Development of the candidate operational regimes and the assessment strategy for the M42 ATM Pilot project:

M42 ATM Pilot CORE Proposals

Issue 1

by T Strong

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DEVELOPMENT OF THE CANDIDATE OPERATIONAL REGIMES AND THE ASSESSMENT STRATEGY FOR THE M42 ATM PILOT PROJECT:

M42 ATM PILOT CORE PROPOSALS

Issue 1

by T Strong (Networks Group, TRL Limited)

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EXECUTIVE SUMMARY

As part of task T026 “Development of the Operational Regimes and the Assessment Strategy for the Active Traffic Management Pilot”, TRL has produced this document for submission to the ATM Pilot Project Board by Chris Byrne (ATM Pilot Project Sponsor). The document contains TRL’s recommendations for the set of Candidate Operational REGimes (COREs) that should be developed in detail by the ATM Managing Consultant and implemented at the M42 ATM Pilot site. The document is presented to seek the approval of the ATM Project Board in relation to the proposed COREs.

The infrastructure and operational resources proposed for the M42 ATM Pilot site will allow a wide range of Operational Regimes to be implemented along the site to address current and future problems along the M42 motorway. The COREs recommended within this document for further refinement and detailed design work are:

- **Integrated Incident Management** – co-ordinated deployment of emergency resources and traffic management from an Integrated Control Office in response to unplanned incidents according to pre-agreed plans.
- **Lane Control for Improved Safety and Efficiency during Maintenance** – use of the processes and techniques developed for (and tested under) emergency incident situations applied to planned/routine maintenance and in particular the use of a red cross to provide additional protection to operatives.
- **Variable Speed Limits** - controlling the speed of vehicles by changing local speed limits posted on overhead gantries.
- **Conversion of the Hard Shoulder** – to create an ‘Extra Lane’ which can be made available to traffic at times when the temporary provision of additional capacity would prevent the onset of congestion and queuing.
- **Access Management** - use of traffic signals at those on-ramps that warrant the control of the rate of vehicles entering the main carriageway to avoid the onset of congestion on the mainline.
- **Exit Queue Management** – use of part of the converted hard shoulder at or near an off-ramp to store traffic wishing to leave the motorway for a destination that, at least temporarily, does not have sufficient capacity to absorb it.
- **Designated Vehicle Lanes** – dynamically dedicating sections of the converted hard shoulder for specific vehicle types.
- **Lane Marshalling** – use of variable signs (subject to available funds) to dynamically designate lanes by destination.

Work by TRL has identified that there are many operational problems along the M42 ATM Pilot and the recommended COREs described in this report are proposed as potential operational solutions to these problems. However, limited current traffic data has been available within the time constraints of TRL’s current commission. A flexible approach has therefore been adopted and as such the COREs in this document are therefore presented in a flexible manner so as not to constrain their further refinement and detailed design by the Managing Consultant once more detailed traffic data from the site becomes available.

This document will be made available to the Managing Consultant and should be considered as a ‘living document’ that will be developed and refined throughout the M42 ATM Pilot (in the light of new information and eventually operational experience) to inform future ATM Pilots.
M42 ATM Pilot CORE Proposals

1 Background

The purpose of the Active Traffic Management (ATM) project is to pilot the ATM concept, test the technology, develop the Operational Regimes and guidance for the wider use of ATM on the motorway network through a monitored scheme on an existing section of the motorway network. ATM has the potential to make significant contributions to delivering the Government’s Ten Year Plan for Transport.

In January 2001 an opportunity was identified to bid for the early funding of an ATM pilot through the Capital Modernisation Fund (CMF). The CMF funding mechanism aims to improve public service through the funding of innovative electronic service delivery projects. The Department for Transport, Local Government and the Regions (DTLR, formerly DETR) submitted a bid on behalf of the Highways Agency (HA) for an ATM pilot. The bid was successful and £40 million was made available to enable the HA to implement the ATM pilot over a three year period (commencing 2001/2002).

On 27 July 2001 an HA press release announced that the M42 between Junctions 3a and 7 had been selected as the ATM Pilot project site.

The Managing Consultant (MC) has just been appointed to support the HA in the management, co-ordination, implementation, control and assessment of delivering the ATM pilot. The early work that was previously undertaken on the Development of the Business Case for ATM highlighted the need to take forward a number of key work areas prior to the appointment of the MC. In October 2001, the HA let Task T026 “Development of the Operational Regimes and the Assessment Strategy for the Active Traffic Management Pilot” with TRL. There are two parallel strands to this task:

(i) Development of Candidate Operational Regimes (COREs) for the ATM Pilot;
(ii) Development of an Assessment Strategy for the ATM Pilot.

This document has been produced as part of the first strand of work. This strand of TRL’s commission provides the Managing Consultant with a valuable resource to assist in the development of the detailed designs and procedures for the final set of Operational Regimes to be implemented on the M42 ATM Pilot site.

TRL has reviewed, refined and developed the initial list of objectives for undertaking the ATM pilot. A series of consultations with key members of the HA and a review of research and on-road implementations of speed, lane and incident management have provided significant input to this commission. A workshop was held in November 2001 to determine the perceived operational problems at the pilot site, and the limited traffic data available from the site (within the time constraints of TRL’s commission) has been used to quantify the problems. Visits have been made to Germany and the Netherlands to observe innovative traffic management schemes in operation. Based on this information, TRL produced initial recommendations for COREs to be considered in further detail for implementation at the M42 ATM Pilot site.

These proposals were presented to an HA audience in February 2002 for initial reactions. This document has been subsequently produced by TRL for submission to the ATM Pilot Project Board by Chris Byrne (ATM Pilot Project Sponsor). The document contains TRL’s recommendations for the set of COREs that should be developed in detail by the ATM Managing Consultant and implemented at the M42 Pilot site. The document is presented to seek the approval of the ATM Project Board in relation to the proposed COREs.

This document will also be made available to the Managing Consultant and should be considered as a ‘living document’ that will be developed and refined throughout the M42 ATM Pilot to inform future ATM schemes.
2 ATM Concept

The purpose of ATM is to make use of innovative and existing technologies to reduce congestion, improve safety and provide more reliable journey times. ATM has the potential to provide a more cost effective and environmentally acceptable solution than motorway widening. This will all be achieved by developing new institutional arrangements to provide an actively managed and operated motorway environment to a degree never before seen in this country.

Integrated operational management including incident management and planning will involve the HA, police and maintenance organisations working together from a dedicated Integrated Control Office (ICO). The Operators within the ICO will introduce a range of Operational Regimes to make best use of the available roadspace and to address current and future problems on the network. The range of Operational Regimes is made possible through the provision of the ATM roadside infrastructure. ICO operators will have available a ‘fleet’ of HA funded on-road resources to be deployed for both incident management and maintenance. The control office will contain all of the control systems and real-time traffic monitoring equipment necessary to operate ATM. Inter-visible lightweight overhead gantries will support lane specific signals and new generation (MS4) Variable Information Signs. Emergency Refuge Areas (ERAs) equipped with emergency telephones will be provided for use by motorists in an emergency. Figure 1 shows an early illustration produced by the HA depicting the ATM concept.

Figure 1: HA publicity illustration of ATM concept (Strategic Roads 2010)
3 The M42 ATM Pilot

The M42 ATM pilot requires the development and integration of new and existing technologies in new applications. The M42 ATM Pilot will use real-time data to control traffic using signs and messages on gantries from a dedicated Control office.

In order to facilitate a wide range of Operational Regimes on the M42, the operational resources and infrastructure listed below (and detailed in Sections A1 to A3 of Annex A) are recommended for installation along the length of the Pilot site which runs from the junction of the M42 and M40 (Junction 3a at Umberslade) north to the junction of the M42 and M6 (Junction 7 south of Coleshill). This infrastructure and resource is considered to be sufficient to support a wide range of COREs and is in-line with the ATM concept and ideas detailed in the original Capital Modernisation Fund bid.

