warming) also indicate an extremely disproportionate impact between the individual motorized mode and collective ones.** The only exception occurs in the emission of PM2.5, because, even when we consider the emission per travel*km, the bus ends up being a more relevant emitter than the car (but not more than the motorcycle). In any case, as shown in the report, the emission of PM2.5 does not represent a negative externality as relevant as the others.

With regard to environmental externalities, if we consider the **estimates of carbon dioxide equivalent (CO2e)** as an aggregate indicator of the potential to induce the greenhouse effect, **cars contribute practically three times more than buses to the daily emissions in the city of São Paulo, being responsible for 72.3% (75.4% if we also add motorcycles) of emissions compared to the 24.6% emitted by buses (summing up municipal and intermunicipal buses).**

In the case of atmospheric contaminants (particulate material), buses are responsible for a cost of BRL 7.9 per 1,000 kilometers traveled, while for cars this value is BRL 1.6 but still below the rate for motorcycles, of BRL 17.3. This is a potentially favorable point for migration to electromobility, although this discussion needs much more depth.

In analyses that adopt very conservative assumptions for speeds on the road network, it is estimated that, for **travels made by car in the city of São Paulo[1], 45% of their total duration corresponds to additional time due to the slowness caused by road saturation**. In the afternoon peak hour, between 18:00 and 19:00, congestion accounts for 56% of the total duration, which means that people traveling by car spend 128% more time when compared to the free-flow scenario, more than double the minimum time. A very relevant aggravating factor for this analysis is also the additional time that car drivers impose on public transport trips, because, even if the additional time in CPT is comparatively smaller than in IMT, and even though a large portion of the trips are by subway, train and exclusive bus lanes, **bus passengers spend an average of 20% more time commuting compared to the scenario without congestion**. At peak hours, this additional travel time imposed on the CPT rises to 26% compared to the free-flow situation. **In absolute terms, car users spend an additional 1.07 million hours in traffic[2], while public transport passengers spend an additional 1.25 million hours[3] due to the excess of vehicles.**

Still with regard to social externalities, analyses of traffic accidents claims were carried out based on data available in GeoSampa. Although it was possible to identify a certain trend of general decline in the number of victims over the period analyzed (2013 to 2020), the drop was concentrated in the first period (2013 to 2016), when it stagnated at around 1,000 deaths per year. **The share of individual transport in claims is much greater than that of collective and active modes, with cars involved in 46% of claims and motorcycles in 40% of non-fatal claims. Considering fatal accidents (except pedestrian accidents), motorcycles accounted for 43% of all fatal victims in the analyzed period, followed by cars (34%) and, with a significantly lower participation, by buses (10%).** In this regard, bicycle appears as a considerable generator of accidents, to the point that its contribution to the reduction of negative externalities is questionable.

To estimate the costs related to traffic accidents, the methodology proposed by IPEA (2015) was adopted, with values corrected for 2019 using the IPCA. Analyses indicate that **motorcycles are responsible for the highest costs, totaling an annual loss for society of BRL 263 million on average.** This stems from the predominance of fatalities associated with this means of transport. **Next, cars are the ones that most impact society in terms of accidents, reaching losses of BRL 240 million per year. Claims involving buses and trucks generate average annual costs of BRL 53 million and BRL 32 million, respectively**.

[1] Considering the travels with origin and destination within the MSP.
[2] Corresponding to the 4.8 million daily travels by car in the MSP (driver and passenger), whose average duration is 29.6 minutes.
[3] Corresponding to the 7 million daily TPC travels in the MSP, with an average duration of 64.2 minutes.

Considering all fatal and non-fatal claims (except pedestrian accidents), the average annual cost of claims involving victims in the MSP reaches an annual value of approximately BRL 624 million. Analyzing pedestrian accidents exclusively, we reach an average value of approximately BRL 220 million, with approximately 40% of this total involving cars. Motorcycles and buses contribute 20% each to the total. The remainder is distributed between pedestrian accidents involving trucks, bicycles and other modes of transport.

2.2.1 Monetizing the externalities

2.2.1.1 Emission costs

If we consider the estimates of carbon dioxide equivalent (CO2e) as an aggregate indicator of the potential to induce the greenhouse effect, **automobiles contribute to 72.3% of daily emissions in the city of São Paulo, while municipal buses contribute to 23. 7%. Therefore, if we moved 1% of passengers from the IMT to the bus, we would generate a net reduction of 1.38% in carbon equivalent emissions.** If we consider the price of the carbon credit on December 31, 2021 in the futures market (€ 80.65) and the total volume of daily emissions of the city of São Paulo (10,000 tons of CO2e), **the change of 1% of users from the IMT to the bus would generate savings for society of approximately € 11,100 per day**. If we consider the 7.06 million IMT travels, we can say that each IMT trip costs € 0.08 a day for the environment.

Every 1,000 kilometers that we reduce the use of cars and replace them with active modes represents savings of BRL 65 for society if we take into account that the carbon credit market reflects the social cost of emissions. This is certainly a debatable hypothesis, as the carbon market essentially depends on supply and demand, which in turn depend on a series of political factors. For example, in January 2020, the carbon credit was quoted at € 24.31. Announcements by the newly elected US president led to more than threefold growth in market value over the year. Many people believe that the value of carbon in the market does not really reflect its social cost due to political factors and others that have no effect on the market, but that affect society. Thus, this measure can be considered a “lower limit” on the social cost of emissions.

In addition to allowing, from the point of view of emissions, a direct comparison between modes, monetarization, regardless of possible criticisms to this criterion, serves to compare externalities. The estimate gives an idea of the social cost of this externality to society. For example, if we intend to charge cars for what they generate as an externality in terms of greenhouse gas emissions, we could charge cars 6.5 cents of Brazilian Real per kilometer traveled, and 2.3 cents of Brazilian Real from motorcycles per kilometer traveled. If the decision were not to charge bus users, which may be justifiable for several reasons (including the space savings discussed above), we should charge 5.4 cents of Brazilian Real per kilometer (the difference between the social cost of the externality generated by cars and the externality generated by buses) and 1.3 cents per kilometer from motorcycles.

A relevant issue for public policy is whether we should charge for emissions at the local scale or not. As emissions have a global effect, it doesn't matter where they occur on the planet. Emitting GHG in São Paulo or in China causes the same deleterious effect on the planet. In this case, we are talking about emissions resulting from fuel consumption. Therefore, the most logical thing would be to charge the externality directly on fuel consumption. However, local charging could be justified if we think about incentives for modal switching, which is the logical basis of the Task C report. We believe that this measure is very useful for thinking more broadly about public transport policies before implementing them.

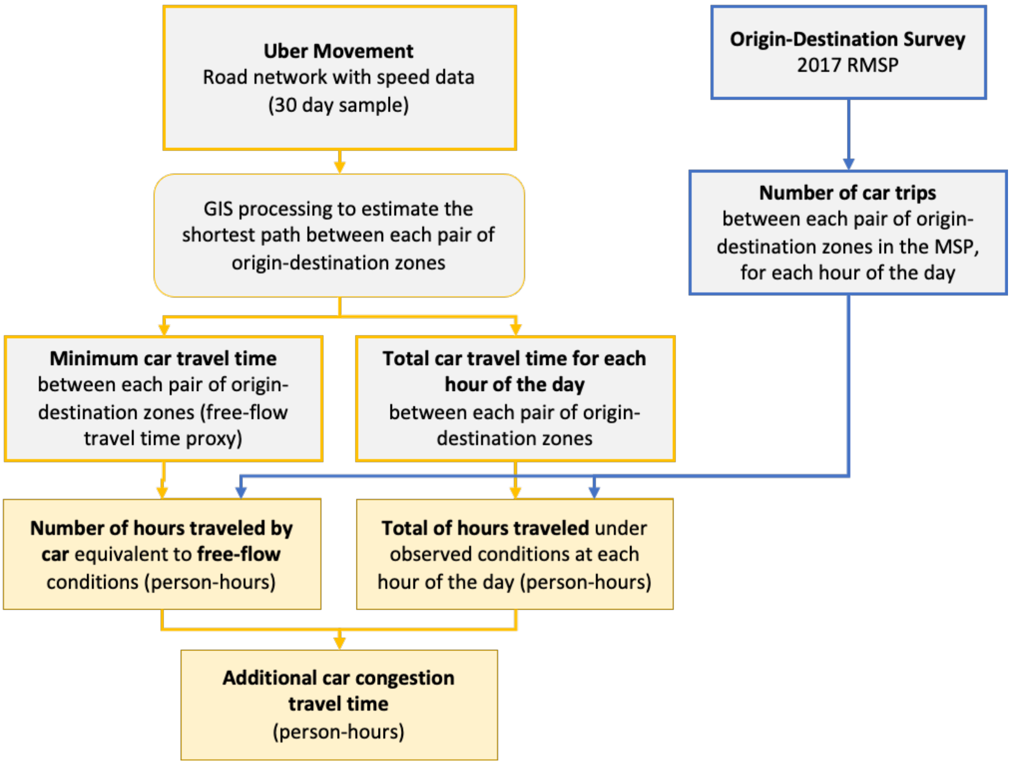
2.2.1.2 Cost of time

In order to estimate the time spent, we compare the actual time spent in traveling from one point to another with the time it would take to travel without any congestion, which is known as "free flow". The additional congestion time (ACT) is calculated by the difference of two reference values: the free flow time (FFT) and the total travel time (TT). To obtain the total value of this externality for the entire day in the study area, we multiply the ACT of each pair of origin-destination zones (OD pair) by the number of travels in each hour of the day. Due to the differences between the data sources, the analysis is performed separately for individual private transport (IMT) and collective public transport (CPT), but the basic mathematical formulation is the same.

Travels made in individual private transport, despite being the main responsible for road saturation, are not the only ones affected by congestion. **Buses that operate in mixed traffic, that is, without exclusive or priority infrastructure, also circulate more slowly in stretches where speed is reduced due to road saturation.** For this reason, the two main modes of motorized transport in the study area, responsible for most of the total externality for time in congestion, were addressed: IMT, consisting mainly of private cars, and CPT, which combines the RMSP bus, subway and train systems. For the purposes of this analysis, the rail system has no impact on travel times on roads due to their absolute segregation, and we assume that motorcycles and bicycles do not affect travel times either.

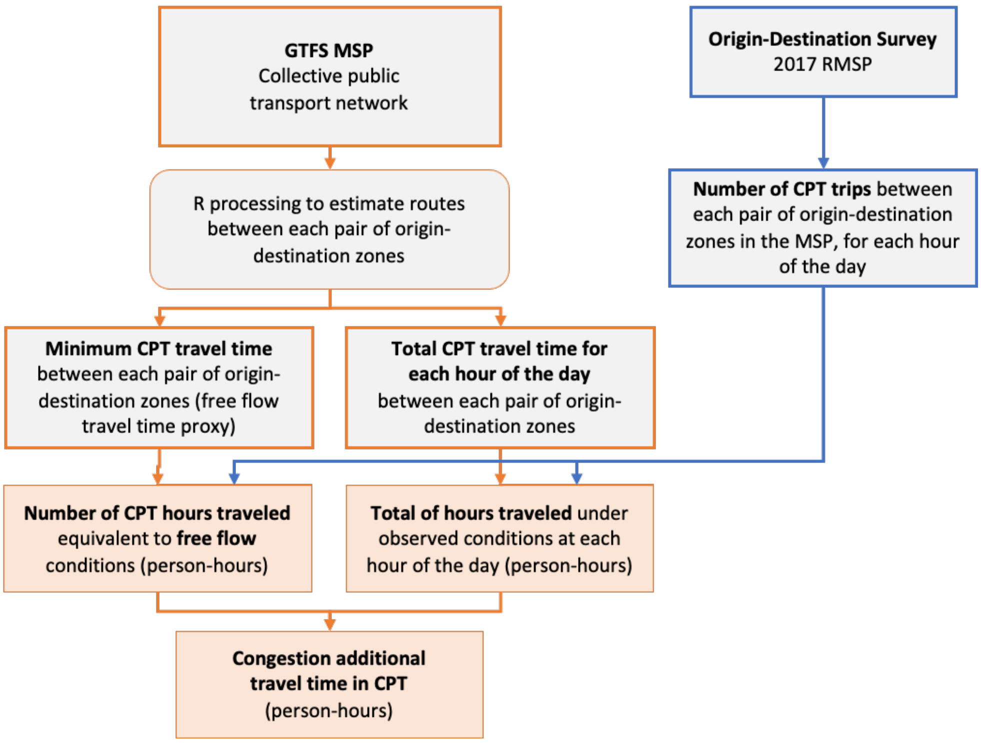
Figures 4 and 5 schematically present the data source and its use for estimating ACT:

Figure 4. Summary of data and methods for additional congestion time for IMT



Source: Own elaboration

Figure 5. Summary data and methods for additional congestion time for CPT



Source: Own elaboration

To allow comparability with the other components of negative externalities, it is necessary to "convert time into money". The basic model for estimating the value of time in transportation seeks to find the marginal rate of substitution between time and money in the individual's utility function. By definition, this replacement rate is the value of time in transport; how much the individual would be willing to give up money to reduce his time in transportation. Small (2007) derives the value of time (VOT) of the individual in relation to his salary, finding a value per hour inside the vehicle of 49% of the individual's salary and a value of 129% of the salary for the time waiting for transportation. **For simplicity, we will use 50% of family income as a measure.**

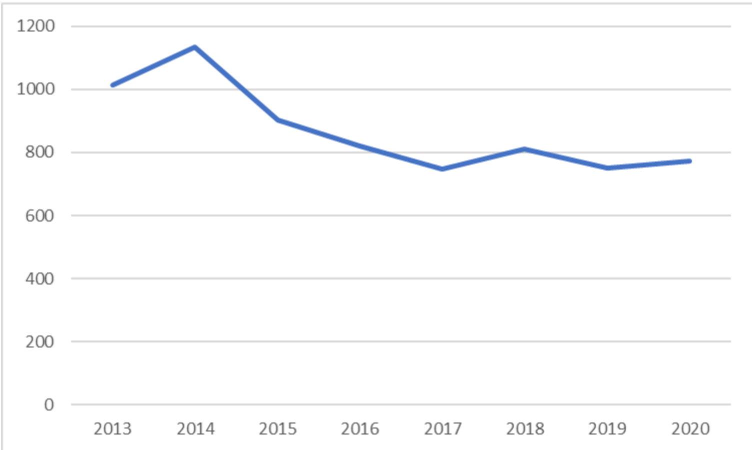
In one day, the loss of time generated by the excess of vehicles imposes a cost of at least BRL 6.6 million on all car drivers and BRL 3.9 million on bus users. Every 1,000 kilometers of car use generates a social cost between BRL 168 and BRL 191, depending on the criteria used for defining free flow (in September 2017 currency) without including the cost imposed on bus users. **The additional time imposed on bus users is very similar to that observed for the car (69 million minutes on the bus versus 68 million minutes on the car)**. The value of this time is lower, reflecting the fact that bus users have a lower income than car users. This is, to a certain extent, a problem with this criterion of valuing time as a function of income. We can say that **the excess of vehicles causes a loss of time for society (car and bus users) of 207 seconds per kilometer of car use, which is equivalent to BRL 0.35 per kilometer in September 2017 values.**

2.2.1.3 Costs of road (un)safety

The city of São Paulo provides, through Geosampa, the database of traffic accidents recorded between 2013 and 2020, discriminating the events of pedestrian accidents and also separating fatal and non-fatal accidents. The base only covers claims that led to hospitalization or death, therefore ignoring claims without victims. The database is organized so that victims are associated with the types of vehicles involved in the accident. Thus, in order to avoid double counting of total victims, it was decided to establish a hierarchy by type of vehicle when allocating responsibility for the accident by mode. The hierarchy follows this order: automobile > motorcycle > truck > bus > bicycle. For example, if a car and motorcycle are involved in a claim with 1 victim, the victim will be associated with the car. **The participation of automobiles in victims of non-fatal accidents corresponds, on average, to 76% of cases, followed by accidents involving motorcycles, which account for 18% of victims. Bus accidents account for around 5% of non-fatal traffic victims.**

The trend of deaths per accident in the period 2013-2020 was downward, but this trend stagnated from 2017 onwards. Figure 6 presents data only for fatal accidents, adding the cases of pedestrian accidents to the others, and makes it clear that the curve becomes flat from that date on. The upward and downward variations from 2017 cannot be considered a worsening nor an improvement, as they are small enough to remain within the margin of error. In recent years, the CET has managed to reduce the rates of deaths in traffic, then around 1,200 per year, to 800 per year, despite population growth and the increase in the proportion of travels by IMT, which reveals the excellent work made by the company. However, there is still a need to reach lower rates, compatible with what is observed in first world countries. The proposals discussed in Tasks B and E seek to offer an overview of what has been done in other cities, with objectives that include, among others, the improvement in road safety with some success stories around the world.

Figure 6. Deaths per claims (2013-2020)



Source: Geosampa, CET

Cars, in gross terms, are the main responsible for accidents, being surpassed by motorcycles, the second greatest responsible in almost all cases, only for accident claims (excluding pedestrian accidents). These two individual motorized modes account for more than 80% of accidents with victims, except for cases of fatal pedestrian accidents, in which buses are responsible for 26% and motorcycles for 24%. In absolute values, bicycles can be considered responsible for a small proportion of accidents. However, when we take into account the number of kilometers in each mode, bicycles become the second highest proportion of accidents, second only to motorcycles.

