ParkShuttle II : Review of the Antibes Experiment

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1 INTRODUCTION

1.1 Background

In many urban environments, the use of private automobile has led to severe problems with respect to congestion, energy (dependency on oil resources), pollution, noise, safety and general degradation of the quality of life. Therefore, city centres are facing severe problems, traditional commerce in them declines, moving to the periphery, and they become less attractive to visitors and businesses. Although public transport systems have seen many recent improvements (mostly due to information technologies), in many cases the private car still offers a much better service at the individual level. This leads to a constant increase in its use, hence to non-sustainable development of urban transport.

Figure. 1.1.1 : Frog at Schiphol

An innovative approach for mobility, emerging now as an alternative generic solution to the private passenger car, offers the same flexibility and much less nuisances: small automated vehicles that form part of the public transport system and complement mass transit and non-motorized transport, providing passenger service for any location at any time. These vehicles were developed during the 1990's are now called cybercars and, under the control of a management centre, they form a transportation system called Cybernetic Transport System or CTS. The first CTS was put in operation at Schiphol airport (Amsterdam) in December 1997.

In 2001, the European Commission funded two projects. One, called CyberCar, was aimed at the improvement of the technology necessary to implement and run such a CTS and was funded under the transport and tourism key action of DG INFSO research programme. The second, CyberMove, was aimed to demonstrate the feasibility of CTS in present urban environments and was funded under the City of Tomorrow key action of DG TREN research programme. Both programmes ended in 2004.

1.2 Project objectives

The potential advantages of autonomous driving capabilities and the new transport systems, based on environment friendly vehicles, are numerous.

First, they provide reduction of congestion, and better traffic flow, air quality and energy conservation.

Second, the system is much safer than manual driving, there is no need for a drivers' license and anybody can use it, including children, people with handicaps and elderly.

Third, the cars can be moved easily from one location to another, using fully autonomous platoon formations with a single driver.

Fourth, the cars can drive autonomously to a remote parking area when not needed, hence leaving valuable urban space free for pedestrians and cyclists.

Fifth, the concept and technologies are also appropriate for delivery of goods in city centres and even for garbage collection: the same infrastructure could be used by specifically adapted vehicles with delivery (or collection) “boxes”.

Finally, flexible design will make it possible to optimise the overall system performance, taking into account the needs and requirements of the private consumer, the system operator and the public (e.g. municipality), permitting the system to operate in different modes at different times of the day, week and year.

The main goal of the CyberMove project was to prove that a Cybernetic Transport System (CTS) is able to provide all the listed advantages. To do so, a number of sites in Europe carried out field trials and feasibility studies for the implementation of CTS applications.

One of the field trials was carried in June 2004 in the city of Antibes on the French Riviera. We will now report on this field trial and on the simulation of a full scale deployment of a CTS in this city.

2 EX-POST EVALUATION

2.1 Overview of the evaluation process

CyberMove evaluation methodology is based on MAESTRO guidelines, a major strategic initiative fully funded under the Transport Research Programme of the European Commission, that provides a standard methodology for selection, design and evaluation of pilot and demonstration (P/D) projects for transport in Europe.

According to the MAESTRO methodology flow, Figure 2.1.1, the evaluation steps are four, namely the definition of the objectives plus initial, ex-ante and ex-post evaluations, each one followed and preceded by one of the three project design/implementation phases.

