

Design of a Paratransit System for Rural Areas

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CHRISTINE MASTROGIANNIDOU

Systems Optimization Laboratory

Department of Mechanical and Industrial Engineering

University of Thessaly

Pedion Areos, Volos, 38334 GREECE

Phone: +30 2421 0 74 041

Fax: +30 2421 0 74 059

Email: hrmastro@uth.gr

ATHANASIOS LOIS

Systems Optimization Laboratory

Department of Mechanical and Industrial Engineering

University of Thessaly

Pedion Areos, Volos, 38334 GREECE

Phone: +30 2421 0 74 001

Fax: +30 2421 0 74 059

Email: lois@uth.gr

ATHANASIOS K. ZILIASKOPOULOS

Systems Optimization Laboratory

Department of Mechanical and Industrial Engineering

University of Thessaly

Pedion Areos, Volos, 38334 GREECE

Phone: +30-697-349-0007

Fax: +30 2421 0 74 059

Email: ziliasko@uth.gr

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Abstract

This paper is concerned with the key stakeholders and design parameters of a deployable paratransit system with emphasis on the system users and the operator. A user survey was conducted in the municipality of Philippi in Northern Greece consisting of 19 villages to obtain potential users' perception of the key system parameters in connection with the likely market share. A heuristic pickup and delivery routing algorithm was implemented and used to evaluate alternate system designs with varying levels of provided service and pricing policies. Some computational results are provided for the network of Philippi, Greece.

Keywords: paratransit systems, travel survey

1. INTRODUCTION

Paratransit is a flexible demand responsive transport system that aims to function at a cost of bus while providing personalized service as close as possible to a taxi. Typically, a user is expected to contact the system requesting a service between two nodes of a network and for a specific time window. The paratransit system aims to facilitate personal mobility needs and fight social exclusion while providing high quality services at a relatively low cost. The system uses a version of a pick up and delivery routing algorithm, known in the literature as Dial A Ride Problem (DARP), to group the trips of the users in such a way that the cost of the system is reduced without deviating too much from the shortest path of each user.

Several versions (one vehicle or multi vehicle, static or dynamic) of the DARP have been studied over the past 30 years. While none is identical to each other, it helps reviewing them. Since the definition of the DARP varies from one author to the next, we only consider cases where time window constraints are imposed and the number of vehicles is greater to one. One of the first heuristics presented for the m-vehicle case was Jaw et al. (1). The basic concept of that algorithm is that it tests the feasible assignment of each available vehicle, and finally the vehicle that produces the smallest additional cost is assigned. Another approach presented by Sexton and Bodin (2). They proposed a heuristic algorithm for multi vehicle static DARP that first partitions the set of customers into M vehicle clusters and then solves the single vehicle problem for each vehicle cluster. After that, it moves customers from one vehicle to another while attempting to reduce total customer inconvenience. Finally, for each of the resultant vehicle clusters solves the resultant single vehicle routing schedule.

Fisher – Jaikumar (3) presented a variant of the classical vehicle routing problem in which a fleet of vehicles delivers products stored at a central depot to satisfy customer orders. The proposed algorithm is a generalized assignment problem with constraints and the objective function approximates the cost of the travelling salesman tour in order to assign the vehicles to service the customers. Once this assignment has been made, a complete solution is obtained by applying any travelling salesman heuristic or optimizing algorithm to obtain the delivery sequence for the customers assigned to each vehicle.

In recent years many modern heuristics and metaheuristics have been developed for the DARP problem – dynamic or static. We can refer to Toth and Vigo (4) that solved the problem by a heuristic consisting of first assigning requests to routes by means of a parallel insertion procedure and in the second phase a tabu - by using intra-route and inter-route exchanges - heuristic algorithm can be executed

additionally to improve the total solution. It is worthwhile to refer also the multi vehicle tabu heuristic by Cordeau-Laporte (5). According to that technique the search for feasible solutions can be done through infeasible solutions and a continuous diversification mechanism is put in place in order to reduce the likelihood of being trapped in a local optimum. To avoid cycling, solutions possessing some attributes are declared forbidden, or tabu, for a number of iterations, unless they produce a new incumbent.

Paratransit started as an element of public transport services in low density areas in the early 1970's. The U.K. and the U.S. were among the countries that very early deployed systems exhibiting this service concept. During the late 1970s, the concept evolved to its present role of a specialized door-to-door service for disabled passengers who cannot use conventional public transport.

