

# **Regular public transport rescheduling or university intervention in enhancing students' transport to the Campus do Agreste at UFPE**

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## **ABSTRACT**

This paper aims to evaluate quantitatively and qualitatively the conditions of mobility in relation to the Campus of Centro Acadêmico do Agreste at the Universidade Federal de Pernambuco based on the regular public transport available and the viability of university intervention in providing a special transport service to meet the students' needs. The operation of this line is subject to constant complaints from its users with respect to its offer as travel and waiting times are considered high. To undertake the evaluation, questionnaires were administered to the line's users on trips both up and down the line to try to establish the most viable solution to meet the users' needs from technical, operational and users' perspectives. The research proposes operational reprogramming, increasing the frequency of service at peak hours and undertaking express trips during periods of low demand.

## **1. INTRODUCTION**

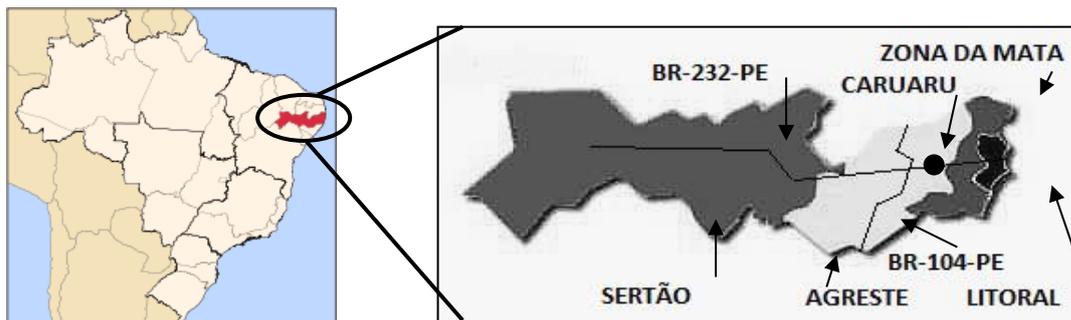
Brazilian higher education has a past characterized by the centralization of its educational structures, which were usually located in large cities, as well as a limited number of places and courses offered. According to Martins (2002), in the 1960s the Brazilian educational system had approximately 100 higher education institutions, most of them small and located predominantly in large urban centres, focused on knowledge transmission and populated by faculty with little academic professionalization. These establishments had just over 100 thousand students, predominantly male. Access to university became a barrier to be overcome for students residing in distant cities given, among other things, the costs of displacement and maintenance during the period of study.

However, in recent years the internalization of the educational structures of higher education and the increase in access to it, especially on public courses, has altered the dynamics of access to education. Since the launch of Brazil's Federal Government Programme called "Reuni", 126 new public university campuses have been created, meaning that there has been a considerable increase in the number of higher education institutions from 148 in 2002 to 274 in 2010 and there are estimated to be 321 in 2014. Today, Federal public universities are present in 237 municipalities and the number of students at these institutions increased from 109,200 in 2003 to 222,400 in 2010 (Brasil, 2013). However, this new situation has only been taken into consideration to a limited extent in analyses in the area of transport.

The Universidade Federal de Pernambuco (UFPE, Federal University of Pernambuco) originally had only one campus in the city of Recife, the capital of Pernambuco state, located in north eastern Brazil (Fig. 1). Two new campuses have been developed: the Centro Acadêmico do Agreste (CAA) in Caruaru (140 km from Recife) and the Centro

Acadêmico de Vitória (CAV) in Vitória de Santo Antão (60 km from Recife). The regional character of these new campuses raises a key issue in terms of access. In relation to this, it is important to study the conditions of accessibility to and mobility of students, gaining an understanding of their needs, perspectives and socioeconomic backgrounds.

Given the above, the focus of this article is the analysis of student mobility in relation to one of these campuses, the CAA, located in the Agreste region of the state of Pernambuco (Fig. 1). Geographically, the Agreste region of Pernambuco extends over an area of approximately 24,400 km<sup>2</sup>. It covers 71 cities, representing 24.7% of Pernambuco's territory and has around 1.8 million residents, or 25% of the state population. The most populous cities of the region (IBGE, 2010) are: Caruaru (314,912 residents), Garanhuns (129,408 residents) and Santa Cruz do Capibaribe (87,582 residents).

