EVALUATING ORIENTATION LEVEL OF SERVICE AT PASSENGER TERMINALS AT MAJOR BRAZILIAN AIRPORTS

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Abstract

This paper presents an analysis on the orientation and legibility of internal spaces of some Brazilian airports. The main issue states the fact that most of the users have experienced embarrassing situations whenever moving around an airport and even localizing their destinations in a passenger terminal (TPS). Considering the frequent time restriction, it is noticed that the lack of orientation, and therefore the difficulty of finding their way through, may lead passengers to insecure uncomfortable stressful sensations. The identification of variables that may infer orientation is expected to provide architects and engineers with principles, which should consciously guide them in the sense of the required parameters to design. Therefore, it allows better TPS efficiency in terms of orientation, offering passengers the means of finding their ways as well as identifying their destinations quicker. Moreover, users would be able to read and perceive the space, resulting in a better level of satisfaction for them.

Keywords: wayfinding, orientation, level of service, passenger terminals, airports.

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1. INTRODUCTION

One important aspect of a trip nowadays concerns the ability of the users to find their way through large transport terminals, be they air, road, or rail terminals. Minimizing disorientation and confusion is a difficult task for the terminal designer because there are often no instruments to help (Braaskma and Cook, 1980). In large public spaces that are outside the range of human's environmental perception, the need for projects that aid in finding ways has increased significantly (Dogu and Erkip, 2000).

The magazine Passenger Terminal World, in different issues, published relevant reports about the importance of orientation for passengers at airports. The 2001 issue suggests that the architectural TPS design should be planned so that passengers can, intuitively, know which direction to take to find their destination (Bodouva and Bodouva, 2001). The June (2005) issue indicates the layout of the building to facilitate the operation of the terminal, so that passengers can move quickly and efficiently (Daniels, 2005). As reports an evidence of a traveler, in the September (2006) issue, when a passenger arrives at an airport, there is a combination of anxiety and disorientation, particularly in cases of non-familiarity with the airport (Osborn, 2006).

2. LITERATURE REVIEW

The design of a terminal should have, among other requirements, a setting that encourages good direction, enabling users to make decisions quickly to achieve their goals. Wayfinding must be developed in passenger terminal because many passengers have a restricted time in the terminal, as Dada and Wirasinghe (1999) suggest. In addition, the airport configuration has to take into consideration orientation in emergency situations, such as fire (Raubal and Egenhofer, 1998).

It is essential for a designer to be aware that ease in wayfinding must be a significant consideration in the design (Lam et al, 2003). According to Hart (1985), orientation can be defined as a perception of position relative to the adjacent activity whilst users move around, with direction and orientation being interactive and inseparable aspects that must be jointly considered when planning the movement of people in a building.

Weisman (1981) states that one potential factor influencing orientation could be an individual's degree of familiarity with a given environment. Braaskma and Cook (1980) mention that orientation can be affected by: lighting, color, density of traffic, and so on. Dada (1997) investigates the effect of variables such as decision points, numbers of signs, and change of level. For Schindler and Werner (2004) the performance to find a way and the ability to guide people depend on the geometric relationships of a building.

3. PRELIMINARY ANALYSIS

An initial study was carried out at the São Paulo/Guarulhos International Airport (SP) to investigate passengers' attitudes towards orientation. The survey was carried out in August 2006, using questionnaires in domestic and international departure lounges. A total of 83 passengers were interviewed. The key elements in the survey were the score and explanation given by passengers for orientation in that airport, from 1 (terrible) to 5 (excellent). Figure 1 shows that certain factors can justifiably be said to interfere in the orientation of a terminal, depending on the passengers' perception. Significantly, the lack of signing was cited 47 times, being identified by over half those interviewed (approximately 56%).

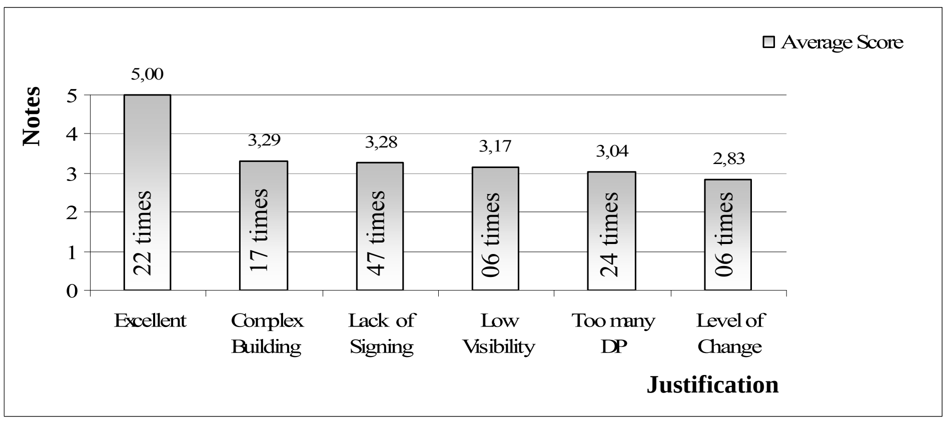

Figure 1. Relation between explanations and scores.

