Automatic People Transportation: Operational Achievements

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Abstract

By delivering its second fully-operational Cybernetic Transport System (CTS) to Vulcania, a French theme park, ROBOSOFT demonstrates that long term R&D efforts are leading to real applications: the existing robotic technologies allow implemention of reliable and efficient CTSs, which can now be certified and used in sites open to the public such as theme parks, exhibition centers, campuses, airports, hospitals, etc.

1. Introduction to CyberCars

CyberCars are driverless and autonomous vehicles that can provide point-to-point and on-demand transportation services. They can be operated in fleets to optimize transport services. They can also be used in a more traditional way as automated shuttles. The latest generation relies on GNSS information for the precise localization of the vehicles, combined with hybridization techniques to improve availability and quality of the localization as well as redundancy for improved safety (figures 1 and 2).

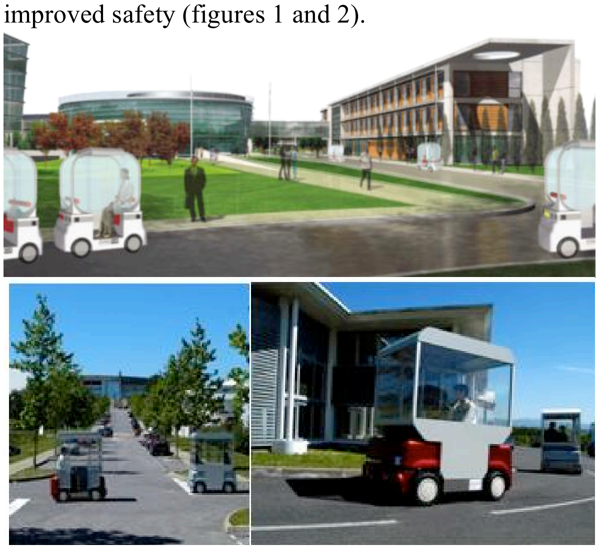

Fig1 : CyberCars in a campus environment

Fig 2 : CyberCars as automatic shuttles for parking services in tourist or pedestrian areas

This new approach of shared public transport can be applied to all private sites open to the public, and to transportation over short distances (a few kilometers) in indoor or outdoor environments.

ROBOSOFT is designing, manufacturing and producing two types of CyberCars, the robuCAB™ (4 passengers) and the robuRIDE™ (up to 30 passengers). They are both powered by the robuBOX™, ROBOSOFT's dedicated software solution for the control of such vehicles and systems.

CyberCars is a new generation of robotized vehicles: they are closer to mobile robots than to traditional electric or thermic vehicles. They are designed so that all of their functions (throttle, braking, steering, etc.) are computer controllable. Sensors on the vehicles control all of these functions by providing real-time information to the automatic robuBOX™. They use the "drive-by-wire" concept developed in aircraft, which eliminates all elements of mechanical transmission such as steering columns, drive shafts, connecting rods, etc. The direct consequence is that vehicles with this design are extremely simple, and that the space thus created by the absence of these mechanical components can be used to add more passengers in better comfort, thanks to a larger interior layout. These vehicles are quite modular and customizable to take into account not only the varying nature of the passengers but also environmental factors such as climate, safety, etc.

2. Operational realizations

2.1. Simserhof cultural site

The first commercial application of such a fleet of CyberCars was ROBOSOFT's robuRIDE in the Simserhof Fort cultural site in the French region of the 2nd World War Maginot line. Five vehicles are in exploitation and have transported more than 500,000 visitors since the opening in 2002 (fig 3).

Fig. 3: Simserhof entertainment park. CyberCars using embedded wires.

For this site, the vehicles are guided by buried inductive wires which control the steering. This technology has proved its robustness and safety, but requires a bit of infrastructure preparation as the wires must be precisely installed.

Another limitation is the limited flexibility left for future extensions or reconfiguration of the paths.

Nevertheless, this commercial application paved the way for driverless automated CyberCars transporting people in an everyday situation.

2.2. Vulcania theme park

Located in the mountains of the Massif Central in the Auvergne region of France, Vulcania is a theme park dedicated to volcanoes.

One of the latest attractions, the volcanBUL experience, opened in March 2008 and consists of three robuRIDE vehicles; each transporting 28 persons at 8 km/h in a scenic evnironment with surrounding volcanoes and geyser attractions, as illustrated in figure 4.