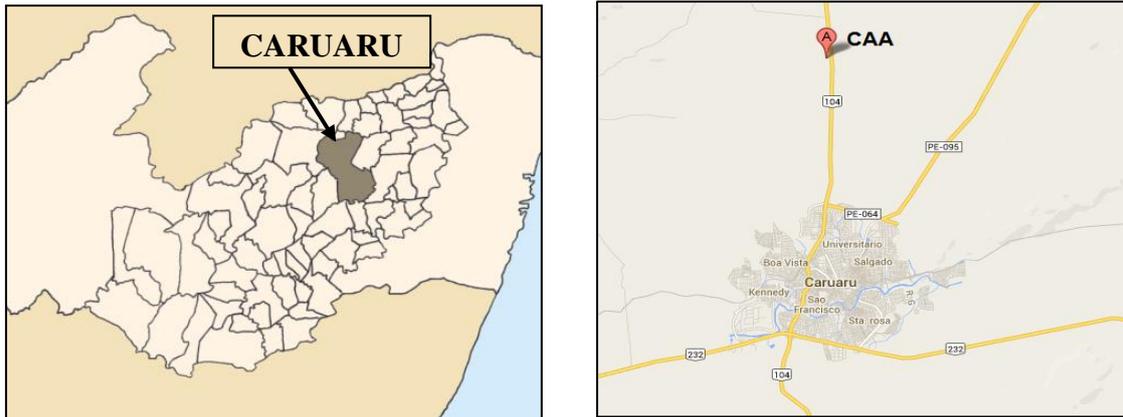


**Fig. 1 – Location of the state of Pernambuco and its regions**

Analysing the educational aspects of Agreste in the year 2008, the region had 15 universities, including federal, state and municipal institutions, as well as private and philanthropic institutions. However, the level of education of its population is low, with over 50% of the population (895,493 of 1,536,565 inhabitants over 10 years) having up to seven years of study and thus not even finishing high school (Condepe-Fidem, 2011a).

From the employment point of view, only 10% of the region's population is in formal employment. In contrast, this is a region that is experiencing high rates of economic growth. In terms of gross domestic product (GDP), Pernambuco and the Agreste region have been growing faster than the average for Brazil. The quarterly variation in GDP at market prices for the first quarter in 2011 compared to the same period in 2010 shows that the GDP of the state increased by 7.6%, whereas that for Brazil overall increased by 4.2% (Condepe-Fidem, 2011b). In the specific case of the Agreste region, GDP per capita grew by more than 120% between 2001 and 2008, from USD 2,620.85 to USD 5,776.60. The increase in GDP observed in this region of the state suggests an increasing trend in demand for and access to education at a higher level due to the requirement for more and better skilled human resources and the progress of science and technology.

Focusing specifically on the CAA, it is situated at the northern limit of the urban area of Caruaru. It is 8 km from the downtown area of the city, with road access through the BR-104-PE route and 138 km from Recife, with road access through the BR-232-PE route (Fig. 2). It should be highlighted that these roads were widened to dual carriageways in 2004 and 2012, respectively. Therefore, they provide good levels of service and accessibility and have no capacity problems.



**Fig. 2 – Location of Caruaru and the CAA in the Agreste region of Pernambuco**

In 2013, the CAA offered 10 graduate courses and four postgraduate courses, serving approximately 3,500 students from around 70 different municipalities. The profile of these students' trips to and from the campus was investigated in field research conducted by Andrade *et al* (2013) and reflects the regional character of the campus. In Andrade *et al*'s (2013) study, among the sample of students who accessed the CAA daily, 55% were resident in Caruaru and 45% were from 41 other municipalities in the Agreste, Zona da Mata and Litoral regions of Pernambuco with travel distances distributed as follows: i) 20–40 km (10% of total); ii) 41–60 km (15%); iii) 61–80 km (6.5%); iv) 80–100 km (3.5%); v) over 100 km (10%). The modal split of all trips attracted by the CAA shows that 23.2% of travel is by private modes (car and motorcycle), 34.1% by regular urban bus and 42.7% using chartered vehicles (buses and vans).

When considering only students who are resident in Caruaru, the modal split shows that 31.3% use private modes (car or motorcycle) and 68.7% use collective modes. Of those who use collective modes, 80% travel by regular public transport on the single bus line that serves the CAA and the others use chartered vehicles, typically vans from various areas within the city. It should be noted that one in three students who use public transportation regularly take an additional auxiliary suburb–CBD line and then take the CBD–CAA bus line. These lines are not integrated, resulting in additional costs and travel time for the students.

According to Andrade *et al*'s (2013) study, the average travel time of CAA students is 45 minutes, with a range which varies from 15 to 80 minutes depending on the distance from the point of origin, transport mode used and the number of transfers carried out. Analysing only the regular public transport, the average travel time within Caruaru (from the home exit) is 60 minutes, with variations of between 20 and 80 minutes, for an average distance of 8 km, with variations of 5.2 to 10.5 km. This average time and the lower and upper limits are practically equal to the travel times reported by students living in cities located up to 40 km away from the CAA. This is in part because the two major road links to the campus are dual carriageways and have good levels of service.

