CONNECTIVITY BETWEEN NETWORKS AND TRANSPORTATION SYSTEMS

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ABSTRACT

This article sets out to identify the main connection points among transport networks and to analyze which improvements to major coach terminals would result in the greatest benefits to the transport system as a whole. An exploratory study was carried out in the Brazilian state of Goias. Based on an analysis of economic characteristics, local demand and geographic locations, coach terminals in key cities were defined where interventions could result in considerable benefits to the various transport systems in operation in that state. Those cities have a high demand for transport and perform as connecting points between networks permitting and facilitating the transfer of passengers from one to another. The study can be applied to other regions showing which improvements in certain coach transport terminals could extend benefits to various different transport networks enhancing the quality of services provided to transport users.

Keywords: transport networks, coach terminals, connectivity

INTRODUCTION

In terms of spatial outreach, road passenger transport can be classified as urban, inter-municipal, interstate and international. In Brazil, outreach is also associated to the responsibilities attributed to the various spheres of government. Thus urban transport is the responsibility of municipal governments, inter-municipal transport is the responsibility of the states and interstate and international transport is the responsibility of the Federal Government.

However, there are several situations in which different systems overlap causing interference and impacts on one another. In Brazil such situations are particularly evident in the regions of state borders insofar as neighboring municipalities may very well come to be served by distinct urban and inter-municipal networks and are often connected to one another by interstate networks.

In the state of Goias, located in Brazil's central-western macro-region, four distinct transport networks currently operate: (i) inter-municipal; (ii) interstate; (iii) semi-urban; and (iv) international. Although they are separate networks, they share infrastructure such as highways, lines and nodes such as coach terminals and accordingly planning and infrastructure need to be capable of handling the respective passenger flow volumes.

The number of lines and the number trips conducted in these networks are by no means equitably distributed among the many connections, so the demands vary distinctly from one coach terminal to another. Furthermore, each terminal is connected to a given set of municipalities, states and countries connecting nodes of different networks.

The spatial distribution of nodes and lines of transport, associated to the characteristics of the supply, offer constitute the functional model. Joint planning of the transport networks' functional model starting from the municipalities with greatest degree of connectivity and greatest passenger flows coupled with actions designed to improve infrastructure of their respective terminals would promote better quality in the service offer to passengers constituting an incentive to development for the region as a whole.

In that light, this paper aims to analyze the overlapping of transport networks with different outreaches and administered by different spheres of responsibility in order to explore the dynamics that result from inter-network connections. To achieve this goal an exploratory study to identify the major points of connection among transport systems in Goias and to show how certain defined improvements implemented in those key-points can benefit the various transport networks and, consequently, the entire set of municipalities that are served by those networks in the state.

Are also objectives of this study: (i) identify if the main connection points among transport networks are also the most populous ones; (ii) present the degree of the nodes and of their centralities; and (iii) identify the infrastructure conditions of the coach terminals of the main connection points and what improvements would impact the various transport networks.

SOCIO-DEMOGRAPHIC CHARACTERIZATION OF THE STUDY AREA

Situated in Brazil and Latin America's most central region, the State of Goias is made up of 246 municipalities covering an area of 304 thousand km², 4% of Brazil's entire land surface (Sepin, 2011). The state has borders with five others: Tocantins to the north; Bahia and

Minas Gerais to the east; Minas Gerais and Mato Grosso do Sul to the south and Mato Grosso to the west. Precisely because of its location and connection with those other states, Goias shows clear signs of overlapping of transport networks with different areas of outreach, and it is also a region of passage to other Latin American countries, particularly Paraguay.

According to the Brazilian Geography and Statistics Institute – IBGE (2010), the state has a little over six million inhabitants predominantly living in urban areas: 90.3% live in the cities and just 9.71% in rural zones. That reality was once completely different. Up until the 1970s the greater part of the population (54%) lived in rural areas but as a direct result of the technology introduced into agricultural and livestock raising activities associated to the 'Green Revolution', a vast rural exodus was set in motion.

It should be noted that the population is growing but at an increasingly slower rate. The population growth index went up from 31.30% in the period from 1970 to 1980 to 20.16% in the period 2000-2010. Growth for the year 2011 has been estimated as 1.28% compared to the preceding year reaching a total of 6.08 million inhabitants.

According to IBGE (2010) statistics, 50.55% of the population lives in the ten most populous municipalities of Goias. The state capital Goiania is the most populous of all with 1.3 million inhabitants, which is 21.7% of the state's population. In decreasing order come Aparecida de Goiania (455 thousand inhabitants), Anapolis (334 thousand inhabitants), Rio Verde (176 thousand inhabitants), Luziania (174 thousand inhabitants), Aguas Lindas de Goias (159 thousand inhabitants), Valparaiso de Goias (159 thousand inhabitants), Trindade (104 thousand inhabitants), Formosa (100 thousand inhabitants) and Novo Gama (95 thousand inhabitants).

