Integrated Structural System: better mobility and accessibility levels for the inhabitants of the Metropolitan Area of Recife-Brazil

O. Lima Neto & E Cavadinha

Federal University of Pernambuco,Department of Civil Engineering, Recife, Brazil

ABSTRACT: Most of the population in great Brazilian cities depends on the public transit for the development of their daily activities. A huge difference between levels of mobility and accessibility can be observed between people who owned and use private cars and those who depend upon public transit. This difference is characterized by (i) the unequal spatial coverage of the transit network when comparing the possibilities available to private car users and public transit users, (ii) the difference in hours of service, (iii) the different levels of the impact on the increasing traffic jam in the operation of both systems, and (iv) the difference in the quality of the information provided for users. These differences configure one more iniquity that the low-income people are submitted. The planning and implementation processes of an Integrated Structural System (ISS) for public transit tried to reduce the iniquities mentioned above offering better levels of mobility and accessibility.

RÉSUMÉ : La majeure partie de la population des grandes villes brésiliennes dépend du transport public pour ses activités quotidiennes. Une différence énorme entre les niveaux de mobilité et l'accessibilité peut être observée entre les gens qui ont acquis et utilisent des voitures particulières et ceux qui dépendent du transport public. Cette différence est caractérisée par (i) l'envergure spatiale inégale du réseau de transport si on compare les possibilités offertes aux utilisateurs de voiture particulière et aux usagers des transports publics, (ii) la différence dans les heures de service, (iii) les niveaux différents de l'impact sur les embouteillages en augmentation dans l'exploitation des deux systèmes et (iv) la différence dans la qualité de l'information fournie aux usagers. Ces différences configurent une iniquité supplémentaire à laquelle les gens à faibles revenus sont soumis. Les processus de planification et de mise en oeuvre d'un Système Structurel Intégré (SSI) pour le transport public ont essayé de réduire les iniquités mentionnées ci-dessus en offrant des meilleurs niveaux de mobilité et d'accessibilité.

1 CHARACTERIZATION OF THE METROPOLITAN AREA OF RECIFE - MAR

The MAR is located in the sea coast of the State of Pernambuco, occupying 2.766 km² corresponding approximately to 2,8% of the total area of the State. With a population of 3.337.565 inhabitants (IBGE,2000) it is the fifth largest metropolitan area of the Country, concerning the population, being below just of São Paulo, Rio de Janeiro, Belo Horizonte and Porto Alegre. The MAR integrate 14 Municipalities: Abreu and Lima, Araçoiaba, Cabo de Santo Agostinho, Camaragibe, Igarassu, Itamaracá, Ipojuca, Itapissuma, Jaboatão dos Guararapes, Moreno, Olinda, Paulista, Recife and São Lourenço da Mata. In the Capital of the State, Recife live 1.422.905 inhabitants (IBGE,2000), which correspond to 43% of the population of the MAR.

Even if spatially MAR's population occupies only 2,89% of the State area, however it is responsible for 75,9% of all the income generated in the State. In the Municipality of Recife with only 0,23% of the State area it is responsible for the half of that income (Arlindo &Pontes,1998). These data indicate a high economic concentration in the MAR and it emphasizes its importance.
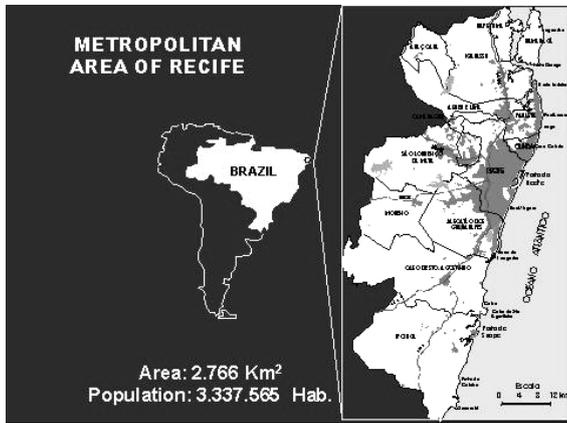
Figure n°1 - Location of the Metropolitan Area of Recife

