Cybernetic Transport Systems: Lessons to be learned from User Needs Analysis and Field Experience

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Abstract

CyberCars is a European project in the Information Society Technologies Programme of the Fifth Framework. The Project's main goal is to accelerate the development and implementation of novel urban transportation systems, based on automated vehicles for movement of people and goods. These systems aim at improving mobility, while reducing negative effects of the private car use in cities (congestion, pollution...), by complementing today's mass transit systems and hence offering a real alternative with better convenience and efficiency than the private car in the cities.

This paper investigates: the user needs of cybercars; valuable field experience in the area of human-machine interface (HMI) and the legal hurdles encountered in first implementations of "cybercars" in Switzerland.

1. Introduction

CyberCars is a European project with the goal to accelerate the development and implementation of novel urban transportation systems, based on automated vehicles for movement of people and goods. These systems aim at improving mobility, while reducing negative effects of the private car use in cities (congestion, pollution, demand on space), by complementing today's mass transit systems and hence offering a real alternative with better convenience and efficiency than the private car in cities and interurban areas.

The main characteristics of these systems are the use of small electric automated vehicles, in this project also called "cybercars." Cybercars are road vehicles with fully automated driving capabilities. A fleet of such vehicles forms a transportation system for passengers or goods on a network of roads with on-demand and door to door capability. The fleet of cars is under control of a central management system in order to meet a particular demand in a particular environment. In early implementations, Cybercars are designed for short trips at low speed in an urban environment or in private grounds. For the long-term, cybercars operate on a larger network, (possibly in dual mode) driving in mixed traffic [1].

This paper describes (1) the inventorisation of user needs in the Netherlands carried out by TNO Inro in the period of October 2001 to January 2002; and (2) field experience in the areas of HMI and legal barriers in three applications of Automated People Movers (APM).

2. Understanding User Needs

In the CyberCars project, four major user groups were differentiated: End-users (General needs and special needs and interests), Decision makers (national, regional and local levels), Operators (both public transport and general service providers) and Combined Decision-maker & Operator (for example airports, theme parks, large businesses and Universities). The research design recommended a focus group approach for general end-users, and in-depth structured interviews for the remaining categories.

2.1 Focus Groups

In order to find out how the public reacts to cybercars and to obtain information on the desires and expectations potential users may have regarding this new transportation concept, group discussions are to be held in various European countries, including the Netherlands. TNO Inro co-ordinated the research activities conducted in the Netherlands.

Conducting these Focus Groups aimed to obtain information on and gain insight into (a) The impression respondents have of the Cybercars concept after having seen its presentation and their ideas about the strengths and weaknesses of this transportation concept; (b) The desires and expectations potential users have with respect to Cybercars; and (c) The intentions respondents have of using the system in the future and the conditions they stipulate in terms of ease of use, safety, availability etc.

2.2 Structured Interviews

In December 2001 TNO Inro carried out seven Structured Interviews. During the interviews, the interview protocol of the Work Package leader was followed [2]. The following Dutch organisations were contacted and interviewed for the CyberCars project:

End-Users: Special Needs and Interests

- ROVER:protects interests of (users of) public transport.
- ANGO protects the interests of disabled people, from the perspective of the disabled person as a consumer.

Decision maker (public):

- Municipality of 's-Hertogenbosch: a city of 130.500 inhabitants in the South of The Netherlands. The city has a historical, medieval city centre.

Operators:

- Stichting Gedeeld Autogebruik (Dutch Foundation for Car Sharing).
- Transvision BV (operates Train Taxi[1] among other services). Transvision specialises in connections with public transport by rail.
- Connexxion is the largest mobility provider in The Netherlands. They transport 300 million people each year. Public transport services include (fast) bus, tram, fast ferry and people movers.

Decision makers & Operators:

- Bloemenveiling Aalsmeer (VBA, the Flower Auction): VBA built an auction site, initially 85.000 square metres in 1972, now 850.000 square metres, soon to be 1.000.000 square metres. There are 10.000 people working at VBA. VBA is the largest flower auction in Europe.