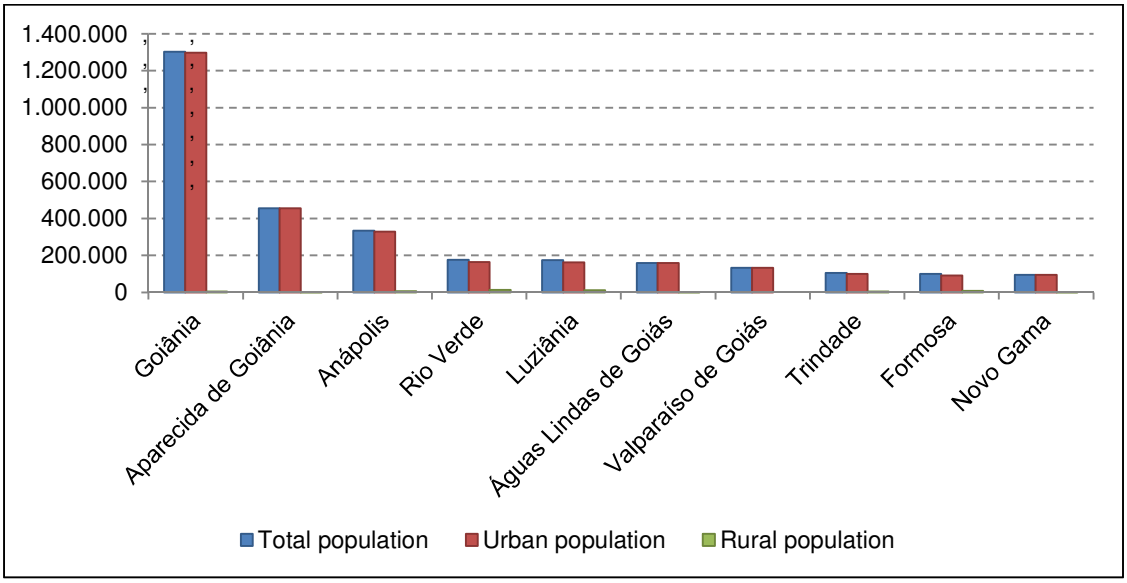

Figure 1 – Ten most populated cities of Goias
Source: Based on IBGE data (2010)

In all of them the population is predominantly urban (over 90% in each one) and in the case of Valparaiso de Goias there is no population in the rural category at all.

Figure 2 illustrates the geographic concentration of the population in the state of Goias in the municipalities of Goiania, Aparecida de Goiania and Trindade in the center, Anapolis to the northeast of Goiania and Rio Verde to the southeast. Other notable concentrations are in Luziania, Aguas Lindas de Goias, Valparaiso de Goias, Formosa and Novo Gama, all located in the region surrounding the Federal District, where the Brazilian capital is located.

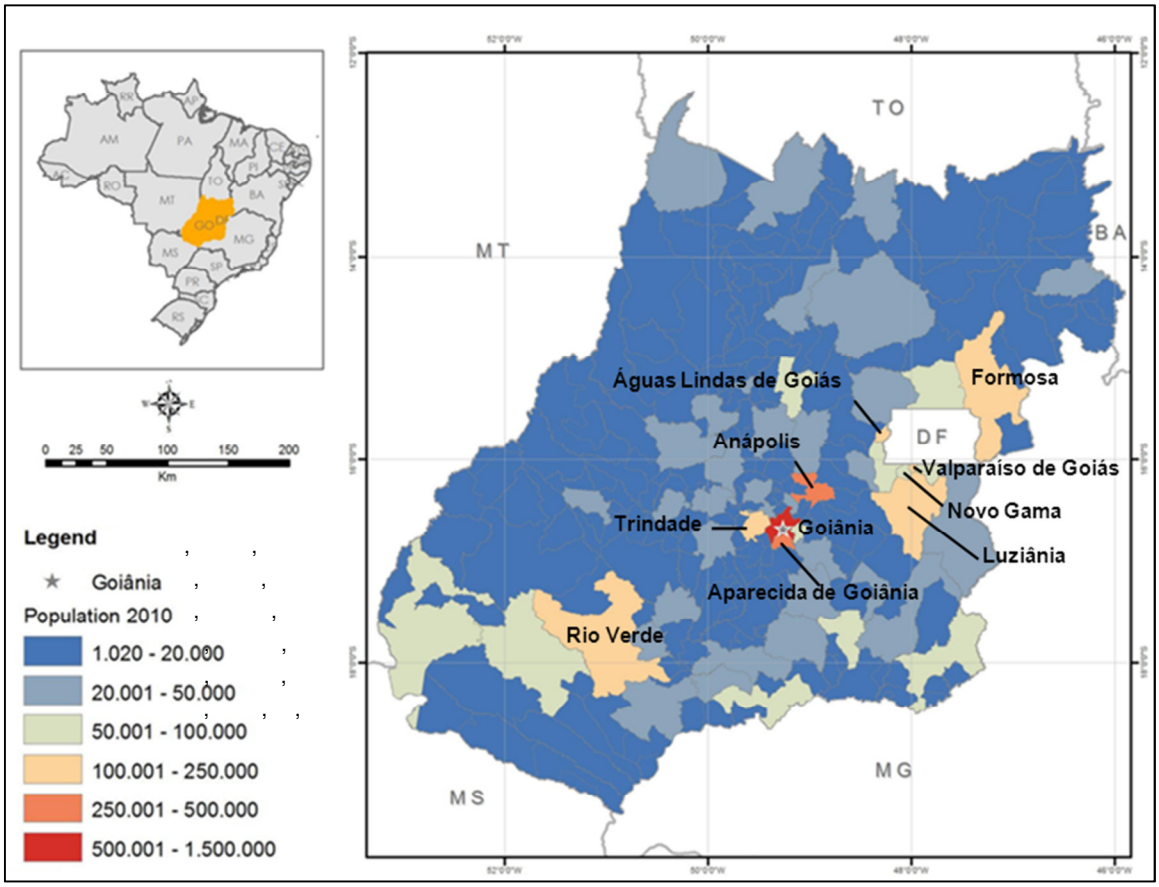

Figure 2 – Population of Goiás
Source: Based on IBGE data (2010)

It is well known that one of the factors that have a strong influence on the rate of trip generation is the number of people residing in a given region. Thus, taking as a starting point, the high degree of concentration of the population of the state of Goias and the associated generation of movement flows, the question that must be asked is: are the main points of connection among existing networks those where the population figures are highest? To answer that question, the transport networks present in the state need to be analyzed as well as overlapping and the connectivity between networks that is offered to service users.