The pilot survey allowed a wide-ranging investigation of passenger attitudes as regards to orientation in an airport. It was noted that passengers who already know the terminal, tend to give a better score for orientation. The possibility of continuing the research in form of interview was aborted, since it is a doubtful approach to identify criteria that really affect guidance, and because there is a strong interference of each passenger's individual characteristics.

4. METHOD

To investigate the factors influencing orientation at passenger terminals, the following steps will be followed: (1) airport selection, (2) selection of analysis activities, (3) definition of variables, (4) data collection from architectural plans, and (5) data processing.

4.1 Airport selection

Studies will be carried out in ten Brazilian airports, as in Table 1. Note that the airports of analysis are in descending order of movement and that the codes to designate the airports are as standard ICAO (International Civil Aviation Organization).

Table 1. Accumulated Operating Traffic (January to December, 2005).

Code ICAO - Locale	Passengers (unit) *		
	Domestic	International	Total
SBSP – São Paulo/ Congonhas International Airport	17.147.628	0	17.147.628
SBGR – São Paulo/ Guarulhos International Airport	7.257.196	8.577.601	15.834.797
SBBR – Brasília International Airport	9.391.797	34.772	9.426.569
SBGL – Rio de Janeiro/ Galeão International Airport	6.254.196	2.402.943	8.657.139
SBSV – Salvador International Airport	4.292.989	261.583	4.554.572
SBRF – Recife International Airport	3.422.657	181.995	3.604.652
SBCT – Curitiba International Airport	3.337.401	55.678	3.393.079
SBRJ – Rio de Janeiro/ Santos- Dumont Airport	3.562.297	0	3.562.297
SBFZ – Fortaleza International Airport	2.524.606	249.634	2.774.240
SBFL – Florianópolis International Airport	1.443.912	104.921	1.548.833
SBMO – Maceió International Airport	740.610	24.972	765.582

(*)Passengers – departure and arrival (plus connection, not military) – Source: INFRAERO (2006).

4.2 Analysis Activities

Martel and Seneviratne (1991) say that whatever the configuration of the terminal, passengers complete a sequence of primary activities in the airport. Figure 2 shows the flow of primary activities through which orientation in the selected airports will be identified. As for Correia (2000), connecting passengers for this survey are those reporting at check- in, after the aircraft arrival.

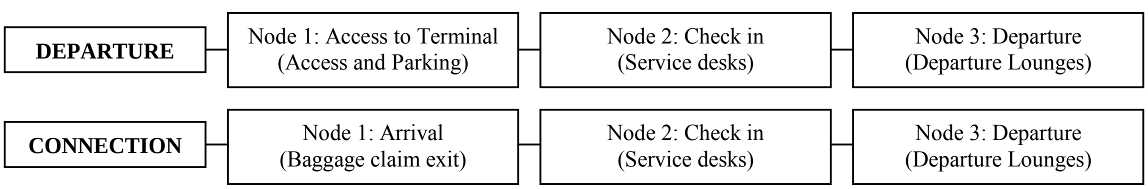

Figure 1. Study activities. (Source: The author)

4.3 Selection of analysis activities

The variables selected to conduct the survey at airports are: (1) change of level, (2) distance, (3) decision points, (4) type of configuration, (5) visual connection, (6) inter-connection density and the number of links, (7) dimension, (8) elements reducing visibility, (9) visibility index and (10) level of service of orientation.

4.3.1 Change of Level (MN)

The existence of different levels can separate, for example, the operational activities or environments of arrival and departure (Ashford and Wright, 1992) and has the advantage of a better use of the airport site; however, there may be higher costs for the operator besides causing major difficulties for orientation. As shown in Figure 3, according to the collected data, there is a trend indicating a higher number of changes of level (MN) when a terminal presents a complex configuration (ICD).

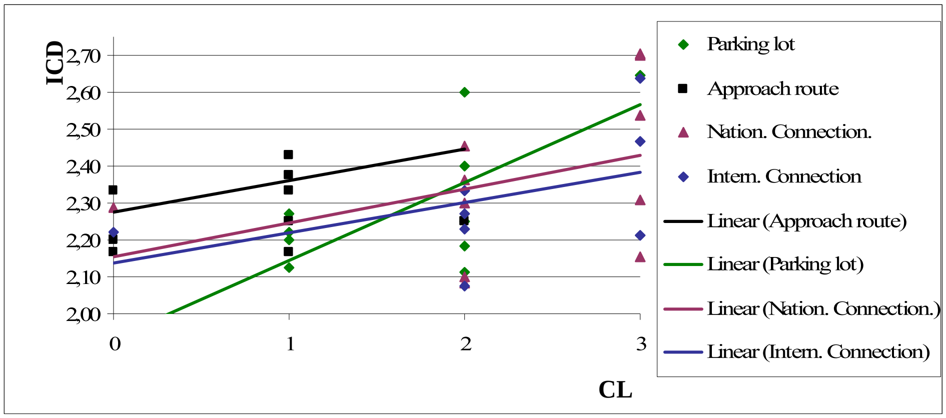

Figure 3. Relationship: number of changes of level (CL) and the complexity of the lay out (ICD).