2 THE TRANSIT SYSTEM IN THE MAR: AN OVERVIEW

In the 1980's occurred changes in the urban structure of the MAR ,where the existent monopolar structure became a multipolar one. Each important neighborhood of the area developed its own net of trade and services, changing the population trip pattern, basically radial toward downtown to privilege local and traverse displacements. The public transit network, consisting of bus routes, no more assisted satisfactorily the population. Another change begins, in 1985, the operation of a Metro line that was constructed under an obsolete conception of only serving radial displacements, but needing to be integrated to the existent bus routes network. To face this situation, the Transit Authority of the MAR, called Empresa Metropolitana de Transportes Urbanos- EMTU/Recife together with the Planning Authority of the MAR, called Fundação para o Desenvolvimento da Região Metropolitana do Recife-FIDEM, made a study that had the objective of designing a new transit network. This study developed the conception of a network integrating bus routes and the new metro line, finally called Integrated Structural System - ISS. The EMTU/Recife has the attribution of managing the intermunicipal transit routes received the delegation to administrate the Municipal Transit System of Recife in 1980, and part of the Municipal Transit System of Jaboatão dos Guararapes (second Municipality of the State) later in 1995. It is the Authority responsible for the ISS.

The Transit System of the MAR presents a registered fleet of 2.529 buses, distributed as follows: 2.485 standard buses, 18 articulated buses , and 26 small buses. This fleet accomplishes 23.604 trips on an average working day, 17.741trips on Saturdays and 13.886 trips on Sundays. The extension traveled in a working day is of 721.081,82 km on a working day, 539.103,50 km on Saturdays and on 428.293,50 km Sundays. This transit system carries in an average working day 1.366.123 passengers, on Saturdays 961.570 passengers and on Sundays 640.308 passengers.   It has 382 routes of different types as fallows: 196 radial, 76 traversal, 7 circular, 11 semi-circular, 6 inter-terminal, 45 feeder, 41 evening service. In this distribution, three types predominate: the radial routes, which represent 51% of the total, the traversal routes with 20% and the feeder routes with 11% of the total (EMTU/Recife, 2003).

3 THE CONCEPTION OF THE ISS

The conception of the ISS was a work that brought in detail the recommendation of the Transport Master Plan of the MAR, elaborated in 1982. This conception took advantage of the region road network that is formed by eleven radial corridors and four semi-circular corridors which cut those radial corridors. The ISS conception, used as transit corridors six of those eleven radial corridors and the four semi-circular corridors. This last type of corridor, the semi-circular, came to serve the transversal displacement without passing through the city centre. In this transit- network- structure operates four types of routes:

- radial routes – are line haul routes with high frequency services to accommodate heavier passenger loads, located on corridors leading into downtown, those corridors are served by buses and the metro;
- semi-circular - are line haul routes with high frequency services to accommodate heavier passenger loads between two urban bus terminals, located on the same semi-circular corridor;
- inter-terminal routes - are line haul routes with high frequency services to accommodate heavier passenger loads between two urban bus terminals, located on different semi-circular corridors; and
- feeder routes – local area route designed to pick up/drop off ridership connecting to a line haul route in an urban bus terminal.

The ISS conception tries to give an opportunity to the user of transferring between a radial and a semi-circular corridors in the major intersections of the network. In this transfer points it will be necessary to build up urban bus terminals that make possible the transfer between modals without the payment of another fare. Therefore a user can travel from North to South or East to West in the region with the cost of only one fare.

By the end of the implementation process, two transit system will be operating in the MAR, the Integrated Structured System-ISS and the Complementary Transit System. The last one will maintain the bus routes that will not suffer any change, because it will serve through a direct connection, a specific demand.
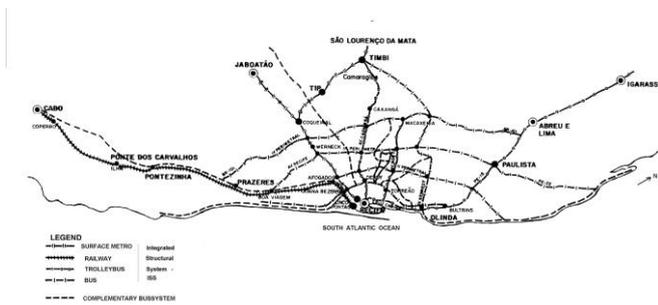

