Transport Mobility at the University of Brasilia, Brazil

Ref 008

Ana Paula Barros
UnB, Department of Engineering, Brasilia, Brazil
anapaulabgb@yahoo.com.br

Paulo Cesar Silva
UnB, Department of Engineering, Brasilia, Brazil
pcmsilva@unb.br

Frederico Holanda
UnB, Department of Architecture, Brasília, Brazil
fredholanda44@gmail.com

Valério Medeiros
UnB, Department of Architecture, Brasília, Brazil
vaugusto@digi.com.br

José Augusto Fortes
UnB, Department of Engineering, Brasilia, Brazil
afortes@unb.br

Keywords
spatial configuration; urban morphology; urban growth; urban space

Abstract
This paper explores urban mobility at the University of Brasília main campus, in Brasília – Federal District, Brazil, aiming to compare performances between two models: (1) configurational, based on the Theory of the Social Logic of Space, by means of axial and segment maps, and (2) SATURN – Simulation and Assignment of Traffic to Urban Road Networks – a traditional model used in transport studies. Both techniques are hereby applied to forecast vehicular flows (cars and buses) in accordance with their specific parameters, intending to assess the validity of the tools faced with the real flow obtained for the area. Methodological procedures considered the analysis of the campus grid network according to both configurational and transport strategies. The SATURN simulation was considered in its macroscopic level (the whole network is investigated, while details such as number and length of lanes are disregarded) in order to allow for a proper comparison with the configurational model. Space Syntax, on the other hand, required the linear representation map to be drawn including the surroundings of the campus at different metric and topological radii, so as to avoid border effect. Finally, integration values from space syntax axial and segment maps and predicted counting from the transport model (traffic assignment features) were then correlated with real vehicular counting. Results have demonstrated that the configurational model is useful in identifying general trends for concentrations of flows (for both local and global radii), especially supporting simulations of future projects for new roads to be added to the present day local urban grid. The high correlation levels identified between space syntax and real counting confirmed the technique is a powerful tool to aid urban and planning design. On the other hand, SATURN findings were more precise at a local scale, especially on account of output values being in number of vehicles, allowing proper actions concerning traffic congestion, the proposal of new routes for cars or buses, the creation of binary systems, etc. Therefore, models are to be used in a complementary way, where results are more refined when investigated under both approaches. Findings have demonstrated the necessity of a joint use of configurational and transport tools for urban planning,

what may lead to a sustainable mobility solution, based on the investigation of the city's relations between form and space. It is supported by the understanding that sustainable projects demand the pursuit for better conditions of: mobility – ease of displacement of people and goods within the urban space; and (2) accessibility – degree of ease of access in a given network.

1. Premises

This article seeks to discuss how the road network structure in urban fractions (road set design/layout), understood in their relational character, that is, of interdependence amid diverse component parts, is able to interfere in matters of circulation (the action of circulating) and accessibility (capability of reaching a certain place – cf. Sathisan and Srinivasan 1998).

For that purpose, it proposes a comparative investigation between traffic simulation models, to name – (a) conventional, with the use of the SATURN application (Barros 2006); and (b) configurational, according to the Theory of the Social Logic of Space or Space Syntax (Hillier and Hanson 1984; Hillier 1996) – produced for project "Plano de Circulação do Campus Universitário Darcy Ribeiro da Universidade de Brasília/Circulation Plan for Darcy Ribeiro University Campus at the University of Brasilia" (Brasília, Brazil), a joint effort involving the Federal District Traffic Department – DETRAN/DF and several university organs, including the Office of the Chancellor, the Oscar Niemeyer Planning Center – CEPLAN, and the Post-Graduation Program in Transport.

The study proceeded from some of the initiatives developed for the project, and it is motivated by the observation of how modes of articulation throughout the city restrict or foster movement according to the road network design, producing significant implications for the urban mobility. Therefore, it is assumed that urban configuration is an aspect of great interference in the definition of flow in the city, as investigated by Holanda (2002), Barros (2006) and Medeiros (2006).

1.1. A Different View for Traffic Issues

Investigations on flow are useful for understanding urban dynamics and the several variables which fall upon movement in space relations. They allow for the exploration of new tools which may become substantial aids in intervention projects, enabling the simulation and visualization of future scenarios, what tends to convert into works of more refined results.

In this context, the city – and its fractions – may be understood as a system of relations composed of full (buildings, blocks, etc.) and empty (roads, sidewalks, plazas, etc.) spaces, in which all of the component parts are interrelated and interdependent, in a way in which any alterations in one part will implicate alterations on the whole, to different degrees.

This view assumes that the circulation in the urban space depends directly on arrangement manners between the elements (configuration), in a way in which distinct arrangements correspond to different frames of movement (configurational view). Here, space is comprehended according to the capability the constructed form has in conditioning circulation relations.

It occurs that such approach is not recurrent in traffic engineering discussions. In these, the line of research utilized observes traffic based on factors such as the amount of vehicles, traffic lane width, traffic zones, signal timing – among others, here denominated traditional or conventional view.

Thus, there are two specific strategies, established according to specific theoretical, methodological and conceptual apparatuses.

In order to confront the results from both views – configurational and traditional – the present research explores two of the techniques, so as to investigate the respective ranges and applicabilites.

Among the existing utilized tools, those adopted include: (a) the modes of transport, based on an extensive number of data such as: the area's socio-economic characteristics, number of trips made, mode of transport chosen, motives for trips, etc.; and (b) configurational models, those

which study the configuration of space in towns – concerning the town's spatial form – and its topological relations – relations which show how the parts interact among themselves.

In conventional transport models, the Four Step Model is most recurrent, and the traffic assignment or trip allocation consists in its 4th stage. This, in turn, deals with the method used for the choice of routes in trips made from one traffic zone to another. It consists in an extremely important stage for a good understanding of the utilization of the town's road structure, allowing for the generation of interventions in the structure's conditions so as to avoid certain derangements, especially in what concerns urban traffic flow.