Nonetheless, it is apparent that something is amiss in the provision of urban transport to CAA in terms of travel time. The perceptions of the students who use public transportation are that service on the regular line is poor, as illustrated by the repeated requests to the UFPE's Central Administration to intervene; the poor level of service is a problem that has consequences for the students' quality of life and possibly their academic performance. As a result of these complaints, the UFPE's Central Administration pledged to intervene in the

problem, even suggesting the operation of its own university bus as a reinforcement to reduce the deficiencies in the current service should such a solution be proved to be effective.

It should be noted that the Brazilian Federal Constitution, in art. 30, V, says it is “the responsibility of municipalities to design and deliver, directly or by concession or permission, public services of local interest, including mass transport, which is of an essential nature” (Brasil, 1988). Therefore, considering the short distances to the CAA and the obligation of the municipality to provide transportation services and not specifically responsibility of the university, which would be acting in a secondary capacity, the objective of this study is to evaluate the viability of ways of addressing this issue, taking into account technical, operational and student perspectives. At the same time, we aim to examine the degree of fit between users’ perceptions of potential solutions to the problems posed, the consequences of these problems and the proposed solutions, and the technical solutions recommended from the strictly technical and legal standpoint.

## **2. METHODOLOGY**

To study and analyse the students’ mobility and accessibility issues in relation to the CAA and contribute to the decision-making process concerning which solution(s) should be adopted, two surveys were developed: (1) the first applied the stated preference approach with students and explored the problems with the regular public transport public service, their causes and consequences, as well as possible solutions; (2) a field survey was conducted to test the operating conditions of the transmission line that serves the CAA in relation to the offer of transport and loading conditions. The goal of these stages in the research was to characterize the performance of the line, gain an understanding of the problem as perceived by the users and test the consistency of the proposal by the UFPE’s Central Administration against these.

There is a preference for using case studies in research on transport. Kroes and Sheldon (1988, cited in Brito, 2007, p. 42) define case studies in the transport context as a family of techniques using statements from individuals concerning their preferences given a set of transportation options for the estimation of utility functions. These options can be descriptions of actual situations or hypothetical scenarios constructed by the researcher. The technique was developed for marketing research in the 1970s, becoming widespread by the end of the decade. It is a relatively recent development in transport, some of the first publications on the subject dating from the early 1980s, such as those by Steer and Willumsen in 1981 and Sheldon and Steer in 1982 (Bates, 1988).

The opinion poll was conducted through the application of a structured questionnaire concerning the major problems faced with regular public transport and the consequences of these in student life. Respondents were also requested to rank certain alternatives in a hierarchy related to proposals for solving or mitigating the problem. The sample size to be interviewed was determined based on research conducted by Andrade *et al* (2013), who verified through a count on two representative days that approximately 34% of all students access the CAA using regular public transport. Thus, seeking to ensure a minimum of 90% confidence and a maximum statistical error of 10%, the sample size calculated for the user population of approximately 1,200 students was 398 interviews, estimated using the following expression:

$$n = \frac{N \cdot \sigma^2 \cdot \left(\frac{Z_{\alpha/2}}{2}\right)^2}{(N - 1) \cdot E^2 + \sigma^2 \cdot \left(\frac{Z_{\alpha/2}}{2}\right)^2} \quad (1)$$

where: n is the sample size, calculated as 398;

N is the population, in this case 1,200 students;

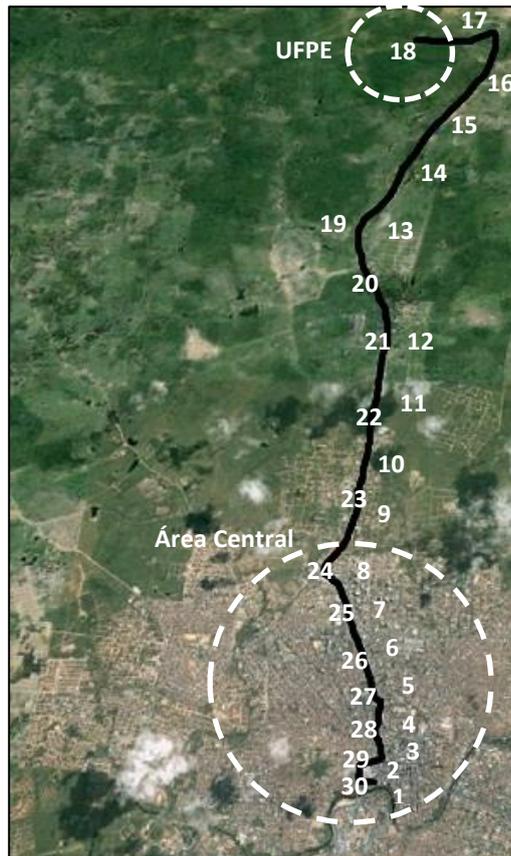
$\delta$  is the standard deviation = 1.39 km (for the variable of average travel distance);

$z_{\alpha/2} = 1.645$  (the critical value for the 90% confidence level);

E is the statistical margin of error (10% average for 8 km, also obtained in the research).