2.3 Results of the Focus Groups and Structured Interviews

What did the different users groups find important in Automatic People Mover systems? Here, we first provide a translation of the topics that the user groups stated as important into technical implications for Cybercars, grouped by topic. Following the list, we provide a qualitative analysis of the differences between the groups

Availability: The system must have vehicles available when they are called, so that the wait for a vehicle is short. This implies that:

- Fleet management must work: vehicles should be located at strategic locations so that they can respond in a timely way to a call. Stacks of vehicles in particular locations should be avoided.
- The number of vehicles must be sufficient to meet demand
- The system must be reliable (failsafe)
- Vehicles must travel at a reasonable speed so as to reach the individual requesting a vehicle.

Safety: The technical implications of ensuring system safety are legion, depending on the chosen path. They include:

- Need for separate infrastructure or car-free zones for efficient transport in traditionally congested areas, such as city centres.
- Make use of separate infrastructure for Cybercars in order to prevent accidents
- Exclusive use of shuttles in the centre of a city, increases pedestrian safety
- Supervision from an aid / operator station
- Improved sensors, navigation, etc.

Speed:

- Average speed must be about 30 km/hour in the city

[1] A nation-wide taxi-sharing system of feeder transport in connection with rail transport.

- Maximum speed should be 50 km/hour for connections between the city and the suburbs.

Service: Payment by bus and tram card or by pin (electronic means)

Vandalism-proof: Focus Group participants expressed the concern that the vehicles should be designed and manufactured to be as “vandalism-proof" as possible. This is especially critical in the scenario that cybercars are public vehicles. Technical requirements for the design of the vehicles include:

- "Less is more" design concept: the less there is in the vehicle, the less there is to tear out of it
- The materials chosen for the vehicle interior and exterior must be designed to resist graffiti and other types of vandalism.
- Network design also plays a role. Locating waiting spots and parking places for Cin low-risk locations for vandalism is part of network design.

Appearance

- Shuttles look like mini-vans
- Show similarity with already existing shuttles
- Preferably no strange shapes or forms

System Flexibility The technical implications of system flexibility can be summed up as

- Flexible routing. This point involves software issues, fleet management and the hardware on the street.
- Provide incentives for several potential developers of cybercars systems in order to avoid the development of a cybercar system monopoly.

Safety, Equity issues and Passenger Comfort:

- Shuttles not too small; there must be room for luggage, wheelchairs and baby buggies
- Low entering possibility so that it can be used by less mobile people
- Height of call buttons must be reachable for all users, including persons in for example wheelchairs
- Shuttle does not need to accessible for every kind of less mobile person, but within an acceptable range of disability.
- Information (announcements, instructions) must be available in an accessible form for persons who deaf or blind.
- Information on how to use the vehicle, how to pay, travel time, current location, route descriptions, etc. must be intuitive and understandable to users.
- Need for "observer"; driver is missed implies that the use of video/ surveillance cameras in the shuttles is necessary.
- Emergency break/emergency button
- Transparent shuttle enlarges safety feeling
- Doors on one side of the shuttle, in the middle
- Seats are necessary
- Viewing screens that show films/advertising

System Costs and System Feasibility address the initial operational and maintenance costs of the cybercars vehicles and system. The technical implications of these points are often related to the

- Particular design of the vehicles,
- Reliability of the vehicles, components, infrastructure, communications system, etc. to reduce repair costs.
- Saving of costs associated with a driver in each vehicle
- Network design in capturing e.g. not only peak commuter travel but also recreational, tourist, education types of travel.

2.4 Summary of the User Group Analysis

In this study, four different user groups identified the criteria most important to them when considering the new fully automatic transport mode cybercars. Potential end-users from the Dutch city of Amersfoort discussed the cybercars concept in focus groups. Local authorities, special interest groups and operators from all over the Netherlands voiced their opinions in structured interviews. One common criterion was identified, but, beyond this one, the list of most important criteria diverged.

Safety and security, referring to the avoidance of accidents, personal and perceived safety, was an important criterion for all user groups. The user groups discussed ways to achieve acceptable levels of safety and security, ranging from maintaining a separate infrastructure for cybercars to avoid accidents with other road users to surveillance cameras in the vehicles to increase personal safety while using cybercars.

