Technical and economical appraisal of Praxitèle trial

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Summary

During the trial, INRETS directed monitoring and appraisal work which had two objectives:

The first was to test or validate the self-service electric car concept with regard to the public response and to understand its dynamics in relation to users and their travel practices

The second was to analyze the size and organization of the resources (in terms of vehicles and staff) required in order to meet demand, the challenge facing the management and organization of service provision being just as new and fundamental to constructing the future service as the challenge of social and commercial validation.

In what follows we shall begin by considering the experimental system and management procedures implemented for the trial in order to evaluate their effectiveness, continue by presenting the knowledge gained about the operation of the system and the sizing of resources and end with an evaluation, within the limits imposed by the experimental nature of the service and the technologies employed, of the system's operating costs.

Introduction

PRAXITÈLE is an innovative transport concept which aims to provide the public with : a clean, relatively quiet mode of transport, the electric car; a personal mode of transport which is used by different people at different times; a self-service transport mode offering flexibility and 24-hour a day service; a personal transport mode that is designed to supplement the public transport system.

PRAXITÈLE provides users in urban areas with self-service electric cars which are available at special stations to which customers must return them after use. What is innovative about the PRAXITÈLE concept is that it provides a foretaste of a system of self-service vehicles, for short urban trips between dedicated stations. The quality of service provided by PRAXITÈLE depends on a number of aspects of the system's performance. Some of these involve the implementation of new technologies, such as real-time vehicle positioning, data and speech transmissions between vehicles and the control centre and the non contact smart card with which the user opens, closes and starts the car and which is also used to identify clients and manage payment.

PRAXITÈLE is an innovative transport system which has resulted from research conducted by the PRAXITÈLE GIE: RENAULT, CGEA (a transport operator), EDF, THOMSON-CSF DETEXIS and two national research institutes: INRETS and INRIA. Its trial was a world first.

Although the concept originated in 1990, the decision to conduct real-site trials was not taken until 1995. The town of Saint-Quentin en Yvelines in the Paris region agreed to embark on the adventure. The trial was originally intended to last one year but in fact took place over 20 months, from October 1997 to July 1999. Trying to reap the greatest possible benefits from this first time experience, we have gradually devised a commercial context in which to place the highly advanced technical concept. However, it must be considered as a prototype, if only because the tested service, designed 4 years ago, uses some technologies which are now outdated.

During the trial, INRETS (Massot et alii, 1999; Blosseville et allii, 1999) directed monitoring and appraisal work which had two objectives:

to test or validate the self-service electric car concept with regard to the public response;

to analyze the size and organization of the resources, the challenge facing the management and organization of service provision being just as new and fundamental to constructing the future service as the challenge of social and commercial validation.

The experimental system

The new town of Saint-Quentin

This new town was created in 1968 by merging 7 villages and covers 70 km_. The town has a low population density and is multipolar (150 000 inhabitants); it was designed to function with the private car. The rate of household car ownership is high (96% of households have at least one car and 36% have at least two). The town's different poles are connected to Paris by a system of urban roads including an urban motorway. One hundred buses operate of the local public transport network, nevertheless the quality of public transport services is uneven, considered by residents to be very good during peak hours and inadequate at off peak hours and at weekends. Saint-Quentin is linked to Paris by a motorway and suburban railway (R.E.R.).

The road system in Saint-Quentin is also larger than traffic levels would justify, and parking problems are virtually unknown - except at RER station. This could lead one to think that this transport situation would mean that the value of the PRAXITÈLE system with regard to guaranteed parking and car sharing would only be perceived by a minority of the population (persons without a car or who suffer from the quality of public transport).

The size of the experimental service

The trial was a "full-scale" trial in the sense that the service was available to all, had to be paid for and those using it did so spontaneously. It took place in two phases:

Initially, until June 98, the system was in what is known as "operator" mode, that is to say a "jockey" at each station provided customers with cars. This was a limited service, operating between 7.30 am and 7 pm on working days and from only five stations.

This was followed by a second phase, from June 98 until the end, during which the system ran in self-service mode. With the introduction of self-service operation, the service was modified: the system could be accessed 24 hours a day 7 days a week; a new pricing system was introduced in response to the different rhythms of use of the system; and 9 stations were opened with very minimal equipment.

