Transit-oriented development (TOD) in a scattered city: applied study in Brasília, Federal District

Desenvolvimento orientado ao transporte (DOT) em uma cidade dispersa: estudo aplicado em Brasília, Distrito Federal

Desarrollo orientado al transporte (DOT) en una ciudad dispersa: estudio aplicado en Brasilia, Distrito Federal

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Abstract
This research aims to analyze the territorial urban strategy entitled transit-oriented development (TOD), a methodology originated in the United States, which for at least 30 years has been little discussed and applied in Brazil. Faced with the challenges imposed in the 21st century in terms of sustainability and the projection of upward population growth of Brazilian cities, DOT planning is a viable concrete alternative for the transformation of today's dispersed, distant, and disconnected (3D) cities into future compact, connected and coordinated urban complexes (3C). Thus, based on the characterization of the DOT, it has led to the conclusion that this methodology is suitable for application in Brasília, Federal District,

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so that mass transport planning in the city would integrate with urban planning, in a fairer and more equitable way.

**Keywords:** TOD. Urban Integration. Urban Planning. Urban Mobility.

**Resumo**

Esta pesquisa tem como objetivo a análise da estratégia territorial urbanística intitulada desenvolvimento orientado ao transporte - DOT, uma metodologia oriunda dos Estados Unidos, que há pelo menos 30 anos, vem sendo discutida e aplicada de forma pontual no Brasil. Diante dos desafios impostos ao século XXI no tocante à sustentabilidade e a projeção de crescimento populacional ascendente das cidades brasileiras o planejamento DOT é uma alternativa concreta viável para a transformação das cidades hoje dispersas, distantes e desconectadas (3D) para futuros complexos urbanos compactos, conectados e coordenados (3C). Desta forma, a partir da caracterização do DOT, conclui-se que essa metodologia é adequada para aplicação em Brasília, Distrito Federal, de maneira que haja a integração do planejamento do transporte de massa da cidade com o planejamento urbano, de forma mais justa e igualitária.

**Palavras-chave:** DOT. Integração Urbana. Planejamento Urbano. Mobilidade Urbana.

**Resumen**

Esta investigación tiene como objetivo el análisis de la estrategia territorial urbana denominada desarrollo orientado al transporte - DOT, metodología originaria de Estados Unidos, que desde hace al menos 30 años, ha sido discutida y aplicada de manera puntual en Brasil. Frente a los desafíos impuestos en el siglo XXI en materia de sustentabilidad y el proyectado crecimiento poblacional ascendente de las ciudades brasileñas, la planificación DOT es una alternativa concreta viable para transformar las ciudades dispersas, distantes y desconectadas (3D) de hoy en complejos urbanos compactos, conectados y coordinados (3C). De esta manera, a partir de la caracterización del DOT, se concluye que esta metodología es adecuada para su aplicación en Brasilia, Distrito Federal, de manera que exista la integración de la planificación del transporte masivo de la ciudad con la planificación urbana, de una manera más justa e igualitaria.

**Palabras clave:** DOT. Integración Urbana. Urbanismo. Movilidad Urbana.
Introduction

The concept of transit-oriented development (TOD) represents an alternative to build and transform cities into more dynamic, sustainable, and integrated spaces for the population. There is an urgent need to rethink urban mobility as the main guiding axis for the creation of efficient and intelligent policies, aligned with demographic projections for the 21st century in the Brazilian context.

The World Cities Report 2022, published by UN-Habitat states that the world population will be 68% urban by 2050. In the years of the COVID-19 pandemic there was a slowdown in the speed of urbanization globally. In search of health security, a large-scale migration from large centers to the countryside or small towns was noticed. However, this was a short-term response: the global urban population continues to grow, and cities are expected to have 2.2 billion more inhabitants by 2050 (UN-Habitat, 2022). At this rate, it is estimated that the urban population will increase from 56% of the global total in 2021 to 68% in 2050, figure 1.

