
Public Transport Fleet Management

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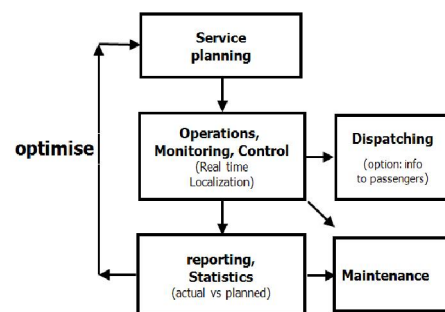
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Purpose

The aim of a public transport fleet management, well known as automated vehicle management (AVM) for public transport fleets, or automated vehicle localization (AVL), for simpler implementation, is to enable the efficient management of bus and tram services by the transport company organization involved in operations, based on the following main units:

- Planning
- Operations, monitoring and control
- Maintenance service



Several examples of AVM have an impact on all the transport organization and are based on systems integrated, such as AVL, automated vehicle location, RTPI, Real Time Passenger Information, and service planning (we refer from now on to AVM, considering that AVL is a part of the overall system).

AVM systems help to ensure that the services run according to schedule and also facilitate the operator's task of monitoring services and dealing with problems, such as delays due to traffic congestion and breakdowns. The timely dispatch of buses and the ability to predict and react rapidly to changing circumstances help to:

- improve the operational performance and reduce the costs of running services through increased efficiency in the use of fleet vehicles;
- provide a regular and dependable service for passengers;
- minimise the waiting time and trip time for bus/tram journeys;
- provide an accurate and reliable real-time information service to passengers (e.g. about delays or service interruptions);
- improve the perception of public transport in the eyes of the travelling public.

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Description

The key requirements of a AVM fleet management system are the ability to locate a vehicle throughout its journey and to transmit this information to the Control Centre in order to make it available to the operator. Most fleet management system use the vehicle location information as a basis to provide several functions.

The main components of the AVM system are:

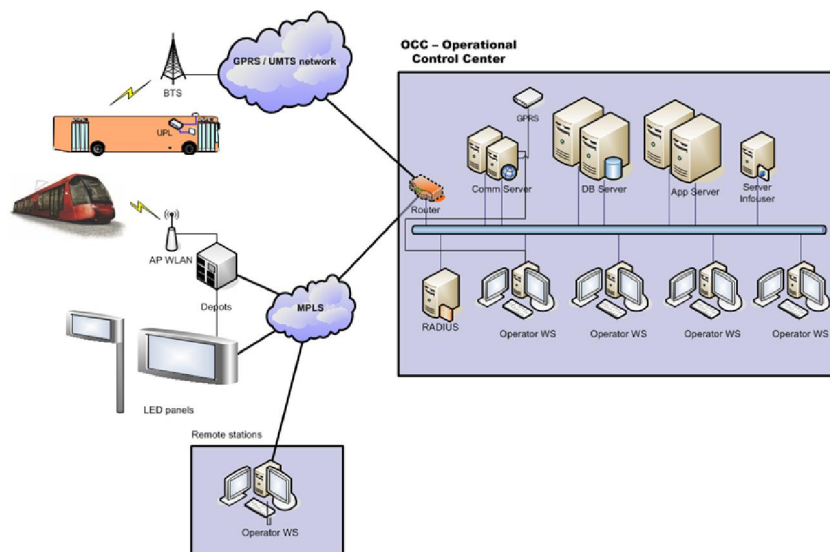
- AVL - Real time monitoring module: it includes all the functionalities that have a real-time impact on the management of the fleet and the information feed toward the passengers, this requires an easy-to-read graphical representation of the real time status of services for the public transport operator, a system for the automatic and manual regularisation of services, and interactive communications with drivers (via data and voice); The communication with drivers may be managed automatically (e.g. via pre-coded messages) or involve direct intervention by the operator (e.g. via voice contact).

