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INTEGRATION AS A COMPETITIVENESS INSTRUMENT FOR PUBLIC TRANSPORT IN RURAL AREAS

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ABSTRACT

The market of interurban mobility to rural areas is one of the most challenging for Public Transport (PT). In Portugal it has been quite difficult for Public Transportation to establish itself in this market as an effective alternative to the use of private cars. Two of the main reasons for this are the low accessibility of long distance railway services and urban sprawl in many Portuguese regions.

Integration facilitates the use of several services of the transport chain and facilitates a more efficient resource allocation on the supply side of the system. By making local distribution possible in connection with long distance services, even in low demand areas, integration may foster a higher patronage of PT and its competitiveness compared to private car.

This paper presents the study of five short-range road transport services in connection to the railway network in the Médio Tejo region, including the key elements that are to be considered on their design. The research identified the possible interested agents and made an account of their related costs and benefits. The conclusion is that these services can be commercially interesting and may bring considerable increase in the market share of PT.

Keywords: Integration, Multimodal Transport, Public Transport, Interurban Transport, Economic Evaluation.

INTRODUCTION

Over the last decades Public Transportation lost its importance while the availability and use of private car rose significantly. This evolution generates serious problems of sustainability, as is widely acknowledged (Kinnock, 1996).

Evolution in PT: mechanisms & challenges

The rise of living standards over the last decades led to a significant growth in car ownership. This favoured urban sprawl, making operation of PT services less efficient, and leading to reductions in its supply (completing a vicious cycle) and of patronage (CE, 1996).

The continued reduction of PT use led PT operations to depend in most cases from State support, and this, in conjunction with Public budget constraints, caused resource deficiencies, both in equipment and personnel. These resource problems aggravated the quality deficit of PT (CE, 1996).

Besides these, other factors contributed to the reduction of PT use. Among them is the poor integration of PT services when no direct service is available for the client (CE, 1996).

The difficulties in sustaining PT in certain areas due to urban sprawl let the populations dependent on private cars, thus causing serious social problems (Kinnock, 1996) for those who don't have access to the private car, due to low income, age or health restrictions. On the other hand, the increase in travel needs due to urban sprawl together with an increased use of private cars caused a significant increase in transport externalities (CE, 1996).

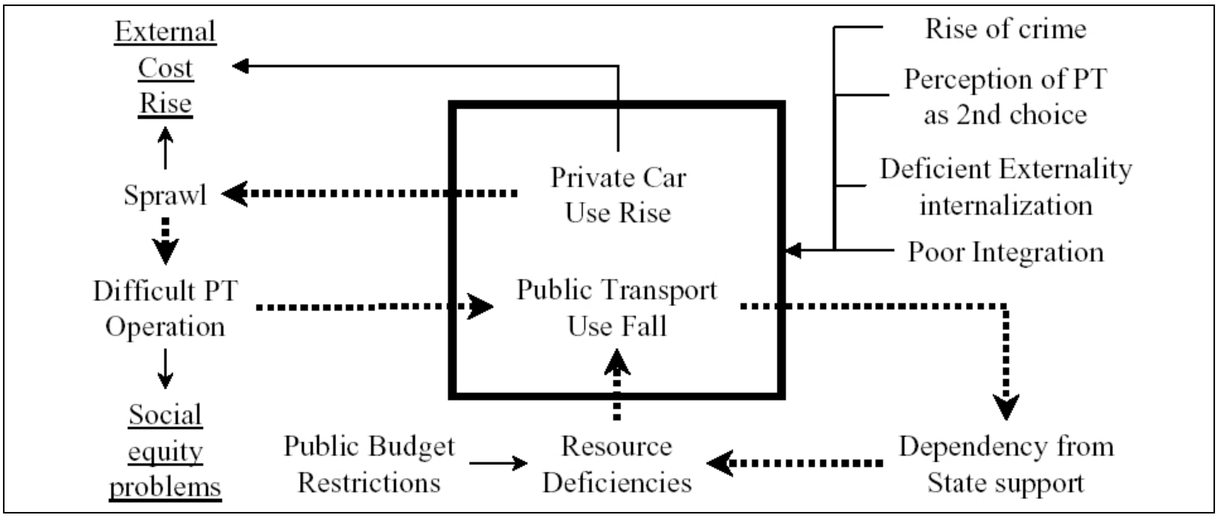

Figure 1: PT evolution mechanisms (Adapted from: Cristóvão, 2005)