TRANSPORT NETWORKS IN GOIAS

Transportation's main function is to make translocations of goods and people possible (Ferraz and Torres, 2001), and do so by means of the available network. One way of defining a transport network is to give a systemic explanation of its constituent elements and objectives. According to Bertalanffy (1968), due to the connections that exist within it, any stimulus applied to any one elements of the network affects the others precisely due those relations that exist among them. Thus any improvements made to a given node in the network will not only affect the immediate object of improvement but the network as a whole. In the present study a transport network is taken to be a structure made up of the physical elements of a transport system and other abstract elements which are the relations that exist between the transport infrastructure and the physical space in which it is inserted.

According to Menezes (2004), road passenger transport can be classified according to geographic levels in which it is operated, which refers to the translocation or displacement (over short, medium or long distances and the sphere of responsibility it is associated to in terms of administrative division in force in the region). Thus there is urban transport, semi-urban transport, inter-municipal transport, interstate transport and international passenger transport.

Urban transport is charged with conducting translocations that take place within the urban perimeter of a city (Ferraz and Torres, 2001). The 1988 Constitution determined that the municipal authority is responsible for the organization of public services of local interest and, accordingly, the management of urban transport is the responsibility of the local government. It means that this kind of transport will naturally have characteristics that reflect the particularities of each municipality. Urban transport makes short distance connections and is allowed to transport standing as well as seated passengers, emission of tickets is controlled by mechanical tallying (a ratchet entry gate for example), and it makes use of vehicles with urban characteristics and doors appropriate for the boarding and disembarkation of passengers (Menezes, 2004).

The category 'semi-urban transport' is characterized by routes of seventy-five kilometers or less and other urban road transport characteristics but that go beyond the borders of the state, Federal District or Territory and accordingly the Federal Union is attributed responsibility for its regulation, inspection and execution (Brazil, 1998). The Ministry of Transport also considers services with the same characteristics but that go beyond national frontiers to be semi-urban transport.

Inter-municipal road passenger transport uses coaches suitable for highways (or sometimes even urban transport buses) to connect municipalities within the same state. The responsibility for regulating and inspecting it lies with the state governments so it presents characteristics that vary from state to state. Generally speaking it makes connections over medium or long distances, does not allow standing passengers and the vehicles are fitted with reclining seats.

In specific situations, the inter-municipal road transportation system is provided in a manner similar to the urban, being classified as inter-municipal semi-urban. This is characterized by the state government as a semi-urban transport service performed with the transposition of the territorial limits of the municipalities (Governo do Estado de Goiás, 1996), without having, however, a detailed regulation. Thus, the scope of this service is flawed and does not exclude situations that have no character of urban transport.

Resolution nº 16, May 2002 (ANTT, 2002), states that interstate transport is that which goes beyond the borders of states or the Federal District or a federal territory. It usually makes use of highway vehicles with mechanical design and passenger comfort features appropriate to the execution of long hauls. In turn that same resolution defines international road passenger transport as that whose itineraries cross national borders.

Menezes (2004) reports that because of its geographic location Brazil has international overland transport agreements in place with almost all South American countries, especially road transport agreements. Those agreements are part of a bid to facilitate trade, tourism and cultural exchanges among the countries by making it possible to circulate among them in safety.

Currently the provisions governing interstate and international road passenger transport are set out in Act nº 10.233, dated June 5, 2001, Act nº 8.987, dated February 13, 1995, and Act nº 9.074, dated July 7, de 1995, and the corresponding regulations are set out in Decree nº 2.521, dated March 20, 1998, and in normative documents in the form of Resolutions issued by Collegiate decision of the National Overland Transport Regulatory Board – ANTT.

In spite of the networks in question being under the administrative aegis of various different spheres of government, in many situations they overlap and are interconnected giving rise to direct impacts on one another in response to the demand for translocations stemming from the population at large. In that light the methodology that follows has been designed to identify points where networks overlap and analyze the connectivity of the networks which have an influence on service user decision making.

METHODOLOGY FOR ANALYZING TRANSPORT NETWORK CONNECTIVITY

This study analyzes the connectivity of four transport networks in the state of Goias. The data used was gathered from the IBGE, the State and National Regulatory Boards, and the University of Brasilia. The structure used to unfold the study is illustrated in Figure 3.

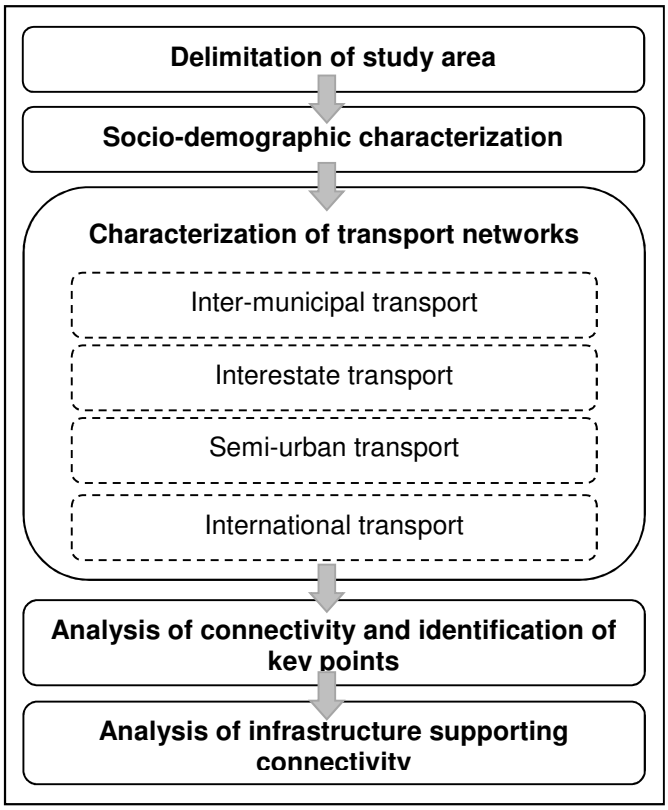

Figure 3 – Study Methodology

The first step was to delineate the area of the study which in this case was the State of Goias. Next, a socio-demographic study was undertaken followed by a characterization of the transport networks operating in the state. Based on that information, an analysis of connectivity was made and key points of integration among networks were identified. In addition, an analysis of infrastructure supporting connectivity was made, identifying the structural modifications that could have an impact on the various networks. The analysis considered an index created by the State Regulatory Board and other information about the terminals, as: size (m²); number of bays; state of conservation and parking.

