

NOTES FOR THE IDENTIFICATION OF LARGE SCALE MOVEMENT ROUTES – A CONFIGURATIONAL APPROACH OF PORTO ALEGRE METROPOLITAN REGION

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ABSTRACT : The present work, based in Space Syntax theory and methodology, aims to help on diagnostic and prognostic studies necessary to street grid planning. After a brief review on the technical approaches adopted so far, and under the hypothesis that in Brazilian metropolitan areas, lack of articulation, continuity and hierarchy in street systems, large scale movement is drawn to a relative small number of streets, avenues or roads - the study proposes a procedure to make possible the identification, in a given spatial configuration, of a subsystem that potentially better captures wide movement within the whole conurbation. Having the conurbation degree of comprehension – a proposed syntactic indicator – as a control variable, each spatial unity is analyzed according to its global and local integration, connectivity, topological distance, linearity and angular incidence in relation to connected spaces. Preliminary tests make emerge from configuration a large scale subsystem which reveals space hierarchy in whole conurbation. At the end, necessary corrections and new procedures for model improvement are described.

KEYWORDS: metropolitan planning, urban mobility, urban modeling, space syntax, space structuring

1 INTRODUCTION

In 2006, municipalities included in Brazilian metropolitan areas, concluded their master plans, for federal determination. Particularly, in the Metropolitan Region of Porto Alegre - MRPA, clear regional development guidelines should have been provided by the state government to these cities, since decisions taken in one of them may affect the whole conurbation.

However, without regional guidelines, local plans turned out to be restricted to particular and limited views of the whole metropolitan territory. Regarding to urban mobility, this problem can be detected in the grid layout, when maps of the parts are joined together. Due to the lack of important street connections and hierarchy, relevant continuities were missed. As a result, we have a large scale grid chosen to allow wide movement that, apparently, did not efficiently provide even accessibility to all parts of conurbation, what will certainly affect metropolitan functionality (Ugalde et al, 2009).

Despite difficulties, these plans were elaborated with community participation. Therefore they express a common sense about the city development and the fact that a subsystem of the grid, here called “city main street grid” (CMSG), was pointed out by society (community and planners), make us accept this process as a collective comprehension of space, because it is related to a grid through which a large number of people daily move. CMSG is seen by local citizens as the group of streets, avenues or highways, that allow movement between neighborhoods, sectors and metropolitan cities. It contains the idea of urban expansion too, in the sense that they have in mind the necessity of new areas for occupation, although, for the purpose of this work, only existent streets are being considered. CMSG is also seen by community as a group of streets along which high densities should be allowed by building regulations, so that they become object of investment in terms of paving and other utilities.

On one hand hand, it can be argued that urban and metropolitan mobility must be approached as a complex phenomenon. The street grid is a large group of continuous public spaces that allow pedestrian and vehicle movement. City structure is strongly influenced by a bottom-up process which is the result of spatial configuration: relations between each element with all the others in the system, from which other subsystems

emerge. Thus, configuration proprieties make some streets different from others and they emerge as being potentially better to form pathways and routes between parts of the city which are distant. Therefore, the way the whole system is structured also influences the more or the less capacity of being understood. On the other hand, CMSG can be seen as a top-down process, considering the way it is selected, in most cases, with insufficient quantitative data, diagnostics and simulation, important variables not taken into consideration, mostly subjective aspects or particular visions of the whole.

For dealing with part/whole problems, Brazilian metropolitan planning must take into account spatial approaches of movement phenomenon before using traditional transportation models. Space Syntax provides this discussion with a theory and a methodology that takes account of a significant part of complexity involved in accessibility. The spatial configuration of urban systems is revealed or evidenced by axial maps where properties which influence pedestrian and vehicle movement in built environments can be measured, generate elements for analysis and to decision-making support. Clearly, the contents that communities had in mind when selected CMSG, are closely related to perception/cognition aspects, which will not be object of this preliminary paper, because we are not dealing directly with the necessary theory and methodologies to precisely investigate all factors that influenced the decision process in each municipality.

The present study is part of an ongoing research about the influence of spatial structuring of Brazilian conurbations on metropolitan routes, and specifically aims to verify how the degree of comprehensiveness of this subsystem (main routes) can be measured.

