Rural areas, high-speed train accessibility and sustainable development

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Abstract

This paper analyzes the key steps in the reorganization of demand-responsive transport systems in rural areas with low population density, and their connection with the high-speed railway network. The deficiencies of public transport in sparsely populated rural areas means that captive users of public transport avoid trips, or even that they move to live near more accessible places, with the consequential abandonment of the poorly served areas towards urban centres where accessibility is not a problem. On the other hand, those who can use private vehicles are forced to do so, consequentially giving up using public transport altogether and thus reducing demand for this type of transport, which increases the environmental impact caused by the private vehicles. To confront these difficulties, demand-responsive transport systems came into use, responding to the needs of low density territories.

The study carried out analyses of the territorial experiences of demand-responsive systems and their implications. Results obtained in this investigation, regarding the definition of potential users, the confluence of diverse types of travellers and merchandise and the support points of compatible attraction of activity with the station, among others, are reviewed in this paper. The experience analyzed in the study cases demonstrates the suitability of this type of system as an alternative to regular transport, contributing to a sustainable use of the territory and public services, among which high-speed railway stations are very significant

Keywords: demand-responsive system, high-speed railway, low-density territories, strategies, transport effects.

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1 Introduction

The arrival of the high-speed train pre-supposes the development of a station, and the effects of the new infrastructure are focused on this site, including access problems and the other advantages that it brings. However, the route of the train to the station passes through an area that expects to benefit from the infrastructure and not just suffer the environmental drawbacks. As well as the necessity to give back to these areas some benefits, the high-speed train (HST) station must be as accessible as possible in order to extend its area of influence widely in terms of space [1].

Nevertheless, this need to increase the penetration of the HST does not only depend on a principle of "equality" among the affected territories, but also on the interest of the urban nucleus where the station is situated [3]. The experience of other European countries, and especially the French one with the TGV, indicates that the magnitude of the effect of the HST (AVE in Spain) has a lot to do with the type of timetables, frequency and the number of trains [5–6]. In this sense, the wider the area of influence of the station, the greater the number of potential travellers and the more interesting the train offer, which is a key aspect for optimizing the arrival of the train to a region.

Moreover, there are other social and economic criteria that in all cases recommend expanding the accessibility of the station as much as possible, which implies the reorganization of the regional transport system [6, 16]. In the case of low population density areas, as will be seen later, transport on demand provides the best alternative to achieve this aim.

The transport on demand system is a part of the public transport network and it arises as a means of adapting to the new requirements linked to the disperse urbanization models, while, at the same time, reducing the economic and energetic costs of public transport [8]. In this way the difficulties provoked by low population density can be avoided, where only a few lines are maintained with reduced frequency and low usage. The application of this system solves a problem by responding to a specific demand in real time, which allows a system that adapts better to the demand, thus providing a more economically profitable solution which is also more efficient from the energy cost reduction viewpoint [9, 10]. Furthermore, new technologies facilitate the organization of routes, the measures help to promote sustainable development and the system offers an excellent opportunity to magnify the beneficial effects of the HST in the area.

2 High-speed transport and problems in rural areas

In the last forty years there have been important changes in the transport habits in urban and suburban areas. The rural environment is no longer necessarily linked to agriculture, and the social necessity and demand for access to services is growing in the inhabitants of low density zones. However, this new demand for mobility is not answered by a suitable public transport, because the profit margins are low as there are few possible clients [11, 12].

The problems of public transport in these areas just add to the deficiency of the service. In fact, faced with the insufficient service, the captive users of public transport avoid travelling or even move to more accessible areas, leading to the abandonment of areas with poor service towards urban centres with greater activity. Therefore, those that can use a private vehicle are obliged to do so, consequently no longer using public transport and causing a further reduction in demand for this type of transport and an increase in environmental impact due to the use of a private vehicle.

Obviously, the population that is most affected is the group that relies on public transport [10]. This group includes the old, those with impaired mobility, and other groups such as the young and people with low income. Guaranteeing access to the services is especially important in the case of the old, whose quality of life is directly related to their mobility. The same is true for adolescents, children, women and those on low income, who require public transport to get to educational centres or work and who depend on others or do not have a vehicle to make the journey. Among the social issues in rural areas [13] highlights the lack of public transport as a structural obstacle which women have to face in order to reconcile their family life with their professional aspirations.

Confronted with these sectors' difficulties to access a specific group of services from areas with low population density [14], demand-responsive transport systems came into being a little more than three decades ago, based on making the transport offer more flexible to address the particular needs of low density areas.

