

# ITS RADAR Intelligence Report

## Developments in Automatic Enforcement Technologies

**Relevant Topics:** *Traffic Management Technology, Pilots, Driver, Technology Solutions, Enforcement, Standards & Policy.*

**Background:** This Intelligence Report has been produced as part of the ITS RADAR project. The aim of the project is to summarise key information for Highways Agency decision makers and practitioners alike regarding innovative pilot projects worldwide and emerging ITS technologies.

This particular report concerns developments in Automatic Enforcement Technologies.

**Summary:** This report describes current applications of technologies and systems for automatic enforcement of traffic violations. It highlights where new technologies might become more prevalent in the future. The objective is to provide intelligence to the Highways Agency and some background information to assist in the selection of appropriate enforcement concepts and methods to suit the needs of Highways Agency practitioners. There is a continuing evolution of technology types and the way technologies are applied. This reflects both advances in Research and Development and in the range of violations which now need to be enforced.

**Technologies Used:** Basic technologies that have been most frequently used for detecting violations are:

- Radar
- Laser
- Inductive loops
- Pneumatic tubes
- Piezoelectric cables
- Infrared and other optical sensors
- Camera / Video image processing
- Electronic detection based on in-car electronic tags

New and emerging technologies used for enforcement purposes include Fibre-optic cables and ultrasonic sound emitters / detectors.

Applications of these technologies are provided below.

## Context

In the context of this report, an automatic enforcement system is a technical device, triggered automatically by a traffic violation, so that information about the violating vehicle is recorded. The recording of the information makes possible the subsequent identification of the vehicle, for possible sanctioning of the driver / vehicle owner.

The violations that are enforced by some form of automatic system include:

- Speeding
- Red light running
- Inappropriate driving behaviour
- Toll payment violations

- Illegal use of a dedicated vehicle lane / road space
- Vehicle weight restrictions

The technologies deployed can be used for two distinct purposes, detecting violations and identifying the vehicle. The third step in the process, which is not addressed by the Report, is identification of the vehicle driver / owner.

## Technology Types

The following table summarises major application areas for mainstream technologies used for automatic enforcement.

	Speeding	Red Light Running	Short Headways	Toll Payment Violations	Lane Occupancy	Excessive Vehicle Weight
Radar	✓					
Inductive Loops	✓	✓		✓	✓	
Pneumatic Tubes	✓					
Piezoelectric Cables	✓	✓	✓	✓	✓	✓
Infrared Detectors	✓		✓			
Image Processing	✓	✓	✓	✓	✓	
Laser	✓		✓			
Electronic (tag) Detection				✓		

Some technologies, such as image processing and inductive loops, are used for detecting a range of different violations. Others, such as electronic (tag) detection or ANPR, are particularly tailored to detecting a specific kind of violation. However, this technology type in particular can also be used for identifying the vehicle. Other technologies used for vehicle identification include wet film and digital cameras.

## History of Automatic Enforcement

One of the earliest examples of automatic enforcement was a photo-radar system installed on the A3 between Cologne and Frankfurt, Germany in 1973. A radar device was mounted over each of 3 lanes on the Autobahn. If vehicles were detected as exceeding the speed limit a picture was taken (from the rear), showing the site, date time and licence plate of the vehicle. In darkness a flash light was used. The film was changed at least once a day by the police. The Police inspected the pictures and speeding tickets were then mailed to the vehicle owners.<sup>i</sup>

Although most subsequent applications of automatic speed enforcement have employed basically the same principle, there have been certain variations, such as use of mobile units and the use of other devices than radar (induction loops, optical sensors etc) for measuring the speed. More recently, speeds have been computed over distances, as the basis for speed limit enforcement, rather than being measured at a spot. This relies on the matching of registrations (using Automatic Number Plate Recognition technology) to determine the time taken by individual vehicles to travel a known distance.

Automatic enforcement has also now extended to other types of violations than speeding, with, for example, red light enforcement trials beginning in the Nottingham in 1987 and bus-mounted cameras for bus-lane violation enforcement being introduced in London around 1995.

New detector technology has also opened up the possibility of detecting an increasing range of violations. Piezo-electric cable detectors, for example, newly developed in the early 1990s for high speed weighing of vehicles and used as a screening mechanism, with vehicles suspected of breaching weight limit regulations being escorted to a slow speed or static weigh scale are now being used for identifying vehicle speeds, tailgating vehicles, lane occupancy etc.