Despite it being amongst the most utilized of tools, in regards to trip assignments it is known that:

a) conventional assignment tools require a great amount of data, besides essentially considering the geometric relations of the space, even though their output results are presented in the form of flow in units of vehicles;
b) under a different perspective, configurational models require a little more than maps, besides the fact that they incorporate the topological relations of the space, presenting a more prompt result of good graphic apprehension, although their output results are in a flow potential. In other words, these models analyze relations of road network accessibility, what is associated with the understanding of what topology is.
c) on the other hand, it must be registered that models of the first type estimate assignments, on a road network whose elements have defined capacities, of trips that exist de facto (or which are forecast), whereas models of the second type estimate the potential that, proportionally, each road has of accommodating a non-quantified volume of trips.
d) Therefore, the tools are compared in order to extract viable joint use possibilities for transport planning, with the primordial purpose of assessing the Space Syntax potential as a tool for estimating routes, what will collaborate with traffic engineering more adequately, similarly to what occurs with SATURN.

In addition to that, the research is justified in three perspectives:

a) Instrumental: previous studies have been made involving configurational models and transport – Maha (1997) – and models of traffic assignment – Alves (1999), as well as Cybis et al. (1996), who conducted similar researches to the present study, though they did not obtain a satisfactory level of analysis and conclusion;
b) Theoretical: the incorporation of topological relations analyzed by Space Syntax into the studies carried out on flow assignment analyses, complementing traffic assignment models, points to a productive interaction between areas of knowledge;
c) Practical: there is a possibility the instrumental may be adopted in transport planning projects as presented in recent studies (Barros et. al. 2005; Barros 2006), which approach the tool application in the definition of road hierarchy parameters.

1.2. The Project for the University of Brasilia

The ever-growing amount of vehicles incorporated into urban traffic implicates the need for more and more planning and organization of road space. In that context, the city of Brasilia (Federal District/Brazil) stands out for its demographic growth and a significant increase in the vehicle fleet. Since such populational growth was not predicted at the time of its construction, several problems have occurred in the pedestrian and vehicle circulation, such as congestions and lack of safety, all of which are reflected at the University of Brasilia Campus – UnB.

Over the last few years the city of Brasilia has been experiencing a significant increase in its vehicular fleet. Data from DETRAN indicates that in 2008 a total of 1.000,000 vehicles was reckoned for a population of approximately 2.500,000 inhabitants. The urban consequences are diverse and affect all fractions of the city.

As an example, a 1994 survey undertaken by the University of Brasilia Urban Transport Masters Program indicated a population of 11.000 university goers at Darcy Ribeiro Campus: today, that

number has risen to 30.000 individuals. It is known that, despite the ascribed growth, the road and traffic systems have not been adjusted for that movement nor have investments kept up with it, aggravating the detected disfunctions.

That way, the Postgraduate Program in Transport from the Civil and Environmental Engineering Department, along with CEPLAN, the Campus Administration and DETRAN are working up a study on circulation aspects for the University of Brasilia: the approach hereby presented integrates the strategies developed for the "Plano de Circulação do Campus Universitário Darcy Ribeiro da Universidade de Brasília", initiated in 2008, and which is being developed by professors, researchers and students from the Civil and Environmental Engineering Department at the Technology Faculty and from the Postgraduate Program in Transport, organs pertaining to the institution.

The plan comprehends an all-inclusive action which seeks to establish more adequate guidelines and projects for on-campus circulation, fostering the well-being and safety of those who circulate in and around UnB. It aims to elaborate a diagnosis, analysis and assessment of the diverse functions of transport of the road and pedestrian circulation type, cycling facilities, parking lots, signaling, mobility for the differently-abled, collective urban transport, and later on, the definition of proposals which seek the improvement of dislocations.

For such, the fundaments of Traffic Calming are employed as a conceptual basis. They comprehend specific methods for dealing with urban traffic functions and field research and information surveying techniques.

Traffic Calming, arisen in the 1970s in Germany and Holland, consists of a set of physical and regulation measures to make traffic safer and less aggressive to the environment (Fortes 2008). It is based on three fundamental ideas: (a) the creation of environmental areas outlining roads ("Traffic in Towns"); (b) the end of the traditional separation of road and sidewalk (Woonerf), a project in which there is just one circulation surface, limiting the maximum speed); and (c) prioritization of pedestrian areas.

Additionally, the strategy has gone on to mean a set of measures for solving road issues. Today it is an initiative which aims at reducing the average road speed and fosters the traffic of pedestrians, cycling, public transportation and urban renewal, reducing environmental impacts caused by traffic.

Many are the actions for the reduction of vehicle speed and the creation of an environment which induces to a prudent way of driving. In areas with considerably intense traffic and with the transit of buses, as is the case of the area analyzed by the UnB Campus Circulation Plan study, the main Traffic Calming methods and techniques are:

a) vertical deflections – speed bumps, speed humps, speed cushions, speed tables and rumble strips;
b) horizontal deflections – chokers, chicanes, lane narrowing, roundabouts and turning radius reduction;
c) traffic management – closing of streets, entrances and gateways, shared spaces; and
d) support measures – forestation/vegetation, optical width, alignment strips, lighting, street furniture and change of paving.

Based on such concepts, and in conformity with the actions developed for the UnB Circulation Plan, roads have been assessed according to both the conventional and configurational view for the present article, what allows for a first subsidy for the area in focus. The main purpose comprehended the contribution of aspects understood as useful for the improvement of circulation in the Campus (here approached exclusively in the vehicular scope), in such wise as to promote better flow and safety for users, as well as to reduce vehicle pollution and improvement of quality of life on Campus.

2. Procedures: on Tools

Keeping in mind the apparent dialog between Space Syntax (or the Theory of the Social Logic of Space) and transport models, for both are based on the existing urban structure and in the relations between diverse parts of town as flow/traffic-generating points, the use of these tools was decided for the research at the University of Brasilia, taking into account the individual and comparative behavior of each.

Moreover, the fact that studies associating syntax and transport developed so far did not reach a satisfactory stage of analysis and conclusion has motivated the execution of the research, what promotes debate and the desire of greater consistency in the arguments that may be developed (Cf. analysis developed by Barros 2006).

2.1. SATURN (Simulation and Assignment of Traffic to Urban Road Networks)

The SATURN application, produced by the Institute for Transport Studies (University of Leeds/England), comprises of two functions which accomplish different objectives: the traffic assignment module – which chooses the network routes to be used – and the simulation module – which models the behavior of road junctions in the system.