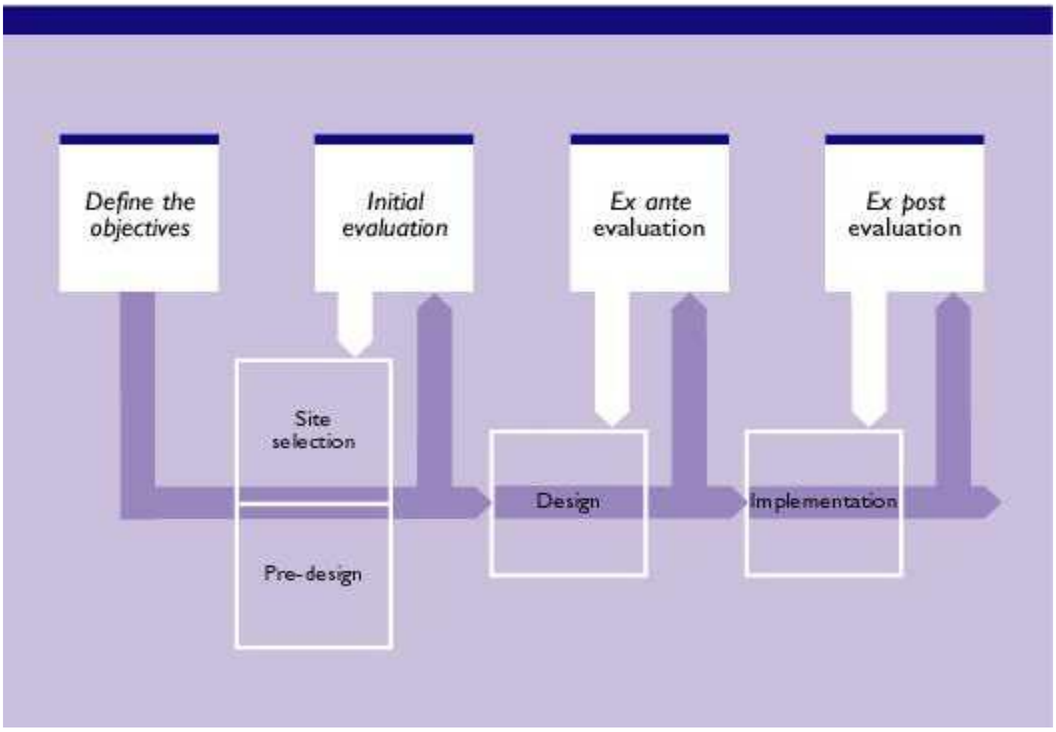

Figure 2.1.1 MAESTRO methodology flow (source: MAESTRO Guidelines)

This article will concentrate on the ex-post evaluation of the Antibes site where a full demonstration took place during two weeks in June 2004, at the end of the CyberCars project.

2.2 CTS system description and simulation hypotheses

The track in the Antibes project, represented in Figure 2.2.1, has a total length of 2989 m, that is about 1.5 kilometres from the station closest to the city centre (numbers 6 and 7) to the most remote station (numbers 1 and 12).