The digital revolution, which began in earnest around the same time, has also opened up the possibility of the whole process from detecting the violation to fining the violator being undertaken automatically (and in near real time). Digital cameras have also significantly reduced the operational costs of systems, when compared with wet film camera technology, leading to more wide spread deployment and, largely as a result of this, more effective overall enforcement of traffic laws.

## Recent Trends

One of the major recent trends has been a move away from in-pavement detectors, such as inductive loops, to using predominantly above ground detection and combining several technologies within a 'combination detector'. Triple-technology detectors, for example, use three different sensing techniques within a single gantry- mounted unit to gather data, which, if desired could be used to identify a range of different violations:

- Microwave Doppler Radar is incorporated to provide accurate information on the speed of each vehicle;
- Ultrasonic sound bursts, reflected from the surface of the vehicle, are used to calculate the vehicle profile / classification; and
- Passive Infrared provides the width of a vehicle and position with respect to a monitored lane

Similarly, radar combined with the recently developed high frequency scanning laser (with the laser beam focussed vertically down the road and scanning across lanes) is now capable of computing speeds, following distances and vehicle profiles. When combined with image processing they can be used to enforce a wide range of violations.

Just as technologies advance, so do the areas requiring enforcement, reflecting changes in policy and the way roads authorities manage the road network and control its use.

Examples of new areas for enforcement within the UK at least those of road user charging, now operating in parts of London (with enforcement predominantly based on Automatic Number Plate Recognition (ANPR), an application of image processing technology) and enforcement of High Occupancy Vehicles (HOV) Lanes, such as Bus Only lanes, where, over relatively short stretches within urban areas, enforcement is also predominantly based on ANPR.

Whilst road user charging and HOV lanes are currently little used within the UK, a roll-out of these network management tools will most likely be matched by the development of new technology applications for automatic enforcement, which can be deployed on a more cost-effective basis than those used as part of a small scale 'trial'.

## Recent Developments in Detector Technology

The studies which are summarised in the following sections of the Report highlight some recent developments in detector technology. These might possibly provide the basis for cost-effective automatic enforcement of wide area deployment of new approaches to network management. In contrast, they may also be able to add value to existing approaches and aid the development of be-spoke solutions to managing high risk parts of the network, such as congested intersections.

## Vehicle Occupancy Detection - Possible Application Area HOV Lane Enforcement

### Canadian Ministry of Transport Study on Automated High Occupancy Detection

A study was carried out by McCormick Rankin Corporation in 2004 for the Ministry of Transport in Ontario, Canada. This study reviewed the state of the art in Automated High Occupancy Detection.<sup>(1)</sup> This report documents the study and includes commentary on the technologies available and views of stakeholders such as Highway Authorities, States, Enforcement Agencies and Vehicle Manufacturers.

The report considers trials of automated systems that have already taken place and concludes that detection systems external to the vehicle do not currently provide a feasible method for enforcement. The report does however suggest that the trial currently taking place in Leeds may produce a feasible method of enforcement in the future. The Leeds trial is discussed later.

The Canadian report then goes on to consider in-vehicle detection and enforcement options in detail, considering a wide range of technologies available and the issues with each type of technology. The technologies considered are:

- Mechanical systems;
- Photography / video;
- LED imaging;
- Thermal / infrared imaging;
- Weight sensors;
- Ultrasonic / Radar;
- Capacitive Sensor;
- Heartbeat / Breathing monitors;
- Fingerprint and Biometric information; and
- Smart cards and readers.

The report also considers how the costs of in-vehicle occupancy detection could be reduced by introducing such a system as part of systems already under development, such as security / safety systems. The report then presents a business case on the likely costs and benefits of using in-vehicle monitoring units.

### Leeds Trial (HOVMON)

The Leeds trial (HOVMON project) is funded by DfT/EPSC and involves Golden River Traffic Ltd, Laser Optical Engineering Ltd, Leeds City Council, Photonics Consultancy, and the University of Sussex. Photonics Consultancy reports<sup>(2)</sup> that the system uses both an infra-red camera and a visible light camera, as using only an infra-red camera would require expensive laser diodes to allow the system to function in low natural light. However, Photonics expect that the cost of laser diodes will fall over time and then remove the need for the second camera.

The trial system works because infrared light with a wavelength of approximately 1.5 microns can pass through the heat resistant layers on car windscreens and at this wavelength, human skin is very absorbing of this type of infrared, although hair and clothing reflect the light quite strongly. This means that human faces appear black whilst surroundings appear grey and white in images from this camera.

The infrared camera being trialled on the A647 in Leeds is perceived as a possible means of enforcing the High Occupancy Vehicle lane. This camera, developed by Laser Optical Engineering uses a combination of infrared and visible images, which are digitally processed to distinguish between skin and background.