- RTPI - Real Time Passenger Information: location data is fundamental for making available the forecast arrival times at stops, for responding to requests for information from travellers (e.g. via Internet services, Call Centres, Apps for smart phones, etc), and providing information on-board or on the ground (e.g. display and voice announcement on board, display at bus stops);
- Service planning module, used for entering the schedule data, the fleet service need to be planned in advance, and operational records can also be used as a basis for future planning of services and planning the regular maintenance of vehicles.

Another modules can be made available within AVM, such as the reporting and certification module that covers the service certification and performance statistics creation. The data regarding the status of the fleet is generally stored as part of a record of operations and may also be analysed in order to automatically compile reports on operational performance. The comparison of the planned service against the runs actually made (contract compliance verification) provides important information not only for the service operator but also the transport agency letting the service contract, as it serves as a certification of the level of service provided.

A typical AVM system is based on:

- On-board systems, to be installed on the buses, including on-board computer with GPS, GPRS, Wi-fi, a Driver Terminal, TVCC, passenger counters, displays, Audio announcements, connection with other units such as Ticketing machines); in simpler implementation is connected directly to Ticketing machines.
- Depot systems, with WiFi Access Points
- AVM Control centre (hardware and software hosted in the Operations Control Centre - OCC)
- Information displays at bus stops and terminals
- Infomobility system for the distribution of information on arrival times



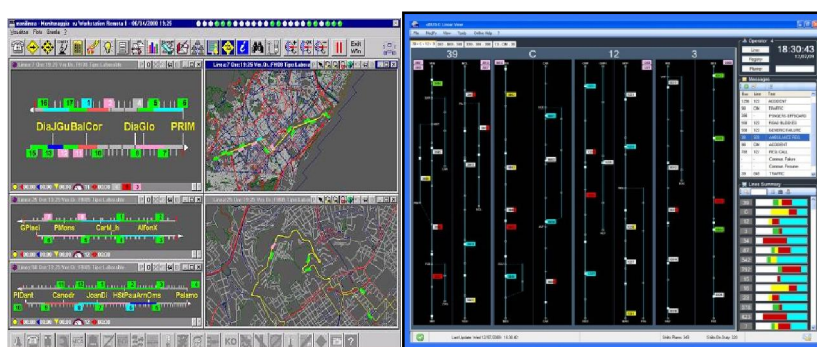
The AVM system is connected to other systems, such as external RTPI, for passenger information, AFC for ticketing purpose, Parking systems, for integrated transport and Park and Ride systems, UTMIC for bus priority.

In more advanced systems, with integration with CANBUS interface available in the buses/tram, the following data may also be included:

- Fuel consumption and trip/totals;
- Engine performance, e.g. temperatures.
- Driving style and speed/revs/idling/braking.

Knowledge of these last parameters makes it possible to calculate both the economic performance and the environmental impact of running the public transport service. They also provide a basis for providing recommendations on optimised driving behaviour (eco-driving characteristics).

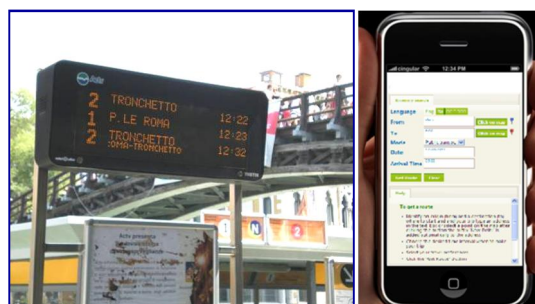
Here is an example on how information can be displayed by the operator.



Here is an example of on board unit, display and passenger counter installed on board.



This is an example bus stop display and information to passengers on mobile phones



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Relevance for Large Scale Events

The ability to transport large numbers of people by public transport during events helps to relieve pressure on the road network by reducing the number of private vehicles. While special categories of users, such as event competitors, technical staff and VIPs are likely to be transported in special vehicles other travellers will need to rely on the regular bus and tram services. Use of BRT lines (bus rapid transit) are in addition suggested to improve the public transport service during large scale events.