4.3.2 Distance (Dist)

The variable Dist was obtained through the airport project, and this is the most likely route traveled by the user at each of the forms of arrival at the airport. The measurement unit was the meter.

4.3.3 Decision Points (PD)

The variable decision points are related to places where passengers have to decide which way to take. It considers the total number of points in the full way traveled by the user. A brief observation made indicates that, for all the airports of analysis, the number of decision points for a passenger who accesses the terminal through the parking area is always greater than the number of decision points for a passenger who accesses it through the route of arrival, as shown in Figure 4. In most configurations, the parking area is farther away from the main access routes than the passenger discharge area usually planned in front of the passenger buildings (de Neufville and Odoni, 2003).

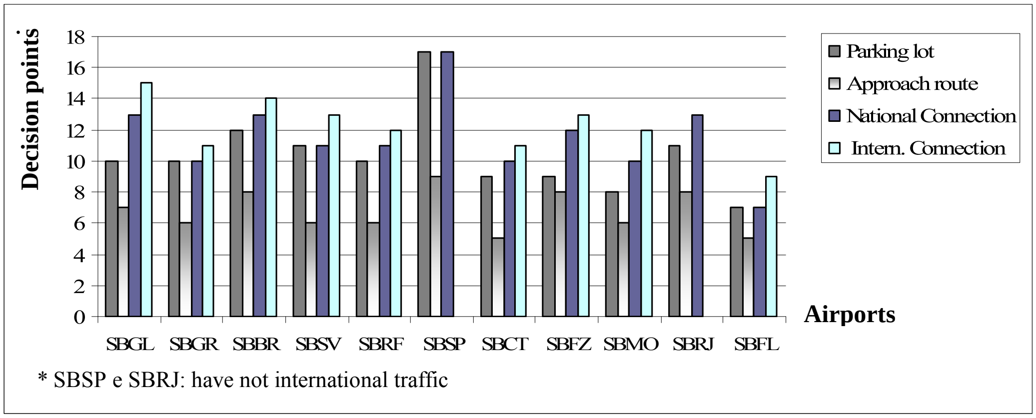

Figure 4. Relationship: Airports and number of decision points – considering form of access to airport. (Source: The author)

4.3.4 Type of Configuration (Config)

According to Hart (1985), there are basically four configurations of passenger buildings. In the "Pier" configurations, the aircraft are stationed in line on both sides of a corridor connection and, in the "Satellite" configurations the aircraft are stationed around a structure connected to the terminal, through a corridor (Hart, 1985). A "Linear" building is a long, relatively thin structure with one side devoted to aircraft and the other facing roads, parking lots and "Transporters" are the broad category of rubber-tired vehicles that move passengers between passenger buildings and aircraft (de Neufville and Odoni, 2003).

As shown in Table 2, for this work, the variable "type of configuration" will be treated as binary and airports of studies are separated into: (1) linear airports, the value of which is represented by one and (2) non-linear airports, the value of which is represented by zero.

Table 1. Value of binary variables for each airport (Source: The author).

Locale	Configuration	Categories	Binary
SBSP – São Paulo/ Congonhas International Airport	Linear	Linear	1
SBGR – São Paulo/ Guarulhos International Airport	Pier	Non- linear	0
SBBR – Brasília International Airport	Satellite	Non- linear	0
SBGL – Rio de Janeiro/ Galeão International Airport	Linear	Linear	1
SBSV – Salvador International Airport	Pier	Non- linear	0
SBRF – Recife International Airport	Linear	Linear	1
SBCT – Curitiba International Airport	Linear	Linear	1
SBRJ – Rio de Janeiro/ Santos-Dumont Airport	Linear	Linear	1
SBFZ – Fortaleza International Airport	Linear	Linear	1
SBFL – Florianópolis International Airport	Linear	Linear	1
SBMO – Maceió International Airport	Linear	Linear	1

4.3.5 *Visual Connection (CV)*

The visual connection is a variable obtained by a matrix where its elements c_{ij} (with i = 1, 2, 3, ..., n_{ej} = 1, 2, 3, ..., m) are binary variables (zero or one) and indicate whether there is direct visual connection between two sequential central activities. Figure 5 presents a flowchart showing how to complete matrix (Table 3).

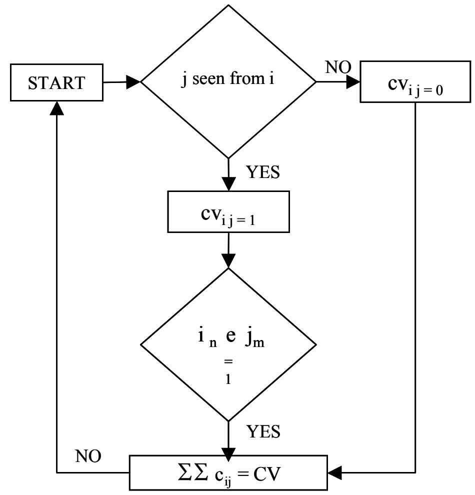

Figure 5. Flowchart for CV matrix

(Dada, 1997 - adjusted).