The second step was to undertake a field survey to test the operating conditions of the regular bus line serving the CAA both up and down the line. According to TecBus (2013), surveys of passenger traffic are used as an instrument to obtain the consistent information needed for sizing the lines of a transportation system, enabling an increase in productivity without compromising the quality of service offered. Varied research methodologies have been used by professionals in the area of transport to examine passenger traffic and the approach examining the combination of up and down trips has been found to provide a wider range of results than other approaches. The methodology adopted in this study thus comprised the following steps:

- 1) Identification of the existing bus stops on the route of the line. The bus line to the CAA has a total of 30 stops, which were numbered from 1 to 30 (Table 1), with the initial bus stop located at the CBD and the final stop at the CAA. Stops 1 to 18 indicate the route from the CBD to the CAA and 18 to 30 the route in the opposite direction.
- 2) Following this, the researchers were divided into pairs to conduct the survey. The research was undertaken on 9–11 April 2013, from 7 am to 10:30 pm (which are the hours of work of the CAA) and corresponded to day of typical travel behaviour (Tuesday, Wednesday and Thursday). One of the researchers presented a card to each of the users who boarded the bus. These cards contained the identification of each bus stop used by each user. When the users alighted, the cards were collected and separated according to where they did so. Thus, it was possible to establish exactly the number of passengers who boarded at each stop and where they alighted, allowing the construction of an origin–destination matrix for each time range.



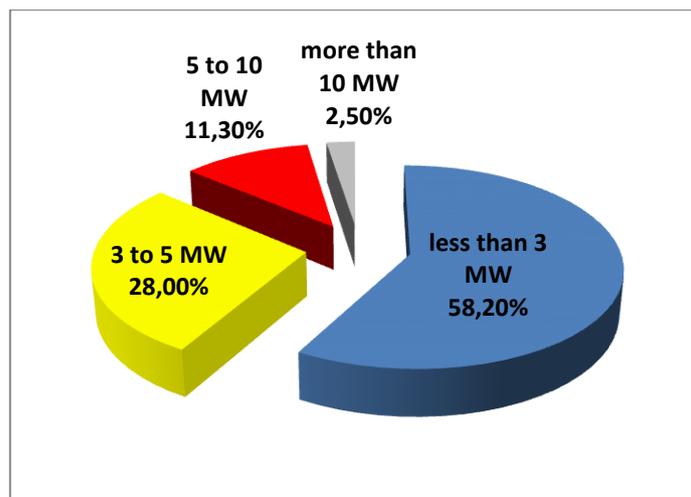
**Fig. 3 – Public transportation route for the regular bus line serving the CAA**

No.	Bus stop	No.	Bus stop
01	Casas Cabral	16	Retorno da BR-104-PE
02	Banco do Brasil	17	Entrada do CAA
03	Farmácia A Fórmula	18	CAA
04	Shopping Difusora	19	Polo Comercial
05	VIP Informática	20	Ramos Transportadora
06	Ótica Nassau	21	Tupan
07	Laboratório Cerpe	22	Rodobenz Caminhões
08	Posto Texaco	23	Posto Petrobras
09	Clínica Ortoface	24	Doydo Motos
10	Justiça do Trabalho	25	China Veículos
11	Churrascaria Sabor da Fazenda	26	Caixa Econômica
12	Jordão Moraes	27	Nagem Informática
13	Hospital Mestre Vitalino	28	Estádio Luiz Lacerda
14	Afonso Auto Molas	29	Academia Physical
15	Churrascaria Asa Branca	30	Prefeitura de Caruaru

**Table 1 – Location of bus stops for the CAA’s bus line**

### **3. RESULTS OF STATED PREFERENCE RESEARCH WITH STUDENTS**

The results indicate that the regular users of the public bus to the CAA are members of families with varied profiles of monthly income, as shown in Fig. 4. The transportation problems that affect CAA students living in Caruaru were therefore analysed according to this income distribution.