In the USA and Canada paratransit services are used extensively as part of the American with Disabilities Act (ADA). In Cyprus, a paratransit taxi-based system exists, mainly for airport service and other intercity trips offering a cheap alternative to a regular taxi. While it is not exactly a door-to-door paratransit application, a popular transit option in Turkey, called "*dolmus*", is a good application example of a new public transportation mode that is more flexible than the public bus and still more affordable compared to taxi/car option.

Many EU countries such as Italy, Finland, Sweden, Netherlands and Belgium have employed paratransit systems, mainly funded by the European Commission. Experience from Europe shows that strategically it is more straightforward to implement paratransit systems in regulated environments, as there is less conflict with other public transportation modes. In 2000, the UK Government pledged in its Ten Year Plan for transport to remove or (at least) relax constraints on the development of flexible bus services and to promote a greater role for community-based services (6). In addition, research commissioned by the Department of the Environment Transport and the Regions (DETR) argues that flexible public transport services— provided by local authorities and bus operators in partnerships with employers, stores and leisure centers —would help to break down social exclusion (7). Similar initiatives have been reported in Ireland, in 1999 (8). More recently, in 2001, the UK Rural White Paper proposals for the extension of Bus Service Operators Grant (BSOG) –formerly Fuel Duty Rebate (FDR) – to community transport were adopted. Finally, the recent successes of local authorities in winning substantial funding under the Rural and Urban Bus Challenge programs for the implementation of demand responsive transport services confirms this new interest in flexible forms of transport.

Very little has been reported for such a service in Greece. As part of the Program Connected Cities funded by the European Commission, the deployment of such a service in remote villages in Greece is investigated. In this paper the analysis of such potential deployment is investigated. While a DARP algorithm has been developed as part of this program, the objective of this paper is not to report on the algorithm but rather on how the algorithm in connection with a user survey can be used to perform an analysis of alternate system designs.

In the next section, the potential stakeholders involved in carrying out a paratransit system are identified and their potential role is briefly discussed. The role of the two critical stakeholders (users and the operator) is analyzed next. In Section 3, the perception of the potential users is investigated through a structured questionnaire and the critical parameters (price and level of service) are quantified. Section 4 is concerned with the role of the system operator and how the results from the survey in

connection with the implemented DARP algorithm can be used to evaluate alternate system designs. Section 5 concludes this paper.

2. DEFINITION OF STAKEHOLDERS

The difficulty of employing paratransit systems in most cases has proven to be the balance that should be achieved between the involved stakeholders. Those are all the entities affecting the operation of the system. The stakeholders identified are summarized below as well as the role they play in the deployment of a paratransit system.

• Users

The potential users of the paratransit system could be categorized into different groups based on occupation, age, gender, etc. The attitude of each user plays an important role and is affected by their mobility needs, financial situation, whether they own private means of transport, trip purpose and origins/destinations. Students, housewives, elders, disabled and retired people appear to be more willing to use such a service, while tourists appear to constitute a special category of users. The paratransit system may accommodate their mobility needs providing transportation solutions of better quality and cost. The users are obviously the most critical stakeholders and their perception will determine the market share attracted by such a system. The most important parameters determining the market share are the cost and the level of service. In the next section, the users' perception is analyzed through a structured questionnaire and the parameters determining the market share are broadly quantified.

• Operator

The operator is responsible for the efficient operation of the paratransit system. Additionally, he is responsible to take all the decisions related to the level of service and the pricing policy. The operator may be a municipal entity, a private entity or a Public Private Partnership (PPP). The objective of the operator is obviously to ensure the financial viability of the system and depending on its corporate structure, to increase profit or social benefit. The operator will be responsible for designing, deploying and maintaining the system. The general impacts of the system on land use, environment and socio-economics are of interest from the point of view of negotiating tax breaks, subsidies and cost-sharing schemes. The operator is probably the second most important stakeholder, as he can determine the pricing policy and level of service that affects users' perception and ultimately market share. The critical design elements related to these parameters are discussed in Section 4.

• Government

Local governments are potential stakeholders as they can be the operator or participate in a Public-Private Partnership (PPP) and of course they have to represent the people in general. In addition, they are also responsible for the compliance with state regulations and for any potential subsidies of the system. Finally, local governments are interested in serving their constituency, especially the old and disadvantaged that have mobility problems. Paratransit can positively impact environmental problems and have important implications on land use and the economy. The system may need to be subsidized through taxation or participation from the local market, which also involves the local, regional and central government. In most cases, because the implementation of a paratransit system requires a large amount of money to be invested, the participation of the local or national government in subsidizing the system would constitute a viable solution especially for the first years of the system's operation.