The social costs associated with traffic accidents were calculated based on the methodology developed by IPEA (2015). Even though a death or a permanent sequel has immeasurable costs, for the purposes of comparison, tangible costs associated with a fatal claim and with a non-fatal one were taken into account. These costs include expenses with hospitalization and care (public agents involved, removal and rescue costs), the indirect impact on congestion, damage to urban equipment, deterioration of private assets, loss of productivity, social security and legal costs. The IPEA (2015) provides different estimates for minor and serious accidents and fatalities. As the database does not indicate the seriousness of the injuries, we used WHO data, which indicate that, on average, 10% of the claims are serious.

Table 3. Breakdown of claims per mode

Claim Type	Car	Bicycle	Motorcycle	Bus	Total
Non-fatal claims	49%	2%	42%	7%	23,549
Fatal claims	37%	4%	48%	11%	701
Non-fatal pedestrian accidents	58%	1%	30%	11%	3,284
Fatal pedestrian accidents	50%	1%	24%	26%	288

Source: Geosampa

2.2.1.4 Health costs of air quality

In Brazil, in 2019 alone, 61,000 people died as a result of air pollution (IHME, 2020). Poor air quality seriously affects people's health at all stages of their lives, causing a range of illnesses and complications. It is responsible for 40% of global deaths from chronic obstructive pulmonary disease, 26% of deaths from stroke, 20% of deaths from diabetes, 20% of deaths from ischemic heart disease and 19% of deaths from lung cancer (IHME, 2020).

Inhalable particulate matter is the most relevant indicator for pollutants harmful to health, as it is highly harmful to health when penetrating the respiratory system. This pollutant is composed of very fine particles of solids or liquids suspended in the air and is classified according to its size: MP10 and MP2.5 for particles with a diameter equivalent to or less than, respectively, 10 μm (micrometers) and 2.5 μm. Its main sources of emission are motor vehicles, industrial processes, biomass burning and soil dust resuspension.

Long-term impacts of air pollution are defined as the health impacts attributable to annual exposure to air pollution. Health outcomes addressed include six specific causes of death (chronic obstructive pulmonary disease, diabetes mellitus, lower respiratory tract infections, lung cancer, ischemic heart disease, and stroke) and adverse outcomes in children (prevalence of infant mortality, prevalence of babies born with low birth weight and prevalence of prematurity). These data were obtained from the following sources: SIM, SINASC and DATASUS.

In the metropolitan region of São Paulo, particulate matter emitted by vehicles (light, heavy and motorcycles) represents 40% of PM10 emissions and 37% of PM2.5 emissions (CETESB, 2020). To estimate deaths attributable to PM2.5 pollution, we applied the concentration-response relationship (or relative risk – RR) between PM2.5 exposure and specific causes of death based on new MR-BRT RR curves developed by Global Burden of Disease Collaborative Network (2021). We then calculated short-term health impacts. To this end, we surveyed the number of hospitalizations due to cardiovascular diseases (CVD) and respiratory diseases (DRESP). Data on daily hospitalizations were collected for all age groups, organized by diagnosis and counted to obtain the total number of hospitalizations that could be attributed to exposure to PM2.5 for 2019. Applying dose-response functions, we estimate for the year 2019 the mortality of 181 children, 144 cases of low birth weight, 1,040 cases of premature births and 2,701 deaths in all age groups, which can be directly associated with the effects of exposure to fine particulate matter.

We used a procedure similar to that carried out for the accident rate, computing direct costs (hospitalizations) and indirect costs (loss of productivity) related to cardiovascular diseases caused by excess microparticles in the air. In this case, hospitalization costs are not associated with costs of care, removal, damage to private and public property or congestion, as in the case of traffic accidents. There is some cost of removal by ambulance in a few cases, which was disregarded in this estimate. Additionally, hospital cost data also need to be estimated for this specific case. The treatment time and the medical specialties required are different. Thus, the estimate for the cost of hospitalization resulting from the emission of PM2.5 differs from the cost of hospitalization resulting from accidents. In the case of death, the costs are essentially the same, since 99% of the social costs of a death refer to the loss of productivity.

Finally, we relate health impacts to vehicular emissions, per vehicle category, assigning the proportion of vehicular emissions to total PM2.5, and then separating by mode, according to their relative particulate contribution. This is the same strategy as employed by Sá and collaborators (2017). Thus, we multiply the impacts of PM2.5 by 0.37 (CETESB, 2020) and then multiply the relative contribution of particulate matter emissions by type of vehicle: automobiles (3%); motorcycles (4%); buses (31%). For example, the impact of the automobile on health outcomes was estimated to be 1.11% (0.37*0.03*100) of the total impact of particulate matter on health. Using data from 2019, this means that we can associate 8 hospitalizations and 32 deaths with car use. We performed exactly the same analysis for motorcycles and buses.

To find the economic cost associated with hospitalizations and deaths, we used data on total hospitalization expenses extracted from the SIH (equivalent to BRL 1.35 million), the

indirect cost due to loss of productivity (BRL 357,000) and the total cost of deaths (BRL 1.48 billion). We estimated that 382 hospitalizations due to CVD corresponded to a cost of BRL 751,000, and that 70 hospitalizations due to DRESP corresponded to BRL 50,000. Regarding expenditures for child deaths, a total of BRL 551,000 was attributed to low birth weight and premature births. In total, the public health system spent BRL 1.4 million on hospitalizations caused by poor air quality. The loss of productivity due to hospitalization is, respectively, BRL 296,00 and BRL 62,00, totaling BRL 357,000. We can attribute BRL 93 million to infant mortality. Summing up these values and dividing the result by the number of cases, we reached the average cost of hospitalization (per case) and mortality (per death). The social economic cost of PM2.5 emission by motor vehicles can then be estimated simply by multiplying the total number of cases by its average value. The summary of all these estimates is displayed in Table 4.

Table 4. Social cost per vehicle category and due to the issuance of PM2.5 in the MSP in 2019 (values in December 2021 Real corrected by the INPC)

Vehicle category	Hospitalization		Deaths	
	Cases	Value	Cases	Value
Cars	8	BRL 18,970.62	32	BRL 16,389,794.56
Motorcycles	11	BRL 25,294.16	43	BRL 22,023,786.44
Buses	85	BRL 196,029.71	331	BRL 169,531,937.48

Source: Own elaboration, based on Sá and collaborators (2017), CETESB (2020), IPEA (2015), SIH and Datasus.

When we consider the use of the mode, the motorcycle causes more damage (BRL 17.3 per pax*1,000 km) followed by the bus (BRL 7.9 per pax*1,000 km) that is well above the car (BRL 1.6 per pax*1,000 km). This is due to the greater share of emissions of particulate matter generated in the combustion of buses. This fact partially justifies the replacement of the diesel bus fleet with cleaner technologies, such as electric buses. The Euro 6 standard already guarantees a much lower emission of particulate matter. Due to the physical characteristics of motorcycles, even with a much lower use than cars, they are responsible for twice (or more) the number of hospitalizations and deaths per kilometer related to the emission of PM2.5 and for a cost 2.2 times the cost associated with bus use.

2.3 CAPEX and OPEX

The penultimate section of Task C estimates capital costs (CAPEX) and operating costs (OPEX) for both buses and cars. This estimate is key to the public policy assessment

carried out in the last section. Differences in space and social cost by mode, using economic theory, imply that the pricing structure is economically inefficient. Cars and motorcycles receive a subsidy in spatial and monetary terms that distort consumer behavior. In fact, as is known, this distortion should also occur in a "pure" market economy precisely because of the existence of negative externalities. The economic mistake is to subsidize buses beyond CAPEX and not charge cars and motorcycles for the total negative externalities they generate.

2.3.1 CAPEX and OPEX for cars

The CAPEX estimate for cars is based on the fleet of registered vehicles and the average prices of vehicle purchase and sale transactions. The capital stock of vehicles in the Metropolitan Region was estimated at BRL 204 billion. Information regarding the fleet is released annually by CETESB. Note that we do not consider the CAPEX associated with the space dedicated to cars. If we take into account only the parking space occupied by the fleet of non-commercial cars in the RMSP, taking a standard space of 2.5 m × 5 m as a reference, we reach a total of 50 km^2, which, if we take the value of the average square meter of the city as BRL 4,00, produces a value of over BRL 200 billion, doubling, therefore, the stock of capital dedicated to automobiles. The issue of space was treated differently and was already discussed in the first section of Task C.

The OPEX estimate took into account consumption elements (fuel, tires, lubricants) and maintenance, totaling BRL 12 billion per year. To estimate CAPEX as a flow, we used the capital charge cost (insurance, taxes, financial costs and depreciation), reaching a conservative estimate of BRL 26 billion. To define the capital charge cost, we considered the four items listed above. The IPVA, which is the tax for vehicle ownership in Brazil, is 4% of the value of the vehicle in the state of São Paulo. Insurance costs between 5% and 7% of the value, so we worked with a value of 6%. In 10 years, the vehicle is estimated to have a value of approximately 20% of an equivalent new vehicle. Thus, we defined 8% of the value as a loss factor. Finally, to consider that the resource is immobilized, we assign a cost equivalent to real interest, around 2% per year, arriving at a total value of 20% per year in relation to the value of the vehicle. Using the value of the stock of capital, we arrived at a total value of BRL 52 billion per year. The information is only available for the RMSP. Conservatively, we considered that the municipality of São Paulo corresponds to 50% of vehicle ownership in the RMSP, in order to arrive at the CAPEX value.

2.3.2 CAPEX and OPEX for buses

Based on values from November 2019, the Municipal Public Transport System in the city of São Paulo has a total monthly cost of BRL 748.2 million, or approximately BRL 9 billion per year. SPTrans's data sheet for defining the fare from January 2020 breaks down the system's operating costs. If we consider depreciation, revenue contribution and gross profit as capital costs, we arrive at a value of BRL 114.41 million per month or BRL 1.37 billion per year of fixed cost, in the economic sense of the term. What we call fixed costs are those that do not depend on production. Strictly speaking, fixed cost is depreciation and return on capital. Here, we add taxes to fixed costs, as return on capital depends on net income. If we observe the annual net profit, we will have approximately 10% of the value of the vehicles, which reaches BRL 3.5 billion. In reality, the return on capital is lower than this percentage, as we do not add the value of the garages to equity.

As we arrived at an amount of BRL 1.4 billion for CAPEX, OPEX can be obtained by residue, that is, it is equivalent to BRL 7.6 billion per year. The estimated subsidy for 2019 was of BRL 3,167.17 million, quite above the cost of capital described previously. The subsidy, however, according to the City Hall, has a social objective that goes beyond the economic logic, leaving the user with only the marginal cost of public goods. We will discuss this policy in more depth when we consider aspects of public finances in a possible redistribution of expenses towards equity between modes, taking into account the negative externalities generated by each mode. In any case, the total costs of public transport, of BRL 9 billion in 2019, which guarantee the use of 115 million passengers*km per day, contrast with the (private) expenditure on transport by car, in the order of BRL 26 billion for a use of 57 million passengers*km per day.

2.4 Towards an equitable public transport policy

Throughout Task C, we assessed the distribution of public space, social costs and direct financial costs of various modes of transport. **It is worth compiling all the information in order to discuss the consequences of an increase in equity between modes on the division of space, costs and benefits of a possible change in transport policy.** In line with the most modern public policies (Gov 2.0), tax collection should focus as much as possible on charging negative externalities. Thus, in order to carry out an economic-financial analysis of this macro proposal for public mobility policy, we started with this source of revenue with great economic appeal. Unlike taxes in general, which can generate distortions in the economy, contributions on consumer goods that generate negative externalities increase the efficiency of the economy. When it is possible to raise public funds from fees on negative externalities, we are simultaneously financing the provision of a public good and increasing the efficiency of the economy.

Table 5 presents simultaneously the impacts of each mode on the "physical" variables (as opposed to the monetary variables). That is, the measuring unit depends on the type of externality: CO2e for GHG emissions; seconds for congestion time; victims or deaths for accident claims; and hospitalizations or deaths for PM2.5 emissions. It makes no sense to add these indices, as each of them uses different measures. **In Table 6, we present the same categorization as in Table 5, but computing the cost per 1,000 kilometers.** In this case, it makes sense to add the rows, as the numerators are now in the same unit of measurement: in Brazilian Real of December 2021. Even in this case, it makes no sense to add the columns, as the denominator is different: in each mode we use pax*km of the mode.

Table 5. Negative externalities per type associated with each mode in physical units

Negative externality	Car	Motorcycle	Bus	Bicycle
CO2e emissions (g/km)	127.43	45.65	20.66	
Congestion time per auto (sec/km)	206.84			
Congestion time per bus (sec/km)	91.24			
Non-fatal casualties resulting from an accident per million km	0.7858	1.6646	0.0412	0.2813
Fatal casualties resulting from accidents per million km	0.0242	0.1027	0.0038	0.0445
Hospitalizations resulting from the emission of PM2.5 per million km	0.0005	0.0051	0.0023	
Deaths resulting from the emission of PM2.5 per million km	0.0018	0.0201	0.0092	

Source: Own tabulation based on data from IEMA, OD Survey 2007 and 2017, SPTrans, GeoSampa, DataSUS and Cetesb.

Table 6. Negative monetary externalities per type associated with each mode, in Brazilian Real of December 2021, per 1,000 km

Cost of negative externality	Car	Motorcycle	Bus	Bicycle
CO2e emissions	64.94	23.26	10.53	
Congestion time per car	350.80			
Congestion time per bus	212.31			
Non-fatal casualties resulting from accidents	34.13	72.31	1.79	12.22
Fatal casualties resulting from accidents	20.81	88.35	3.24	38.23
Hospitalizations resulting from the emission of PM2.5	0.0013	0.0139	0.0064	

Cost of negative externality	Car	Motorcycle	Bus	Bicycle
Deaths resulting from the emission of PM2.5	1.55	17.26	7.89	
Total	472.23	201.20	23.46	50.45

Source: Own tabulation based on data from IEMA, OD Survey 2007 and 2017, GeoSampa, DataSUS, Cetesb, IPEA and Central Bank.

As discussed at the beginning of this summary, our perspective is a comparative one, that is, we estimate what the reduction of negative externalities would be when changing the modal distribution. We took the bus as a reference. Thus, by using the unit of measurement per travel*km, we find out what should happen in "physical" and monetary terms when we remove kilometers from a mode with the migration to the bus, which is the reference. As the bus is the reference, it makes no sense for it to appear in Tables 7 and 8, which show the relative gain when we migrate from the other modes to the bus, as all rows would be zero (by definition). On the other hand, in these tables it makes sense to present the "walking" mode. In the previous tables, such a column would have made no sense, as this mode does not generate any negative externalities (also by definition). Now, walking appears with negative values, emphasizing that this mode does not generate negative externalities.

Table 7. Monetary externality variations with a reduction in a mode and an equivalent increase in bus use (in Brazilian Real of December 2021, per 1,000 km)

Negative externality	Car	Motorcycle	Bicycle	Walking
Emissões CO2e (g/km)	106.78	24.99	-20.66	-20.66
Congestion time per car (sec/km)	206.84	0.00	0.00	0.00
Non-fatal casualties resulting from an accident per million km	0.74	1.62	0.24	-0.04
Fatal casualties resulting from accidents per million km	0.02	0.10	0.04	0.00
Hospitalizations resulting from the emission of PM2.5 per million km	-0.002	0.003	-0.002	-0.002
Deaths resulting from the emission of PM2.5 per million km	-0.01	0.01	-0.01	-0.01

Source: Own tabulation based on data from IEMA, OD Survey 2007 and 2017, SPTrans, GeoSampa, DataSUS and Cetesb.

When we consider the volume transported by bus, we notice that this mode generates much fewer negative externalities than cars or motorcycles. The reduction in CO2e emissions, congestion time and traffic crashes victims is really high. Transferring 1,000 kilometers of car use to buses would generate a reduction in greenhouse gas emissions of 106.78 tons and a 45-hour reduction in congestion time for car and bus users. The only case in which the bus presents a loss to society in relation to the car (but not in relation to the motorcycle) occurs with the emissions of fine particulates. This result should not occur if the entire fleet were constituted by electric vehicles. We are unable to make this estimate, but it is possible that emissions per pax*km would be lower than those of cars if the fleet were made up of 100% Euro 6 vehicles. pax*km are low when compared to the other externalities.

Note that Table 8 presents the gain (positive value) or loss (negative value) when we reduce the use of the mode in the column and increase this volume in the bus mode. Negative values quantify the social benefits associated with active modes, vis-à-vis the bus. Active modes have essentially negative values, with the exception of cycling, with regard to road safety. There is a gain in road safety by reducing bicycle use and increasing bus use. It is worth remembering that accident claims attributed to bicycles are those that did not include any other mode. Even so, there is an annual average (from 2013 to 2020) of 70 non-fatal accidents and 11 fatal accidents involving just the bicycle. We do not know if the fact that only the bicycle appears is related to some omission (for example, whoever caused the accident fled the scene of the crime). What we do know is that these numbers are extremely high if we take into account the low volume of bicycle use. Anyway, these are the official data, and we should treat this issue uniformly for all modes. Ignoring the negative impact of cycling on road safety might create faulty incentives for this group.

Table 8. Changes in the social cost of the externality per mode with the switching to bus, in Brazilian Real of December 2021, per 1,000 km

Cost of negative externality	Car	Motorcycle	Bicycle	Walking
CO2e emissions	54.41	12.74	-10.53	-10.53
Congestion time per car	350.80	0.00	0.00	0.00
Hospital costs due to accident claims and air contamination	25.99	79.88	2.54	-9.68
Deaths due to accident claims and air contamination	11.22	94.48	27.09	-11.14
Total	442.42	187.10	19.10	-31.35

Source: Own tabulation based on data from IEMA, OD Survey 2007 and 2017, SPTrans, GeoSampa, DataSUS and Cetesb.