- Integrated Control Office and Operational Resource;
- Mobile Lane Closure vehicles (with rear-end crash cushion protection);
- Vehicles carrying road cones and temporary signs;
- Vehicles equipped with infrastructure repair equipment;
- Recovery vehicles both for light and heavy vehicles;
- Gantries;
- Real-Time Traffic Monitoring;
- Lane specific signals;
- Variable Information Signs;
- Emergency Refuge Areas;
- Fixed Signs and Markings.

The list below (detailed in Section A4 of Annex A) refers to rather more solution-specific infrastructure which it is recommended should only be installed in a targeted manner at specific locations on the M42 Pilot site to resolve particular problems (once identified).

- Enforcement systems;
- Variable Advanced Direction Signs (VADSs);
- Access Management signs and signals.
4 Identified problems along the M42 ATM Pilot site

4.1 General Description
The M42 ATM Pilot site extends between Junctions 3a and 7 of the M42 motorway, which constitutes the eastern edge of the ‘Birmingham Motorway Box’ (Figure 2). This section of the M42 has high traffic flows with very significant peak hour commuter flows and high levels of local traffic. It is prone to regular congestion and flow levels are increasing, as they are on motorways nationwide. Birmingham City Centre, the National Exhibition Centre (NEC) and Birmingham International Airport (all of which are major traffic generators) are all situated to the West of the Pilot site. The NEC generates large volumes of traffic travelling to and from events. This traffic contributes to the general high flows along the length but often the problems are focussed around Junction 6 (which also serves Birmingham International Airport). The M42 ATM Pilot section also represents a significant route on the Strategic Network carrying traffic from both the M42 and M40 north to the M6.

![Figure 2: Map of Birmingham Motorway Box showing M42 ATM Pilot site](image)

4.2 ATM Workshop
TRL and HA arranged a workshop in November 2001 to identify potential causes (and solutions) for perceived traffic problems along the ATM Pilot project site. Delegates were invited from different organisations (with different perspectives) so as to provide a broad-range of operational experience and so generate lively debate. A wide variety of potential operational problems and candidate solutions were highlighted. The day proved an invaluable input to TRL’s commission, helping to identify suitable COREs for the M42.
In addition to the list of perceived operational problems and candidate solutions, the following main points were emphasised:

- That limited current traffic data is available for the Pilot site. This is important data, which if available would increase confidence in the output from TRL’s commission.
- The importance of ‘casting the net widely’ in terms of considering all potential Operational Regimes which data may prove both feasible and beneficial to implement along the M42 Pilot site at a later date.
- The importance of developing a flexible monitoring specification that would support the future deployment of all feasible OR at any location.
- The importance of ensuring that sufficient ‘before’ monitoring is conducted to support both the final selection of OR and the assessment of their impact.

4.3 Available traffic data
The value yet lack of availability of a rich source of current data was highlighted at the workshop. The report by Rees et al. (2001) contains an analysis of limited traffic data from 1999. TRL also connected standalone counters to MIDAS loops at 6 sites (2 sites per link) along the Pilot length and collected speed and flow data from October 2001 to February 2002. Although insufficient to provide an in depth analysis of the operational problems and their causes, the two sources of data do serve to provide an indication of the traffic problems along the M42 ATM Pilot site.

**Northbound (A) carriageway:**
- High flows between J3a and J6 during both peak periods with some congestion between J6 and J7;
- During the evening, queuing back from diverge at J7, weaving, merging problems at J6.

**Southbound (B) carriageway:**
- Some congestion during the morning with higher flows in the southern section;
- During the evening, high flows between J6 and J3a, congestion on most days so merging problems at J6, queuing doesn’t always tail back to J7 because flows are lower.

The morning and evening peak periods are well defined, with a recovery period during the middle of the day. The flows are sufficiently high for flow-responsive speed signal settings (as used on the M25 Junctions 10 to 16) to be active for between 4 and 8 hours per day on each carriageway.

Towards the end of February 2002, full MIDAS detection was switched on along the length of the Pilot site. Once fully operational, this will provide ‘continuous’ lane-speed, lane-flow and carriageway vehicle type data that will be invaluable for the Managing Consultant in developing the detailed Operational Regimes to be implemented along the M42 Pilot site.
5 Recommended COREs for the M42 ATM Pilot

As a result of a worldwide review (and two overseas visits) and consultation with the HA, TRL has developed a suite of Candidate Operational REgimes (COREs) which may be deployed under ATM. The review has focussed on operational schemes while taking account of HA experience that may be applied to the ATM concept.

Presented in Sections 5.1 to 0 are those COREs that are proposed for use at the M42 Pilot site (see bulleted list below). While the recurrent areas of congestion along the Pilot site are reasonably well accepted, it is essential that these proposals are refined as further traffic data and information on conditions along the M42 becomes available.

- **Integrated Incident Management** – co-ordinated deployment of emergency resources and traffic management from an Integrated Control Office in response to unplanned incidents according to pre-agreed plans.
- **Lane Control for Improved Safety and Efficiency during Maintenance** – use of the processes and techniques developed for (and tested under) emergency incident situations applied to planned/routine maintenance and in particular the use of a red cross to provide additional protection to operatives.
- **Variable Speed Limits** - controlling the speed of vehicles by changing local speed limits posted on overhead gantries.
- **Conversion of the Hard Shoulder** – to create an ‘Extra Lane’ which can be made available to traffic at times when the temporary provision of additional capacity would prevent the onset of congestion and queuing.
- **Access Management** - use of traffic signals at those on-ramps that warrant the control of the rate of vehicles entering the main carriageway to avoid the onset of congestion on the mainline.
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- **Designated Vehicle Lanes** – dynamically dedicating sections of the converted hard shoulder for specific vehicle types.
- **Lane Marshalling** – use of variable signs (subject to available funds) to dynamically designate lanes by destination.

The following sections contain a description of each of the proposed COREs. The COREs are presented in the main as separate schemes, however there is vast scope for deploying more than one individual CORE in unison to resolve a specific problem. Although some reference is made to potential synergies, the point is not often laboured. Annex C contains a description of a ‘day in the life’ at the M42 ATM Pilot site to indicate the potential to deploy the COREs as part of an integrated approach.

The detailed design of the road layout and operational procedures is one of the Managing Consultants’ most significant tasks. It is at that point that all of the issues associated with interactions between Operational Regimes must be addressed and resolved.
5.1 Integrated Incident Management

Integrated Incident Management is a framework rather than a regime as such. It is likely to be a set of organisational structures, control mechanisms and procedures permanently in place, which will provide continuous intelligent management of the motorway.

The M42 ATM Pilot is expected to operate from a dedicated Integrated Control Office (ICO) at Perry Barr, with the HA working in continued partnership with the Central Motorway Police Group (CMPG). The control office is likely to contain all of the control systems and real-time traffic monitoring equipment necessary to operate ATM. This partnership approach may result in the HA supporting CMPG in their current operator roles in relation to the functions currently carried out by CMPG (e.g. monitoring CCTV cameras and answering emergency roadside telephone calls). The HA and a reduced presence of CMPG personnel may then work in partnership using integrated control systems and on-road resources. It will also be necessary to establish links and working practices with other emergency services and TCC (Traffic Control Centre project). The Dutch have developed an integrated approach to traffic management. Figure 3 shows an integrated Regional Control Office from the Netherlands.

![Integrated Regional Traffic Control Office, Utrecht, Netherlands](image)

Integrated Incident Management under ATM along the M42 aims to co-ordinate all the bodies and systems which have responsibility for the safe and efficient running of the motorway, including CMPG, Fire and other Emergency services, TCC, and ATM, with particular reference to the management and clearance of incidents.

As part of the on-road resource it is recommended that ATM operators have available a ‘fleet’ of HA funded\(^1\) on-road resources to be deployed in response to planned and unplanned incidents. These resources may include:

- Mobile Lane Closure vehicles (with rear-end crash cushion protection);
- Vehicles carrying road cones and temporary signs;
- Vehicles equipped with infrastructure repair equipment;
- Recovery vehicles both for light and heavy vehicles.