**Fig. 4 – Profile of CAA students’ monthly income (in relation to the Brazilian minimum wage)**

Table 2 shows the main problems reported, such as long waiting times, lateness/irregularity in the operation of buses and the poor condition of the buses. Table 2 also shows that the level of annoyance is related to the family income, which suggests that there may be a higher tolerance for the low quality of transport among the poorer population. It can also be observed that the problems resulting from the tariff charged and the lack of alternative lines affect only those from families with incomes up to five times the Brazilian minimum wage (in 2013, the Brazilian minimum wage was USD 278.51), deriving from the greater economic vulnerability of the poor and their concentration in the suburbs with low levels of access to the CAA; this is in contrast to the results for those from wealthier families using the route, which also runs through middle- and higher-income areas.

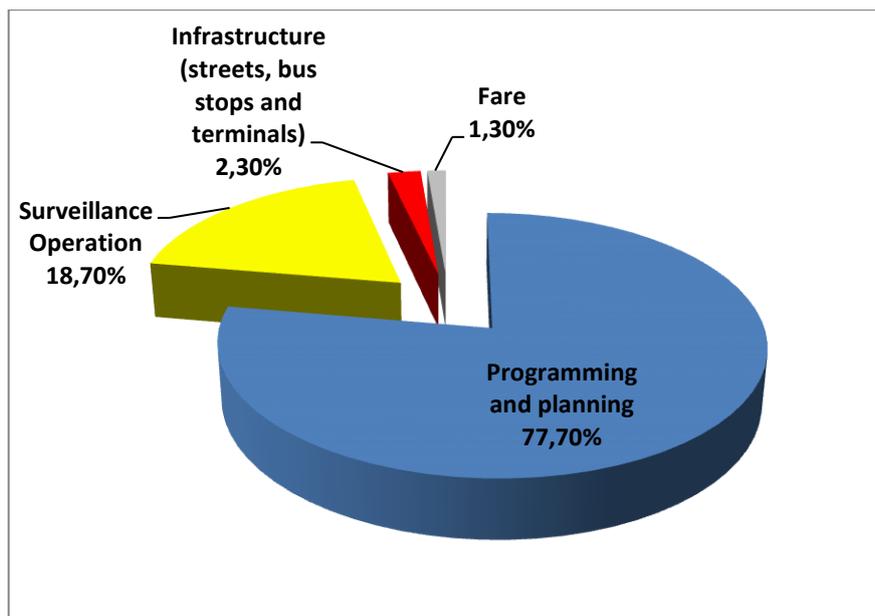
Concerning the aggregated sets of related problems, the following aspect were noted, as shown in Fig. 5: (1) inadequate urban transport planning for the CAA (77.7%); (2) deficiencies in supervision of operations (18.7%); (3) the poor quality of road infrastructure and operational support (location of stops and terminals) (2.3%); (4) high tariffs (1.3%). That is, the planning and supervision of the operation are the main concerns mentioned, both of which lie within the remit of the municipal administration, with the other issues being ranked at a much lower level.

Family income	Insufficient alternative lines	Fleet incompatible with the demand	Lack of infrastructure	Long waiting time	Lateness and irregularity
less than 3 x MW	7.0%	12.7%	2.2%	27.0%	14.8%
3 to 5 x MW	6.1%	13.9%	2.6%	34.8%	15.7%
5 to 10 x MW	0.0%	6.7%	2.2%	37.8%	20.0%
more than 10 x MW	0.0%	8.3%	0.0%	41.7%	25.0%

Family income	Poor upkeep of the buses	Poor timing	Overcrowding	High fares	Total
less than 3 x MW	1.7%	11.4%	22.3%	0.9%	100%
3 to 5 x MW	3.5%	5.2%	16.5%	1.7%	100%
5 to 10 x MW	6.7%	2.2%	24.4%	0.0%	100%
more than 10 x MW	0.0%	8.3%	16.7%	0.0%	100%

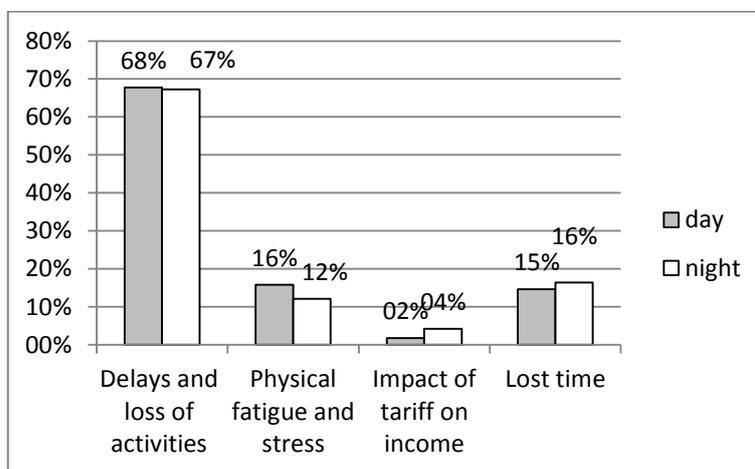
**Table 2 - Main problems distinguished by family income distribution**



**Fig. 5 – Aggregated classification of causes of problems**

In relation to planning problems, 67% of the interviewees complained about the effects of scaling and inadequate programming on the line that serves the CAA, which generate excessive waiting and travel times and overcrowding on buses. Furthermore, 27% complained about the inadequacy of the itinerary and the lack of alternative lines with points of origin in other parts of the city. Regarding the problems arising from deficiencies in the inspection of the operations, 85% of users highlighted failures to comply with timetables, generating irregularities in the intervals between buses and 15% complained about the poor maintenance of buses.

