THE EFFECTIVENESS OF THE COMBINED USE OF DIFFERENT TYPES OF SURVEYS FOR PREDICTING DEMAND IN FLUVIAL TRANSPORT: A CASE IN AMAZON-BRAZIL

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ABSTRACT

Nowadays, two million people live in Belém Metropolitan Region (RMB) which is located by the riverside of Guajara Bay in the Amazon delta. Despite of its position in the planet´s biggest hydrographic basin, Belém and the other cities of the RMB based their development on road systems. The islander population used to be neglected in the metropolitan plans, creating a cyclic process where the 70.000 inhabitants of the BMR's islands are socially excluded. D-Fluvial project applied different types of surveys to allow for the first time the transport behaviour modelling of the islanders of the BMR.

Keywords: Survey planning, research tools, fluvial service, Amazonia

INTRODUCTION

Belém Metropolitan Region (BMR) covers 1,819 km2 in the Amazon delta, located by the riverside of Guajara Bay. Around a third of this area, where two million people live, is within 400 meters from a road. Despite of its position in the planet´s biggest hydrographic basin, Belém and the other cities of the RMB based their development on road systems. The city of Belém, in Brazil northern region, is known as the gateway to the Amazon. Capital of Pará state, with 1.3 million of population, Belem is located in a peninsula at the Guajara bay, and comprises two sectors: the continent and the islands. Belem is also part of a metropolitan region that includes 4 municipalities (Ananindeua, Marituba, Benevides and Santa Barbara do Pará) comprising two million people in 1,800km^2 (Fig. 1).

The RMB circulation is practically done only by land transport and the provision of transport facilities has been following the demand tendencies without considering their sustainability or at least trying to change it through demand management. That way the BMR fits to a center-periphery development pattern where the city of Belém is in the center and the periphery are the other cities of BMR (Ananindeua, Marituba, Benevides and Santa Bárbara). The socio-

economic development level is intrinsically related to the road distance from Belém business centre.

Figure 1: Belém Metropolitan Region – BMR, study area

The accessibility to the city centre issue also has reflections on the BMR's urban and transport planning. Given the household survey logistic obstacles in the BMR's islands, their population was neglected in the metropolitan plans, creating a cyclic process where the 70.000 inhabitants of the BMR's islands are socially excluded (Fig. 2).

Figure 2: Transportation daily scenes in islands – study area focus

The D-Fluvial project joins the studies of the two main universities of BMR to complement the BMR strategic transport schemes and to provide the islanders with viable transport

alternatives to increase their social inclusion. The D-Fluvial main issue is the design of a new boat, suitable to the islanders with low purchasing power, living in remote areas of BMR where the fluvial transport is the only way to export their agriculture and extractive production and to import energy, potable water and food, as well as, to have access to health and education services and employment in the mainland's BMR.

The study's approach allowed for the first time the transport behaviour modelling of the islanders of the BMR. D-Fluvial carried out three surveys types: an origin-destination survey of fluvial trips, a survey of boarding and alightment in bus lines and a state preference survey. These surveys answered the following essential questions to transport planning: how many trips are generated in BMR islands; how these trips are distributed into BMR; the behaviour of potential users of the new services, given a specific quality attribute, fare and travel time; how many passenger trips will be attracted to the new service, given specific attributes (Fig. 3).

Figure 3: D-Fluvial Team in the Islands

This article describes the demand transport survey methodology applied and, keeping a theoretical focus, discusses how it answered the above questions, the problems faced and the proposed solutions.

PROBLEMATIZATION

Some essential questions must be formulated in the design of any system. In transport planning these questions are about demand and supply aspects of the system. A transport system can be subdivided in several ways, but one simple approach is to consider an infra-structure system, a vehicular system and an user system. The relations between these subsystems are the demand/capacity and cost/benefit relations. So the essential questions are all regarding the size and nature of demand. As soon as this information is available, it is possible to design the system.

The four step method is an approach that solves this problem answering how many trips are generated in the study area, how is the spatial and modal distribution, as well as its network allocation. So some questions must be formulated to the D-Fluvial before the engineering task force could make the technology conception.

The problem changes to a second level or a methodological level and questions such as: "how to measure the number of trips generated in the study area?" and "how to identify their origin, destination and mode choice, by period of time and the relation of all these with the traveller socio-economic characteristics?" are raised.