In addition to the institutional components, Integrated Incident Management can be considered to embrace the technical components of Incident Detection, Incident Warning, Queue Protection, Incident Response, Driver Information, and potentially Advanced Accident Analysis.

\(^1\) These on-road resources although funded by the Highways Agency are likely to be provided by local contractors.
Improved incident detection techniques (based on 100m detector loops and CCTV Image processing systems) are expected reduce the time it takes to detect an incident and therefore will support quicker responses both from automatic queue protection systems and Control Office staff. Enhanced traffic management capabilities offered by ATM including Lane and Speed Control create possibilities for maintaining greater throughput in the event of a lane-blocking incident than would otherwise be the case. With the CMPG, the Highways Agency and its contractors working together from an ICO using systems and procedures developed in partnership, increased efficiency in deploying resources in response to incidents is expected to deliver savings in terms of reduced response times and a consequent reduction in fatalities.

The key conceptual stages within Integrated Incident Management are outlined below by way of an illustration:

1. Pre-plan for particular incidents so that the correct resources can be used in response;
2. Detect Incident;
3. Initial Evaluation;
4. Immediate Response;
5. Despatch Resources;
6. Police investigate;
7. Repair infrastructure;
8. Re-open road.

Whenever an incident is detected, a Control Room operator will be made aware of the presence of an incident. Initial evaluation will be made to identify the location and severity of the incident (using CCTV cameras) and to select the most appropriate plan from the pre-prepared list of plans. These pre-agreed response plans form a significant part of the Integrated Incident Management CORE and must be created as a result of close liaison between all incident response bodies.

The HA Control Room staff will implement the traffic management plan (using the AMI lane control signs to guide traffic around the blockage and signs to warn approaching drivers). TCC and the media may also be informed if the plan dictates. This constitutes the immediate response.

HA Control Staff will then despatch police, ambulance, fire and HA on-road resources who will all work to make the incident site safe. Only once the site is safe can the police investigators begin to gather evidence. As part of the provision of new on-road resources under ATM, there are technologies currently available that may assist in speeding up this part of the process. 3-dimensional imaging systems and GPS location devices could be used in tandem to greatly reduce the time required to carry out accident investigation.

Once the evidence has been gathered, the HA on-road resources can repair any damaged infrastructure, and remove damaged vehicles from the road (to a suitable storage compound). Once the site is clear from debris and deemed to be safe, the pre-planned procedures can be implemented to direct traffic to re-use the previously blocked lane(s).

ATM can assist in managing the whole incident ‘lifecycle’, including accident investigation and traffic management during and post incident. A significant effort will be required to plan and agree all response procedures with all relevant parties, this will be a key factor in the success of ATM under Integrated Incident Management.

It is therefore recommended that Integrated Incident Management procedures and techniques be implemented along the entire M42 ATM Pilot site.
5.2 Lane Control for Improved Safety and Efficiency during Maintenance

This CORE represents a natural progression from Integrated Incident Management. The processes and techniques developed for (and tested under) emergency incident situations can also be applied to planned/routine maintenance. In certain respects, the Maintenance CORE can be considered a member of the Integrated Incident Management ‘family’ – the main difference being whether the “incident” in unplanned (traffic accident) or planned (maintenance).

The efficiency with which routine maintenance is conducted but moreover the safety of the maintenance operatives is an area where improvements are always welcomed. With gantries approximately 500m apart, each with lane specific signals, CCTV and an MS4, it is clear that there will be a high reliance on technology which in turn may create the need for high levels of maintenance. Section A3.3, Annex A refers to the design elements that it is envisaged will reduce the need for maintenance of Advanced Motorway Indicators (AMIs) – similar arguments can be made regarding the other gantry-mounted technologies. By focusing on making technology to the highest quality standards and so more reliable and easier to maintain, disruption due to maintenance of AMIs will be minimised. It is certain however, that routine maintenance will still be necessary along the entire M42 Pilot site.

It is accepted that one of the greatest risks to maintenance operatives occurs in relation to laying out cones to close off a lane(s) to facilitate static roadworks. Lane Control systems should be used to further reduce this risk. Components of lane control systems for maintenance management involve the depiction of a red-cross indicating that the lane ahead is closed. Additional signing must indicate the presence of roadworks, and may consist of warning signs and diagonal arrows directing traffic to move out of the lane.

![Figure 4: Lane closed for maintenance using 'cones' and 'red-cross', A7, Hanover, Germany](image)

The red-cross may also serve to reduce the frequency and severity of accidents where drivers collide with Mobile Lane Closure vehicles (mobile maintenance representing another potentially high risk situation for both maintenance operatives and the driving public).

While the ability to close a lane(s) for static maintenance without using coning may be a long way off, ATM infrastructure can be used in the first instance to supplement existing roadworks signing and systems and so increase the safety of operatives working in and around roadworks. While it is certain that a driver education campaign will be necessary, enforcement of red crosses may also be shown to be necessary. However, in the future red-cross compliance may be at similar levels to red-light compliance (at an urban signalised junction) and therefore deemed sufficient to denote that a lane is closed without the need for coning. In this ‘future world’, efficiency savings would result from the time ‘gained’ from not laying out road cones to protect a works area. This however is not proposed for the M42 ATM Pilot.

*It is therefore recommended that red-crosses be used in support of existing lane closure methods along the entire M42 ATM Pilot site.*
5.3 Variable Speed Limits

Variable Speed Limit (VSL) systems aim to control the speed of vehicles by changing local speed limits, posted on overhead gantries. They may also involve the use of variable message signs (VMS, EMS) to influence drivers’ behaviour. The M25 Controlled Motorways Pilot (Figure 5) affords in excess of 5 years direct experience of the use of VSL (on a 4-lane motorway), although it is also used in 10 other European countries.

![Figure 5: Variable Speed Limits in operation on M25 Controlled Motorways Pilot, England](image)

The main objectives of VSL are to reduce traffic speeds under heavy traffic flow conditions, or under poor environmental conditions, and by implication to warn drivers in advance of congestion or queuing ahead. Speed control is also used to lower speeds in foggy conditions, with the aim of reducing accidents. By delaying and sometimes preventing the on-set of flow breakdown VSL aims to reduce lane changing, maximise capacity, shorten journey times, reduce accident risk and increase driver comfort.

Mandatory speed limits provide a more positive form of control than advisory speed limits or lane-use signals. For most of the time, the impact of VSL in practice appears to be psychological, reassuring drivers that things are under control, and encouraging them to use lanes in a more even manner. For short periods, where traffic flow is rising or falling rapidly, the signals can influence traffic speeds. In particular, when combined with fast-reacting Automatic Incident Detection such as HIÖCC as is proposed for the M42, it can reduce the risk of rear-end shunts in stop-start traffic or incident conditions. However, experience from the M25 and The Netherlands (White et al, 2001c) suggests that speed enforcement may be required to ensure compliance.

In addition to these expected impacts, VSL hardware (detector loops and gantry mounted lane signals) is considered to be part of the ATM infrastructure (Section A3, Annex A). It can be considered as a basic ATM tool that creates the possibility to introduce and support other Operational Regimes.

Based on analysis of traffic data from 1999 and using factored M25 flow threshold values, Rees et al. (2001) estimate that 60 mph (or lower) speed limits would be automatically set along the M42 Pilot site on an average weekday for an average of 2.5 hours in the morning and 4 hours in the evening.

It is therefore recommended that VSL be implemented along the entire M42 ATM Pilot site.
5.4 Conversion of the Hard Shoulder

The most significant benefits offered from ATM along the M42 Pilot site are expected to be realised by converting the hard shoulder to form an Extra Lane. It is worth noting that the Controlled use of the hard shoulder as a running lane during peak periods accounted for over 70% of the benefits in the original Business Case for the ATM Pilot.

The M42 ATM Pilot Site is prone to regular morning and evening peak congestion and queuing. Incidents on the motorway often quickly lead to congestion. Bouts of congestion are also associated with major events at the NEC, most specifically located at Junction 6 but extending north and southwards.