One of the main benefits for a transport agency of having an Automated Vehicle Management (AVM) system to support the management of bus or tram fleets during a large event, is that it permits constant monitoring of vehicles and therefore makes it easier to intervene when there are unexpected problems. Especially when integrated with travel information services, it can help to provide passengers with constantly updated indications of services and routes available. It is also highly beneficial when linked with the Events Organisation, so that advance warning of heavy demand, e.g. at the start or end of an event attended by large number of people, can be taken into account in service planning.

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Options

The basic configuration of AVM system is based on AVL (to be integrated with existing RTPI and service planning). In a wider configuration, is provided with a combination of RTPI and Service Planning.

Considering the users, several combination can be available:

1. AVM for a single transport service operator

The most typical form of AVM consists of a system designed to support a single operator, e.g. the public transport company responsible for bus and tram services in an urban area. The system will in general be set up in the operator's Control Centre and adapted to the specific needs.

2. AVM for multiple service operators

This type of system is required when a fleet management system is required for more than one operator. This situation is typical for interurban areas. In order to be able to manage several fleets at the same time, it is necessary for the AVM to be modular and distributed, since it will need to be able to interface with different kinds of onboard equipment and different communication systems.

3. Remotely managed AVM systems

AVM can also be managed at a distance by means of a web-based service. This solution is useful especially for small transport operators who do not have the necessary resources or qualified personnel to run a fully equipped Control Centre. In this case, the data and analyses are made available online on pages which have protected access and provided as a service (visible only to authorised users).

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Technologies

The following are the most common technologies used to permit automatic vehicle management (AVM):

- Detector loops: these are devices set in the road surface which interact with transponders (tags) on vehicles passing over it. The loops register information from the transponder and pass this to a local processing unit on the roadside or the Control Centre.
- Roadside beacon: this has a similar function to the detector loops but is mounted on the roadside;
- Global Positioning System (GPS): This uses a passive device (such as a radio receiver) installed on the vehicle. It can read signals from up to 12 satellites (but needs a minimum of 3) which are used to calculate a vehicle's surface position to within 10 to 20 meters (or 1 to 5 meters if differential GPS is used).
- Gyro with dead reckoning function, used when GPS is temporarily not available, like in galleries or due to other reasons, and used to maintain and correct the bus position,
- Data transmission to the central system: public wireless technology GSM/GPRS/UMTS or private networks (analogue/digital private network/TETRA/WLAN),
- Standards for data exchange with other systems, such as SIRI, Transmodel, Transxchange.
- CANBUS standards for bus data collection.

The first two technologies are dependent upon equipment installed on road and therefore require relocation or replacement if the network changes or the road is repaired. There has therefore been a move towards GPS technology.

The type of detection provided by GPS can be passive and active. The former notifies the Control Centre of the presence of a vehicle in a pre-specified location, whilst the latter provides constant information about vehicle location. To improve the position is used a Gyro with dead reckoning function.

The data transmission systems utilized are dependent on the type of vehicle location technology used. If the system is transponder based, a short wireless communication is required between the vehicle and the detector, then generally a wire-based communication to the Control Centre. GPS systems communicate to the depot and other offices using a wireless system such as General Pack Radio Systems (GPRS) or Private Mobile Systems (PMS), such as a VHF network, a digital network, such as TETRA, or a WLAN (when buses arrive to depots). The typical flow of data from the vehicle to the Centre includes the following:

- Vehicle and driver identification;
- Vehicle location at calibrated intervals or upon request;
- Vehicle location when entering a pre-specified area (virtual fence placed around a destination, e.g. to inform a depot of a vehicle's imminent arrival);
- Vehicle location when the panic alarm is triggered;
- Alarm message;
- Timed trip data: start, stops, average speed, distance;
- Driving hours.