PRAXITÈLE PRICES, July 1998 to July 1999

Pricing formula	Duration	Price of subscription	Peak period rate	Off-peak period rate
Basic per trip	30 minutes	0	50 francs**	30 francs***
Monthly subscription + payment per trip	30 minutes	40 francs	20 francs**	10 francs ***
Monthly fee	1 hour	90 francs	2 francs per additional minute	
Monthly fee	3 hours	190 francs	1 franc per additional minute	
Monthly fee	6 hours	290 francs	0.5 franc per additional minute	

*Peak period: 6 am - 10 am, 4 pm - 8 pm, Off-peak period 10 am - 4 pm,

** + 2 francs per additional minute and *** + 1 francs per additionnal trip

The resources mobilized

To begin with thirty (47 at a later stage) Renault "Clio" electric cars which were accessible with anon contact smart card. These were used both by the customers for commercial trips and by

the operating team responsible for routine maintenance, recharging batteries, and distribution of vehicles between the stations.

A Control Centre near the RER station which housed computers and communications equipment for the real-time management of the system.

The staff running the service consisted of one person in charge of operation and operating staff working at the Control Centre who were responsible for managing the operating system.

More versatile staff known as "jockeys" who essentially have three functions: driving vehicles from one station to another in response to demand, cleaning and minor maintenance of vehicles and, specifically during "operator" mode, customer reception and opening the cars.

Major system management procedures

The procedure for managing redistribution services : self service system requires a procedure which redistributes cars between stations on the basis of the relative levels of demand at each. Jockeys are driven in a Praxicar by another jockey to the stations from where cars are to be removed.

The procedure for recharging batteries : Battery charging is commanded from the Control Centre. Because there were no induction recharging facilities, jockeys recharged the batteries during the daytime.

The procedure for maintenance, cleaning and repairs : the jockeys are responsible for these tasks. Important maintenance repairs are conducted by the industrial partners.

The vehicle access and customer invoicing procedure : each customer had a personal card that provided access to the service. Each customer with a card was considered to be a subscriber to the service and had a Praxitèle" customer account.

Utilization has validated the concept of self-service vehicles moving between stations

Continuous increase in utilization and the number service users

The utilization graph tells us a great deal (Graph.1): the number of commercial trips increased throughout the trial to reach 2000 trips in April 1999. The number of customers using the service also increased up until the end of the trial: the number of "subscribed" users increased from 206 to 369 between July 98 and April 99, at an average rate of 10 new customers a month. The third feature of increased use of the service for personal travel is the increase in the frequency with which badge holders used the service: the average number of trips per badge increased from *4 trips in June 1998 to more than 11 trips in April 1999*. This shows that a considerable structural change took place in the utilization of the service by badge holders.

Utilization which is in line with the concept

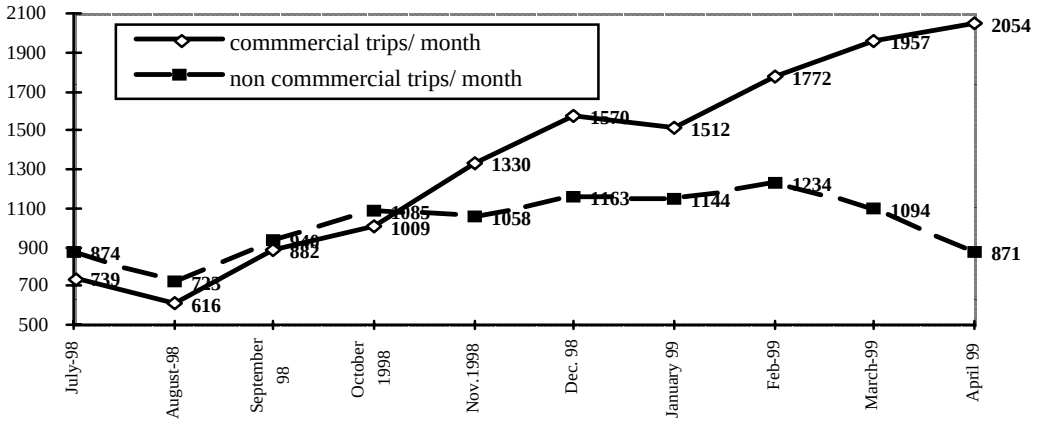
Analysis shows that utilization of the service was completely in line with the concept: short duration trips between different stations operating as an addition to public transport.

Short duration trips between different stations ***:*** in March 1999, the average trip involved a short distance : **7,6 km ;** a short duration: **23 minutes**, and movements between different stations: **90% of trips.**

A service used as an addition to public transport: 75% of trips in March 1999 had RER station as either their origin or destination, frequently for work-related purposes, which accounts for an increasingly polarized utilization of the service during peak periods.