Figure nº 2 - Conception of the ISS of the MAR

The implantation of the ISS should reach the following objectives:
- to improve significantly the quality of service offer to the population;
- to reduce the fare, especially for the low income population that lives mainly in the periphery of the MAR;
- to integrate the new transport modes to the system, taking advantage of its potentialities and improving the quality of service for the users; and
- to guarantee the financial equilibrium of the MAR's Transit System and at the same time to afford a level of fare that is compatible with the income of the users.

It is expected that the implantation of the ISS propitiates the following benefits:
- rationalization of the operational costs;
- reduction of the travel time;
- improvement of the service level;
- reduction of the fare;
- increment of displacement options, through transfers that take into consideration spatial, fare and operational integration;
- reduction in the level of environmental pollution, noise and visual in the centre of Recife;
- increase of the larger attractiveness for the public transit system;
- reduction of the traffic congestion in the central area; and
- support of a decentralized urban structure.

4 THE IMPLEMENTATION PROCESS

Due to the budget government restriction for infrastructural investment the ISS project is gradually implanted in stages, the principal phases of this process will be listed bellow:
- 1985 – Began the operation of the metro line with 20 km and 17 stations. It operates with a 12 electric train units with four cars each.
- 1990 – Finished the enlargement of the PE-15, road that links downtowns Recife with the North of the MAR in a segment of 2,6 km, the road did reckon with exclusive busway.
- 1994- It was opened the first Urban Bus Terminal of the ISS, located at the end of this new segment of the exclusive busway in the intersection of the PE-15 road with the II semi-circular corridor. This PE-15 Terminal serves initially part of population of the Municipality of Paulista through feeder routes. The terminal has the following characteristics: total area of 36.000 m² covered platform area of 7.200m² and stock area for buses, it has bathrooms and rooms for or user's information/complains, security, administrative and operational tasks, and it has also 18 stores. At this time started to operate four feeder routes, 2 radial routes and one semi-circular route to the Boa Viagem quarter in the South.
- 1996- it was given a great step for the consolidation of the ISS with the construction of tree urban bus terminals located on the intersection of the metro line with the I, II and IV semi-circular corridors. Those terminals were constructed beside the metro stations of Joana Bezerra, Afogados and Barro. Another bus terminal was built beside the metro station of Jaboatão located in the end of the metro line in the West side of the MAR, an the setting in operation of the Urban bus terminal of Macaxeira located on the intersection of the IV semi-circular corridor with one of the radial corridors denominated Av. Norte. These five terminal summed with the existent formed the nodes of an integrated transit network. These terminals have the following characteristics:
  - Macaxeira: total area of 10.000m², built area of 3.124 m², bathrooms and rooms for the others functions of the terminal, 6 stores and a snack bar, parking, taxis and bus stock area. It operate eight feeder routes, 2 radial routes to downtown and two semi-circular routes, one to the Barro Terminal and the other to Municipality of Abreu e Lima in the North.

- Joana Bezerra: total area of 1.023 m², covered platform area of 372 m², and all installations need to the terminal operation. It operates one semi-circular route that does connect to the PE-15 Bus Terminal through the I Semi-Circular Corridor;

- Afogados: total area of 2.022 m², covered area of 360 m² . Initially operates one semi-circular route that's connected to the PE-15 Bus Terminal through the II Semi-Circular Corridor.

- Barro: total area of 5.681 m², covered platform area of 1.626 m², and all installations needed in a terminal operation. It operates five feeder routes and two semi-circular routes, one to the Macaxeira Terminal and the other to the quarter of Prazeres in the Municipality of Jaboatão dos Guararapes in the South, both operate on the IV semi-circular corridor.

- Jaboatão: total area of 1298 m², covered platform area of 1298 m² with all installations needed to a terminal operation. It operates nine feeder routes, one radial route to downtown and two inter terminal routes to the Long Distance Bus Terminal in the quarter of the Municipality of Jaboatão dos Guararapes in West, named Curado.