In Table 8, we present the gain (or loss, if the number is negative) in negative externalities when we change 1,000 kilometers of usage from header mode to bus mode in monetary units. Although monetization is questionable, it has the great advantage of allowing comparison between different types of externalities. This attribute of the estimate in monetary terms allows externalities to be added, which would be impossible in "physical" measuring. In this case, we consolidate hospital costs resulting from non-fatal accidents with hospitalizations resulting from excess PM2.5 in the air and deaths resulting from fatal accidents with deaths resulting from PM2.5 emissions by transport. Although cycling generates a reduction in externalities (vis-à-vis the bus) in relation to GHG emissions, its impact on the accident rate per passenger*km is so high in monetary terms that it causes bicycles to generate more negative externalities than buses when consolidating total externalities per mode. By replacing 1,000 kilometers of bicycles with 1,000 kilometers of buses, society saves up BRL 19.10. On the other hand, each 1,000 kilometers of walking replaced by 1,000 kilometers of bus generates a social cost of BRL 31.35. We must not forget that we are only considering tangible externalities, ignoring, among many other elements, the health benefits that one has when exercising by riding a bicycle or walking, vis-à-vis the sedentary lifestyle of motorized modes.

When replacing 1,000 kilometers of car use and transferring them to bus, society saves up BRL 442, and when replacing 1,000 kilometers of motorcycle use with the equivalent of bus use, society saves up BRL 187. When we look at the cost resulting from externalities generated by cars, it is easy to see that their greatest source is the extra time imposed by the excess of vehicles on both car and bus users. This is a classic negative externality. The great social cost of motorcycles is linked to the accident rate. Despite generating more emissions per passenger*km than other modes, hospital and life costs induced by motorcycle use generate a loss of BRL 174.36 more for society than if motorcyclists opted for the bus. Whether for motorcycles or bicycles, safety policies implemented by the government, as well as changes in behavior by users of these modes, should reduce the accidents rate and, therefore, reduce the cost to society.

One way of using these results is to take them as a reference for charging on negative externalities generated directly by the user, thus "internalizing externalities". This procedure should generate a decrease in the volume of cars and motorcycles in circulation, which, in turn, would reduce the time spent on traffic congestion. If we consider that there will be no charge on bicycles, the potential collection of this policy would be around BRL 8.3 billion per year. This figure is overestimated, as we should first charge the cost of congestion only for the portion of travels that take place within the area where there is actual congestion. Second, congestion charges should only be applied at times of the day when there is congestion. Other costs do not depend on location or time of day. The last row of the table conservatively presents these adjustments, reaching a value of BRL 3.2 billion in fees collection.

Table 9. Collection resulting from fees on negative externalities

Item	Car	Motorcycle	Total
Collection per km-day	0.44	0.19	-
Passengers*km	56,916,017	6,847,735	-
Collection per day (1,000 BRL)	25,181	1,281	26,462
Collection per year (1,000 BRL)	7,878,058	400,834	8,278,891
Adjusted collection	2,758,477	400,834	3,159,310

Source: Own tabulation based on data from IEMA, OD Survey 2007 and 2017, GeoSampa, DataSUS, Cetesb, IPEA and Central Bank.

The fact that it does not matter where on the planet the CO2e emissions are produced leads to the questioning of a local charge on this negative externality. As we are charging based on the idea that it would be possible to simply change the mode of travel, local charging is partially justified. For this reason, we deduct from users the amount issued for bus transportation. In fact, the correct thing, in economic terms, would be to charge directly the consumption of fossil fuels, depending on the consequences of their consumption. This fee would ensure that energy-efficient vehicles pay less per kilometer than inefficient ones, which is correct. An electric vehicle would not pay this fee, except if the energy were generated by thermoelectric plants fueled by fossil fuels. In this case, the fee should somehow be reflected in the price of electricity. In any case, it would be logical for part of this collection to remain with the city government so it can invest on sustainable modes of transport.

The previous analysis also provides a clue about how to spend the extra funds raised. It should be invested in mobility, giving preference to sustainable modes. The first point, we understand, refers to the maintenance of the sidewalks and the roadways. As we have discussed, space is very poorly distributed and considerable investment would be required to ensure a "desirable" width for all sidewalks and a widespread increase in partially segregated lanes for buses. As noted, this policy would imply an increase of 1,654 ha of sidewalks and 412 ha of partially segregated bus lanes. In reality, the cost of increasing space for these two modes is similar to the cost of maintaining roads and sidewalks in already urbanized areas.

In order to assess the investment required for this public policy in large numbers, we estimated the cost of maintaining lane widths and sidewalks based on two recent municipal government programs: "Asfalto Novo" [New Pavement] (AN) and "Programa Emergencial de Calçadas" [Sidewalk Emergency Program] (PEC). Between November 2017 and June 2020, AN was able to repave 557 km of roads with an investment of BRL 1 billion[4]. Bringing the data up to values for December 2021, we estimate the cost of road renovation at BRL 2.2 million/km, generating an approximate value of BRL 262.89/m^2 of paving. In the case of the PEC, based on the analysis of the Price Registration Minutes, we have an average value of BRL 114.40/m^2 of renovated sidewalks in 2019, or BRL 135.53/m^2. The durability of the paving of both roadways and sidewalks is estimated at approximately 10 years. Thus, it is estimated that it would be necessary to renovate 10% of the roads and sidewalks per year so that they are kept in a good state of conservation. Putting all this information

[4] Available at: https://www.prefeitura.sp.gov.br/cidade/secretarias/subprefeituras/noticias/?p=301102. Accessed on: Feb. 12, 2023.

together, we arrive at the annual investment required for the maintenance of roads and sidewalks, as shown in Table 10.

Table 10. Approximate estimate cost of provision and maintenance of road infrastructure in the city of São Paulo (12/2021 Brazilian Real)

Type	Cost/m2	Current area (ha)	Annual cost (BRL 1,000)	Proposed area (ha)	Annual cost (BRL 1,000)
Sidewalks	135.53	6,211	841,754	7,865	1,065,927
Roads	262.89	13,133	3,452,566	11,479	3,017,746
Total		19,344	4,294,320	19,344	4,083,673

Source: Own tabulation based on data from GeoSampa and CEM.

Just to maintain the current infrastructure in good condition over the next 10 years, it would be required (per year) BRL 841 million (for 621 ha) of investment in sidewalks and BRL 3,452 million (for 1,313 ha) in roads. There is no way to add this operating cost using only treasury funds. Hence the proposal to charge on externalities. Cost estimates implicitly assume that it will not be necessary to increase the area dedicated to the thoroughfare (considering sidewalks and roads); any increase in the width of sidewalks will take place over the space dedicated to motorized modes other than buses. Certainly, this is not a realistic hypothesis, but the investments necessary for the expansion of roads, such as expropriations, for example, may come from the investment account. On the other hand, **this is the essence of shared space: there is no way to dedicate so much space to the individual motorized transportation, which needs to share this space with other more sustainable modes.** As the cost of renovating sidewalks is considerably lower than that of resurfacing roadways, the total budget drops when we “exchange” road area for sidewalk area.

A somewhat sensitive issue is whether car users should contribute for road maintenance. If we consider that this maintenance is equivalent to CAPEX, as it only takes place every 10 years, we would have an argument for employing treasury funds. However, if we believe that car users should also be responsible for all CAPEX, we should at least partially charge for lane maintenance. If we take the total pax*km as a basis, cars represent approximately 80% of motorized modes, excluding buses: motorcycles, taxis, school and private buses). If the current infrastructure were maintained as it should, it would cost BRL 2.4 billion per year, or BRL 0.14/pax*km. With the proposed redistribution of space, this value drops to BRL 0.11/km. **Adding the negative externalities to the cost of road resurfacing, cars circulating in the expanded center would have to pay BRL 0.55/km if the proposed reallocation of space were carried out.**

If we compare it with the cost of OPEX and CAPEX, of the order of BRL 26 billion per year, we will note that this contribution per kilometer would represent 16% of the annual cost of transport by car – a value that should not be disdained, but that is just reasonable in average terms. The problem is that 80% of the cost of using a car is linked to its value, which in turn varies a lot. There are vehicles with an average value of BRL 4,200 and others with an average value of BRL 100,000. If we add this to the identical operating costs for both types of vehicles, of the order of BRL 2,000 per year, we will note that **the automobile's contribution to externalities and road maintenance, in relation to its annual cost, will be around 7 times higher for cheaper vehicles than for more expensive vehicles.** This disproportion occurs regardless of the fee for road maintenance. **Such a disparity constitutes a political difficulty for the implementation of a full fee for negative externalities of car use**. This distributive problem can be even more serious in the case of motorcycles.

Following purely economic logic, we should reflect a little more on subsidies to bus operators. The subsidy planned for 2020 (last year for which data is available) was of BRL 3.2 billion in the year (for a total expenditure of BRL 9 billion)[5] or BRL 3.7 billion in values for December 2021. Economists criticize subsidies, as these can distort the behavior of individuals. There is a "meritorious" side to this "distortion": removing individuals from individual motorized transport. On the other hand, it also reduces the incentive to travel by active modes that are not subsidized. **The subsidy that makes economic sense is the one that is made at a fixed cost. Whether a bus runs with one passenger or 100, the costs directly linked to the vehicle are exactly the same.**

Fixed costs, in the economic sense of the term, were, in 2020, around BRL 1.4 billion – less than half of subsidies to bus operators. The public transport subsidy strategy beyond capital costs, **as a distributive strategy, is somewhat debatable, as the most relevant attribute of a distributive policy is its focus.** The widespread subsidy of public transport undoubtedly affects the lower income population more intensely; however, it ends up privileging other income brackets. It would be possible to focus much more on the distribution of transport subsidies. The transport voucher (VT) mechanism is an example of a very focused distributive policy, as it ensures that a maximum of 6% of individuals' income is spent on transport. The problem with the VT has nothing to do with the system, but with the high level of informality in the country, which ends up leaving many individuals (precisely the poorest) out of this policy.

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[5] Available at: https://www.prefeitura.sp.gov.br/cidade/secretarias/mobilidade/acesso_a_informacao/index.php?p=150849. Accessed on: Feb. 12, 2023.

We must also consider a key aspect in the investment in infrastructure dedicated to buses: the Bus Rapid Transit (BRT). The assumption of similar road maintenance costs is reasonable for exclusive lanes, but it certainly does not make sense for BRTs. The most recent BRT project in São Paulo is "Aricanduva", with an approximate cost of US$ 9 million/km, as indicated in the World Bank document calling for bidders[6]. Considering a 20% increase in the originally estimated cost and the same financing cost (3.25% per year) with the same maturation time (25 years), and assuming full investment financing, to reach a 500 km BRT network in the city, it would be required an investment (in December 2021 values) of BRL 1.19 billion per year. **Table 11 presents the summary of the large numbers of sources and expenses for the current system and how this distribution would be in a future perspective, following the proposal consistent with a change towards a model of shared streets.**

Table 11. Mobility system's collection and expenses (BRL billion of 12/2021): current and future

Current sources		Current expenses	
Treasury	3.68	Operating costs	10.42
Fee revenue	6.74	Road resurfacing	0.25
Fines	0.30	Sidewalk renovation	0.05
Future sources		Future expenses	
Fees on externalities	2.53	Investment in BRT	1.19
Fee for road maintenance	1.63	Road maintenance	2.77
Fee for improvement	0.31	Sidewalk maintenance	1.02

Source: Own tabulation based on data from IEMA, OD Survey 2007 and 2017, GeoSampa, Secretariat of Finance DP, DataSUS, Cetesb, IPEA and Central Bank.

In Table 11 we present the major expenses and collection items for financing mobility in terms of flow. We ignored public administration expenses, whether those of the Municipal Transport Secretariat or those of SPTrans and CET companies. We know that the collection of fines is around BRL 1 billion, but around 70% of this amount is used to fund the CET[7]. We did not include the portion of revenues allocated to direct administration nor expenses with this item, as we focus on direct spending on mobility, not indirect ones.

[6] Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/551661565301639508/concept-project-information-document-pid-sao-paulo-aricanduva-brt-corridor-p169140. Accessed on: Feb. 12, 2023.
[7] Available at: https://g1.globo.com/sp/sao-paulo/noticia/2021/08/16/prefeitura-de-sp-arrecadou-r-1-bi-em-multas-em-2020-mas-pode-receber-calote-de-outros-r-76-bi-por-falta-de-cobranca-diz-tcm.ghtml. Accessed on: Feb. 12, 2023.

Roughly speaking, the current structure, added to the fees on externalities and for the maintenance of the road for individual motorized transport, associated with a consistent investment in roads and sidewalks, does not allow financing the BRT. This is not a problem, as BRT is definitely a fixed cost, which makes perfect sense to be funded by the treasury. Here we have an essentially public policy decision, which is, of course, up to those who were elected to do so. Currently, substantial resources from the treasury are allocated to mobility, which are essentially concentrated in subsidies to bus operators. With the proposed increase in revenue (Future sources) and increase in expenses (Future expenses), this value would represent 23% of total expenses, below the current 35%, but still quite high.

Evidently, this analysis of "large numbers" depends on a series of details so that the measures are actually implemented. The municipal government, despite having resources and international support, has had great difficulty in bidding for the Aricanduva BRT. It does not seem at all trivial to produce around 40 km of BRTs per year. The AN and PEC programs have shown considerable capacity to resurface roads and renovate sidewalks, but the current need is many times greater than the largest programs implemented in this specific area in the last 20 years. We are talking about an increase from the current BRL 300 million per year to more than BRL 4 billion in this type of expenditure. It is possible that the Price Registration Minutes system makes such a jump possible, but we have no idea of the administrative structure behind this change in spending.

A change in the way we implement public mobility policy for (thought in an aggregated way) is possible without necessarily increasing the pressure on the treasury resources currently allocated to mobility. However, it requires a radical change in citizens' behavior – a change that only becomes possible with communication actions such as those discussed in Task B. The hypothesis that it would be possible to simply take space away from cars and pass it on to buses and modes assets is probably too optimistic. The fees on negative externalities also require a very complex movement regarding the current attitude of citizens. Within the budgetary reality of the city hall and the city's road infrastructure, there is no way to make this change in public mobility policy without these two changes. It would take a lot of political courage to implement a fee of this magnitude. If there is no change in the travel pattern, around 70% of the cars would pay around BRL 10 per day, with electoral effects difficult to manage.

With these results, it is possible to concretely envisage public mobility policies in "large numbers". The estimates can be used in different ways for designing mobility policies based on the concept of shared streets, equality between modes and equity among families. We present some ways of using the aggregated results for specific public policy designs. There are several other ways of allocating resources that can be simulated based on the data presented in this report, including changes in decisions regarding the volume of resources collected or spent depending on the design of the policy to be carried out. This is the main legacy of Task C for the (aggregate) design of public mobility policies that take into account the social cost of each decision.

3 TASK D: SIMULATION OF TRANSPORT DEMAND MANAGEMENT POLICIES: STRATEGIC ACTIONS

Task D's report addresses the development of strategies for promoting sustainable mobility that result in a fair distribution of shared public space. Indirectly, the approach of this study is based on the assumption of the possibility of changing behavior, to assess the degree of impact of the rebalancing of the modal division on the mobility pattern in the urban space, due to the prioritization of active and sustainable modes (such as the collective one). In this report, we present outcomes achieved through the use of two open simulation tools, applied directly for use in the city of São Paulo. We used the first tool for a macro analysis of what could happen in the East Zone if we adopted public policies to encourage active transport (assuming they were successful). We also used this tool to analyze the emergency sidewalk program. We then used a second tool (A/B Streets) to analyze a specific micro-intervention in the São Miguel Paulista neighborhood.

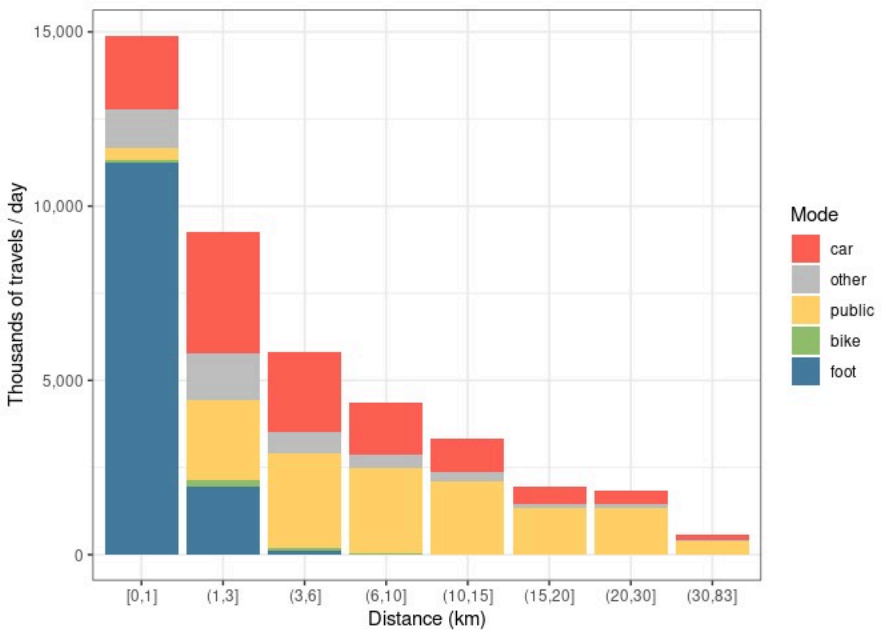
On a macroscopic scale, an analysis was applied to the East Zone (ZL) of São Paulo, the densest region of the city. The first scenario affects more the transport on foot, while the last two end up affecting more profoundly the transport by bicycle. Behavioral changes that favor the use of public transport were not included in these scenarios. Some consequences, for ZL, of three types of behavioral changes were studied:

1) (ATUM) all citizens now behave like the 25% most likely to use active transport;
2) (Go Dutch) all citizens start to behave like the Dutch;
3) (E-bike) all citizens start to behave like the Dutch and have electric bicycles available.