2 CONFIGURATION INTELLIGIBILITY IN LARGE URBAN SYSTEMS

In this section, we try to keep in mind some important concepts and ideas, from different authors, that must be present in our attempt to better understand configuration aspects that influence spatial cognition in large urban systems.

Investigation results (Tlauka and Wilson 1994; Magliano, et al 1995) which indicate less importance of land marks than configurational information for navigation in urban environment, as suggested by Lynch (Lynch 1960), reinforces our option for Space Syntax theory and methodology for the present discussion, since movement routes planning in large systems has a tendency to use paving, color and lightning differentiation as well as landmarks and ornamentation to call pedestrian and conductor's attention for a supposed importance of a certain street.

The syntactic concept related to the comprehension of urban space during navigation is intelligibility. The following transcriptions show clearly the nature of the syntactic concept and measure of intelligibility defined by Hillier.

Since by definition urban space at ground level cannot be seen and experienced all at once, but requires the observer to move around the system building up a picture of it piece by piece, we might suspect that intelligibility has something to do with the way in which a picture of the whole urban system can be built up from its parts, and more specifically, from moving around from one part to another. (Hillier 1996, 65)

The essence of urban form is that it is spatially structured and functionally driven. Between structure and function is the notion of intelligibility, defined as the degree to which what can be seen and experienced locally in the system allows the large-scale system to be learnt without conscious effort. Structure, intelligibility and function permit us to see the town as social process, and the fundamental element in all three is the linear spatial element, or axis. (Hillier 1996, 171)

It is known that as the system grows, intelligibility tends to decrease. Grids of real cities naturally get more deformed, interrupted, sometimes irregular regarding to connectivity and less probability of existing lines linking center to the edge, what affects this learning process.

Hillier (2002) analyzed a group of large cities from different cultures, evaluating, among other tests, the presence and position of long lines in their configurations and concluded that only longer lines maintain intelligibility as a system grows.

The incidence of local centralities, not necessarily related to long lines, takes us to the question that they might be representing a system attempt to recover intelligibility at a local level, since, as it is known, it is more difficult globally achieved. If this is so, although the concept of intelligibility is converted into a mathematical correlation, which measures and certifies if the whole configuration is intelligible or not, the

sense of movement, brought clearly in the first transcription, should lead us to the idea that a dynamic intelligibility could be discussed and proposed.

Read (1997, 36) observed in a group of cities in Holland, that integration core (axial lines with the highest integration values usually clustered closed to the center of the global configuration), representing spaces with tendency to high occupation rates, didn't correspond to all spaces with high activity level and prioritized for regional scale movement in the rest of the configuration. He defined the concept of "supergrid" and identified the pattern of its spaces as being similar to the "highlighted important streets found in any way-finder map" (pp.36.08). He tested some measures that could capture those spaces, and, among others like connectivity and local integration, found that the measure of choice, once choice map have a tendency to highlight continuities in the axial map, could be a good model. In fact, he succeeded modeling supergrid by calculating new integration values considering the values of the connected spaces at radius 1, 2 or 3. The obtained output - integration gradient map – when selected for 10 and 25 % values - highlighted the supergrid spaces. Read's investigation made us interested in measuring the intelligibility of the integration gradient map, in 10% of the most integrated spaces, reported as having captured supergrid spaces, those better distributed in the whole configuration and containing a great amount of through movement.

This brief reference leads us to the idea that people might be organizing their routes thinking in a higher layer, with the tendency to "forget" short and fragmented spaces, frequently confused and unintelligible in many Brazilian metropolitan areas, highly deformed and interrupted grids, and operating mentally in a higher layer with supergrid spaces. If so, would this subsystem have its own intelligibility, or what definition and model could be used to evaluate the degree of comprehension of a large urban system?

3.THE EMERGENCE OF A COMPREHENSIVE MAIN STREET GRID

Space Syntax model describes spatial configuration through the axial representation and the group of measures conceived to evaluate topological properties and correlate them with social phenomena. Axial lines are the elements able to capture these properties. However, some researchers have improved this tool and obtained better correlations.