Given these problems, the need to address the lack of resources, to operate cost-effective services (especially in low density areas) and to increase market share by improving competitiveness against private car may be defined nowadays as the main challenges for PT.

Integration as a competitiveness instrument

Each traveller chooses the alternative that maximizes his utility, i.e., with the lowest generalized cost. Integration brings efficiency to the demand side (use) of the system by cutting transition costs of those travellers that have no direct service for their journey (Viegas, 2005). Given the impossibility to provide direct services to all journeys, integration promotes customer satisfaction (allowing more and longer trips) and competitiveness of PT (more travellers), favouring the generation of more revenue (ISOTOPE, 1997).

Integration also brings efficiency to the supply side of the system (cost reduction) by making easier the balance between demand and supply in the different parts of the network and by promoting the introduction of economies of scale and/or density (Viegas 2003).

By allowing the use of more than one type of vehicle in the same journey, integration also brings flexibility to the operation of the system. Thus, it both makes easier the balance between demand and supply in the different parts of the network (opportunity to cost reduction) and gives more freedom (flexibility) to eliminate redundancies in the network every time they bring no apparent benefit to the user (Macário, 2004). This flexibility represents, together with the demand increments, an opportunity to get economies of scale and/or density.

The easier balance between demand and supply made possible by the easy use of different vehicles in the different parts of the network also promotes the possibility to provide services in different and new environments, promoting increases in demand and in revenue.