According to the Brazilian Institute of Geography and Statistics (IBGE, 2022) Brasília became the third largest city in Brazil in terms of population, with 2,817,068 people. In 12 years, Brasília grew by 9.6%, second only to São Paulo and Rio de Janeiro. According to IBGE (2022), "core" municipalities of urban concentrations are losing dynamism, due to the territorial exhaustion of the core municipality. In this sense, population expansion occurs in cities neighboring the core cities.
The urbanization process of the Federal Capital, as well as in other Brazilian cities, was marked by the prioritization of individual transport and the peripheralization of low-income populations, especially the black population, resulting in large daily commutes to work and little infrastructure in public transport. According to Santaréém (2021):

“[…] there is a dialectical relationship between black people and mobility, since transport was organized to colonize, objectify and animalize blackness – however, assigning to black people the task of building and operating the entire system. The black desire to humanize/move collides with transport’s colonization, which seeks to improve its technology and colonial technique. In slave transport – express from the slave ship –, the black people were simultaneously the merchandise to be transported and the engine of the vehicle. Thus, the black struggle for self-governance conflicts with the process of trafficking.” (SANTAREM, 2021, p.58)

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Thinking about an inclusive policy based on transport means, fundamentally, giving access to the city to all inhabitants and repairing historical injustices. The transit-oriented development (TOD) is one of the alternatives for thinking about integrations that can favor social struggles in the right to the city.

**Transport-Oriented Development (TOD) and Brasilia’s Context**

TOD principles first emerged after a debate started with the oil crisis in 1973 by architect and urbanist Peter Calthorpe. The excessive dependence on automobiles in the United States gave rise to the awareness against car use and the questioning of the sprawled city’s urban model, the opposite of what was imagined as the “American dream”.

Em 2021, o Banco Interamericano de Desenvolvimento - BID, com recursos do Clean Technology Fund, lançou uma cartilha com recomendações para aplicação do DOT nos municípios brasileiros, com a participação dos Ministérios da Economia e do Desenvolvimento Regional. Com base nesse documento, o presente artigo traz uma abordagem dessa estratégia territorial aplicada ao caso de Brasília, o BID conceituou o DOT como:

In 2021, the Inter-American Development Bank (IDB), with resources from the Clean Technology Fund, launched a booklet with recommendations for TOD application in Brazilian cities, with participation of Ministries of Economy and Regional Development. Based on this
document, this article brings an approach to this territorial strategy applied to the case of Brasilia, the IDB et al. (2021) regards TOD as:

“a territorial strategy based on urban projects that aim to articulate urban components with mobility systems, building more compact and environmentally correct cities. It seeks to encourage the concentration of housing and socioeconomic activities close to corridors and mass public transport stations, promoting urban development with greater constructive and population density in this area.” (IDB et al., 2021, p.23)

Briefly, this system consists of applying mass public transport planning to urban planning. In the world there are several successful applications towards sustainable urban development in cities as Bogotá, Washington, Bilbao, London, among others. Among the advantages, there is the reduction of pollutants, the mitigation of disordered horizontal growth (a worrying problem in Brasilia), reduction of displacements and optimization of the use of public spaces and basic services.

To maximize the use of this plan, the IDB et al. (2021) lists five necessary macro tools for application in municipalities, namely: governance and inclusion, transformative legislation for TOD, planning and management instruments, financing and land gains recovery, sustainable mobility, and public transport, figure 2. Today, the Brazilian context has “3D” model cities: “distant, dispersed and disconnected” and the TOD application logic produces “3C” cities: “compact, connected and coordinated”.
Regarding Brasília, Frederico Holanda (2005) analyzes the urban complex in three indicators that determine its characteristic based on spatial syntax. The analysis regarding their centrality indicates that the Monumental Axis and the Road Axis, considered as the central roads of Plano Piloto, are not among the most integrated city roads, that is, the considered central zone is not the morphological center of Brasilia, the more integrated roads are EPIA and EPTG, as can be seen in figure 3.
Brasília has a total of 35 Administrative Regions (ARs), with Ceilandia being the AR with the highest demographic index (figure 4). However, it is in Plano Piloto that the highest concentration of jobs in Federal District takes place. Therefore, the inhabitants of the other ARs undergo daily long daily journeys to their jobs.
Brasília can be considered a “3D” model city – distant, dispersed and disconnected. It urges an urban planning that results in efficient land use and occupation, the decentralization of basic services and jobs, and the expansion of multimodal trips, including improvements in pedestrian displacement. According to an American Development Bank (IDB et al., 2021) report, the TOD strategy must consider:

- Optimizing land use: establish land subdivisions for strategies to increase occupation density and, simultaneously, limit urban horizontal expansion.
- Taking advantage of land added value opportunities: encouraging urban projects that reassure financial sustainability or use little or no public resources.
- Articulation between public and private sectors: jointly plan the mapping of specific urban areas that return long-term benefits to the population.
- Development and infrastructure improvement for public transport: diversification of modes and use of clean renewable energy.
- Urban regeneration projects: recovering or developing areas based on housing supply, as well as democratizing access to public facilities for different population segments.
- Promotion of decentralized economic diversity: meeting market demand, generating decentralized jobs and reducing travel times.