• 1999- The construction of the urban bus terminal of Igarassu made possible to extend the service of the ISS to the Municipalities of Araçoiaba, Itamaracá , Itapissuma and Igarassu (North of the MAR). This terminal has a total area of 4.026 m² and a covered platform area of 2.968 m², with all installations needed in the terminal operation. It operates four feeder routes, one radial route to downtown and one inter terminal route to the Macaxeira Terminal

• 2002 – The construction of the urban bus terminal of Camaragibe took place at the same time of several improvements: the expansion of the metro line to Camaragibe and the constructions of the metro station of Camaragibe. The bus terminal was located besides this metro station. This new bus terminal made possible to extend the service of the ISS to the Municipalities of Camaragibe and São Lourenço. It has a total area of 9.900 m² and a covered platform area of 1.554 m², with all installations needed in the terminal operation. It operates nine feeder routes, four radial routes, three of then to downtown and one to the Federal University Campus; and another inter-terminal to the Macaxeira Terminal.

• 2003 – The construction of the terminal Abreu e Lima (North of the MAR) that incorporated this Municipality to the ISS. It has a total area of 2.200 m² and a covered platform area of 360 m², and the necessary installations for a terminal operation.

Figure nº3 – Urban Bus Terminal of PE-15

Figure nº4 - Urban Bus Terminal of Macaxeira

Figure nº5 – Metro of Recife

It can be noticed by the description above and through the Figure nº 6, that the ISS has already a very dense network that makes displacements possible for the whole MAR with a cost of only one fare.

Figure nº6 - Configuration of the ISS

5 THE USER INFORMATION SYSTEM

All the bus stops of the ISS received a special treatment through a new visual conception and information about the operation system, one of these instruments was a map presented in Figure n°7.
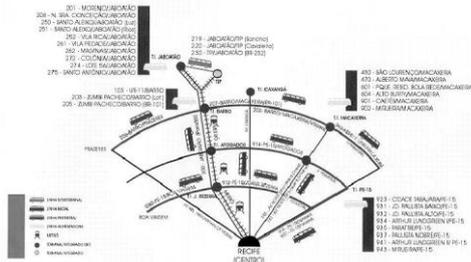

Figure n°7-Operational Structure of the ISS

To facilitate the visual communication of the system for the users, the vehicles of different types received specific colors:

- yellow bus – feeder route;
- red bus – semi-circular route;
- blue bus - radial route; and
- green bus – inter-terminal route.

Figure n° 8 – The ISS vehicle visual communication

6 THE CURRENT SITUATION

At the begin of 1997 the ISS carried 331.000 passenger/day that represented 24% of the demand of the transit system in the MAR. The participation of the ISS grows today for 564.997,00 passenger/working day and represent today 35% of the total demand for transit in the MAR.

Now the ISS has 72 routes, of the 321 existent routes in the transit System of the MAR, they are grouped in the following categories: 43 feeders, 11 semi-circulars, 9 radials and 4 inter-terminals. The fleet in operation from the ISS has 521 vehicles, which make 6.131 travel/day and covered 155.778 km/day.

The present situation of the ISS has a monthly total costs of R$ 4.715.502,00 (US$ 1.598.476,00) and an operating revenue of R$ 6.492.673,00 (US$ 2.200.907,00), presenting a ratio: operating revenue / total costs of 1,38, showing a surplus operation. The ratio(monthly total costs / monthly passengers),

that pay the fare without reduction, gives us an estimation of the average fare of the system. It should be remember that in Brazil doesn't exist governmental subside for the transit fare, in this case, the average fare would be R$1,14 (US$0,39) (EMTU/Recife, 2003). This results prove that the operators were wrong, when at the beginning they affirmed that the ISS will provoke a worse financial situation to the transit system, because of many displacements, where the user must take two buses and would pay only one fare, instead of two, and this would increase the system deficit.