On a microscopic scale, a simulation analysis was carried out with the A/B Streets tool, focusing on a specific public mobility policy that goes by many names: "micro-intervention", "micro-mobility" and "tactical urbanism" are some of them. The most advanced microintervention, to our knowledge, was used as a case: the center of São Miguel Paulista, around the train station. This micro-intervention is symbolic, as it received a lot of investment in its planning (Bloomberg Philantropies, ITDP, WRI, City Foundation), but it could never be implemented. Micro-interventions are difficult to implement. Typically, technicians resist this type of intervention, as they fear that they will end up creating bottlenecks in the traffic flow. The adaptation of the models described for São Paulo and the case studies to explore different counterfactual scenarios consider data from the Origin-Destination Survey, carried out by the Metrô de São Paulo, 2017 (Companhia do Metropolitano, 2017), from GeoSampa (São Paulo City Hall) and data natively incorporated by systems such as Open Street Map.

In São Paulo, the number of travels made on foot per day slightly exceeds the number of travels by car and public transport (Figure 4). The predominance of travels on foot occurs in travels of up to 1 km. In travels between 1 km and 3 km there is still a significant participation of walking, but the largest proportion is made by car or public transport. Above 3 km, the share of active transport becomes derisory, with progressive increases in the share of cars and public transport.

Figure 7. Distribution of travels per mode and distance



Source: Own elaboration based on simulated data

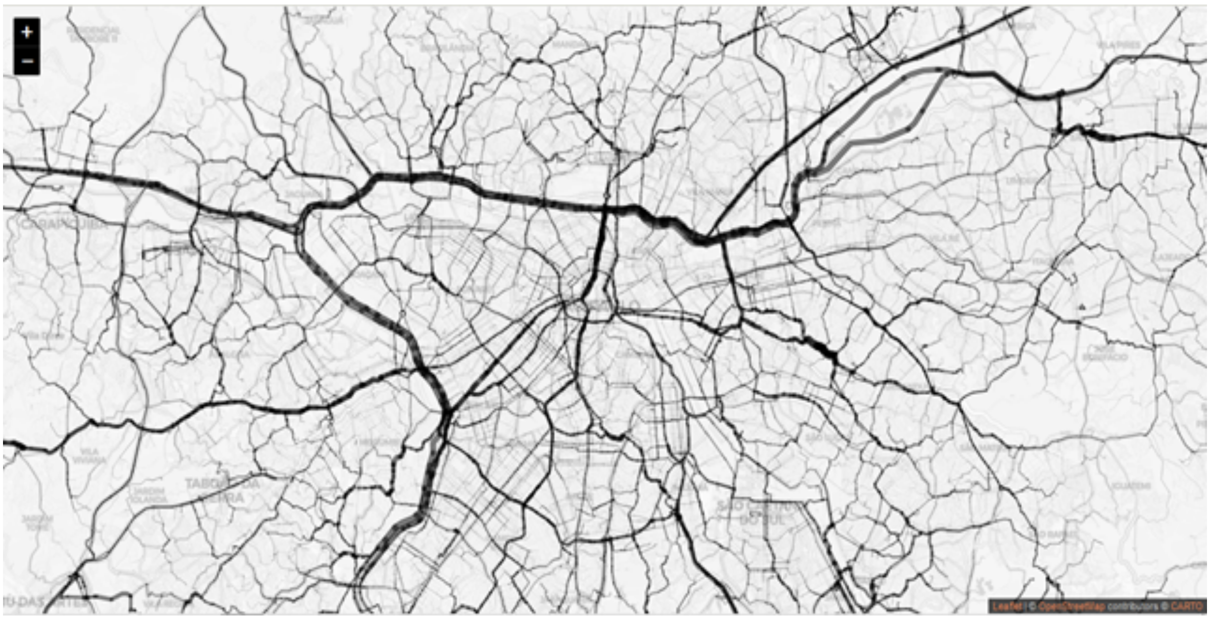
The spatial distribution by origin and destination of travels by zone shows a well-defined pattern for travels made in the morning and in the evening. While the former have the central regions of the city of São Paulo as their main destination and originate in a very scattered way in space, the latter depart from that same center and spread out in their destinations. This is a reflection of patterns of commuting to work and reveals a clear pattern of strong monocentrality, which also extends to the RMSP. The slightly more dispersed spatial character of travels made in the afternoon is related to the fact that, in this period, commuting to school is quantitatively more important, which ends up attenuating the pattern of general commuting.

We estimate potential routes according to the characteristics of the RMSP road system, using the Open Source Routing Machine (OSRM), an online routing service that uses OpenStreetMap data. The views in which the number of travels using each lane is represented by its thickness (Figures 8 and 9). On bicycle routes, there is a concentration of trips on roads whose topography is less winding and there is dedicated infrastructure for this (see Av. Faria Lima). The desire lines for commuting by car does not necessarily capture what is indeed traveled, an eventual comparison of the desire line with counting data could illustrate how far the path actually taken by people is from the one that would be more logically preferred by them.

Figure 8. Bicycle routes obtained by the Open Source Routing Machine (OSRM) API

Source: Own elaboration, based on data from OD Metrô 2017

Figure 9. Car routes obtained by the Open Source Routing Machine (OSRM) API



Source: Own elaboration, based on data from OD Metrô 2017

3.1 Modal replacement modeling

Active modes of transport are less harmful to the environment and improve the health of individuals, as well as being cheaper and reducing traffic congestion. We adopted the Propensity to Cycle Tool (PCT) model, developed by Lovelace and collaborators (2017), an open-source tool that seeks precisely to identify "more cycleable" routes and estimate the gains obtained with the use of the bicycle as a transport mode instead to other modes related to counterfactual scenarios (for example, maintaining the status quo). The model considers the characteristics of potential routes in terms of distance and slope. From individual commutes, the PCT is calculated using logistic regression that relates the probability that the route was traveled by bicycle with terms that capture the effects of distance, slope, their interactions, and nonlinearities. The predicted values obtained at the individual, zone and route levels inform the share of travels that could be made by bicycle. The alternative scenarios are constructed by altering the regression coefficients to capture possible behavioral changes, as a response to some public incentive policy or even due to physical alternatives in the transport network that could interfere with the attributes of the path, making it more attractive.

As the vast majority of active mode travels in the RMSP are made on foot, we created an equivalent model that we called the "Propensity to Walk Tool" (PWT). We call the general

formulation, which also includes PCT and ATUM (Active Travel Uptake Model) PWT. The data needed for these exercises come from the following sources:

- OD2017 presents all displacement flows per mode and associated demographic characteristics;
- in the "optimal" routes calculated by OSRM, for walking and cycling modes, we have the travel distances;
- in GeoSampa, we have topography data for the city of São Paulo, with which we can calculate the average slope of each of the trips.
- there is also the possibility of including the specificities of the sidewalk infrastructure (also available on Geosampa) as a determinant of the modal choice.
- We use a methodology inspired by the PCT, which consists of training a statistical model on a subsample of travels and using it, through predicted values, to create an alternative scenario for travels on foot.

3.2 Simulations for São Paulo's East Zone

Based on a subsample of travels made within the city of São Paulo, we implemented a simulated scenario based on ATUM for the East Zone of the city of São Paulo, which includes 121 of the 517 zones of OD2017 (Figure 7). Around 7 million travels are made daily in this perimeter, which represents 29% and 17% of all travels made in the city of São Paulo and in the RMSP, respectively.

- We created a **short-term scenario** using the general formulation (ATUM) mentioned above and trained a model using a subset of travels in the region in order to predict changes in the levels of walking and cycling travels. Objectively, we consider the scenario in which people behave as the top quartile of the distribution of active trips (cycling and walking, separately), given the distance and slope of each route. Thus, there is a reasonable increase in trips by bicycle and on foot.
- In the second, we considered cases in which people had the same propensity as the Dutch (Go Dutch) to choose the bicycle as a means of transport; however, we account for differences in topography and their effect on the distribution of road slopes and travel distances.
- Finally, we also analyzed the scenario with the adoption of E-bikes, which allows cyclists to take longer routes and overcome most of the barriers imposed by the high slope terrain.

The aggregate results of these scenarios are illustrated in Figure 10.

Figure 10. Simulated scenarios in the East Zone per mode and distance ranges

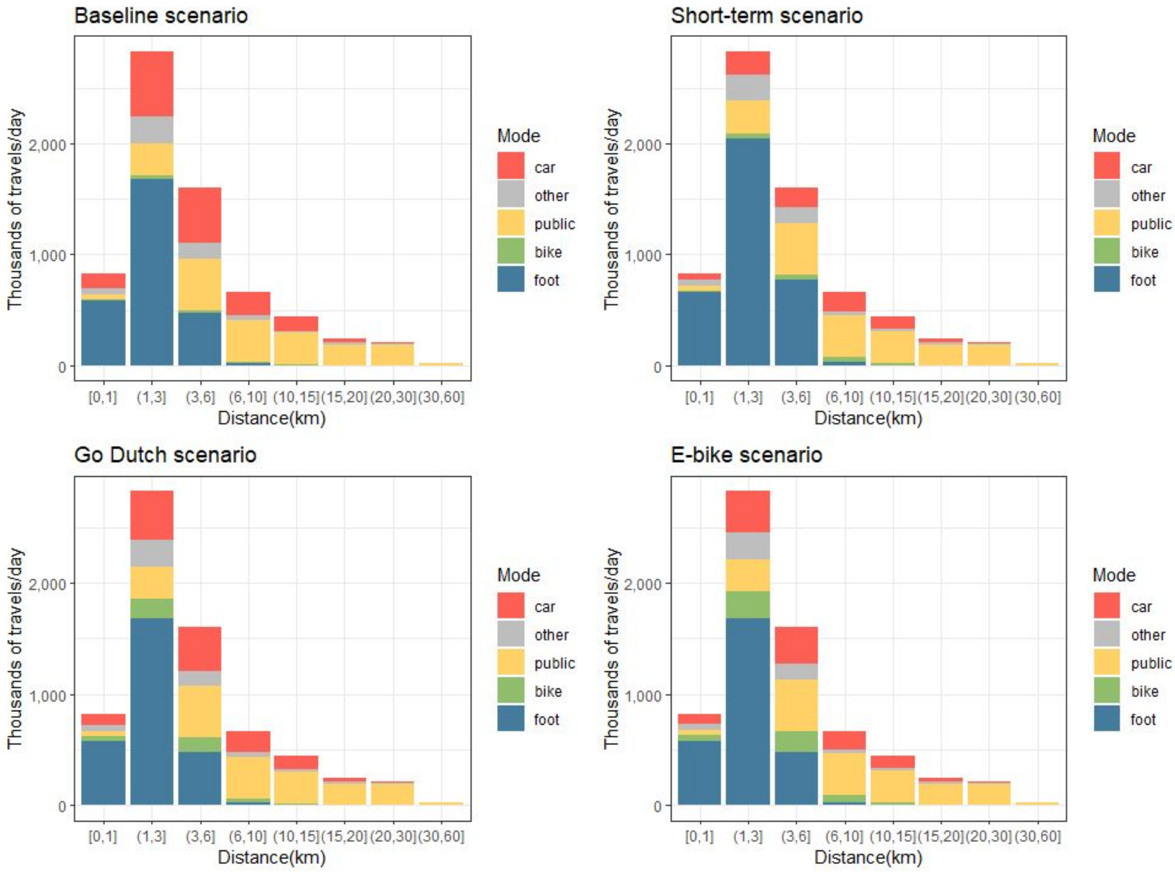


Table 12 presents the aggregate data of the results for the different scenarios in terms of total travels per mode. **To visualize how these changes affect the transport network in the city of São Paulo, we overlapped the routes and added up the number of bike and foot travels that pass through each section.** In this way, we have a number of how many travels occur on each stretch of road in the selected perimeter. It is important to highlight that these routes and the respective volumes associated with them consider the fastest routes, and not necessarily the calmest and safest ones. Even so, they allow for a detailed analysis of potential demand in different scenarios.

- In the baseline scenario, bicycle travels do not exceed 10,000 for travels up to 1 km, and are around 34,000 for travels up to 3 km.
- The simulation of short-term contexts raises these numbers to 12,000 travels of up to 1 km, and 36,000 travels between 1 km and 3 km.
- If the population's propensity to use bicycles reached Dutch parameters, there would be 37,000 travels for distances up to 1 km, and 181,000 for trips between 1 km and 3 km.

- Also considering a scenario with massive use of electric bicycles, these numbers would reach approximately 50,000 travels for distances up to 1 km, and 250,000 for travels between 1 km and 3 km.

Table 12. Total travels per mode per simulated scenario

Total travels per mode considered in the modeling				
	Bicycle	**Car**	**On foot**	**Subtotal**
Baseline scenario	71,453	1,620,211	2,758,498	4,450,163
Short-term	167,864	781,262	3,501,037	4,450,163
Go Dutch	391,475	1,300,189	2,758,498	4,450,163
E-bike	572,535	1,119,130	2,758,498	4,450,163
Percentage of travels per mode considered in the modeling				
	Bicycle	**Car**	**On foot**	**Subtotal**
Baseline scenario	1.6%	36.4%	62.0%	100.0%
Short-term	3.8%	17.5%	78.7%	100.0%
Go Dutch	8.8%	29.2%	62.0%	100.0%
E-bike	12.9%	25.1%	62.0%	100.0%

Source: Own elaboration, based on data from OD 2017 and GeoSampa

In the scenario assuming that foot trips substitute for car trips, there is a significant increase in walking travels across the region. Walking travels increase mainly for distances up to 3 km:

- For distances up to 1 km, the number of travels on foot would increase from 580,000 to around 660,000.
- For distances between 1 km and 3 km, the simulation predicts an increase of around 350,000 travels, reaching over 2 million travels on foot, as shown in Table 13.

The simulation indicates that short travels on foot can still increase considerably with appropriate promotion policies. This result suggests that there must be some factor that leads individuals to take travels by car which could perfectly well be made on foot. When we aggregate walking and cycling travels per Zone OD, it is possible to notice a relative coincidence in the zones that show the greatest increases in travels. The zones that show the greatest growth in travels are essentially the same. The greatest impacts occur in areas located in the neighborhoods of Sacomã, Cursino and Ipiranga. They also occur in the Jardim Helena area, in the extreme northeast of the city, and in the areas of Guaianases, Lajeado and Vila Curuçá. The latter are areas that notably concentrate socially vulnerable populations and that would benefit from cycling infrastructure, since, according to the bases of the cycling system available in GeoSampa, there are no cycling lanes or tracks in these areas.

Our analysis in the East Zone indicates that successful policies to support active modes, without a radical change in the behavior of São Paulo residents, can lead to an increase of 2.2 percentage points in cycling, reaching a very high level for the city, of 3.8%. But

the relevant thing could happen in short travels on foot, which would go from the current 68% to 79%. It is important to note that in the Go Dutch and E-bikes scenarios, as we did not implement any policy for walking (by definition), the proportion of this type of travel does not change. Although the E-bike scenario shows an increase of 11.3% percentage points in the proportion of bicycle use, reaching very rare proportions in the western world (12.9%), the impact on car use is much lower than in the short-term scenario.

Considering the simulation results for distances traveled by cars, that is, production of transport in travels × km, for each analyzed scenario (Table 13), we can see that the short-term scenario generates a 34% decrease in the distances traveled by cars. This implies that, in the universe of travels we analyzed for the East Zone of the city, there would be a decrease of around 2.66 million kilometers traveled by cars. This impact would be particularly intense on short haul routes. Considering the scenario in which we simulate the propensity to use E-bikes, we have a 24% reduction in the distances traveled.

For each scenario, we applied a synthetic estimate of the reduction of negative externalities related to traffic accidents, air pollutant emissions and travel time. As we have for each of these variables a ratio proportional to the total distances traveled by car, we can apply these factors to estimate in terms of externality costs in the three simulated scenarios. Here we focus solely on transferring car travels to active modes. Thus, we will only analyze this transition. The simulation results are based on the total number of daily travels in the East Zone of the city collected by the subway OD survey.

- With regard to greenhouse gas emissions, the ATUM scenario, which considers migration to walking mode, would generate a reduction of 339 tons of CO2e per day.
- In the scenarios that consider the migration to bicycle mode, there would be a reduction of 139 tons in the Go Dutch model and 237 tons in the E-bike scenario.
- With regard to the time spent in traffic congestions, the ATUM scenario would bring about a reduction of around 162,000 hours per day.
- In the Go Dutch and E-bike scenarios there would be a reduction of 66,000 hours a day and 114,000 hours a day, respectively.
- It is also possible to estimate the impacts on fatal and non-fatal casualties resulting from accidents. In the ATUM scenario, there would be a reduction of 62 non-fatal casualties per month. In the others, this reduction would be of 26 for the Go Dutch scenario and 44 for the E-bike scenario.