Looking at Fig. 6, it can be seen that 67% of the students attending the CAA, regardless of whether it was during the day or at night, when asked about the consequences of the problems with the service for their quality of life or academic performance, point to the loss of activities and missing classes due to delays; approximately 16% of the students who attend daytime classes and 12% of those who attend night classes highlighted the excessive loss of time, which could be usefully spent on school activities. Furthermore, 15% also report experiencing stress and physical exhaustion. However, the impact of fares in relation to income is less salient.



**Fig. 6 – Evaluation of the consequences of problems**

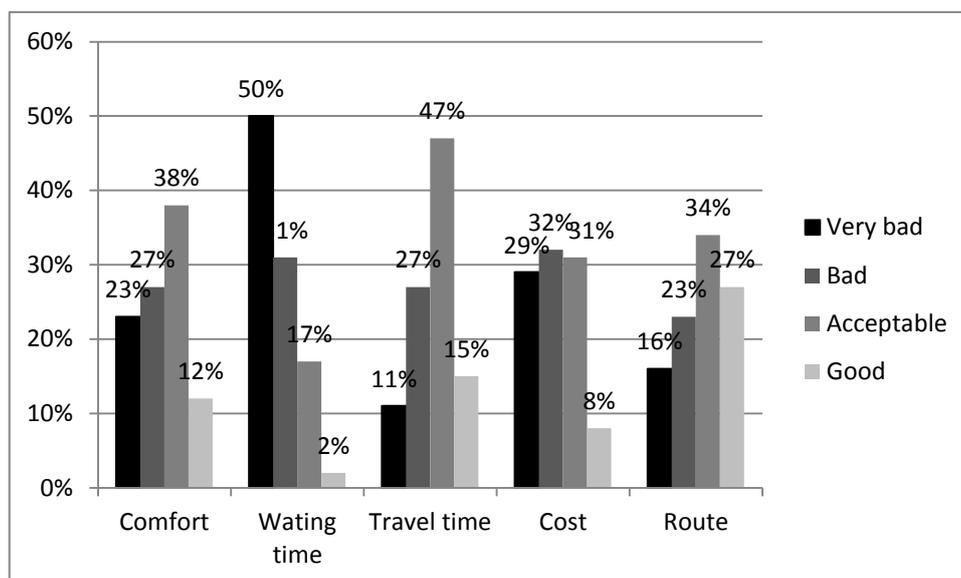
In Table 3, which illustrates the consequences of the problems reported by students distinguished by the income level of the family, it can be observed that the impact of the fares charged on income, for example, only affects the group of students in families earning up to three times the minimum wage as might be expected. It can also be seen that the perception of the importance of time lost increases in line with higher income levels, being especially salient for those from families with an income of more than ten times the minimum wage. This confirms the theory that the value of time lost is directly proportional to the cost of missed opportunities in the case of higher income families. On the other hand, the consequences in relation to delay and the consequent loss of activities and stress/physical exhaustion have no correlation with family income.

	Delays/loss of activities	Physical fatigue/stress	Impact of tariff on income	Lost time
less than 3 x MW	70.3%	10.8%	5.4%	13.5%
3 to 5 x MW	60.4%	19.8%	0.9%	18.9%
5 to 10 x MW	62.2%	15.6%	0.0%	22.2%
more than 10 x MW	72.7%	-	-	27.3%

**Table 3 – Consequences of problems in relation to students’ family income**

In relation to the quality of service of the single bus line offered, Fig. 7 shows that the waiting time is classified as very bad/bad by approximately 81% of users. This reinforces the characterization of the main causes of problems comprising predominantly the planning and supervision of the operation as reported by over 95% of the interviewees (see Fig. 5). Furthermore, almost 50% of users complain about the comfort of the vehicles.

Regarding the usefulness of the line, 37% reported the route to be bad/very bad for their purposes, thus suggesting the need for other options. This is linked to the fact that an equal number of students use auxiliary lines to the centre from more distant points of origin. In addition, although not identified among the main problems in assessing the quality of the service, when asked about transportation costs, the evaluation shows that 60% of users consider the tariff for transport to be strongly negative (bad and very bad).