In these questions the International Union of Public Transport (UITP) stated that most regional transport corresponds to rural areas, characterized by their low and heterogeneous demand, which obliges the provision of service for a diffuse demand over a wide area. As a consequence of this special issue, they state that public transport in rural areas contributes to maintaining the population, avoiding the exodus towards urban areas. Moreover, it has a primordial role in avoiding social exclusion and isolation of the rural zones. For these reasons, when the service provision is unprofitable, it is recommendable to develop demand-responsive transport solutions [15].

It should also be remembered that the principles of the European Transport Strategy [16] are focused on considering transport as an essential factor in improving quality of life and achieving sustainable economic development. Here, it is stated that "*the problem of accessibility is not only a physical problem, but also a social and economic one."* As a consequence, transport problems in low population density zones are a very interesting transport issue, for which the response considered is the creation of integrated systems of transport and promotion of transport in combination.

The creation of a services that only function when there are passengers has been instigated following diverse modalities: virtual lines, door-to-door, substitution of regular lines, airport access, night services and with different types of agents (associations, taxis, transport workers), who guarantee the right to transport and who adapt to the greater mobility necessities in a context of increasingly diffuse temporal and spatial needs [18]. Their functions vary: from

guaranteeing a transport service (or combining with existing ones) to help to preserve the rural population, to contributing to social integration of outlying neighbourhoods and marginal zones, guaranteeing access to specific equipment or responding to specific necessities of captive public transport clients or providing specific timetables.

Nowadays, the extension of this type of systems to a wider range of services is being studied, and not only for the captive users of public transport [20, 21]. The aim is to offer an alternative to private transport, to contribute to the sustainable use of the land and services, including infrastructures such as the HST.

3 Demand-responsive transport and the high-speed railway: an opportunity to increase penetration in low population density areas

The demand-responsive transport system originated in the low population density areas of the United States during the last century, in the seventies. The European experience started in the eighties in Scandinavian countries [8], although nowadays it is more developed in Germany, the United Kingdom, Sweden and France.

The number of experiences applied to connection with high-speed railway stations is still scarce [21], so the analysis must be done starting with examples linked to other types of services. Their analysis enables the detection of key aspects in the definition of these systems, which later can be applied to the definition of a system linked to a high-speed railway terminus. Key elements, such as the selection of the type of vehicles or the type of routes, the booking management systems, the type of marketing necessary, etc. are studied using the European experience in the following section. To do this, previous studies [8] and public documentation from diverse sources reviewing the characteristics of this type of systems are used. The aim of this work is to lay down some guidelines for the adaptation of this system to the areas served by high-speed train stations.

3.1 Results of case studies

To carry out a more detailed analysis, which allows conclusions to be drawn about its applicability to systems around high-speed stations, the European database provided by the VIRGIL project [22] was used. The project examined the conditions of operation in eleven European countries, with their different demand-responsive flexibility mechanisms, considering twenty-eight cases in detail. Using this, a database with one hundred example cases has been created, reflecting the wide range of possibilities and characteristics of these types of systems. It summarizes the conclusions about the characterization of 12 distinct rural service schemes, which vary in; the vehicle types and users, the territory in which they are developed and the type of management, although they all share the common element that they are unconventional demand-responsive solutions.

VIRGIL highlights the large number of possible models that exist in terms of management, type of vehicles and organization of routes and stops, revealing a great potential for the use of new technologies. Among the selected cases, the ones that can be applied to the aims of this research have been analyzed:

Firstly, Allarbus (Galicia) is a municipal company operated by local transport workers giving continuous conventional services at the same time as providing more flexible services to enable rural inhabitants to access colleges and sports and cultural centres, with goods transport and not just passengers.

The Irish case of the Lisdoonvarna Mail Feeder Service PostBus, is a programmed service, operated by the postal company, combining the delivery of mail with the carriage of working adults, pensioners doing administrative and commercial tasks, children going to school and tourists visiting the area.

The case of Mobimax, in Achterhoek, Holland, is also of interest to the study. It started operating exclusively for disabled people, which is now available to any citizen, with routes, stops and timetables that are completely flexible. Although it operates with minibuses, it also guarantees connection with coaches and railway services when the booking is made at least two hours earlier.

Another easily applied system is operated by taxis, depending on demand, as is the case of Taxitub in Douai, France or Taxibus in Lüdinghausen, Germany. The latter has a fixed timetable and stops, but the Taxibus, which covers an area of 650 km2, only goes to the stops if a booking has been made. The main transport centres in the zone are among the stops, and coverage is offered depending on their timetable. This system is one of the most suitable for application with the high-speed network.

The Videobus, in Borgo Panigale (Italy) also offers a demand-responsive service that connects small villages with an important transport route. Based on a fixed route and timetable, the trip is only made by one of the 60 families using the service.

From the comparison among the previous cases, the following results can be obtained in terms of the type of routes, users, vehicles, bookings and fares. The applicability of the different systems has been analyzed to draw conclusions about their suitability for combination with high-speed railway stations.