Given the clear necessity to answer several questions, two more are needed: what exactly is the study area? And what are the necessary resources and their restrictions?
Putting all this information together, you can see a logical task sequence that could be set to a demand assessment:

- Survey Planning;
    - Study area delimitation and subdivision;
    - Observation sites and period definition;
    - Needed information and research tools definition;
    - Field work logistics;
    - Data processing tools and method definition;
    - Data analysis method;
    - Decision methods;
    - Synthesizing information method;
- Survey;
- Data treatment;
- Modelling; and
- Demand assessment.

This sequence can be presented in several ways, because this problem is well known in transport planning, and here only those tasks which needed a special solution given the Amazonian case conditions are discussed. But before starting a final question must be considered: How much is the desired information worth?

In the case of BMR two questions emerged and it was necessary to answer them to attend the project objectives through the survey:
Is there demand for a road and fluvial transport, operating in an integrated system?
What design is needed for the boat to provide the service?

These and other questions were supposed to be answered with the survey.

SURVEY PLANNING

Once decided to perform a survey, planning is obviously important, but in this case it had a special consideration because of the extremely limited project budget and the BMR area

extensiveness. Fortunately, BMR is one of few Brazilian urban areas with household origin and destination surveys available. Thanks to the OD 2001 survey the D-Fluvial could allocate better its resources to observe insular areas and their population transport behaviour, complementing the information already available.

The study area delimitation and its subdivision was based in a pre-conception of a metropolitan fluvial network (Fig. 4) based in a preliminary survey to determine some acknowledgement aspects to compose the survey properly. Given the previous knowledge about the current islanders transport behaviour, and thanks to the natural obstacles the strategic observation sites where easily determined, but the time periods needed a previous survey.

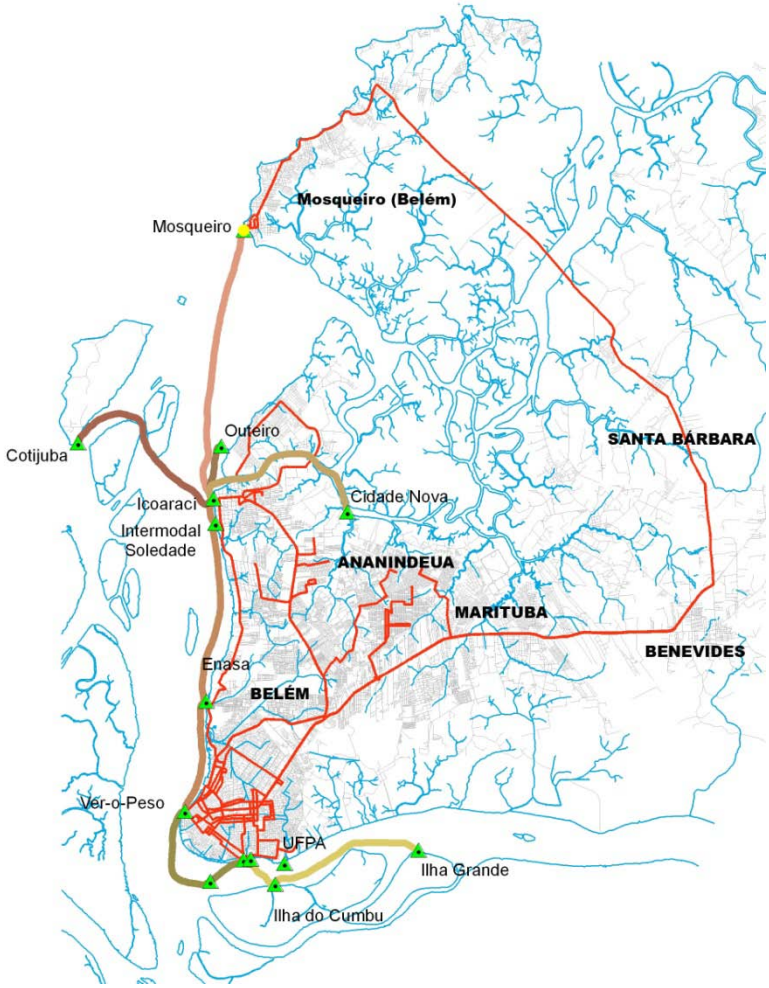

Figure 4: BMR – Intermodal network

Considering the previous information and the traffic zones used in the OD 2001 survey, it was possible to obtain the survey area division that is present in Fig.5.