The complete system can transport more than 5,000 persons every day, and is available 365 days a year.

Christophe Camus - Vulcania

Fig. 4: Vulcania's volcanBUL Grand Opening, with a fleet of three driverless vehicles transporting 28 persons at 8km/h.

For this world's first commercial exploitation of GPS driven automatic transportation of people, the vehicles are equipped with an L1/L2 RTK-GPS, hybridized with a 6-axis inertial measurement unit and a wheel odometer, allowing real-time to-the-centimeter localization at 20Hz, even in difficult areas, for instance where the vehicles are passing under trees.

The vehicles follow pre-recorded trajectories. Security is achieved by a bumper and a laser range-finder combined with obstacle detection algorithms.

Thanks to the already existing software modules within robuBOX, the development of this application, from the vehicle definition and hardware low-level control up to the vehicle's navigation and scenography definition was achieved in less than 3 months.

2.3. Anglet beach experiment

Within the scope of a French nationally funded research project, a one-month experiment was conducted in the city of Anglet, France, in 2006. The technical goal was to validate the control and safety systems of the CyberCars in very crowded areas.

The commercial and societal goals were to ensure that the public was ready to accept such driverless vehicles.

The experiment was conducted over a full month, 8 hours a day, transporting people on demand in a pedestrian area along the Atlantic Ocean (figures 5 and 6). The only action users had to perform was to select their destination on a tactile screen, all the rest was autonomous.

The vehicle was equipped with an RTK-GPS that was integrated with vehicle, odometry, proving that such technology was viable for robust and safe commercial exploitation. Public acceptance was also very high and strong expectations were raised.

This experiment also demonstrated that CTS, like traditional transport systems, cannot be efficient nor make sense in crowded areas, even if the technology works well: vehicles always move at very low speeds, because of pedestrians!

Fig. 5: Anglet experiment: using the robuCAB as a CTS in a crowded pedestrian area

Fig. 6: The tactile onboard interface for passengers to select their final destination.

3. Efficient CTS combining taxi and shuttle services

CTS involves two automated transportation applications – one is the "taxi-type" (individual on-demand transportation); the other is the "shuttle-type" (pre-programmed multi-person transportation). These modes of transportation are appropriate for all types of delimited sites receiving a high density of persons needing to travel relatively short distances (i.e., up to several kilometers) either inside or outside their perimeter. Among the examples are:

- **Center-city** pedestrian and semi-pedestrian zones
- **Industrial or academic sites**, including factories, business or academic campuses, technology parks, research centers, laboratories, etc.
- **Public parks** such as amusement parks, vacation complexes, theme and cultural parks, historic sites, archeological sites, museums, etc.
- **Airports and train/bus stations** for their internal terminal connections as well as connections to parking lots, city centers, etc.
- **Health care sites**, including hospitals, retirement communities, rest homes, convalescent centers
- **Shopping centers**

All of these sites are finding advantages in automated transportation solutions – whether in taxi mode, in shuttle mode, or in some combination of the two.

4. CTS advantages

The ROBOSOFT automated transportation solutions offer not only currently available technology, flexibility and comfort but also economic advantages for both the system installer and the end-user. These features make the new taxi and shuttle systems an attractive package compared with traditional solutions and offer clear advantages for the overall quality of transportation.

CTS also offers planners long-term development solutions that bring advantages which are simultaneously economic, environmental and societal.

From an *economic* standpoint, the ROBOSOFT automated transportation solutions provide great flexibility and a reduction in operating costs for a limited initial and ongoing investment :

- **Flexible operations**. The vehicles are available 24/7/365 in whatever quantities the system installer desires; it is the fleet size that determines the limits of the solution, rather than the number of available drivers as in traditional systems. The fleet management system *robuFLEET Manager*™ optimizes fleet use by providing all necessary software tools to the system installer to calculate at any given moment the optimal fleet size to meet profitability, availability and other criteria.
- **Reduced operating costs**. In traditional public transportation systems, personnel costs represent up to 70% of the total operating budget. The robuCAB and robuRIDE automated transportation solutions considerably reduce operating costs compared to traditional solutions due to the absence of any driver. The systems' automated functioning provides better protection of the equipment against human error, which also reduces maintenance costs.
- **Limited up-front costs**. The robuCAB and robuRIDE vehicles cost significantly less than traditional vehicles with the same capacity due to the fact they were developed specifically for automated transportation. A 28-seat robuRIDE shuttle costs 30-40% less than a 15-seat electric bus. The only variable costs are those infrastructure costs (steering and safety) that may differ from one site to another as a function of the specific site characteristics.
- **A potentially profitable service**. Initial studies show that end-users are willing to pay up to 2 € per ride. Moreover, sponsors may be interested by the forward-looking originality of these vehicles as part of their marketing communications program.

