Monograph:
Sherborne, D.J. (1992) Existing Techniques for Detecting Vulnerable Road Users. VRU-TOO Deliverable 4. Working Paper. Institute of Transport Studies, University of Leeds , Leeds, UK.

Working Paper 383

VRU-TOO

Vulnerable Road User Traffic Observation and Optimization

DRIVE II Project V2005
Deliverable 4
Workpackage PP1

Existing Techniques for Detecting Vulnerable Road Users

D.J. Sherborne

West Yorkshire Highways Engineering and Technical Services

Deliverable type:	P
Contract date:	June 1992
Submission date:	December 1992
ITS Working Paper:	383

Commission of the European Communities — R&D programme
Telematics Systems in the Area of Transport (DRIVE II)

The research reported herein was conducted under the European Community DRIVE II Programme. The project is being carried out by a consortium comprising: Institute for Transport Studies, University of Leeds; West Yorkshire Highways Engineering and Technical Services; Traffic Research Centre, University of Groningen; Department of Traffic Planning and Engineering, Lund Institute of Technology; FCTUC, University of Coimbra; and FEUP-DEC, University of Oporto. The opinions, findings and conclusions expressed in this report are those of the author alone and do not necessarily reflect those of the EC or of any organization involved in the project.

West Yorkshire Highways Engineering and Technical Services
Selectapost 6
Dudley House
133 Albion Street
Leeds LS2 8JX
UK
Tel.: +44 532 476326, Fax: +44 532 476357

EXECUTIVE SUMMARY

One of the main aims of this project is to show that it is possible to use the information obtained my detecting pedestrian movements prior to them crossing the road in order to make the signal control system more responsive to their needs. In DRIVE I, field trials were carried out which proved that there were in existence a variety of detection devices that were suitable to be used in this situation. Within later stages of this projects field trials will be carried out in three different countries using pedestrian detection devices, but before the trials can be properly designed it is necessary to carry out a comprehensive survey of what systems are already in production, albeit not for the express purpose of detecting pedestrians in such a situation. This report therefore presents the results from such a survey of existing methods and the commercially available products that could be used in the pilot trials.

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1 OBJECTIVES OF THE WORKPACKAGE

In order to design pedestrian-friendly crossing facilities which use ATT to identify pedestrians at various points before and during the crossing of the highway, it is necessary to ensure that the technologies employed are the most appropriate. The project was aware that there were already on in commercial production a variety of methods for detecting pedestrians. It was therefore important as a preliminary stage within the project to identify both the technologies available and the companies who produce such equipment.

A literature review was carried out to identify the technologies that could be employed to detect pedestrians in an "on-road" situation. All the appropriate companies were contacted and analysis was carried out of the specifications provided on their equipment. Since at this stage it was determined that the commercial companies had already carried out extensive trials on their equipment, it was deemed to be inappropriate to repeat their work at this stage and so the formal evaluation under laboratory conditions that had originally been planned was not carried out.

It is the overall objective of this report that it can be used as the foundation upon which the decisions on which the type of pedestrian friendly crossing facilities can be chosen.

2 METHODS EMPLOYED

One of the principle aims of the overall project is to use the automatic detection of pedestrians approaching a crossing point to improve their safety and mobility, whilst minimising the detrimental effects upon other road users. Two projects within DRIVE I were directly relevant to this work and in many respects the work within V2005 will be seen as a direct extension of this work. It is therefore apparent that the results and experiences from V1031 (DRIVE Project V1031, 1992) and V1061, Pussycats (DRIVE Project V1061, 1992) will be used as the starting point for the DRIVE II work. The results from these studies have been examined as far as possible and contacts have been made with the personnel who worked on the projects.

In addition, contacts have been made with many industrial companies who are involved within the field of traffic signals and also within the field of detection, not necessarily on the highway. The technical specifications of the equipment were provided, together with other information relating to the reliability, accuracy, etc. In view of the provision of this equipment it was decided that it would not be necessary to request an external laboratory validation of the equipment, because since the equipment had been manufactured by the companies for use on a highway environment there was a requirement that the equipment was meeting the stipulated national standards. In the circumstances no additional information would be obtained by carrying out these rechecks.

As well as industrial organizations, university research centres have been carrying out work on VRU detection, and many contacts have been made with researchers in the field. The literature review identified several examples of detection devices being incorporated in signalised junctions. Relevant reports here include those of Billings and Walsh (1991) and Briquet (1990). The available techniques have been assessed and their adoption for "on the road" use has been evaluated.