The camera technical specification describes the trials conducted so far and claims that occupants can be detected in the rain at 50mph and the latest windscreens with infrared filters do not cause any significant drop in contrast. However, the technical specification does indicate that the camera requires sufficient lighting to function and may require street lighting. The company Vehicle Occupancy Limited which markets this product has produced guidelines on installation issues.

## **Fibre Optic Detection - Possible Application Areas Include Speed, Headway, Vehicle Weight and Lane Enforcement**

### **Fibre Optic Detection – Lateral and Longitudinal**

Fibre optics are one of the detection technologies currently being investigated to replace induction loops to improve the MIDAS system and allow the installation of this system on sections of the network where loops cannot be installed. The two types being considered are:

- Lateral fibre optic detection (FOND) – providing coverage at intervals along the length of the carriageway and being investigated to demonstrate ability to measure headway, axle count, etc.
- Longitudinal fibre optic detection (FOLD) – providing continuous coverage along the length of the carriageway.

The primary benefits of fibre optic detection are the potential for higher reliability and a lower requirement on the amount of kerb-side equipment over that required by inductive loops.

HA research conducted by QinetiQ started in 2002 specifically for the Highways Agency.

### **Fibre-Optic Traffic Sensors for Axle Detection – Road Traffic Technology**

Sensor Line GmbH has developed fibre optic load sensors for use in road, railroad and airport traffic situations. The technology developed enables axle detection for any vehicle type at any speed, and is not dependant on a specific installation layout as they can be placed in slots, frames or on the road surface. The use of fibre optic detection also allows the length of time a vehicle is stationary to be determined as signal strength does not diminish over time.

Sensor Line's fibre optic systems do not use the same type of multiplexing that has been researched as part of the FOND project meaning there will be similar number of road side cabinets to a conventional induction loop system.

### **Fibre-Optic Implementation of a Cumulative Momentum Model for Natural Urban Intersection Traffic Management**

A system has been proposed by academics in North Carolina that is claimed will provide an agile and cost-effective urban intersection traffic management model based on the use of an in-ground fibre optic load sensor system. The system is aimed at addressing problems associated with congestion, bus and truck signal priority and the prevention of drivers running red lights by using a process that determines the competitive cumulative momentum of vehicles.

The use of in-ground fibre optic detectors is to establish various factors such as vehicle size and speed of traffic flows approaching crossroads or intersections. This information is then fed to a central computing unit which runs an algorithm to determine cumulative momentum of traffic before assigning it a value, referred to as a 'Green Score'. The 'Green Score' for each opposing traffic set are then compared, with the highest score commanding a green light for that particular traffic flow. As the cumulative momentum in the traffic flow falls as a result of the green light, the 'Green Score' also falls. Once the 'Green Score' has fallen below the value for the opposite traffic flow the lights change to reflect this. The system constantly monitors the situation on the road and keeps similar vehicle composition and numbers on opposing sides of the road through using the competitive process.

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## Concluding Remarks

This report has described current applications of technologies and systems for automatic enforcement of traffic violations and highlighted where new technologies might become more prevalent in the future. The objective has been to provide intelligence to the Highways Agency and some background information to assist in the selection of appropriate enforcement concepts and methods to suit the needs of Highways Agency practitioners. There is a continuing evolution of technology types and the way technologies are applied. This reflects both advances in Research and Development and in the range of violations which now need to be enforced.

As further evidence emerges on developments in automatic enforcement technologies this will be highlighted within future ITS RADAR 'Newswires'. To seek registration for the Newswire service please go to the ITS RADAR website [www.itsradar.co.uk](http://www.itsradar.co.uk) where you can apply online.

## References:

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**The "Escape" Project - Working paper 7 Automatic enforcement technologies and systems**  
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<http://www.laseroptical.co.uk/specialprojects-hovmon.html>

**"Automated HOV Enforcement? Don't hold your breath"**

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**Fibre Optic Traffic Sensors for Axle Detection – Road Traffic Technology, [http://www.roadtraffic-technology.com/contractors/detection/sensor\\_line/](http://www.roadtraffic-technology.com/contractors/detection/sensor_line/)**

**Fibre Optic Implementation of a Cumulative Momentum Model for Natural Urban Intersection Traffic Management – Chung Yu & Sheldon Muir, ECE Department & Urban Transit Institute, North Carolina A & T State University, Greensboro <http://www.ctre.iastate.edu/pubs/midcon2003/YuFiber.pdf>**

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