AN ACTIVITY-BASED COSTING MODEL FOR STRATEGIC DECISIONS IN TRANSPORTATION ON DEMAND PROJECTS

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ABSTRACT
Today there are many people who lack access to adequate means of transportation (people with reduced mobility, elderly, people in rural areas of low population density, etc.). In these cases the conventional solutions do not serve and tend to worsen due to increased costs of private transport and the reduction of conventional transmission lines at these sites. In this context, emerged alternative transportation models called "transportation on demand".

However, although there are some experiments, these new models are still not consolidated due to problems of technical and economic. Beyond the technical aspects necessary to develop cost models suitable for designing a system with economic viability and to set prices and pricing policies that ensure the attractiveness of the service without compromising their economic viability (namely with recipe above cost). The complexity of this system and the relative weight of significant indirect costs justify the application of a costing system based on activities. In this article we present a cost analysis based on the strategic ABCM model to discuss the conditions of economic viability of a transport on demand system applied to the municipality of Terras de Bouro. These results are important to support strategic and operational decisions.

INTRODUCTION
The rural area is a region where population density is low with a tendency to continue to decline. People migrate to urban areas where they find better infrastructures and services which meet their needs. A consequence of this move is the reduction in the supply of products and services in rural areas due to reduced demand. The operating model of the traditional public transport is inadequate for rural areas (Brake and Nelson 2007). Traditional line transportations need to transport a certain minimum of people daily to be viable. Thus, operators have been abandoning lines and services in rural areas. In this context, the rural areas tend to fail in terms of collective public transportation service, forcing people to use individual vehicles.

Thus, it is important to explore alternatives to conventional public transport in rural areas and areas with low population density. These alternatives must be more effective and more responsive and they should meet the needs of specific mobility. These alternatives do not require schedule, route or fixed stopping, or vehicles of a certain capacity but a service adjustable to users' needs. In this context, emerged a new concept of public transport characterized by dynamic routes and free of any fixed schedule, which can be adjusted to the needs of users, called “transport on demand” or DRT (demand responsive transport).

The transport on demand requires a strong technological component and the integration of several technologies, being this aspect a key factor for the system efficiency. Furthermore, a good communication system is fundamental to satisfy the needs of the users. For example, to know the real needs of the users, it is necessary to have a constant and effective communication between the system and the users (Frosini et al. 2004). The planning of the routes, which are calculated on a daily basis to meet demand assessed for each day is another complex and critical aspect in a DRT system. Indeed, route planning is considered “NP-hard” problem. In this article, it is presented a cost model that will assist in the calculation of tariffs or tariff models, the analysis of routes and transport lines profitability, the analysis of customer profitability and, ultimately, the analysis of viability conditions of the on demand transport system itself. This cost model will be important to support strategic and operational decisions in terms of the design of the DRT system. To accomplish this purpose it is suggested the use of an activity based costing system, particularly the strategic ABCM (Kaplan and Cooper, 1998).

The transport on demand is an intermediate solution between the taxi (individual transportation) and the bus (public transport). Thus, it cannot be applied a bus fare or charge the price of a taxi. But how much should a customer pay for the trip? How to calculate the cost of transporting a specific passenger or the cost of satisfying a specific request? The fare should be a hybrid model, namely, with a variable fare starting from a value basis?
On the other hand, the system must be attractive to the customer through a price acceptable but must be financially viable. Total costs must be lower than revenues. Eventually, subsidies for the promotion of people mobility in low income social groups, or with limited mobility, etc. can be considered.

This paper is structured in six sections, including the introduction. Next section discusses the concept of transportation on demand. The third section is related with the designing of the DRT system. The fourth section focuses on the main concepts behind a strategic activity-based cost management system. The fifth section discusses the conditions of economic viability of the transportation on demand system applied to the municipality of Terras de Bouro. The final section presents the main conclusions and suggests opportunities for future work.

**TRANSPORT ON DEMAND**

Traditional systems of public passenger transport offer services with schedules and routes predefined. In general, these systems are suitable for patterns of high and concentrated demand, but often become inadequate when demand patterns are low and scattered. The problem consists of design a system of public passenger characterized by a high transport flexibly that responds to real-time demand. During the last decade we have been assisting the appearance of alternative systems based on flexible services rendered in terms of schedules and routes permitted, which are created according to the actual needs of the population, reflected through explicit requests for travel. For example, the service as Personal Bus Tuscania (energie-cites, 2002), the AGATA project (Frosini et al. 2004) which involve four countries (Italy, Spain, Portugal and Morocco), or collective taxis in Beja (Portugal).