The impetus behind the work of VRU-TOO in the Pilot Project area is to take advantages of new technology which is being developed in the field of detection and apply this to the real world situation in an on-street urban environment. Three separate locations will be chosen at which will be installed automatic detection of pedestrians to form an integral part of an intelligent pedestrian crossing facility. The three pilot trials are at urban junctions in different countries and in each case the members of the project want to be certain that the most appropriate type of detection system is chosen.

Although it is not specific, part of the brief for this workpackage is to assess the variation in conditions between the three pilot trial locations. These will be considered when the selection of the different types of detection devices available is being made.

The essence of the choice in the method for detection will be determined by the site details and what exactly is required. This report requires to give some of the options that might be required in certain situations so that the availability or otherwise of the equipment can be determined, it is necessary to be aware of some of the possibilities that can be included within a pedestrian friendly intelligent crossing. (In this context we are defining intelligent as meaning that the system has the

ability to respond to knowledge of pedestrian presence (or non-presence) or of the need for pedestrians to cross the road. This is excluding the need for the pedestrian to take a positive action such as pressing a button.)

The possibilities that exist, that are been considered include:

Identifying pedestrians approaching the crossing point
Identifying pedestrians who are waiting to cross the road
Obtaining a measure of how many pedestrians want to cross the road
Identifying the situation when pedestrians no longer wish to cross the road
Identifying the situation when all pedestrians have crossed the road

The extension for the crossing facility is that when these conditions have been identified then changes in the signal timings can be made.

The major part of the work carried out within this area has been to contact as many industrial companies throughout Europe to find what products are on the market which could be used to detect pedestrians *and* use the response from this signal to alter the appropriate signal timings. A summary of the most relevant responses are given in the subsequent stages, this is given in a standard presentation so that direct comparisons can be made. The specific items itemised include:

Brief description of technology
Range/Area for target
Reliability
Summary: Advantages/Disadvantages

Also included within the appendix of this deliverable is a selection of the information that has been collected from the industrial companies that seem appropriate.

3 RESULTS

3.1 INFORMATION FROM DRIVE I

3.1.1 Results from V1031

This project used microwave detectors attached to signal poles to identify pedestrians as they approached a signalised junction. The response from the detectors was then used to make alterations to the signal timings which, it was hoped, would improve the safety and mobility of pedestrians. Two trials were carried out, one in Sweden and one in England. The results from these trials showed that in the environments used microwave detection was a viable method to amend the signal timings to be more responsive to the needs of pedestrians.

However the work within this project did identify some restraints upon the situations where the type of microwave detectors used could be employed. It was this fact that lead to a further investigation of the different options.

3.1.2 Results from V1061 (Pussycats)

The pilot trials carried out in England consisted of installing a completely new type of crossing facility at two locations in England. A detailed description of the system has been made available, and one of the trial sites in England has been visited. The final report has not been available for detailed analysis but certain factors could be ascertained from an examination of one of the locations and discussions with members of the project. It is not part of this investigation to analyse the overall effects of the pedestrian crossing system in its entirety, but just to comment upon the pedestrian detection systems used within the project.

The system used two methods of detection, firstly a pressure mat on the pavement adjacent to the crossing point and secondly a infrared detector which would detect the presence of either vehicles or pedestrians actually on the crossing.

The basic concepts of these systems was that the pedestrian would still have to press a push button to request a pedestrian phase; the pressure mat would record the continued presence of the pedestrian and if there were no pedestrians standing on the mat then the pedestrian demand would be cancelled. The infrared detection device was focused upon the crossing width and was used to extend the red time to vehicles until all pedestrians had completed their crossing manoeuvre.

The ideas incorporated in this work have already been taken on board by the British Government and commencing in 1992/3 they will be installing new Puffin Crossings (Department of Transport, 1992).

3.2 REVIEW OF DETECTION EQUIPMENT

3.2.1 Overview

The objective of the design of the pedestrian friendly facilities to be installed in the later stages of this programme is to use the detection of pedestrians to automatically alter the timings of the signals. In this respect it is not relevant whether the signal is for junction control or at a mid-block crossing. Neither is it relevant as to what type of signal system is installed at the junction; however it is vital that at some stage on the design stage of the system the appropriate enquiries are made that the signal controllers will cope with the specified response. This is important for all three trials, but is perhaps more vital in the cases of Greece and Portugal where the systems of signal control might not be advanced enough at the present time to cope with an external response. The detailed design of the pedestrian crossing facilities for the three trials will be to a large extent dependant upon the actual locations selected. It is therefore important that the project members have criteria for them to select the type of detection system most appropriate. It is also important that the differences between the available options.