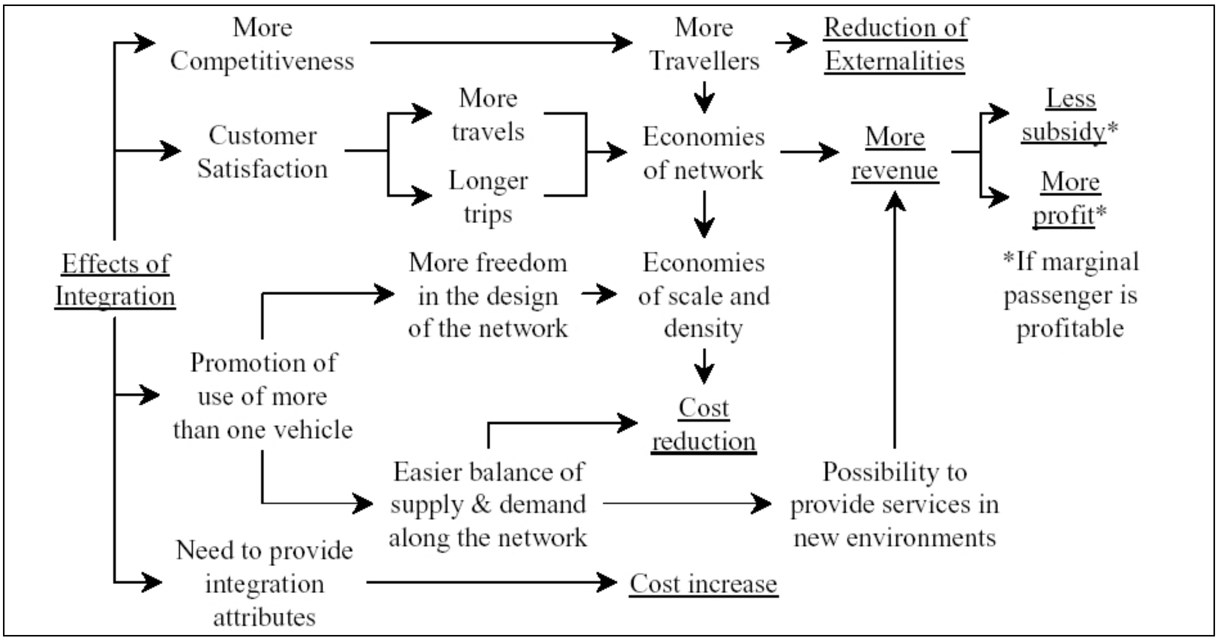

Figure 2: Possible effects of integration (Adapted from: Cristóvão, 2005)

Although the need to provide the desired integration attributes has its costs, by contributing to costumer satisfaction (1), to an easier operation in low-density areas (2) and to productive efficiency (3), integration may be a way to break the negative cycles mentioned before, to address the challenges of competitiveness (1), cost-effectiveness (2) and lack of resources (3), and an important (Transport Policy) instrument to meet social and environmental goals.

PT and the market of interurban mobility to rural areas in Portugal

This paper is focused on the Portuguese market of urban mobility to rural areas. Some specificities of the market of urban mobility to rural areas are:

1. The high percentage of non-frequent users and the high value they apparently tend to give to accessible and reliable transportation.

2. Sprawl and the low density in rural areas together with the low accessibility (by road based PT) to the interurban railway stations – partly related to the low extension of the railway network (UIC, 2004).

These specificities explain why the market of interurban mobility to rural areas is one of the most challenging for PT (regarding the problems identified before) and show that the reasons explaining it can be found both in the demand side (1) and in the supply side (2) of the system.

Approach

This paper is based on a study, the main goal of which was to evaluate the economic feasibility and the social interest associated to the operation of road based PT services complementary to interurban railway passenger services.

The object of the research consisted of five hypothetic (short-range) road services to be integrated with the existing railway supply, aiming at the mid-and long range travellers. Each service connected one town (or group of towns) to a railway station nearby.

The locations of these services were areas with poor level of PT service in the Médio Tejo region (around 100Km North of Lisbon). The towns to be served were Atalaia, Golegã (both connected to Entroncamento station), Ourém (connected to Caxarias station), Pego and S. Miguel do Rio Torto (both connected to Abrantes station).