Trips where Praxitèle replaced bus or private car use: 38% of users stated that without Praxitèle they would use the car and 60% the bus. The level of use of the service at night (8% of working day traffic), and in the early evening and daytime off-peak periods (40% of working day trips) provides the basis for the success of the system.

The aim of increasing the density of the network by opening new stations which was to increase movement between different stations, has been achieved **:** although the service was extended to cover a larger area after its availability times were increased, this extension has nevertheless had a real effect: 25% of the trips made in March 1999 had Montigny RER station as neither their origin nor destination. The links within the new town are dominated by trips between the shopping centres and residential areas while use of the stations located at employment centres or firms has in most cases never done so. In addition, this local traffic rose steadily as new stations were opened later on, in spite of the poor facilities at some of them. As a result, 7 stations were responsible for 95% of the April 1999 traffic.



From: Bases de données du système, Exploitation INRETS, 1999

Graph 1 : Month to month variation
in the average numbers of commercial and non commercial trips

System operation : a learning process

An increasing number of available vehicles

The presence rate of the vehicles increased progressively throughout the trial as a result of improvements in maintenance practices. The maximum number of vehicles was during April 1999, when there were 43 Praxicars, i.e. 90% of the fleet available for the trial. About 10% of the vehicles were therefore unavailable, an order of magnitude generally regarded as acceptable for other fleet management systems.

A considerable reduction in the number of non commercial or redistribution trips needed for system management

In spite of increased customer use of the service, since February 1999 there has been a very marked drop in the use of vehicles for service needs. From February 1999 to April 1999 the relative reduction in redistribution trips was very large (30%), particularly in view of the 14% increase in traffic that took place during the same period with practically the same number of vehicles (See Graph. 1).

A high "rate of customer satisfaction"

Between 13 April and 20 April 1999 we have conducted an on-site survey to assess the "rate of customer satisfaction": this rate is the proportion of customers arriving at a station for whom a car was available. All the customers who arrived at a station to pick up a car obtained one without waiting

Optimized management of redistribution trips

All the indicators confirm an increase in use of the service combined with an optimization in the management of resources. Thus, while in July 1998 there were 0.85 commercial trips for one redistribution trip, this ratio progressively increased to attain 2.36.

To analyze this optimization process and clarify the issues, we conducted simulations to calculate the maximum number of vehicles required to serve the commercial trips in the absence of any car redistribution strategy except at the end of the day in order to redistribute cars ready for the next morning's services. Two reference months were used for these calculations. This method provides worthwhile potential for optimization.

Table 1 presents the results: in the absence of any redistribution of cars between stations during the daytime, the size of the fleet must be considerably increased, from 43 to 59 vehicles in April 1999. Between these limits (43 and 59) a large number of fleet and labour management strategies can be envisaged. It is also noteworthy that in November 1998 (when the traffic was only 65% of the level in April 1999, the manager used 85% of the April fleet (36/43) while only 51% of the fleet without redistribution would have been required (30/59).

	Method/Hypothesis	**November 98**	**April 99**
Number of commercial trips/month	Automatic data collection	1330	2054
Number of vehicles on the site	Trial	36	43
Maximum number of vehicles	Simulation	30	59
Number of evening redistribution trips	Trial	600	500
Number of evening redistribution trips	Simulation	150	300

From : Bases de données du système, Simulation-Exploitation INRETS, 1999.

Table 1 : Number of vehicles required with different hypotheses

A considerable reduction in human resources

Resources in terms of the number of jockeys and operating staff were considerably reduced between October 97 and April 99, the number of jockeys actually being halved and the number of operating staff reduced by one third. The introduction of self-service operation explains, but only partially, this rationalization: in " operator mode " 12 jockeys were employed, at least one on a permanent basis at each of the five stations in order to open and close the cars for the customers. In self-service mode the number of jockeys was substantially reduced, from 8 in the autumn of 1998 to 5 in April 1999, during which period traffic doubled.