SATURN analyzes small networks with a small number of junctions (borough-wise) – Simulation Network – and large networks with a greater number of junctions (city-wise) – Buffer Network. The simulation network is more detailed because it uses junction data such as signal timing, delays, etc.; the buffer network, on the other hand, does not require many details due to the fact it is a larger network, what would be impracticable considering the amount of time to be spent on the modeling.

According to Van Vliet (2004), SATURN is an essentially macroscopic model, but it may, in some cases, be mesoscopic. In the case of this work, the first model is used due to it being equivalent to Space Syntax characteristics. Moreover, the application, as any other traffic assignment program, is based on the shortest route (what may be rendered as time), what allows for a clear association with the tools offered by configurational models.

See Barros et al. (2007) for details concerning the process of building models in SATURN in its five stages: (a) conception of the model, (b) data collecting and codifying, (c) calibration, (d) validation and (e) modeling.

2.2. Space Syntax

The Syntax is a theoretical and methodological approach, constituted by several techniques which seek to comprehend how the built space, that is, the form of the city or part of it, interferes in movement patterns by means of its topology relations – the study of spatial relations which take into account the articulation between space and roads regardless of form and size – and not just geometry relations – description of component physical elements as to dimension, proportion, scale, etc. (Medeiros 2006).

The approach is based on the Theory of the Social Logic of Space and it comprehends a set of techniques for the configurational analysis of spaces, in which aspects of potential pedestrian and vehicle flow, circulation and movement in cities and buildings are investigated (Hillier and Hanson 1984). Holanda (2001) adds that the approach is not only a set of techniques, but “a theory, which implicates a method, besides a set of techniques”.

Amidst these techniques, the one adopted for this study is that of axiality, indicated for dealing with flow movement potentials in a given urban space. There are four steps the researcher goes through in the generation of axial maps: (a) the linear representation of space (axial map); (b) a computerized analysis of the representation (calculation of the mathematical matrix); (c) correlations (association of the axial map with other data); and, lastly, the simulations (new maps) (cf. Hillier and Hanson 1984 for details).

3. Results

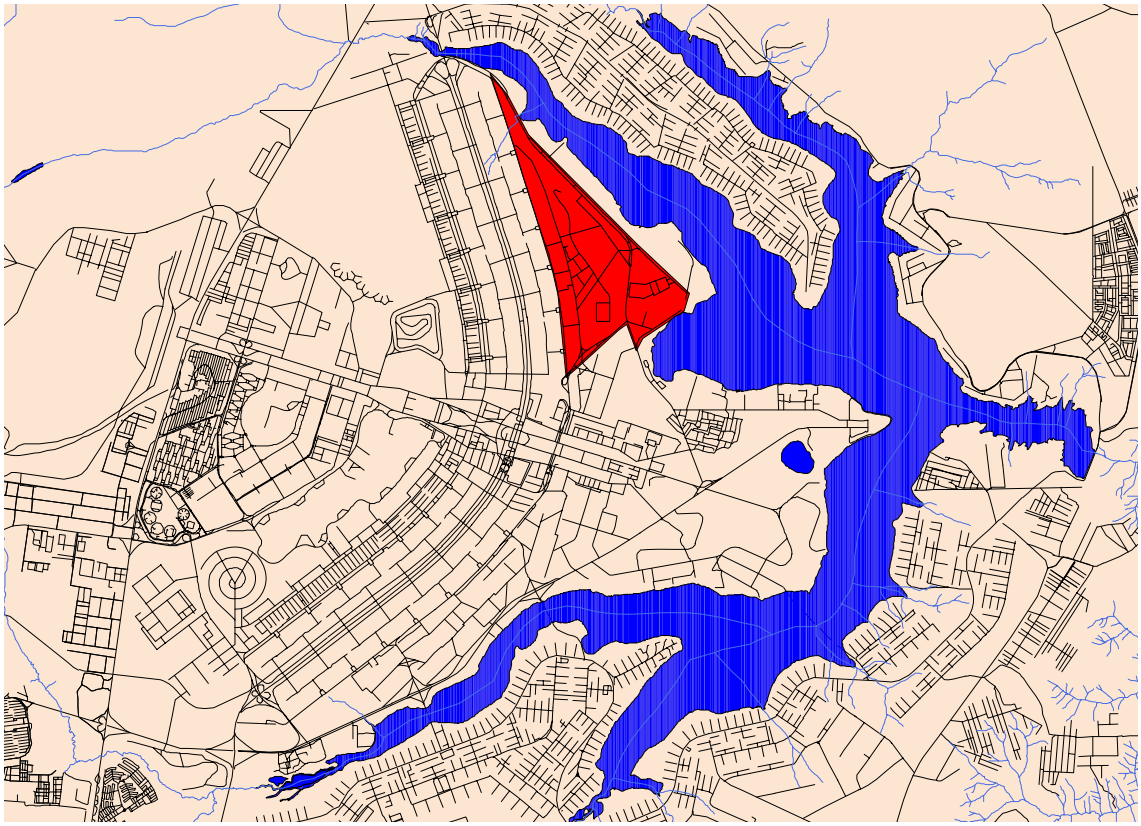

Figure 1
Investigated area (University of Brasília).

The research study area, Darcy Ribeiro Campus at the University of Brasilia, is located in Asa Norte in Brasilia (Figure 1), adjacent to the superblocks in Pilot Plan. The local road network was modeled according to the two strategies chosen for investigation: configurational, by means of an axial map, and traffic assignment, through SATURN software.

Two scope segments have been utilized in the modeling for the analysis of the axial maps, according to Space Syntax: (a) global (full Pilot Plan map – Figure 2), in which the investigation focus is the insertion of the campus network into the supporting city, observing the connections and feeds between roads, and (b) local (campus road network map – Figure 3), whose focal point is the internal circulations within the campus.

The SATURN modeling, in turn, requires greater data input, including the design of the network under study (direction, hierarchy and number of road lanes) and the elaboration of an origin-destination matrix (vehicular flow from one previously established traffic zone to another).

These traffic flows were surveyed on field, by means of counting equipment and on roundabouts through filming, at four different times: the first morning peak – 7:30am to 8:30 am (situation 1); the second morning peak – 11:30am to 12:30pm (situation 2); the first afternoon peak – 1:30pm to 2:30 pm (situation 3); and the second afternoon peak – 6:15pm to 7:15 pm (situation 4). After the data was collected, it was inserted into the four models developed on SATURN for the simulation realization.