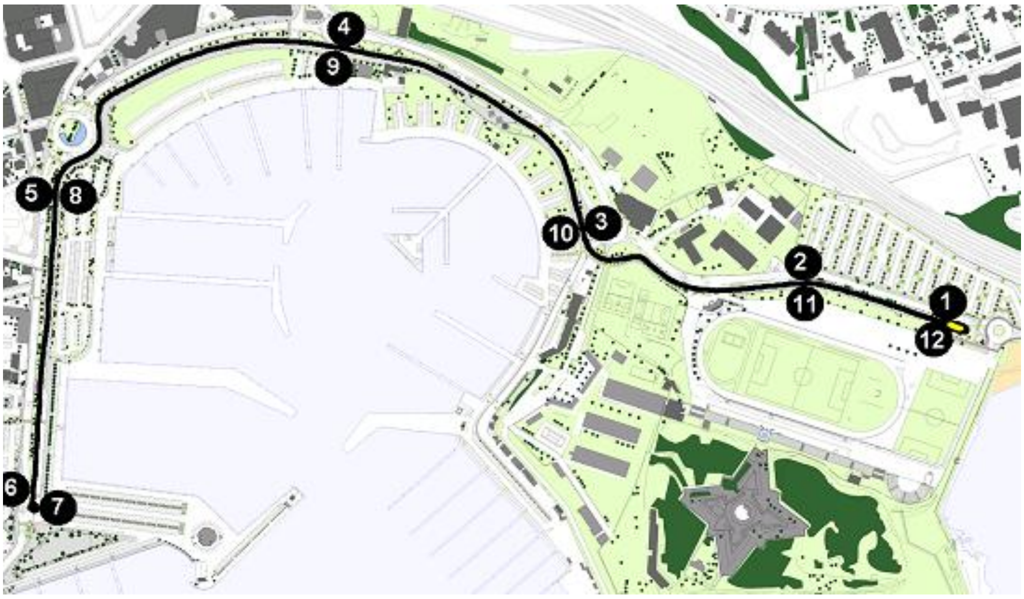

Figure 2.2.1 Projection of cybercar track on Antibes map

The total number of stops (locations on the track where people can get in or out the vehicles) is 6. In the simulation, the stops are considered separately for both directions, numbered as in Figure 2.2.1.

The stations at each end of the track, namely station 1 and station 7, are locations where the cybercars wait when there are no people to be picked up. In the simulation, we call these points "Standbypoints".

In the Antibes simulation, the maximum number of passengers per cybercar is 20. The length of each cybercar is 6 m and the width 2.1 m. The number of cybercars is 3.

Consistent with the real FROG vehicles, obstacles are detected if they are found within 40 m in a straight line from the cybercar and within an angle of 100 degrees from the front of the cybercar. Obstacles can be crossing vehicles, crossing pedestrians and other cybercars. To other cybercars, the range of 100 degrees is not taken into account. If an obstacle is detected, the distance over the track to the obstacle is determined.

Each cybercar holds a distance of at least 2 meters to its predecessor and other obstacles. The cybercar brakes as comfortable as possible starting with a normal deceleration of 1 m/s^2 up to 5 m/s^2 depending of speed of the cybercar and the distance between cybercar and obstacle. The jerk during braking will be limited to ensure a smooth stop. In the simulation the following brake strategy is adopted: if the distance to the obstacle after one time-step with the current speed and acceleration will be shorter than 2 m plus the brake-path of the cybercar with normal deceleration, it is going to brake with the normal deceleration in this time-step. If the distance to the obstacle is already shorter than 2 m plus the brake-path of the cybercar with normal deceleration, it is going to brake with an emergency deceleration of 2.7 m/s^2 in this time-step. If the resulting speed after one time-step is negative, it is set to 0.

The maximum speed of the cybercars is limited to 20 km/h from station 8 to 12 and 1 to 5 and to 10 km/h from station 5 to 6 and 7 to 8. In sharp curves, the speed is further limited according to the following formula, which is really used by FROG vehicles: $v = \sqrt{0.6 \cdot r}$, with r the radius of the curve. The cybercars always try to drive with the maximum allowed speed. If they drive slower and there is no obstacle or other cybercar within short distance (see obstacle detection), they accelerate with the normal acceleration of 0.6 m/s^2.

Each cybercar is controlled by the 'control manager', that decides which cybercar picks up which people. As soon as one or more people arrive at a station, it is assumed that they push on a button. Then the closest cybercar (in time) will be warned to pick them up. A cybercar will pass a station with waiting people if it is full (contains 20 passengers). If a cybercar has no instructions to pick people up, it waits at one of the standbypoints. That is, in order to try to minimize the waiting times of the people, it waits at the standbypoint farthest from the city centre in the morning, in the evening it waits at the standbypoint closest to the city centre and during the rest of the day it waits at the closest standbypoint from its actual position.

2.2.1 Demand analysis

The following three periods where considered.

- "May": an average day in May which is considered to be representative for the months January, February, March, May, October, November, December (228 days).
- "Salon des Antiquaires": activity with higher demand in April (15 days).
- "July": an average day in July with high demand caused by tour activities, considered to be representative for the months June, July, August and September (122 days).