However, these systems ask for greater requirements in terms of operations management, given their terms of operations management, given their...
The requests will be stored in the server until the planning stage. A request may be modified or canceled during the planning stage, but not after the planning stage, because it may modify a planned route. A change in terms of time schedule may cause impact in other customers and if it implies a violation of the time window of other clients they can no longer travel. It may be a company policy to charge the customer in these situations. Thus, in this first step customers can make changes or cancel demand.

The Planning of the Routes
Planning is a central problem in a transport on demand system, because of the need of calculating the daily route that each vehicle should do. The problem to be solved is NP-hard problem, namely with the increasing number of requests the number of variables to consider in the formulation grows exponentially. Therefore, the time needed to achieve a solution may be so high that it exceeds the useful time, namely the computation time be greater than the acceptable waiting time.

So, often the option is to use a heuristic to performing the planning. Not being the best solution, this approach solves the problem in a useful time with an acceptable good solution. Another factor to take into account in the planning process is to know when the system should starts planning on the basis of the requests made. The number of requests directly influences the calculation time of the routes and limits the possibility that customers have to modify their requests. There are several assumptions that characterized the model which result from a strategic choice that can be modified over time.

The Communication with the Users
After calculating the route it is necessary to communicate the results to service users and motorists. This communication depends on the communications and the technologies available for the users and for the motorists, and in this last case of the existing technologies in the vehicles. Users can be informed via text or voice message. Users can set the time when they want to receive the information. The web portal information is updated in terms of schedules and routes after the planning.

During the service execution, the operational center may receive information from vehicles depending of the available technology. However, there is important information that will be always available particularly, times of arrival and departure of the vehicle at each stop and full details of requests that were satisfied.

Strategic Decisions
In the communication between the customers and the system, firstly, and between the system and the customers, after, arise several problems such as sending correct data when carrying out a new request; particularly, the presentation of a valid and useful contact. It will be through this contact that the
communication between the system and the client will be done. Another problem occurs when customers are not able to use the available technology which will be an obstacle for the use of the system. Which strategies can be pursued to solve these problems?

With regard to the policies of flexible transport service, time windows length affect the system's flexibility, since the time windows of each request must be fulfilled. Thus, the shorter the time window is, the lower the system flexibility is.

But, there are more aspects that determine the degrees of freedom of the service provider and users. Reducing the level of flexibility of the system facilitates the convergence of system solutions for greater technical and financial viability. The most flexible system in terms of picking/delivery is one in which the stops are the users' own homes, i.e. a door-to-door service. A system less flexible is those who use the bus stop of the traditional transportations lines. From a practical perspective, flexible transport services can be designed assuming intermediate stops which are not the homes of the service users but which are not the traditional bus stops. Instead, stops will be locations preset by the planning system and the customers.

On the other hand, there are other strategic decisions that affect the fleet flexibility and subsequently the flexibility and the viability of the entire system. Firstly, vehicle capacity because the larger the vehicle the lower the flexibility of the system. The availability of each vehicle also influences the definition of the different routes. It is necessary to take into account which vehicles and motorists are available for travelling in each planning moment. The flexibility of the system depends on the number of vehicles available, their capacity and available motorists. The number and type of available vehicles depend on company's fleet, the conditions of having access to leased vehicles, and the combination of DRT services with other transportation services including taxi services and conventional transport. The type of vehicles used will also determine the type of customers who may be served. For example, some vehicles will not be adequate to users with reduced mobility. Some vehicles will not permit the access to certain places or do not will have the comfort desired by some customers, etc. All these questions must be considered because they will have implications on the service provided and on the conditions of the service. Thus, they will define the DRT service in terms of market positioning and customers served. These issues are strategic and should be weighted before the design of the DRT system in order to maximize the probability of success. Strategic decisions are not likely to be changed in the short time, only may revised after each business cycle, i.e. some each 3, 5 years and others in longer periods.

**STRATEGIC ACTIVITY BASED COST MANAGEMENT**

Strategic activity based cost management is a powerful tool for pricing strategies and for profitability analysis of customers, services and business units. Cost management concepts and tools are particularly relevant in environments characterized by high levels of indirect costs, product or service diversity and complexity and business flexibility. In this context, activity based costing and activity based management emerge as very useful tools to determine the amount of cost-to-serve and to perform profitability analyses.