POINTS OF NETWORK CONCENTRATION AND OVERLAPPING

As mentioned, the state of Goias has (i) inter-municipal; (ii) interstate; (iii) semi-urban interstate and (iv) international transport networks. Furthermore each municipality in the state operates a municipal network which, however, will not come within the scope of the present study as they have very different operational and spatial characteristics.

Adopting Scheurer and Porta's (2006) approach, two points stand out in regard to any analysis of public transport network connectivity. The first concerns the fact that public transport systems are structured in networks of pre-determined movements concentrating the demand for trips in already known connections. In that way, the service user is free to choose which lines he will use but is not in a position to spontaneously create new connections as a pedestrian or a cyclist or a vehicle driver can.

The second refers to the fact that not all geographic intersections of segments of different networks will be considered as connecting points in the system. Thus it is possible for itineraries of different networks to cross paths at various points but without there being any stops for boarding, disembarking or transferring passengers from one network to another.

It should be noted that knowledge of the network's connectivity makes it is possible to calculate the degree of a node and its degree of centrality (Porta, Crucitti, and Latora, 2006a, 2006b). The degree of a node expresses the number of other nodes that can be reached from it; that is, the number of municipalities that can be accessed departing from a given municipality. In turn, the centrality of a node expresses the proportion or percentage of the total number of nodes that can be accessed from a given municipality. The more connections a municipality has, the more centralized it is considered to be (Cox, 1939). In Figure 4, considering each row as a link between two nodes, it can be seen that the node A is the most centralized, connected directly to eight nodes.

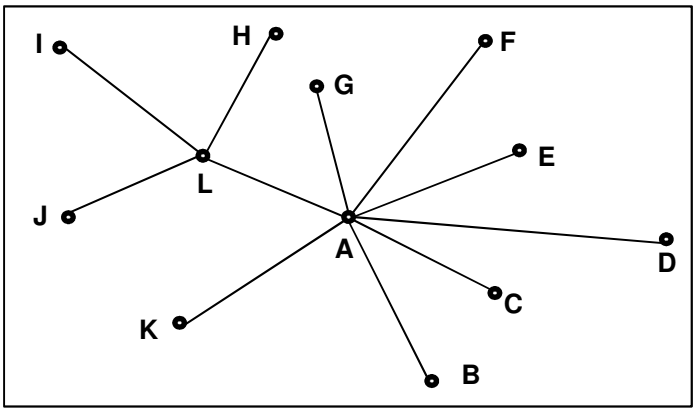

Figure 4 – Example of network

In the state of Goias, an analysis of the number of lines as a function of the category of service (Table 1) revealed that there are 845 lines serving the municipalities. Of those, 457 are inter-municipal, 347 interstate, 38 semi-urban and three international.

Table 1 – Lines serving municipalities in Goias, by type of service

Transport type	**Number of lines**
Inter-municipal	457
Interstate	347
Semi-urban	38
International	3
Total	845

Source: AGR (2010) and ANTT (2012)

It must be underscored that some municipalities in the region known as the Integrated Development Region of the Federal District and Surroundings (*Região Integrada de Desenvolvimento do Distrito Federal e Entorno* – RIDE/DF) have semi-urban lines[1]

[1]Of the 19 municipalities that make up the RIDE/DF (Abadiania, Aguas Lindas de Goias, Agua Fria de Goias, Alexania, Cabeceiras, Cidade Ocidental, Cocalzinho de Goias, Corumba de Goias, Cristalina, Formosa, Luziania,

(connecting them to Brasilia). Furthermore, in spite of the fact that the National Regulatory Board's figures showed that there were 38 semi-urban lines operating in the RIDE/DF, a survey conducted by the Interdisciplinary Center for Transport Studies (*Centro Interdisciplinar de Estudos em Transportes* – CEFTRU, 2009) showed that there are over 530 itineraries being operated in this area, showing that there exists a demand that is not being officially registered, and which is probably being met by an illegal transport system.

Thirteen of the 246 municipalities in the State of Goias are not served by inter-municipal lines and therefore they have no centrality in the network. They are: Agua Fria de Goias, Amaralina, Baliza, Cachoeira de Goias, Cumari, Guarani de Goias, Guarinos, Lagoa Santa, Mimoso de Goias, Santo Antônio de Goias, São Miguel do Passa Quatro, Sitio d'Abadia and Uirapuru. Out of these last, only five (Agua Fria de Goias, Baliza, Cumari, Mimoso de Goias e Sitio d'Abadia) are served by one of the types of service being analyzed, namely interstate services.

In Table 2 and Figure 5 the municipalities that have the highest numbers of connections with others in Goias are identified. They also identify the number of states and other countries they have connections with. Goiania stands out as the leader with the highest number of connections to other municipalities and to other states, 196 and 18 respectively. The degree of centrality associated to those figures is 84% in the case of inter-municipal transport (excluding from the calculations those municipalities in the state that are not served by inter-municipal transport) and 67% in regard to interstate transport. Anapolis takes second place as it is connected to 89 municipalities (degree of centrality 38%) and 17 states (degree of centrality 63%). Proportionally those figures reveal that Anapolis is more connected to other Brazilian states than to other municipalities in Goias. It is noteworthy that the data in the Figures 5, 6, 7 and 8, were normalized by the square root to be presented.