The demand for these periods is derived from the final demand estimation of the ex-ante evaluation. In the ex-ante the total number of 4126 trips per day in the area was calculated starting from the counted vehicle flows and the counted passengers on the presently available public transport service;

than applying an iterative supply-demand simulation procedure a modal share of 23% (967 trips per day) on three twenty passenger-vehicles was calculated... To get the O/D matrices for the periods May, Antiquair and July we used seasonal factors 0.842, 0.887 and 1.834 respectively. Although the route of the CTS was slightly chanced between ex-ante and ex-post the same figures for demand and supply were used to make the two evaluations comparable.

The average demand is given per 30 minute interval. This is derived from a given hourly distribution of the ex-ante evaluation. The arrivals of the passengers at the stations from which they start their trip are generated by a Poisson-process. All passengers of the CTS are assumed to be arrived by car. Therefore they arrive in groups of people who came with the same car. All people in one group have the same origin and destination and arrival time

2.2.2 CyberMove simulation statistics

All statistics are related to one day, averaged over 100 simulation runs.

Figure 2.2.2 shows the waiting times of a passenger per station. The waiting times increase for the periods with higher demand. Comparing figures 2.2.2 and 2.2.3 it strikes that waiting times are quite long when compared with travel times. This is due to the fact that passing from ex-ante to ex-post the route length grew from 2 to 3 km but the number of vehicles remained the same thus the waiting time increased. To avoid un-realistic simulation a “walk-off” condition was inserted; if the passenger waits too long in comparison to the in-vehicle time he walks away. According to this rule station 5 has the shortest waiting times because it has the shortest travel time and therefore passengers walk away earlier from station 5 than from anywhere else.

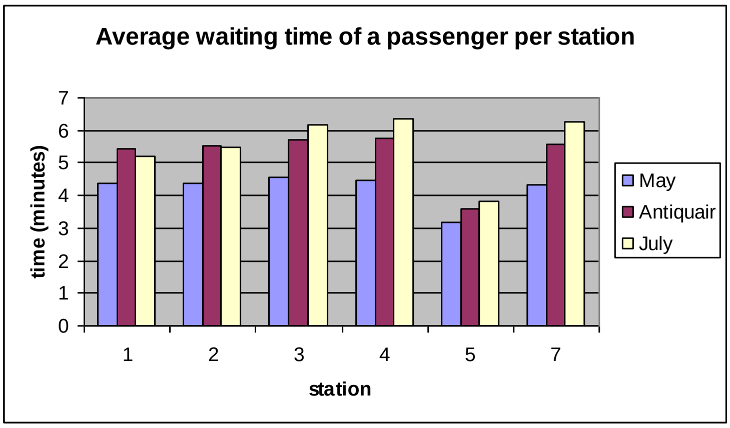

Figure 2.2.2 Average waiting time of a passenger per station

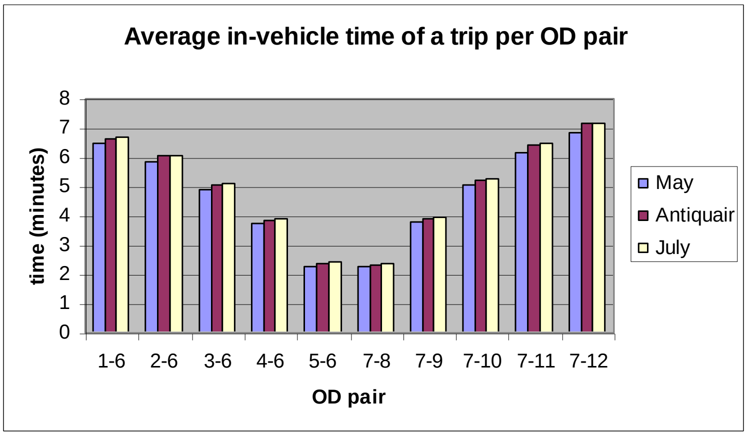

Figure 2.2.3 Average in-vehicle time of a trip per O/D pair

Figure 2.2.3 shows that the in-vehicle times are shorter for shorter trips, which is of course logical. Also, it shows that the in-vehicle times differ only little between the different periods.