Activity Based Management (ABM) can be viewed as an extension of activity based costing (ABC) – (Lindahl, 2000) - and they can both be included in the broader concept of Activity Based Cost Management (ABCM). In an ABC system it is necessary to define resources, activities, cost objects and cost drivers. Basically, in an ABC system the cost of a product is the sum of raw materials (and other direct product costs) and the cost of the different activities used to produce it (Shields and Young, 1989; Gunasekaran et al., 1999). In addition, activities are grouped in different levels: unit level, batch level, product or process level, and plant level (Cooper, 1990). The conceptual basis of ABC can be found in Cooper (1988a, 1988b, 1989a, 1989b, 1989c, 1989d, 1989e). The switch from ABC to ABM represents a change in focus, from a cost-assignment view (resources – resource drivers – activities – activity drivers – cost objects) to a process management view (cost drivers – activities – performance measurement) - see Raffish and Turney (1991) and Turney (1992a, 1992b, 1996). Thus, ABCM systems are an extension of ABC and they comprise the use of ABC information for three main applications: product costing, activity and costs driver analysis and the identification of opportunities for improving performance (Raffish, 1991).

In an ABCM system activity cost are attributable to the product in different levels: the unit level, the batch level and in a product support level (Cooper, 1990). *Unit-level* costs occur each time a unit of product is produced or a service is provided (e.g. drilling holes in a component, metal polishing, inspection piece by piece). The occurrence of these activities is proportional to production volumes and sales. On the other hand, *batch-level* activities are developed for each production lot (e.g. a machine to prepare a new production order, purchase of materials). Activities to *support the product* are those designed to allow the production of a particular product or service (e.g. tools and exclusive product testing, technical support for a specific product). Moreover, there are activities attributable to the customer (Cooper, 1990) or *customer support*, which imply going beyond the production perspective. Customer support activities reflect the cost of selling to a particular customer, regardless the quantity and the mix of products and services sold.
Conversely, the ABCM systems are concerned with the analysis of capacity. The rate of inducing activity should reflect the capacity of resources supplied. Measure, create and manage the capacity used and unused is a central element of an ABC system. The fundamental equation is then derived as follows: Cost of Resources Supplied = Cost of Resources Used + Cost of unused capacity.

Resource needs are not only for activities which support the products but also those that support customers, distribution channels and suppliers. Featuring information on the costs of serving different customers can support better decisions, including the following: protecting and growing business with customers that ensure high margins, redefining prices of expensive services based on "cost-to-serve" analyses, offer discounts on cases with a low "cost-to-serve" increasing the turnover, to negotiate the type of relationships firms-clients in order to reduce "cost-to-serve" with benefits for the company and for the clients, abandon customers who are not profitable, seek to attract good customers, etc. "The rule of gold" is that expenditure that is corporate-sustaining, i.e. that one that is made to support the company, should not be imputed to cost objects. However, the imputation of distribution and administrative expenses to customers is important because customers do not consume equally these resources.

An ABC system allows us to understand the costs of serving different customers. These costs should be not imputed according on the amount of sales but they should be imputed in terms of the consumption of resources. Some customers represent high service costs and other reduced costs; there is a set of characteristics that define these types of customers. Both types deserve attention, the former because may be not profitable serve them and the second because if they realize their low cost-to-serve situation may push for lower prices. It is necessary to understand which factors explain high cost of serving: unpredictability, frequent changes, a too often service, customized products, different logistics, and large demands for activities before and after the sale. It is important to turn unprofitable customers into profitable customers. To do that, the buyer may change the pricing policy with measures taken by the company or in partnership with customers. Customers who are not profitable should be abandoned? Not necessarily, at least in the short term. Nevertheless, if non-profitable customers are not new, strategic or permit to learn something and all the initiatives taken to make them profitable were not successful than these customers should be discontinued and the activities used for other customers. There are several strategies which can be undertaken to increase customer profitability namely, protecting customers who represent high returns to the firm, increase prices of the more expensive services considering the cost-to-serve analysis, offer price reductions to increase sales to customers with low cost-to-serve, to negotiate with clients (cooperating) win-win strategies which can reduce the cost-to-serve, leave (to competitors) permanently unprofitable customers, seek to win customers with high profitability from competitors.

**CASE STUDY**

The ASTRA project focuses on three counties in the Portuguese region of Minho, which are Amares, Vila Verde and Terras de Bouro. In this article we will examine the particular case of the municipality of Terras de Bouro, from the three it is the one that has the lowest population density and it fits well the concept of DRT. Moreover, in the county of Terras de Bouro it is possible to clear identify four distinct areas for which there must be a transport solution.