3.1.1 User types

Demand-responsive transport is traditionally utilized by persons with reduced mobility, for different tasks, but in the cases analyzed the general public has also shown a lot of interest, often, when the purpose of the trip has to do with a connection with a railway or coach station.

Some fundamental markets can be established for demand-responsive transport, specifically services with high added value, mostly based on reducing the travelling times, with a large number of travellers and door-to-door, such as access to airports. This type of services, coinciding with the characteristics of high-speed stations, are no longer just for captive public service social groups, but also for business and tourist travellers. The Scottish experience detected a weakness of the demand-responsive transport system in this high added value transport market, highlighting the necessity to adapt timetables to rush hours, as well as extending the routes to other reference points.

A system that is open to all user types: school children, commuters, old people, disabled people seems to be the most suitable. The tourism sector also sheds some light in some areas. In this case, it would be essential to extend the availability of information to this sector, marketing it in tourism centres, hotels, agencies, as well as local diffusion. From the cases analyzed in more detail, more applied conclusions can be extracted which can be used to design a demand-responsive transport model more closely tailored to the high-speed station. These conclusions are related to the type of routes, the types of vehicles, the type of booking system and the fares:

3.1.2 Organization of routes

The design of the routes often has fixed reference points, especially destination and origin, although the options vary in terms of the flexibility to pick up users. In the cases where it is possible to take advantage of existing infrastructures linked to the stops, the system functions more easily. This is the case of the Mail Feeder Service PostBus, where the fixed points are part of the postal route, given that the service of postal distribution is combined with the passenger one. On the other hand, there are various systems that group points of attraction, such as civic centres, hospitals or shopping centres. In this sense the high-speed train station can add its attraction capacity to the other destinations.

3.1.3 Type of vehicles

As far as the vehicles are concerned, there are principally three types: midibuses (25 seats), minibuses (between 8 and 17 passengers), and taxis (between 4 and 8 seats). In some cases, these vehicles also have space reserved for cargo, as happens with the Postbus, since it combines the distribution of post and on-demand transport of passengers. The profitability of using minibuses is clear, for territories with relatively small extension and destinations and origins with a level of coincidence in terms of users. In the context of the high-speed train stations, the possibility of combination with car parks that are unsuitable for commuters is useful.

On the other hand, the minimal initial investment can be achieved by an organization based on taxis, as can be seen from the French experience studied, and also following the indications of VIRGIL. This system, although less profitable than those that can carry larger numbers of users per trajectory, is suitable for territories with very low population density and for more diffuse usages, and also it could also be a good option in zones for high-speed train commuters. The vehicles used must be accessible to the disabled as they are obviously potential users.

3.1.4 Type of investment

The number of contracted workers varies depending on the number of daily services. From the minimum that is the employment of a telephone operator in the case of the Taxitub, where the taxi available in the moment is called, with which there is a previous economic agreement, to more complex services such as the Allarbus, in Galicia, which has five full-time workers and one part-time one to drive the vehicles for the nine public services offered.

The case with the lowest investment is the Taxitub, where it is only necessary to offer a telephone number for reservations, and then to reach an agreement with the local taxi companies. This system, the simplest of all, can only be maintained in areas with very low population density, where the low demand and the disparity of routes make the exclusive use of taxis advisable.

3.1.5 Type of reservation and use of new technologies

The way demand-responsive transport works in the cases analyzed has a common denominator, namely, the initial user reservation. In the Italian case of the VIDEOBUS, this booking is done using touch screen terminals at the stops, while in the rest of the cases it is done with a telephone call. The process starts with this call, in one case manually (with the Postbus), with a fax sent by the telephone operator to the local taxi companies; and in other cases automatically via information technology means.

The cases of Taxitub or Mobimax are significant as far as the use of new technologies is concerned: specific software receives the call with an intelligent voice interpretation system from which the most efficient route is traced and the vehicle that can respond to the demand is selected, informing the driver. In this sense, the use of new technologies permits the on-demand transport to be flexible to the users, and it is one of the key aspects highlighted in all the studies that have analyzed the topic, as well as in the European recommendations for the development of this type of systems. In many cases, the connection with specific local buses or trains is guaranteed if the reservation is made at least two hours before departure, which would provide a plausible solution for connection with the high-speed train station.