- **Drivers/Employees**

Deploying a paratransit system influences all the employees responsible for its efficient operation such as drivers, system operators and administrators. Employees may be either private employees, owner operators or even taxi drivers that can participate in the operation. The employees of the system will also be responsible for the quality of the provided services.

- **Local markets & Touristic SMEs**

Local market includes all the public and private organizations like schools, hospitals, commercial markets, etc. These entities may benefit from the increased mobility (in addition to any latent demand) and the flexibility & convenience provided by the system. The increased economic activity is of interest to these entities and they may be asked to participate in sharing the cost of the system.

- **Competition: other Transportation Service Providers**

Other transportation service providers may be the official public bus system that operates in the area, or taxis. The introduction of a new transport system will undoubtedly affect them. Additionally, because the desired service quality of the paratransit system is equivalent to taxis' while the cost remains at lower levels, comparable to those of buses, it is expected that these operators will oppose to the implementation of such a system. There is also a case, however, that the paratransit system accommodates the mobility needs of passengers in favour of the public bus system. Paratransit may be a valuable tool to increase the efficiency of the public bus system and this depends on the type of relationship that will be established between them. On the other hand, paratransit may also collaborate with taxis. It may form contracts with taxis in order to use them in cases where the existing infrastructure cannot satisfy the requests in the system.

3. USER SURVEY

The most important issue that should be taken into consideration in deploying a paratransit system is the perception of the users. The most obvious reason for that is the level in which the users feel satisfied by the currently operating transport systems. In case that the users cannot see the need for the introduction of a new system, even when they have not completely understood the advantages and the disadvantages, it would be less likely to use the new system. Then, it is crucial to identify the market potential of the area in which the new system is going to be deployed.

In addition, if the results of a survey like this are positive, then the paratransit system will be easier to be deployed in terms of financial support by the local government or private entities. But mostly, the purpose of this survey is to capture all the critical elements that need to be taken under consideration in the designing phase and define some crucial steps in the phase of deploying a paratransit system in a rural area. Moreover, all these issues are of interest to the stakeholders in their decisions to deploy or not a paratransit system because finally, the viability of the system depends on these elements.

In many countries that paratransit systems have been already deployed, surveys were conducted but usually only after the system was in operation. Thus, they wanted to capture the perception of the users in terms of enhancing the existing paratransit system and provide services of better quality. The majority of these questionnaires were conducted on-board or even by phone. Additionally, many questionnaires have been presented that deal with the issue of transportation of handicapped persons and how the paratransit system can be adapted in order to provide quality services and easy access to disabled.

Till now, in the literature, there is no survey that investigates the potential acceptance of a paratransit system in any area, urban or rural, and/or independently of the profile of the user. Moreover, there is no survey that investigates the procedure for the design phase of a paratransit system, which is the objective of this paper.

The most widely used method in order to identify the market potential is to conduct a survey by questionnaire. This is the method that we are going to follow in this paper. Next, we discuss the steps that have been followed for the design of the questionnaire.

3.1 Design of the Questionnaire

In order to understand the potential acceptance of the system by the users, we conducted a survey. The purpose of the survey was to investigate the market potential and the potential acceptance of the system in a rural community in Greece.

As we have already discussed in the previous section, the matter of identifying the potential acceptance of the system by the users is quite crucial in deploying a public or private entity to provide paratransit services. It is also crucial because it can help securing subsidies by the government.

The questionnaire was designed in such a way that we would be able to capture the intention of the inhabitants of the area and to elicit answers that are of interest to the stakeholders. The method of data collection that was followed is face-to-face interviews by trained people that had also a good knowledge of the area and the needs for transport. The method was stratified sampling of approximately 2% of the population.

The questionnaire is comprised by four parts. The first part includes some general questions such as the sex, the age and the occupation of the respondent. In order to understand the perception of the biggest part of the population, we divided the population into several categories according to their age. For the deviation calculations we also took into consideration whether the respondent is able to drive or owns a vehicle.

The second part of the questionnaire deals with the usual trips of the respondents. They were asked for the day of the trip, the origin and the destination location, the time of departure and the trip duration, the cost and the purpose of the trip and finally the means of transport that he/she used and whether this were also the desirable means. From the aforementioned questions, we tried to draw some useful conclusions -mainly statistical results- about the trips of the respondents, the days and the hours they usually travel, the destination, the time it takes them and the cost of the trip. The results of these answers can provide an estimate of the cost of the system if it was to be deployed as well as the viability of the system in the target area.