2.3 Field Test in Antibes

CyberMove organised a field trial in collaboration with the city of Antibes Juan les Pins and Sophia Antipolis transport authority. The experimentation has been limited to 2 x 320 meters, on the Verdun Avenue, the last part of the complete CyberMove project track. The installation took only two days, public tests started the 1st of June, until the 12th. One Park shuttle, 20 places, from Frog, was running from 9a.m. to 7p.m., about 32 km per day, so totally 288 km without any technical problem. The maximum speed was 14.4 km/h. A demonstration was performed with a speed of 32 km/h. Three intermediate bus stops (~100 m interleave) were installed in order to simulate a normal transport systems, but with systematic stops. In fact, it was not possible to install an information system on each bus stop, making on demand services impossible.

Figure 2.3.1 ParkShuttle II in Antibes

3000 passengers tested the vehicles, plus several schools and associations. About 285 questionnaires have been issued. Each questionnaire, having 15 questions, was used to assess users' opinions and expectations about CTS and how and how often they would use it.

The questionnaire was made of ten statements, one per each indicator. Respondents had to use a scale from 1 to 5 to indicate to what extent they agreed with the statements, 1 meaning "in complete disagreement" and 5 being "in complete agreement". The sum of the percentages of answers 4 and 5 was assumed as the percentage indicating the measurement to compare with the initial thresholds.

To evaluate **Usefulness** indicator the statement was: "The service provided by the new system is very useful; much more than the transport services previously available". The result obtained was 77% of people answering 4 and 5, meaning that the more than three quarters of the respondents considered the system more or much more useful than conventional public transport. Although very high this is the second lowest scoring indicator, probably because the demonstration service was not really useful for transport purposes and people responding positively did imagine how useful the system would be once fully implemented.

To evaluate **Ease of use** indicator the statement was: "The system is very easy to use; much more than the conventional transport systems". The result obtained was 96% of people answering 4 and 5, meaning that the users consider the system much easier to use than PT.

Perceived performances have been measured by the statement: "The system performances are very good; much better than those of conventional transport systems". The result obtained was 80% of people answering 4 and 5, meaning that CTS performances satisfied most of the users more than the conventional transport systems. This result is in countertendency with respect to the previous trials that highlighted the perceived performances as one of the weaknesses. Probably the performances of the new shuttle are better perceived by users; nevertheless it must be noticed that, with respect to the enthusiasm of the Antibes respondents, this indicator is in the lower side.

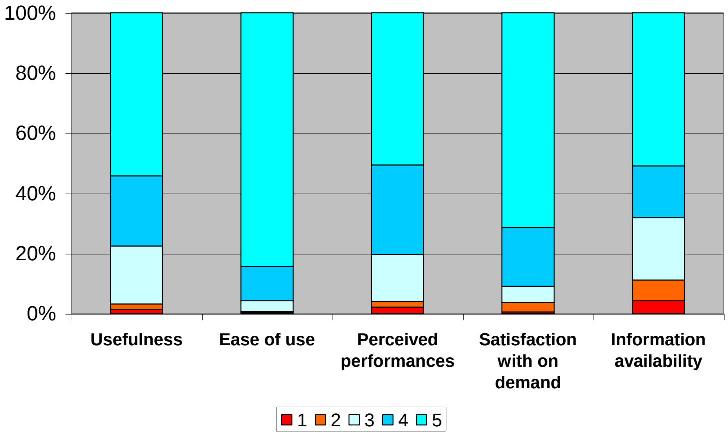

Figure 2.3.1 Acceptance and quality of service indicators (1)

Satisfaction with on demand has been measured by the statement: “The fact that service is provided on demand is very satisfactory; much more than conventional public transport service”. The result obtained was 91% of people answering 4 and 5, meaning that users like this new mode of request although in Antibes the service was not on demand. Probably the interviewed users imagined how the system may satisfy them once it will be on demand.