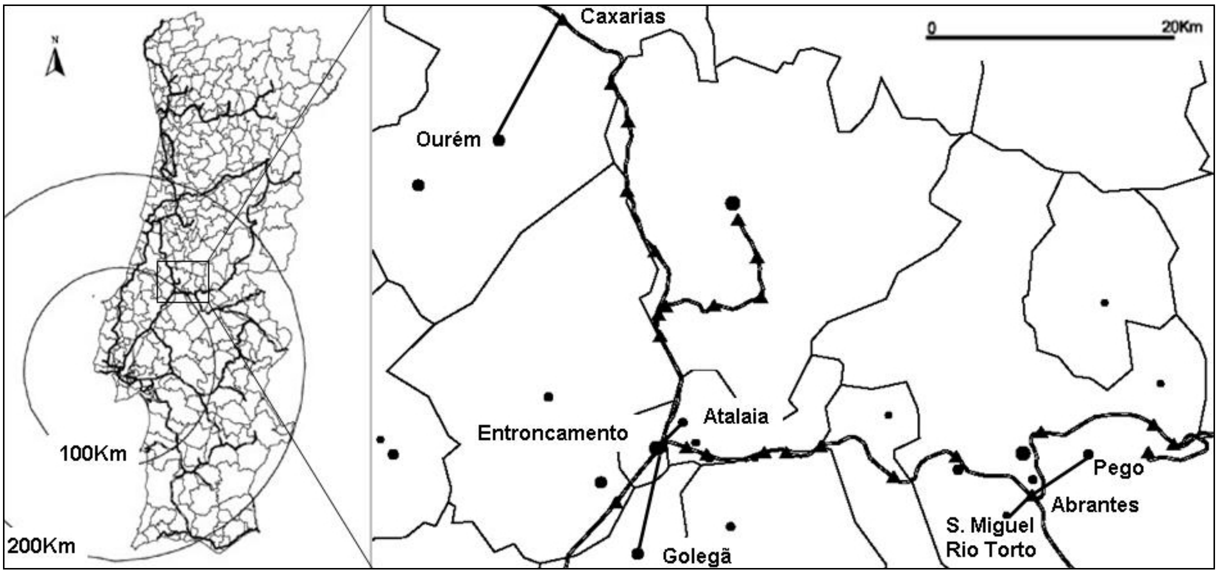

Figure 3: Location of the studied services (Source: Cristóvão, 2005)

The methodology in the research included:

1. The estimation of the demand potential of the complementary road transport services, including the study of present and future consumer mobility habits and their willingness to pay for those services;

2. Planning of those services, including the choice of the route, interchange and stops, the estimation of the duration of the course, the definition of the size of the fleet and the construction of the schedule according to the existing railway supply;

3. The estimation of the necessary supply resources, i.e., vehicle fleet capacity, vehicle-km, requisites in personnel and duration of driving periods;

4. The estimation of the related costs and benefits, i.e., service direct revenue, expected rise in railway revenue, external cost reduction, on the side of the benefits, and complementary service operation cost, on the side of the costs (rise in railway costs was not considered, given the available slack capacity).

This paper presents some of the main results of the study, namely those related to the design of the services (key elements of the design and impacts of the service).

The second part of the paper presents evidences of the pertinence of these services. The third presents details of the design of the services and the fourth presents the results and the synthesis of the key elements taken during their design.

CONTEXT ANALYSIS AND DETECTION OF OPPORTUNITIES

Existing interurban services

The focus of research was the mobility between the towns to be served by the short-range road services and the group of main cities directly reached by the mid-and long distance railway services touching on the corresponding interchanges. Among these cities, Lisbon is the main destination for the population living in the area, which is why the values in the next table concern Lisbon. As it can be seen, only Ourém and Golegã (the two most populated towns among those studied) have direct PT services (express coaches) connecting them to Lisbon (one per day per direction).

Town	Atalaia	Golegã	Ourém	Pego	S. Miguel
Population (2001 census)	1708	3743	5258	2360	1150
Services per day	0	1	1	0	0

Table 1: Frequency of direct services (Source: Cristóvão, 2005)

Anyway, there are interchanges (Hubs) in the neighbourhood of these towns that concentrate a considerable amount of competitive railway interurban services to the main cities. The next table shows the average values of price (including fuel and tolls) and time spent on a car journey between each of those towns and Lisbon. The table also shows, both for train and bus, price and travel time (hh:mm) and the number of daily services per direction on connections between Lisbon and the respective nearest Hub in the region of each of those towns (Frequency).

Mode	Town	Atalaia	Golegã	Ourém	Pego	S. Miguel
Car	Travel Time	1:09	1:12	1:23	1:30	1:31
	Price	15.59€	15.42€	18.17€	18.11€	18.11€
Train	Hub	Entroncamento		Caxarias	Abrantes (Rail Station)	
	Frequency	35		8	11	
	Travel Time	0:50 to 1:23		1:16 to 2:32	1:40 to 2:44	
	Price	9.5-6.0€		8.0-6.5€	7.5-6.5€	
Bus	Hub	Torres Novas		Fátima	Abrantes (Bus Station)	
	Frequency	11		21	12	
	Travel Time	1:15 to 2:05		1:25 to 2:30	1:45 to 2:25	
	Price	6.50€		8.90€	7.00€	

Table 2: Interurban transport supply in the region (Source: Cristóvão, 2005)

Accessibility to the existing interurban services

Although these Hubs concentrate a considerable amount of competitive interurban PT services, local access to them by PT is quite unsatisfactory, due to the reduced number of transport services connecting them to the surrounding areas and/or to the poor integration level of the PT system, both at physical, tariff and logical level. As result of this, the use of the private car to access the Hubs is predominant, once taxi services are expensive.

