#186
ROAD DUPLICATION IMPACT IN URBAN AREAS TOWARDS SPACE SYNTAX ANALYSIS

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ABSTRACT

The proposed study discusses the application of Space Syntax Theory in road infrastructure and urban circulation infrastructure integrated planning. The structure of the urban environment provides an endless range of readings systemic descriptions and analysis. Among those, the ones provided by Space Syntax Theory and methods display robust results that comprise significant relationships between pedestrian and vehicular movement depicted from spatial configurations, what recommends its application in research problems that target these phenomena. In its turn, the interaction between road and urban networks is undeniable. Historically, road systems are powerful attractors that organize spatially urban settlements the occupancy population centre generating conurbations. However, paradoxically, at the same time that cities and roads are inextricably linked, this relationship has a conflictive nature with negative implications for both systems. In this paper, we intend to focus on spatial discontinuities imposed by roads stretches on intersections with urban grids that give emergency to social phenomena referred in literature as "community severance". This notion applied in situations where regional transport infrastructure or motorized traffic acts as physical or psychological barriers segregating urban areas. In this context, our aim is to assess "community severance" impacts related to road crossings duplication in urban spatial configurations. The analysis of such impacts on urban accessibility and segregation patterns between settlements areas rely on space syntax literature about the theme and its potential application in transport studies. The methodological test was performed on an empirical case - the district town of Anhanduí, located in Brazil Midwest Region state of Mato Grosso do Sul that is crossed by BR-163 highway. The results confirm the hypothesis that urban crossings duplication, in the way they are usually designed in Brazil, induces "community severance" processes with negative impacts on city life and functional centralities, generating urban discontinuities which tend to deepen socio-spatial segregation processes and modify urban dynamics. This research intends to present Space Syntax methods and tools within transportation infrastructure technicians and policy makers, and raises their awareness to negative impacts of road crossings on urban territories.

KEYWORDS

Space Syntax, Syntactical Measures, Urban Highways Crossings, Community Severance.

1. INTRODUCTION

The close link between cities and roads is undeniable. Historically, road pathways attracted people, and organized settlements and their surrounding territories, informing tendencies for urban expansions can be said that cities are composed, basically, of the flows of people and goods and land use. In this sense, Panerai (2006, p. 18) states that *"The strength of the road/city relationship is such that certain cities seem to be only a succession of roads around which the city is organized"*[1]. According to road engineering terminology, the segments of roads that cross these urbanized areas are named as *"Urban Crossings "*. However, paradoxically, cities and roads are closely linked, but from such relationship cause a series of conflicts and negative implications for both networks: urban and road ones. Regarding the impacts generated by roads on cities, the ones that should be highlighted are environmental, visual and noise pollution; changes in land use and fringe occupation; and urban displacement issues due to spatial and urban grid discontinuities. In this sense, it is appropriate to cite Secchi (1989, p. 553) for whom *"the road is now the crucial space for reflecting on the territory and the city, since it becomes a place of maximum concentration of noise, air and visual pollution, incongruously fragmenting the urban space and the territory, thus dispersing origins, destinies and movements ".*

In this paper, we propose to describe and analyse city territory fragmentation caused by the *barrier effect*, a consequence of highway stretches crossing the urban grid. The usual solution for urban crossings would be implementing road detours; however, nowadays there are dissonant voices questioning the cost-benefit of such strategies that brings socio-environmental restrictions. Impacts on urban fabric accessibility patterns increase exponentially when highway lanes are duplicated with physical barriers between them. For safety reasons, highways technical regulations prevail over urban ones, imposing access control to its bordering land plots, through physical obstacles (guard-rail, concrete barriers, etc.), that reduce drastically connections between parts of the urban grid. Restrictions to pedestrian movement range restricting or confining such flows to a few specific points, where it remains possible movement across the road system. This kind of crossing is not levelled, but usually done above or below the road level through viaducts, underpasses and footbridge (Figures 1 and 2).

Figure 1 - Example of crossing urban road with simple lanes.

1 Along the same lines, at the beginning of the last century, Marcel Pöete wrote that the two elements that are the basis for the formation and development of cities are the location and the geographical frame, considering that the location receives the city, but the road gives it life. POËTE, Marcel. *Introduction à l'urbanisme: l'évolution des villes, la leçon de l'antiquité.* Boivin, 1929.