**Fig. 7 – Evaluation of the quality of the bus line operation**

When asked to rank solutions to the problems (see Table 4), the students demonstrated a greater concern for the resolution of transport at peak times (51% of choices in first and second place) than for other issues. In particular, they stressed the operational redesign of the existing line (reducing the intervals between buses) and building on operations through the use of free buses provided by the UFPE. Simply reducing the intervals between buses at peak times and throughout the day would meet around 47% of users' expectations. However, this does not address the remaining 37% of users, who would prefer the introduction of an express line or one with a route that provides access to residents in other parts of city.

Analysing this preferences strategically, it can be seen that the first four alternatives relate to increasing the provision of services on the current route. It is clear that if there were a reprogramming of the line currently in operation with a view to achieving an acceptable total travel time (including waiting and walking), the main problems identified would be resolved. This requires the intervention of the University in providing an additional service, in which case the proposal for the creation of an express line on the same route could be dropped. This would leave the implementation of other options in the air, pending the demonstration of their feasibility.

<b>Planning proposed solutions</b>		
1 <sup>a</sup>	Reduce intervals at peak times	26.4%
2 <sup>a</sup>	UFPE providing extra buses at peak times	24.6%
3 <sup>a</sup>	Reducing intervals throughout the day	20.5%
4 <sup>a</sup>	Deploying a public express bus line with differentiated prices	16.7%
5 <sup>a</sup>	Implementing another bus line on a different route	11.8%

**Table 4: Ranking of proposed alternatives**

Given the above, the next section is devoted to a review of the problems defined, their causes, and their consequences for students, as well as the potentially most viable options to overcome the difficulties, in relation to the extent to which they are consistent with the results of the survey conducted up and down the line of the bus route, used as a technical paradigm. As stated in section 2, the study aimed to detect the loading conditions of sections of the line and points of higher demand, and check the number of trips and intervals during peak hours.

#### **4. RESULTS OF THE UP AND DOWN LINE SURVEY**

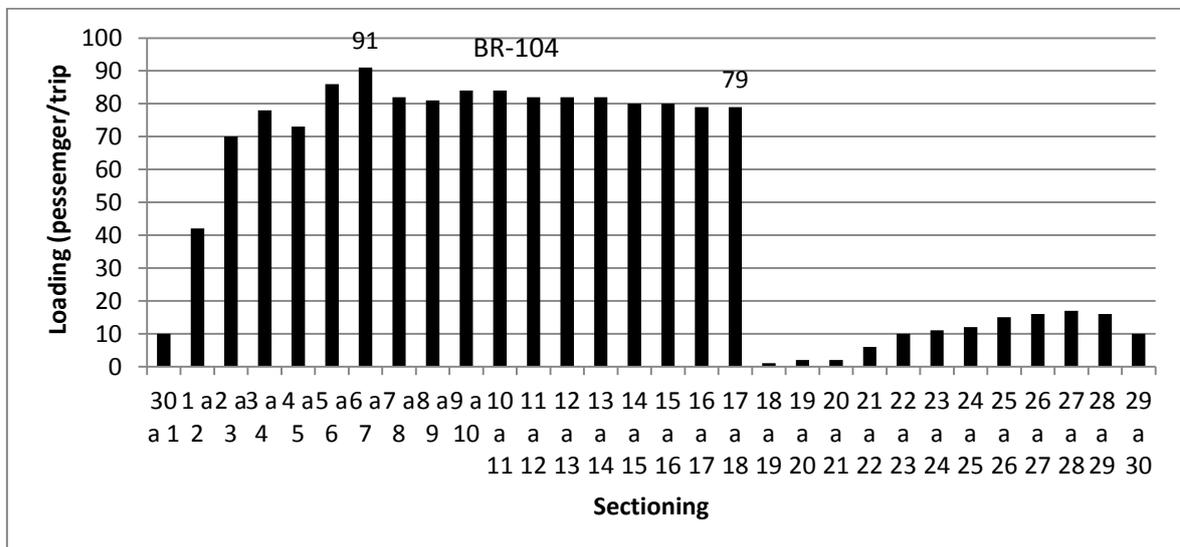
Analysing the survey of trips up and down the line of the CBD–CAA bus route, the first observation is the emergence of a strong pendulum movement between the extreme points of the regular route of the line, that is, central Caruaru and CAA. From Table 5, it can be observed that 85% and 100% of passengers boarding and alighting are concentrated at these points. This pendulum characteristic is strengthened when we note that the peaks relate strongly to the early and late day periods and night time, making it clear that the line needs to be (re)designed exclusively to meet the demands of the campus.