The three main types of detection that can be considered as being used within the proposed system are:

1. Microwave detection
2. Infrared Detection
3. Pressure mats

The remainder of this chapter deals with these three systems of detection. It describes the similarities and differences between the systems, gives examples of the available equipment and quotes examples of studies that have been carried out. In chapter 4 of this deliverable an assessment of the possible options is presented. This presents an overall impression of the way forward for the project and on what basis the decisions needs to be based for deciding the method of detection that may be most appropriate in specified situations.

3.2.2 Microwave detection

Microwave detection is the method of detection that was used in DRIVE I, to detect pedestrians as they were approaching a crossing facility. The full details of the system used are given in the deliverable for V1031 and are summarised in the Final Report, the main intrinsic advantages of using such a method of detection is that it provides a proven means of being able to detect an object moving towards a given location. This advantage was used to great effect in V1031 as it allowed for a quicker response to the pedestrian needs and also it meant that the traffic system new in advance that there would be a pedestrian demand. Hunt and Lyons (1992) did however have some reservations about the suitability of using such methods, but these were rather more do to with the perceived problems of siting such detectors rather than there effectiveness as detection devices. Dickinson and Wan (1990) have also shown that in situations where vehicle detection moving towards a specified location is required then microwave techniques can be very efficient.

A summary of the main features that are incorporated, possibly to different extents within the commercial products are:

PRINCIPALS

Microwave detection is based upon the Doppler Radar principle. The detector generates a beam of microwave energy at particular frequency. A moving target reflects some of this energy at a slightly different frequency. To enable the detector to differentiate between targets approaching or retreating from the detector, mixing of the reflected energy is carried out at two points within the receiver.

ADVANTAGES

Microwave detection is able to detect directional movement. Therefore it is possible to identify those pedestrians who are approaching the crossing. There is scope within the receiving system to "count" the number of targets approaching the detectors.

DISADVANTAGES

There is some difficulty in only identifying required targets. there targeting of the beams has to be accurate. This is especially true when the size of the target might be significantly less than other moving objects.

The main types of microwave detection devices that have been examined for possible use within the subsequent pilot trials are:

HB Modules

As was mentioned earlier these detectors were used in DRIVE I V1031, at the time they were taken as prot-type models that had been manufactured for use as vehicle detection and then adapted to accept pedestrians as suitable targets. These detectors proved very reliable in use and also proved very efficient in detecting pedestrians who were travelling in a specified direction and passed through the target area. Particular detection systems might have problems related to the slow speeds of pedestrians.

Detection Frequencies:	10.5 or 24G Hz
Range:	For detector at height of 3 metres, with specified tilt. The detection will identify objects at 10m from detectors
Reliability/ Durability:	Confirmed in DRIVE I trials

Microsense

This company also provides an above ground microwave system that was developed for use within traffic detection methods, but have now been modified as use for pedestrian detection. The specification for the detection devices are very similar to that for H B Modules and the major differences that users will notice are the variation of controls for amending the sensitivity of the detector and its cut off approach speeds.

Detection Frequencies:	10.5 or 24G Hz
Range:	Adjustable for between 8 and 25 metres
Reliability:	Microsense laboratory trials showed 97% detection rates. Use of similar equipment (with different speed thresholds are proven in many street situations)

As was identified by Hunt and Griffiths in their synopsis of work carried out within the field of pedestrian detection, one of the major problems involved with using microwave detection devices in pedestrian friendly intelligent facilities is the problem of being able to identify the "correct" pedestrians as they approach the point at which they wish to cross the highway, however this is more of a problem relating to the locations chosen for the pedestrian crossing and should not detract from the fact that the use of microwave detection can provide a most reliable method of detecting pedestrians in advance of them approaching the crossing.

The work of Head, Hext and Leathersich (1991) confirms that microwave detectors can be used in confidence, but does add the rider that care must be taken with their siting.

3.2.3 Infrared detection

The use of infrared detection is already well established within the field of both vehicle detection and also within the area of pedestrian detection in off the road situations. Examples of locations in which infrared detection is used to detect pedestrians include shops, banks and other entrances to other civic buildings.

The main factor involved in passive infrared detection is that it will detect the movement of an object within the specified area. There are limitations to the efficiency of this type of detection if an object remains still, but in the situation where a pedestrian is moving near the crossing point this is unlikely to be a problem. However this method of detection does not allow for the direction of the pedestrian to be discriminated and hence it is not possible to determine whether the pedestrian is moving towards the crossing point (in fact they may be moving away). In particular this was used in V1061 to record the presence of an object on the highway where the pedestrian was allowed to cross. This is a rather different usage of the detection process as essentially is objective was to identify the time when the roadway was clear of all road users.