Given the complementary role of this project the classical research tools had to be adapted to the needed information and the field conditions specially the state preference survey.

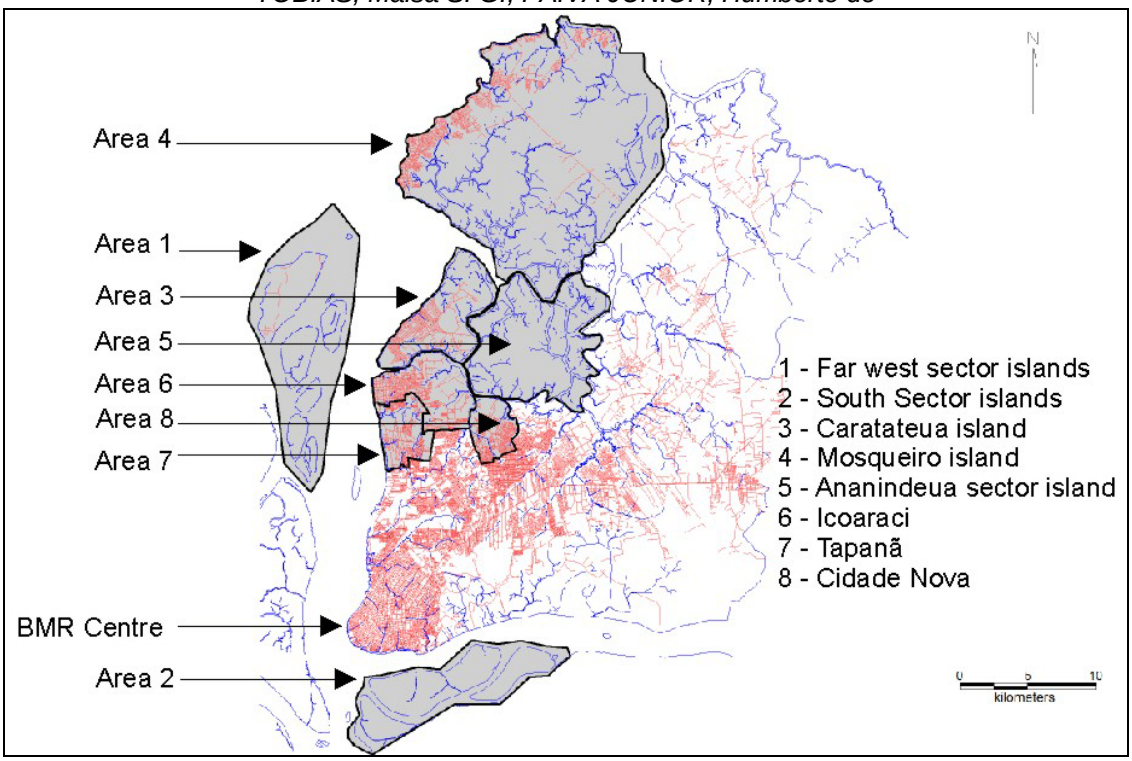

Figure 5: Study areas

As in the former surveys, the spatial dispersion of islanders' households made a household survey unfeasible, so the solution to observe the islanders transport behaviour was a selection of a control set and the use of local communitarian leaders to assist in contacts with the population more dispersed and in supporting the completion of the questionnaires. The other aspects of survey planning followed the normal routine.