The next table shows the distance to the train Hubs, the number of PT daily connections to those hubs from those towns, the percentage of people who finds that PT local services don't provide satisfactory integration in the connection to the interurban services (rate of perception of lack of integration – RPLI) and the resulting market share of PT in the access to the Hubs (Access by PT).

Town	Atalaia	Golegã	Ourém	Pego	S. Miguel
Rail station	Entroncamento		Caxarias	Abrantes (Rail Station)	
Distance	3,5 Km	7,0 Km	11,5 Km	5,6 Km	3,0 Km
Daily Connections	7	3	18	2	1
RPLI	90%	91%	94%	98%	95%
Access by PT	0%	0,6%	6,3%	6,8%	3,8%

Table 3: Accessibility to the railway services (Source: Cristóvão, 2005)

However the park & ride also carries serious disadvantages on the user perspective (security of the vehicles and capacity problems in the parks of the most attractive Hubs). These disadvantages together with the inability of the PT network to assure seamless door-to-door connections for the main cities in the country (both direct and indirect, using Hubs) explain the low use of PT and the high use of the private car in most places. The next table shows, for each town, the market shares of private car, bus and railway on trips to Lisbon.

Town	Atalaia	Golegã	Ourém	Pego	S. Miguel
Private Car.	13%	75%	82%	24%	71%
Bus	0%	0%	14%	3%	1%
Railway.	87%	25%	4%	73%	28%

Table 4: Interurban transport current market shares (Source: Cristóvão, 2005)

Although the variables that explain the market structure of transportation to and from a certain town are multiple and diverse in their nature, many of the values previously shown, together with some additional information, are consistent with the market shares displayed in this table. The cross analysis of all these values indicates that:

1. For similar conditions of frequency, speed and price, rail seems to get higher market shares than bus;

2. The market share of PT tends to be higher around Hubs with higher frequencies and shorter travel times. Entroncamento station is a good example of that – travel time to Lisbon is very competitive and service is very frequent;

3. The attractiveness of these Hubs is such that it is even felt in distant places. The best example of this is Entroncamento whose influence is felt in all towns, especially in Pego, where the use of Entroncamento station as a way to access the railway network (specially among its frequent users) is nearly as high as the use of the much closer Abrantes station;

4. Market share of PT tends to be higher in towns with higher accessibility to the Hubs.

Influence of accessibility over the attractiveness of the existing interurban services

More generally, these results show that, although the specific geographic, social and cultural factors affect the transportation market structure (e.g., Golegã), the supply characteristics seriously influence travelers' preferences to an extent that PT may be competitive with the private car (e.g. Atalaia). The results indicate that among the supply characteristics influencing the modal choice are price, travel time and frequency of the interurban services as well as accessibility to the stations. Further results confirm the influence of accessibility and of good integration's over the market share of interurban services:

1. Among the eight factors of modal choice that travellers living in these towns mostly mention, three are connected (directly) to integration and other two more may be (indirectly) connected to it;

2. At those places, former PT users revealed that the reasons to abandon PT (and railways in particular) for their travel to the main cities are (directly) related to the lack of integration attributes of PT in 48% of the cases and that they may be (indirectly) related to that lack of integration in other 12% of the cases.

Considering the possible influence of integration over the attractiveness of PT interurban services, the effect of the supply of complementary services in terms of modal shift towards the railways has been estimated. The table shows the estimated market share for each mode of transport at each town:

Town	Atalaia	Golegã	Ourém	Pego	S. Miguel
Private Car.	8%	8%	30%	8%	24%
Bus	0%	0%	6%	3%	0%
Railway.	92%	92%	64%	89%	76%

Table 5: Estimated interurban transport future market shares under conditions of good integration (Source: Cristóvão, 2005)

These results, together with an apparently genuine enthusiasm (of the interviewees) for the possible introduction of the complementary services, show that these services may induce a considerable increase in the railway usage, although some values in the table reflect extremely low present market shares of railway and carry a significant level of uncertainty due to reluctance or incapacity to give proper answers, probably due to poor knowledge of railway travel resulting from lack of use experience.