Table 13. Car travel distances per distance interval in baseline and simulated scenarios

Distance range (km)	Distance traveled by cars (km)			
	Baseline	Short-term	Go Dutch	E-bikes
(0.1)	85,574.1	31,058.5	66,711.1	58,229.4
(1.3)	1,183,047.5	413,846.3	888,467.4	747,900.9
(3.6)	2,128,211.0	772,155.3	1,672,875.9	1,406,117.3
(6.10)	1,645,332.5	1,348,126.1	1,438,711.1	1,256,305.5
(10.15)	1,568,150.8	1,388,915.6	1,474,767.1	1,352,724.3
(15.20)	622,902.9	618,577.4	608,212.2	578,094.8
(20.30)	397,632.1	397,626.3	393,313.7	379,813.9
(30.60)	147,705.9	147,705.9	146,120.8	139,881.2
TOTAL	7,778,556.8	5,118,011.4	6,689,179.2	5,919,067.3
Total variation	0.0%	-34.2%	-14.0%	-23.9%

Source: Own elaboration, based on data from OD 2017 and GeoSampa

By applying the monetary cost factors associated with each externality, we can estimate the total cost reduction in monetary values that each scenario would generate. The short-term result generates a cost reduction of approximately BRL 0.5 billion per year for society. The effort of the radical scenarios – Go Dutch and E-bikes – generates a smaller impact on social costs (BRL 0.2 billion and BRL 0.3 billion, respectively). The monetary result is also valid for the physical variables: the short-term scenario reduces emissions, accident claims (fatal and non-fatal), hospitalizations and deaths at a higher rate than the other scenarios.

Considering the differences between the costs of each type of externality in relation to the baseline scenario, it is possible to verify that the daily impacts would significantly reduce in each modeled scenario:

- in the ATUM scenario, the reduction in daily externality costs would be around BRL 1.25 million;
- in the Go Dutch scenario, of BRL 514,000;
- in the scenario with intensive use of E-bikes, of BRL 878,000.
- If we consider the annual values, the cost reductions would be of BRL 393 million for the ATUM scenario, BRL 161 million for the Go Dutch scenario, and BRL 275 million for the E-bikes scenario (Table 3).

Table 14. Difference between the costs of externalities among each simulated scenario and the baseline scenario

Cost of negative externality (daily values)			
Reduction effect in the different scenarios	**Short-term**	**Go Dutch**	**E-bikes**
CO2e emissions (BRL)	-172,774.63	-70,743.69	-120,754.42
Congestion time per car with adjustment (BRL)	-933,317.12	-382,152.76	-652,307.37
Non-fatal casualties resulting from accident claims (BRL)	-90,810.79	-37,183.07	-63,468.83
Fatal casualties resulting from accident claims (BRL)	-55,360.21	-22,667.60	-38,691.96
Hospitalizations resulting from the emission of PM2.5 (BRL)	-3.33	-1.36	-2.33
Deaths resulting from the emission of PM2.5 (BRL)	-4,111.36	-1,683.42	-2,873.48

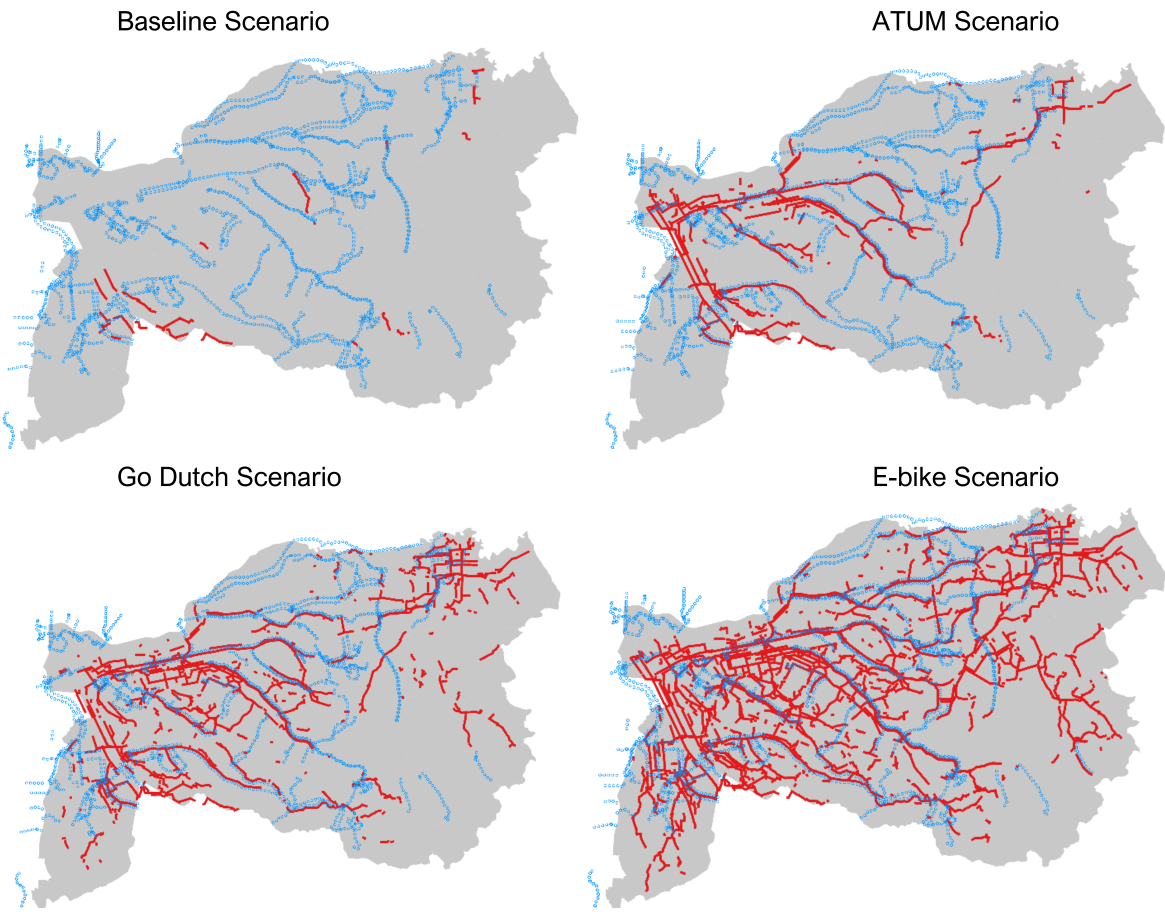
Cost of negative externality	ATUM	Go Dutch	E-bikes
(BRL/day)	-1,256,377.44	-514,431.90	-878,098.40

Source: Own Elaboration using ATUM and data from OD 2017, GeoSampa and Task C applied to the East Zone of São Paulo

3.3 Infrastructure supply and simulation results

The results obtained from the simulations also allow a spatial evaluation of the simulated routes in the different scenarios and the offer of bicycle infrastructure, a relevant aspect in the discussion about the needs for investments and expansion of the network. The routes that would be preferred for cycling (following the criteria of distance and slope) are not always served by cycling lanes or tracks in the East Zone of the city. Figure 8 shows the current supply of cycling infrastructure superimposed on the routes that, in different scenarios, would receive daily volumes of cyclists equal to or greater than 5,000 cyclists/day. In scenarios that simulate large volumes of bicycle travels, the need for cycling infrastructure to meet the simulated demand is more evident. When we analyzed the short-term scenario, we found 177.8 km of routes with a potential demand of more than 5,000 cyclists/day. Of these, about 40% coincide with routes served by infrastructure, which indicates that the mere presence of infrastructure is not enough for this demand to be fulfilled. In the two other scenarios, Go Dutch and E-bikes, we found that 37.1% and 33.6%, respectively, have some type of cycling infrastructure.

Figure 11. Simulated routes with high volumes of cyclists/day and current cycling network



Note: In red, routes with more than 5,000 cyclists/day, and in blue, the current cycling network.
Source: Own Elaboration using ATUM and data from OD 2017, GeoSampa and Task C applied to the East Zone of São Paulo

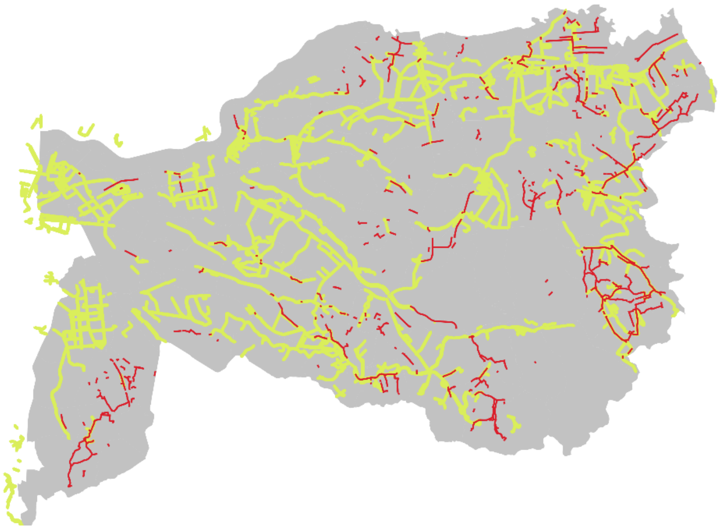
Considering the scenarios developed in the simulations, the implementation of cycling lanes to meet all the demand in the East Zone for potential routes with a high flow of cyclists in the most radical scenario (E-bikes) would cost BRL 229 million. According to CET data presented at the Faria Lima Urban Operation Meeting, in 2019 (CET, 2019), the cost for creating cycling lanes was estimated at BRL 571/meter. Obviously, this overlapping exercise simplifies the analysis and focus, as it disregards the levels of continuity and connectivity that the cycling system presents. Even so, it provides a good reference on the infrastructure needs required to serve potentially more demanded routes.

For the simulations carried out for travels on foot, juxtaposing the simulated routes with large daily volumes of pedestrians to the areas selected by the city hall to receive investments from the Emergency Plan for Sidewalks (PEC), it is possible to notice that

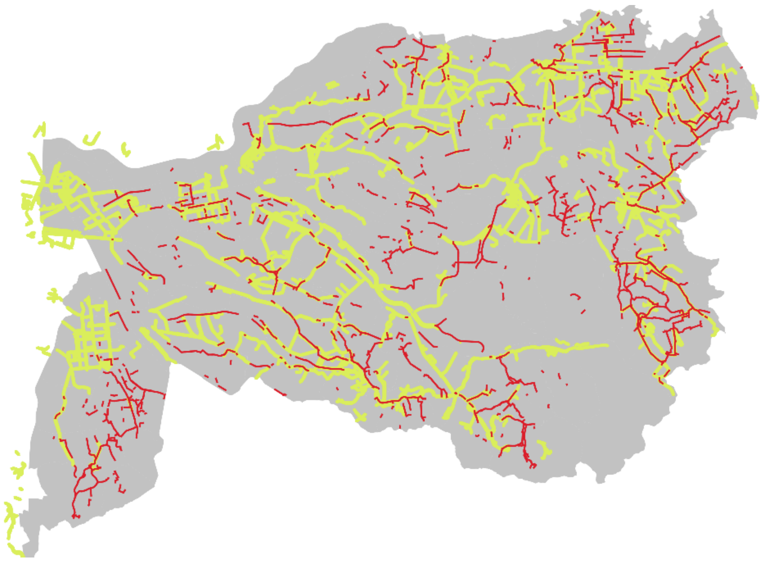
they do not always coincide (Figure 12). This does not necessarily indicate a lack of criteria in defining priority areas, since the magnitude of the pedestrian flow may not have been the public administration’s only decision criterion. Other variables, such as the condition of roads and proximity to public services, are also considered when deciding on this type of investment.

Figure 12. Simulated routes with high volumes of pedestrians/day and sidewalks included in the PEC

Baseline scenario



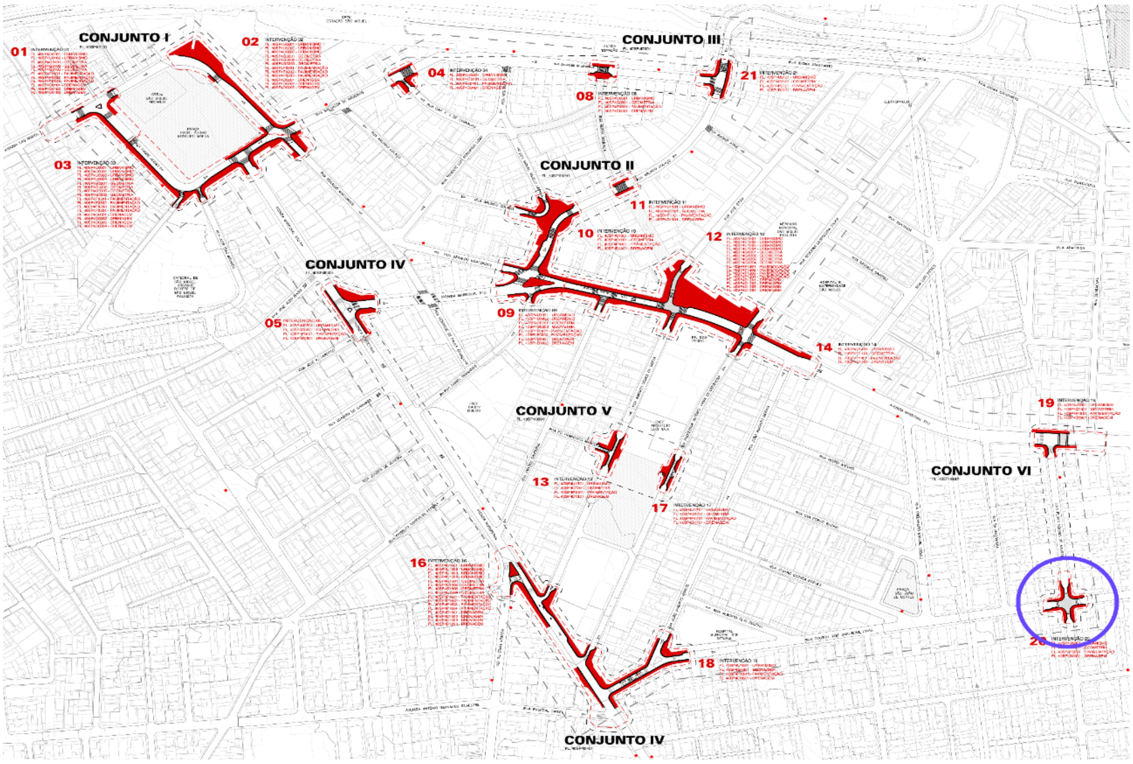
Short-term scenario



Note: In red, the routes with more than 10,000 pedestrians/day, and in green, the sidewalks included in the PEC . Source: Own Elaboration using ATUM and data from OD 2017, GeoSampa and Task C applied to the East Zone of São Paulo

We use A/B Street, open-source software built to measure how small road changes affect cyclists, drivers and public transport users. Using microsimulation, it is possible, for example, to transform a lane dedicated to parking into an exclusive lane for buses and measure its effects on the travel dynamics at the local level. A/B Street is based on OpenStreetMap data, which facilitates its adaptation to other cities in the world. The area chosen for the agent-based simulation is around the São Miguel Paulista station. This area is already the focus of a public intervention aiming to improve road safety, as planned by the city hall. This is an “area 40”, a determined perimeter in the city within which the maximum permitted speed is 40 km/h. In the city hall project, there are a series of initiatives to reorganize the existing road space[8], providing adequate infrastructure in order to promote pedestrian and cyclist safety. Figure 13 shows a map with the indication of the works foreseen in the plan for the area under analysis.

Figure 13. Planned interventions in the simulated area



Source: ITDP, 2019

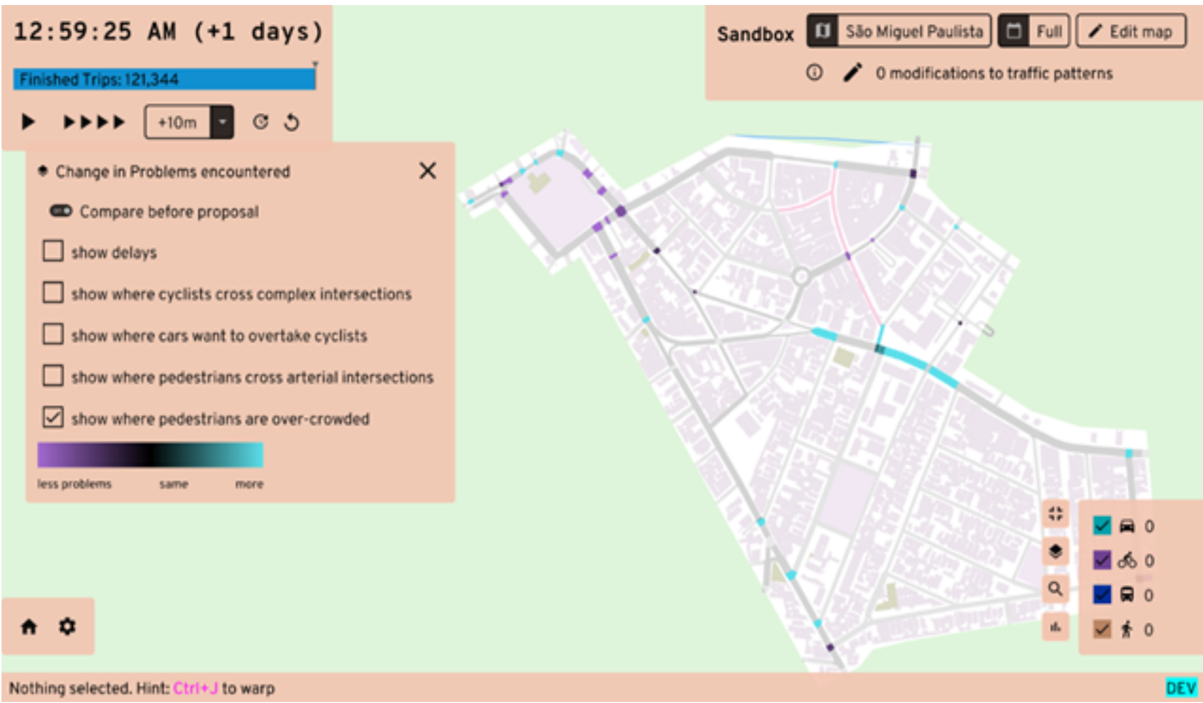
To create the data that feed the simulations, we started from the perimeter of interest and proceeded as follows: 1) we identified the OD Zone that contains the region of São Miguel Paulista and we selected all the travels that originate from or that have the aforementioned

[8] Widening of sidewalks; revitalization through paving and leveling between sidewalks and streets; insertion of setbacks and safety posts, etc.

location as their final destination zone; 2) we expanded the OD2017 travels using the survey sample weights, which results in 178,000 trips that have the perimeter of interest as origin or destination; 3) we randomized the origin and destination coordinates and the start time of travels in order to avoid that many travels originate/end at the same point in space and also that a large volume of trips start at the same time; 4) we selected a sample of these trips that, at the same time, represents well the travel flow in the region and that is computationally feasible. After this process, we arrived at a scenario for simulation with around 121,000 travels, divided between car, bicycle and foot transport modes.