Figure 2 - Example of crossing urban roads with divided lanes and barriers, with only a few transpositions.

In this context, becomes relevant the concept of urban resilience, in the words of Cutini (2013, p. 102.1) is the "*(...) the capacity of an urban system, thanks to the features of its spatial elements, to take abruptly imposed transformations, without significantly changing their mutual relations (...)*". This design meets the purpose of this study, given that the doubling of urban crossing promotes an abrupt change in the urban fabric. To operationalize the evaluation of urban resilience, Cutini (2013) proposes the use of certain configurational measures.

Therefore, in order to assess the impact of the highway duplication on the urban environment around, we propose a study applying the theory and methods of Space Syntax. Thus, this study aims to analyse the effects of the implementation of urban crossings duplication in the spatial configuration, gauging the level of urban resilience to such intervention, which effects on urban grid are simulated, modelled and through syntactic measurements.

2. THEORETICAL FRAMEWORK

2.1 URBAN HIGHWAYS CROSSINGS

In this study, we use the concept of urban highways crossings presented by Amin (2012, p. 35): *"Urban crossings are segments of roads that run across urban areas. They are characterized by population concentrations in their adjacent areas and the need to fulfil and reconcile the traffic demand of two different types of users: long-distance and local."*

Regarding their functions, urban crossings have negative impacts on both highways´ and city´s e environment. Sharing the highway with local traffic interferes traffic flow and increases conflicts and accidents, which directly impact the mobility of vehicles in long-distance intercity journeys. In addition, highways with the access restrictions hinder the movement and connection between one side and the other of the highway, negatively impacting the accessibility of intra-urban displacements.

At this point, interventions on highways near urban areas have an element that corroborates the lack of harmony with their surroundings by imposing legal, administrative and design specificities that the consequent contribute to urban grid fragmentation, along with autonomous governance and planning responsibility unrelated to municipality institutions and legislation. Thus, the design of a new highway (or even an intervention for increasing its flow capacity) is federal or state department attribution, which policies may conflict with urban and territorial planning and transit jurisdictions of the city.

The transportation engineer has a key role in such context, since this technician goal is to guarantee long distance traffic fluidity, and, in most cases, they act similarly in highway projects for rural and urbanized regions, disregarding the peculiarities of the latter. Following this idea, Marshall (2005) believes the focus on traffic summarizes the planning process to mathematical calculations for optimizing a limited number of variables and subordinating all other elements.

2.2 COMMUNITY SEVERANCE AND URBAN SEGREGATION

Mouette and Waisman (2004, p.33) defined the road barrier effect as follows: *"[...] to denote the restrictions or inhibitions caused by interurban traffic and roads on urban mobility that generating an impedance to free pedestrian movement between the two sides of the road."* Internationally, the term *community severance* indicates this phenomenon, which, as Ancien *et al.* (2016, p. 293), *"[...]describes the effects of transport infrastructure or motorised traffic as a physical or psychological barrier separating one built-up area from another built-up area or open space."*

Thus, when a highway is duplicated, it must be more than one lane, with a separation between them due to the presence of physical obstacles. In this sense, Ulysseá Neto and Dias (2003) conclude that are no longer allowing indiscriminate crossings, because this type of longitudinal blocking often causes the interruption of existing streets, which forces people to travel much longer distances than those they would usually travel before the intervention.

Mouette's (1998) affirm that the road barrier effect results in restrictions or inhibitions to the free movement of pedestrians caused by two obstacles: physical or vehicular traffic. Therefore, the population is forced to make detours or deviations that are impedance to movement, increasing daily displacements time or distances, what tends to reduce or even suppress journeys across highways.

The Brazilian National Department of Transport Infrastructure – DNIT, (an executive stance under the Ministry of Transport), admits publicly that *"The existence or insertion of a highway in an urban area establishes a conflict, road space vs. urban space, with serious negative impacts for both. (...) The most important negative impacts detected in these cases are: (...) b) urban segregation/alteration of accessibility conditions"* (DNIT, 2005, p. 41).