From an *environmental* standpoint, automated transportation systems represent a decisive step towards "clean" or environmentally friendly vehicles :

- **An intermodal development**. By complementing existing modes of transportation, ROBOSOFT's automated transportation systems are a tool for promoting mass transit. By concentrating on short trips (less than five kilometers), these systems favor a new way of thinking about transportation compared with the current "100% automobile" approach: "I'll take the bus and then the automated shuttle – it's less expensive, and I'll save time; I have fewer unpleasant surprises and I can read while I'm traveling."
- **An improvement for persons with reduced mobility**. Beyond the improvements in general public services, the robuCAB and robuRIDE also make short trips much easier for persons with reduced mobility, such as persons with handicaps or the elderly.

Finally, from a *societal* standpoint, CTS constitutes a significant advance in the way that people can organize their internal movements within high population areas, whether in a professional or personal context :

- **No atmospheric or noise pollution**. By using electric propulsion systems, robuCAB and robuRIDE do not emit any gases or particulates that are harmful to the environment and are completely silent.

5. Safer transportation

Automating transportation vehicles makes them less sensitive to human error, which is the cause of most motor vehicle accidents. Also, the regulations imposed upon automated systems, which are much more restrictive than safety regulations for vehicles with drivers, oblige suppliers to install several levels of security that do not exist on traditional vehicles – including speed limitations, obstacle detection systems and manual and automatic emergency brakes. The robuCAB and robuRIDE systems have been designed to conform to the European Union machine directive (98/37) and its people transportation annex; they also conform to the EMC regulations of the CE marking system. Installed systems must in addition undergo a safety audit by a government-approved auditing organization before being put into service.

6. Certification

Certification is the process by which all the actors of a CTS can demonstrate that they comply with legislation related to this type of activity.

At this stage, a difference exists between private and public roads. Public roads are those where the traffic code applies,.

Public roads are open to common use by the general population. They are generally public paved roads, where traffic laws apply, such as speed limits, drunk driving laws, limited access for unusual vehicles, bicycles, etc. Strict worldwide rules govern the orderly operation and interaction of motor vehicles, bicycles, pedestrians and others upon public roads. Using automatic vehicles on public roads remains not a dream, but a long-term vision because of the time needed to define and adopt rules for these new driverless vehicles. Organizations, such as those in charge of certifying semi-automatic public transport systems with driver assistance (such as STRMTG in France) will probably become the main actors of CTS certification on public roads in the future.

Private roads can be very similar to public roads, except that traffic code does not apply. Virtually any type of vehicle can be used in private sites, but according to the law, suppliers must comply with safety rules. Because CTSs are not yet common systems, and also because sites are very different, the certification process is specific to each system. The supplier has to demonstrate the safety of its system, and the EC 98/37 Machinery Directive [9] has been used successfully in the three cases described above. The process is the following: identify the risks for people and equipment, implement solutions to manage the identified risks, and get an audit from an organization to check the compliance of the solutions with the Directive. Generally, the process takes no more than a few weeks, providing that vehicles have been designed with this Directive in mind.

7. Conclusion: a huge potential market

Even when only considering private sites as described above, market analysis demonstrates that the potential for both CyberCars and CTS is huge,, big enough to justify a fleet of automatic vehicles. Potentially all sites open to the public may need a CTS with from one to 30 CyberCars. After proof of feasibility, annual sales may reach more than 1 billion € within a few years, for 100,000 CyberCars. One of the conditions now needed is the involvement of car and transport system manufacturers, who now have a new diversification and fast development perspective. But it is also a field where robotics companies, as early pioneers, may find one of the killer applications they have been looking for thanks to 15 years of intensive R&D effort.

8.Acknowledgments

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- **EC-funded R&D projects** : CyberCar, CyberMove, CyberCar 2, CityMobil
- **French Government funded projects** : eBUS, MobiVIP

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