In a survey conducted within the ASTRA project in 2008 found that only 3% of the population used public transportation. Thus, it is considered that the demand for flexible transport service will be at least 3% since in the same survey it was found that a reason for the non-use of public transport is the lack of time consistent with the needs of the population. Thus, it is expected therefore demand rises with flexible transport. Table 1 shows the estimated daily demand for the DRT service in each of the four areas identified for transport in the municipality of Terras de Bouro (zones 1-4).

<table>
<thead>
<tr>
<th>zone</th>
<th>pass</th>
<th>dist</th>
<th>dur</th>
<th>trip</th>
<th>veh</th>
<th>cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99</td>
<td>25,800</td>
<td>90</td>
<td>9</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>15,100</td>
<td>50</td>
<td>8</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>13,700</td>
<td>45</td>
<td>4</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>73</td>
<td>8,600</td>
<td>30</td>
<td>8</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

The column "pass" shows the estimated demand for each of the 4 zones based on the residents. This number means the total number of passengers carried per day in one direction (namely for or from Terras de Bouro). The daily average distance in meters of each one way trip is indicated in column "dist".

The column duration represents the total time required to attain a route. In calculating this time it was considered farthest point in each of the zones in relation to the village of Terras de Bouro (considering the column "dist"). The average speed of this kind of service that stands at 30 km/h, a multiplier which reflects the deviations resulting from changes to the "normal" route in order to collect the users in the arranged point, the maximum delay allowed to users and also an additional safety margin for unexpected, adverse weather conditions, etc.

To get the number of trips/day per route in each area (variable "trip") they were considered several aspects including the period of greatest flow, the duration of the trip, how many passengers are transported in average per day in both directions and the vehicle capacity. The number of vehicles and their capacities are presented in the two last columns of Table 1.
The capacity of vehicles which should be assigned to each zone is influenced by the level of demand in the hour of greatest flow, which lies between 7 and 9 am. In this time interval they are performed approximately 60% of travel departures. For zone 1 it is expected that 60 will be transported in the hour of greatest flow, and as the route takes approximately 1 hour and 30 minutes there is a need of 2 vehicles with 30 seats or three vehicles with a capacity of 20 persons. A vehicle with a larger capacity (e.g. 60 people) would be inappropriate given the context of DRT.

An additional vehicle implies high incremental cost (acquisition costs, maintenance, fuel and at least another motorist). Most costs are related to motorists’ wages and other related costs plus the costs of acquisition of the vehicle. Thus, they were considered two vehicles with 30 places instead of three vehicles with 20 places. The system optimization is achieved by maximizing the available capacity, namely, take paths with the maximum number of passengers and having the vehicles permanently performing routes.

For zones 2 to 4, routes are shorter, allowing more trips per day. However, there are a minimum number of passengers transported by trip in order to guarantee the economic viability of a route and these areas have less population (see minimum cost/passenger and breakeven (average trip passengers) in Table 4).

Thus, although there is greater availability in zones 2, 3 and 4 they could not be done more trips per day than in the first zone, on the contrary. Considering also that in zone 2, 60% of people are transported between 7 am and 9 am this would be possible making three trips in this period with one vehicle of 20 places. But system flexibility only one vehicle should be enough to make the three trips extending a little the time of the trips and complying with time windows defined by service users. Furthermore, an efficient combination of resources will turn possible to use the same motorist and one vehicle for zones 3 and 4, whereas zone 3 has a low demand level but the routes are relatively short, allowing various combinations.

Motorists will work on average 8 hours per day and considering that the transportation service will be operational from 6:30 to 21:00, they will work in two shifts per day. The calculation of the different routes allowed us to conclude that there are four routes that run concurrently in the morning and three courses during the afternoon. Thus, it will be necessary to have at least seven drivers available daily. Additionally, it is accounted a technician who could, if necessary, replace one driver in specific situations.

The DRT service is characterized by having structural costs common to several areas where the service runs. In structural costs it is necessary to include the costs of informatics for planning and management the routes, administrative costs, marketing expenditures, financing costs, etc.