According to Villaça (2001, p.142), *"segregation is a process where different classes or social strata focus more and more on different areas or neighbourhoods of the city."* Obviously referring to residential segregation phenomena from homogeneous socioeconomic foreground. Mouette (1998, p.40) relates population segregation to road barriers effect, since it *"can segregate part of the population, in detriment of another share, by preventing the former from reaching a certain area, thus separating and isolating it from places and people."*

At this point, we highlight studies, such as Vaughan's (2007), which demonstrate the importance of addressing socioeconomic conditions on urban design, consistently verifying the correspondence between poverty and spatial segregation.

2.3 URBAN RESILIENCE

Regarding the urban resilience, which is the study subject, we reiterate the concept presented by Cutini (2013, p. 102.1), for whom urban resilience is the *"(...) capacity of an urban system, thanks to the features of its spatial elements, to take abruptly imposed transformations, without significantly changing their mutual relations (...)"*. Following in the same direction, Rigatti (2016, p. 3) says that *"(...) resilient urban systems are able to withstand transformations in their morphological characteristics without modifying their underlying structure, that is, the city is able to function and adapt to changes."*

The great majority of works dealing with urban resilience relate to the capacity of cities to withstand abrupt changes in their structure related to natural events such as earthquakes and floods. Regarding the transformations caused by urban infrastructure works, the work of Professor Décio Rigatti (2016) must be mentioned; he addressed the resilience of the urban structure of Porto Alegre resulting from the works for the 2014 World Cup.

2.4 SPACE SYNTAX

The use of Space Syntax appliance to analyse urban crossings related phenomena is justified by Hillier *et al.* (1993), who state that urban road network configuration, the largest spatial pattern in the city - is determinant for movement flows and, therefore, urban grid spatial patterns relate intrinsically to co-presence in spaces, with enormous consequences for both the land use and functions of cities.

Hillier and Hanson (1984) understand that the system of open public spaces in an urban system is constituted by elements that can be individualized and identified. Thus, they start from the premise that this system can be decomposed in one or two dimensions represented as a map of axial lines. The linear features of the axial map represents better the transport flows and pedestrian movement interactions we intend to analyse in this paper. According to Holanda (2002), the axial map is the linear representation of space, allowing the syntactic description of the configuration and the clear visualization of topological distances in the urban network. This type of representation is based on the axial lines that would be the longest lines of visibility and continuous movement in the system.

In axial analysis, spatial configuration features (morphological properties) are quantified by extracting syntactic measures. In the words of Rigatti (1997, p. 176), *"syntactic measures are, then, configurational properties transformed into a measured pattern, enabling analyses and comparisons".*

At the beginning of this century, Turner (2001) proposed a methodological improvement to describe, analyse and represent movement potentials and flow probabilities within urban grids so called Angular Segment Analysis. According to Zampieri (2012, p.41), this analysis *"is a tool that allows thinking of axial lines according to the deflection of each route. This process segments the axial lines at their intersections to others, so weights can be assigned, depending on the angle at which the segments are connected."* Thus, in this type of analysis, in addition to the topological structure depicted in axial analysis, the connection between axial lines is pondered by its angulations what ponders the notion of topological distance (depthness) with that of perceived spatial and visual continuity. Another thing that makes the angular segment analysis different is that it splits the axial line at the intersection with other axes, so it is possible to correlate each segment to movement potential and activities location, what is most relevant for local scale analyses, as proposed in this article. In this sense, Braga (2013, p.270) concludes that this analysis *"allowed the peculiarities of uses and social appropriation in the stretches of an axial line to be understood in a more objective way, in a reduced scale, so the dispersion of urban functions could be analysed not from potentials of movement, but from the probability of flows along segments."* Following the work of Hillier and Iida (2005), the high correlation index between the *Angular Segment Analysis* and pedestrian or vehicular flows are foremost important to build our case.

Thus, considering the particularities of the proposed research, and considering that it seeks to evaluated the urban resilience level, we use the lessons of Cutini (2013) and Rigatti (2016) with the following axial syntactic measures:

a. Mean connectivity value;

b. Choice;

c. Sinergy.

In addition, as a research deals with the verification of flow trends, we chose to use the segmented map, since it transforms the axial map lines into segments, allowing the assessment of each segment of the axis. The following angular measures are used: integration and choice.