**It is recommended that infrastructure be installed along the entire length of the Pilot site to support Operational Regimes which make use of a converted hard shoulder at times when the temporary provision of additional capacity would prevent the onset of congestion and queuing.**

The ability to regulate the use of this additional capacity will create possibilities for selective management of traffic according to vehicle type or destination giving rise to a wide range of further potential Operational Regimes (such as Exit Queue Management, Designated Vehicle Lanes, Lane Marshalling, Lane Control for improved Safety and Efficiency during Maintenance, and Integrated Incident Management).

Four “Peak Lane” schemes currently operate in the Netherlands (Figure 6). A recent visit to the Netherlands has provided a wealth of knowledge and experience regarding the operation of converted hard shoulder schemes which has greatly informed the development of proposals for M42 ATM. All evidence from the Netherlands suggests that their Peak Lanes have been successful in reducing or eliminating recurrent congestion and queuing at specific sites. The Dutch even report accident reductions at the same sites which they jointly attribute to the reductions in congestion and the provision of Emergency Refuge Areas (ERAs, Section A3.5, Annex A).

![Figure 6: A15 Peak Lane, Gorinchem, Netherlands showing 'Peak Lane' closed (left) and open (right).](image)

Emergency Refuge Areas (ERAs) equipped with emergency telephones will be required along the entire M42 ATM Pilot site, both within and between junctions as dictated by land-take constraints. Signing must advise drivers that when the Extra Lane is closed to traffic, they may only enter the lane to cross into an ERA. ERAs will in effect become the new safety area under ATM that offers the additional safety buffer of an empty lane between distressed vehicles in an ERA and moving traffic in lane 1 (when the Extra Lane is closed to running traffic).

Lane specific signs (gantry mounted) above the Extra Lane will indicate to drivers whether they can use the Extra Lane as a running lane – this will be supported by messages on MS4 signs. Reduced carriageway speed limits (50mph maximum suggested) will be imposed when the Extra Lane is opened as a safety feature. It is worth noting however that when the Extra
Lane is used at times of heavy traffic or under incident conditions, that VSL is likely to have already automatically set low speed limits.

Real-time traffic monitoring will be a very important aspect of managing Extra Lane COREs safely. While ATM will take advantage of available automatic detection systems, it is more likely to rely on operator confirmation (using CCTV cameras) for the safety critical decisions such as whether the Extra Lane is free from obstruction or debris before instigating the procedure to permit traffic to use the lane. Closely-spaced inductive loops (100m is suggested) will be required to give dense coverage of the entire carriageway to provide rapid detection of incidents, most critical perhaps when the Extra Lane is in use. The procedures developed under Integrated Incident Management (Section 5.1) will dictate whether a specific incident requires closure of the Extra Lane to general traffic to allow emergency service access to the accident site.

Detailed analysis of current traffic data will determine the exact nature of the control measures required to deliver the maximum benefits. Detailed computer simulation modelling will then be necessary to design the road layout and signal sequences to allow the management of traffic into and out from the Extra Lane under all conceivable circumstances. The Dutch have only implemented solutions with a converted hard shoulder that runs between junctions and as this is the simplest solution in terms of road layout, signing and vehicle movements, it is recommended for use on the M42 ATM Pilot site. However, with the benefit of Origin-Destination data (currently unavailable but expected within the next 6 months) detailing traffic movements between entering and exiting the Pilot site, it may be possible to justify a converted hard shoulder which runs through a junction.

This section has focussed on the ability to make the Extra Lane available to traffic at peak times. Using the figures quoted in Rees et al. (2001) relating to projected peak-time VSL activity, it is likely that the Extra Lane could be opened to traffic along the M42 Pilot site on an average weekday for an average of 2.5 hours in the morning and 4 hours in the evening.
5.5 Access Management

Access Management delivers the ability to regulate flow onto the main carriageway by controlling the merging traffic. By regulating the merge flow (and preventing large platoons of vehicles joining at once) it may be possible to avoid the onset of congestion on the mainline. It may also be possible to ‘protect’ the benefits delivered by an Extra Lane scheme. Drivers queuing at a merge may be compensated by the benefits they receive once they drive past the next ‘managed’ on-slip having joined the main carriageway. There are many schemes throughout the world that regulate the merging flow of traffic onto the main carriageway. These are typically referred to as “Ramp Metering”.

[NB. Access Control is also a member of the Access Management family of COREs. Access Control is defined as automatically closing certain on-ramps to all or certain classes of traffic under certain conditions (e.g. under severe incident conditions) using automatic barriers. Access Control is not recommended for implementation along the M42 Pilot Site (see Section B5, Annex B).]

Access Management of merging flows (Ramp Metering) requires additional infrastructure over and above what will be installed along the M42. The key elements include traffic signal heads, additional detectors, signs upstream of signals to warn of operation, and anti-skid surfacing on the signal approach.

The HA can offer a depth of knowledge based on operational experience at the M3/M27 and M6 Ramp Metering Pilot schemes, not least in terms of site selection.

Figure 7: Ramp Metering Pilot, M3/M27, Southampton, UK (J3 eastbound)

Until detailed data is available to identify congestion which it is believed is caused by high volumes of merging traffic, Junctions 4, 5 and 6 (northbound and southbound) must all be considered as potential sites. Once the potential need for merge controlled Access Management has been established, then design issues can be considered with the benefit of measured traffic data and a computer simulation model. Issues which need to be considered at each potential site include requirements for physical storage capacity at the on-slip and the frequency with which the queue override mechanism releases a large platoon of queuing merge traffic onto the main carriageway.

The signalling sequence at each junction must be co-ordinated with the signals on the junction roundabout (the roundabouts at Junctions 4 and 6 are already signalised, and it is expected that Junction 5 will be signalised by 2004). Access Management at each junction should also be co-ordinated, to ensure that any interaction between ramp metering at adjacent sites is beneficial.

It is recommended therefore that Junctions 4, 5 and 6 (northbound and southbound) must all be considered as potential sites for merge controlled Access Management. Once the final sites have been selected, it is also recommended that Access Management should be introduced sequentially (rather than at all sites at once).
5.6 Exit Queue Management

Exit Queue Management is a technique proposed for situations in which queues of traffic wishing to leave the motorway extend back into lane 1 of the main carriageway. The technique would allow controlled use of part of the motorway hard shoulder at or near a diverge to ‘store’ the traffic wishing to leave the motorway. Instead of a queue extending back into lane 1, Exit Queue Management would allow the queue to form in the hard shoulder instead. A queue extending into lane 1 of the main carriageway may result in mainline congestion, but will almost certainly represent an increased safety risk (queue tail accidents being all too common). Although a queue protection algorithm (eg. HIOCC as used on the M25 Controlled Motorways Pilot) would set reduced speed limits to warn approaching drivers of the queue, Exit Queue Management offers a solution based on removing the queue from the path of the oncoming traffic altogether.

Control algorithms are required to establish the onset of a critical queue and so instigate the procedures to instruct drivers to use the converted hard shoulder to exit the motorway. Gantry mounted AMIs will indicate to drivers that the hard shoulder is open for traffic (in a very localised region near to the off-slip but extending back upstream as the exit queue grows). Variable signs will indicate that vehicles wishing to leave at this junction should use the converted hard shoulder. Variable Advanced Directional Signs (VADSs) may be required to inform drivers of the altered lane use set-up. The use of signs dynamically designating lanes by destination represents another CORE – Lane Marshalling (see Section 5.8). The design options will need to be examined on a site-by-site basis based on comprehensive traffic data and computer simulation modelling.

Exit Queue Management will have to be co-ordinated with or developed in concert with any Local Authority signals (the roundabouts at the end of the exit slips at Junctions 4 and 6 are signalised and there are plans to signalise Junction 5 as well).