For communication between the operators in the Control Centre and drivers, data exchange can take place between the central operator and the drivers (through a screen and dedicated user interface), and/or separate radio or cell phone systems can be put in place (in UK there is in addition a service provided by

some wireless operators named push to talk service, that behave like a private radio network, with single / conference calls, but using the GPRS connection).

SIRI, Transmodel, Transxchange are some of main standards used for AVM systems.

Transmodel provides a comprehensive conceptual model for public transport information systems including passenger information systems, with coverage of a number of different subdomains of PT information, including transport network infrastructure and topology, public transport schedules, journey planning, fares, fare validation, real-time passenger information and operational aspects of public transport.

The Service Interface for Real Time Information (SIRI) specifies a European interface standard for exchanging information about the planned, current or projected performance of real-time public transport operations between different computer systems. SIRI comprises a carefully modularised set of discrete functional services for operating public transport information systems. SIRI aims to incorporate of the best of various national and proprietary standards from across Europe and delivers these using a modern XML schema and TransModel terminology and modelling concepts. All SIRI services are provided over a standardised Communications layer, based on a Web Services Architecture.

TransXChange is a UK national XML based data standard for the interchange of bus route and timetable information between bus operators, the Vehicle and Operator Services Agency, local authorities and passenger transport executives, and others involved in the provision of passenger information. The format is a UK national de facto standard sponsored by the UK Department of Transport. The standard is part of a family of coherent transport related XML standards that follow UK GovTalk guidelines and are based on the CENTransmodel conceptual model. Although TransXChange is currently used mainly to exchange bus timetables, it may also be used for schedules for rail and other modes.

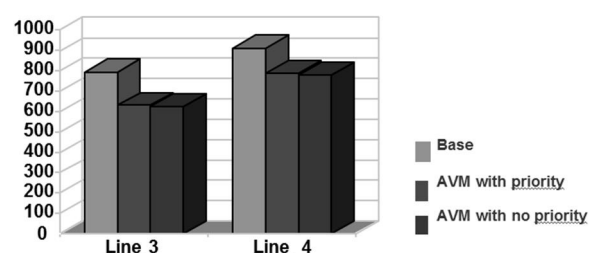
CAN bus (for controller area network) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer, and data are exchanges according FMS standard interface. The six European manufacturers Daimler AG, MAN AG, Scania, Volvo (incl. Renault), DAF Trucks and IVECO have developed the so called FMS-Standard in 2002 to make manufacturer independent applications for telematics possible. Several data are broadcast at the FMS interface, such as Vehicle speed (wheel based), Vehicle speed (from tachograph), Clutch switch (on/off), Brake switch (on/off), Cruise control (on/off), etc.

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Impacts

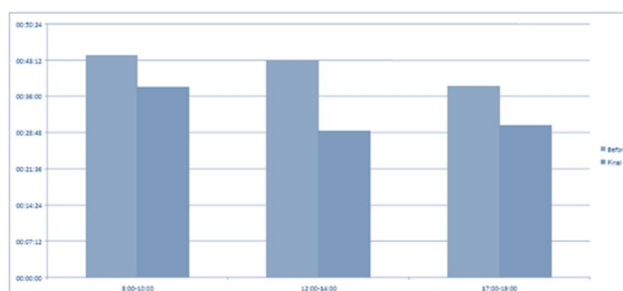
Reduced trip time:

Measurements made in the Quartet Plus project in Torino Italy (1997) provided evidence that an AVM system (FLASH) integrated with Urban Traffic Control (the UTOPIA system) can produce a reduction in bus/tram travel times and also in travel times for general traffic of between 17% and 20%. This advantage is evident even when traffic signal priority is



given to public transport vehicles (see the graph below).