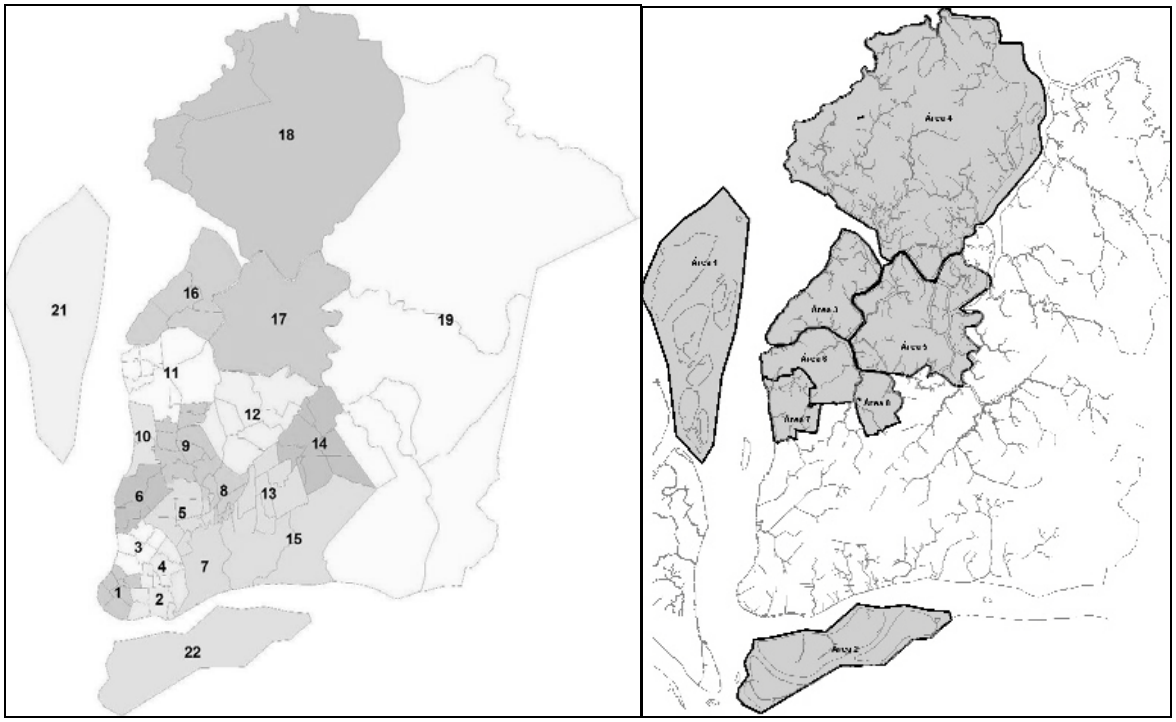

Figure 6 – Traffic zones and subdivision of the D-Fluvial study area

RESEARCH TOOLS

From the three surveys performed, the OD survey and state preference survey had to be adapted to specific needs of the project. These needs include travel production and attraction for new traffic zones and identification of their mode distribution given cost, time and service quality attributes. The OD survey was realized in the current fluvial terminals used by islanders to access continental areas and by island visitors during tourism high season. This survey works like a cordon line count of the number of travels that get in and out of the continental areas, but at the same time, gathering socio-economic data about the travels. This task was performed by two teams, one to count all passengers in transit through the current fluvial terminals, identifying a universe to be used in the expansion of the socio-economic data sample of interviewed users.

The best practice in state preference survey applies portable computer to generate a user customized factorial experiment during the interview. This procedure is more expensive, but it increases the suitability of the hypothetical scenarios and reduces errors in the data input. The state preference survey was adapted a limited predefined set of alternatives and their form had a graphical presentation (Figure 7) to minimise a possible bias due a low literacy level in some cases. To apply this predefined set of alternatives, the study area had to be subdivided in a peculiar fashion to keep a small but enough variation of the cost and time alternative attributes for each area. Figure 7 presents the cost and time attribute of an incomplete factorial design. The quality attribute were presented implicitly to the user through the description of the new service characteristics. To do that, two research teams worked in the same area constructing two different images in the users mind.