The third part of the questionnaire deals with the specific trips the respondent undertook last week. The purpose of this part was to capture the exact trips that were being made by the respondents at a specific time period, rather than capture their actual habits. This was done because at such questions people tend to exaggerate or state less real-world scenarios. Thus, comparing the answers of the second and the third parts we can draw some safe conclusions about the exact trips of the respondents. The third part contains exactly the same questions with the second part with the only difference being that they are limited to the trips actually performed last week only.

Finally, the fourth part contains some qualitative questions, such as the amount of money that the respondent is willing to pay in order to travel faster, or the extra time that they are willing to spend travelling so that the cost is reduced. They

were also asked for their opinion about the existing transport system and if they would use the proposed paratransit system.

3.2 Conducting the Survey by Questionnaire

The questionnaires were conducted in the rural Municipality of Philippi, Greece. The Municipality consists of 19 villages with a total population of 10,827 inhabitants. A sufficient sample was considered to be around 2% of the population. We followed a stratified sampling methodology, using 210 questionnaires that were equally distributed among the population subgroups or approximately 30 questionnaires per age group. The interviews were conducted by trained people that had a good understanding of the area, available modes and mobility needs.

The elaboration of the official existing public transport system (KTEL) itineraries showed some interesting results. In some villages the frequency of the trips to the biggest urban centre of the area, the city of Kavala, is fairly high while in other villages there are sparse. We also observed that in some villages there are no bus trips at all.

In order to draw useful results from the 30 questionnaires that corresponded to each age group, half of them were conducted in villages with easy access to big urban centres and the rest in villages without easy access. Problems arise during the data collection process due to the lack of inhabitants in some villages. In the Municipality of Philippi there are villages as large as three thousands inhabitants but there are also others as small as only twenty or thirty inhabitants. Another important measure was the distance of the villages from the big urban centres and the facilities provided in those villages. Obviously, people prefer to live in big urban centres despite the substantially higher cost of housing, because they can enjoy these amenities without excessive travelling. Paratransit aims to provide an effective transport system in such rural areas so that people could maintain their residence in a village and have access to the urban area facilities.

3.3 Analysis of the Results

The analysis of the questionnaires revealed some interesting findings regarding the perception of users for the proposed transport system. It also revealed the needs for transport in the target area, the acceptance of the system by the users and some critical elements regarding the categories of population and trip purposes that can be mostly attracted by the paratransit system.

Some of the results were intuitive, such as that the paratransit system would be preferred by women that do not own a private car or they do not have a driving license and they are between forty-five to seventy years old, while men at the same age would not leave their cars in favor of the paratransit system. The system could also comprise an attractive solution for students that want to travel to their schools or take part to extracurricular activities, etc.

The first and most interesting result from the elaboration of the questionnaires was the perception of the users regarding the level of service and its pricing policy. We define as the optimum level of service the one provided by taxis, because they drive you directly to the desired destination location, following the potential shortest path route. The lowest level of service is that of the bus, which usually makes a lot of stops before delivering the passenger to the desired location and usually is associated with walking and waiting. Furthermore, we define the cost of the taxi to be the highest while the cost of bus the lowest. The expected output would be the users to answer that they want the level of service equal to taxi and the system to be free of charge or

cost the price of the bus ticket. On the contrary, as can be seen in figure 1, the majority of the respondents would be happy with a system that would cost half of the price of the taxi and taking twenty-five percent more travel time than the taxi.