The measure of integration represents the potential to "*go to*", that is, how easy it is to go from one point to another. According to Oliveira *et al.* (2015, p. 162), *"it is a measure of the degree of centrality, relating to the movement of destiny, [...] [it has] the ability to identify significant places from the point of view of the functionality of urban agglomerates. Integration usually emphasizes spaces in the city commonly known as 'main streets', where a large part of non-daily commerce is located, often associated with the concept of (functional) urban centre."*

For Turner (2007, p. 540), the measure of choice based on that of betweenness centrality in network theory consists in *"for all pairs of possible origins and destination locations, shortest path routes from one to another are constructed."* So, for each time a node is traversed in an origin-destination path, the choice-value increases one point.

3. THE STUDY EMPIRICAL CASE AND ITS DATASETS

The District of Anhanduí, located in the city of Campo Grande, capital of the state of Mato Grosso do Sul, Brazil, is our case study. The choice of this location is mainly due to two factors: the situation in which BR-163 highway crosses the entire urban perimeter of the district; and the forecast of duplication of the highway.

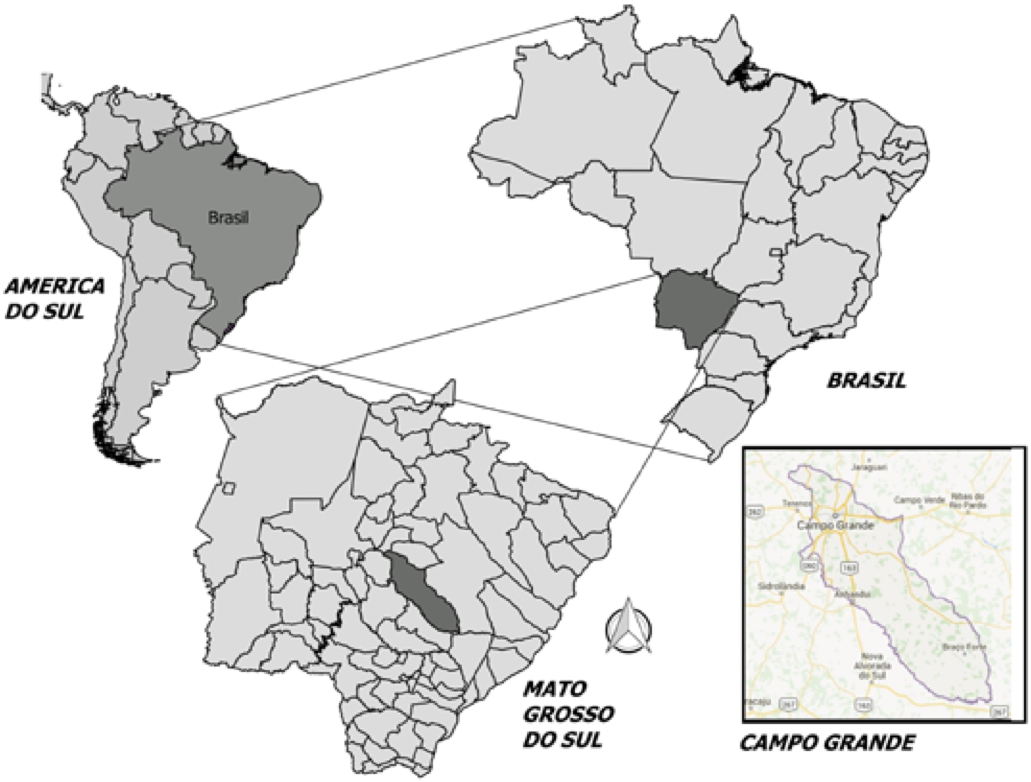

Figure 3 - Location of the city of Campo Grande and the Anhanduí District.

The occupation of Anhanduí began in the 1950s, but the current configuration corresponds to a project of subdivision of land approved in the mid-60s, which planned the execution of 2,800 plots of land. The original plan had a city square, and around it would be the city hall, church, forum and post office, creating a kind of civic centre. It is observed that the current urban fabric of the District of Anhanduí is characterized by an orthogonal grid layout with chessboard format, with connections in "X", forming a non-hierarchical system

According to census data (IBGE, 2010), the district has a total population of 4,267 inhabitants, with 2,040 people living in the urban area and 2,227 in the rural area. The district main economic activities are agriculture and informal commerce, along the BR-163 Highway, where local products, mainly handmade objects, homemade sweets, cheeses and pepper are sold directly by locals to travellers. Formal commerce and services are located along the highway.