Table 2 – Municipalities with the highest numbers of connections to other municipalities

Territorial Unit	**Municipalities**	**States**	**Countries**
Goiania	196	18	1
Anapolis	89	17	1
Jaragua	50	7	0
Petrolina de Goias	50	1	0
Ceres	44	8	0
São Francisco de Goiás	43	1	0
Rianapolis	41	2	0
Rio Verde	40	15	1
Aparecida de Goiania	39	3	0
Morrinhos	36	4	0
Nova Gloria	36	0	0

Source: AGR (2010) and ANTT (2012)

Mimoso de Goias, Novo Gama, Padre Bernardo, Pirenópolis, Planaltina, Santo Antônio do Descoberto, Valparaiso de Goias, Vila Boa) only eight have semi-urban lines: Aguas Lindas de Goias, Cidade Ocidental, Formosa, Luziania, Novo Gama, Planaltina de Goias, Santo Antônio do Descoberto and Valparaiso de Goias.

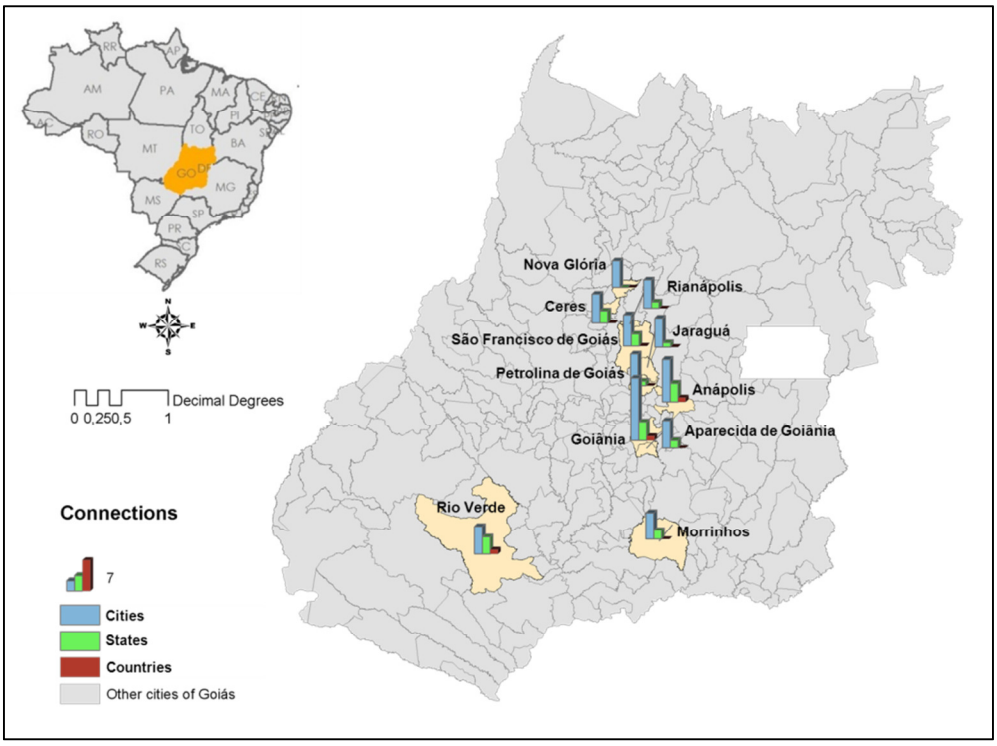

Figure 5 – Municipalities with the highest numbers of connections to other municipalities

However, when the classification is made of those with the highest number of connections with other states, the order is different (Table 3 and Figure 6) insofar as only Goiania, Anapolis and Rio Verde appear in the second list. That shows how important those three municipalities are in connecting the various transport services that exist in Goias.

Table 3 – Municipalities with highest numbers of connections to other states

Territorial Unit	Municipalities	States	Countries
Goiania	196	18	1
Anapolis	89	17	1
Rio Verde	40	15	1
Mineiros	20	14	0
Jataí	30	13	0
Ipora	27	12	0
Itumbiara	30	11	0
Aragarças	17	11	0
Uruaçu	30	9	0
Porangatu	26	9	0
Catalão	25	9	1
Caldas Novas	20	9	0
Posse	16	9	0

Source: AGR (2010) and ANTT (2012)