What has been learnt about the sizing of system resources

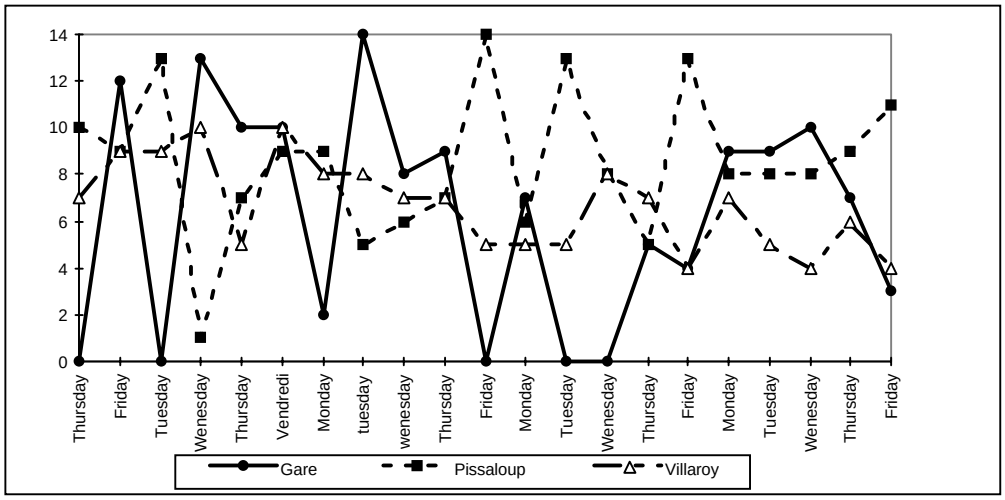
A system which requires a large number of vehicles during its adolescence

The high temporal and spatial concentrations of the observed traffic naturally raises questions about the operation of the system and the sizing of resources. More the short duration of the trial did not permit the system to attain a certain level of maturity ; before the " maturity ", the system was characterized by instability and/or variability in use and difficulties for some stations in gaining customers. Adolescence Praxitèle's is costly in terms of vehicles.

Our measurement of the impact of daily variability in usage on the sizing of vehicle resources was based on the maximum number of vehicles for each day and each station required to meet all demands for cars, still in the absence of daytime redistribution of vehicles (which is a convenient hypothesis in the absence of fleet optimization algorithms).

Graph 2 thus shows that during the working days of April 1999 a maximum of 14 cars is needed to cover departures from both the Praxitèle station at Montigny RER station and that in the residential zone of Pissaloup ; this number was required on one day only during the month as day-to-day variation in demand is considerable.

However, if we make a brief comparison with the situation in November 1998 as established using the same approach, it appears that the increase in traffic and the opening of new stations are factors that stabilize the system and its operation.



From : Bases de données du système, Simulation-Exploitation INRETS

Graph 2 : Maximum number of cars required on each working day in April 1999 to cover departures from the three most used stations

In addition to the variability of use, the difficulty experienced by some stations in gaining customers also raises questions about the size of the fleet.

The success of the concept of self-service vehicles, as applied in the Saint-Quentin trial, was assisted by spatial and temporal extension. The system gained a considerable, if dispersed, amount of local traffic by opening new; if the emergence of principal traffic production and reception centres is inherent to the concept (as it is to any transport system), it is clear that spreading over a greater area requires considerable resources, at least in the initial stages : we have estimated (without redistribution procédure) that 34 vehicles would be able to serve the traffic from the 3 principal stations (75% of trips). For the whole system, a maximum of 59 cars is required, which shows the scale of the resources required for new stations to gain customers (~25 additional cars). These resources are disproportionate to the generated traffic but necessary to allow the system to operate as a network which is an essential aspect of the concept and to provide it with a degree of stability**.**

Human resources

The Saint-Quentin trial has not only demonstrated that a system of self-service cars did not pose any insuperable fleet management problems but also that such a system can operate with relatively limited human resources to redistribute the cars in the stations.

The spatial and temporal redistribution of vehicles, a manageable task *:* a result of detailed monitoring and reconstruction of the work of the 5 jockeys, is that in April 1999 redistribution took up only slightly more than 50% of their working time. Redistribution, previously a source of pessimism seems after the trial to be easier to implement and less extravagant in human resources the more the system operates as a network.

Recharging the electric cars, an activity that must not be underestimated : recharging the cars accounted for almost 25% of jockey working time. In terms of amount of time and distances covered this is the second most important activity. The fact that recharging facilities were concentrated at only 5 of the 14 stations impeded optimization. If automatic recharging had been available a large amount of the jockeys' time would have been saved.