The axial representation, and the measures derived from it, has been proven to be successful to study the social and cultural roles of space, particularly for the evaluation of the impact of spatial configuration on pedestrian and vehicular movement patterns, levels of co-presence and co-awareness, which have also proven to be relevant for the analysis of urban sites and buildings, and the evaluation of design proposals. Indeed, many designers of today take all the knowledge and expertise of space syntax community to the drawing board as an important tool for design decision-making. Recent studies, however, have revealed some limitations of the axial representation (Peponis et al, 1997; Turner, 2001; Asami et al, 2003; Dalton, 2001; Thomson, 2003), even though acknowledging its robustness, mostly in its association to the analysis of movement patterns and the probabilistic correlation between configuration and the pattern of encounters.

(Figueiredo & Amorim 2005)

Figueiredo & Amorim (op.cit.) developed the concept of "continuity lines" based in the fact that the construction of axial maps often contains individual interpretation, particularly in representation of curved and sinuous paths. The authors say that common sense often recognizes these paths as a continuous line of movement, despite being formed by a sequence of lines of sight and that the standard axial representation breaks these continuous lines into a set of short sequential axial lines, misrepresenting important inherent global properties of the spatial system. In order to obtain continuity lines, axial lines must be aggregated under criteria. The angle of continuity is the first parameter. Tests for several types of urban grids in Brazil and USA suggest 35° as the maximum angle. When axial maps are gradually aggregated, continuity lines emerge from their grids revealing long curved and sinuous paths, which seem to assume similar position in the configuration as the pre-existing long axial lines. As a result, a clearer hierarchy based on line length become apparent, mainly within organic grids, but also within regular grids. Such effects lead to the investigation of the relationship between metric and topological (configurational) properties, according to the researchers.

We have tested the syntactic measure of choice to see if it would be able to capture CMSG in Esteio/Sapucaia do Sul/São Leopoldo (MRPA) conurbation since the model could be more representative of

a highly deformed grid with low mean integration and where there are few possibilities to go from one neighborhood to another, or from one municipality to another (Ugalde, op. cit.). Let's remember how this measure works: for all pairs of possible origin and destination locations, shortest path routes from one to other are constructed. Whenever a node is passed through on a path from origin to destination, its choice value is incremented. Thus, frequently used nodes take high values, while those that fall on fewer paths take low values. Many researchers have noted choice seems to be a more intuitive model for movement than the traditional space syntax measure of integration, according to Turner (2007).

In the occasion, with no axial line aggregation, results were not considered satisfactory and were below the ones obtained with integration gradient model (Read, op.cit.). Only 39 out 276 CMSG spaces were captured by the choice measure, in São Leopoldo, for example, and the intelligibility of the 78 choice top value axial lines was 0,2051 (r^2). Aggregated lines model is now applied and results are presented in next section.

Turner (op.cit.) suggests that, according to cognitive scientists, the angle of turn in urban navigation has to be considered in movement analysis. It has been proved that people tend to minimise angle towards their destination. He proposes the axial line segmentation in order to evaluate configurational properties weighted by metric and topological distances associated to angular turns. In this sense, he improved choice measure and formulated what he called "angular betweenness" where journeys with the lowest angular cost for each possible origin and destination pair of segments are computed.

Van Nes (2009) demonstrated how a main route network through and between urban areas can be calculated in DEPTHMAP, software developed by Turner, combining angular choice (geometric distance) with topological distance. Applying different radii, it was possible to identify and distinguish more traditional grids from the modern ones. The researcher also wanted to know if Randstad (metropolitan region of Amsterdam) spatially functions as one metropolis, but verified that although Amsterdam is located in the edge of the metropolitan configuration, it still concentrates integration, under a topological analysis, as well the highways linking satellite cities.

4 PROCEDURES FOR THE IDENTIFICATION OF A METROPOLITAN MAIN STREET GRID

Conurbation reaches 14 municipalities of the whole Metropolitan Region of Porto Alegre - MRPA, in Brazil. Its population reaches more than 3 million people. It concentrates 36.40 % and more than 40 % of the Value Added, in only 3.4% of the territory of Rio Grande do Sul, the southernmost state of Brazil. It is located by Lake Guaíba and is cut by Sinos and Gravataí rivers, and other important creeks, which also influence its territorial occupation, as shown in Figure 1.