The Transit System of the MAR has been presenting in the last decade a unsatisfactory financial result with systematic monthly deficit in order of 5-10% of the monthly total costs. Last year the EMTU/Recife did make several cuts in service to diminish this deficit. This measure brought gut results in May 2003, when the system presented 10% surplus. The ISS since its beginning had not presented deficits and today it show a better financial condition than the conventional transit system with a ratio of total costs/ operating revenue of 1,38 bigger than the one showed by the conventional transit system, that is of 1,11.

7 ISS RESULTS EVALUATION

To do a evaluation of the effectiveness of the ISS Project we must analyze if the new system could reach the following proposed goals:

- rationalization of the operational costs – as we could see in the last paragraph the ISS has a lower operating costs and a ratio operating revenue / total costs bigger that the convention transit system;
- Reduction of the travel time – the ISS made possible more direct traverse displacement, without passing through downtown, what reduces the travel time. With the implementation of the ISS services the frequency of the routes were increased, principally for the feeder routes in comparison with the old service. The radial and semi-circular routes have a line haul service with average headway that some times became inferior to 5 minutes in peak. In general the new ISS could reduce the headways in 25%.
- improvement of the service level – the ISS forced the operators to renew their fleets and to use equipment with a better level of quality for the users, as for instance, buses with 3 doors, which facilitate the access to the vehicle, vehicle with better layout and the

introduction of vehicles of larger capacity as the articulate. The level of information on the operation system got better considerably;

- reduction in the value of the tariff- all of the accomplished expansions has gotten tariff reductions that varied from 18% to 35%, what results in reduction for the daily expenses with displacements of a family served by the ISS, in approximately 50%;
- Increment of displacement options- as can be seen above, each new urban bus terminal incorporated in the network brings new options of displacements. Today a user can travel from a locality in the North of the MAR to any other locality in East or South paying only one fare. Using the ISS network they have accessibility to all important attractor of travel in the region: Hospitals, Shopping malls, market places, Industry zones, business centers, recreation centers, etc.
- Reduction in the level of environmental pollution, air, noise and visual, principally where the density of buses is high, the city centre. The introduction of each new urban bus terminal of the ISS bring a reduction of the operating fleet to the city centre, because we have one or two line haul routes to the centre instead of several routes from each localities.
- enlarger the attractiveness of the public transportation system - the system of public transportation of the MAR, was suffering in the last years of a illegal and malicious competition of thousands of vans (Kombis) that operate in a clandestine way, operating without governmental permission, and has been provoking a average fall in the total demand of the official transit system of 10%. The interesting aspect of this problem is that the routes belonging to the ISS didn't suffer from this competition, proving that it has characteristics that the user recognizes as good and demonstrating a level of fidelity to the system.; and
- support to a decentralized urban structure - the location of the urban bus terminals in the central areas of the periphery of the municipal districts, made from this point an obligatory passing point for the inhabitants of a specific area, instead of the one in the old system, where the traveler has a direct connection between his home and downtown. This user can decide to stay in this sub centre, satisfying their needs which
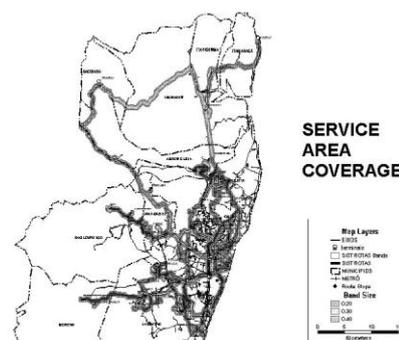
can help to process an urban decentralization.

Figure nº 9 -Service area coverage of the ISS

8 PROCEDURES FOR EXPANSION

Next we will describe the proceedings that EMTU/Recife is using to plan and implement the expansion of the ISS. We do this taking as example the recent incorporation to the ISS of the two area of Camaragibe and São Lourenço Municipalities. This incorporation is projected through a new urban bus terminal located besides the metro station of Camaragibe, and takes the following steps :

   i) Collecting socioeconomic, operational and cartographic data and information about the actual bus network of the study area and the accomplishing an origin-destiny survey in the buses of the present network;

   ii) Elaborating a diagnosis of the current situation;

   iii) Defining the criteria to incorporate a route to the ISS structure, elaborating a new integrated network with the center in the Urban Bus Terminal of Camaragibe and defining a the fare and operational policies;

   iv) Discussing and obtaining the communities' agreement about the transformation of a direct route in a feeder route of the terminal;

   v) detailing new network with the elaboration of a service order to each route, containing: name, type, fare, vehicle type, fleet, operation period, headways for each hour period and the itinerary;

   vi) implementation;

   vii) monitor and controlling the operation; and

   viii) evaluating the results.