PRINCIPALS
Two detection zones are illuminated by encoded streams of infrared light. Technical analysis determines the presence of an object, but it does depend upon its movement.

ADVANTAGES
The use of infrared detection is a well proven technique and is used in many other applications. It is also used commonly for pedestrian detection, though not so far in on-road situations.

DISADVANTAGES
The ability to determine the direction of pedestrians is not available, neither is it possible to count the number of targets.

Microsense

Microsense Systems Ltd manufacture a range of infrared detection equipment that could be used to identify a pedestrian who was within the target area. The voltages that are available are such that the can be adapted for use within any european country.

However it is not possible with the available equipment to distinguish the number of objects that are within the target area.

Detector Frequency:	7–14 micrometres
Range:	Variable 14–21 metres
Reliability:	Proven use
Presence Time in Area:	Range from 5–30 seconds

Siemens

Siemens have developed a range of infrared detectors that can be used within the road environment. The specifications for the equipment at the present time is such that the equipment cannot be used in all european counties, but with the resources at the disposal of Siemens it is unlikely that this will be a problem. In its present state the available equipment is not capable of providing an accurate count of the number of pedestrians moving near the crossing point since the minimum gap between responses at the present time is 0.5 seconds.

Detector Frequency:	7–14 micrometres
Range:	2–25 metres
Reliability:	Proven use

3.2.4 Pressure Mats

In V1061 the pedestrian waiting to cross the road had to stand on a pressure sensitive mat. This mat did not trigger off the demand but to cancel demand if the pedestrian should move away. The mat employed was provided by Electronique Controle Mesure from Nancy, France. The specifications and results from those trials have been presented in the V1061 report. It should however be noted that the British Government in their new Puffin crossings are looking at alternative suppliers. Two other companies also supply pressure sensitive mats.

PRINCIPALS
The objective is to use sensors of some form, situated below the surface of a mat to identify the fact that an object is on the mat. The moment when the object goes on to the mat, and when it leaves the area of the mat is recorded.

ADVANTAGES
The mat is a permanently installed system, which pedestrians may not be aware of. It is therefore highly unlikely to be subject to vandalism. It can identify the fact that there are no pedestrians present. The British Government have given their approval to use this method in an integrated pedestrian facility.

DISADVANTAGES
The footway will require construction work to install the system. The long term life of the system is unknown. the maintenance costs will include construction work. Cannot identify pedestrians before they reach the crossing point.

Electronique Controle Mesure

This system uses piezo resistive elements embedded within a mat and separated from each other. The unit is embedded in embossed polyurethane. An output relay trips when one or more element is tripped.

Detection Threshold:	Above 10Kg
Reliability:	Not proven for extended use. An auxiliary relay detects and signals faults.
Counting:	Although the mat can work as a weigh machine, it will not be able to accurately count the number of pedestrians waiting.

The final results from the DRIVE I project are not yet known, but it is considered significant that the British Government are considering alternative methods in their Puffin Crossings.

Traffic 2000

The Traffic 2000 firm has produced a specimen mat for testing. The system is based upon using piezo-electric sensors. Traffic 2000 is a British company which is active in the field of vehicle detection and counting. The systems that they use are based upon the use of piezo-resistive cables embedded within an appropriate surface to detect the presence of an object. The company has not had any direct experience of providing equipment for detecting pedestrians, but have worked in collaboration with members of this project to produce a mat which will be sensitive to pedestrians treading upon it. These mats also have the facility to give an approximation of the number of pedestrians standing upon the mat. basic trials have shown that this can be done by subdividing the area of the mat into sub-sections and then recording the number of sections that receive a signal. Obviously this only gives an approximation and is dependant upon the size of feet and whether a pedestrian is standing fully on the mat; however it does give some estimate for demand.

Detection Threshold:	Over 5Kg
Reliability:	Unknown at present
Counting:	The mat will be made up from a very large number of sensors, and hence a count from the number of sensors activated can be converted into numbers of pedestrians

Herga

Herga use fibre-optic mats to detect the presence of objects within the area of the mat. This system is at the present time under trial from the British Department of Transport, so far the details from this trial are not available and in view of the fact that this trial is under way it has been decided not to duplicate this work by requesting the firm to carry out a further series of trials but it has been declared that the results from trials will be made available to the project.

The major problems relating to the use of mats in general is the length of their working life in on-road situations and how susceptible they will be to effects of weather. It is also considered that there will be some resistance from the Highway Authorities to their installation because of the need to make structural alterations to footways, this could be a very sensitive situation in urban city centre areas where environmentally pleasing surfaces have already been introduced. However in spite of this the British Department of Transport are proceeding with their use in certain locations and it seems very likely that one of the above companies will be employed.