Based on the criterion of conurbation, minimization of "edge effect" (Penn et al. 1998, 61), and non existence of significant altitude differences, a subsystem of Greater Porto Alegre (MRPA), corresponding to three satellite towns, was selected for the present study case: Esteio and Sapucaia do Sul. The edges of the subsystem are real: Sinos River (west), Sapucaia Creek (south) and the limit of dense occupation of this conurbation sector, to the east and north. Due to the extension limits of the present article, São Leopoldo was excluded, but it still maintains satisfactory conditions regarding to edge effect though, because the city of São Leopoldo is somehow separated from Sapucaia do Sul and Esteio.

In the global configuration, we can observe which axial lines belong to Esteio (white), and Sapucaia do Sul (light grey). In dark grey each CMSG is highlighted forming the large scaled grid. We can clearly see the fusion of grids between Esteio and Sapucaia do Sul and main street grid conflicts inside circles (Figure 2).

The long and thick line in the left side of the system is, in fact, a group of axial lines corresponding to the highway BR-116, which plays an important role in the structuring of not only the sectors object of the present study but also the whole MRPA (Ugalde 2002; Ugalde and Rigatti 2007).

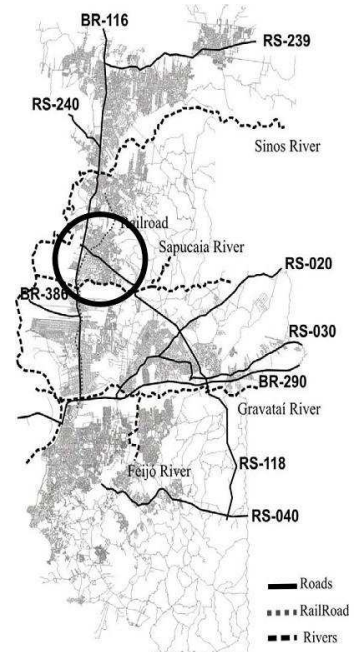


Figure 1 MRPA and conurbation sector

Black circles were used to point out some problems which denote how the way space is being structured, and, as a consequence, how its accessibility pattern is affecting the global understanding of the system. The axial map allows some comments about it, as below.

The linearity, connectivity, length and relative position of BR-116 resulted in high integration values to this group of axial lines and consequently a considerable traffic flow. Nowadays, although well connected, along its parallel lanes, it turned out to be a true obstacle which is also affecting comprehension of the west side of the “wall”. This becomes evident when Sapucaia do Sul does not prioritize any space to conduct local traffic flow to the rest of the system, as it was done in the east side of the highway. Although occupation of that part of the city is limited for being close to Sinos River, we observe that Esteio, under the same circumstances, in fact made that selection.

The southern border of Esteio happens to present no conditions to configure a set of axial lines to better integrate this sector to the rest of configuration. On the other hand, it seems that the staff and citizens who participated in Esteio Master Plan didn't have in mind the necessity to solve large scale movement problems in the east part of configuration, not only expressed by the lack of necessary alignments in east-west direction but also for not recognizing two of the few long lines coming from Sapucaia do Sul and interrupted in Esteio territory. By the way, the fact that RS-118, another highway well connected, but not so strongly demanded as BR-116, is relatively closed to the important Luis Pasteur Avenue, the formal city boundary, seems to cause such a confusion in the sense of territoriality of both communities. It can be verified by the lack of connections in a considerable part of the formal limit between the two cities.

The way low-income population informally settled in the north east part of Sapucaia do Sul caused difficulties for the community in selecting spaces to maintain linearity in CMSG. However, what calls our attention is Valdemiro Machado Avenue not being selected. It is, in fact, a long line with high local integration value and also has global importance, besides being close to São Leopoldo expansion areas.

The investigation consists in testing choice measure (5% of highest values) in the aggregated lines map (B) - continuity lines model - and compare results to the ones obtained with the conventional axial map (A) as showed in figures 3, 4 and 5.

Before processing axial maps with MINDWALK, software developed in 2002 by Lucas Figueiredo de Medeiros, from Federal University of Pernambuco/Brazil, they must be revised in order to avoid “trivial rings”, resulted from unprecise axial lines crossings, which don't let lines to be aggregated in wider angles. According to Figueiredo & Amorim (op.cit.), 35° was the angle adopted to join axial lines in continuity lines, due to consistent correlations obtained with movement flows in previous investigations.