Informal/irregular commerce in 'tents' on the sides of the highway.
Formal commerce along the side streets.
Original location of the 'civic centre', with square, city hall, church and forum.

Figure 4 - Anhanduí District in 2015.

BR-163 is a highway that connects Brazil from South to North crossing the Centre-West of the country, comprising the entire state of Mato Grosso do Sul, and constitutes the main logistics corridor of this State, transporting agricultural goods to the ports of Paraná and Santa Catarina.

4. METHODOS AND DATABASES

A set of *orthophotos* of the District was obtained what enabled the urban grid decomposition into an axial map (AutoCAD 2017). At this point, it is important to note that this paper focuses on non-motorized forms of transportation, and, therefore, all permeability's urban public space was considered included elements such as walkways and passageways throughout which pedestrians and cyclists can move. On the other hand, when physical obstacles were identified, such as road elements that make it impossible for pedestrians and cyclists to move freely, especially concrete barriers and metal fences, the axial lines were interrupted. After that, the functional design for the duplication of BR-163 Highway was obtained and the design changes were added to the axial map in order to express the further changes to spatial continuity due to road lanes duplication. The changes consist basically of a barrier between the two lanes of the highway (which sections, in the model, the transversal routes), the inclusion of two footbridges and an underground, and two viaducts located at both ends of the urban settlement.

After the linear representation of the map the next methodological step is the process of calculating the models through a specific software. The procedures for obtaining measurements are identical, in the original situation and in the projected situation.

This research uses the angular analysis of the segment maps. Thus, a new map is created, with the syntactic angular measures in. Different theme maps are generated for each syntactic measure and, in addition, a text file with all the numeric data of the maps.

Finally, the variables from segmented analysis are assessed and compared in the two ways: in roads after and before the duplication with obstruction to movement in urban crossing. This analysis will indicate urban configuration changes due to the road duplication in urban crossing. In addition, the values of the variables of the entire study system are compared with others cities of Brazil and the world.

Therefore, two thematic maps were created for each measure, related with these two analyses, that is, to the period before and after the duplication.

5. RESULTS

5.1 ORIGINAL SITUATION

Preliminarily, it is observed that the current urban fabric of the District of Anhanduí is characterized by an orthogonal grid layout with chessboard format, with connections in "X", forming a non-hierarchical system, which model refers to the correspondence between global and local morphological properties.

To examine the level of urban resilience, the axial measurements "connectivity", "choice" and "synergy" were measured, according to values below:

Mean connectivity value	Choice max /k	Int. R3 x Int. Rn R^2
6,09	0,4236	0,9631

Table 1 - Values regarding the urban resilience index in the original situation

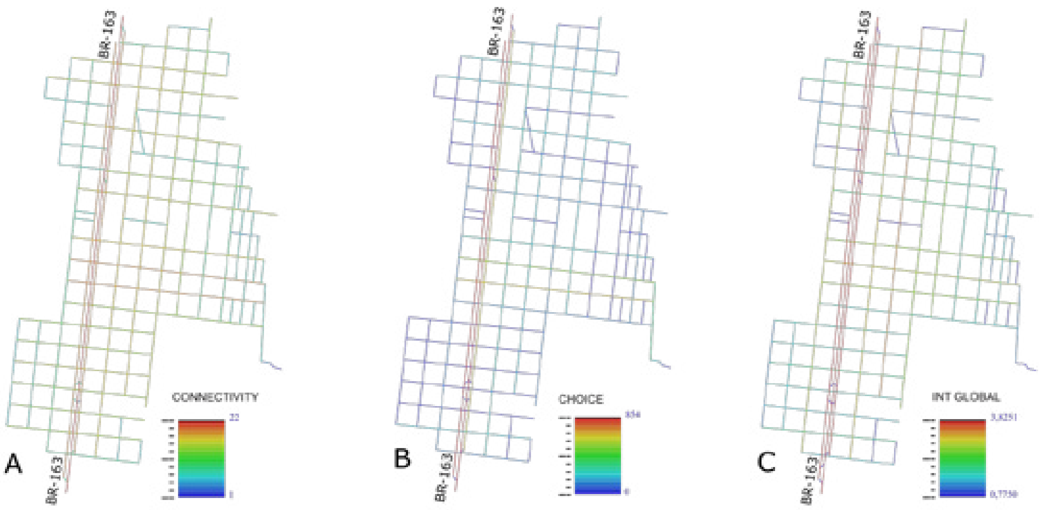

Figure 5 - Axial map / original situation – Distribution of connectivity (A), choice (B) and global integration (C)