Once the simulations were realized, the models were compared in some streets (Figure 4) through correlation of their data – integration indexes on the first model and vehicular flows on the second – on Excel® software.

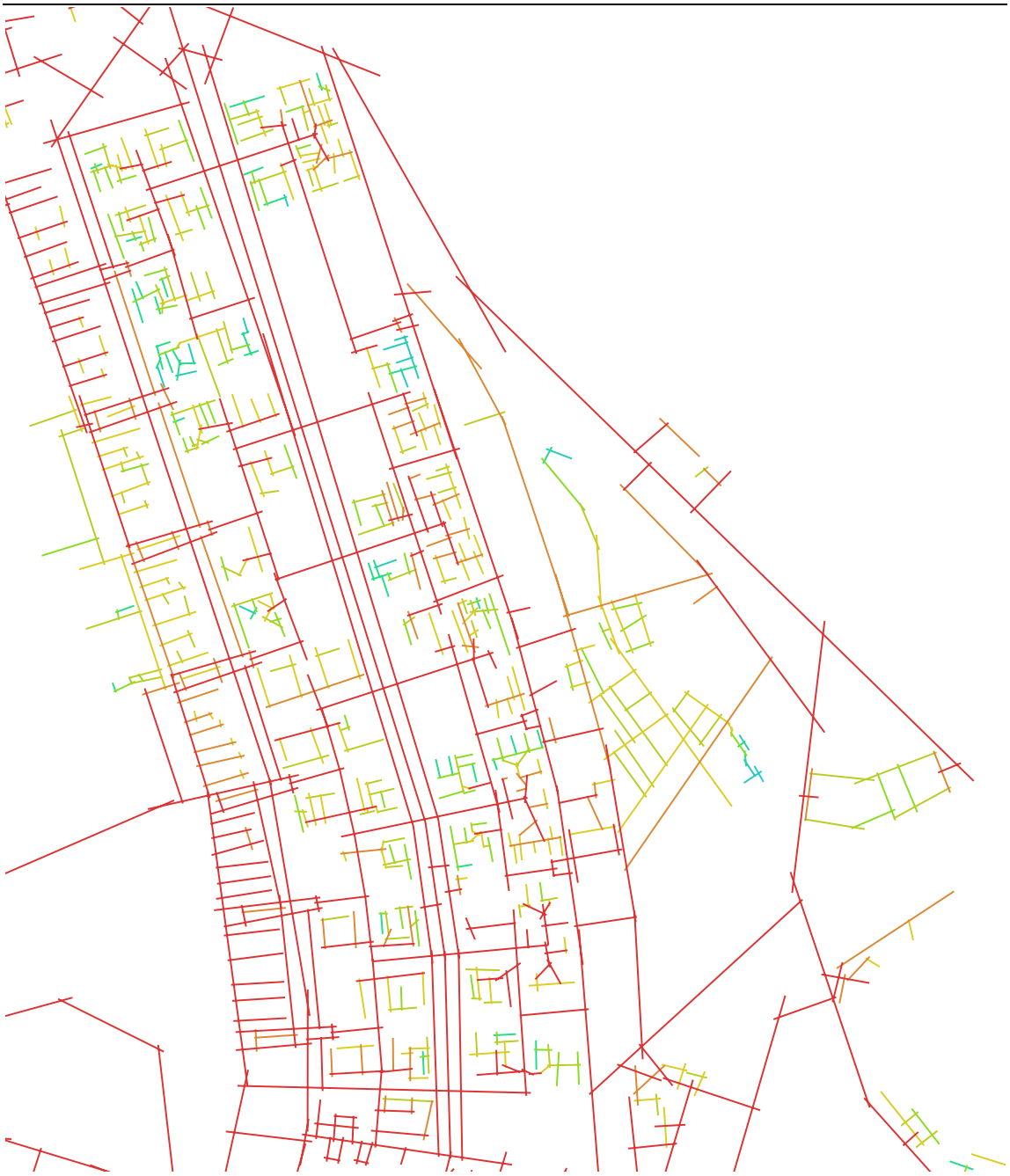

Figure 2
Axial Map (Global).

The result was that for the four situations there are significant similarities between the traffic assignment and the global (peak hours) and local (all scenarios) axial maps.

Herein, the roads which feed UnB campus – L2, L3 and L4 – present considerable flow potential, as per the chromatic indication in red (L4, L2 and a portion of L3) and orange (a portion of L3), corresponding to greater movement. The scenario coincides with the values obtained for the four SATURN models, which vary between 500 to 1000 vehicles per hour (v/h), on average.

Situation 1 (Figure 5) presents intense flow on roads L2 (varying between 688 and 1083 per hour), L3 (varying between 809 and 1102 per hour) and L4 (516 to 574 per hour), coinciding with the axial map (Figure 3), in red and orange, with integration indexes varying between 0.848 and 1.026 (correlation between simulated flow and integration is R^2=0,88 – Table 1). The same thing occurs on internal streets (the polygon around ICC), where were verified the following flows: Reitoria = 551v/h, Biologia = 607v/h, ICC = 528v/h and Direito = 755v/h.