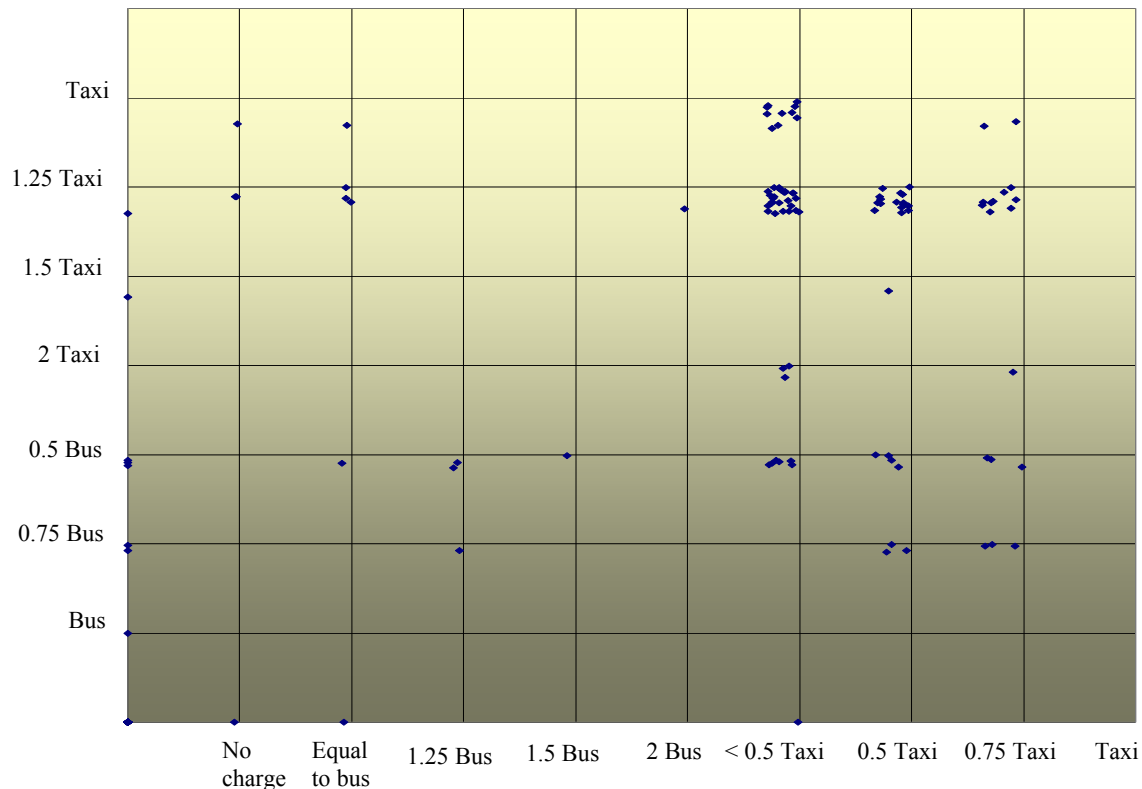


FIGURE 1 Level of service vs. price.

Another important result is that the majority of the trips were accomplished by unemployed / pensioners and housewives / housebased employees while the greatest part of trips was undertaken by women between eighteen and forty-five years old (Figure 2). The most frequent purposes of transport are shopping, business and social reasons (Figure 3).

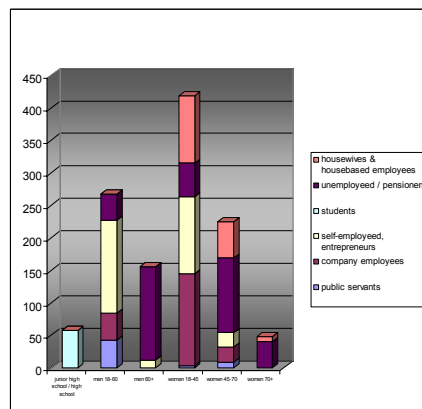


FIGURE 2 No of trips vs. age and occupation

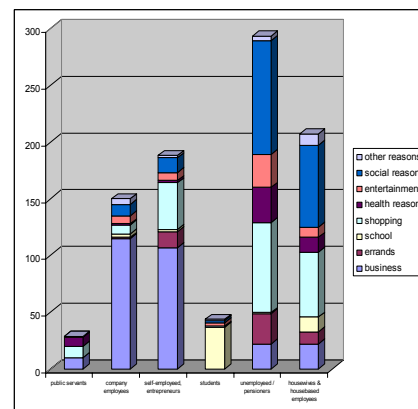


FIGURE 3 Trip purpose.

We also examined the number of respondents that use bus and taxi for their transportation needs. The results revealed that mostly women use bus for shopping and children to go to school. Taxi is also used by women when there are health reasons for the trip and for shopping but the number of respondents that use taxi are much less than those using bus.

