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Intelligence

making journeys work

Look no wires - white paper

Magnetometer vehicle detection and  
wireless communications in action

## **Blackburn gained the benefits of magnetometer based vehicle detection for junction enhancement with MOVA.**

The issues of unexpected inductive loop failure caused by: poor reliability, road degradation and utilities digging up and cutting through loop tails; are well known and were regularly being experienced by Blackburn with Darwen Borough Council. The borough working in partnership with Capita Symonds required the upgrading of three major intersections to MOVA and wanted to look at minimising some of the issues with the traditional vehicle detection that they had been experiencing. The decision was taken to totally upgrade these junctions using Golden River Traffic M100 magnetometer vehicle detection equipment interfacing with new signalling infrastructure installed by Peek Traffic Limited along with their Chameleon MOVA controllers.

## Exploring the issues with traditional vehicle detection

It is generally accepted that the traditional method of vehicle detection for the majority of traffic signal applications is via the simple inductive loop. Whilst the loop has proved to be generally reliable in many applications and locations it has some inherent potential risks and problem areas.

It could be considered that the very nature of the design of the inductive loop itself can be the cause of reliability issues. Most of the configurations utilised and the usual method of slot cutting using straight saw cuts creates over cut corners. These corners can become weak areas that can cause the road surface to crack and break away, this combined with high trafficking can also cause the loop sealant to fail and water to get into the groove causing loop failure.

Another regular cause of failure is due to damage to loop tails by either utility and or communication installation companies cutting through them as they install or maintain their own services.

When detectors fail they go into permanent detect, the failsafe mode of the controller in these instances is to extend the phase on the actuated movement to the maximum green time regardless of the presence of a vehicle. This can cause problems with the efficiency of the junction and cause frustration for motorists who perceive their time as wasted on movements that do not need green time. It can also cause a safety issue when motorists notice there is no cross traffic, but they have a red indication for prolonged time periods.

This results in disruption to traffic not just from the initial effect on the traffic signal control but also when traffic management is required to re-cut the loop, especially if in a multi lane situation where both or all lanes require closing to allow the tails to reach the carriageway edge.

A past study carried out in New York (Bikowitz and Ross, 1985) looking at the failure rate of inductive loop detectors in New York State, found that one quarter of the State's 15,000 loop detectors were out of order at any given time. Loop detectors were found to be maintenance free for an average of only two years. Given these results, it is apparent that these types of detection systems have high maintenance costs in such environments.

Re-cutting loops multiple times at a similar location results in sights such as the picture below. This results in a weaker road surface that may cause premature failure of the



newly installed loops and so the cycle continues. Other locations where the inductive loop creates an issue are those where detection is required in alternative road surfaces such as block paviers or where existing iron work in the road prevents the loop being installed in the correct location.

**Loop detectors were found to be maintenance free for an average of only two years.**

## Alternative vehicle detection technologies

A range of alternative technologies for vehicle detection have been developed and employed to overcome some of the issues highlighted.

One such technology is the magnetometer based vehicle detection system and this paper describes the advances made in that technology that has allowed its adoption on a commercial scale into the United Kingdom and led to Blackburn with Darwen Borough Council and Capita Symonds choosing the Clearview Intelligence M100 magnetometer vehicle detection system.

The basic principle of the magnetometer sensors is using three magnetic detection sensors to measure the X, Y and Z axis of the earth's natural magnetic field. When no vehicles are present the sensor will calibrate itself by measuring the values of the background magnetic field and establishing a reference value. The passage and presence of vehicles are detected by measuring deviations from that reference value. Each sensor automatically self calibrates to the specific installation site and to any long term variations of the local magnetic field by allowing this reference value to change over time. This ensures that operation accuracy is maintained despite external factors such as movement of the sensor due to road surface wear, tear and it shifting over time.

It is this ability to calibrate to the local environment that also gives flexibility of installation allowing the sensors to be located close to any existing ironwork and also within carriageway surfaces containing a reinforcing bar.

One of the previous issues with such magnetometer devices was that their sheer size, being about the diameter of a dinner plate and over 100mm deep meant a complex installation. They also had a short battery life of approximately two years due to the type of wireless radio communications being employed.

Sensys Networks Inc., the technology partner of UK based Clearview Intelligence, born out research carried out at Berkeley University in San Francisco, have taken the development, use and acceptance of the magnetometer detectors a huge step forward by developing extremely low powered two way radio communications that has enabled the detector stud to be dramatically reduced in size, only 74mm x 74mm x 49mm deep, including a battery with an operational life in excess of ten years.

Mechanically the sensors are designed to survive being embedded within a road, operating over a temperature range of -40 degrees C to +85 degrees C. To some extent the sensors compact size and how it is typically used, being generally installed in the middle of a lane also helps to prolong its operational life. However they are designed to withstand more than the full weight of passing traffic should they drive directly over it.

The sensors compact size, its installation in the middle of a lane and a battery lasting in excess of ten years prolong the M100's operational life.