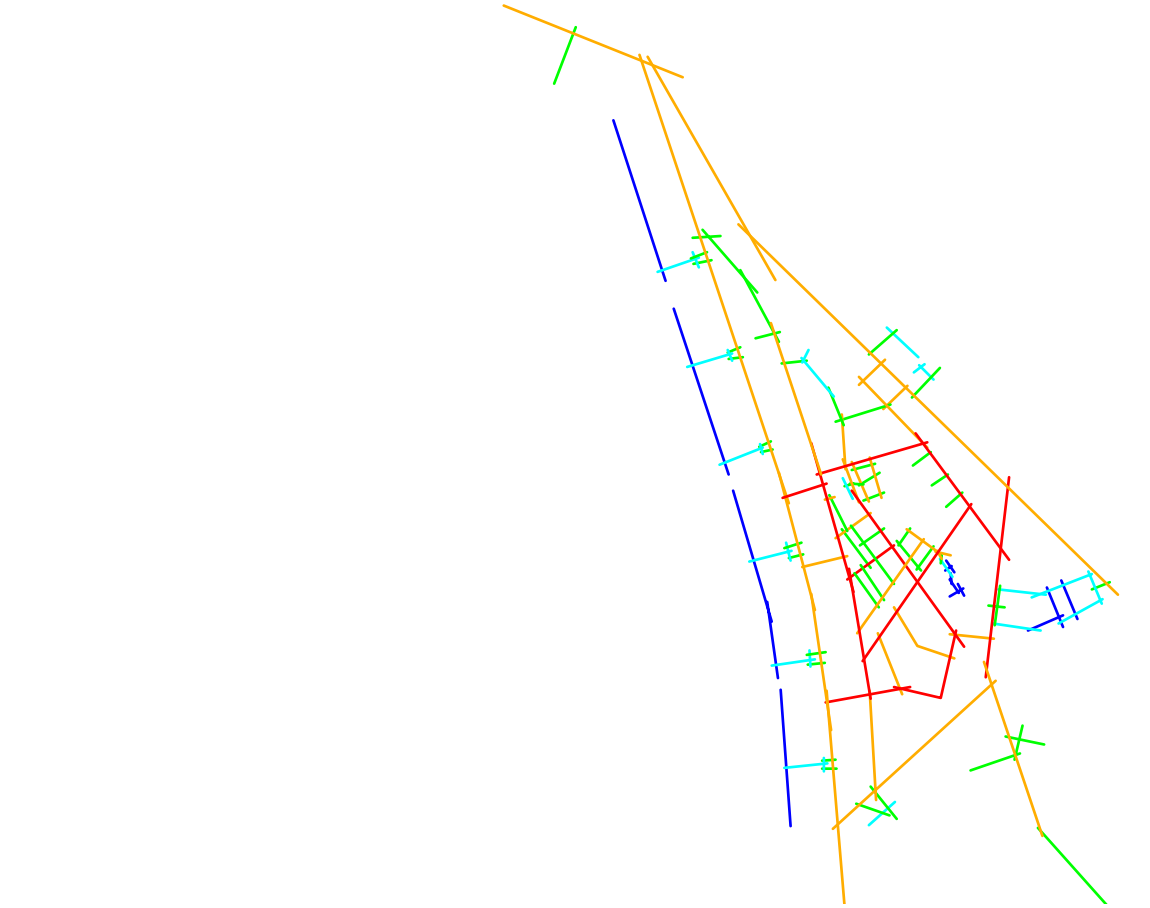

Figure 3
Axial Map (Local).

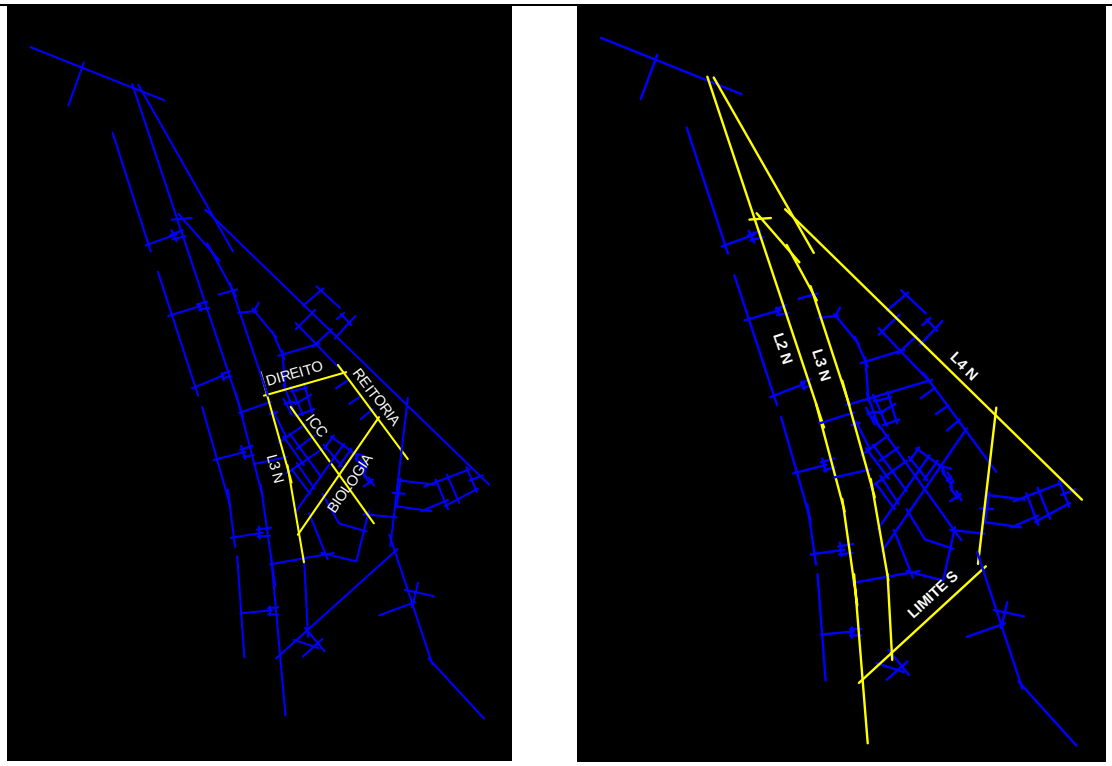

Figure 4
Selected streets for local (left) and global (right) correlations.