4 CONCLUSIONS AND NEXT STEPS

This deliverable has presented a synopsis of the present situation with regards to the use of pedestrian detection at intelligent pedestrian crossing facilities within Europe. It has concluded that at the present time the project is not aware of any standard system that is regularly used. The British Department of Transport has announced its intention to install such facilities that will be based upon prototypes that were developed in DRIVE I. However recent research has confirmed that the whole concept of using pedestrian detection techniques to improve the conditions for pedestrians wanting to cross the highway at signalised junctions is a feasible method for trying to improve the safety and comfort for this important section of road users.

An examination of the techniques available to carry out such detection has been undertaken, as has been a consideration of the industrial companies that have produced products that could be used in such a situation or are developing such a system, which could be incorporated into such a facility. There are three main types of detection device that can be used for the production of such intelligent crossing facilities and it is the case that all three can be used to identify objects in the targeted locations.

From a study of these systems it is concluded that all three types of detection facility do have a useful place in an overall policy of being able to identify pedestrians. It seems likely at the present time that there will be continued pressure to use infrared detection devices because these are the systems that have been used most commonly for vehicle detection. The types that have been examined do face some problems in the fact that they are used to record presence and movement within a defined target area. It is not possible at the present time to utilise existing equipment to record pedestrians moving in a specified direction or to give an indication of how many pedestrians might be required to cross. However as has been previously mentioned this technique has been employed by major traffic signal companies in vehicle detection situations and so has a proven ability to provide information to the signal controllers. It is considered likely that this method of detection will continue to play an important part in the developing field of pedestrian detection. In addition it is felt that there is the will within these companies to look at ways to improve their detection techniques using infrared detection.

The use of presence mats has so far been only been used in this context by the British Department of Transport and it is the considered opinion of this author that they will have a limited use in this field. One of their major attractions is to identify when pedestrians have left the zone and hence no longer wish to cross the road.

Microwave detection systems are very similar to infrared detection systems in that they can record the presence of pedestrians. However it is felt that they have the overall advantage in being able to identify pedestrians moving towards the crossing point and make an estimate of the number of pedestrians wishing to cross. Their limitation is really in being able to identify suitable locations in which this facility can be included in the overall scheme. if this cannot be done then it is considered they will yield no additional benefits over and above infrared detection.

In conclusion it must be recognised that we are really trying to use these methods of pedestrian detection as sophisticated tools to be able to respond to the needs of pedestrians. The choice of a particular type of detection system, or indeed the type of pedestrian crossing design chosen will for a large part be dependent upon the site that is to receive the facilities. The two DRIVE I projects have used sites that at first appearances appear to be identical in that the objective is to provide the facilities for pedestrians in an urban environment. However their actual locations are completely different and I believe that on of the most important lessons to be learnt is that the facilities have to be compatible with the existing situation. As was succinctly stated by Hunt and Griffiths, there are problems in trying to identify those pedestrians that are going to cross a given road in a given position. This observation is most relevant when considering the use of microwave detection at a pedestrian crossing. It is considered that the use of microwave detection for pedestrian is the most promising way forward in able to provide pedestrian friendly facilities. However the problems involved in using this type of method should not be overlooked. Put very briefly the advantage of using a proven system of microwave detection devices is that it can, in advance give information on what pedestrians and how many wish to cross a given road. However this can only be done if the sensors can be aimed at a target area at which just those pedestrians who are wishing to cross the road are entering.

The use of presence sensitive mats is undoubtedly a valid method of identifying pedestrians who are waiting to cross the road, and as recognised in the proposed British Puffin crossings can be used to cancel the demand for pedestrian time if they have been able to cross in gaps. However it is felt that their limitations may only render them as a short term measure, before more sophisticated detection systems are fully developed.

The next stage within the project is to incorporate the information gained from this workpackage with the identification of the sites where the detection devices are to be installed. The feasibility studies in the three countries in which the pilot trials are to be carried out have identified the needs of pedestrians; the work from this workpackage has shown that there are presently available a number of different techniques to identify these pedestrians, the project now needs to combine these results. In at least one of the feasibility studies the need to obtain count of the number of pedestrians wishing to cross the road has been identified, this probably implies that, initially at least, microwave detection or pressure mats will be the favoured technique. One other point that needs to be taken into account is that whatever detection technique is chosen it will need to interface with the traffic control system; all of the detection companies approached said that this would not be a problem, but the experiences gained from DRIVE I shows that this potential problem has to be faced at an early stage.

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