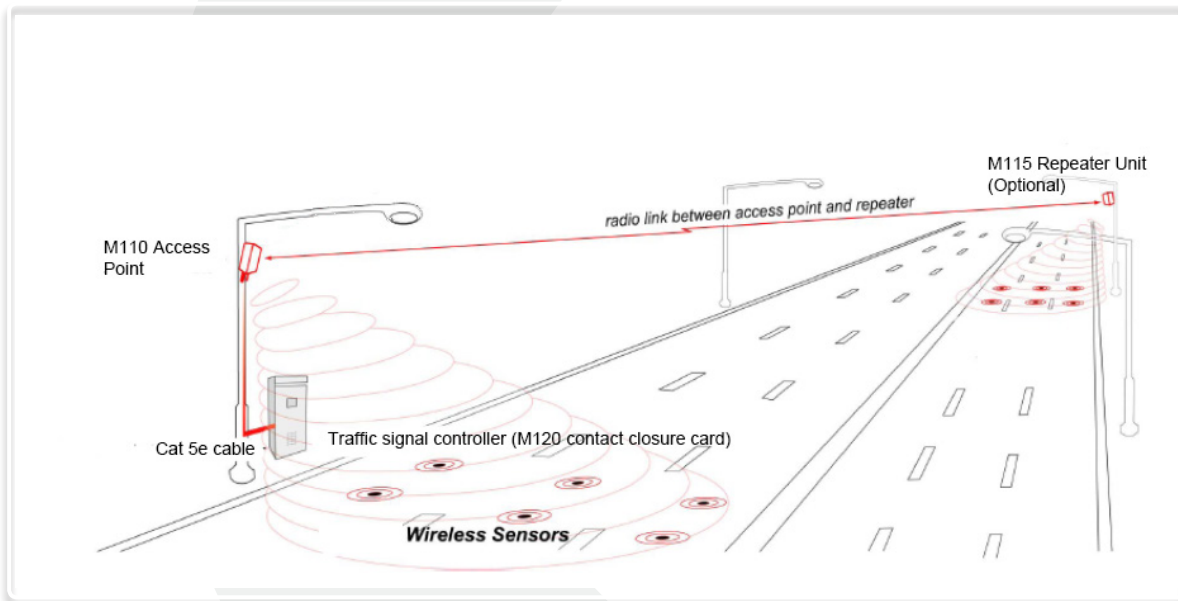
## Magnetometer vehicle detection wireless system operation

All three of the major junctions that were to be upgraded in Blackburn are on main routes in, to, and around the town and located in densely populated urban areas. Two are located on the A674 main western approach whilst the third is on the A666 northern approach.

The typical systems installed in Blackburn have a number of components. The first is the in road M100 magnetometer sensor itself. It is installed in a small 100mm x 50mm deep hole and requires no specialist slot cutting, ducting or trenching, it sits approximately 4 to 6mm below the surface of the road and in the centre of the carriageway or lane. A durable two pack epoxy resin is used to complete the installation. This means that a sensor can be installed in only 15-20 minutes, including the resin cure time, resulting in greater productivity when installing the sensors compared with inductive loops and also reducing the amount of disruption to road users and the traffic management required.

These sensors can be tuned if required, even once in the road, to detect a specific vehicle types away from the norm such as pedal cycles or trams.

Quicker installation  
equals greater  
productivity.



The in road sensor communicates wirelessly using a low power, highly secure and unique radio protocol, to send time stamped detection data to the M110 Access Point, within a range of 30 to 40m away, that forms the heart and hub of the system. The Access Points are usually mounted on top of a suitably positioned signal head.

This radio communication is two way and any signal from the sensor is acknowledged back from the Access Point, and buffered within the sensor and resent until the acknowledgement is received ensuring continuity and completeness of the detection data.

The Access Point is capable of collecting data from up to 48 sensors and via up to 15 Repeater Units.

## Magnetometer vehicle detection wireless system operation

There was a requirement at all three junctions in Blackburn for sensors to be located out of the range of the Access Point; some of the 'X' and 'In' detectors were 90m from the stop line. Therefore M115 Repeater Units were employed. The Repeater Unit is battery powered, with either two or eight year user replaceable battery options available. Each repeater can support up to 10 sensors, also within a 30-40m range, relaying the detection data back to Access Point and extends the range of an Access Point by up to 300m. There is also the facility utilised on three occasions in Blackburn for two repeaters to operate in tandem to allow for complex sighting and relaying the detection information back to the Access Point. This tandem arrangement could also be used to further extend the range from the Access Point.



Finally, for traffic signal control the M120 contact closure card is located within the traffic light controller and is linked to the Access Point by an external grade Cat 5 cable, this carries both power to the Access Point from the card and also the communications. The card is a standard 3U rack size and is therefore traffic light controller manufacturer independent to ensure compatibility with all systems currently in use. The card simply replicates traditional loop inputs, and has four detection output channels per card.

At each site multiple M120 contact closure cards were employed, daisy chained together to provide the required number of output closure channels (up to 64 cards can be so linked together should it be required).