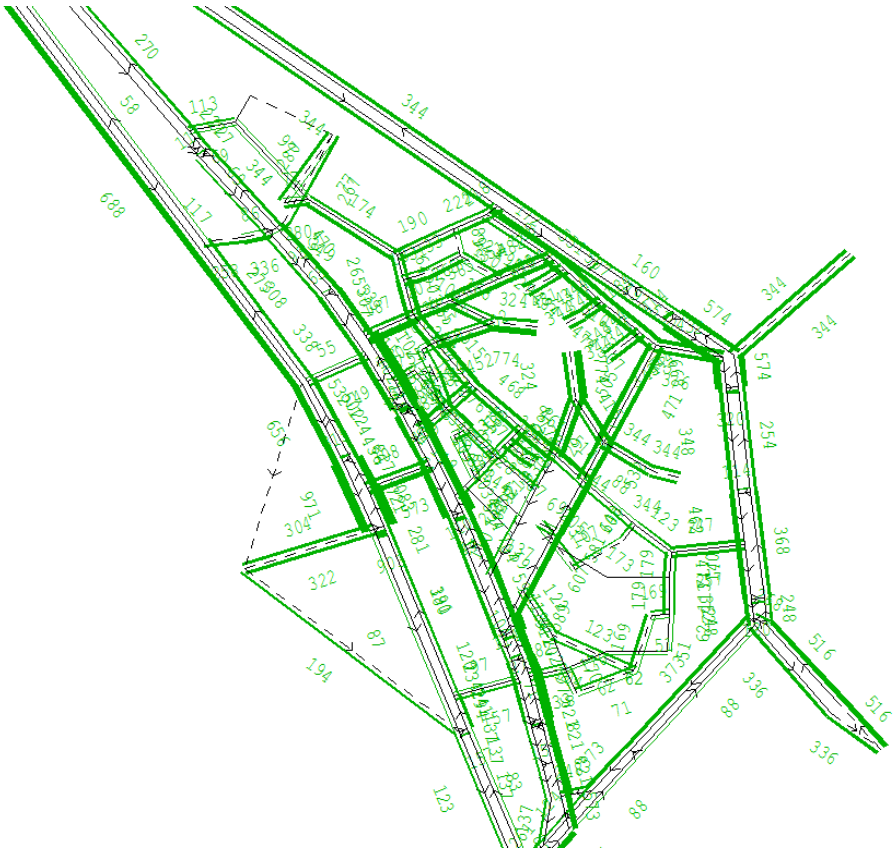

Figure 5
First morning peak (situation 1).

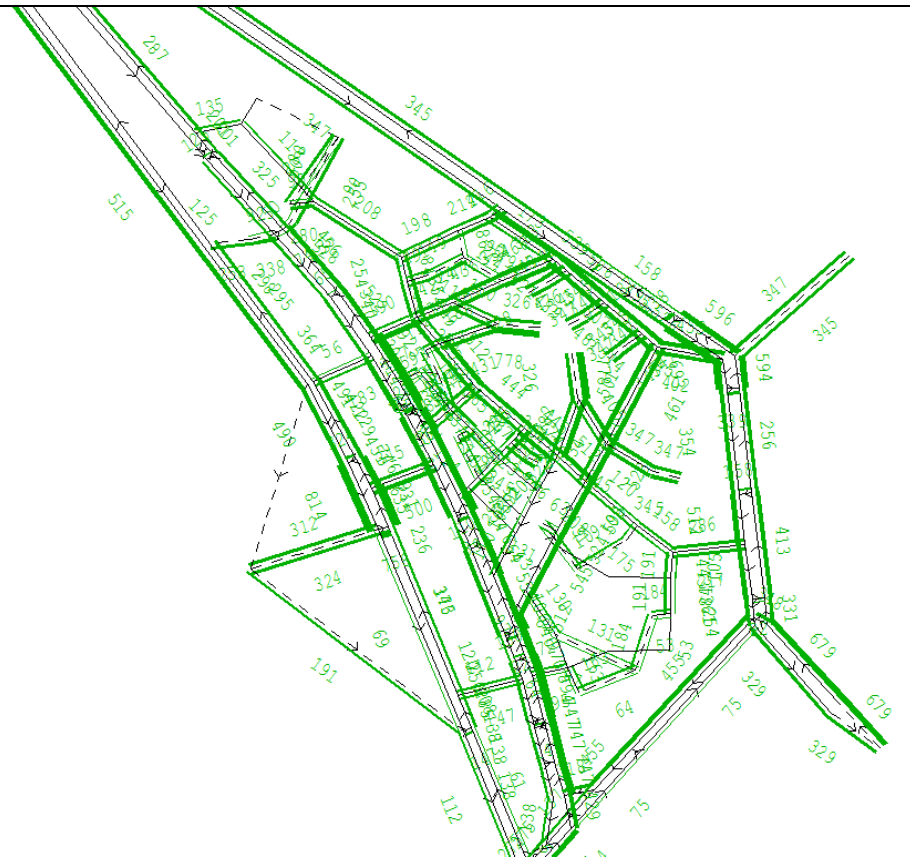

Figure 6
Second morning peak (situation 2).

For situation 2 (Figure 6) the exit flow on L3 (of 451 to 635 vehicles per hour) is smaller than the entrance flow, once many students and campus staff remain in the institution from early morning through evening. On internal streets (Reitoria = 539v/h, Biologia = 593v/h, ICC = 523v/h and Direito = 593v/h), it was identified a reduction in the flows: here R^2 is 0,80, smaller than in the previous scenario. In this case, the axial map result (Figure 2) does not match directly with the data verified on the SATURN network, once it comprises a movement potential on roads in a situation of full use of the road network – having in mind that this representation disregards flow oscillations that occur during the day.

The first afternoon peak, situation 3 (Figure 7), presents a similar result to the previous scenario whether as to the SATURN modeling or to that of the axial map (Figure 2) –R^2=0,82 (Table 1).

Lastly, in situation 4 (Figure 8) where is analyzed the evening peak, the traffic assignment reveals a robust intensity in flow on L2 (of 563 to 951 vehicles per hour) and L3 (596 to 1094 vehicles per hour) – on the latter also due to the fact that there is a private college in the vicinity of UnB which thickens vehicular flow at that time, and it reveals itself as a magnet – and also on the internal streets (Reitoria = 567v/h, Biologia = 454v/h, ICC = 513v/h and Direito = 716v/h). In that case, the axial map (Figure 3) presents very close results to those of SATURN with integration indexes varying between 0.848 and 1.026 (R^2=0,84 – Table 1).

Furthermore, in all four situations it was verified that the internal campus polygon – which incorporates the Central Institute of Science (ICC), the Chancellor's Office (Reitoria) and the Library (Biblioteca) – presents significant vehicular flow constantly varying between 242 and 515 vehicles per hour, which means there are internal congestion problems in all four peak hours.

It is necessary to clarify, however, that the axial map is a road network product and it presents potential flow in a situation of full use of the space. Thus, it means that the map does not incorporate the flow variations occurring throughout the day, what implicated in a correspondence between the axial map and situations approaching the peak, that is, of near-full use of the space.