The Transit System of Camaragibe and São Lourenço da Mata Municipalities are constituted by intermunicipal routes, in the majority, managed by EMTU/Recife, and municipal routes managed by the respective Municipality.

The 27 intermunicipal routes carry in a working day, 85.434 passengers/day, through 1.447 travel/day accomplished by a fleet of 182 buses. The ratio operating revenue / total costs of this network in

agosto/2002, corresponds to 0,91%, in other words, this group of routes has a financial deficit.
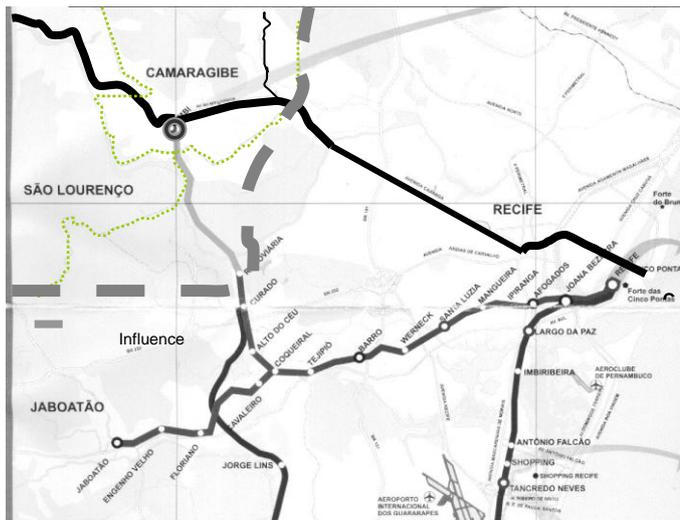

Figure nº10 - Influence zone of the Camaragibe Urban Bus Terminal

In the principal corridor of this area, named Av.Belmiro Correia and in the corridors that follow it in downtown direction PE-05 and Av.Caxangá, exist a great superposition in the majority of the routes itinerary. The majority of these routes use to go downtown through the Caxangá/ Conde da Boa Vista Corridors, and only 26% of them return in downtown border, in a locality named Derby. The Caxangá Corridor has in the middle of its sections a reserved bus lane in each direction, and in the stops it has an additional bus lane for to overtake.

In the previous network it had already two feeder routes of the Macaxeira Bus Terminal, which allowed the users of this region to use the ISS. They transported 10 thousand pass/day. It exist another feeder route that does connect the Municipality of SãoLourenço da Mata to the Intermunicipal Routes Terminal, where a metro station exists too.

The fare for a intermunicipal displacement to the centre of Recife was at the time in Camaragibe R$ 1,05 (US$0,30) and R$ 1,60 (US$0,46) in São Lourenço da Mata.

The municipal system was not take in consideration in the study , because it has few routes with a fleet in bad condition and without capacity. The EMTU/Recife has the understanding that the feeder routes make part of a displacement that is intermunicipal, therefore the feeder routes can be operate by the intemunicipal operator. The proposal of the new network was discussed with the local communities.

The inauguration of the Station of the metro station in Camaragibe happened in December of 2002, and the Urban Bus Terminal constructed besides the station, due to financial restriction, could receive only one platform, which reduced the number of routes to be operated on it. This restriction plays a problem that some local community will not receive the benefit of using the ISS. The criterion to define which feeder routes would operate on it privileged the routes with greater fare, because those users would receive a large reduction of their expenses with transport. Through the application of this criterion were defined 9 feeder routes - four from localities in the Municipality of São Lourenço and 5 from localities in the Municipality of Camaragibe. The terminal operates five line haul services, four are radial routes, two of them going downtown, one returning to the beginning of the downtown area, in a locality named Derby, and the last one goes to the Federal University Campus. The other line haul service is a inter-terminal route and goes to the terminal of Macaxeira.