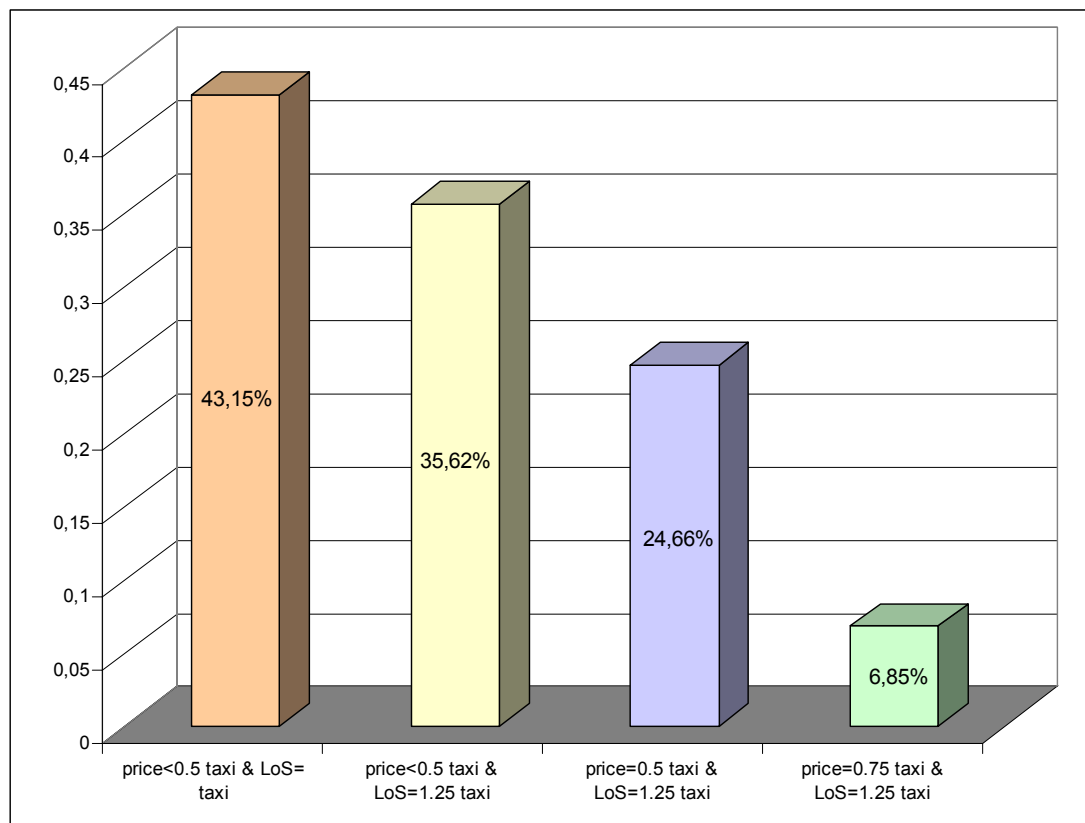


FIGURE 4 Paratransit market share versus price and level of service.

The potential market share of the paratransit system, as shown in Figure 4, depends on the level of service and the price. It is extremely interesting that about forty percent of the surveyed is willing to use the paratransit system if it costs less than the half price of the taxi while providing the exact level of service with taxi. For a system like this it is often difficult to achieve the same level of service with taxi due to its purpose to transport simultaneously more than one passenger. But, looking carefully at the plot, we observe that the next column which is about thirty-five percent of the examined sample would use the proposed system if it was half the price of the taxi and the travel times were twenty-five percent more than the taxi. If we translate the above percentage into the number of passengers per week it is almost four thousands passengers per week which is large enough.

4. DESIGN OF A PARATRANSIT SYSTEM

One of the most useful benefits of the above study is to help the operator of the paratransit service to identify the key operating elements of the system. The components that are critical in the design of the system are the number and the capacity of vehicles, the level of service in terms of time and distance deviation compared to that of taxi, basic operating costs and the minimum charge per kilometer per passenger in order the system to be profitable. In order to produce specific numbers for the aforementioned key elements, we followed the procedure described below:

First step: we specified the main user groups depending on pricing policy and level of service. The following table gives the demands defining these groups. Attention must be given that those numbers are not mentioned on the total demand of the area, but are related to the sample size of the survey; the demand that is based on

the sample size can simply extrapolated to capture the perception of the whole population.

TABLE 1 Market Share Groups

Group Name	Level of Service	Pricing Policy	Demand
GRP01	1.25*(Taxi Time)	=0.75*Taxi cost	78
GRP02	1.25*(Taxi Time)	=0.5*Taxi cost	48
GRP03	1.25*(Taxi Time)	<0.5*Taxi cost	114
GRP04	Taxi time	<0.5*Taxi cost	28
GRP04+GRP03	<= Taxi time	<0.5*Taxi cost	142=28+114
GRP04+GRP03+GRP02	<= Taxi time	<=0.5*Taxi cost	190=28+114+48
GRP04+GRP03+GRP02+GRP01	<= Taxi time	<=0.75*Taxi cost	268=28+114+48+78

For example group GRP04 is willing to pay less than half of the taxi charge while the respondents that belong to GRP04 are not willing to travel more than a taxi does. Group GRP03 is willing to pay less than half of the taxi charge and likes the travel time to be no more than 25% longer than the taxi time. The combined group GRP03+GRP04 is willing to pay less than half of the taxi charge and likes the travel time to be no more than the exact taxi time.

In the same way we combine groups GRP02+GRP03+GRP04 and GRP01+GRP02+GRP03+GRP04. The various groups added because it is obvious that the responders willing to pay the most will also use the system on the assumption that the level of service will be at least equal with the accepted level of service.