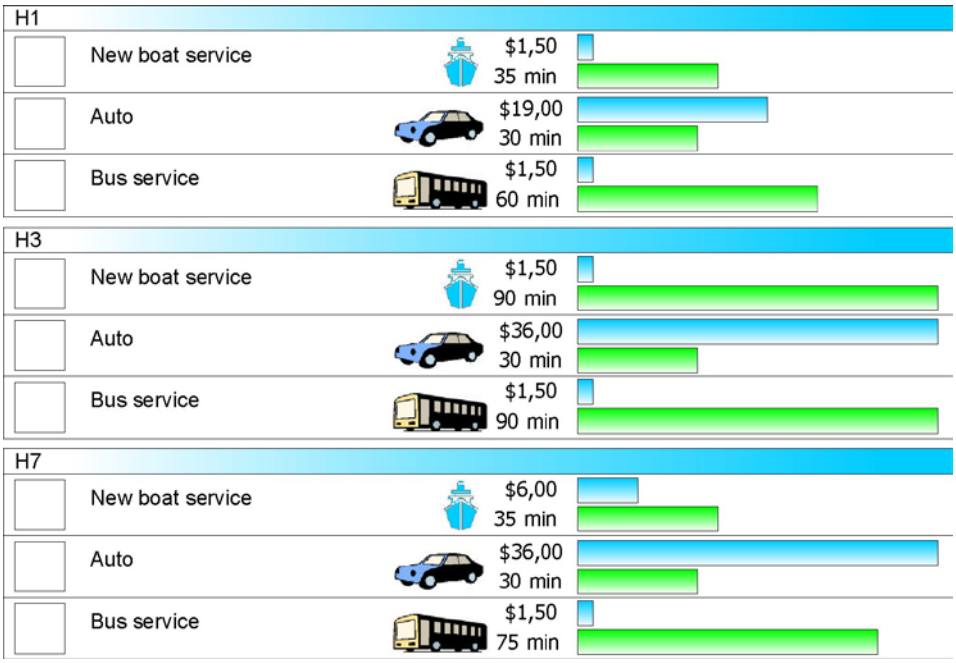

Figure 7 – Factorial experiment layout use in the state preference survey

DATA TREATMENT

As mentioned before, the data treatment had the same concern and care with data gathering, organization, depuration, and transformation to useful information than in any other ordinary transport survey. The only exception was the state preference because the complexity of the research tool and the abstraction and analytic effort demanded from the passengers interviewed.

But another important issue about the data used in this study is the update assumption applied to the household origin and destination survey performed in 2001 and the method to integrate D-Fluvial data with this secondary information source to build an OD matrix.

The 2001 origin and destination household survey produced a land travel matrix considering 20 macro traffic zones. D-Fluvial adds two insular traffic zones where the travels are a direct result of the survey, but the mode distribution is an estimation of a discrete mode representing the fluvial user's behaviour interviewed, and the behaviour of the continental areas included in the D-Fluvial project to allow the application of the division mode model to existent OD matrix.

MODELLING

As the main objective of D-Fluvial is subsidising a fluvial ship design, and broader than this, conceptualize a new transport system, the state preference model and factorial experiment are the best choice to demand assessment and potential users behaviour modelling.

As represented in figures 5 and 6 the study area was divided in 8 sub-areas and for each one a specific state preference was carried out. This procedure allowed the use of predefined factorial experiments, keeping the realism of the scenarios and also produced a set of discrete models of the mode choice behaviour of a sample of potential continental resident users. These models are needed to integrate the D-Fluvial demand model with the former demand studies and future ones.

Demand modelling

D-Fluvial does not use a complete four step method model formulation because its objective is to assess the near future demand of a new transport mode without any other changes on the RMB transport system. So the generation and trip distribution models are dispensable. The generation model is unnecessary because of the short horizon planning project and the availability of a projected OD land travel matrix to the RMB. The distribution model also does not need any modification because it is considered that the BMR generalized cost matrix will not be changed significantly in the same way.

So the demand assessment rely only on the set of discrete choice models calibrated to each subdivision of the study area and the OD 2001 journeys projections to present date. The model applied is a simple logit function (Equation 1)

$$P_{iq} = \frac{e^{U_{iq}}}{\sum_{j=1}^{J} e^{U_{iq}}} \quad (1)$$

$U_{iq} = a_{0i} + a_1 Tv_i + a_2 Tf_i + a_3 Am_i$

U_{iq} – Utility function of transport alternative *i* perceived by user *q.*

a_{0i} – Alternative *i* specific constant.

a_1, a_2, a_3 – Variable coefficients.

Tv_i – Total travel time by transport alternative *i*

Tf_i – Fare or total cost of utilization of transport alternative i

Am_i – Dummy variable to represent the amenities availability ($Am = 1$) or their absence ($Am = 0$)

Supply Modelling

Despite of the study area size and distances between origins and destinations there is no need to a specific supply model. Here the modelled fluvial journeys OD matrix was allocated as a simple network flow problem, inserting all the aspect of an allocation model directly in the generalized cost function applied in the demand model (Figure 8).

FINAL CONSIDERATION

The Belem Metropolitan Region insular population socio-economic condition is correlated with their accessibility to the market and social services of the mainland. The absence of public investments in infrastructure, together with the low performance transport systems, are the main causes of social exclusion, highlighted by the low rates of literacy, predominance of elderly people, since the youngsters go away in search of better job opportunities. The research showed that the new fluvial system can be viable, as part of a bigger intermodal system. The main beneficiaries of this work is the Belem Metropolitan Region population, in special, the most deprived of urban mobility. During the research it was possible to understand the importance and significance of the river to the population and the relevant contribution that the recovery of the river transportation sector in the Amazon region could bring.