The fundamental point of TOD is prioritizing development poles that are attractive to mass urban transport and the extensive capillarity of the transport network. In Brasília, the public transport network and the diversification of modes is insufficient to serve the population. It is necessary to plan for adequate transport and expand the network of other modes, in this case the subway and the train. The existing subway line works basically to supply workers to the city center during business hours, figure 6.

![Ring road and subway in the Federal District](source: authors, 2023)

When analyzing the map in figure 11, with the metro networks of Atlanta and Barcelona (figure 12), Brasília has only one line that forks to meet the demands of ARs; very similar to what happens in Atlanta, which adopts the individual transport model as the main transport. At the opposite pole is Barcelona, which has a compact footprint, 26 times smaller than the American city, a vast network of subway lines and almost the same number of inhabitants, figure 7.
Source: IDB et al., 2021

According to the IDB et al. report (2021) there are four modes of public transport, namely: air, land, waterway and underground, with different financial resources needed for implementation. The TOD methodology prioritizes the use of walking, the use of bicycles and micro mobility, which consists of small non-polluting vehicles. The equipment and public spaces needed to encourage this type of displacement must be designed in such a way that they serve this purpose.

Although the TOD considers the return on the initial investment for adapting the surroundings of stations or terminals through the payment of transport fees, it is at this planning moment that the involvement of social movements must have a basis within the negotiations. According to Marcela Gomes (2008), the struggle for free transport began in 2000, led by the “Independent Youth” group. It was in 2004 that the movement became more cohesive and was named the “Free Pass Movement”, made official at the V World Social Forum in 2005 and in 2015, with the amendment of Article 6 of the Federal Constitution, transport began to be considered a social right.

In Brasilia, the involvement of the 35 Administrative Regions is necessary to rethink the transport policy of Federal District, since today the city is in Class 1 of planning policies (figure 08) and there is a long way to go until the metropolitan region achieve Class 3, with planning policies developing urban life in the city.
In the IDB et al. report (2021), there is a simplified summary of how to carry out the transition from Class 1, which consists of the indiscriminate use of cars and the expansion of road networks and parking spaces, passing through Class 2, with the incentive of different non-motorized modes and efficient integrated massification of public transport, until reaching Class 3, the democratic use of the city, improvement in urban living with positive changes in social indicators of quality of life. According to that document, actions should focus on reducing the number of trips, diversified offer of modes and energy efficiency.

There are different TOD results depending on the type of transport that is involved in the planning and the surrounding activities, specific to each city. They are characterized on two fronts: regional DOT, which reaches a macro scale developed from the infrastructure of airports, ports and intermodal stations and urban DOTs, created from train and subway stations, Buss Rapid Transport (BRTs) or Light Vehicles under Rails (VLTs). Each case will determine the economic influence on the execution of the plan.

To understand the type of TOD influence in Brasilia, it is necessary to carry out a diagnostic plan based on the metropolitan macro-region. The factors to be considered, according to the IDB et al. document (2021), would be:

- Mobility: identify people's daily commuting conditions and the distances covered and how these commutes occur, the predominant times and modes categories.
- Territorial organization: morphologically understand the territory, the use and occupation of the soil, the index of segregation, compactness, and centrality, based on
the previously presented spatial syntax method, the concentration of jobs and income, etc.

- Existing projects: identify strategic projects with urban impact and traffic generating poles.
- Urban and mobility legislation: carry out a survey of all district and federal norms in terms of urban mobility and urban legislation, as well as listing laws, in the case of the Brazilian capital.
- Prospective analysis: analysis of population behavior in terms of mobility and the impact of this change for the territories functioning.

Based on the diagnosis of the macro-region, project planning is carried out in the micro-region, which can be around a bus or subway terminal, the development of sidewalk and cycle path projects and the installation of urban equipment. The project is conditioned so that it is easy to access the station or terminal by means of displacement by bicycle, micro mobility or by foot and, for this, the area of influence of action must be identified, a radius of 250 to 500 meters around the core element. The new Land Use and Occupation Law of Brasilia, through the Geoportal/DF website, already makes available the study of the radius of influence around existing metro stations and bus terminals (figure 9).

![Figure 8. Public Transport Terminals areas of influence in Federal District.](image)


In Curitiba, for example, the new Zoning, Land Use and Occupation Law was approved in 2019 and stipulates mixed use and densification along the green line axis (figure 10).
10). The new law stipulates the strengthening of housing in the central area and the encouragement of commercial areas and services in structural sectors, with greater constructive potential. However, according to the IDOM report (2021), in Bogotá the implementation of the BRT system, a pioneer in Latin America, did not consider the population and commercial density in the vicinity, which caused the non-development of the quality of life.

