

# A brave new world?



Almost 50 years since R&D work on vehicle automation began, concepts, acronyms, and research programs have come and gone, but thanks to recent advances in information processing, sensors and communication technologies we could, at last, soon see widespread implementation of this technology. TOM VOGEL looks at the historical developments, current trends and future outlook of automated vehicles

**Many urban planning issues, including the separation of working and living, out-of-town developments and urban sprawl have led to a strong private car dependency in urban areas, which in turn have led to the degradation of urban environments through congestion, parked cars, community severance, noise and pollution and to social exclusion.**

The issue of social exclusion will become even more important with the increasing ageing of society. Various improvements to the quality and concept of public transport have helped address some of these issues, but many real or perceived disadvantages of public transport often still leave the private car as the preferred mode. Therefore without any major restrictions to private car use (e.g. due to policy measures, or as response to natural disasters) only a step change in the provision of public transport will be able to change this situation.

## **A step change in public transport**

One option to radically improve public transport that has been suggested is the introduction of automated transport systems (ATS), which have the potential to combine most of the advantages of private cars (e.g. flexibility, convenience, and comfort) with the advantages of conventional public transport (e.g. sustainability, environmental impacts, and cost), but at the same time being able to avoid most of their disadvantages.

ATS have the potentials of using the existing road network and allowing interaction with other users (i.e. con-

ventional manually driven vehicles, cyclists, and pedestrians), and therefore do not require any costly rail infrastructure. System design and implementation for this is based on recent advances in sensor and information processing technologies, including vehicle guidance, vision systems and obstacle detection and avoidance.

## **Potential of (and for) automated Transport**

The system will not require extensive parking spaces and can operate very quietly and without generating pollutants at the point of operation using electric engines. Through traffic management and platooning technology (vehicle following at minimum distance), congestion will be decreased because of a higher capacity of the existing road network. Furthermore, automated vehicle control will also result in reduced emissions and increased traffic safety, making ATS a more sustainable mode of urban transport.

On a small scale some targeted ATS applications with road capabilities, e.g. the ParkingHopper (in operation 1997-2002) on the long-stay car park at Schiphol Airport in Amsterdam or the ParkShuttle (in operation since 1998) at the Rivium business park near Rotterdam, have proven their ability to operate safely and efficiently in a contained environment with some interaction with pedestrians and other conventional vehicles. A similar system is also currently being implemented at London's Heathrow airport.

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Furthermore, a series of EC-funded projects (CyberCars, CyberMove, NetMobil, CyberCars2, CityMobil, CityNetMobil, and Niches+) have addressed the issue of ATS and have provided continuous funding in this area over the last eight years and the funding is set to continue. The aim of these projects is to help move ATS from the current small scale niche applications into the public transport mainstream. EC-funded research on ATS, particularly the CityMobil project was covered in the last issue of *Thinking Highways*.

This article will look back at earlier attempts at introduction of vehicle automation, focussing on the personal rapid transit (PRT) concept in the 1960s/ 1970s and the automated highway system (AHS) in the 1980s/ 1990s as major examples, describe achievements and setbacks, and illustrate the lessons learned from this. Based on this the implication for ATS will be analysed and recommendations for future development of automated vehicles will be developed.

### Personal Rapid Transit

An early example of a radical idea to provide more sustainable urban mobility was the personal rapid transit (PRT) concept in the 1960s/ 1970s. In this period of time the US government provided huge funding for the PRT concept, and following the enthusiasm of the successful Moon Landing Program, President Nixon said in his budget speech to the Congress in 1972 "If we can send 3 men to the moon 200,000 miles away, we should be able to move 200,000 people to work 3 miles away."

But history proved the introduction of PRT to be more problematic, with only few small-scale niche applications implemented. The main barriers to the widespread introduction of PRT were the lack of maturity of the technology involved, the need to radically reshape urban environments (e.g. visual intrusion through elevated tracks, and the vision of PRT not complementing but replacing the convention multi-modal public transport system in urban areas.

### System characteristics

The main concept of PRT is to provide individual on-demand transport through a system of small vehicles on a network of monorails. PRT is primarily an automated, low polluting, demand-responsive form of transport. The first PRT initiatives were in the mid-seventies, motivated mainly by the sharp increase in oil price and the sudden necessity for solutions with existing technology. The striking visual feature of PRT is the elevated guide-way. Cabs may ride on top of this guide-way or be suspended from it. To maintain minimum headways, stations are off-line and merging is controlled by the system. One early example of the PRT is that in Morgantown, USA, connecting various parts of the University of West Virginia campus with the central business district. It began operating in 1975 and has carried 50 million people without incident.

### Operating environment

The use of PRT (at least theoretically, as it was never realised on this scale) was envisaged to provide a new and



improved form of public transport to replace (rather than complement) the existing combined multi-modal public transport and private car system for personal mobility in urban areas. But the general concept was also suitable for smaller sites and due to the cut in funding (and loss of enthusiasm) for this technology before implementing large scale systems, the few working systems were limited to these environments.

Smaller sites (as opposed to implementation of a city-wide system) include e.g. university campuses (like the Morgantown system), large factories or company campuses, exhibition centres, theme parks, or airports. Airports seem particularly well suited for the use of innovative technologies, with use of automated vehicles e.g. at Shiphol and Heathrow airport and widespread implementation of fully automated people movers at airports throughout the world.