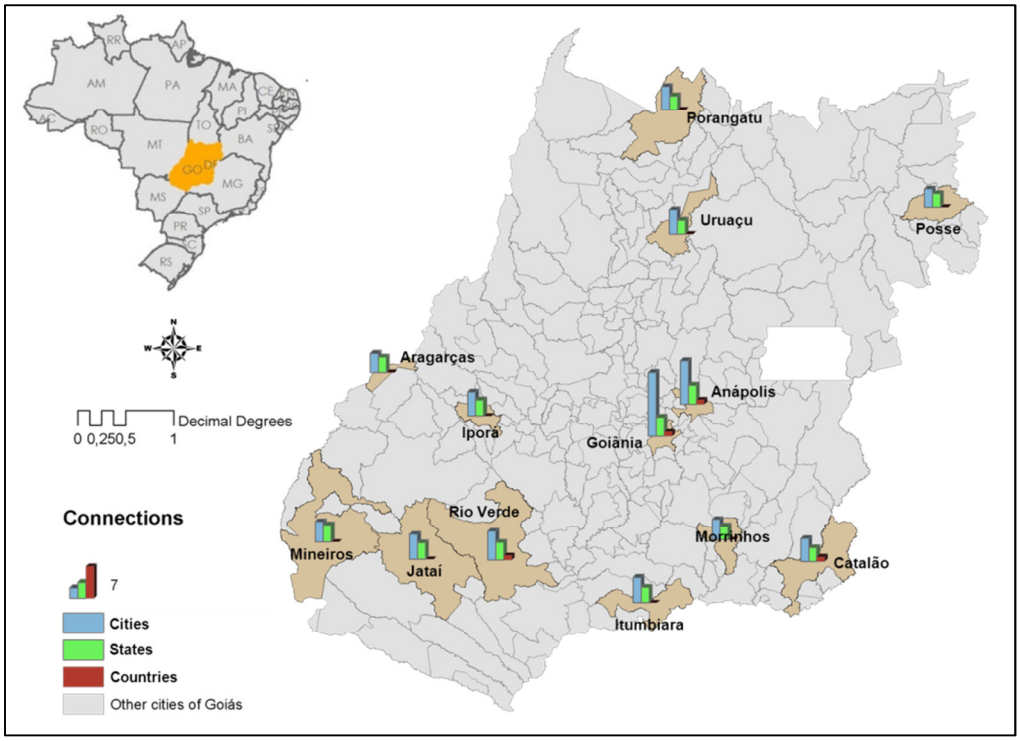

Figure 6 – Municipalities with highest numbers of connections to other states

As for municipalities that have connections with other countries (Figure 7), four of them appear in Table 3 and Figure 6 (Goiania, Anapolis, Rio Verde and Catalão) and there is one other, Caçu, all with connections to Paraguay.

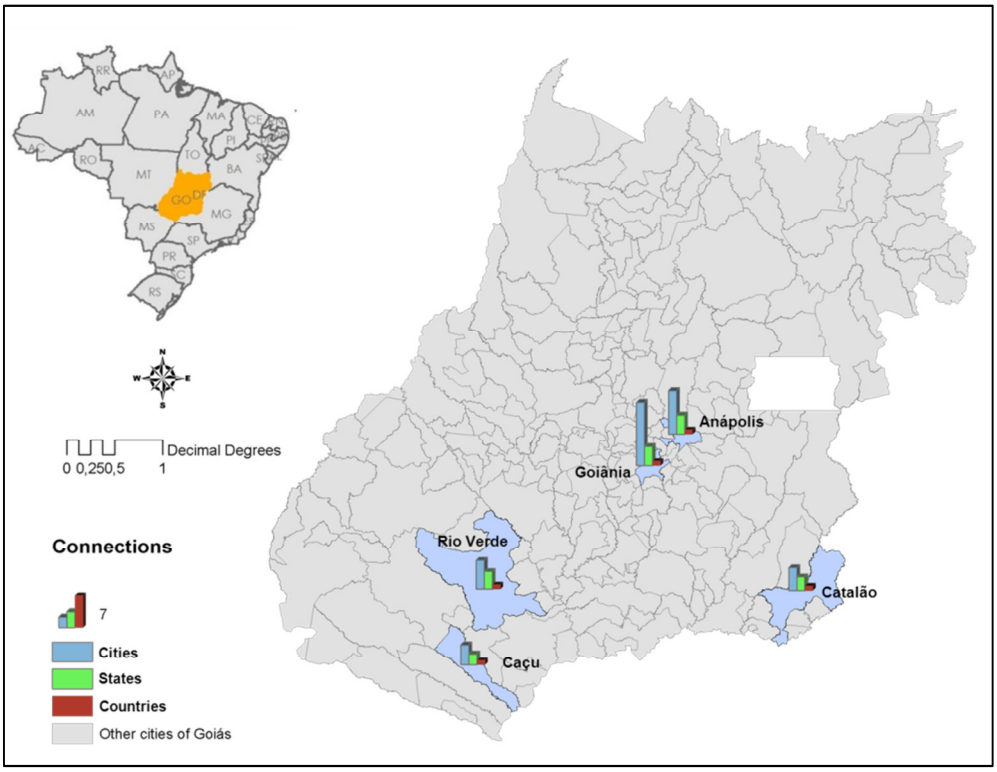

Figure 7 – Municipalities with connections to other countries

Based on an analysis of the centrality of the municipalities in the various types of transport being operated in the state of Goias, it was possible to identify those that perform as facilitators of network integration, permitting transfers from one network to another.

The question arises as to what the real conditions of road transport terminal infrastructure are in the 22 municipalities presented and what improvements would have the greatest impact on the various transport networks.

ANALYSIS OF INFRASTRUCTURE SUPPORT FOR CONNECTIVITY

Once the situations of overlap and connectivity have been analyzed, it is vital to evaluate the infrastructure responsible for offering adequate conditions to passengers that have to use more than one transport network and are the eventual beneficiaries of any connectivity among the networks.

Road Passenger Transport Terminals are highly important components of any public road transport network where the populace at large can gain access to transport services. The terminals may be public or private but they are all open to the public and equipped with the necessary services and installations for boarding and disembarking passengers. Their classification may vary from state to state

Resolution nº 055/2005-CG, issued by the Council of the AGR (2005), sets out its classification of the State of Goias's road passenger transport terminals according to an indicator known as the Terminal Comfort Verification Index (*Índice Verificador de Conforto em Terminais* – IVTC). The index was defined in Resolution 542/2004-CG (AGR, 2004) and designed to be used to classify road passenger transport terminals into groups and it makes use of the following formula to do so:

$$IVCT = \frac{Po}{M^2 \times NH \times (1 + A1 + A2 + A3)} \quad (1)$$

Whereby:
IVCT= Terminal Comfort Verification Index;
Po= Municipal population;
M²= Terminal constructed area in square meters;
NH= Number of trip times scheduled per day in the municipality;
A1: 0.6 = Shopping Mall;
A2: 0.3 = Pole city;
A3: 0.1 = Tourism city.

It should be noted that the factors taken into account by the IVCT indicator are municipal population figures, the constructed area of the terminal, the number of scheduled trips per

day in the municipality, the existence of Shopping Malls or not, and the classification of the city as a regional pole or a center for tourism.