But firstly, it is necessary to investigate the margins released with the provision of the service in each of the municipalities under study and analyze the profitability of each transportation line or set of lines corresponding to a "zone". Thus, they were accounted the margins of the DRT service in the municipality of Terras de Bouro, i.e. the overall margin and the margins for each of the four areas defined for the DRT service in this municipality. The tariff plan may adopt different configurations, for example, with a variable component depending on the kms traveled. But, for the cost analysis we just need to use an average fare. After some simulations and considering the price of conventional transportation alternatives, they were considered the following average tariffs: 3.20€ for zone 1, 2.20€ for zones 2 and 3 and 1.75€ for zone 4.

Taking into account these average tariffs and the estimated number of passengers listed in Table 1 the expected annual revenues were computed. The supplies and external services are mainly direct costs of the routes, i.e. fuel and maintenance expenses. Labour costs include wages and other expenses with 7 drivers and 1 technician. Depreciations were calculated for a total investment of 450.000 € in 4 vehicles.

<table>
<thead>
<tr>
<th>Table 2: Overall Margin for DRT in Terras de Bouro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
</tr>
<tr>
<td>Supplies and Extern. Services</td>
</tr>
<tr>
<td>Labour costs</td>
</tr>
<tr>
<td>EBITAD</td>
</tr>
<tr>
<td>Depreciations</td>
</tr>
<tr>
<td>EBIT</td>
</tr>
<tr>
<td>Margin</td>
</tr>
</tbody>
</table>

This margin (14.364 euros, equivalent to 4% of Revenues) was obtained considering only the direct costs of the DRT service in Terras de Bouro. To this margin it will be necessary to subtract the annual cost with the global structure of the DRT service for Vila Verde, Amares and Terras de Bouro. These costs of structure include the costs with the planning and management systems, administrative and commercial costs, etc. They were estimated at an amount between 75.000 and 90.00.00 euros. Therefore, the implementation of DRT in the three municipalities will be viable if the sum of the 3 margins (before structure costs) is higher than 75.000-90.000 euros plus the cost of financing, if exists, calculated on the amount of funding. The expected level of activity of the DRT service in Vila Verde and Amares is much higher than in Terras de Bouro. Thus, it is expected that the implementation of the DRT service in these three the municipalities is feasible under the conditions of the study presented in this article. However, it is important to mention that the amount of funding and the level of interest rates could derail the operation.

Moreover, it is interesting to examine in more detail the profitability of the DRT service in the Terras de Bouro of the four areas served considering the operating
conditions and the cost model used. To do this, i.e. established the operating margins of the four zones it was used the strategic ABCM model. Table 3 presents the results obtained. Unit-level costs include expenses with fuel and maintenance (these costs are direct costs of each trip) and batch-level costs include labour costs and vehicles depreciation (these costs are costs of running the service in each zone). Service-support costs are general costs to the 4 zones directly traceable to the DRT service in Terras de Bouro, in this case are the costs with the technician.

Table 3: Margins by Zones

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>164.736</td>
<td>81.224</td>
<td>12.584</td>
<td>66.430</td>
</tr>
<tr>
<td>Unit-level costs</td>
<td>28.805</td>
<td>14.805</td>
<td>6.716</td>
<td>8.432</td>
</tr>
<tr>
<td>Batch-level costs</td>
<td>104.800</td>
<td>63.200</td>
<td>-</td>
<td>63.200</td>
</tr>
<tr>
<td>Unit and Batch-level costs</td>
<td>133.257</td>
<td>73.005</td>
<td>6.716</td>
<td>71.632</td>
</tr>
<tr>
<td>Margin (Zones)</td>
<td>31.479</td>
<td>3.219</td>
<td>5.868</td>
<td>-5.202</td>
</tr>
<tr>
<td>Service-support costs</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Margins (Terras de Bouro)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Zone 3 complements Zone 4 and both should be viewed in an aggregated way. Zone 4 has the less profitable routes and it has unused capacity used to serve passengers of Zone 3. Independently Zones 3 and 4 are unprofitable but running both results in a positive contribution margin (666 euros).

On the other side, appear routes in Zone 1. This one is the most profitable group of routes even having more costs (more expensive vehicles, more fuel expenses and more labour costs). This shows that the DRT service is more profitable in long and medium-sized courses than in short courses because several reasons. Firstly, in short courses the tariff applied will be reduced and revenues will be lower. Secondly, batch-level costs are so high that transporting a reduced number of passengers is not profitable. Thirdly, if distances are shorter we are pushed to suggest more trips by day in order to transport more passengers.