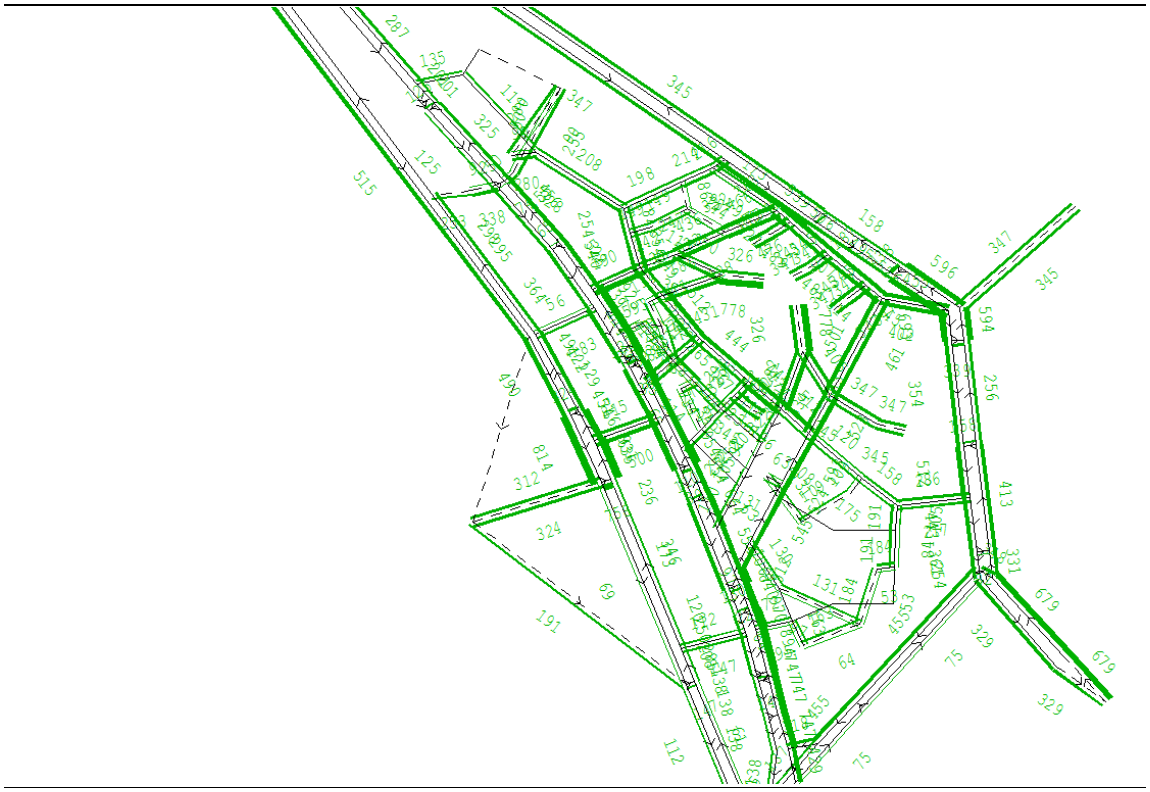

Figure 7
First evening peak (situation 3).

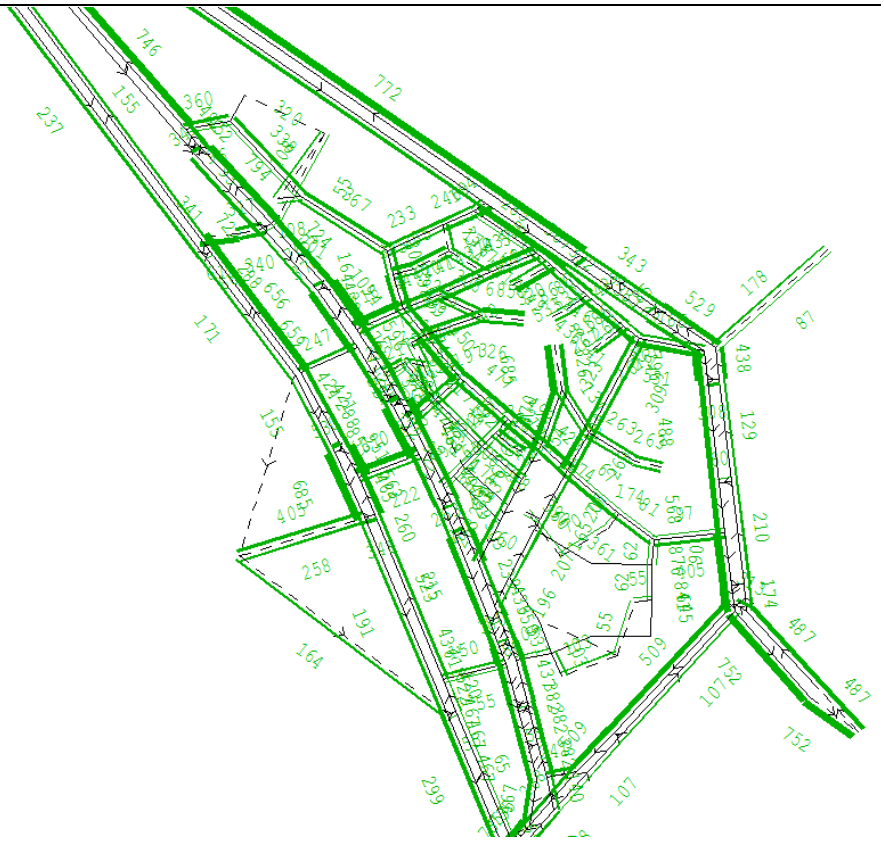

Figure 8
Second evening peak (situation 4).

CORRELATIONS	SAT/AM(UnB)
Situation 1	0,88
Situation 2	0,80
Situation 3	0,82
Situation 4	0,84

TABLE 1
Correlation between vehicular flow (SATURN) and integration (Axial Maps)

4. Conclusion

4.1. On the Need for Planning

Urban roads in Brazil have been presenting vehicle flow related problems. It is observed that traffic is not the same today as it was three decades ago, city structures have changed and most of the circulation roads have not kept up with the increase. Such fact can be explained by several factors of social, political and economical origin, not to mention urban policy priorities, ever favoring the use of the automobile over collective and non-motorized transport.