These simply slotted into the Peek Traffic controller racks, being used at Blackburn, and were easily configured using the bespoke TrafficDot software. This simple and intuitive software can be freely loaded on to any traffic signal engineers laptop and as well as for system configuration it also enables the status of all equipment in the system from radio signal strengths and quality to battery voltages to be monitored.



## System benefits

One of the main benefits of utilising magnetometer based vehicle detection with wireless communications is the reduced installation costs, due to the elimination of the amount of ducting that would be needed especially in these urban areas. The added complication in Blackburn was that due to the sheer amount of other utilities etc. in the area the ducting would need to be hand dug, further increasing the potential costs especially with the required distances from the stop line of the 'In' detectors. Additionally considerably less disruption to traffic and local residents was achieved, eliminating any potential need for night time working and long periods of traffic management as the sensors could be installed quickly and easily during the daytime, even on junctions on busy main arterial routes.

For example at the intersection between Old Preston Lane and the B6447 Buncer Lane alone, over 380m of ducting would have been required had traditional loops been employed. With twenty sensors communicating via four Access Points (one per leg) and including ten repeater Units, due to distances from the stop line and road layout, the initial capital savings alone at this junction were still considerable.

Chris Pearson, traffic signal engineer with Capita Symonds advised that: "the problematic nature of providing ducting in the service-congested footways in these urban areas increases the costs which in this instance would have been at least £100 per metre and therefore substantial savings were made by eliminating this need using the M100 magnetometer wireless range."

Ian Richardson, Capita Symonds' Director also commented on the benefits in terms of installation costs and ongoing efficiency: "By implementing the M100 wireless vehicle detection system at three major sites we have reduced installation costs by £60,000 and will continue to create efficiency savings through reduced replacement and maintenance costs."

These cost savings were realised even with the installation, in some locations, of dedicated poles for the mounting of the Repeater Units, where suitable lamp columns were not available.

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## Applications

The M100 wireless magnetometer range can be used for a variety of applications where traditional inductive loops have been used in the past.

Combined with the M120 Contact Closure Card the magnetometer sensors are suitable for use with all the standard traffic signal control systems such as: System D, MOVA, SCOOT and SCATS. The system as a whole including the M120 contact closure card is fully type approved to the Highways Agency standard TR2512A for below ground vehicle detectors, inclusive of appendices A to D covering all of the above traffic signal control applications.

It is not just Blackburn with Darwin Borough Council that has benefited so far from the M100 Magnetometer range. For example, the transportation and highways maintenance department of the State of Jersey government have no slot cutting facilities on the island and therefore inductive loop replacement costs are substantially higher. The simplicity of installation of the M100 magnetometer sensor has already returned cost savings for the Island authorities.

As part of the regeneration of the southern quarter of Belfast's City Centre, Multi-Development UK has built a brand-new shopping centre called Victoria Square. Due to its city centre location, access to the loading bays is via a thirty metre entrance on a narrow public road that experiences high levels of pedestrian traffic. This obviously led to fears about the safe operation of the loading bays, and so an innovative and cost effective solution was sought. Detecting vehicles in the area was a difficult technical challenge as traditional inductive loops can not be used due to the large quantities of reinforcing steel embedded in the concrete roadway. Most forms of light beam solutions would have been susceptible to false triggering as people pass through the beam area. M100 magnetometer sensors were installed being unaffected by the large amount of re-enforcing bar and used, as a vehicle leaves the loading area to trigger a string of mains powered embedded Clearview Intelligence LED SolarLite Road Studs that flash brightly providing a clear and unambiguous indication of the hazard.

Other applications besides traffic signal control are currently being developed for this alternative vehicle detection technology. This will bring the advantages of many of the benefits outlined above in to other areas of the Intelligent Traffic Systems sector.

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## The use of wireless communications

The M100 magnetometer system communicates using 16 channels in the open access, licence free, 2.4 GHz band as specified by the 802.15.4 PHY standard. The actual communication protocol is unique to the system, therefore highly secure and can not be interfered with externally.

The utilisation of the 802.15.4 frequency minimises any risk from any radio interference from 802.11b/g frequency devices such as WiFi networks and Bluetooth devices, this is of particular importance in densely populated urban areas. Also any MESH4G networks are totally unaffected.



## Applications

The use of the M100 magnetometer vehicle detector system provides accurate vehicle detection in all conditions and combined with its flexibility and ease of installation that demonstrates a range of benefits and costs savings. Such benefits are realised especially where inductive loop reliability is poor perhaps due to derogation of the road surface combined with where heavy traffic occurs; or where extensive ducting is required particularly in densely populated urban areas.

As well as a reduction in the initial capital expenditure, ongoing maintenance and life time costs are reduced. Councillor Alan Cottam, executive member for regeneration and environment, Blackburn with Darwen Council welcomed the innovative technology: "Keeping traffic flowing is important for businesses, commuters and air quality. This is cost effective technology, which is easy to install and reliable, providing a real benefit to motorists."

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