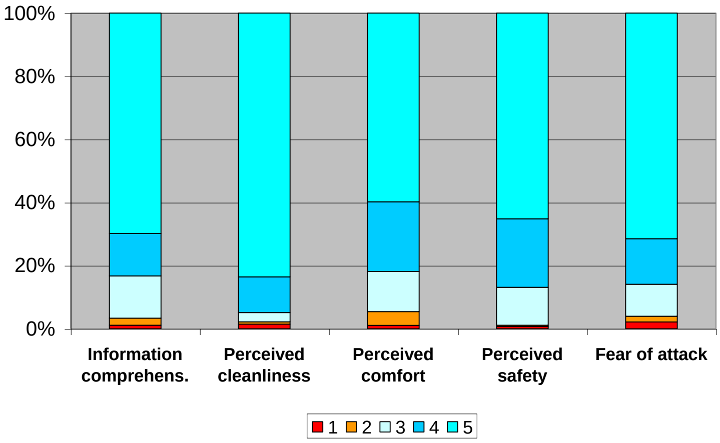

Figure 2.3.2 Acceptance and quality of service indicators (2)

To evaluate **Information availability** indicator the statement was: “Information about the service is very easily available; much more than for conventional transport systems”. The result obtained was 68% of people answering 4 and 5, meaning that more information about the service was available during the demos than for PT. This result may appear strange because no dynamic information was available at the stops while in Antibes a new information system has been recently installed on the buses but maybe the users evaluated positively the presence, most of the time, of personnel at the stops.

To evaluate **Information comprehensibility** indicator the statement was: “Information provided is very easily comprehensible; much more than for conventional transport systems”. The result obtained was 83% of people answering 4 and 5, meaning that information was clear; probably referring to the posters pasted on the stop shelters because no dynamic information was provided.

The statement “Vehicle and stops cleanliness is very satisfactory; much more than for conventional transport systems” was chosen to measure **Perceived cleanliness**. 95% of the respondents answered 4 and 5, thus considering CTS satisfactory clean.

To evaluate **Perceived comfort** indicator the statement was: "Trips on the new system are very comfortable; much more than on conventional transport systems". The result obtained was 82% of people answering 4 and 5, indicating CTS as more comfortable than PT.

Perceived safety has been measured by the statement: "The new system is really safe: much more than conventional transport systems". The result obtained was 87% of people answering 4 and 5, meaning that users felt much safer on CTS than on PT vehicles.

The statement "I felt really secure travelling on the new transport system; much more than on conventional transport systems" was chosen to measure **Fear of attack**. 86% of the respondents answered 4 and 5, thus considering CTS more secure than PT.

To calculate **User Willingness to pay** four scenarios were taken into account in the questionnaire: 1) Unchanged parking prices and free CTS ride, 2) Unchanged parking prices and 1€ for a round trip on the CTS, 3) Increased parking prices and free CTS ride, 4) Increased parking prices and 1€ for a round trip on the CTS. For each one of them people had to answer to the question "How would you travel in case this scenario is implemented?" and the possible answers considered the possibilities of using private car directly to reach the destination, parking the car and go on foot and parking the car and take CTS.

In order to consider the influence of different parking prices on users' choice, two willingness to pay have been calculated: one concerning the first two scenarios (unchanged parking prices) and the other concerning the other two scenarios (increased parking prices).

The values obtained are: 0.72 € for the unchanged parking prices scenarios and 0.86 € for the increased parking prices, meaning that interviewed people considered CTS installation as very valuable and 72 % of them would pay a 1€ fee even leaving the parking fee policy unchanged. Such percentage grows to 86% when changing the parking fee policy.