We recorded all occurrences of a pedestrian agent walking along a sidewalk (measured per block) or intersection and the points where the density exceeded 1.5 people per square meter. Pedestrians on these overcrowded sidewalks move at half their normal speed. Then, we repeated the simulation, keeping all the parameters fixed, except for the changes in the widths of the sidewalks that approached the intervention schemes indicated by the city hall as Area 40. As the simulation is deterministic, we can then theoretically isolate the changes in overcrowding events on an individual level. For travels lasting between 5 and 15 minutes, 3,600 people experienced 1 to 5 points with the least congested sidewalks, while 2,200 experienced 1 to 5 most congested sidewalks. The change is generally positive; more people benefit from it. Figure 11 shows the spatial distribution of changes in overcrowding. The user can access the base interactively, selecting specific streets to obtain the count of before/after events.

Figure 14. Changes in total circulation problems before and after the simulation



Source: Own Elaboration using A/B Street and data from ITDP (2019)

The second problem identified in the simulations focuses on the intersection of Avenida Marechal Tito and Rua Pedro Soares de Andrade, close to the boundary of the study area (Figure 11). The issue has nothing to do with the widening of the sidewalk. A/B Street has a pathfinding issue where some people choose to change paths in the edited version of the map as there are multiple paths with the same predicted cost. Many people decide to cross the street at a slightly different point, causing crowding patterns to change dramatically.

The A/B Street application shows where bottlenecks may occur with the proposed changes, which would be a very useful tool for CET programming. If, on the one hand, there is an improvement in the flow of pedestrians in general (the focus of the intervention), on the other hand there are also some problems with the flow not only of vehicles, but also of pedestrians themselves. In places where vehicular traffic accumulates, this accumulation also ends up harming the flow of pedestrians when they cross the street. CET could use this result to, for example, rethink traffic light times, create path options on less demanded roads, and so on. The inclusion of detailed displacements of pedestrians and cyclists would enrich the design of solutions for active mobility. For this modeling, however, it is worth highlighting the need for more precise data; therefore, field surveys of pedestrians and cyclists need to be added to traditional traffic counts and local “origin-destination” surveys.

4 TASK E: CONDITIONS AND OPPORTUNITIES FOR THE MANAGEMENT AND FINANCING OF SIDEWALKS IN THE CITY OF SÃO PAULO

Sidewalks – basic infrastructure for the construction of complete streets – are the key to advancing the transformation of public space and, simultaneously, responding to the urgent challenges of combating the climate crisis and creating adequate conditions for public health in the city. There are, however, limitations and challenges related to the improvement of management and the search for financing alternatives for improving sidewalks in the city. Sidewalks, fundamental to the functioning of the city, still do not occupy a prominent place as a central component of the mobility system, whether from an institutional, financing, political or even thematic point of view. The sidewalk is not an "extension" of private property, but mainly an infrastructure for pedestrians, fundamental in urban mobility policies.

In a survey of citizen complaints about the city of São Paulo, both in terms of infrastructure and services, sidewalks are at the top of the list. The sidewalks have serious problems of provision, maintenance and standards lower than desired, penalizing a sustainable and healthy way of moving. But management aimed at improving sidewalks in the city also demands the participation of citizens and the private sector in a process of cooperation with the municipal government.

The current legal framework for sidewalks in the city comprises two major areas: the structure of responsibilities for provision and maintenance and the management structure of the arrangement of responsibilities defined for each city. In the city of São Paulo, similarly to many other cities in the world, the sidewalk is a municipal public good, with a structure of responsibilities for provision and maintenance distributed between the government and private individuals (the majority of owners in the city). The current legal regime for sidewalk care follows the "frontage" rule, distributing responsibilities between city owners: government and private individuals. In the case of sidewalks that in front of private properties, the responsibility for implementation, conservation and maintenance lies with: a) the owner of the property; b) of the owner of the property in any capacity; c) the holder of the useful domain or bare ownership of the property; and d) the condominium. In the case of sidewalks that in front of public properties, the following are responsible: a) the National Government and the bodies and entities of the respective Indirect Administration; b) the State Government and the bodies and entities of the respective Indirect Administration; c) the Municipality and the bodies and entities of the respective Indirect Administration (Municipal Decree No. 59,671/20).

This arrangement also needs a government structure for managing responsibilities, in order to guide its own actions and those of individuals (including both the citizen owner and several companies operating in the public aerial, underground and carriageable space). The panorama of responsibilities and management indicates the recognition of the possibility of instituting programs to improve the conditions of the sidewalks by the government, without, however, giving up an active role and cooperation with residents and the private sector. The debate on the governance of sidewalks in the city also implies understanding the interface between the government and citizens regarding their individual responsibilities in maintaining sidewalks, as well as possibilities for supporting active mobility policies.

Important regulatory changes were observed, which operate at the federal level, signaling a gradual transformation in the role of the State. Above all, the approval of the National Urban Mobility Policy (federal law no. 12,587/12) and the amendments to the City Statute (federal law no. 10,257/01 combined with federal law no. 13,146/15).

At the municipal level, the Master Plan of the City of São Paulo (municipal law no. 16.050/14) incorporates the determinations of federal legislation and provides for a series of guidelines and strategic actions related to sidewalks. Among them is the need to expand sidewalks, walkways and living spaces; the reduction of falls and accidents related to the circulation of pedestrians along the system components, as well as the standardization and readjustment of public sidewalks on routes with greater pedestrian traffic (art. 233), even pointing to the need to reduce space of parking areas for the implementation of cycling lanes and tracks structure and the expansion of sidewalks (art. 241, item X). Also noteworthy is the directive to establish a body responsible for the formulation and implementation of programs and actions for the Pedestrian Circulation System (art. 233, item V).

In 2017, the approval of the Pedestrian Statute (municipal law nº 16.673/17) was added to the master plan in order to strengthen policies focused on mobility on foot. The statute has among its objectives the promotion of the treatment of pedestrian infrastructure in a similar way to other transport networks; the understanding of mobility on foot as an efficient and healthy mode of transport; the improvement of mobility conditions on foot with comfort and safety, especially for people with reduced mobility; improving integration with other modes of transport; the homogenization of the infrastructure for pedestrians in all regions of the city (art. 8).

Both the Master Plan and the Pedestrian Statute contain principles and guidelines capable of guiding the implementation of complete streets in the city, but the first one in particular can be improved, as detailed at the end of this summary. That is, both planning instruments understand the road as a public space that must be designed taking into account the urban context in which it operates, aligning mobility needs with social coexistence, and giving priority to this objective in public action. In this sense, the complete street puts the pedestrian first and ensures safe, comfortable and convenient access for everybody, regardless of their walking abilities and the mode of transport used.

It became evident that the public management of sidewalks is a highly segmented process, depending on specific actors and interests, without a common view on the sidewalk and still under construction as a specific object of public policy. This evidence indicates the need to consider the provision, maintenance and renovation of sidewalks from the point of view of internal public management. Numerous municipal bodies – for example, the Traffic Engineering Company (CET), subprefectures, the Green Secretariat, etc. – have specific competences and attributions to act over the sidewalks in accordance with their functions, views and priorities.

The absence of internal flow regarding the procedures for the development of projects and the implementation of road renovation works without the presence of a body capable of making comprehensive decisions creates a series of obstacles for actions aimed at improving sidewalks. There are several instances in the city hall of São Paulo whose attributions include the sidewalks. According to the diagnosis made by the Urban Design Guide Working Group (GT-MOV, SGM Ordinance no. 787/2018), there is a lack of a flow of procedures common to the bodies of the PMSP for the development of projects and the implementation of road renovation works[9]. To address this issue, GT-MOV planned the establishment of the Unified System of Approval of Urban Interventions in the city of São Paulo, composed of several components, including the Urban Design and Road Works Guide. This system was developed throughout 2019 and 2020 and is currently under discussion by the São Paulo city hall, with the objective of raising the flow of procedures and creating an interdepartmental instance for deliberation and monitoring of projects.

The evaluation of the information channels available to citizens about the sidewalks, as well as the inspection and sanction procedures currently used by the city hall, indicates the need for actions aimed at orientation, awareness, publicity and mobilization of residents in the maintenance of public sidewalks. To ensure that citizens participate satisfactorily in the provision and maintenance of sidewalks, it is required an effort from the

[9] The diagnosis can be consulted in the ""Nota Técnica – Minuta de Decreto de Instituição do Manual de Desenho Urbano e Obras Viárias do Município de São Paulo e do fluxo de procedimentos para desenvolvimento de projetos e implantação de obras viárias pela Prefeitura de São Paulo (PMSP)", which appears in process SEI 6020.2018/0004716-4 through the following consultation platform: http://processos.prefeitura.sp.gov.br/Forms/consultarProcessos.aspx. Accessed on: Feb. 12, 2023.

public administration bodies in order to provide guidance, information, incentives, coordination, facilitation and inspection (understood as a public power-duty). The three main channels for citizens to access information about sidewalks are: i) the São Paulo City Hall website; ii) the SP156 channel of the city of São Paulo; and iii) the on-site service squares at the respective subprefectures of the city.

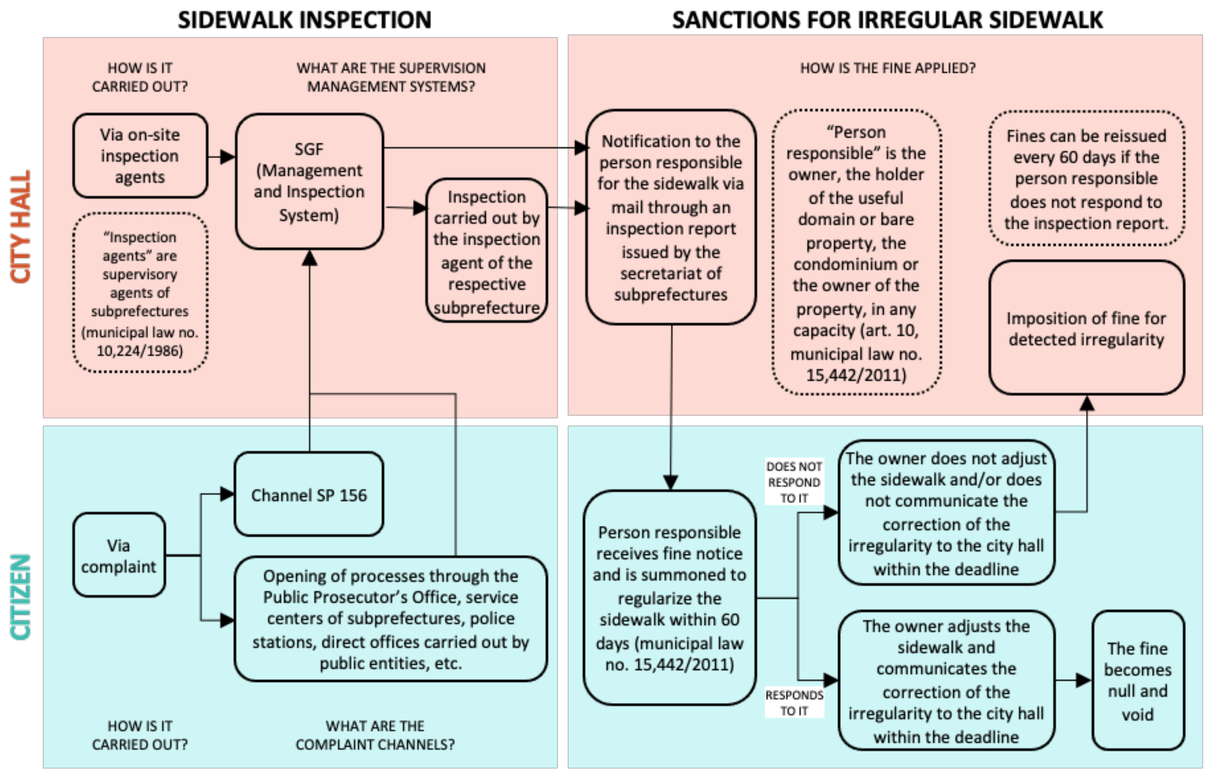
The territorial scope of the deficit that this infrastructure presents points to the urgent need to increase investment in sidewalks and identify possible sources of financing. Among the mapped measures, it is worth mentioning the urban measures – such as the transformation axes and the PIUs, present mainly in the moments of provision and transformation of the built space –, tax measures – in particular the fee for improvement for the realization of several works, especially road safety works, such as Areas 40, in addition to existing resources in municipal funds (such as Fundurb and the Municipal Transport Fund), arising from actions to take advantage of the urban potential of the city (such as the onerous grant of the right to build and urban operations), the economic exploitation of public space and partnerships with the private sector. In these cases, the priority or not of active mobility in the use of resources was evaluated.

With regard to the possibilities of executing work on sidewalks, municipal legislation includes the city hall, those responsible for private and public properties that faces sidewalks; professionals and companies, residents' associations or non-governmental organizations in a joint-effort regime. Those interested in executing or renovating sidewalks will be accredited by the city and must have a training certificate, as well as issuing a note or registration of technical responsibility. In general, the provision and renovation of sidewalks is one of the items required in processes of: (i) execution of subdivision or land dismemberment; (ii) implementation of housing developments; (iii) implementation of urban and land regularization programs for low-income informal settlements; and (iv) poles and axes of centralities.

The need for gradual adaptation of current sidewalks to adequate accessibility parameters is expressly provided for in municipal legislation (art. 34, §2, municipal decree no. 59,671/20); however, such normative provision, especially in cases where it is necessary to carry out work to expand the sidewalks, depends on public action with guidelines and coordination strategies. In addition to serving as a space for pedestrians to circulate and stay, the sidewalk is also the place that accommodates urban furniture and where various underground and aerial infrastructures are installed. This tangle of "attributions" related to the sidewalks results in a great complexity of actors responsible for different facets of the sidewalks, from their design to their maintenance, as well as their execution, approval and inspection.

Prominent sidewalk improvement programs make inspection a supportive resource, rather than a starting one, for achieving changes in citizen behavior. In practice, the police power, one of the main tools to guarantee the preservation of the collective interest in the urban space, in addition to its punitive character, can also establish mechanisms of awareness and cooperation between public authorities and private agents, pointing out paths that go beyond the mere application of fines and sanctions. In this sense, it can be said that the functioning of the sidewalk management model in the city – marked by public and private responsibilities in the construction, renovation and maintenance of sidewalks – has as its fundamental pillar the exercise of sensitive and guiding police power, but it depends directly on the effective and permanent supervision of the city hall. In short, the procedures for inspection and application of sanctions on sidewalks were compiled in a flowchart (**Figure 15**).

Figure 15. Flowchart. Inspection of sidewalks: procedures and sanctions for irregularities.

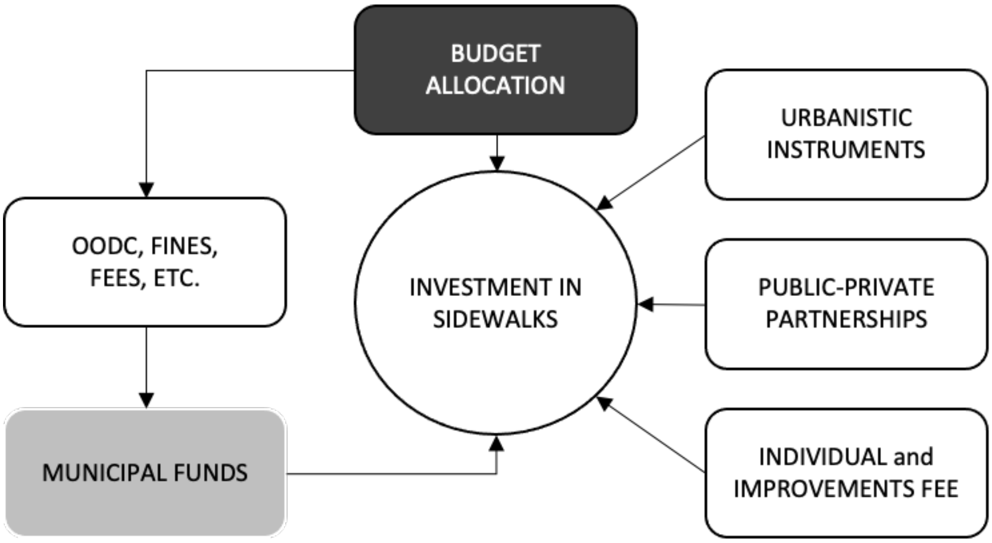


Source: Own elaboration.

Financing sidewalks follows a logic similar to that of other urban public goods, divided into two major moments: provision and maintenance. The provision, in the case of São

Paulo, is characterized more by transformation, in areas of densification and reconfiguration, rather than by expansion of the city. Maintenance, on the other hand, without including in this definition the expansion that many sidewalks in the city need, follows the frontage rule and must be financed mainly with the resources invested by the citizens themselves and by the owner government. At the time of provision, the obligation typically derives from urban planning obligations. In terms of maintenance, tax instruments are available to help citizens fulfill their obligations, especially those linked to the idea of benefit, such as the improvement fee. Additionally, given that the sidewalks are components of the public space, which is the object of care and also of economic use by individuals, there are several mechanisms of shared management that can favor the maintenance and care of the sidewalks by private groups, as illustrated in **Figure 16**.