Second step: identify and run specific experiments in order to simulate the real demand requests for every market share. Each experiment is a combination of the group (or group combinations), the number of vehicles and the different capacity. Table 2 shows the exact concept behind the experiments.

TABLE 2 Experiments Specification

Fleet size	Capacity of each vehicle	Group(s)	Number of Demands
2	8	GRP04	28
2	8	GRP03+GRP04	142
2	8	GRP02+GRP03+GRP04	190
2	8	GRP01+GRP02+GRP03+GRP04	268
2	12	GRP04	28
2	12	GRP03+GRP04	142
2	12	GRP02+GRP03+GRP04	190
2	12	GRP01+GRP02+GRP03+GRP04	268
4	8	GRP04	28
4	8	GRP03+GRP04	142
4	8	GRP02+GRP03+GRP04	190
4	8	GRP01+GRP02+GRP03+GRP04	268
4	12	GRP04	28
4	12	GRP03+GRP04	142
4	12	GRP02+GRP03+GRP04	190
4	12	GRP01+GRP02+GRP03+GRP04	268

One of the most effective heuristics that have been successfully applied to solve the DARP, as well as the general vehicle routing problem with time constraints is the parallel insertion algorithm (1),(4). This algorithm has been extended to produce specific results useful to our application. In short, the algorithmic steps can be described as follows:

Initialization step of our algorithm just initializes our system by sorting the demands and vehicles set. Constructs also routes set which has the same number of members as the vehicles set.

Optimization Step1 does the appropriate demand allocation to the route, provided that the additional cost of the insertion is the smallest. This is done by examining every insertion to every route.

Optimization Step 2 does an intraroute optimization by first removing the allocated demand from the route it belongs and then reinserts it into a better position in terms of decreasing TOTALROUTE COST

Notations

DEM set of experiment demands

VEH set of vehicles

RTS set of routes

PPOS pickup position when demand is inserted on a specific route

DPOS deliver position when demand is inserted on a specific route

COST additional cost when demand is inserted on a specific route

TOTALROUTE COST total route cost concerning all allocated demands on that route

Function: main()

1. Initialization Step:

1. Sort demands by the earliest pickup time and construct DEM set
2. Sort vehicles by capacity size (descending order)
3. For every $V \in \text{VEH}$ create the initial empty routes set RTS including only depots (start, end) nodes

2. Optimization Step1:

For every demand in DEM set, do

MaxDemCost = Very Large Number

For every route in RTS set, do

Call the function Find_Best_Route_Insertion_Position which returns (PPOS, DPOS, COST, feasibility condition)

If (MaxDemCost > COST) and feasibility condition is true

MaxDemCost = COST

Mark Route, PPOS, DPOS

End if

End routes processing

Call the function Insert_Demand

End demands processing

3. Optimization Step2:

For every route in RTS

MaxRouteCost = old TOTALROUTE COST

For every demand allocated on that route

Remove demand from that route

```

    Call the function Find_Best_Route_Insertion_Position which returns
    (PPOS, DPOS, TOTALROUTE COST, feasibility condition)
    If (MaxRouteCost >= TOTALROUTE COST) and feasibility condition
    is true
        MaxRouteCost = TOTALROUTE COST
        mark route, PPOS, DPOS
    End if
End allocated demands processing
Call the function Insert_Demand
End routes processing

```

Function: Find_Best_Route_Insertion_Position

MC = Very Large Number

For every position, insert demands pickup node

 If the insertion is feasible in terms of time windows violation

 For every position (after pickup position), insert demands deliver node

 If the insertion is feasible in terms of time windows violation

 Check feasibility in terms of (Vehicle capacity, User Ride Time,
Vehicle Ride time)

 If feasibility check is true

 Calculate (COST or TOTALROUTE COST)

 If MC > (COST or TOTALROUTE COST)

 MC = (COST or

 TOTALROUTE COST)

 Mark Pickup and Deliver Pos

 End if

 End if

 End if

 End demands deliver position processing

 End if

End demands pickup position processing

Returns MC, pickup pos, deliver pos

Function: Insert_Demand

By using marked route, PPOS, DPOS insert demand on the specific route on specific pickup and deliver position

Third step: identify for every experiment the critical results that are useful for the operator. Such critical results could be the total distance covered by the vehicles, total passenger distance (in passenger kilometers) covered by all vehicles, average number of passengers per kilometer, shortest path distance for all the demands, average percentage of distance deviation per passenger from the corresponding shortest path.

Using these results, the operator can identify the operating costs in such a way to be useful to balance the service levels and operating costs. In the following table we give the results produced by the experiments.