Table 3. Visual Connection Matrix (Dada, 1997 - adjusted).

Decision Point	i_1	i_2	i_3	…	i_n	Σline cv_{ij}
j_1	1	cv_{12}	cv_{13}	…	cv_{ln}	
j_2	cv_{21}	1	cv_{23}	…	cv_{2n}	
j_3	cv_{31}	cv_{32}	1	…	cv_{3n}	
…	…	…	…	1	…	
j_m	cv_{m1}	cv_{m2}	cv_{m3}	…	1	
Σcolumncv_{ij}						$\Sigma\ \Sigma$column$cv_{ij} = \Sigma\Sigma$linecv_{ij} = CV

4.3.6 *Inter-Connection Density (ICD) and Number of Links (Nlinks)*

O'Neill (1991 *apud* Dada 1997) shows an objective measure called inter-connection density (ICD) to measure the complexity of the layout. ICD is the average number of links or corridors per choice point (decision point). Note that the links refer to the number of possible ways that the user has at each decision points.

$$ICD = \frac{\text{Total number of links}}{\text{Total number of decision points}} \qquad (1)$$

4.3.7 *Dimension (Dim)*

The variable Dim refers to the total size (square meters) of the passenger terminal and has been incorporated since, among other types of interference, the larger the size, the more complex the building layout (ICD), as shown in Figure 6.

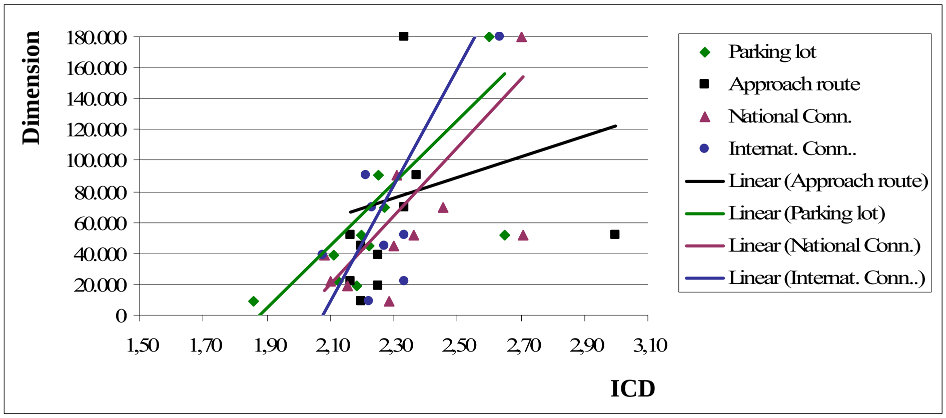

Figure 6. Relation between dimension (Dim) and Inter-connection Density (ICD). (Source: The author).

4.3.8 Elements Reducing Visibility (k_{ij})

As stated by Dada (1997), the k_{ij} represents the visual access when the physical variables between positions i and j are considered and it is a factor that can help or hinder arriving at destinations in an environment. When k_{ij} has a value of 1, there is a direct visual connection between the two activities centers i and j. When the value of k_{ij} approaches 0 (zero), there is no direct visual connection and most wayfinders will find it difficult to get to their destination. The effect of the loss of visual access is expected when related to the change of level (MN) and the decision points (DP), as the following equation shows:

$$k_{ij} = e^{-(0.01PD+0.1MN)} \quad (2)$$

4.3.9 Visibility Index (IV)

To quantitatively measure orientation inside a building, Braaskma and Cook (1980) used the visibility index (IV):

$$IV = \frac{Ls}{N(N-1)} \quad (3)$$

in which: Ls = number lights of sight and N = number of nodes.

Tosic and Babic (1984) classify the activities as essential and secondary. The determination of the importance of secondary activities and the visibility index was given by:

$$IV = \frac{\sum_{ij} c_{ij} w_j}{\sum_{ij} r_{ij} w_j} (r_{ij} \neq 0) \quad (4)$$

in which: c_{ij} = An indicator of visibility relevant and equal to 1 if, and only if, there is a visual connection between i and j. The w_j = weight of the destination activity and r_{ij} is a binary variable that represents the relevance of the connection.

Dada and Wirasinghe (1999) showed that two variables contribute to delays in wayfinding, namely the number of decision points and the number of level changes. The visibility index was modified, incorporating a variable (K_{ij}):

$$IV = \frac{\sum_{ij} r_{ij} K_{ij} w_{ij}}{\sum_{ij} r_{ij} w_j} \quad (5)$$

in which: K_{ij} = 1 (if there is a direct visual connection between two activities) or 0 (if not).