It is recommended that the off-slips on both carriageways at Junctions 4, 5 and 6 should be considered as potential sites that may benefit from Exit Queue Management. It is however noted that Junction 6 has both a dedicated NEC feeder off-slip and a ‘standard’ off-slip leading to a signalised roundabout (Northbound and Southbound). If there is sufficient carriageway width on both approaches this represents a large potential Exit Queue storage area.
5.7 Designated Vehicle Lanes

ATM delivers increased ability to manage the roadspace according to known or expected demands. It has previously been recommended that sufficient infrastructure be installed to allow the controlled conversion of the hard shoulder to form an Extra Lane which traffic may use when directed to do so by the ATM controllers. **It is here recommended that under certain traffic conditions, sections of the converted hard shoulder should be opened for the exclusive use of specified vehicle types.** (Solutions involving the creation of a Designated Vehicle Lane from an existing running lane are rejected as they would involve reducing available capacity for other vehicle types).

Significant benefits are expected from the temporary creation of lanes feeding into and out of Junction 6 for the exclusive use of buses and coaches headed to and from the NEC. Through close liaison with the NEC it is envisaged that ATM controllers will have advanced knowledge of events expected to generate significant volumes of traffic.

Junction 6 already has dedicated NEC bound slip roads on both the northern and southern approaches. By designating the use of the converted hard shoulder (Extra Lane) on the sections approaching this junction for buses and coaches bound for the NEC (when demand is high), potential problems associated with queues of buses extending back onto the main carriageway could be avoided. This solution has many similarities with **Exit Queue Management** (Section 5.6). Gantry mounted AMIs will indicate to drivers that the converted hard shoulder is open for traffic. Variable signs will indicate that only buses and coaches for the NEC should use the converted hard shoulder. Variable Advanced Directional Signs (VADSS) may also be required to inform drivers of the altered lane use set-up. The use of signs dynamically designating lanes by destination represents another CORE – **Lane Marshalling** (see Section 5.8). The precise road layout and signing options will need to be examined based on comprehensive traffic data and computer simulation modelling.

![Figure 10: Fixed-time operation Bus Lane in converted hard shoulder, M1, Northern Ireland](image)

Perhaps the bigger benefit however is expected from the designation of a lane for bus and coach traffic leaving the NEC and joining the M42. The north and southbound M42 sections leaving Junction 6 could have the converted hard shoulder designated as a Bus (and Coach) Lane at times when large volumes of vehicles leave an NEC event. In order to ensure the
junction flows as freely as possible, it may also be necessary to give priority to the non-bus traffic joining at Junction 6.

Figure 11: Illustration showing indicative M42 ATM Bus Lane for buses and coaches merging at Junction 6 (north or southbound)

It is suggested that the Bus Lanes running from Junction 6 need not extend all the way to the next junctions in order to deliver the benefits (benefits which are expected both on the surrounding network and to a certain extent also in the vicinity of the Junction 6 merge). Computer simulation modelling based on detailed traffic counts from significant NEC events will be required to design the optimum length of the Bus Lanes extending north and south from Junction 6. It will also be necessary to establish whether at the end of the Bus Lane that the vehicle restriction is removed (so that other vehicle types may enter the Extra Lane) or that the Extra Lane be closed to all traffic (in which case the buses and coaches will need to be able to safely merge into lane 1).
5.8 Lane Marshalling

Lane Marshalling under ATM consists of dynamically designating lanes by destination. Lane Marshalling most often takes the form of dynamic direction signing in association with special events. Experience of such schemes exists in Munich and Hanover in Germany. Prism Signs for giving variable directions are in use on the A2, A7 and A37 motorways near Hanover (White et al 2001b). Traffic bound for events at the Millennium Stadium, Cardiff, is managed using VMS to direct traffic to different routes into the city with associated bus priority and parking provisions (White et al 2001).

![Figure 12: Rotating prism signs to marshal traffic into Trade Fair, Hanover, Germany (A2 and B3 roads respectively)](image)

Lane Marshalling has already been mentioned as a component in support of other COREs (Exit Queue Management and Designated Vehicle Lanes). In each instance, the ability to affect lane usage by directing traffic to use a particular lane for a particular destination is required to deliver the benefits of each CORE.

The recommendation is that Lane Marshalling should be considered for implementation along the length of the M42 ATM Pilot site. However, Variable Advanced Direction Signs\(^2\) (VADSs) are expensive, and it may not be feasible to cover the whole of the ATM section of the M42. Therefore, it may be best to focus on the areas expected to deliver the biggest benefits, which in the case of the M42 Pilot site would be to use Lane Marshalling in the vicinity of Junction 6 to manage traffic bound for and leaving very large events at the NEC (eg. The Motor Show).

In the morning, these may be used to inform bus and coach drivers that the Extra Lane is open for them up ahead and will allow them to move into lane 1 in preparation to join the NEC bound Bus Lane. It may also inform drivers of all vehicles that lanes 1 and 2 are both dedicated exit lanes (due to the large volumes of traffic wishing to exit). Lane 3 can then be signed as a dedicated through lane for non-NEC traffic.

Towards the end of an event, these may then be used to inform drivers of all vehicles on the approach to Junction 6 that lane 1 is closed to through traffic (due to the large volumes of traffic merging) and that lanes 2 and 3 are dedicated through lanes. By giving priority to merging traffic at this location it may be possible to reduce the severity and duration of congestion on the surrounding network. Priority could therefore be given to merging traffic by using gantry mounted lane control signs to close lane 1 between the Junction 6 off and on-slips to allow merging traffic a ‘clear run’ onto the motorway. This would in effect create a dynamic lane-drop lane-gain junction. VADSs (electronic or rotating prism) would also be required on the mainline approach to Junction 6 to advise drivers of the lane designations

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\(^2\) The cost of VADSs was not included within the original Capital Modernisation Fund Bid for the ATM Pilot. Another consideration is the additional loading that these VADSs will put on the lightweight gantries. One solution would be to erect separate VADSs instead of gantry mounting them.
ahead. Computer simulation modelling based on detailed data of previous high levels of traffic leaving the NEC may reveal that a solution which closes lanes 1 and 2 to through traffic may be required.

Figure 13: Illustration of indicative ATM Lane Marshalling at M42 Junction 6 (northbound) to give priority to merging traffic

Lane Marshalling is likely to be switched on either when total traffic exceeds a pre-determined threshold or when it is found or anticipated (from historical data) that heavy flows to specific destinations are occurring, almost certainly in combination with Exit Queue Management and/or Designated Vehicle Lanes.

Care will need to be taken to ensure that instructions given to drivers via VADSs do not contradict other static sources of driver information (such as road markings or fixed signs). Signal sequencing procedures will be required to introduce signing in a way that does not create confusion or unnecessary or sudden weaving. These procedures must take account of any other COREs that are currently (or planned to be) implemented to ensure consistency.
6 Conclusion

As part of their current commission, TRL has produced this document for submission to the ATM Pilot Project Board by Chris Byrne (ATM Pilot Project Sponsor). The document contains TRL’s proposals for the recommended set of COREs that should be developed in detail by the ATM Managing Consultant and implemented at the M42 Pilot site. The document is presented to seek the approval of the ATM Project Board in relation to the proposed COREs.

Section 5 contains the proposals for the 8 COREs for approval by the ATM Project Board. These have been developed by TRL through consultation with HA, a number of its Contractors and with the benefit of a worldwide review of similar technologies previously applied and relevant research. The proposed COREs are:

- **Integrated Incident Management** – co-ordinated deployment of emergency resources and traffic management from an Integrated Control Office in response to unplanned incidents according to pre-agreed plans.
- **Lane Control for Improved Safety and Efficiency during Maintenance** – use of the processes and techniques developed for (and tested under) emergency incident situations applied to planned/routine maintenance and in particular the use of a red cross to provide additional protection to operatives.
- **Variable Speed Limits** - controlling the speed of vehicles by changing local speed limits posted on overhead gantries.
- **Conversion of the Hard Shoulder** – to create an ‘Extra Lane’ which can be made available to traffic at times when the temporary provision of additional capacity would prevent the onset of congestion and queuing.
- **Access Management** - use of traffic signals at those on-ramps that warrant the control of the rate of vehicles entering the main carriageway to avoid the onset of congestion on the mainline.
- **Exit Queue Management** – use of part of the converted hard shoulder at or near an off-ramp to store traffic wishing to leave the motorway for a destination that, at least temporarily, does not have sufficient capacity to absorb it.
- **Designated Vehicle Lanes** – dynamically dedicating sections of the converted hard shoulder for specific vehicle types.
- **Lane Marshalling** – use of variable signs (subject to available funds) to dynamically designate lanes by destination.