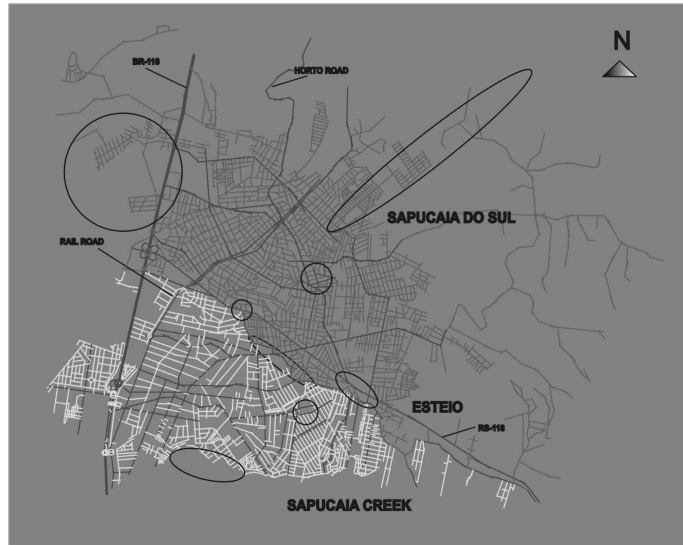


Figure 2 Conurbation sector and main street conflicts



Figure 3 Choice model processed in axial lines map (A) and continuity lines map (B) - Esteio



Figure 4 Choice model processed in axial lines map (A) and continuity lines map (B) – Sapucaia do Sul

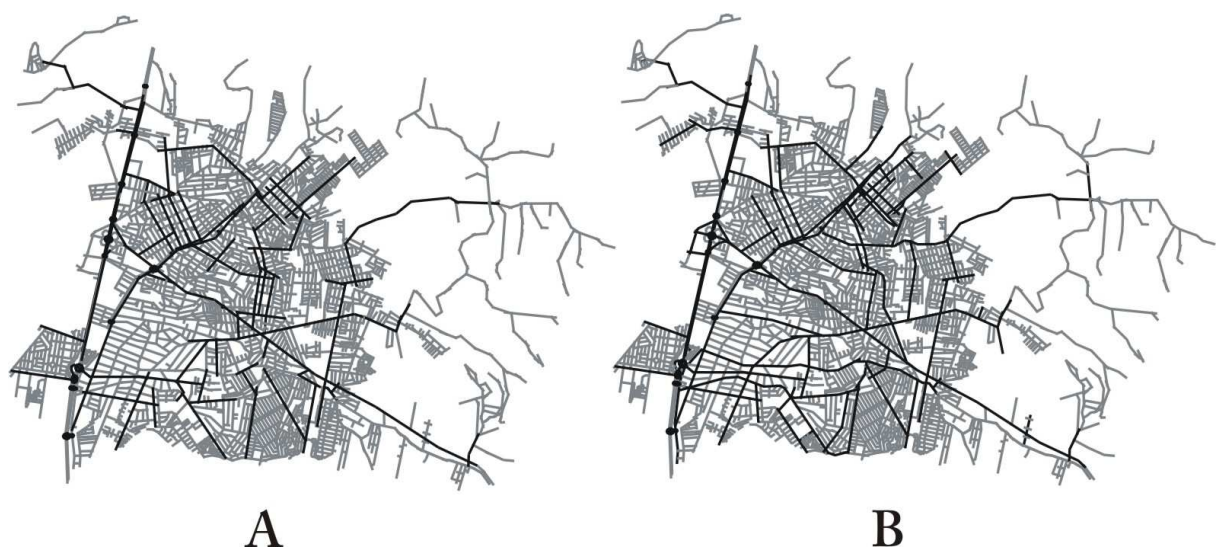


Figure 5 Choice model processed in axial lines map (A) and continuity lines map (B) – Conurbation