Similar results were produced in a more recent deployment of the AVM system in Bucharest, Romania. The following measurements were made by the Polytechnia of Bucharest (2010).



| | Average time [min] | | Gain [%] |
|-------------|--------------------|---------|----------|
| | Before | Final | |
| 8:00-10:00 | 0:44:11 | 0:37:49 | 14.40% |
| 12:00-14:00 | 0:43:11 | 0:29:03 | 32.74% |
| 17:00-19:00 | 0:38:01 | 0:30:16 | 20.41% |

It can be seen from the table that the gains in trip time depend on the time of day. However, even in the evening traffic peak, travel times by public transport were reduced by over 20%.

Increased fleet efficiency

The decrease in travel time made it possible to operate the same service with fewer vehicles (the number of trams required to run line 3 could be reduced by one). It was calculated that, taking into account the resulting benefits to the company, the payback time for the purchase of the AVM was less than three years (922 days). This was reduced to 131 days when the social benefits (improved service) were included.

In the same project, a survey involving a panel of 1000 travellers, showed that an integrated system (with AVM, traffic signal priority of buses and real time information service) produced a 3% change in modal split towards public transport (from 30% to 33%).

Here is a table with a summary of main impact on use of AVM.

| CRITERION | IMPACT | MEASURED IMPACTS* |
|--------------------|--------|--|
| TRAFFIC EFFICIENCY | ** | <ul style="list-style-type: none"> Average travel time decrease for private traffic estimated to be 14-17% (AVM integrated with UTC with bus priority). Queue reduction approx. |
| PT EFFICIENCY | **** | <ul style="list-style-type: none"> Reduction in PT trip time estimated to be 14-20% (Quartet Plus in Torino, Italy 1997, Univ. of Bucharest, 2009). Increase in efficiency in fleet use (fewer vehicles needed). |
| MODAL SHIFT | ** | <ul style="list-style-type: none"> Shift to PT resulting from reduced trip times, approx 3% measured, Torino. |
| AIR POLLUTION | ** | <ul style="list-style-type: none"> Reduction when AVM combined with traffic signal priority (estimated to be 10% CO2 decrease, Quartet Plus, Torino) |

Other studies (reference www.thetis.it) suggest the following:

Benefits for bus operator:

- the **paybackperiod** of a AVM system implementation can be from 2 to 3 years;

- b) 20% improvement **on-time performance**;
- c) **less fleet for the same performance**: we could have a relevant unatantum benefit by the reduction of some buses;
- d) **cost saving**: we could reduce the number of personnel, operations, consumption;
- e) requalification of personnel.

Benefits for customers:

- a) service quality is much higher;
- b) better info to passengers and so less claims;
- c) public transport becomes more attractive to users.

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Integration potential

The potential of an AVM system is greatly enhanced when it is integrated with other ITS applications. An indication of the type of systems with which an AVM can be usefully connected is given below.

The main advantages of integration of AVM with other ITS services are summarised below:

- Integration of AVM with **Urban Traffic Control (UTC)** systems makes it possible to implement a strategy in which priority (absolute or selective) is given to public transport vehicles. In order to achieve this, a special software application takes into account the information on traffic light phases (from the traffic signal controller) and the location of approaching vehicles, and carries out a 'negotiation' process which decides whether and how to modify the traffic light phases to allow the priority vehicle to go through the intersection on a green light. Different variations are possible. For example absolute priority can be given to certain types of vehicle (which always have a green light), or selective priority (only for vehicles which are behind schedule). A series of studies carried out in Norway in the 1990s by SINTEF company measured the effects of the bus priority system on travel time. The results are shown below. They indicate that such systems produce advantages not only for public transport but for the travel times for private traffic.

| City | Comparison of different signalling schemes with original signalling | Changes in travel time | | Change in waiting time for pedestrians | Survey year |
|----------------------|---|------------------------|-----------------|--|-------------|
| | | Public transport | Private traffic | | |
| Oslo, Grünerløkka | SPOT/UTOPIA with priority of public transport | -15 % | -15 % | -30 % | 1998 |
| Bergen, Christies gt | SPOT/UTOPIA without priority of public transport | - | -5 % | -10 % | 1998 |
| Trondheim lla | SPOT/UTOPIA with priority of public transport | -10 % | -10 % | - | 1999 |

- Integration with **Ticketing and fare systems** has the advantage of making it possible to discover not only the public transport services available but also the cost of fares before making a journey. When this is offered as an online service, and to purchase the tickets in advance.
- Integration with **Parking management and booking systems** facilitates the planning of trips in urban areas (e.g. to city centres) in which parking is difficult or which operate access restrictions. It

permits a traveller to organise in advance a parking space and continuation of the journey by public transport (i.e. Park and Ride systems).