The overall second most important criterion to the general end users, availability, indicated that the cybercar vehicles should appear within five minutes of requesting it, requesting a vehicle should be via something similar to a mobile telephone, and stops should not be too far apart. The technical implications of these criteria are very important for the cybercars concept: fleet management, sufficient numbers of vehicles strategically placed to meet demand, reliability of the vehicles and system, telecommunication system, and reasonable speed must all be perfected in order to meet this "availability" criterion.

The other user groups emphasised on the need for system flexibility and feasibility, the importance of system costs, equity issues and passenger comfort. Not surprisingly, operators found the first three the most important criteria, and the special interest groups found the last two most important, next to safety and security of course. The large business put both cost and equity at the top of the list. Decision-makers emphasised urban planning issues and technical experience.

New criteria emerged which were common to almost every group. These were the needs for vandalism-proof vehicles, system reliability, and a payment system that is both accessible and self-explanatory.

3. Field Experience in the Netherlands

The unique field experience Frog Navigation Systems has acquired over the last 4 years operating 2 pilot systems in different applications gives input to further development of the multiple Human Machine Interfaces (HMI's) of an APM system. Frog learned that taking account of the functional aspect of the HMI is not enough. Engineering the customer interface needs to pay attention to the emotional attitude of the customer being faced with an unfamiliar and unmanned system. To meet customer expectations is not just a matter of supplying the right functionality. Expectations are based on perception. There is a psychological element to it. Understanding this can be the basis for a successful development of the HMI.

The first system started operation in 1997 at Schiphol at the P3 long term parking area. It transports people over a 600m track to the central station of the shuttle service to the terminal building. The ParkShuttle operates at a round the clock schedule.

The second system opened in 1999 in Rotterdam as a link between a subway station and a Business Park in the neighbouring city of Capelle aan den IJssel. This is a commuter system operating under public transport conditions.

Both systems operate with 10 person vehicles that run on demand under the control of a stationary traffic management and supervisory system. The vehicles bring the user directly to the chosen end destination.

The systems have been evaluated in depth on all operational aspects including customer observation and several customer interviews. The surveys indicated a high customer appreciation for this kind of individualised transport service as well as clear improvement areas, one of them being the HMI.

Frog decided to translate all this into the development of a new generation of the ParkShuttle, a project that will start by January 2002. Frog has set up a new company for the concept and market development of its APM activities: *2getthere*

3.1 The Importance of Understanding the HMI components

The customer: Goal for the HMI of the ParkShuttle was to make it self-explanatory. To realise this Frog aimed for an analogy with a commonly known transport system offering individual transport. There is only one transport system everybody knows that operates automatically and offers individual transport service: an elevator. Frog decided to shape the HMI of the ParkShuttle to the image of an elevator. It proved not as simple as that. Everybody understood the operation needed to call a vehicle at the station, but when the ParkShuttle arrived people felt like stepping in a bus, sat down and waited for the driver to drive off without selecting a destination.

The Operator: The ParkShuttle systems run under the supervision of a human operator. His/ her tasks are to instruct and help passengers via the intercom and solve operational problems when they arise, for instance obstacles on the track or bad weather conditions. When everything goes fine s/he has nothing to do, but when the system produces an alarm signal s/he has to act swiftly and skilled in both handling the system and the customer. This HMI requires a highly trained employee, always alert and available who sits idling most of the time. This presents a dilemma, as the main buying reason for an automatic system is the lower cost per passenger that thus can be achieved. This reality should be the basis of developing the operator/machine interface.

3.2 Designing the Customer Interface

Designing the various customer interfaces mentioned above involves more then just engineering the functionality required to make the system work. It also requires additional functionality to satisfy the emotional aspects of the customer attitude towards automated people mover systems. Functionality is thus categorised as 'soft functionality' and 'hard functionality'.

Soft functionality deals with building confidence in the automated system. This confidence is built by providing (a) Feedback in the form of Request acknowledgement and by providing information about the expected waiting time until vehicle arrival; (b) Travel information about the end destination, next stop, travel time and unexpected incidents; (c) Security, to increase the feeling of safety or perceived safety, by providing access to the operator, video surveillance, and an emergency alarm.