The most connected lines stand out for their color, which varies from red (more connections) to dark blue (fewer connections). Regarding the average connectivity, a value of 6.09 connections per line was verified, which can be considered a very high value. This situation is characteristic of regular and orthogonal mesh cores. According to Medeiros (2006, p. 357), *"(...) the orthogonal grid optimizes the number of connections due to 'X'-crossings that reinforce the possibility of lines crossing most systems."*

Medeiros (2006) also affirm that the average connectivity of Brazilian cities is 3.9, that is, Anhanduí, according to the information above, has a much higher average connectivity when compared to other Brazilian cities. In addition, in a worldwide comparison, the highest results of this variable are found in Latin American cities (5.7), which, despite being a value close to that found in Anhanduí, still is lower.

In addition, the map shows that the 3 most connected lines refer to the highway and its side streets.

The index choice proposed by Cutini (2013) varies from 0 to 1 and corresponds to the following expression:

v=choice max/k

Where k = n2/2-3/2 n + 1, with n = number of lines in the axial map.

Increasing the index "choice", the level of resilience of the urban system decreases. This is justified by the fact that it is plausible to assume that systems with a diffuse presence of shorter paths across the network have a higher level of resilience. In a single-crossing situation, the index found corresponds to 0.4236.

Synergy corresponds to the correlation between global and local integration of a system. The Depthmap software allows the direct calculation of the "R2" index of this variable. The value found is 0.9631, which is a very high correlation. This high correlation is explained by two situations: first, according to Medeiros (2006), "to synergy, the larger the system, the smaller the value"; so, for a small system, as is the case in this study, the synergy value will be higher. Second, the regular orthogonal mesh results in a high convergence of global and local integration scales.

An angular analysis is used to assess the fragmentation of the urban system and the potential of flows in the segments. Segment maps will be used to achieve this. In this method, the axes are "broken", which results in an increase in the total number of axial lines, reaching 390 segments.

	minimum	average	maximum
Integration Rn	4,491	209,627	279,071
Choice	0	2979,420	11926,000

Table 2 - Values referring to the measures of integration and choice, in the original situation, using the segment map.

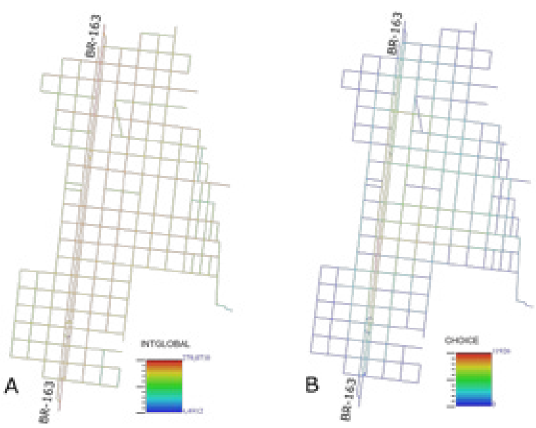

Figure 6 - Segment map / original situation – Integration (A) and Choice (B).

It is possible to observe that the segments with the highest integration values diffuse parallel the axis of the BR-163 Highway and its side streets, covering the entire extent of the urban sprawl. However, it is also possible to verify that the network has distributive integration features typical of shallow system that concentrates integration along the longest and most connected lines and is subdued to border effects. In addition, it is possible to affirm that there is no significant difference between the values found on one side and another of the highway; continuity between segments establishes the spatial pattern.

As a role, it is possible to say that the lines with higher integration measure are those that have, potentially, higher movement potential. It was inferred that easier to reach segments from any other point within the system tends to concentrate economic activities. In a brief comparison between the integration map and the current land use, it is possible to verify that there is some correspondence between commerce location and integration measures.