Anyway, complementary services only generate this enthusiasm because they provide (in association with interurban transportation) seamless door-to-door travel, making the travel possible without the use of the private car, both for most present railway users (park & ride or lift from another traveller) and many present car users (tolls, parking costs and congestion). Given the need to deliver good integration attributes, some restrictions will have to be considered in the planning of the services. The analysis of those restrictions is the object of the next section.

KEY ELEMENTS DURING DESIGN STAGE

As seen above, the evaluation of the economic viability of the complementary services was based on the estimation of their potential costs and benefits. The process of cost estimation followed the methodology presented in (Allport, 1981), based on the determination of three technical dimensions of the service – vehicle-km, vehicle-hour and total number of vehicles of the fleet. These values can be computed based on the design of the service, which was divided in two stages:

The first covered the definition of basic properties of the service; during the measurement of the attractiveness of the service those properties were the object of people's judgements.

The second corresponds to the full design of the service; this design is meant to support the accurate estimation of the costs resulting from the operation of the service.

Design of the service before the estimation of the Demand Potential

Choosing the location of the interchange

The design of the complementary services begins with the definition of the railway stations where the connection to the interurban services is to be established. The interchange should be as near as possible to the town being considered but, on the other hand, it should provide as many connections as possible. Thus, the chosen interchange shall provide the best balance between proximity and favourable railway supply factors. These factors are favourable if they contribute both to costumer satisfaction and to make the coordination between local and interurban services easier.

Among the variables that contribute to costumer satisfaction are service frequency and diversity available at the interchange. Among the factors that contribute to make coordination of complementary services with interurban supply easier is the pace of arrivals and departures (of trains) at the interchange. The best situation occurs when the interchange is located at a symmetry point of the line (which depends on the train schedule). As on single-track lines symmetry points are usually located at stations and on double-track lines stations usually are not symmetry points, the coordination between the rail services and the complementary services tends to be easier on single-track lines than on double or on multiple lines (Clever, 1997).

Estimating the complementary service travel time

With the choice of the interchange station, it is possible to define the route between the town being considered and the station. Considering the level of congestion of the route and the likely stops on the way, it is possible to estimate the travel time between the town and the interchange. Although this may be done in the office, some field trials are advisable for greater reliability of the estimates.

Additionally, given the fact that accessibility to the service may influence its attractiveness, it’s important to decide if there will be distribution circuits at the town under analysis. If so, the time needed for this local distribution must be added, requiring analysis of the urban structure, the identification of points to serve, circulation rules and the definition of the route to take.

Defining the interchange duration

The interchange period is the interval between the arrival of the incoming vehicle and the departure of the departing vehicle. It shall be as short as possible but it must be enough to allow all passengers to exit the incoming vehicle, to cross the pathway between vehicles, to access the departing vehicle and, if necessary, to buy the ticket for the subsequent transportation. This means that the accurate definition of the interchange duration must consider factors connected to:

1. The users (number and composition, including the elderly, etc.);

2. The vehicles (size, door width and gap between the floor and the stop/platform);

3. The pathway between the stops and the platforms (extension, availability of guiding signs, existence of stairs and obstacles like roads, tracks or others);

4. The integration level in terms of tickets, tariffs and selling points (need to buy tickets during the interchange, prices and types of available tickets, number and type of ticket selling points available, etc.).

Thus, the definition of the interchange duration requires, besides some analysis in the office, the knowledge of the specific conditions in the field. In the specific case of the study it was defined that the interchange duration would be around 5', mainly because the local bus stops could be located close to the entrance of the station, there would be no need to buy tickets during the interchange (neither for the train, nor for the complementary service) and this period would be more than enough for all passengers (including the elderly) to exit and access the vehicles and walk all the way between them.