The economics of the system

What costs are we discussing ? This question needs to be asked because the version of "Praxitèle" in the trial is a prototype and not a fully developed system. Consequently, the costs involved are those of a laboratory and cannot be transposed. Our analysis of the costs associated with this "prototype" will focus on **operating costs**, as supplied to us by the GIE[1] . These consist of:

Costs associated with the central management of the service, (manager and operating staff), management, administration and marketing costs, maintenance for the operating system and stations, fixed charges for electricity supply and renting dedicated telephone lines.

Costs associated with car use: the jockeys, car cleaning and maintenance, consumables such as electricity, fuel and communications...

High central management costs

These costs account for about 59% of monthly operating costs. Such high costs result from a complex operational organization, which was necessary in the context of a trial but which was obviously capable of managing a much larger fleet of vehicles (4 times the size). In addition, it would probably be possible to reduce the cost of maintaining the operating system as technology has improved and fallen in price. There has also been a considerable amount of marketing and advertising (25% of central management costs); it is likely that this percentage would be lower for a system that is up and running.

Vehicle utilization costs that can be limited

On a monthly basis, the utilization costs of Praxicars account for 41% of operating costs. We can make two comments about this:

Cleaning, maintenance, insurance and energy costs account for 56% of the utilization costs for a Praxicar. These seem quite realistic as they are close to those given in a study for the French Post Office dealing with the management of a fleet of electric cars.

The communication costs are extremely high -(1,5 euro per trip). A less expensive solution must be found.

It would therefore seem possible to limit the utilization costs of prototype " Praxicars ", by rationalizing costs, particularly communications costs..

To conclude, in the absence of further investment, it would seem possible at the present time to imagine a service production cost of approximately 1,4 Euro per commercial kilometre with the service and utilization configuration observed in Saint-Quentin; this could be achieved with only a slight rationalization of costs.

What would a cost of 1,4 euro per commercial kilometre mean in the context of Saint-Quentin?

If we compare this with the 3,8 Euro fare for an 8 kilometre trip which the great majority of users of the service regard as an acceptable pricing level (Massot et alii,1999) equilibrium for just variable costs is still far from being achieved - we have a cost of approximately 10,9 Euro a trip for an average revenue of 3,8 euros. Under these conditions equilibrium for variable costs is still some way off, but not beyond the bounds of what is conceivable.

Thus, for example (in order to obtain an approximate idea of the levels that need to be reached) let us imagine a tripling of the number of commercial trips and kilometres covered - an increase which corresponds to the increase in traffic during the last seven months of the trial and which would be achievable by an increase in the utilization rates of the existing number of vehicles and a concentration of the network around those stations with the greatest amount and best balance of

[1] This data was obtained from invoices and not consolidated accounts.

traffic. Under such conditions the per kilometre cost would fall to 0,8 Euros, but equilibrium for variable costs is still not attained if the revenue per trip remains at 3,8 Euros.
Going further than these hypotheses would entail reconsidering all the technologies (including the use of electric cars) as well as the computing architectures but it was outside the terms of reference of this study.

Conclusion

A concept and service with the approval of the community
Despite the shortcomings of supply in the trial, which was spatially limited, utilization of the Praxitèle service showed a steady non-asymptotic rise giving grounds for the hope that a genuine commercial system will one day be possible. Ultimately, the trial has shown that the concept of shared cars is mature for local use and a widely differentiated clientele, including car owners. The wide variety of those who found the concept convincing and the multiplicity of the needs that have been met by the service contain the seeds for a secure future.
Management of the service appears to be effective
Another outcome of the trial is that it has demonstrated the technical feasibility of the concept. The Praxitèle operating team has succeeded in producing "prototype" supply that was appreciated by the clientele and which would be capable of meeting higher demand..
A service with a difficult adolescence
A first difficulty stems from the high temporal variations in traffic combined with low volumes. This makes it very difficult to forecast demand and means that precautionary management measures using large resources are required. A second difficulty is associated with the spatial diversity of demand: the concentration of trips in both time and space can be accentuated by the presence of initially successful stations. But it is important not simply to attempt to increase traffic figures by favouring the "poles" as this may cause management problems and ultimately result in the system losing impetus.
Finally, costs related to the scale of the operation and its structure, which are major difficulties for all transport systems, represent a major challenge as a result of technological innovation.
The costs in the context of the trial are for a **prototype**. We can nevertheless conclude that the system, like other transport systems, has very high fixed costs; an important part of the Praxitèle challenge is to increase the amount of utilization while limiting the size of the fleet. At present the level of cost means the system is still far from achieving equilibrium for variable costs, but does allow us to envisage a future for the system.

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