Angular choice measure (n) relates to urban navigation through the urban grid, depicting the shortest routes crossing the system. For Turner (2007, p. 6) "*Betweenness, or choice as it is called in the space syntax community, is calculated by generating shortest paths between all segments within the system".* According to Ugalde (2013, p.194), choice is "*the syntactic measure with the greatest ability to capture movement paths in spatial configurations."* In Figure 6.B it can be observed that, in general, the segments with higher values for this measure correspond to places where there are more commercial uses, especially, it depicts the informal commerce concentration (Figure 4).

It is worth noting that the civic centre location supposed to exist in the original project does not currently have the characteristics of centrality, the expected outcome of which would be a symbolic centre. The commercial establishments, as already shown, are clustered along BR-163 Highway and its adjacent roads, where the highest indexes were found for the measures of integration and choice, therefore, concentrated where movement potentials and flow probabilities area higher.

5.2 PROJECTED SITUATION WITH THE DUPLICATION

With the duplication project and the construction of new devices, as well as the sectioning of the transverse routes to the highway, there will be an increase in the number of existing axial lines. In order to identify changes due to interventions on the highway, the actual situation map was modified, including projected elements prescribed for road lanes duplication: viaducts, walkways and the underground passage. The modelling considered unlinks, where segments are superposed but have no connectivity. The pattern of cross-sections in "X" persists, but the transversal routes overpassing the highway were suppressed by blockages between the duplicated lanes. Thus, cross-sections in "T" appear along the side streets of the highway modifying continuity patterns between both sides of the lane.

The table below shows the measurements verified from the simulation of the space system, with the duplication project already inserted.

Mean connectivity value	Choice max /k	Int. R3 x Int. Rn R^2
4,09	0,5184	0,5849

Table 3 - Values referring to the urban resilience index in the projected situation

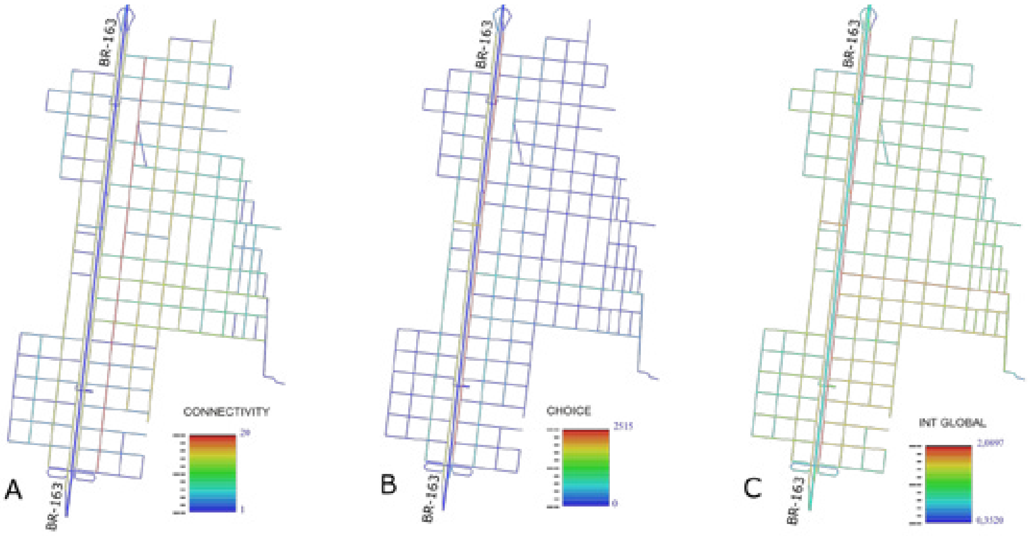

Figure 7 - Axial map / projected situation – Distribution of connectivity (A), choice (B) and global integration (C)

As to the mean connectivity, there is a decrease of more than 30% in its value, making it 4.09 connections per line, which reflects a lower internal articulation of the grid. This is explained by the fact that the transverse axis is cut off from the road. This number of mean connectivity is slightly higher than the average of Brazilian cities (3.9). In a brief analysis on the map, it should be noted that the highway (and its side streets), which, in the original situation, are the ones with the greatest number of connections to other roads, now, with the changes caused by the duplication project, are not anymore.

In the assessment of the index "choice", the situation simulated with the duplication project caused an increase in this index, reaching the value corresponding to 0.5102. This difference is perceptible by analyzing the maps. In this second situation, it is possible to verify a smaller amount of shorter paths in the network (greater presence of lines of strong blue color)

The value found in the synergy index, with the duplication project, drops to 0.5849, which corresponds to a decrease of approximately 40%. This decrease in values reflects a separation between integrations, globally and locally. In addition, it was verified that the size of the system is not the most determining factor for this measurement.