Correia (2005) states that the impact of a deficient orientation system usually takes the form of additional distance to be covered, especially for users unfamiliar with the environment. This author suggested the creation of the following orientation index (OI):

$$OI = \frac{\text{Real route distance}}{\text{Minimum route distance}} \quad (6)$$

For this work, the visibility index used is the model presented by Braaskma and Cook (1980) and adapted by Dada (1997):

$$IV = \frac{Ls}{N^2} \quad (7)$$

in which: Ls = number of lines of vision and N = number of central activities or nodes.

The use in the present work of the proposals for the visibility measurement index previously illustrated were discarded, since they incorporate the variable in model w which is related to the weight of the destination activity. As this work includes only the primary activities of the airport, this implies that all of them have equal weight of importance.

4.3.10 Level of Service (NS) of the Orientation

The level of service of an airport can be measured based on different criteria. Many organizations and airlines have their level of service measurement standards, especially in terms of quality of service and level of comfort. Table 4 shows that, for this survey, the level of service will be assessed as to the direction and is directly coupled to the values of the visibility index.

Table 4. Visibility Index and Level of Service of Orientation - (Dada, 1997).

Level of Service (NS)	Representation	Visibility Index (IV)
A	Well above average	$NS_A > 0.58$
B	Above average	$0.46 \leq NS_B \leq 0.58$
C	Average	$0.34 \leq NS_C < 0.46$
D	Bellow average	$0.22 \leq NS_D < 0.34$
E	Well bellow average	$NS_E < 0.22$

4.4 Data collection

Data was collected from architectural plans and site visits at each airport. The next tables present data for each airport and the study variables in relation to the forms of access to the airport. Note that airports are presented in the tables in decreasing order of size (m2).

Table 5. Data: Samples and Variables - Access: Parking lot

Airport	Dim	MN	Dist	PD	Config	CV	N*Links*	ICD	K_{ij}	IV	NS
SBGL	280.681	2	425	10	1	26	24	2.40	0.74	0.26	D
SBGR	179.790	2	550	10	0	28	26	2.60	0.74	0.28	D
SBBR	90.100	2	480	12	0	33	27	2.25	0.73	0.23	D
SBSV	69.750	1	480	11	0	29	25	2.27	0.81	0.24	D
SBRF	52.000	1	445	10	1	28	22	2.20	0.82	0.28	D
SBSP	51.535	3	720	17	1	54	45	2.65	0.63	0.19	E
SBCT	45.000	2	300	9	1	27	20	2.22	0.83	0.33	D
SBFZ	38.500	2	335	9	1	23	19	2.11	0.75	0.28	D
SBMO	22.000	1	250	8	1	20	17	2.13	0.84	0.31	D
SBRJ	19.000	2	500	11	1	35	24	2.18	0.73	0.29	D
SBFL	8.703	0	290	7	1	17	13	1.86	0.93	0.35	C

Table 6. Data: Samples and Variables – Access: Approach route (Passenger discharge).

Airport	Dim	MN	Dist	PD	Config	CV	N*Links*	ICD	K_{ij}	IV	NS
SBGL	280.681	1	385	7	1	19	17	2.43	0.84	0.39	C
SBGR	179.790	1	380	6	0	16	14	2.33	0.85	0.44	C
SBBR	90.100	1	430	8	0	20	19	2.38	0.84	0.31	D
SBSV	69.750	0	375	6	0	12	14	2.33	0.94	0.33	D
SBRF	52.000	0	335	6	1	15	13	2.17	0.94	0.42	C
SBSP	51.535	2	660	9	1	19	27	3.00	0.83	0.23	D
SBCT	45.000	0	250	5	1	13	11	2.20	0.95	0.52	B
SBFZ	38.500	1	390	8	1	20	18	2.25	0.84	0.31	D
SBMO	22.000	1	270	6	1	14	13	2.17	0.85	0.39	C
SBRJ	19.000	2	480	8	1	24	18	2.25	0.76	0.38	C
SBFL	8.703	0	245	5	1	13	11	2.20	0.95	0.52	B

Table 7. Data: Samples and Variables – Access: National Connection

Airport	Dim	MN	Dist	PD	Config	CV	N*Links*	ICD	K_{ij}	IV	NS
SBGL	280.681	3	690	13	1	33	33	2.54	0.65	0.20	E
SBGR	179.790	3	740	10	0	24	27	2.70	0.67	0.24	D
SBBR	90.100	3	720	13	0	39	30	2.31	0.65	0.23	D
SBSV	69.750	2	715	11	0	29	27	2.45	0.73	0.24	D
SBRF	52.000	2	590	11	1	28	26	2.36	0.73	0.23	D
SBSP	51.535	3	920	17	1	44	46	2.71	0.63	0.15	E
SBCT	45.000	2	320	10	1	26	23	2.30	0.74	0.26	D
SBFZ	38.500	2	445	12	1	33	25	2.08	0.73	0.23	D
SBMO	22.000	2	300	10	1	28	21	2.10	0.74	0.28	D
SBRJ	19.000	3	700	13	1	39	28	2.15	0.65	0.23	D
SBFL	8.703	0	350	7	1	17	16	2.29	0.93	0.35	C