- Integration with other external RTPI – **real time passenger information services**: when an AVL system is integrated with passenger information services, this makes it possible to provide real-time updates and hence greatly enhances the quality of the information. In the case of multimodal trip planning services, it enables public transport to be included as a travel option.

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Implementation

The implementation of an AVM system requires a detailed assessment of the public transport requirements of the area in which it is to be deployed. It will be necessary to define the architecture of the system, including the location and functions to be carried out by the peripheral systems and the Control Centre as well as the technical staff required to operator it.

In order to set up the system itself, it is necessary to provide the coordinates of all bus stops and details of the timetables of all lines.

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Examples

Edinburgh, 'Greenways' (Bus Priority Measures)

As part of a wider package of measures to reduce traffic congestion and improve local bus services, 'Greenways' were introduced on key routes throughout Edinburgh

Background and objectives

The problem of traffic congestion in Edinburgh has been acutely felt in the 1980's and 1990's, causing unacceptably high pedestrian accident rates, unpleasant conditions for pedestrians and cyclists, noise and pollution, pressure on parking space, higher business costs and a slower journey into work for many commuters. However, during the period 1986 to 1994 private car ownership in central Edinburgh soared by 37% against an average rise in the UK of only 19%. Increasing dependence on private cars has led to more congestion for public transport in a vicious circle which grinds down the public transport level of service for those without a car.

The "Greenways" scheme, along with other public transport initiatives, was introduced with the aim of restoring the balance of car use and public transport. The "Greenways" primary aim is to improve the reliability and speed of bus services. It aims to cut bus journey times by at least 10% and thus to encourage more people to abandon the car in favour of the speedier and more reliable bus services. At the same time, it will be helping to achieve the Council's objectives of reducing pollution, as buses are many times 'cleaner' per passenger. "Greenways" is an integral part of the Council's "moving FORWARD" strategy which aims both to develop an efficient public transport system and also to create a "Safer, Cleaner and Better" environment in which the city's inhabitants and businesses can prosper.

Implementation

"Greenways" are controlled under the City of Edinburgh Council Greenways Order 1997. The order was finally approved by the Scottish Office, with certain modifications, in February 1997. Only then could the physical implementation work commence. The target date for Phase I (the first two routes) to become fully operational under the Greenways Order was 04/08/97. For the Greenways scheme to work, rules regarding access, parking, loading and stopping on the Greenway route have to be enforced and Lothian and Borders Police have been responsible for this.

Key elements of the scheme, include:

- Greenways bus lanes were painted green and made highly visible
- Large explanatory road signs have been placed at the start of the routes; which are marked by continuous double or single "no stopping" red lines at the edge of the route
- New parking and loading bays, with new regulations, have been established
- More cycle lanes have been provided; with advanced start positions to give priority for cyclists at traffic lights
- More bus shelters and bus stop information provision is an integral part of the upgrading of passenger facilities
- On the issue of road safety, more pedestrian crossings and raised level crossings have been installed; together with traffic calming measures in the side streets.
- An electronic detection system has been installed in the road surface at 25 traffic signals on the routes giving buses, fitted with transponders, priority at traffic lights, further improving journey times
- Cameras will also be fitted to buses, to catch offending motorists and assist the manual enforcement by the police.