From the analysis of the questionnaire the number of people that would shift from car to CTS could also be calculated. With the help of the same four scenarios described above the questionnaires filled by the 169 car users were used to quantify the modal share of the CTS. 85% of the car users would use one of the car-park and then the CTS in case the parking fees remain unchanged and the CTS ride would be free. 76% of them would shift to the CTS even if a 1€ fee was set leaving unchanged the parking prices. 97% of the car users would change to CTS in case the parking fees are changed and the CTS is free and 96% would change with the new parking fees even if the CTS fee would be 1€. Such results are clearly too optimistic. They prove once again that only people really attracted by the CTS demonstration went for a ride and replied to the questionnaire. To validate such result a telephone survey among Antibes citizens should be made.

3 Conclusions

These conclusions are based on the Antibes test case and on the other CyberMove sites. Antibes, being one of the few sites which run all the evaluation stages (initial ex-ante and ex-post) provided most of the findings.

Depending on how it is designed a CTS can virtually accomplish any transport task: it can provide a park shuttle service for an historic city centre, or a business park; it can be a feeder for the main public transport network or the only available transport service in a quarter or a village; it can serve students and personnel in a campus; and it can even be a city wide transport system. For each of these services CyberMove experimented, tested or simulated different design solutions and can now provide, depending on them, figures on performances and costs.

As a general rule the services can be sub-divided according to the transport distance. In CyberMove framework, with the exception of the citywide service studied only in Copenhagen, the transport systems studied are short-distance ones.

The main results for a short distance (~1 km) system are:

- the average commercial speed is between 15 and 20 km/h if the infrastructure is segregated and between 5 and 13 if it is not;
- average waiting time significantly changes with the network extension, the demand and the number of the vehicles employed and ranges between 0.5 and 5 minutes;
- waiting time variability changes according to the average waiting time of the same magnitude;
- start-up costs are affected by segregation, demand density (demand divided by the network length) and, most of all, by the quality of the service to provided but as a general rule they range between 0.5 and 4 M€/km (bidirectional);
- operational costs are affected by the same factors influencing the start-up costs and range between 0.5 €/veh·km and 3.17€/veh·km.

General comments to these results are:

- CTSs are well suitable for low to medium demand areas and short distances, typically the service run today by bus;
- if CTSs are employed to provide the same quality of service of a low frequency bus system they are more expensive than the buses themselves and do not provide any specific transport benefit (there are always environmental benefit being the CTS electric);
- however if the quality of service has to be improved to do it increasing the frequency of a conventional bus service is much more expensive (in ten years) then building a CTS, therefore CTSs are well suitable for low to medium demand areas and short distances trips where a good quality of service has to be provided;
- nevertheless increasing the quality of the public transport service, which is one of the reasons to adopt CTSs, is not sufficient to increase considerably the PT modal share thus combined policies have to be adopted to push more people to use the public transport once its quality is increased by the CTS adoption.

Probably the best solution is to start the CTS market with some very promising short distance system and, meanwhile, adopting the cybercar technology for other innovative mobility initiatives which can contribute to the technology diffusion and therefore to test it more and make it cheaper. An example of these innovative mobility solutions is the advanced car-sharing service with semi-automatic vehicle relocation studied in Turin (annex 2 to the ex-ante deliverable CyberMove consortium (2004)) in which specially designed low environmental impact vehicles featuring platooning technology are made available for people to pick-up and drop at any location and are relocated using the platooning capability.

Independently from the path chosen to increase the CTS market and on its extension, two main CyberMove findings apply:

- CTSs offer good service even in low demand areas due to the on-demand service; however, the system must be interfaced either with cars (trough parking), other CTSs, or with high frequency public transport services in order to realise the benefits;
- users, and how they perceive the CTS and its performances, are the key for any CTS-project success; they must be addressed from the beginning by consensus building actions (information campaigns, focus groups and local meetings).

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