The COREs have been developed as far as is sensible to do so in the absence of sufficiently detailed current traffic data from the M42 ATM Pilot site (which is soon expected to become available). The information in support of these proposals will inform the Managing Consultants and will provide them with the desired ‘head-start’.

The COREs are presented in the main as separate schemes, however there is vast scope for deploying more than one individual CORE in unison to resolve a specific problem. The detailed design of the road layout and operational procedures is one of the Managing Consultants’ most significant tasks. It is at that point that all of the issues associated with interactions between Operational Regimes must be addressed and resolved.

The COREs which are not being proposed for the M42 ATM Pilot are also recorded as they may be relevant for future ATM Pilots (Annex B)

This document will also be made available to the Managing Consultant and should be considered as a ‘living document’ that will be developed and refined throughout the M42 ATM Pilot to inform future ATM Pilots.
7 Bibliography


ANNEX A  Operational Resources and Infrastructure

The M42 ATM Pilot requires the development and integration of new and existing technologies in new applications. The ATM Pilot will use real-time data to control traffic using signs and messages on gantries from a dedicated Control office.

In order to facilitate a wide range of Operational Regimes on the M42, the operational resources and infrastructure detailed in this Annex (Sections A1 to A3) are recommended for installation along the length of the Pilot site which runs from the junction of the M42 and M40 (Junction 3a at Umberslade) north to the junction of the M42 and M6 (Junction 7 south of Coleshill). This infrastructure and resource is considered to be sufficient to support a wide range of COREs and is in-line with the ATM concept and ideas detailed in the original Capital Modernisation Fund bid.

Section A4 refers to rather more solution-specific infrastructure which it is recommended are only considered for installation in a targeted manner at specific sites to resolve particular problems (once identified).

A1  Integrated Control Office and Operational Resource
The M42 ATM Pilot is expected to operate from a dedicated Integrated Control Office (ICO) at Perry Barr, with the HA working in continued partnership with the Central Motorway Police Group (CMPG). The control office is likely to contain all of the control systems and real-time traffic monitoring equipment necessary to operate ATM. This partnership approach may result in the HA supporting CMPG in their current operator roles in relation to the functions currently carried out by CMPG (eg. monitoring CCTV cameras and answering emergency roadside telephone calls). The HA and a reduced presence of CMPG personnel may then work in partnership using integrated control systems. It will also be necessary to establish links and working practices with other emergency services and the TCC (Traffic Control Centre project).

A2  On-road resource
It is recommended that ATM operators have available a ‘fleet’ of (HA funded) on-road resources to be deployed in response to traffic accidents and also in support of routine maintenance. These resources will include:

- Mobile Lane Closure vehicles (with rear-end crash cushion protection);
- Vehicles carrying road cones and temporary signs;
- Vehicles equipped with infrastructure repair equipment;
- Recovery vehicles both for light and heavy vehicles.

A3  Infrastructure
A3.1  Gantries
Closely-spaced, inter-visible (approximately 500m apart depending on driver’s lines of sight), lightweight gantries will be required to display lane specific signals and driver information signs. It is recommended that the gantries be designed to support these signals and signs while minimising ‘clutter’ (negative aesthetic effects) and in most cases will span both carriageways. The use of standardised pre-cast gantry foundations is recommended to reduce clutter. Sufficient space will be provided in gantry cabinets for expected future demands.

A3.2  Real-Time Traffic Monitoring
ATM will take advantage of available automatic detection systems although it is more likely to rely on operator confirmation for the safety critical decisions. The ATM Pilot is expected to support the development of more reliable automatic systems.

ATM requires closely-spaced inductive loops (100m is suggested) to give dense coverage of the entire carriageway to provide rapid detection of incidents. Post-incident analysis will make
it possible to investigate the marginal benefits of loop separation.

CCTV cameras are recommended to provide comprehensive coverage. Fixed CCTV cameras mounted on each gantry would provide upstream and downstream coverage of the hard shoulder (i.e., 4 per gantry). The images from these cameras could then be used to support safety critical operational decisions such as opening a closed lane to traffic and to visually inspect a suspected incident location. Image processing software (and incident alert) could also be used for incident detection purposes and will complement the traditional loop based Automatic Incident Detection system. Operator controlled CCTV cameras are recommended for every other gantry.

A3.3 Lane specific signals
An ATM Motorway Indicator (AMI) will be mounted above each lane (including the current hard shoulder) on the lightweight gantries. AMIs will be used for provision of lane control (to advise drivers to leave a lane or to close a lane to traffic) and speed limit instruction. AMIs should be designed to require less maintenance than existing Controlled Motorway Indicators (CMI). This will be achieved in three ways:

(i) AMIs are being designed with higher requirements for reliability than CMIs (in the region of 100,000 hours Mean Time Between Failure);
(ii) AMIs are being designed (in conjunction with lightweight gantries and pre-cast gantry foundations) as ‘plug and play’ applications which means inactive AMIs can be quickly and easily removed from a gantry, replaced with an operational AMI and taken away for repair;
(iii) AMIs will use LEDs instead of fibre optics as used in CMIs. If a section of LEDs fail on an AMI, the display can be shifted slightly so that the failed LEDs no longer fall within the display section.

A3.4 Variable Information Signs
An MS4 electronic message sign should be mounted on the gantry above the current hard shoulder. The sign should be capable of displaying both pictograms and text and will be used to disseminate information to drivers and to support the implementation of the Operational Regimes.

A3.5 Emergency Refuge Areas
Emergency Refuge Areas (ERAs) are recommended as a necessary feature of any ATM scheme where conversion of the hard shoulder to create a running lane is considered. An ERA is an emergency lay-by to provide a safe stopping place for distressed vehicles to await rescue. Each ERA must be equipped with an emergency roadside telephone. The ERAs are likely to be positioned around gantry bases at 500m intervals. Land-take issues may have an impact on the design and location of ERAs along the M42 ATM Pilot site.

A3.6 Fixed Signs and Markings
Novel fixed signs and road marking may have to be designed to facilitate and support the range of Operational Regimes to be implemented at the M42 ATM Pilot site.
A4  Solution Specific Infrastructure
This section describes the additional infrastructure required for specific ORs or elements of ORs.

A4.1  Enforcement Systems
Real-Time Traffic Monitoring may reveal that driver compliance levels are such that (semi) automatic enforcement systems are required to improve compliance and so deliver the benefits expected from a CORE.

A4.2  Variable Advanced Direction Signs (VADSs)
These are signs that may be required in support of a number of COREs including Lane Marshalling, Access Management and even running a Converted Hard Shoulder. These could be rotating prism signs or alternatively electronic Variable Advanced Direction Signs (VADSs). The cost of these items was not included within the original ATM Pilot Capital Modernisation Fund Bid.

A4.3  Access Management
COREs from the Access Management family would require additional infrastructure over and above that which is currently recommended and expected to be installed along the length of the Pilot. Access Management requires infrastructure to automatically and remotely control the flow of vehicles joining a motorway at an on-slip. In the case of the relatively familiar variant known as Ramp Metering, this will include traffic signals to instruct drivers when they may proceed to merge with the main carriageway. Should access to the motorway need to be temporarily prohibited at a particular junction (eg. a severe incident means the motorway needs to be closed), then automatic barriers may be required to prevent drivers joining the on-slip at all.
ANNEX B  COREs to be considered for future ATM Pilot sites

Section 5 contains the COREs proposed for use at the M42 Pilot site. Annex B outlines the COREs that are not proposed for deployment under the M42 ATM Pilot project (see bulleted list below). Each CORE is presented below with a description and justification of why it has been excluded from further consideration for the M42 Pilot. These COREs may be suitable for deployment at different ATM sites in the future or at the M42 Pilot Site in years to come.