Table 4 sets out the terminal classification based on IVCT results. The terminals with high IVCT ratings and the lowest number of trips being offered to the population are classified as Type V and as the IVCVT goes down and the trip offer goes up the classification draws nearer to Type I.

Table 4 – Terminal Classification according to the AGR scheme

Classification	**NH**	**IVCT**
Type I	NH > 500	IVCT < 0.02
Type II	100 <NH ≤ 500	0.02 ≤ IVCT < 0.11
Type III	50 <NH ≤ 100	0.11 ≤ IVCT < 0.61
Type IV	5 < NH ≤ 50	0.61 ≤ IVCT ≤ 1.11
Type V	NH≤25	IVCT >1.11

Source: AGR (2004)

In addition, the AGR (2010) established three parameters for classifying aspects of terminal quality: good, reasonable and bad. The aspects analyzed in this case were: the state of the pavements, toilets, coach maneuvering area, sign displays, lighting and the existence of parking spaces. In Table 5 those municipalities with the greatest numbers of connections to other municipalities or to other states or the ones that are nodes for international connections are all listed with their respective characteristics and evaluations per aspect analyzed.

Table 5 – Information about the terminals

Municipality	**Terminal Size (m²)**	**Number of Bays**	**Classification**	**Conservation (preservation)**	**Parking**
Anapolis	22,641	41	I	Good	Yes
Aparecida de Goiania	421	3	III	Bad	Yes
Aragarças	762	7	III	Bad	No
Caçu	421	4	IV	Bad	Yes
Caldas Novas	400	10	II	Good	Yes
Catalão	1,600	9	II	No information	Yes
Ceres	1,600	8	II	No information	No
Goiania	37,976	48	I	Reasonable	Yes
Ipora	650	10	III	Bad	Yes
Itumbiara	9,667	16	II	Bad	Yes
Jaragua	762	No information	II	Bad	No
Jatai	3,500	13	III	Bad	Yes
Mineiros	421	4	III	Bad	Yes
Morrinhos	762	6	III	Good	Yes
Nova Glória	421	No information	V	Bad	No
Petrolina de Goias	534.85	4	IV	Bad	No

Municipality	Terminal Size (m²)	Number of Bays	Classification	Conservation (preservation)	Parking
Porangatu	877	10	II	Good	Yes
Posse	534,85	4	III	Bad	No
Rianapolis	406	4	II	No information	No
Rio Verde	2,200	20	II	Bad	Yes
São Francisco de Goias	534,85	4	IV	Bad	Yes
Uruaçu	2,927.46	9	II	Reasonable	Yes

Source: Adapted from AGR (2005, 2010)

The conservation of the terminals (preservation) is also presented in Figure 8. It is possible to observe a concentration of terminals in *bad* state of conservation in the south, west and south-west of Goias, including municipalities as Ipora, Aragarças, Rio Verde, Jataí, Mineiros, Caçu e Itumbiara. Most of these municipalities have high number of connections to other states, playing an important role in the interstate transportation system and in the connectivity between systems.

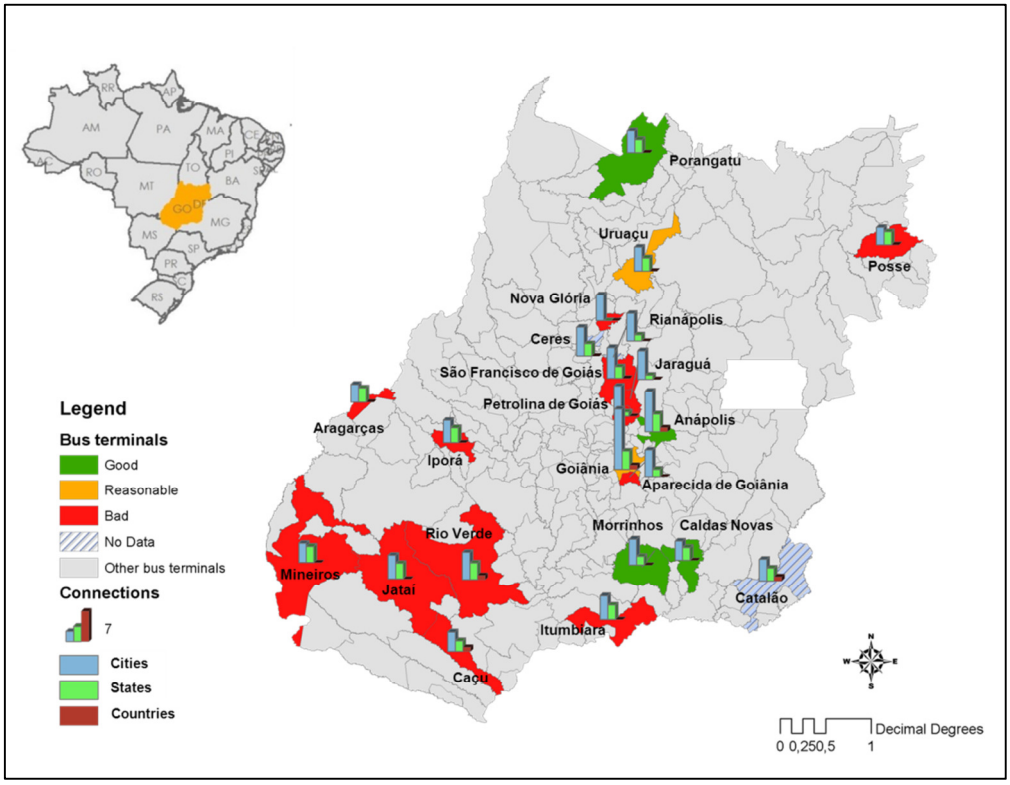

Figure 8 – Municipalities with the highest numbers of connections and the classification of their terminals

It is worth highlighting two terminals that were classified as Type I; Goiania and Anapolis. They happen to be in the municipalities with the greatest level of economic concentration in the state and they also correspond to cities with the highest and third highest population respectively. Furthermore their terminals have the largest constructed areas 37,976 m² in

Goiania and 22,641 m² in Anapolis, and the highest number of bays 48 and 41 in that order. Their states of conservation are rated as good and reasonable respectively.