A considerable number of axial lines were highlighted in the continuity lines map when choice algorithm was processed. Most of them in fact correspond to CMSG spaces of Esteio and Sapucaia do Sul, what turned choice measure out to be better representative of CMSG than other measures tested before (Ugalde et al, 2009). However a few spaces were still left out, what suggests a field investigation to check real movement and local factors. Since the choice configuration is similar do CMSG, it was detached from the global configuration and had its global integration measured to be correlated with its connectivity. Here, we take Hillier's concept and measure of intelligibility because it should reflect the "the degree to which what can be seen and experienced locally in the system allows the large-scale system to be learnt without conscious effort" (Hillier, op.cit.). We propose to call this "higher scale intelligibility" *comprehensiveness*, as a result of this procedure. If correlation is consistent ($r^2 > 0,60$) it becomes possible to think towards the argument that one is moving through a comprehensive large scale grid, emerged from a low intelligibility total grid. That is the case examined so far. Esteio, as a whole, has low intelligibility ($r^2 = 0,1207$) according to Table 1, but its CMSG has a much better comprehensiveness ($r^2 = 0,6255$). The same did not happen in Sapucaia do Sul, where comprehensiveness didn't surpass 0,4132. There are some possible explanations for that. First of all we can say that Sapucaia do Sul CMSG comprehensiveness depends on Esteio large scale grid because conurbation comprehensiveness has a higher index (0,6023). While Esteio CMSG, although deformed, tends to orthogonality, in Sapucaia do Sul the subsystem tends to assume a radial morphology with indefinite rings though, specially affected by interruptions caused by the rail road, which is somewhat eccentric in Esteio. Another reason by which central main street rings cannot be completed in Sapucaia do Sul is the irregular occupation of the northeast part of its territory with low income subdivisions. Axial fragmentation and depth increment make that part of configuration unstructured. At least three streets become options to compose the larger ring.

In conurbation continuity lines map processed by choice algorithm, we can observe some CMSG spaces highlighted in municipal systems which are not present any more. Conurbation Main Street Grid (CoMSG) might be representing a higher scale movement grid. This process seems to be captured by choice measure. Conurbation colored choice map show clearly the importance of the RS-118 as a main route. Being central and well connected, its role is superior to the one played by BR-116 (federal road) in this sector of RMPA, which happens to be more peripheral to the examined system but still important because of its parallel lanes which connect local streets. Another set of axial lines which emerges, after line aggregation process, is Presidente Vargas Avenue, in Esteio, named Mauá Avenue in Sapucaia do Sul. For being constructed along the rail road, they have wide inflection angles and for going through both municipalities a, what makes it work as a real metropolitan pathway.

Table 1 : Syntactic Measurements in a sector of MRPA			
Axial lines (AL)/Aggregated Axial Lines (AAL)			
MEASURES / TERRITORY	ESTEIO	SAPUCAIA DO SUL	CONURBATION
AXIAL LINES			
TOTAL SYSTEM - AL	908	1426	2334
TOTAL SYSTEM -AAL	753	1265	2018
GLOBAL INTEGRATION MEAN			
GLOBAL INTEGRATION MEAN -AL	0,7801	0,8723	0,8347
GLOBAL INTEGRATION MEAN -AAL	1,1336	1,2882	1,3025
SUBSYSTEM COMPREHENSIVENESS (r^2)			
CHOICE - AL	0,3127	0,3833	0,2252
CHOICE - ALL	0,6255	0,4132	0,6023
CMSG* - AL	0,2563	0,3337	0,1794
CMSG* - ALL	0,2446	0,3568	0,3052
TOTAL SYSTEM INTELLIGIBILITY. (r^2) - AL			
TOTAL SYSTEM INTELLIGIBILITY. (r^2) - AL	0,0942	0,2135	0,1030
TOTAL SYSTEM INTELLIGIBILITY. (r^2) - ALL			
TOTAL SYSTEM INTELLIGIBILITY. (r^2) - ALL	0,1207	0,1853	0,1416
*Connectivity limited to subsystem axial lines			

5 EVALUATION AND NEXT STEPS

Intelligibility have the tendency to decrease as real urban systems grow. Despite being large and less intelligible, people keep moving within them or feel encouraged to move through long distances aided by technologies as motor vehicles, for example. If they do so, conurbation grids, despite being highly deformed and interrupted, as in Brazilian metropolis, provides some configurational information which allow them to navigate between distant places. At this moment, they ought to pay attention to another space level. This information, we argue, is in a higher scale grid emerged from the whole system and should be measured by its comprehensiveness. Highly comprehensive large scale grids achieves global integration itself well correlated with its own connectivity. It means that other spaces or axial lines from the same or similar hierarchy cross it with some regularity. In this sense, continuity lines model is fundamental for this approach because connectivity of long pathways composed by many deflected shorter axial lines would be affected as most of it would be restricted to the extremities (2). Being aggregated, lines, besides better representing urban routes in large systems, connect to a major number of transversal spaces bringing better correlations with line integration value and, consequently, better comprehensiveness. In the tested system, results were in favor of this argumentation.