- Tidal Flow;
- Plus Lanes;
- Heavy Goods Vehicle (HGV) Lanes Including Climbing Lanes;
- High Occupancy Vehicle (HOV) Lanes;
- Access Control;
- Contra-Flow;
- Variable Road Markings;
- Lane Specific Speed Limits.

The sections below contain a brief description of each of the COREs and a justification of why they are not appropriate solutions for use under the M42 ATM Pilot.

B1  Tidal Flow
Tidal Flow systems allow the dynamic opening of an additional lane to traffic when demand is sufficiently high. Due to the ‘tidal nature’ of the peak demand, the lane is reversible so that it can allow passage of traffic in either direction to meet demand (but only one direction at a time). Tidal Flow systems in the UK include the A38(M) Aston Expressway in Birmingham and the A38 Saltash Tunnel in Cornwall. White et al. (2001b and c) describe visits under this commission to Tidal Flow sites in Hanover, Germany and Amsterdam, The Netherlands (see Figure 14 below).

![Figure 14: Tidal Flow schemes on B6 Hanover (left) and A1 Amsterdam (right)](image)

Tidal Flow is not currently recommended for use under the M42 ATM Pilot as there is no evidence (based on available data and operational HA and CMPG experience of the M42) to suggest that the M42 experiences a significant Tidal Flow. There are at least 2 heavy bridges with central supports along each section of the M42 Pilot site. These would place an immediate ‘obstacle’ in the way of constructing a central reservation Tidal Flow lane should future demand patterns necessitate the creation of one.

B2  Plus Lanes
Plus Lanes are created by repainting the carriageway to form an additional running lane while retaining the function of the hard shoulder. This is achieved by narrowing some of the lanes including the hard shoulder. The additional offside lane can be dynamically opened at peak times to provide additional capacity to reduce recurrent congestion and queuing. As Plus Lanes are normally narrow lanes, the additional lane remains closed to traffic at non-peak times (driver comfort and safety in narrow lanes being a risk). Reduced speed limits are
required along the Plus Lane section at all times, with more severe restrictions when the Plus Lane is open to traffic. Plus Lanes are used in the Netherlands (White et al., 2001c) and are seen by Dutch Road Authorities to present a more attractive option than Conversion of the Hard Shoulder where there is sufficient carriageway width available.

![Figure 15: Plus Lane on A27, Utrecht, Netherlands shows 'Plus Lane' open (left) and closed (right)](image)

While there are areas along the M42 ATM Pilot site which are prone to regular congestion and queue formation, Plus Lanes are not recommended for the M42 ATM Pilot project for four reasons:

1. There is limited experience of using Plus Lanes in the UK and, as is stated in WS Atkins (2000), “safety issues associated with narrow lane running may be harder to resolve than those associated with reduced or no hard shoulder”. UK public perception of Plus Lane schemes is also a concern.
2. High accident rates observed (during the widening of the M25) have been attributed to the narrow lanes used during construction.
3. Although the re-painting will ‘create’ an additional lane, for the majority of the time vehicles will not be allowed to use that lane (located on the offside - traditionally where the fastest drivers will travel). This may result in the public perceiving Plus Lanes negatively as a ‘take a lane’ scheme rather than a ‘create a lane’ scheme.
4. The M42 carriageway at 14.5m wide is insufficiently wide to allow the necessary re-painting to support the creation of an additional lane (based on the Dutch 3-lane model, 16.5m would be required).

**B3 Heavy Goods Vehicle (HGV) Lanes Including Climbing Lanes**

An HGV Lane is a lane dedicated to the use of that type of vehicle only. This will almost certainly be the nearside lane of a carriageway (or a converted hard shoulder). Depending on the situation, HGVs may or may not be precluded from using alternative lanes (under an HGV overtaking ban), but other traffic is precluded from using the HGV Lane. The aim of the HGV Lane is to reduce conflicts between HGVs and other traffic. A Climbing Lane is specifically intended to enable traffic to overtake slow lorries at long sections with steep inclines.

It is not felt that there are sufficient proportions of HGVs using the M42 Pilot site to justify the creation of an HGV lane – the potential benefits are expected to be small and there are issues around creating platoons of HGVs. There are 3 climbing lanes along the M25 affording operational experience, but with no significant inclines along the M42, HGV Climbing Lanes are not recommended for implementation at the Pilot Site.

**B4 High Occupancy Vehicle (HOV) Lanes**

HOV Lanes are part of the Designated Lanes (see section 5.7) family of COREs. An HOV Lane is designated for vehicles with more than a single occupant; variants include Car Share Lanes and Bus Lanes. The main objective being to provide improved and more reliable travel times for occupants of HOVs. While HOV Lanes are common in the USA, only a small
number of schemes exist in Europe (White et al., 2001), including the offside M4 Bus Lane (see Figure 16). Experience suggests that HOV Lanes do little to influence travel behaviour by encouraging modal shift and that the M42 is not currently used by local buses which could benefit from a dedicated lane.

Figure 16: Permanent offside Bus Lane, M4, England

[Note. At some Ramp Metering sites in the Netherlands, buses are given priority access to a dedicated bus lane which is not controlled by access signals].

B5 Access Control
Access Control is a member of the Access Management family of COREs. Access Control has the strict meaning here of automatically closing certain on-ramps to all or certain classes of traffic under certain conditions (eg. time-of-day based or under severe incident conditions) using automatic barriers.

Access Control is not recommended for implementation along the M42 Pilot Site as the implications for re-routing and consequent impact on the surrounding network is not yet well understood and could be severe. Work being carried out by Southampton TRG is expected to develop understanding of Access Control as a potential CORE in the future.

B6 Contra-Flow
The future of ATM may include solutions to facilitate the dynamic creation of contra-flow lanes. This may be appropriate for both unplanned and planned incidents or even for a Contra-Flow Tidal Flow scheme. Contra-Flow currently requires manual removal of a section of the central reservation barrier at paved ‘cross-over’ points. Future applications of available and emerging technologies may facilitate an automatic system such as currently is used in Hanover (White et al, 2001b). Tidal Flow Contra-Flow may offer a significant enough benefit to justify the development and installation of the necessary technology, however it is not currently recommended for implementation along the M42 ATM Pilot Site as no specific ‘tidality’ problems have been identified that may be resolved using Contra-Flow techniques.

B7 Variable Road Markings
Variable Road Studs have been deployed in many countries in a wide variety of traffic management roles (White et al., 2001). In the Netherlands technologies are being piloted to replace painted lane markings with LED lane markings which creates the possibility of remotely re-configuring the lane markings and so the road layout. There will be a great many applications for Variable Road Markings within the ATM environment once the technology has been fully tried and tested (Strong et al., 2000).
B8  Lane-specific Speed Limits
The current M25 Controlled Motorways Indicators can be manually set under incident conditions to show different speed limits above adjacent lanes – this is the essence of Lane-specific Speed Limits (LSL) (Butler, 2000). LSL could also be implemented using ATM infrastructure. The report by Butler (2000) outlines feasible traffic management applications for LSL which although not recommended for the current M42 ATM Pilot may be worthy of further scrutiny when the M42 ATM Pilot has proven the ATM concept.
ANNEX C  A DAY IN THE LIFE OF THE M42 ATM PILOT

C1  Introduction
The description in this Annex is presented as a vision of the Operational Regimes that might be introduced on the M42 ATM Pilot site. It is intended to act as an illustration of the ATM environment and is based on the assumption that the Operational Regimes that have been recommended to the Project Board are available for implementation on the M42 ATM Pilot.

C2  A day in the life of the M42 ATM Pilot

A typical Tuesday in November 2007

05:45
Temporary increase in traffic around junction 6 associated with the start/end of shifts at the NEC and Birmingham International Airport. Conditions monitored by the Integrated Control Office (ICO) operators. Pre-planned changes to the signal timings on the Local Authority roundabout ensure that no problems are encountered on either the urban or motorway network.

06:00
Traffic flows gradually begin to increase, situation monitored by ICO Operators.