Figure 16. Financing sources for sidewalks



Source: Own elaboration.

There are several potentially available sources for active mobility, but the problem is that, in practice, the share that remains for the implementation of active mobility policies is much smaller than its share in total travels. If we add the fact that this share of walking travels is higher in poorer areas, we see how regressive this allocation of resources is. Active transport in general, especially on foot transport, receives much less resources than it represents in terms of travel, not to mention the benefits of using this mode. In the capital of São Paulo there is no exclusive fund for mobility, which competes for resources with other areas, in the following funds:

- Fundo Municipal de Desenvolvimento de Trânsito [Municipal Fund for Traffic

Development] – FMDT;
- Fundo Municipal de Desenvolvimento Social [Municipal Fund for Social Development] – FMD;
- Fundo de Desenvolvimento Urbano [Urban Development Fund] – Fundurb;
- Fundo Municipal de Habitação [Municipal Housing Fund] – FMH;
- Fundo Municipal de Saneamento Ambiental e Infraestrutura [Municipal Fund for Environmental Sanitation and Infrastructure] – FMSAI;
- Fundo Especial de Meio Ambiente e Desenvolvimento Sustentável [Special Fund for the Environment and Sustainable Development] – FEMA.

Although cycling and walking are already established as means of transport, investment in infrastructure for these means is not listed in the transport infrastructure subfunction. The construction of cycling lanes, tracks and routes is considered within Special Transport, under the action of *improving universal urban mobility*, which received BRL 74 million from the transport budget in 2020 (1% of the total amount). In 2020, transport was the third most expensive government function in the city of São Paulo (BRL 5.3 billion). Of this amount, BRL 4.1 billion were allocated to public transport. Road infrastructure, mainly paving, was allocated in the urbanism function, in which it is possible to find expenses related to actions to *improve universal urban mobility and requalification and promotion of the occupation of public spaces* within the urban infrastructure subfunction (for example: expenses with exclusive bus lanes and paving) and the sub-function of urban services (such as spending on calming areas). Urbanism is the city hall’s fourth most expensive function (around BRL 3 billion), with mobility actions receiving 61% of this share in 2020 (BRL 1.8 billion). Despite the important investment received within urbanism, the allocation of mobility actions in urban services places investment in roads as an object of care, instead of an object for people to circulate.

The Emergency Plan for Sidewalks (PEC) is one of the main programs that the city of São Paulo has implemented in recent years to renovate and build new sidewalks in the municipality. Its objective is to promote the execution of the necessary works for the adequacy of the public sidewalks to the norms foreseen in the municipal legislation. The stretches prioritized by the program, called emergency routes, are those that concentrate large circulation of pedestrians in the vicinity of places where public and private services related to health, education, sports, culture, among others, in synergy with the transport system. collective public. Municipal law no. 14,675/08, which instituted the PEC, assigns the functions of planning, implementation and supervision of the Plan to the Municipal Secretariat of Sub-prefectures (SMSUB), making it the main responsible for its execution. In that same law, it was established that the list of roads that will receive the works of the plan must be defined by the Executive by means of a decree. In May 2008, municipal decree no. 49,544/08 presents a set of 313 roads classified as emergency routes, therefore eligible for PEC interventions.

Of the 7 million square meters of sidewalks demarcated as emergency routes by the PEC, only 721,000 m² were adjusted, that is, only 10% of the routes demarcated by decree no. 58,845/19 were reclassified between 2019 and 2020. It was observed more than 1.6 million square meters of sidewalks to be renovated by the city hall, equivalent to a total budgeted expenditure of more than BRL 273.6 million. At the end of the bidding process, which had the proposal with the lowest overall value per lot as a judgment criterion, it is noted that for the same estimated amount a total value of BRL 187.1 million was allocated, 31% less than the originally budgeted. Looking now at the data for each of the lots, great differences can be seen both in length and in prices. Lot 14, which covers the subprefectures of Butantã and Campo Limpo, has at the same time the highest amount of square meters of sidewalks to be upgraded (2.6 times more than lot 22) and the lowest unit value recorded, R $101.90 for every square foot of sidewalk on average. Due to the low unit value, lot 14 is only the third largest price record in terms of total value to be contracted, behind those relating to lots 12 and 20.

The PEC, as an alternative to renovate the 62 million square meters of sidewalks in the city (not only the emergency routes highlighted in the plan, but also considering the calculations made in Task C), would require from the city hall an investment of around BRL 7.1 billion over several decades[10]. In addition to the large mobilization of resources needed to finance this policy, it does not promote changes in the maintenance and inspection incentives present in the supply of sidewalks, implying a continuous dependence on the performance of the public power in the qualification of this infrastructure. However, other alternatives can be jointly explored to expand the number of accessible, comfortable and safe sidewalks in the city. The works can be carried out by all those responsible for their provision and maintenance, which means involving public authorities, citizens, the private sector, public service concessionaires that take advantage of the underground, and civil society.

The policy for granting rotating parking spaces (Zona Azul) has great potential as a strategic mechanism for reorienting mobility in the city. The expansion and improvement of the sidewalks, allied to the institution of a dynamic fee for rotating parking spaces in the city, were identified as promising paths in the field of active mobility policy in São Paulo. The results of the research carried out point to a reflection on the distribution of public road space between automobiles, sidewalks, cycling lanes and bus lanes, today unbalanced in favor of cars. Task B identified, among other measures favorable to demand management, the use of dynamic tariffs based on demand for certain locations and the charging of progressive tariffs based on the time of use of public space to favor active modes and public transport via disincentives to car use. The impact of the possible reduction of parking spaces located on public roads due to the

[10] Assuming the average price of adaptation of the public sidewalk registered by electronic bidding no. 023/SMSUB/COGEL/2019, of BRL 114.40/m².

expansion of sidewalks must be analyzed in order to identify possible developments within the scope of the current contract for the concession of rotating parking spaces.

Citizens are key partners in the execution of works and active mobility in the city. In order to improve the management model adopted in São Paulo, based on the shared responsibility between public authorities and citizens for the sidewalks, it is important to increase the participation of residents in the execution of renovation works, improvement and expansion of public sidewalks. When creating a sidewalk management program, the city government must, first of all, inform citizens in a clear and pedagogical way about their responsibilities, offer them alternatives to comply with their obligations, make them aware of the importance of their active participation and establishing inspection actions (understood as power-duty).

The city hall needs to take an active role in guiding and coordinating public interventions and private actions, establishing, for example, clear criteria and procedures for carrying out works, especially those related to the expansion of sidewalks, which are not yet clearly regulated by municipal legislation, so that the works are guided by technical criteria and territorial priorities that meet the interests of all residents of the city. The long-term economic sustainability of the program is only possible when set upon solutions based on the fair distribution of the benefits and burdens resulting from urbanization, as well as on the recovery of government investments that result in the appreciation of urban properties. The City Hall can also carry out works on the sidewalks directly. The challenge on this front is to establish a sustainable model for financing these actions. And, just as important, the presence of the government is fundamental for coordinating actions focused on specific areas of the city, in order to concentrate efforts and achieve integral territorial goals.

The private sector urgently needs coordination, as it can participate in multiple ways in improving the city's sidewalks and should be considered a relevant pillar for a sidewalk management program. The ways to include the private sector in the sidewalk management program imply the assessment of existing tools and their potential to involve companies and, simultaneously, ensure that public investments and allocation of funds prioritize active mobility. As an example of these tools, we can cite: (i) public-private partnerships – such as those aimed at housing construction or improving public lighting – provided for in federal law no. 11,079/04; (ii) urban concessions; (iii) urban operations; (iv) urban intervention projects; (v) partnerships for upgrading commercial streets (art. 181 of the Master Plan); (vi) usage permissions for the purposes of economic exploitation of public space; and (vii) private management of public areas; among others.

Civil society organizations – including non-profit private entities (for example, residents' associations or commercial associations), cooperative societies and religious organizations (art. 2, item I, federal law no. 13,019/14) – may also participate in the care of sidewalks in the city and be guided and coordinated for carrying out works. Examples of civil society participation in the preservation, conservation and improvement of public space in the world are not uncommon, in squares, parks, pedestrian corridors, quiet areas and others. The city hall can promote partnerships with civil society organizations in a mutual cooperation regime for the promotion of complete streets in the city, through: (i) terms of collaboration — in cases of public power proposals that involve transfer of financial resources; (ii) terms of promotion — in the case of proposals by civil society organizations that involve financial resources; or (iii) cooperation agreements — in cases of partnerships that do not involve the transfer of financial resources (federal law no. 13,019/14).

It is necessary that these communication efforts are made so that the information is updated, available and presented in a friendly way for the citizen, in addition to being aligned with the campaigns and political agendas, as well as with the sectors of public management responsible for the maintenance and inspection of the sidewalks. The São Paulo city hall has already made efforts to develop information tools, such as the already mentioned Urban Design and Road Works Guide and the Handbook on Sidewalks and Exclusive Routes for Pedestrians. However, the creation of unified dissemination platforms is essential for granting simplified access to citizens. The investigation into the available information found outdated and dispersed documents on different pages, which generates disorientation for the citizen. The creation and use of digital platforms dedicated to the subject, in addition to being informative, also facilitate its constant updating in view of possible changes, such as updating standards, technical aspects (materials used in a sidewalk renovation, for example), changes in current legislation, among others.

The communication strategy is an important part of public policy, particularly in the management of sidewalks. Item 2.4 of this report offers nudge strategies[11] covering proper communication in a sidewalk program.

The diagnosis on the inspection of sidewalks in the city of São Paulo pointed to two main issues: a) the institutional fragility regarding the enforcement of inspection, especially in relation to the resources available for monitoring actions by citizens; and b) the unavailability of enforcement mechanisms for residents to adhere to the appropriate sidewalk model. With regard to the first point, it was found that the scope of action of

[11] The nudges, based on behavioral science, encourage desirable choices through effective and transparent communication with the population, without restricting individuals' freedom of choice.

inspection agents largely transcends their possibilities for inspecting sidewalks, due to the small number of inspection agents in view of the large number of responsibilities and the dimensions of the territory through which are responsible. Therefore, the filing of complaints by citizens turns out to be the main mechanism for identifying irregularities on sidewalks in the city and possible inspection actions. As for the second point, the existence of regulatory and normative parameters of standards suitable for an accessible sidewalk alone does not guarantee, in the current context, a generalized quality of sidewalks. The lack of clear guidance prior to the execution of sidewalks leaves room for non-compliance with the standards established by the accessibility standards and guidelines proposed by the Decree for the Standardization of Public Sidewalks (municipal decree no. 59,671/20), including the design parameters defined in São Paulo's Urban Design and Road Works Guide. Therefore, the management of the sidewalks does not only consist in the clear definition of responsibilities between public and private entities, but also in a wide coordinated performance of management, inspection and execution activities by those responsible.

Some ways to strengthen sidewalk inspection include:

- the allocation of necessary and adequate resources for the inspection activities of the sidewalks;
- simplification and standardization of inspection processes;
- the intensification of a broad communication campaign accompanied by inspection actions;
- the dissemination of simple and accessible booklets on established responsibilities and technical and legal guidelines for repairing, maintaining and adapting sidewalks;
- the institutionalization of a support sector for individuals interested in adapting to urban norms;
- the inclusion of clear indications about the irregularities found in the infraction notices so that the citizen can regularize them.

Among the various essential legal aspects for the implementation of complete streets in the city of São Paulo, it is worth highlighting three main themes that were identified and that should guide the elaboration of new rules: (i) zoning, (ii) expansion of sidewalks, and (iii) improvement fee.

With regard to the zoning regulation, bearing in mind that the review of the current Master Plan is in progress, the mechanisms for managing sidewalks can be expanded, especially to promote the redistribution of spaces intended for parking vehicles and city sidewalks. As central measures, it can be pointed out: the need to include parking spaces in the calculation of the utilization coefficient; the replacement of the minimum limit of spaces currently considered a requirement for constructions, for the maximum limit of parking spaces.

The exclusion of the road system as an essential infrastructure in the land regularization projects promoted by federal law no. 13,465/17 is a legal-institutional bottleneck that compromises the financing of sidewalks with public and private resources. Although the municipal legislation has recently recognized "paving, when necessary", it is important that the mentioned item allows not only the reform of sidewalks, but, above all, the expansion and construction of new sidewalks, that is, both the regularization social interest land (Reurb-S) and specific interest regularization (Reurb E) should include the construction of sidewalks in the concept of basic infrastructure. This is because land regularization projects mobilize public and private resources for the various regions of the city and can ensure the improvement of road infrastructure in these locations. Thus, in the case of Reurb-S, the entity responsible for financing the construction of the sidewalk would be the city of São Paulo and, in the case of Reurb E, the beneficiaries or private entrepreneurs. Such measures can be carried out through municipal legislation.

With regard to the expansion of sidewalks, it is important to solve the regulatory gap related to the rules for the coordination of works when it is necessary to change the curbs and gutters, as well as the establishment of territorial priorities for intervention and inspection. Finally, the implementation of a sidewalk management program may require changes in the current legislation for the improvement contribution of São Paulo, in order to make it compatible with federal legislation – especially with regard to the calculation by area of influence – and the recent experiences of application of the improvement contribution in Brazil and Latin America. Reviewing municipal legislation can also update the technical criteria required for works and adapt them to new technological and regulatory parameters and rethink ways to calculate the valuation resulting from public works.

There is a conflict associated with garages and parking lots, because, if on the one hand there are clear advances in their regulation in favor of active mobility, on the other the urban rules of the city go against the grain. Federal legislative changes and changes in the Master Plan signal a regulatory perspective favorable to active mobility. The National Urban Mobility Plan classified parking lots and garages as part of the urban mobility infrastructure and provides for the possibility for federative entities to establish a public and private parking policy as an integral part of the National Urban Mobility Policy (federal law no. 12,587/ 12, article 2, § 3 and article 23, V). There is also a prioritization of non-motorized modes of transport over motorized ones and collective public transport services over individual motorized transport (art. 5, II). The Master Plan of São Paulo is even more emphatic and provides for the reduction of car parking space for the implementation of a cycling structure and the expansion of sidewalks as one of the strategic actions of the road system (law no. 16,050/14, art. 241, X), in addition to establishing other urban instruments aimed at improving active mobility. However, a logic of strengthening and encouraging the use of the car as a standard of displacement still prevails in the city. This logic has been translated in different ways into incentives for the construction of parking spaces since the 1970s, with the requirement of "minimum" parking spaces in force until today (see the Land Installment, Use and Occupation Law – municipal law no. 16,402/16, Table 4a). The same happens with the non-computation of parking spaces as built-up area in the calculation of the utilization coefficient, in force for the entire city (with the exception of the Urban Transformation Structuring Axes, from the 2nd vacancy, art. 62, municipal law no. 16,402/16). These and other rules stimulate and encourage the construction of parking spaces.

It is possible to observe some recent setbacks in the attempt to increase resources for sidewalks, such as the approval of municipal law no. 17,217/19, which changed the master plan in order to allow Fundurb resources, previously intended exclusively for active mobility and collectively, to be allocated also for "improvements in structural roads", enabling the prioritization of investment in motor vehicles to the detriment of sustainable mobility. In addition to earmarking revenues, the fund's balance of more than BRL 1 billion in 2020 indicates that there are important obstacles to its use, which compromise the financing of the city's development.

The concession structure of the rotating parking service on roads and public places, structured under an atypical and rigid format, far from the gaze of urban mobility. Parking lots, which are part of the urban mobility infrastructure, must serve a broad public policy strategy through which collective and active modes, the rational use of public space, are prioritized.

In the context of revising the Master Plan, the proposition of the following measures is considered strategic:

- <u>Calculation of parking spaces in the calculation of the utilization coefficient:</u> as reported in the document, the non-calculation of parking spaces in the calculation of the utilization coefficient is the result of law no. 14,044/05, that sought to change the rules established in São Paulo after the enactment of the City Statute. In 2014, the master plan tried to move gradually along this path by predicting that the provisions of law no. 14,044/05 do not apply to the areas of influence of the Urban Transformation Structuring Axes (art. 80, paragraph 3).

- Forecast of a maximum limit of parking spaces in the land use and occupation legislation: Currently, this limit exists only for the areas of influence of the Urban Transformation Structuring Axes. For other regions of the city, there is no limit or, on the contrary, there is a minimum limit of vacancies for approval of building projects. A strategy that has been gaining momentum in several cities is the minimum-maximum, the previously required minimum limit becomes a maximum limit and the requirement is suppressed.
- Prioritize non-motorized modes of transport and give centrality to active mobility policies when implementing urban instruments: As we have noticed, many instruments with the potential to provide resources for the implementation of complete streets have been used in order to prioritize the use of the car. This is the case of the Traffic Generator Hub, Urban Operations, Fundurb, the Onerous Grant of the Right to Build and the Environmental Impact Study. An application of such instruments is proposed in line with the new and already described regulatory frameworks, which prioritize active mobility and public transport.
- Extend to other areas of the cities the current counterparts required from new developments located in the axes of implementation of infrastructure focused on mobility on foot. Examples are: donation of public areas when there is no need to subdivision the land; allocation of area for widening the public sidewalk with calculation of the constructive potential according to the original size of the lot and exemption from the payment of the onerous grant referring to the constructive potential of the donated area; areas intended for public enjoyment, with partial exemption from payment of the onerous grant of the right to build; active facade; and wall fence limit at 25% of the front of the lot.
- Application of the Neighborhood Impact Study: The EIV is already included in São Paulo's legislation since the Master Plan of 2002 (municipal law no. 13,430/02) and the Land Use and Occupation Law of 2004 (municipal law no. 13,885/04). However, the understanding prevails that the approval of a specific law would be necessary to guarantee its application. In 2011, bill no. 414/11 was discussed at the São Paulo City Council, aimed at regulating the EIV, which was not approved. Recently, there was an attempt to prepare another bill to regulate the EIV in São Paulo by a working group created in 2019 by the city hall (SGM ordinance no. 177/19; SGM ordinance no. 115/20). So far, however, there is no news of advances in the application of EIV in the city of São Paulo.
- Execution of Fundurb values already collected through instruments such as the Onerous Grant of the Right to Build and with destination linked to active mobility.