Defining comfort conditions on board

Although comfort conditions on board the complementary services may influence the user's quality perception of the service, they seemed not be of great importance, probably because of the reduced travel times in question. Anyway, for capacity and cost computations it was defined that the vehicles would have reasonable comfort standards, including the availability of comfortable seats to most passengers, air conditioning and a low noise level on board.

Design of the service according to the estimated Demand Potential

Fixing the fleet size

Given the travel duration and the interchange interval, the number of available vehicles is the missing element to the definition of the schedule of the service. Fleet dimension is largely determined by the analysis of the pace of train arrivals and departures together with the time needed to perform a new service (rotation time) if:

1. The pace of train arrival and departure is significantly lower than the rotation time for the local service (making only one vehicle necessary);

2. Given the short rotation time, the frequency provided with one vehicle is such that the waiting time for the next complementary service (or for the next transport chain) is not significant.

Defining the schedule of the service

The definition of the schedule may be used as an instrument of (resource use) efficiency and costumer satisfaction as the number of connections is maximized. When the number of available vehicles is not enough to serve all trains, it has to be decided which trains shall be served and which shall not. If the demand for each train is known, the criteria to support that decision may be the minimization of the time lost per passenger or the maximization of passengers benefiting from connections to the train they preferred.

Although the goal of the definition of the schedule is the maximization of the number of connections, there are restrictions limiting that number.

Complementary services in their definition are services offering good integration attributes. Characteristics like the duration of the travel, the duration of the interchange process, together with the elimination of the need to buy tickets at the interchange, seem to be the main attractiveness factors of these services. Thus, it is very important that the definition of the schedule of the service ensures these characteristics. Then, the main restrictions facing the definition of the schedule are the coordination with the schedule of the railway services and the respect of the periods of time needed to the local trip and to the interchange process.

Another important factor to consider during the definition of the schedule of the service is reliability. Although reliability may imply the introduction of restrictions, ensuring that the intervals between services are short and that connections to other services are not lost is very important. The consideration of a lower average speed and the introduction of extra times to be used in the absorption of delays or as work breaks is a way to promote reliability during the definition of the schedule. Other factors beyond the definition of the schedule (e.g., the existence and use of bus corridors in areas with congestion) may be important factors in the promotion of reliability.

Defining the composition of the crew

The existence of staff to sell tickets on board contributes to the reduction of the time at terminals. On other hand, that staff contributes to have higher costs. If there is no need to buy tickets at terminals, then the utility of that staff is smaller. On the study, the existence of staff on board specifically for (i.e. with the only mission of) selling tickets was considered unnecessary.

Building the crew schedule

The definition of the crew schedule begins with the determination of the minimal number of drivers necessary to ensure the service during the day and during the week. This task is designed according to the following regulations:

1. Maximum duration of the daily driving period (9 hrs), compared with the daily supply period, and Minimal duration of the driving breaks (45’ per each 4 hrs), compared with the breaks foreseen in the schedule (only breaks longer than 15’ count);

2. Minimal duration of the weekly period of rest (45 hrs).

The first two regulations (1) give the minimal number of necessary drivers per day and the third (2) gives the additional number of necessary drivers per week comparing to the minimal number of drivers needed per day.

The definition of the crew schedule continues with the definition of the allocation of daily shifts per driver during the week. This task is designed according to the following regulations:

3. Minimal duration of the daily period of rest (11 hrs, more easily addressed as long as drivers start the week with morning shifts and end it with evening shifts).

Other factors that may determine the need to use more drivers or the payment of extra hours are the consideration of fixed periods for meals (if the breaks or the transitions between shifts are not coordinated with them) and labour agreements defining other limits for the working periods (if more demanding than the regulation).

In the research, none of the weekly shifts designed according to the basic regulations exceeded the labour agreements. Actually, in some of the case studies, there was a significant amount of idle hours left.