Figure 9. Curitiba’s skyline along the green axis.
Source: Curitiba’s City Hall. Available at www.curitiba.pr.gov.br access in August 2023.

DOT prioritizes intermodal development and urban mobility infrastructure, but a combination of several factors is necessary for the success of objectives of the territorial planning strategy. In the “NoMa” neighborhood in Washigton/USA, an area with many disused lots and little urban infrastructure was revitalized, and there was densification and the creation of added value for unbuilt lots (figure 11). In addition, other details were considered, such as the access of new buildings, sidewalks, facades’ treatment, maximum height allowed, heritage preservation strategies, among others (figure 12).
Figura 10. NoMa development map, W.D./USA.

Figure 11. Facades articulation in NOmA neighborhood, Washington D.C.

The Brazilian capital, as it is a non-compact city, has numerous areas that can be applied with the same densification strategy, developing the intermodal collective transport network. The identification of these areas carried out through an accurate diagnosis, added to
the flexibility of the norms, can transform Brasília into a reference model for the TOD strategy, if there is good articulation with the private sector, the population, and the public sector.

**Transport Oriented Development – TOD and the use of CIM, BIM and GIS**

With the advent of more advanced technologies, today the use of information and communication technologies to generate flows of information for public sharing is a reality. In “3C” cities, considered smart cities, not only the rulers have access to data on urban dynamics, but also the population, based on tools for claiming improvements in urban functions.

Currently, the database of Brazilian cities is still 2D, stored in different systems and collected using different methodologies. There is not enough precision in the information to guarantee the perfect applicability or updating of any urban project. For example, an aerial photogrammetric survey can be carried out more than once by different government departments without both being aware of the work carried out and, as a result, unnecessary time and money is spent.

BIM (Building Information Modeling) is a technology allied to a process that is based on the use of three-dimensional models with parameterized geometric and non-geometric information from which all the necessary data for the construction of a building are taken (architecture, building installations, structure). It is a collaborative methodology that makes use of the principle of simultaneous engineering aimed at the AECO sector – Architecture, Engineering, Construction and Operation – which ensures precision in the extraction of information and guarantees an accurate and intelligent work process.

For instance, GIS (Geographic Information System) is a system of hardware and software, spatial information, computational procedure and human resources of spatially referenced data based on a known coordinate system. It allows the processing of specific data (geographic and non-geographical) about a cartography.

In this way, the integration of BIM and GIS forms the CIM (City Information Modeling), a large-scale work methodology that aims to improve the development of urban projects and efficiency in the management of urban data. The CIM technology consists in the elaboration of a three-dimensional digital model of city, completely faithful to reality, which integrates the global information of a model in a single source of data – a digital clone that is updated in real time from sensors distributed in the physical space. (JUSTI et CANTUÁRIA,
2021). It is not enough to have an integrated database without it being constantly updated. CIM is considered by some authors as a BIM technology combined with georeferenced data applied on a large scale in the urban context.

Finally, the TOD strategy provides for broad public participation in decision-making for the preparation of the plan adapted to a specific location context. CIM technology with real-time synchronization, allows TOD to have better applicability conditions, mainly in the solution of complex problems that were dispersed and decentralized.

**Conclusion**

Brazil has macrostructural difficulties in large metropolises directly linked to the disorderly growth of cities and the lack of necessary infrastructure to care for people, especially the low-income and vulnerable population. However, there is little dissemination of efficient solutions that reduce the impact of disorderly growth and guarantee the right to the city in all social strata. Given the above, the integrated application of Transport Oriented Development, combined with the precise revision of the Master Plan model can be the guide for a real transformation in the dynamics of Brazilian cities and in the context of Brazil’s capital.

Brasilia, characterized as a “3D” city (disconnected, dispersed, and distant) has many structural challenges to solve and transform itself into a “3C” city (connected, coordinated, and compact). These are common conflicts in large Brazilian metropolises, such as major traffic jams, precariousness in basic services, disarticulation of the center from the peripheries, little capillarity of mass public transport, and deprivation of the right to the city for the low-income population, especially the black population.

The TOD methodology also advocates the use of technologies aimed at integrating information for urban management, in decision-making, such as CIM technology, among others. This paradigm shift in urban thinking, combined with public management focused on the challenges of the 20th century, and popular participation in decision-making, can transform Brasilia into a successful reference in the search for smart cities of the future.

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