The unrestrained increase in the vehicle fleet in circulation, as well as the accelerated urbanization process which has taken place lately, have produced a slower flow in vehicle traffic and a greater need for the enlargement of transport roads. Additionally, aspects such as pedestrian safety, encouragement to the use of public and non-motorized transportation and the preservation of environmental conditions, for instance, have been thrown into the background.

The absence of planning seems to be the root of a good part of these problems. The indiscriminate use of land for the construction of new roads, accidents involving pedestrians, the

lag in the flow of vehicles, poor use of road space (sidewalks used as parking spaces), and local transit roads converted into arterial roads due to the great volume of vehicles are some of the consequences observed owing to the lack of adequate road plans.

In order to ease these externalities, there are techniques for the organization of circulation and the adequate handling of other functions of urban transport, leading to the improvement of mobility and safety for people. Herein the tools offered by both the conventional and the configurational views are set, both of which reveal aspects of interest for a more refined interpretation of circulation matters in towns or fractions, as explained.

4.2. On Tool Use

As to the tools used in this study, the analyses have shown that Space Syntax enables rapidly finding a general situation in a certain urban system, allowing the investigator and professional to have a general view of which guidelines could be followed and how they could direct a certain intervention as to what concerns circulation.

The transport models, in turn, have indicated their application to an extremely minute degree, which finds approximate parallels with the real flows registered in specific areas, demanding, however, a longer period of time for their realization, which is not always possible due to project conditions or the research in progress.

It is, as observed, a clear case where the interaction of the models would lead to a more precise, clear, and principally, multidisciplinary product, concatenating mathematical modeling with geometric and topological features, in the aid to a better understanding of flow within the city.

It is perceived, however, that the applicability of Space Syntax arises as a complementary tool for the analysis of the urban transport system, with evident positive consequences, what confirms previous results explored by Barros (2006, 2007).

Besides, the findings resulting from the axial maps allow for a more precise visualization of flow and movement relations on a given urban fraction, which may be interpreted as auxiliary in road circulation actions and strategies, reducing costs, shortening trips and facilitating the circulation of individuals. Any initiative in the sense of improving transport under this facilitating focus may be interpreted as sustainable, having in view the optimization of corresponding processes of saving time and money, the reduction of gas emissions, etc.

Nevertheless, Space Syntax must not replace traffic tools once its applicability is more global and referent to road network general characteristics, and for that reason suggested for preliminary employment, when general and comprehensive diagnoses on the urban transport scenario are sought to assist in its respective planning. It is equally undeniable that more punctual and detailed results are better refined when derived from traffic assignment tools such as SATURN.

4.3. On Perspectives for UnB

As to what refers directly to actions for Darcy Ribeiro University Campus, the Circulation Plan study, though still in its initial stage, has brought about a joint action with major urban and traffic planning institutions at the University of Brasilia, engaged with a common effort of intervention proposals for the improvement of safety and circulation of the university population.

Besides the theoretical discussions, the study has enabled the involvement of undergraduate and graduate students, what ensures the association between academic theory and practice, revealing great importance in research and transport engineering education.

The first results have demonstrated the need for the adequation of the road system to the increase in the university population and to the modifications which are currently being conducted by the UnB Campus Administration. Reviewing vehicular movements, redimensioning physical interventions, paving sidewalks and alternative passages, dimensioning a cycling facility system

and studying collective urban transport are some of the aspects to be explored by means of the tools hereby exposed in the sequential stages of the research.

Acknowledgements

FAP-DF and UNIEURO

References

Alves, D. 1999. Estudo comparativo entre modelos configuracional e de alocação de tráfego na análise e avaliação da circulação urbana de pedestres em áreas centrais. PhD diss., University of Brasília.

Barros, A.P., Valerio Medeiros, Paulo Cesar Silva, Antonio Paulo Hollanda, Frederico de Holanda. 2005. Sintaxe espacial como ferramenta de definições de parâmetros de hierarquia viária. Paper presented at the annual national meeting for the Society of Research in Transport - ANPET, November 7-11, in Recife, Brazil.

Barros, A. P. 2006. Estudo exploratório da sintaxe espacial como ferramenta de alocação de tráfego. PhD diss., University of Brasília.

Barros, A. P., Paulo Cesar Silva and Frederico de Holanda. 2007. Exploratory study of space syntax as a traffic assignment tool. Paper presented at the biannual international meeting for the Society of Space Syntax – 6SSS, June 12-15, in Istanbul, Turkey.

Cybis, H., Benamy Turkienicz, L. Sclovsky, Antonio Lindau. 1996. Análise comparativa entre modelos configuracionais e de alocação de tráfego. Paper presented at the annual national meeting for the Society of Research in Transport - ANPET, November 18-22, in Brasilia, Brazil.

Hillier, B, and Julienne Hanson. 1984. *The social logic of space*. Cambridge University Press. Cambridge.

Hillier, B. 1996. Space is a machine. Cambridge University Press. Cambridge.

Holanda, F. 2001. Teoria do conhecimento e dos espaços construídos. Lecture Notes. University of Brasília.

Holanda, F. 2002. Espaço de exceção. Ed.: University of Brasília, Brasília.

Maha, Y. 1997. Metodologia para a definição de corredores de ônibus urbanos com a aplicação da sintaxe espacial. PhD diss., University of Brasilia.

Medeiros, V. 2006. Urbis Brasiliae ou sobre cidades do Brasil: inserindo assentamentos urbanos do país em investigações configuracionais comparativas. PhD diss., University of Brasília.

Satisan, Shashi K., and Nanda Srinivasan. 1998. Evaluation of accessibility of urban transportation networks. *Transportation Research Record: Journal of the Transportation Research Board*. ISSN 0361-1981, Issue: volume 1617/1998, DOI: 10.3141/1617-11, Pages 78-83, http://trb.metapress.com/content/j43301722636l5/ (accessed November 21, 2008).

Fortes, J. 2008. Relatório preliminar do plano de circulação do campus da UnB (no prelo). University of Brasília. Brasília.

Van Vliet, D. 2004. Saturn 10.5: User Manual. Leeds, UK: Institute for Transport Studies, University of Leeds.