Defining the vehicle size

Although smaller vehicles provide lower operation costs, they may generate non-served demand. The generation of non-served demand means that fewer passengers will use the service, limiting the obtained revenues. The size of the vehicle shall be the one that provides the most advantageous relation between operation costs and achievable revenues, among the several fleet size scenarios.

Town	Atalaia	Golegã	Ourém	Pego	S. Miguel
Passengers/day	261	105	288	127	33
Frequency	44	38	14	20	19
Seats	16	12	77	24	7

Table 6: Demand, frequency and capacity of the vehicles (Source: Cristóvão, 2005)

The previous table shows for each case the average number of passengers expected (per day and direction), the number of daily services in both directions (frequency) and the chosen vehicle capacity (seats). The study showed that each case has its own best vehicle (depending on the demand level and frequency of the service). If vehicles with different capacities are available for the operation of a given service, the use of different types of vehicle along different periods (day, week or year) may be advantageous if there are significant demand/frequency variations.

RESULTS AND CONCLUSIONS

The table shows the total (annual) benefits[1] and costs related to the services[2]. The table also shows the (annual) net benefits (per agent), if consumer surplus is internalised and idle resources are eliminated (consumer, road operator, rail operator and society).

Annual Results	Atalaia	Golegã	Ourém	Pego	S. Miguel
Total benefits	176 209€	141 227€	617 196€	99 798€	61 168€
Total costs	111 358€	121 604€	119 209€	91 071€	75 658
Consumer	16 378€	14 862€	74 281€	6 189€	2 760€
Road operator	45 114€	17 161€	71 091€	13 575€	12€
Rail operator	46 063€	17 161€	397 598€	13 575€	49€
Society	9 532€	7 400€	75 823€	2 409€	11€

Table 7: Estimated benefits and costs of the services (Source: Cristóvão, 2005)

The obtained costs and benefits show that there are net positive results in most cases. If the consumer surplus was internalized with price discrimination and the idle resources were used in the production of other services, all cases would be profitable. This fact, together with the advantages in the use of different vehicles in different periods, gives advantages to regional operators (operating other services in the same region) on the supply of complementary services.

[1] Service direct revenue, expected rise in railway revenue, external cost reduction (considering climate change, air pollution, noise and road accidents; congestion and infrastructure costs were excluded).
[2] Internalisation of consumer surplus and elimination of idle resources are not considered.

Although there are net benefits, the isolated revenues of a single agent, in general, are not enough to overcome the costs. Given this fact, the cooperation between agents and the existence of contractual (and institutional) integration seems necessary.

To avoid the ticket transaction disturbing the operation of the complementary service as well as losses of time during the interchange, it should be possible to buy complementary service tickets inside the train. On the opposite direction, at least, it should be allowed the users of the complementary service to buy train ticket aboard the train itself (given the need to provide short interchange intervals), while complementary service tickets should be bought before the trip, for instance, at some shop in town.

As seen before, the particularities of the services require a specific design process (and good knowledge on the field). Among the significant amount of critical issues to consider on the process is:

1. The choice of the interchange (distance between the station and the town and railway supply);

2. The travel time of the service (including the course and the distribution circuits);

3. The interchange duration (users, vehicles, interchange configuration and tariff integration, etc.);

4. The fixation of the fleet size (service rotation time and pace of train arrival and departures);

5. The definition of the schedule (demand, rotation time and need to deliver reliable services);

6. The composition and the schedule of the crew (integration level, duration of daily driving periods, breaks and daily and weekly periods of rest);

7. The definition of vehicle size (operation costs, non-satisfied demand).

Although the services seem to be capable to attract a significant amount of travellers, to be economically balanced and to bring significant improvements on the accessibility to the areas they serve, and despite of design restrictions, the main difficulties in their development may actually come from the significant required changes in terms of the agents' enterprise (quality standards, service culture and cooperation between them).

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