TABLE 3 Experiments Results

N of V	CAP	MARKET SHARE	Dem and Num	Total Distance	Total Passenger-kilometers	Avg Passengers/km	Total SP Distance	Avg Distance Deviation	Avg Time Deviation Percentage %	Avg Distance Deviation Percentage %
2	8	GRP04	28	75,4	75.4	2	75,4	0	186	0
2	8	GRP03+GRP04	142	263,74	515.9	2.292	311,66	7.043	125	65
2	8	GRP02+GRP0+GRP04	190	295,06	537.43	2.048	371,81		114	44
2	8	GRP01+GRP0+GRP03+GRP04	268	307,1	608.14	2	360,32	6.044	133	68
2	12	GRP04	28	75,4	75.4	2	75,4	0	186	0
2	12	GRP03+GRP04	142	263,74	515.9	2.292	311,66	7.043	125	65
2	12	GRP02+GRP0+GRP04	190	295,06	570.23	2.173	346,59	6.044	137	64
2	12	GRP01+GRP0+GRP03+GRP04	268	307,1	608.14	2	360,32	6.044	133	68
4	8	GRP04	28	75,4	75.4	2	75,4	0	186	0
4	8	GRP03+GRP04	142	282,86	513.18	2.187	321,22	6.399	118	59
4	8	GRP02+GRP0+GRP04	190	424,9	675.98	2	472,62	4.519	137	43
4	8	GRP01+GRP0+GRP03+GRP04	268	497,36	882.23	2.066	506,35	6.712	146	74
4	12	GRP04	28	75,4	75.4	2	75,4	0	186	0
4	12	GRP03+GRP04	142	282,86	513.18	2.187	321,22	6.399	118	59
4	12	GRP02+GRP0+GRP04	190	399,78	650.9	2.095	441,36	4.762	136	47
4	12	GRP01+GRP0+GRP03+GRP04	268	505,7	852.51	1.958	506,35	6.181	139	68

For example, we examine the experiment where 2 8-seat vehicles are deployed, and the market share is GRP02+GRP03+GRP04, while the total number of demands is 190. The experiment gives the following results for that combination of vehicles, capacity and market share: total distance covered by all vehicles, 295.06 km (the demands in this area were quite short in terms of distance, 2-3 kilometres on average) while the straight shortest path distance (as if the passengers using taxis) is 371,81 km. The averaged distance deviation was 44% (0.9 – 1.2 km) more than the pure shortest path distance.

The customer is charged for the distance that he/she travels according to the shortest path route to their destination, regardless of whether this is the route that he/she has actually travel or not.

Assuming known fuel prices, salaries and vehicle maintenance costs, we compute the appropriate charge per kilometre in our case. Table 4 summarizes these results under the specific assumptions given below.

TABLE 4 Final Charges Table

N of V	CAP	MARKET SHARE	Demand Num	Taxi charge per kilometre	Paratransit charge per km with initial costs	Paratransit charge per km without initial costs
2	8	GRP04	28	1,30	2,09	0,98
2	8	GRP03+ GRP04	142	1,47	0,81	0,54
2	8	GRP02+GRP03+ GRP04	190	1,58	0,72	0,49
2	8	GRP01+GRP02+ GRP03+ GRP04	268	2,05	0,76	0,53
2	12	GRP04	28	1,30	2,2	0,98
2	12	GRP03+ GRP04	142	1,47	0,85	0,54
2	12	GRP02+GRP03+ GRP04	190	1,66	0,8	0,53
2	12	GRP01+GRP02+ GRP03+ GRP04	268	2,05	0,79	0,53

The procedure described should enable the operator to produce the appropriate conclusions in order to make the decision to deploy or not a paratransit system. The use of the procedure could be used as a very useful tool to any organization – governmental or private – wishes to operate paratransit systems.

Of course optimization concerning the identification of market share, the number and the type of quality parameters and the dial-a-ride algorithm could be done in any case. The research area is wide open to those fields.

5. CONCLUSIONS

This paper introduces an approach for analyzing, designing and deploying paratransit systems in rural areas. We identified the potential stakeholders, the critical parameters and the impacts related to the deployment of paratransit systems and comprise critical elements in the designing and the operating phases of the paratransit system. The users and the operator appear to be the most critical stakeholders for a successful deployed paratransit system. A survey was used to identify the users' perception and the potential market share of the system. These two elements are critical for the viability of the system. The data collected were analyzed and the results showed that for specific user groups the expected penetration of the system would be large enough. The results in conjunction with an implemented DARP algorithm were used to evaluate alternative system designs taking into account the market share as revealed from the survey.

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