Table 8. Data: Samples and Variables – Access: International Connection

Airport	Dim	MN	Dist	PD	Config	CV	N*Links*	ICD	K_{ij}	IV	NS
SBGL	280.681	3	740	15	1	39	37	2.47	0.64	0.17	E
SBGR	179.790	3	770	11	0	29	29	2.64	0.66	0.24	D
SBBR	90.100	3	750	14	0	44	31	2.21	0.64	0.22	D
SBSV	69.750	2	770	13	0	35	29	2.23	0.72	0.21	E
SBRF	52.000	2	630	12	1	30	28	2.33	0.73	0.21	E
SBSP*	-	-	-	-	-	-	-	-	-	-	-
SBCT	45.000	2	340	11	1	31	25	2.27	0.73	0.26	D
SBFZ	38.500	2	510	13	1	39	27	2.08	0.72	0.23	D
SBMO	22.000	2	360	12	1	34	28	2.33	0.73	0.24	D
SBRJ*	-	-	-	-	-	-	-	-	-	-	-
SBFL	8.703	0	390	9	1	28	20	2.22	0.91	0.35	C

*** SBSP (Congonhas/ SP) and SBRJ (Santos Dumont/ RJ): have not international traffic.**

4.5 Statistical Method: Multivariate Statistical Analysis

Once the data were collected, the multivariate statistical analysis method was applied. The method was chosen because it orders and groups the parameters of investigation and also the dependences among them (Coelho, 2004). This method was split into several techniques, two of which are applied in this research:

(1) Cluster Analysis: the cluster analysis splits sample elements into groups so that the elements belonging to one cluster are similar to each other regarding the variables measured, and the elements in different clusters are heterogeneous (Mingoti, 2005) and;

(2) The Principal Components Analysis: method was used when it was essential to analyze more than two variables (Collins, 1980), where what was required was the transformation of variables observed into new variables to which they are correlated and organized in decreasing order of importance (Moita Neto and Moita, 1998).

5. IMPLEMENTATION AND ANALYSIS OF RESULTS

5.1 Analysis - Access to Terminal: Parking and Curbside

The cluster analysis was applied for each of the possible forms of arrival at the airports, to generate a cluster diagram to identify those airports with similarities, according to the variables chosen. Figure 7 shows the analysis of the similarity between airports, when access to the airport is by vehicle in the parking lot and approach route.

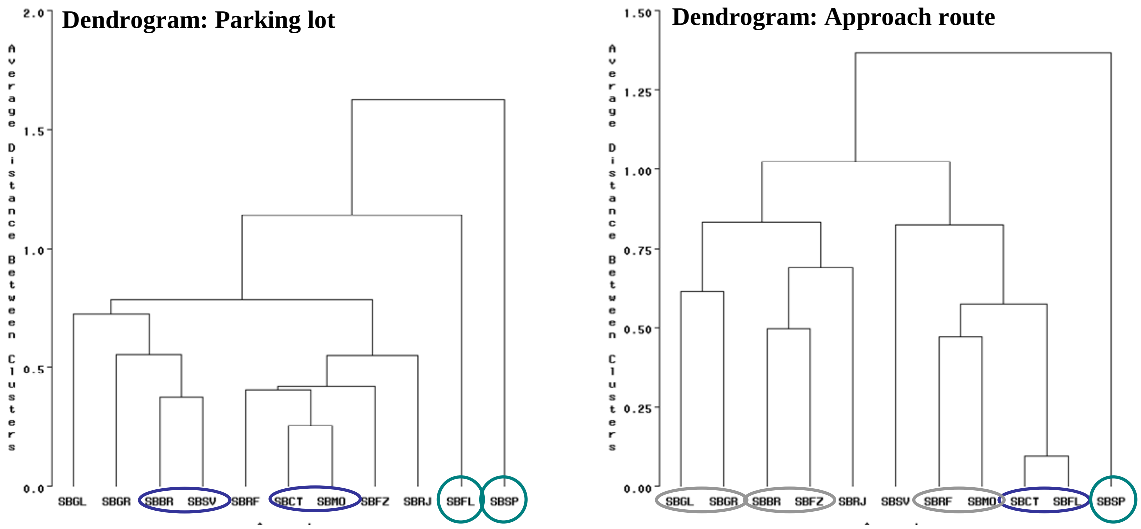

Figure 7. Dendrogram. (Form of arrival: Parking lot and Approach route).

With access through the parking lot of the airports, SBCT and SBMO have been taken together since the kind of linear configuration and similarity in the number of decision points (DP) was shown. The clustering of the SBBR and SBSV occurred because, in spite of the difference between the size of the terminal, both have the configuration "non-linear"; passengers walk the same distance between the parking lot to the boarding gate and the level of service concept for their guidance was classified as "D" (below average).

With access through the approach route, airport SBSP remains isolated from other groups. This shows the way, between the approach route and boarding gate, the greater distance, the greater number of decision points and high complexity of the lay out. The airports with more similar characteristics are SBCT and SBFL (some similar variables: distances, decision points, type of configuration, visual connection, number of links and visibility index). To verify the analysis conducted by the cluster technique, the data collected was applied to the principal components method of analysis, as described in Figure 8.