### Performance and findings

The PRT concept was very ambitious at the time in terms of technologies required as well as the scope envisaged for it. The few systems that were developed beyond the stage of a desk based study were successful and e.g. the Morgantown system is still in operation. But arguably a citywide system would have exceeded the technology



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levels of the time in terms of computing power and speeds for vehicle control and scheduling.

Another major drawback of this technology (and one that, unlike the technology issue, is still valid today - probably more valid now than at the time) is the visual intrusion of the elevated rail infrastructure in urban areas. Elevated urban motorways are still a visible legacy of the urban design philosophy of the time, but this is now widely accepted as being unsuitable.

### Automated Highway System

Research in the area of automated highway systems has been lead by the PATH consortium in California since the late 1980s/early 1990s, which has undertaken some of the most high profile work in vehicle to vehicle communications at the time. The program was dedicated to the construction and test of a range of cooperative prototypes and organised a large demonstration of different vehicle platforms and communication technologies. Despite a large technical and public relations success of the demonstration, the NAHSC project was not continued, with research since focusing on particular niche applications such as snow plough control and automated buses. Since then several high profile demonstrations have been undertaken, including events showcasing developments in Japanese research programs.

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### System characteristics

AHS assumes a system where vehicles are electronically linked, allowing the formation of closely packed groups of vehicles or ‘platoons’. The speed, acceleration, and inter-vehicle separation of each vehicle is measured on-board, and then transmitted to neighbouring vehicles and/ or to roadside infrastructure. With the increased accuracy and reliability of data obtained, it is possible to automate vehicle throttle and brakes to achieve much closer following distances to form so-called ‘road trains’ where vehicles in theory may have spacing down to the meter level.

While a number of vehicles may form a platoon, individual platoons are separated from each other by a larger spacing in the order of 50-100m. In order for such a system to function at full efficiency however, control must be performed flawlessly, with the driver therefore entirely removed from controlling the vehicle. Similarly, in order to allow for full predictability of vehicle movements, vehicles must operate in a dedicated right of way, ideally in their own lanes, barrier separated from non-equipped vehicles.

### Operating environment

As mentioned above, a full AHS requires the vehicles to operate in dedicated lanes, with dedicated entry and exit facilities in order to ensure that equipped and non-equipped vehicles may be separated and subsequently ‘re-mixed’ with minimum risk and disruption to flow.

Although the AHS technology is applicable to both lorries and cars current implementation strategies assumes platoons of a single vehicle type. An additional safety restriction imposed is that ideally all vehicles would pass some manner of ‘certification’/ health check before entering the system to ensure the vehicle is able to respond accurately and quickly to external vehicle dynamics commands.

### Performance and findings

Cooperative/AHS systems have always been associated with the provision of significantly higher capacity increases (typically estimated as being >300 per cent). Most studies for these systems have been undertaken by PATH using the SmartAHS simulation tool, designed to be able to incorporate a wide range of sensor, communication, control policy and human driver models into an integrated simulation environment.

Additionally, through microscopic modelling, it is possible to consider the effect that such convoy systems may have on emissions, and with the elimination of stop-and-go driving, it is clear that savings and decreases in fuel consumption will become apparent. For equipped vehicles it is estimated that this may be in the order of 10 per cent, with reductions in Hydrocarbon and NOX emissions of 48 per cent and 37 per cent respectively, having been calculated.

### Summary and Conclusion

It has been almost 50 years since work on the concept of vehicle automation began. A variety of different concepts and technologies have been developed (with

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varying degrees of success). Two major examples of these systems and technologies, personal rapid transit and automated highway systems, have been described here. Although both concepts have not been realised on a large scale and/or as a permanent implementations, lessons can be learned. And these lessons in turn have implications for the current concepts of vehicle automation as well as for future developments.

There are a number of clear benefits of the AHS system, including largely increased motorway capacity, safety improvements due to reductions in accidents, and decrease in emissions through smoother vehicle operation and elimination of stop-and-go driving. But despite these benefits no applications have been implemented yet, and funding for large scale trials has been cancelled. But more recently work is continuing on cooperative vehicle highway/ infrastructure systems, e.g. through the EC-funded COOPERS and CVHS projects.

There are also various advantages of the PRT system, including flexibility, large savings in staff costs compared to a manually operated shuttles due to the fully automated system operation, improved traffic safety when compared to manual operation, and the system

providing convenient user-friendly transport using an innovative and high-profile technology, which can address the generally low perception of public transport. But despite these benefits most applications are so far confined to small-scale systems implemented on private sites (e.g. in airports, theme parks, etc.).

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Early examples of vehicle automation can now perhaps be seen as overly ambitious and using fairly crude technologies. More recent systems have been more sophisticated, nevertheless implementation has been limited so far. R&D work (as well as the necessary funding) is continuing, and a number of major demonstrations are planned.

Lessons to be learned are that the right application areas have to be defined, that it has to be proven that the technology works, is safe, and is economically viable, that strategies have to be developed to address various implementation barriers, and that the market has to be well informed (maybe even educated) in order to facilitate acceptance of a (still) very innovative concept such as vehicle automation. **TH**

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