In order to perform the comparative analysis with the results verified in the original situation, it is necessary to draw up the segment maps already with the lines referring to the duplication project, in order to ascertain the measures of global integration and choice.

	minimum	average	maximum
Integration Rn	2,5	116,662	160,554
Choice	0	2970,81	39860

Table 4 - Values referring to the measures of integration and choice, in the projected situation, using the segment map.

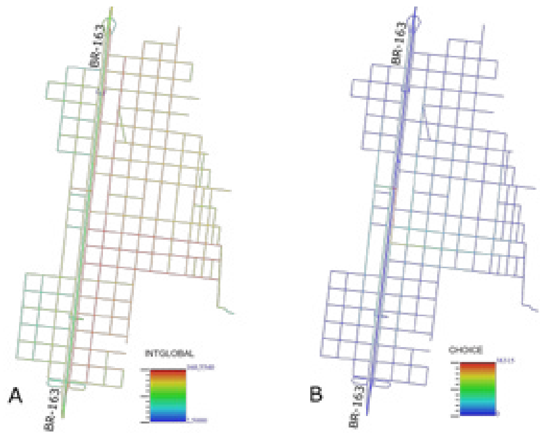

Figure 8 - Segment map / projected situation – Global Integration (A) and Choice (B).

The angular Integration measure including the designed highway duplication is significantly revealing. The first phenomenon that draws attention is the clear distinction between the patterns found between one side of the highway and the other. It is important to note that the highway, which has the most integrated element, loses higher level of integration, becoming a kind of "barrier" dividing the District territory. A plausible conclusion is that this can stimulate a process of spatial and social segregation, or community severance. In addition, it is observed that the average values of the integration measure decrease considerably, so that it can be stated that urban accessibility decreases. In addition, it is expected that, as time passes, new functional centralities will appear along most connected axes transversal to the highway. A new configuration will emerge in which the impact of discontinuities imposed by changes on the road system upon the urban system will transform commerce which today revolves around interregional flows.

As regarding the angular choice measure, due to the barrier imposed by the duplication of the highway, the results were quite different from the current situation. If before there was a concentration of the higher flow probability around the centre of the system corresponding to the main routes, now there is a displacement to one of the extremities next to a U-turn. This fact demonstrates that the previously verified pattern, common to orthogonal grid settlements, was significantly altered, and the physical barrier embodied in the duplication of the highway will significantly the decisions about route choices used for intra-urban displacement.

6. FINAL CONSIDERATIONS

Firstly, this study is the initial part of a research project that is still in progress, and, therefore, it needs further development. Urban interventions alter the spatial characteristics of cities, bringing along social consequences. In the case, we verified that the duplication of BR-163 Highway, which crosses the urban sprawl of the District of *Anhanduí*, alter profoundly the spatial configuration of this location.

Following the Spatial Syntax approach, we found significant changes in development tendencies due to changes on the road infrastructure. The results confirm the assertion that the duplication of an urban highway, in the manner in which it is commonly done, increases the negative impacts derived from the its barrier effect, especially those referring to discontinuity and fragmentation of urban space, which tend to worsen processes of social segregation.

Finally, the findings from the segmented maps enable the visualization of the flow and movement relations, so that such technique, with the necessary adjustments and furthering, can be used in a way that helps the discussion and the studies of interventions in urban highways.

Concepts of urban resilience, usually applied in situations of natural disasters (earthquakes, floods, etc.), can also be applied in situations of significant road interventions and can show the behavior of the urban structure.

The most important is that the symbiosis between the road system and the urban settlement development , specially its functional centrality based on the commerce of local products and services directed to interurban traffic is due to fade, compromising the very existence of this small town. Several small towns that emerge in rural areas along regional roads are sensible to changes in urban crossings. Sometimes the mere existence of such crossings acts as powerful attractors to urban activities such as formal and informal roadside commerce. Inter-urban and intra-urban traffic segregation enhances the efficiency in cargo flows and urban community security, nevertheless, such design strategies must consider the impact on the spatial life of small towns, because sometimes it can promotes severe changes in their dynamics and social organization.

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