The operational programming defined the operation period from 04:00 h to 24:00 h, one hour more in the morning and in the evening than the metro. The network implanted had 13 bus routes and one metro line, operated by 75 buses, accomplishing 957 travel/day, with intervals in the peak varying from 6 to 15 minutes. In the monitoring and control phase it was observed the need of one more feeder route and some adjustments in schedule service of the routes.

The fare did obey the current policies of the EMTU/Recife for the ISS, where in a trip toward city centre, the users would pay a fare classified as B in the feeder route and will pay a fare A to return in a radial route or semi-circular. The fare A is 35% lower as fare B, what make possible a reduction in a round trip of 35%, but when they should take more than one bus, and that bus belong to the ISS, the reduction in the expenses could be greater as 50%. The new network of the ISS stays practically with the same fleet in a working day, but doing more 359 additional trips, with less kilometers (13% kilometers). That makes possible a better financial balance. This new operational condition offers for the people of this region the following benefits:

- large number of displacements options;
- reduction of expense in transport from 18 to 35%;
- improvement in the service level, with reduction of the intervals among trips;
- more comfort and security in the Urban Bus Terminal from Camaragibe;
- better level of profitability to the operator , for the existent deficit could be reduced and

it will be expect in future a ratio : operating revenue / total costs of 1,03;

- decrease of the air pollution in the centre of Recife, where no more circulate 31 buses, that used to do 268 travel/day;
- increase in the commercial speed of the buses in the main roads, mainly caused by the creation of feeder routes and reduction in the number of vehicles in the Av. Caxangá towards the Center of Recife.

The operations resulting from this system in the month of May 2003 are the following:

- Passengers, average working day: 35.357 passengers;
- Cost per kilometer: R$1,77 / km (US$0,58);
- Passenger per kilometer: 1,54 pas/km;
- Monthly total Costs: R$835.912,00 (US$278.637 ,00);
- Monthly operating revenue: R$830.274,00 (US$276.758,00); and
- Ratio: operating revenue/total costs : 0,007, it can be verified that in relation to previous situation the deficit was reduced of almost 10% for almost zero.

In next will be present some results of an opinion survey about the quality of the ISS, which was applied on the users of this network It was requested the user to compare the travel time spend before and after the implementation of the ISS in Camaragibe. The answers were: i) much faster or faster-59%; ii) the same-12%; and iii) slower or much slower-29%.

It was requested the user to compare his transport expenses before and after the implementation of the ISS in Camaragibe. The answers were: i) much cheaper or cheaper - 67%; ii) the same-17%; and iii) more expensive or much more expensive-15%.

Finally, it was asked him to evaluate globally the ISS in Camaragibe. The answers were: i) excellent and good-73%; ii) regular-23%; and iii) bad or very bad-4%.

We can conclude through the results of this survey that the ISS in Camaragibe had a very good evaluation, bringing faster and cheaper travels for the users on this region.

9 CONCLUSIONS

It can be resumed, therefore, that the Integrated Structural System has been collaborating to improve the accessibility and the mobility of the inhabitants of the Metropolitan Area of Recife in many ways, because, besides offering a great number of displacement options with the payment of only one tariff, reduces the expenses with transport and makes the travels faster. Under the financial aspect the ISS has got a reduction of the operational costs, therefore it is collaborating for to the financial balance of the public transportation system. Also, the ISS gave a contribution to the environmental subject, because it reduced the bus number entering downtown. Finally, but not the least, with these results and with the adaptation of the fleet to newer, larger and more comfortable vehicles contribute in some for a better image of the public transportation system.

REFERENCES

Arlindo. J. & Pontes,L. 1998.Os Desafios da Administração Municipal Democrática.:Recife: Centro Josué de Castro.
EMTU/Recife.1997. Anuário Estatístico-1997. Recife: EMTU/Recife.
EMTU/Recife. 2003. Internal Report. Recife:EMTU/Recife
EMTU/Recife.2003.www.emtu.pe.gov.br.
IBGE.2000. Population Census of Brazil. Rio de Janeiro: IBGE