Departure time	Arrival time	Boarding in the centre and alighting at the CAA		Boarding at the CAA and alighting in the centre		Average interval (min)	Passengers per hour
7am	8am	78	87%	2	100%	15	312
9am	10am	14	88%	10	60%	30	28
11am	12pm	4	100%	15	93%	20	12
12pm	1pm	4	100%	15	93%	15	16
1pm	2pm	43	88%	28	93%	20	129
3pm	4pm	23	78%	20	100%	30	46
6pm	7pm	29	100%	26	100%	15	116
7pm	8pm	66	85%	15	100%	15	264
8pm	9pm	50	90%	15	95%	15	200

**Table 5 – Characterization of the home–school pendulum movement for the CAA**

In Fig. 8, which illustrates the numbers of passengers at various points along the line (both up and down) from 7am to 8am, the sections presented are those in which there are concentrations of passengers boarding and alighting, as well as sections in which there is low demand; these fluctuations may be producing unnecessary increases in travel times.

It can be seen that from bus stops 8 to 18 in the direction CBD–CAA and bus stops 19 to 23 in the direction CAA–CBD (all located on the BR-104-PE), there is great variation in the numbers of passengers boarding and alighting. Thus, one way of reducing the total travel time in peak hours is to undertake some express trips favouring those stops where there is greater demand, represented by the most significant boarding points (bus stops 1 to 7 in the central area) and alighting points (bus stops 24 to 30 in the downtown area).



**Fig. 8 – Numbers of passengers per section in the morning peak period**

Analysing the information in Table 5 and Fig. 7 simultaneously, we observe that if the intervals between buses were reduced during peak periods (i.e. the beginning and end of the day) from 15 to 10 minutes, it would be possible to carry the same number of passengers to the CAA in greater comfort, reducing the number of passengers on each bus from 91 to 60 (with 45 seated and 15 standing).

In addition, action to reduce the route can be proposed, at least during peak movements, creating an express line to the CAA and removing breakpoints on the BR-104-PE route, which has excellent traffic conditions and is regularly served by other public transportation lines. Thus, it would be possible to develop higher operating speeds, thereby reducing the total travel time and inconvenience. Equally, it can be concluded that during the off-peak periods (9am to 11am and 2pm to 5pm) there is no need to modify the current intervals or restrict the number of stops along the BR-104-PE.

## **5. FINAL CONSIDERATIONS**

Based on the analysis of the qualitative research conducted with students and the quantitative survey of the bus line, both up and down the route, we can highlight certain aspects of the findings. First, the difficulties reported by the students in relation to the overcrowding of buses and high waiting times and consequently the long duration of the trip, have consequences in terms of delays to classes and physical exhaustion and stress. These issues could be resolved through reprogramming the operations, namely by increasing the frequency of buses on the current line in rush hour and running express trips, eliminating boarding and alighting along low demand segments of the route.

These measures should be promoted by the Municipality of Caruaru, which holds the legal authority conferred by the Brazilian Federal Constitution to implement services of local interest, such as public transport – an essential service. It is recommended that the management of the University make representations to the administration of the Municipality, reporting on the results of this study and highlighting the need for its intervention in the problem. In particular, there is a clear perception among respondents that addressing this issue is the responsibility of City Hall and nearly 65% indicated a preference for solutions involving the reprogramming of the operating line, both in terms of supply and instituting an alternative route.

An alternative bus line following another route would be of interest to approximately 33.3% of the users of regular transportation. However, it would also have benefits for those having to make transfers between forms of transport and the almost 15% of students taking vans direct to the CAA. Thus, this approach could represent an opportunity for the UFPE to improve student access to the CAA. This action would have a positive impact on reducing travel times and costs, as well as alleviating overcrowding on the regular bus line during peak times. This option would involve a discussion with the students to choose the new route to ensure the greatest possible use.

Although the option of an alternative route is only considered second best of the alternatives suggested, it does make sense in that it increases accessibility and avoids problems with disputes over competition with the current line, which could result in a loss of profitability, generating disaffection and reduced quality in operations outside peak periods on the part of the operating company, making the situation even worse.

Finally, we cannot ignore the inherent risk to the university in deploying its own school transport service; once established, this will become part of everyday life and it will not be possible to discontinue it for any reason, whether administrative, technical, or operational (such as lack of operating personnel). Also, the provision of such a service by the university should not substitute for the provision of a high quality service by the municipal government. Thus, in terms of seeking the greatest benefit to users and aiming to improve

access to higher education at the CAA, it is suggested that joint action be agreed and undertaken by the municipality and the university.

### **Acknowledgements**

The authors acknowledge the participation of the three Civil Engineering graduate students in the Tópicos Especiais em Transportes at the CAA, UFPE and their help in the research for this paper.

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