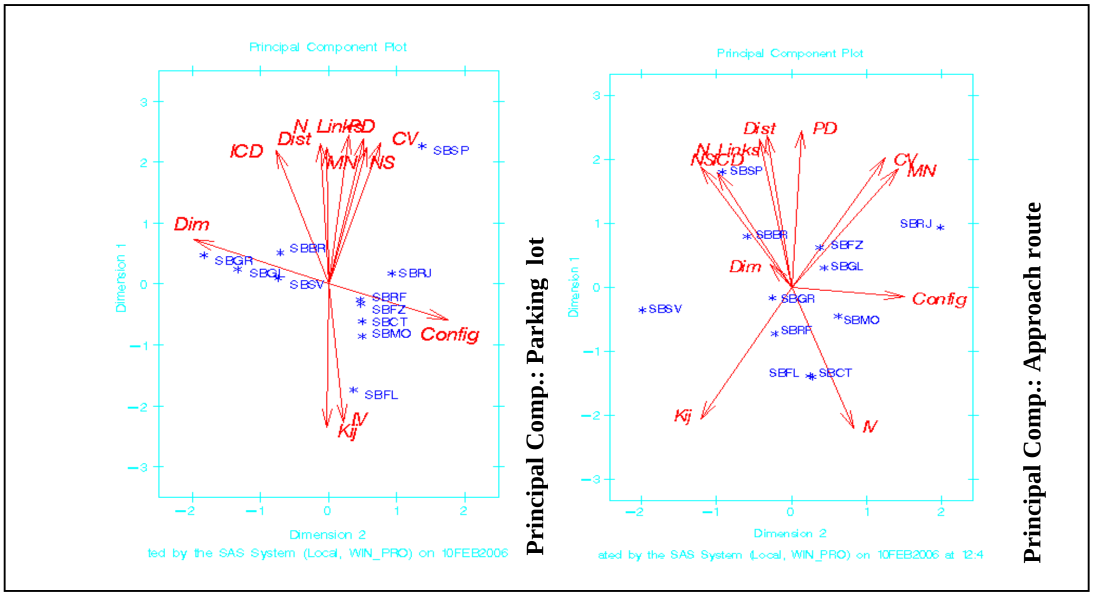

Figure 8. Chart Principal Components, (Form of arrival: Parking lot and Approach route).

As in the dendrogram of Figure 7, SBSP airport is isolated from the others; SBFL airport is also isolated from the groups because it is a small airport. To complete the entire way between the essential activities, level changing is not necessary, in addition to other characteristics, different from other airports (fewer decision points, lower rate of layout complexity and high visibility).

5.2 Analysis – Form of Access: National Connection and International Connection

On arrival at the airport through connection, it is observed in Figure 9 that SBFL airport is isolated. It is a terminal of smaller size, the distance between activities is also smaller and change of level is unnecessary.

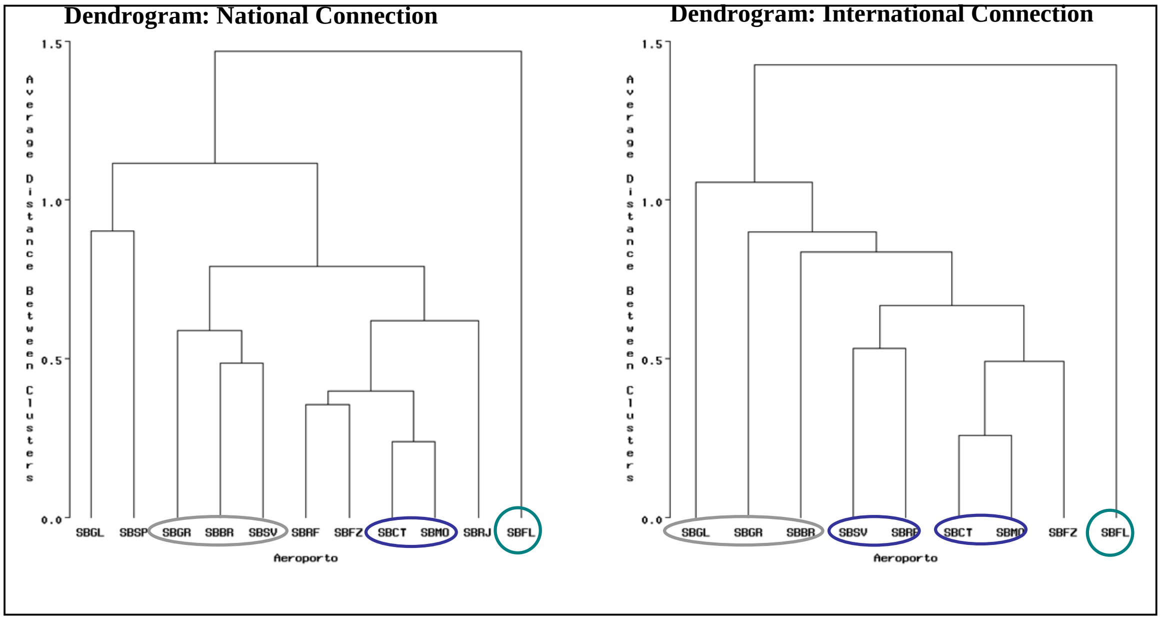

Figure 9. Dendrogram. (Form of arrival: National Connection and International Connection).