Specially in Esteio and in conurbation, choice or betweenness happened to be an appropriate measure. For having it captured most of the CMSG and CoMSG spaces, the test suggests that local planners conceived reasonable main street grids. But we should ask why such differences between choice and CMSG comprehensiveness according to Table 1. The explanation can be in those not captured spaces. Planners elected some routes formed by axial lines connected in closed angles, sharper than 35°. Discussion from now on must be about those spaces like João Pereira de Vargas and Rubem Berta avenues, in Sapucaia do Sul, built to supposed high traffic flows, but syntactically not indicated for such a demand.

Next steps on the present research will be testing the influence of metric distances on selection of routes, aided by Turner DEPTHMAP. After a deeper discussion of the results, it is intended to have the Greater Porto Alegre investigated as a whole, when it will be possible to register and analyze the emergence of another group of lines in the space and scale hierarchy.

The present study describes an investigation motivated by the perception that, in Brazilian context, public investment decisions for the territory are taken with low conscience of space as a real and concrete variable as well as of their effects on every day urban life significantly expressed by movement. Global or regional planning has been rejected by localistic points of view. Esteio and Sapucaia do Sul, neighbor cities, actually a whole sector in Metropolitan Region of Porto Alegre, elaborated masterplans restricted to their boundaries without exchange of ideas and knowledge about global consequences. Not being aware of the complexity involved in this issue, metropolitan planning agents try to approach it through a top-down process about which our work intend to discuss.

REFERENCES

- [1] Figueiredo, L. and Amorim, L., "Continuity Lines in the Axial System", Paper presented at "5th international Space Syntax Symposium", June 13-17, In: Delft, Holland, (2005).
- [2] Hillier, B., "The Space is the Machine", Cambridge: University Press, (1996).
- [3] Hillier, B., "A Theory of the City as Object: Or, How Spatial Laws Mediate the Social Construction of Urban Space", *Urban Design International*, Vol. 7, (2002), pp. 153-179.
- [4] Lynch, K., "The Image of the City", Cambridge: MIT Press, (1960).
- [5] Magliano, J. and Cohen, R., "The Impact of a Wayfinder's Goal on Learning a New Environment: Different Types of Spatial Knowledge as Goals", *Journal of Environmental Psychology*, Vol. 15, (1995), pp. 65-75.
- [6] Penn, A., Hillier, B., Banister, D., and Xu, J., "Configurational modelling of urban movement networks", *Environment and Planning B: Planning and Design*, Vol. 25, (1998), pp. 59-84.
- [7] Read, S., "Space Syntax and the Dutch City: the Supergrid", Paper presented at "1st international Space Syntax Symposium", April 16-18, In: London, England, (1997).
- [8] Tlauka, M. and Wilson, P.N., "The effect of landmarks on route-learning in a computer-simulated environment", *Journal of Environmental Psychology*, Vol. 14, (1994), pp. 305-313.
- [9] Turner, A. "From axial to road-centre lines: a new representation for space syntax and a new model of

-
- route choice for transport network analysis". *Environment and Planning B: Planning and Design*, 34 (3). (2007) pp. 539-555. ISSN 03082164.
- [10] Ugalde, C.M. "Parcelamento do Solo na Região Metropolitana de Porto Alegre; Efeitos das Decisões Locais no Espaço Urbano Regional." Porto Alegre: Universidade Federal do Rio Grande do Sul, MSc Thesis, (2002).
- [11] Ugalde, C.M. and Rigatti, D., "Ring roads in Greater Porto Alegre – would it be an effective solution?" Paper presented at "6th Space Syntax Symposium", June 12-15, In: Istanbul, Turkey, (2007).
- [12] Ugalde, C.M, Rigatti, D., Zampieri, F. and Braga, A., "Intelligibility in large spatial systems – the case of Porto Alegre Metropolitan Region" Paper presented at "7th Space Syntax Symposium", June 12-15, In: Stockholm, Sweden, (2009).
- [13] Van Nes, A., "Analyzing larger metropolitan areas – on identification criteria for middle scale networks" Paper presented at "7th Space Syntax Symposium", June 12-15, In: Stockholm, Sweden, (2009).