The hard functionality addresses the need for the HMI to be self-explanatory and quick to use. Adequate and prominent signs can support the customer-friendliness of the controls for customers at stations, display of short messages leading customers through operation and voice modules to provide advice or reminders.

3.2 Designing the Operator Interface

An automated people mover system cannot be left alone. A system operator must address disturbances to the system, support customers, and provide basic surveillance. However, the operation of the HMI should support these tasks by reduce the number of operations by automating certain functions (e.g., initialisation, parking of vehicles) splitting operations into on-site assistance and technical support, and by providing the operator with adequate tools for remote operations, such as video installations and alarm reset.

3.3 Conclusions

Two main conclusions from the above we can draw as a summary are:

- The customer interface of an APM requires a surplus of system feedback and the feeling of somebody being near when needed.
- A human operator is vital for successful operation of an APM system. For reasons of cost and manning this HMI needs to be developed towards a high content of remote operations while maintaining the system safety level and customer service.

4. Field Experience in Switzerland

The Pilot-Serpentine, in Lausanne/Ouchy, Switzerland, should demonstrate the feasibility of a new ecological, economical and effective urban transport system based on new technologies and cybernetics. The first stage of this Pilot was carried out in 2001. Testing and finalisation are in progress waiting for the running licenses.

The Pilot-Serpentine encountered a legal quagmire in attempting to obtain the necessary licenses for operation. The initial order was placed in June 2000 and the technical development of infrastructures and capsules was completed in June 2001. The building began and, having achieved a first 300-meter stage, was unfortunately stopped awaiting legal authorisation. The Serpentine system, conceived in the early 80s, had been initially classified as "railway". At the end of 2000, an authorisation was required for the experiment in Lausanne/Ouchy. At this point, the lawyers classified this system as a "trolleybus". As a result, the infrastructure was subject to railway regulations and the capsules to road traffic regulations.

The regulations date from the beginning of the 20th century. Electricity networks and legal regulations were developed at that time in order to facilitate the task of the pioneers while at the same time taking into account risks and fears with regard to technical progress. Road traffic regulations were also mainly aimed at easing the flow on the main roads of the country. In brief, the State has set up a "rolling" system in which the so-called "individual risks" are commonplace and covered by compulsory and very profitable insurance.

However, these regulations have not yet integrated the new trends towards sustainable development and soft technologies. The place of bicycles, child's scooters, rollers or child's cycles on urban roads, is still precarious or even non-existent. Regarding intelligent transport, the law cannot keep pace with the development of the last 35 years, from the time when speed limits were enforced in cities. This problem becomes visible in the areas of coexistence in pedestrian and green areas or on cycle tracks.

5. Conclusions

One could conclude on the basis of the user needs analysis and field experience that a gap exists between discussing requirements for a new transport concept and experience with the implementation of the system. Although familiar with the systems, the potential end-users (from the focus groups) had for the most part never experienced either of the two cybercars-like systems operating in the Netherlands. This was most striking at the Rivium ParkShuttle site in Rotterdam. There, the system operator reflected on how he saw the commuters using the system, the problems with the heavy electric vehicles and their need for recharging time, and suggestions he had for the new network and vehicles for Rivium II. Coupling the pilot system experiences into redesign of the new system appears to be crucial. In this respect, the field experience in the Netherlands and in Switzerland make it clear that there are both HMI and legal issues that must be addressed in the next generation of Cybernetic Transportation Systems (CTS).

The European project CyberMove provides the opportunity to address these issues in the next generation. Firstly, a large-scale internet-based survey will be conducted in Europe, in order to deepen the understanding of user needs. Secondly, the deployment of pilot CTS in several European cities allows the second generation CTS to profit from the field experience up until this point and an opportunity to obtain more field experience for large-scale deployment of CTS.

References

[1] *CyberCars: Cybernetic Cars for a New Transportation System in the Cities, Annex 1 - Description of Work*, European Project proposal for the Information Society Technologies programme, Shared Cost RTD No. IST-2000-28487 2001.

[2] Transportation Research Group, *Topic Checklist, CyberCars - WP1 "Status Review" - Task 1.1 "User Needs", Activity 3 "Structured Interviews" - Document 3.2 "Topic Checklist*", 2001.