Concerning the arrival at the terminal through the international connection, there is a cluster: SBSV and SBRF airports. In spite of having different architectural configurations, they have similar variables such as change of level, decision points, number of links, visibility index, and both airports were ranked at level of service "E" for guidance. The SBGL, SBGR and SBBR airports are the three major airports in Brazil and all have the largest numbers of change of level, decision points, and number of links.

The chart “Principal Components”, on arrival at the terminal through the national connection, is shown in Figure 10, confirming that the SBFL airport is distant from the others. The SBSP airport is the closest to the SBGL airport, since they have similarities, even with distant variables such as distance and layout complexity.

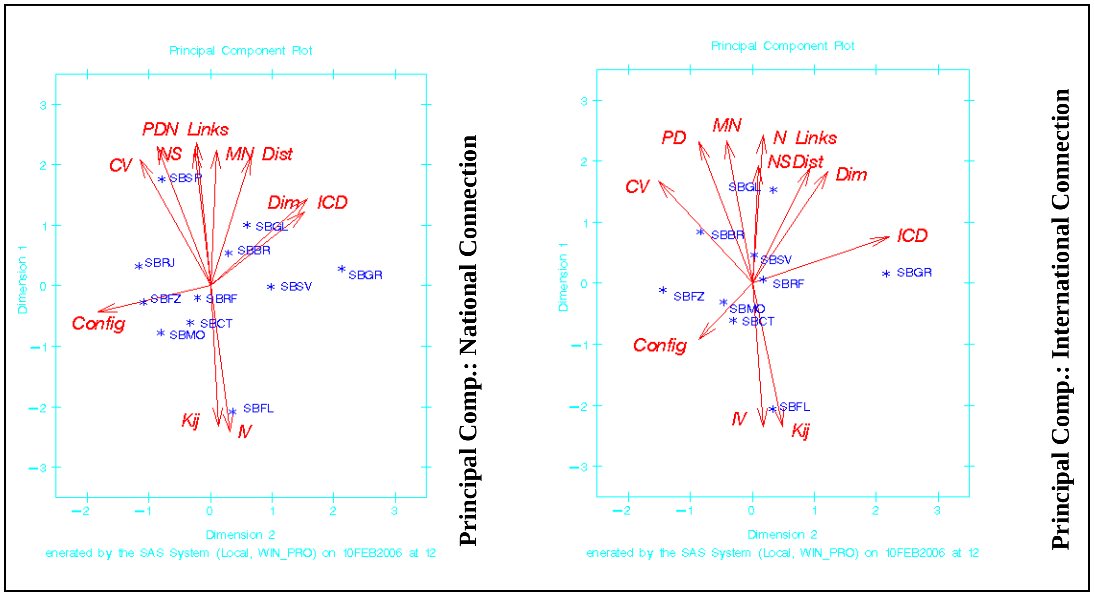

Figure 10. Chart Principal Components. (Form of arrival: National and International Connection).

For international connection, the airport of Guarulhos (SBGR) has a more complex layout configuration (ICD) and also greater distance regarding the pathway from the aircraft to the new boarding gate. The Galeão airport /RJ (SBGL) has the largest dimension of all the airports under analysis and presents the highest number of decision points and links and with the lowest visibility index. The airport in Brasília (SBBR), despite presenting more visual connection between the activities, also presents a large number of decision points.

6. FINAL CONSIDERATIONS

It is well known that corrective actions after the construction phase, when the building is already habitable, involve complex solutions and significant costs. However, corrective actions like as signaling the decision points of the terminal, should be done by the airport administrators, especially those that have been classified as low orientation. Other possible procedures would be to locate properly terminal maps, and even explore architectural solutions or different lighting on the way to indicate the way forward to the passenger.

When designing the architecture of an airport, the professional in charge must be aware of the zoning of activities within the terminal, balancing the interests of directors, airlines and mainly the passengers. When designing a TPS, at the activities planning and zoning stage, it is important for the layout of the building to provide evidence of a sequential footway that the passenger should follow. For this reason, it is important to note that the variables mentioned in this work are significant in designing a logical layout of activities over an airport, to facilitate the process of finding ways.

It is essential that the activities are arranged so as to minimize the distance traveled, number of decision points, changes of level and to broaden the visibility for the sectors. The lack of complexity of layout, with a low number of links at the decision point, makes it easier for the user to choose the correct way. Also, the existence of visual connection favors an increase in the visibility index and, therefore, improves the level of service concerning the guidance offered to the passenger. Integrated access, logical sequence and functionality between primary activities make it easy to find the way, reduce the time to search for activities and, consequently, provide comfort and safety to the passenger.

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