- Link Zona Azul revenue to compensation for negative externalities caused by intensive car use. The impact of a possible reduction in parking spaces located on public roads, resulting from the expansion of sidewalks, must be analyzed in order to identify possible developments within the scope of the current contract for the concession of rotating parking spaces.

Among the main investments made by the municipal government to promote mobility on foot in recent years, the implementation of the Emergency Plan for Sidewalks with funds from Fundurb and FMD stands out, but it is suggested that the prioritization of expenditures be changed Fundurb and the FMD to facilitate the implementation of a sidewalk management program in São Paulo. The approval of municipal law no. 17,217/19 – which made it possible for Fundurb resources, previously intended exclusively for active and collective mobility, to be invested in structural roads – demonstrated how the change in the composition of municipal funds expenditures can favor or disfavor the agenda promoting sustainable mobility. Therefore, the adoption of movements in the opposite direction is encouraged, seeking to increase the participation of active mobility in Fundurb and FMD.

It is also necessary to review the disparity in resources allocated to inspection and monitoring of infrastructure for motorized and non-motorized modes. The elaboration of a sidewalk management policy must provide for the support of an inspection structure that is attentive to the conditions presented for the flow of pedestrians, as well as for the flow of cars.

Non-tax collection (directly charging the property owner) is established by law. Likewise, the improvement contribution and the Community Urban Paving Plan are already existing alternatives that enable the execution of works on public sidewalks based on the participation, in their cost, of the owners of the properties benefited by them. One factor that may favor the application of instruments such as these is the formulation of a sidewalk program inspired by the experiences of Montevideo and Chicago, in which the municipal administration endeavors to raise awareness and encourage citizens to reform sidewalks, coordinate these initiatives and promote several financing alternatives.

The inclusion of investments in sidewalks as counterparts or measures to mitigate the impacts caused by large-scale projects. As noted throughout the report, several urban instruments regulated by the City Statute and the Master Plan of 2014 can be mobilized to promote a fair distribution of benefits and burdens resulting from the urbanization process. Instruments such as the Environmental Impact Study, the Neighborhood Impact Study and the Traffic Generator Hub qualify the urban and environmental licensing process and can be used to strengthen other forms of travel other than by car. Currently, the Traffic Generator Hub is mobilized mainly to force the construction of parking spaces and traffic signaling equipment.

The Environmental Impact Study, as mentioned, has not even been applied in the city, even though it has been foreseen since the Master Plan of 2002 and having been maintained in the Master Plan of 2014 and in the Land Use and Land Occupation Law of 2016.

Charging the negative externalities caused by the use of individual motorized transport to finance a sidewalk management policy. As pointed out in Task B, São Paulo stands out for having implemented, for years, measures to discourage the use of private cars in areas with the highest concentration of jobs and opportunities in the city. The municipality has charged for parking on public roads since 1975, with the adoption of the Blue Zone; restricts circulation in the central region through rotation since 1997 and, more recently, started to charge technology companies for individual paid passenger transport (such as Uber and 99 Táxi) for the intensive use of the road in 2016.

The municipal vehicle restriction could be gradually transformed into a congestion charge, similarly to the charge applied to individual paid passenger transport companies, and the proceeds of both charges be used to subsidize policies to encourage mobility on foot. This combination of charging on car use linked to the financing of more sustainable alternatives is presented as the next step to be taken by São Paulo on the path towards promoting active mobility.

Matching the competences of the federal entities over the public goods located on the public sidewalk – including not only the use and maintenance of this heritage, but above all the regulation and approval of works on the sidewalks – is not a trivial task and can be considered a relevant obstacle in the implementation of a program for the sidewalks[12]. If the sidewalk is part of the public road and, as such, considered a public good owned by the City Hall (federal law no. 6.766/79), the underground and airspace are considered the property of the Federal Government (art. 20, IX, Federal Constitution; Floriano, 2014). In addition, the provision of federal public services – electricity, telecommunications – and state services – such as sanitation and gas – requires the use of galleries, underground ducts and posts.

It is necessary to advance in the structures of governance to include in the management of the sidewalk program in the city of São Paulo the participation — in addition to municipal bodies such as CONVIAS — of federal and state regulatory agencies — such as ANATEL, ANEEL and ARSESP —, as well as public service concessionaires. It seeks to

[12] The legal dilemmas involving the debate on the legal nature of accessory goods that directly interfere with the circulation of vehicles and pedestrians in cities, as well as the rights and duties related to reversible goods and the use of public infrastructure in current public service concession contracts, constitute a relevant future research agenda, but due to the time constraints of the current research, it has not yet been developed to date.

establish more clearly criteria for approval, execution, monitoring and inspection of work on sidewalks by the three federal levels, as well as to agree on information sharing strategies that avoid overlaps and conflicts in the territory, capable of interfering in the quality of sidewalks and pedestrian mobility.

It is also essential to define a managing entity responsible for the sidewalk improvement and management program. This entity can be a specific commission or body, as long as it is strategically positioned to influence the different facets of the sidewalk program, at all scales, from technical detail to mobility policy, as well as execution by both the public sector and the government. private sector. The managing entity would be responsible for leading and coordinating the actions of the various agencies that have competences related to sidewalks, both municipal and state and federal.

In addition to managing a sidewalk program, there is an opportunity to create a commission to manage public spaces in the city of São Paulo. International experiences of institutionalizing public space have proved to be a good tool for improving sidewalks. One of the experiences of solutions for managing public space, already studied and analyzed in the policy briefing (Report B of this project), was the case of the city of New York, with the creation of the Public Design Commission. When the need to institutionalize a public policy is reinforced, it is done based on the ability to create cohesion among the actors to act together towards a common goal and, mainly, to protect the policy area from power shifts, providing the continuity of management. In this sense, in Bogotá (Colombia) the Defensoría del Espacio Público[13] was created, which coordinates the defense, inspection, surveillance, regulation and control of public space, the administration of real estate and the conformation of the general inventory of the city's real estate assets in a way centralized, with clear activities and a well-defined user interface, which politically reinforces the importance of the public space and guarantees specialization in the provision of services over it.

Adopt nudge strategies, which have been increasingly used by the public sector. Nudges (Table 15), according to behavioral science, encourage desirable choices through effective and transparent communication with the population, without restricting individuals' freedom of choice (PMSP, 2020). Nudge actions, in general, have a low implementation cost and are often present in the decision-making environment and context. The innovation of nudge actions lies in identifying cognitive barriers and overcoming them, stimulating beneficial behaviors for the individual and the community. It is important to point out that the City of São Paulo has internal

[13] Available at: https://www.dadep.gov.co/. Accessed on: Feb. 12, 2022.

intelligence to deal with matters of innovation and nudge, through the (011)lab[14]. Therefore, the city hall has the technical capacity to develop policies using behavioral science strategies. This is especially important since testing the nudge solution is an inseparable part of its strategy development process.

[14] 011 lab – Laboratory of Innovation in Government of the City of São Paulo. Available at: https://011lab.prefeitura.sp.gov.br/. Accessed on: Feb. 12, 2023.

Table 15. Ten important nudges used in public policies

TYPE OF NUDGE	HOW IT IS APPLIED
1. COMMUNICATION	Transparency in communication and facilitation of access to information, simplifying it.
2. SIMPLIFICATION	Promotes adoption of existing programs by simplifying formalities and rules.
3. USES OF SOCIAL RULES	Emphasizes majority behavior, collective engagement (eg, “most people pay their taxes on time”).
4. WARNINGS, GRAPHICS OR MISCELLANEOUS	Uses graphic and visual resources to communicate or warn.
5. INDUCE IMPLEMENTATION INTENTIONS	Triggers certain behavior through direct questioning through language (e.g. “you are a voter, do you plan to vote this year?”).
6. INFORM PEOPLE ABOUT THE NATURE AND CONSEQUENCE OF THEIR OWN PAST CHOICES	Provides information on past behavior and can engage behavior change (for example, by reporting on past expenditures and expenses).
7. PRE-COMMITMENT STRATEGIES	Promotes engagement and commitment to future actions (for example, a smoking cessation program).
8. INCREASES IN FACILITY AND CONVENIENCE	Makes visible, encourages behavior, facilitating choices, reduces barriers.
9. STANDARD RULES	Automatic enrollment in social programs (for example, in social security).
10. REMINDERS	Communicates through e-mails and text messages about obligations and commitments, allowing immediate actions.

Source: SUNSTEIN, 2017. Elaborated by the authors.

Among the range of solutions and sources of funding, the Improvement Fee is a possibility little explored by the city of São Paulo, with great potential to be expanded. The Improvement Fee (IF) has a historical trajectory in Brazil, being a tax employed over 87 years and which has its origin in tributes charged during the colonial period. In almost all Latin American countries, the IF is used as an instrument to finance urbanization. In Colombia and Mexico, collection via IF corresponds to approximately US$ 300 million per year, being one of the main sources of funds for public works. In these countries, as well as in Brazil, the IF is predominantly applied to road works, considering, therefore, the set of works and services necessary for the complete implementation of roads, that is, opening, paving and implanting sidewalks. But Colombia also has a tradition of using the IF to finance public transport, which can be seen as one of the ways to solve the financial bottlenecks present when deciding on the implementation of these works.

Finally, an exercise was carried out to simulate the collection of IF in the city of São Paulo to carry out road works aimed at guaranteeing complete streets in the city within the perimeter of the project "Urban Requalification and Road Safety in São Miguel Paulista", which corresponds to the São Miguel Reduced Speed Area, also known as Area 40, taking three situations as a reference. In Case 1, the calculation of the IF of a specific work is carried out, considering the properties with frontage for the paved road, in compliance with the terms defined by the municipal legislation in force. In Case 2, the IF of a specific work is calculated, considering the properties within the area of influence of the intervention, defined according to the radial method. In Case 3, there is a proposal to distribute the costs of a set of works among all properties within a perimeter defined as the area of influence. In respect of the principle of proportionality, federal legislation allows the variation of the IF collection according to the valuation of the property by zone or for each differentiated area (art. 82, item II). This is a determination based on the idea that properties closer to interventions receive more advantages than those farther away. The simulation of the three cases involves an exercise based on the calculation of an estimated real estate valuation of 3.5% and the calculation of the apportionment of the cost of the work for each of the properties benefited or located in the area of influence of the works[15].

The Areas 40 are perimeters defined by the Life Protection Program of the Mobility Department and the Traffic Engineering Company of São Paulo (CET-SP) and their main objective is to reduce injuries and deaths of pedestrians in traffic. In São Miguel, only the first phase of Area 40 was implemented in its entirety, which consists of reducing the maximum speed to 40 km/h, changing the vertical signaling and installing electronic equipment for traffic inspection (radar).

The second phase, which includes the execution of traffic calming works, has not started, despite the basic project having been completed in 2017. The feasibility of these interventions is precisely what will be simulated in the exercises that will be presented below, in which the application of the improvement contribution may be an alternative to finance the implementation of all, or at least part, of the works listed in the São Miguel Paulista Urban Requalification and Road Safety Project (**Figure 17**).

[15] This value was defined based on the calculation method used by Hernando Arenas, for charging IF in Bogotá, Colombia.

Figure 17. Urban Requalification and Road Safety Project in São Miguel Paulista

Source: ITDP, 2019

The three cases studied fully respect the federal legislation regarding the improvement contribution, especially decree no. 195/67. From the point +of view of local legislation, each of the cases makes considerations, from total compliance to the proposition of new norms, updating some devices, in view of the outdated and outdated municipal laws referring to the IF.

Case 1 strictly considered the legislation on IF in force in São Paulo (decree no. 59,579/20), which establishes the collection of IF from the apportionment of the costs of works among the properties benefited by it, in proportion to the **linear measure** of its frontage.

The exercise demonstrates some limitations of this distribution model:

1) The lots with the largest fronts correspond to the highest apportionment values, regardless of their distance from the work.

2) Bearing in mind that the law defines a mode of distribution that considers the properties bordering the road or public area, the area of influence follows a linear pattern, extending along the road and moving away from the specific location where the works are to be carried out.
3) The simple use of the frontage does not take into account the different shapes that the lots can present. Deep lots and narrow lots that have the same frontage will be charged in the same way, even if they are very different in terms of total area.

Case 2 also complies with federal legislation, but does not follow municipal norms regarding the definition of the area of influence. To update the conformation of the area of influence, the value of the property was included as one of the factors in the calculation, proposing a distribution that considers the distance of each property in relation to the work site and its market value. It is understood that this criterion allows for a more balanced distribution of the apportionment of costs, since those properties that are closer to the works will bear larger amounts, as well as those that have greater contributory capacities.

The limitations of this model appear in the case of a set of works, since the radius of influence of the works can overlap, which would mean that a property could belong to more than one area, therefore being subject to more than one charge. Given that it is understood that the execution of a package of works presents a general benefit that falls on the entire region, it is reasonable to propose the division of its costs among all those who are affected by it. This is precisely the principle adopted in the following case (2.2.1.3).

Case 3 takes as reference a set of works foreseen within a specific perimeter. Although it does not strictly comply with the form of distribution established by current municipal legislation, it is understood that this model is more equitable, as it considers the set of properties benefited by the works. Furthermore, by distributing the amount based on the market value of the properties located in the area of influence of the interventions, there is a more balanced apportionment of the costs of the works.

The analysis of the legislation in force in the country, and in São Paulo, indicates the existence of a sufficient legal framework for charging the improvement fee. However, there are still constraints regarding the necessary procedure, especially with regard to demonstrating the real estate appreciation resulting from the work, which is a legal requirement. However, it is considered that, to overcome this situation, there is bibliographic material[16] and case studies that can help to overcome the barriers of knowledge and enable the implementation of the IF collection process.

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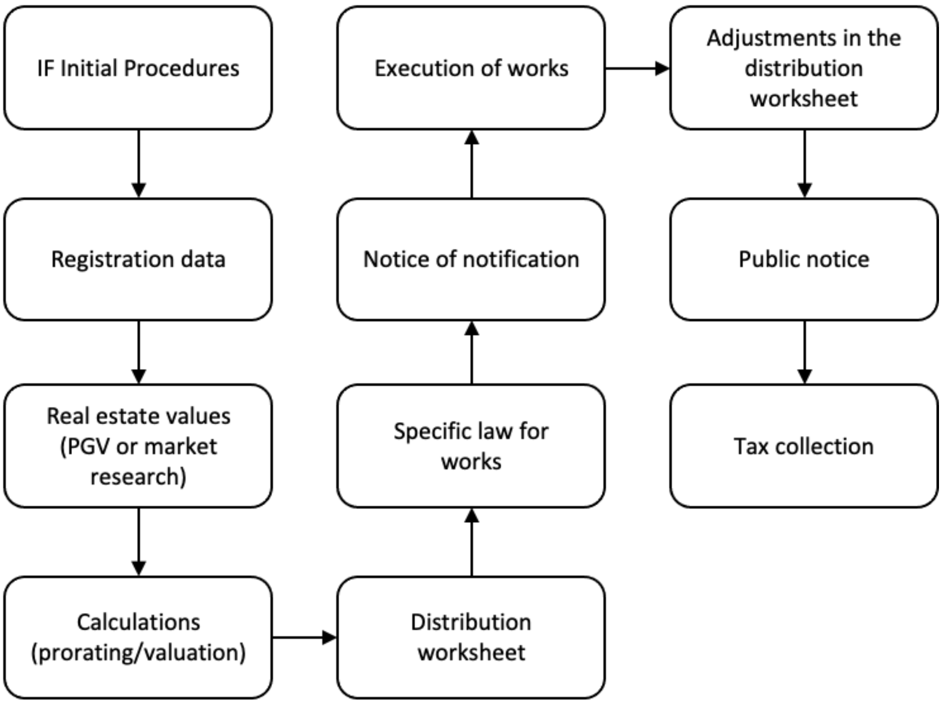
[16] In this regard, see Pereira and collaborators (2018); Borrero (2020); Martingale (2021); Duarte & Baer (2014).

Specifically in the municipality of São Paulo, there is a restriction associated with the fact that the legislation limits the IF charge to paving works linked to a set of technical specifications. However, as already mentioned, those specifications are outdated, not corresponding to the techniques currently practiced and standardized. Precisely because these specifications do not apply to reality, it is understood that updating the table would be easily justified, incorporating specifications of materials and services corresponding to works on sidewalks on urban roads. Figure 15 describes the sequence of actions required to implement a IF billing system.

In summary, the studies carried out indicate that it would be possible to charge the IF for works on sidewalks in São Paulo using the legal framework in force in the municipality. However, in the case of adopting the method of calculating valuation by distance, some legal updates would be necessary, namely:

1) Establishment, by law, of a systematic calculation of real estate valuation – approval of a specific law on improvement fees is recommended.
2) Elaboration of an explanatory booklet/guide of the taxation, in order to facilitate the dissemination and understanding of the process by the general population.

Figure 18. Improvement Fee collection process flowchart



Source: Own elaboration.

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