Phase I(a) of the scheme (A8/Glasgow Road and Leith Walk) consists of 13 km of Greenways bus lanes which have been provided at a cost of £4.5m. Completion of Phase I(b) will give an additional 13 km of bus priority lanes at a further cost of £3m. The whole scheme will give 26 km of Greenways bus lanes at a total cost of £7.5m. The principal Greenways bus operators, Lothian Region Transport and First Bus, have invested heavily in the latest, low emission buses (£8m by LRT alone) which are operating on the Greenways routes. A Quality Partnership agreement has been signed between the main bus operators and the Council; with both sides pledging assistance in providing the highest standards of public transport.

The "Greenways" scheme is one of three major developments now going ahead to improve Edinburgh's urban environment and public transport efficiency. It has been effective since 4 August (1997) on two of Edinburgh's main routes into the city centre, the A8/Glasgow Road corridor and Leith Walk. This is Phase I(a) of the project. Three more "Greenways" routes are to follow in the autumn of 1998: the A70/Slateford Road; A71/Gorgie Road and A702/Lothian Road corridors. This will complete Phase I(b) of the project. Further schemes covering the remaining radial routes will follow in due course.

Results so far

- Buses are encountering fewer delays whilst using the extensive bus lanes which are no longer blocked by illegal and dangerous parking

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- Buses are encountering fewer delays at junctions because of the devices on the buses changing the traffic lights and the construction of 'Bus Boarders' has assisted them in remaining within the main traffic flow; without the need to pull in and out of bus lay-bys.
 - The eradication of delays should result in shorter journey times and a more reliable service. Improved facilities at bus stops, including new shelters and planned passenger information panels, is assisting both current and potential passengers.

Conclusions and lessons learned

- The chief obstacle in the planning stage of the project was the length of time it took for the Greenways Order to be approved by the previous Secretary of State for Scotland.
- During implementation, there has been some conflict with local residents and businesses; with regard to the parking and loading restrictions; although designated bays have been provided.
- Operational problems have included speeding buses and taxis but these have now been identified on camera and dealt with by the Police.
- There has also been conflict between buses and cyclists in the designated lanes; with some intimidation of cyclists by bus drivers.
- Some bus passengers have been complaining of long stationary periods for buses because the actual bus journey times have been reduced but the schedules have not been amended. This indicates an urgent need for re-scheduling and re-timetabling by the bus companies.
- Finally, there was a dispute with the traffic wardens over remuneration and the enforcement of Greenways but this has now been resolved and they are to take over from the Police. However, continued effective enforcement is still the key to the success of the scheme.
- The Greenways scheme would be suitable for any city wishing to upgrade a largely bus-based public transport system with the aim of encouraging modal shift from car to bus by alleviating congestion and increasing bus service efficiency
- Continued effective enforcement is the key to the success of the scheme.

Greenways is an example of a public transport service improvement; in combination with improved conditions for pedestrians and cyclists; at a comparatively low cost. The disadvantage is that it only covers a comparatively small number of routes, although there is scope for expansion and it is flexible, and it has to be utilised in conjunction with other public transport schemes such as the planned CERT Busway and Park and Ride schemes.

The AVM system in Paris

The AVM system in Paris is managed by RATP group, the world's fifth largest public transport company operating all modes of collective mobility, with about 3 billion journeys a year in Île-de-France based on:

- 14 metro lines
- 2 RER (regional express train)
- 3 tram lines

- more than 350 bus lines
- an automatic shuttle service connecting the Paris Orly airport to the capital

This public network is one of the densest in the world, serving 11 million residents in 12000 square kilometre area

The bus network is based on:

- 4300 buses and 13000 drivers,
- nearly 12000 physical bus stops
- 351 bus lines, including 31 Noctilien (night bus lines)
- Nearly 1.1 billion journeys each year (15% more than 10 years ago)
- 31 main bus depots and 2 alternate bus depots in Paris and the surrounding region
- 200 towns and villages and more than 2000 stops (RATP and SNCF) served by the Noctilien (night bus) network.

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