3.1.6 The fares

The user fares in no case are greater than 1.5 Euros, and in many cases they are equivalent to the local public transport fare. In the Spanish case of the Allarbus, the fare is 0.72 Euros. The public administration is responsible for the difference between the fare and the real cost of the service. The real cost of the trips varies greatly among the cases analyzed, and is mainly related to the type of vehicles utilized and the area served: from 8.20 Euros per person and trip of MOBIMAX in Holland (utilizing 8-place minibuses for the disabled, with very flexible trajectories), to the efficacious 0.54 Euros of the Allarbus in Galicia, due to the size of the vehicles (3 minibuses of between 15 and 17 seats, and a Midibus (of 25 places) and a relatively small area of coverage: 86 km2. It should be taken into account, however, that in this case the cost in salaries is much greater than in the rest of the systems analyzed, given that there are six full-time workers.

The case of Galicia shows an optimal territorial situation for efficient on-demand transport: over a relatively small extension, 86 km2, and for a low population density, the concentration of the trips on common destinations, the addition of travellers, such as school children along with the general public and cargo, optimize the system through the use of minibuses and Midibuses that have a 62.5% occupation level.

On the other hand, the management of the Taxibus in Germany should be remarked upon. Although it provides a service for a much wider area, 650 km2,

the cost per trip and per passenger is 3.19 Euros, probably due to the occupation level, with an average of three passengers per trip which, for such small vehicles as it operates (taxis of four to eight seats). As far as the type of management is concerned, in general public management is combined with private, in greater or lesser proportions, but always under the control of the local administration.

3.1.7 The impact generated by demand-responsive transport systems

The repercussions of the implantation of the new system for the users are usually well accepted, although in the cases analyzed we observe distinct types of local impact, depending overall on the situation previous to the instauration of the new system.

In cases like the Allarbus or VIDEOBUS, where the inhabitants did not have access to public transport from their nuclei before implantation of the demand-responsive system, the arrival of this system has had a very positive impact in the local population. In Galicia, this impact has been negative for the taxi drivers, who faced with the new competitive situation, are reacting by offering alternatives that complement the municipal service.

Other cases have a less exceptional impact, such as Mobimax or the Taxibus, given that the demand-responsive transport system installed is in reality an improvement of an existing deficient system. The Taxitub is an intermediate case where the route provides a service for nuclei that previously had a service, but under less suitable conditions, and also for nuclei that had no previous service and that obtain an important improvement, facilitating movement, from the new one.

In any case, the impact is positive both for people with reduced mobility and for those dependent on private vehicles, as has traditionally been the case demand-responsive transport systems. Moreover, the benefits are clear for workers and tourists too. The combination of users, and even the incorporation of goods in the routes, especially postal delivery, is common to all the cases.

4 Conclusions

After considering the diverse experiences of Demand-Responsive Transport in Europe, the enormous contribution to improvement of transport services in areas with low population density can be highlighted. Furthermore, it was observed that one of the main functions is to contribute to the development of inter-modality, something that is achieved when the service links with other public transport services, for which it is necessary to create exchange points. Finally, if these advantages are combined with those of the High-Speed Railway, and used to increase its area of influence, a strong increment will be produced in the penetration of the H-SR in rural areas and disperse urban areas.

Demand-responsive transport appears to provide a very useful tool to compensate the deficiencies created by the arrival of high-speed railway, as it is the only public transport management strategy that enables the penetration of the high-speed railway in areas with low population density. The low density areas that are not served by ordinary services require the organization of a demand-

responsive transport system that, using specific actions, connects these areas with the station. Among the specific actions necessary for the application of this type of systems, and within the European cases studied, we can highlight:

In the first place, service using Minibuses is very suitable in not very widespread areas. Where there are many possible *commuters*, car parking should be controlled so as to dissuade them from using private vehicles. In these cases it is also advisable to combine passenger transport with goods and school transport. It is necessary to link the high-speed train station with other destinations, which in the cases analyzed enables the routes to concentrate more users, and thus, to be more profitable. To achieve this, the routes should include the coach station, the city centre, specific shopping/recreation centres and the large public attractions, such as football stadiums, metropolitan parks, museums, etc.

The use of taxis is recommendable in low population density areas and for very specific uses. This is the service with the lowest initial cost of all those analyzed. The vehicles used for the service must be equipped with disabled places, given that a large proportion of potential clientele require this service. The client should pay a fare equivalent to the ordinary local transport one, while the local authority should accept the additional cost that this service generates.

The use of new technologies is an essential tool in the organization of this type of system. The acquisition of the software necessary for the creation of an automatic booking system, through calls or SMS, and the consequential creation of routes and automatic reservations is recommended. On the other hand, it is necessary to cross-reference information with others means of transport, in such a way that there is intercommunication of information about railway, local buses and coaches on information boards in all transport centres about the rest.

Finally, the demand-responsive transport system must cover the deficits created by the arrival of the railway, but it can also be an instrument for improving the organization of regional transport [23]. As a consequence of the scientific interest in these processes, it is of special relevance to continue the investigation with a detailed analysis of the worst served zones nowadays, as well as the areas potentially affected by the high-speed railway.

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