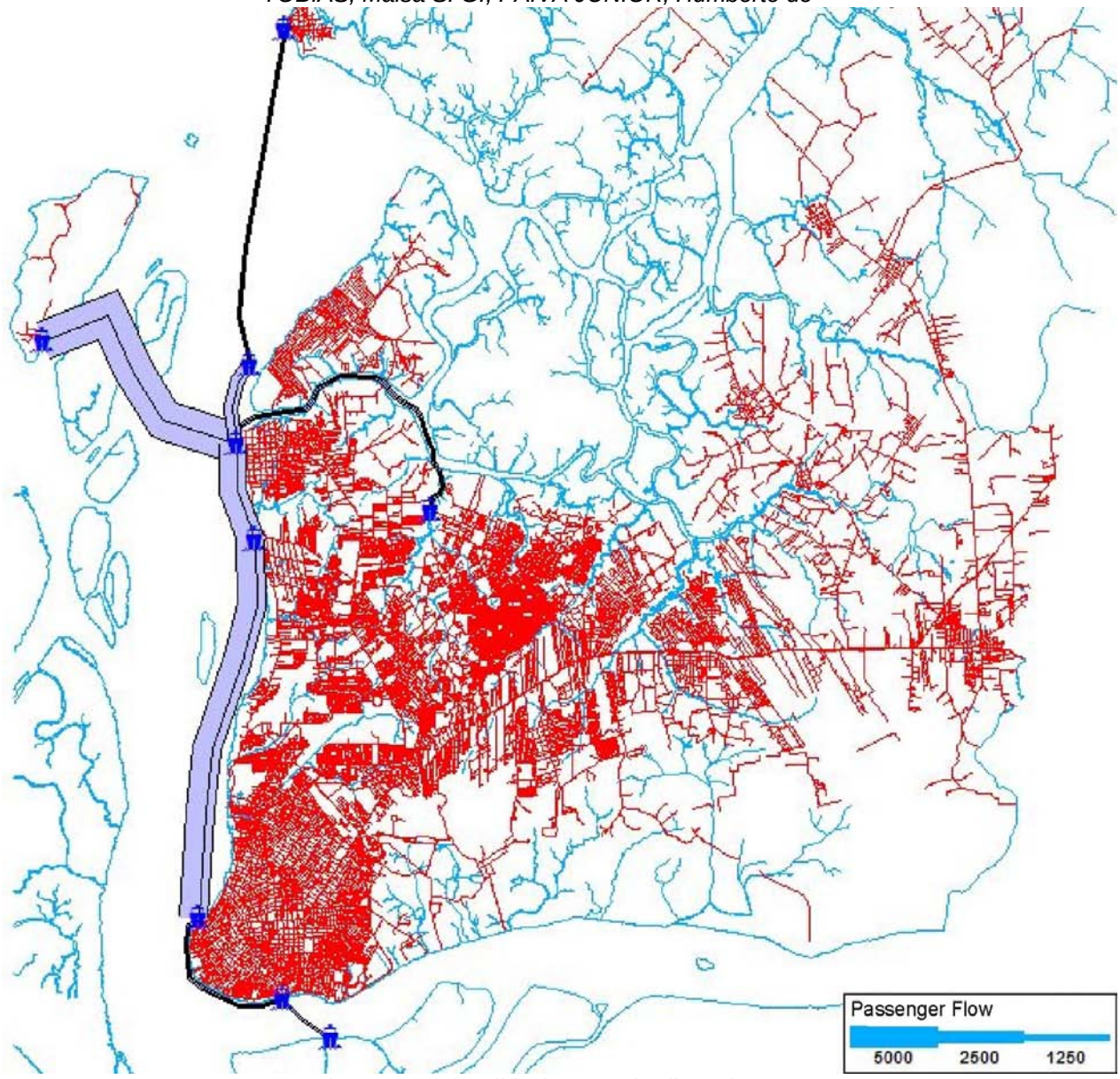

Figure 8 – Simplified network allocation

This project brought several contributions to scientific, business and institutional RMB transport community, changing paradigms, producing new information and training a new generation of transport professional. It also opens a possibility in the next metropolitan transport plan to integrate the insular population in their study and investments program.

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