However, there are a maximum number of possible trips by day which is not so different for short and long distance routes (see Table 1, Zones 1, 2 and 4 have similar number of trips per day, 9 and 8). Thus, in this case, augmenting the number of trips by day will increase costs not revenues. Particularly, it will increase unit-level costs but not revenues. Thus, ticket price, distance and passengers/day are three important factors in the profitability equation of DRT services; and all three are positively correlated.

Furthermore, Table 4 presents additional calculus to complement this discussion. These figures are in a day basis.

Table 4: Cost analysis by Zone

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3+4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost/day</td>
<td>512,53</td>
<td>300,02</td>
<td>301,34</td>
</tr>
<tr>
<td>cost/trip</td>
<td>56,95</td>
<td>37,50</td>
<td>25,11</td>
</tr>
<tr>
<td>cost/passenger (minimum)</td>
<td>1,90</td>
<td>1,88</td>
<td>1,26</td>
</tr>
<tr>
<td>breakeven (passengers by trip)</td>
<td>18,00</td>
<td>17,00</td>
<td>14,00</td>
</tr>
<tr>
<td>capacity (passengers/day)</td>
<td>270,00</td>
<td>160,00</td>
<td>240,00</td>
</tr>
<tr>
<td>used capacity (passengers/day)</td>
<td>198,00</td>
<td>142,00</td>
<td>168,00</td>
</tr>
<tr>
<td>unused capacity (%)</td>
<td>26,67</td>
<td>11,25</td>
<td>30,00</td>
</tr>
<tr>
<td>unused capacity ($)</td>
<td>230,40</td>
<td>39,60</td>
<td>152,10</td>
</tr>
<tr>
<td>sales/day</td>
<td>633,60</td>
<td>312,40</td>
<td>255,50</td>
</tr>
<tr>
<td>ticket price (on average)</td>
<td>2,20</td>
<td>2,20</td>
<td>1,81</td>
</tr>
<tr>
<td>cost/passenger</td>
<td>2,59</td>
<td>2,11</td>
<td>1,79</td>
</tr>
</tbody>
</table>

Table 4 shows that zones with shorter routes have more available capacity because it is possible to do more trips by day (Zone 1 uses two vehicles, i.e. 135 passengers by vehicle). However, small distance routes ask for a better use of the available capacity because revenues by passenger are lower than in long distances routes (average ticket price is lower). In extreme cases, very short routes should be replaced by a car convenience service (e.g. combining DRT services with taxi services).

CONCLUSIONS AND FURTHER RESEARCH

Rural areas have no regular public transport that can meet their needs. This is basically due to the cost of having lines running without a minimum of passengers. Thus operators seek alternative systems for public transport in low density areas. In this context, the flexible transport comes as a new paradigm for collective public transport. It can be an alternative in terms of effectiveness and efficiency responding to customer needs.

In this paper a cost analysis of a DRT system was performed. One of the three municipalities where the DRT system can be tested was analyzed in terms of costs and profitability. They were identified and analyzed four areas or zones for the DRT service in Terras de Bouro. Results defined a set of important variables which should be taken into account if the service is implemented in this area. Particularly, ticket price, trip distance and passengers/day are three important factors in the profitability equation of DRT services; and all three appear to be positively correlated.

It was found that the less costly line is not necessarily the most profitable. This was the case of line or Zone 1. This line has more costs but it generates high revenues. These results suggest that the DRT service is more profitable in long and medium-sized courses than in short courses because several reasons as it was
explained in the previous section. On the other side, it could raise the issue of making more trips to increase revenues, but it is not justified when demand is low. In these cases the additional revenue generated can be less than the cost of the new route. Furthermore, there should be noted that the most profitable itineraries are those in which the occupancy rate of vehicles is greater. Thus, it makes sense to have a daily planning of the routes that maximize the occupancy rate.

These results show how important certain operational and strategic decisions will turn the service more effective and efficient in order to ensure the economic viability of the DRT system.

For future work it is expected to extend this cost analysis to the other municipalities, as well as to make an integrated analysis of the three areas exploring the links between the municipalities. Furthermore, additional data collection and simulation tools will permit to make more detailed cost analyses. Particularly, the analysis of different levels of demand, considering real places of origin and destination, simulation of various scenarios for the DRT service (variation in demand, number of vehicles, vehicle's capacity and flexibility of temporary windows, etc.). Strategic activity-based costing is a very useful tool for the understanding of costs and revenues as well as to perform profitability analysis, to define price strategies and to support operational and strategic decisions.

REFERENCES