On the other hand, the majority of terminals analyzed in this study were assessed as Type II and Type III. Among them, only Morrinhos, Porangatu and Caldas Novas present good conditions while the others show a low level of capacity to address the transport demand. In the terminals with their state of conservation classified as 'bad' the deficiencies are mainly related to state of patio where the coaches maneuver and the conditions of the toilets. Another notable feature in the case of the Rio Verde terminal was the lack of sufficient places for waiting passengers to sit down. No information was available for the terminals in Catalão, Ceres or Rianapolis.

Considering the terminals studied, 18.2% were classified as Type IV or Type V. Among them is Caçu, one of state's five terminals that serve international lines, plus Petrolina de Goias, Nova Glória and São Francisco de Goias. Compared to other municipalities, Caçu, Petrolina de Goias and São Francisco de Goias have a very low number of bays for the coaches; just four each. Furthermore, the second most populous municipality in the state, Aparecida de Goiania, has the lowest number of coach boarding bays of all, just three.

Among the 22 terminals in question, 68.2% have parking spaces. However, among those that do not are Jaragua, Petrolina de Goias and Ceres, which are, respectively, the third, fourth and fifth most connected terminals in terms of connections to other municipalities in the state of Goias.

The terminals of Itumbiara and Jatai, both classified as bad, have a similar number of bays but there is a considerable difference in the size between their constructed areas insofar as the Itumbiara terminal is three time the size of the one in Jatai. Still on the topic of constructed area, it is worth highlighting the terminal in Caldas Novas. In spite of its having the smallest constructed of all those examined (a mere 400 m²), the terminal's state of conservation was considered to be 'good'. Furthermore, it has a parking area and ten bays for the vehicles; one more than Uruaçu, which has a constructed area of 2,927 m² but was only classified as 'reasonable'.

The comparison with Figures 2, 5, 6, 7 and 8 reveal that the four most populated municipalities of Goias (Goiânia, Aparecida de Goiânia, Anapolis and Rio Verde) have high number of connections in the inter-municipal, interstate; or in the international network. The terminals of these municipalities are in reasonable, bad, good, and bad condition, respectively.

FINAL REMARKS

Public Road Passenger Transport Systems are structured in the form of pre-determined networks so that the movements and transfers take place in previously known connection points. In various regions the transport networks overlap and either compete or complement one another. Thus the crossover which takes place in road transport terminals makes it

possible for passengers to have trip origins and destinations in nodes of different systems which is the role played by network connectivity. However distinct the characteristics of the networks may be from one another, they have to share the same infrastructure elements which, in turn, need to be capable of supporting the demands that the connection of networks gives rise to.

In the state of Goias, there are notable centers of population concentration, particularly (i) Goiana and its surrounding municipalities, (ii) Anapolis. (iii) Rio Verde, and (iv) the municipalities bordering the Federal District where Brazil's capital is located. The pattern of population distribution in the state has a direct influence on the transport characteristics. What predominates in the municipalities surrounding the Federal District is semi-urban transport, while in Goiania, Anapolis and Rio Verde there is just as much interstate as inter-municipal transport. In those three municipalities and in Caçu and Catalão there are also international lines in operation, all of them connecting to Paraguay.

Thus in the state there is the interstate transport system in operation, the semi-urban system, that generates high fluxes to and from the Federal District, the inter-municipal and the international system. Each system has its own characteristics but they all share the same infrastructure. The analysis of the socioeconomic characteristics, demand, and geographic location showed that interventions in the bus terminals, like Goiânia, Anápolis, Rio Verde and others, will reflect positively on all transport systems in the region. These cities have high demand for transport, and could act as connecting points between the three networks, facilitating and improving transfers between them.

In addition to all the municipalities mentioned above, others were notable in the course of the work because of their high degree of centrality in the inter-municipal and interstate networks and because they are the site of various connecting points among the networks. Nevertheless it must be stated that among the 22 municipalities analyzed, only four were identified as being in a 'good' state of conservation and another two were classified as 'reasonable, including Goiania. 13, that is 59% were considered 'bad', including the important terminals of Rio Verde and Caçu.

In such a scenario, joint planning of networks' functional structures based on those municipalities coupled with actions to improve the infrastructure of their terminals would make it possible to enhance the quality of the service offered to transport users and in that way contribute to boosting the state's development. For this, some guidelines could be followed, like: (i) the complementation of missing information about the related terminals; (ii) improvements on terminals classified as "bad" starting in ascending order until "Type V"; (ii) maintenance of terminals classified as "good"; and (iii) inter-municipal transport offer to all the municipalities of the state, allowing passengers to access others systems as the interstate; semi-urban interstate and the international ones.

Moreover, the identification of routes and connecting points with high levels of demand among the various transport systems makes it possible to orientate public transport policies. In that light this study could be useful in supporting the planning of the functional structuring

of transport networks in regard to infrastructure, accessibility, mobility and other aspects. It can also foster the optimum destination of investments by identifying the improvements in key network connection points that can most benefit the different transport networks involved, enhancing the quality of their services offer.

Furthermore, this analysis of points where networks overlap can be usefully applied to other regions, where there are also networks with different outreaches installed; and to do so with the same objective of improving the conditions offered to passengers making connections between different transport networks. What is essential is that planning should integrate the different spheres of government administration and the current legal-institutional model should be re-examined with a view to improving road passenger transport terminals that serve more than one transportation network.

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