06:05
Prior to the start of the day shift (06:30) on-coming crews including ICO Operators, Central Midland Police Group (CMPG) Officers, MAC staff and breakdown crews enjoy breakfast within a communal area of the ICO canteen. As well as discussing the weekend football results there is an informal review of the previous days’ activities and discussion of the day ahead. These informal discussions are all part of the partnership approach to ICO operations.

06:30
ICO Operators carry out pre-morning sweeps/checks of ATM systems prior to the build up of the main traffic flows.

These routine checks include:

- Contacting TCC to check conditions and diversions that may impact upon the M42 Pilot section.
- Reviewing overnight fault clearances and passing outstanding faults to maintenance organisation.
- Visual checks of hard-shoulders and main carriageways for debris.
- Confirming that incident recovery crews are on-station.
- Reviewing the day’s operational diary containing information on pre planned events that will impact on operations.

06:45
As traffic levels steadily increase, Variable Speed Limits automatically activated by rising flows and reducing speeds on the North and Southbound carriageways of the M42 between junctions 5 and 6. Mandatory 60mph limit set to control traffic and delay the on-set of flow breakdown. In response to steadily increasing traffic flows and the introduction of Variable Speed Limits along sections 5 to 6, Access Management systems switch on at junctions 4, 5 and 6, and are centrally co-ordinated to regulate the flow of traffic joining the M42. The settings used for this co-ordination are those recommended to the ICO Operator by the Network ATM Supervisory Sub-system (NASS)

07:00am
Traffic flows continue to increase. Variable Speeds Limits of 50mph now in operation between junctions 5 and 6 with 60mph speed limits in place over the remaining length of the M42 pilot section. Mandatory speed limit of 60mph automatically set by flow and speed levels
on the lead into the southern section of the Pilot section. The speed limits reduce lane changing and improve merging efficiency around the M42/M40 interchange. **Driver information** signs set on the M42, M40 and M6 advising drivers of conditions along the M42 together with information on **predicted journey** time to the NEC and Birmingham International Airport.

**07:10**  
Within the **ICO**, Operators are alerted by a **NASS** prediction that extra capacity will be required on both carriageways between junction 5 and 6 and the system recommends that the **ICO** Operators should allow traffic to use the **Converted Hard Shoulder** (or **Extra Lane**) within the next 15 minutes to avoid serious congestion. Operator commences semi-automated procedures to confirm that the hard shoulder is free from blockage and debris using the CCTV cameras and Automatic Monitoring Systems.

**07:11**  
**Access Management Systems** at junctions 4, 5 and 6 continue to regulate the flow of traffic joining the M42. 50mph mandatory speed limits are now in place along the whole of the M42 supported with appropriate messages on the ATM driver information signs.

**07:12**  
The **ICO** Operator completes checks for opening the hard shoulder between junctions 5 and 6 and invokes traffic plan to allow the **Conversion of the hard shoulder** into a running lane between junctions. Drivers are advised of the availability of the hard shoulder as a running lane with mandatory **Variable Speed Limits** now being displayed on the Advanced Motorway Indicators (AMI's) above the **Extra Lanes** as well as above each of the original running lanes. The signalling is supported by the display of pictograms and text messages on the driver information signs.

**07:20**  
Flow levels continue to rise along the M42. **NASS** recommends to **ICO** operators that an extra lane is required within the next 15 minutes on northbound section of the M42 between junctions 4 and 5 to avoid serious congestion. **ICO** operators instigate agreed procedures for the introduction of the extra lane in this section.

**07:30**  
Traffic volumes are high but traffic continues to flow smoothly. Mandatory **Variable Speed Limits** of 50mph now in place along the whole of the pilot section and on the approach to the M40/M42 interchange. **Access Management Systems** continue to regulate the flow of traffic joining the M42, with signal timings being co-ordinated with local authority traffic signals to minimise stops and delays to traffic and ensuring that traffic queuing on the ramps do not impact upon the local road network.

Drivers are being directed to use the converted hard shoulder between sections 4 to 5, and 5 to 6 on the Northbound Carriageway and sections 5 to 6 of the Southbound carriageway. **Integrated Control Room Operators** continue to monitor traffic conditions using comprehensive CCTV and **Automatic Incident Detection** systems.

**07:35**  
Junction 6 Southbound off-slip queue starts to extend and threatens to start impinging on the M42 Southbound main carriageway. Automatic Systems alert **ICO** Operator of the situation and Operator implements **Exit Queue Management** procedure to ‘move’ slow moving slip road queue to the hard shoulder. **Exit Queue Management** arrangements are supported through the setting of **Variable Advanced Direction Signs (VADS)** on the approach to Junction 6. **Exit Queue Management** provides additional capacity both for exiting and through traffic and ensures traffic continues to flow smoothly. **Local Authority** advised through dedicated link that **Exit Queue Management** in operation on Junction 6 off-slip and **Local Authority** amend signal timings to help accommodate the predominant flow of traffic from the motorway onto the urban road network.
Access Management, Variable Speed Limits, Exit Queue Management continue to manage traffic flows on the M42. ICO Operators advise TCC, road users and local media (through the M42 ATM web-site) of conditions along the Pilot site. Operators continue to monitor the situation.

Operators alerted by automatic detection system of slow moving vehicle in lane 1 on the southbound carriageway between junctions 5 and 6. MIDAS automatically sets 40mph speed restrictions across the southbound carriageway of the M42 upstream of the slow moving vehicle. CCTV Cameras automatically pan and zoom in on the area which generated the alert, and images are displayed to ICO operators. Vehicle moves to Emergency Refuge Area (ERA). Driver contacts ICO using Emergency Roadside Telephone (ERT) located in the ERA and advises ICO Operator that he thinks he has run out of fuel! Driver told to remain in ERA and await the despatch of roadside assistance. MIDAS detects that traffic flows and speeds have returned to normal levels in the area of the original alert and speed limits automatically revert to Mandatory 50mph. ICO Operator contacts motoring organisation using dedicated telephone link and requests roadside assistance for driver.

Traffic flows peak and begin to decline slowly. Queuing around junction 6 reduces and automatic detection systems advise ICO Operators that Exit Queue Management can be removed at Junction 6. Operators follow agreed procedure for the removal of the Operational Regime. Driver with broken down vehicle awaits recovery from ERA. Traffic moving freely along all sections of the M42 pilot site. Variable Speed Limits of 50mph remain in place at location where hard shoulder has been converted into a running lane. As flows decline in other sections of the M42, speed limits increase up to the national speed limit. ICO Operators continue to monitor situation closely.

Traffic Flows are now reducing and NASS advises ICO Operators that extra capacity provided by the conversion of the hard shoulder can be removed without creating congestion. ICO Operators start procedure for the removal of traffic from all sections of the converted hard shoulder.

Use of the converted hard-shoulder has now been removed from all sections of the M42. Access Management systems at junctions 4, 5 and 6 automatically switch off due to the reduction in traffic flow.

The increase in traffic speeds and reduction in flows result in the removal of the Variable Speed Limits from all sections of the M42.

Alarm sounds in the ICO. MIDAS automatically sets 40mph limits upstream of incident and warning sign to advise approaching drivers. CCTV camera automatically zooms in on incident and images brought up on Operator Console. Vehicle has collided with central reserve and is blocking lane 3 on the northbound carriageway of the M42 between junctions 3a and 4. ICO Operator assesses situation and selects appropriate Incident Management Plan, which in this case closes lane 2 and 3 to traffic and makes lane 1 and the hard shoulder available to traffic. While one ICO Operator focuses on managing the incident, another ICO Operator contacts the emergency services and provides details including incident type and location. MAC contacted, via dedicated radio channel to effect repair to damaged central reservation and to assist in the removal of the vehicle and the re-opening of the carriageway.

ICO Operators continue to closely monitor the incident in case more onerous restrictions are necessary. Mandatory 50mph speed limits imposed on opposite carriageway to avoid accidents from rubber necking. Information signs set at appropriate locations to advise drivers.
of incident and slow moving traffic. **TCC** advised of situation (through M42 web-site) and set appropriate diversion strategy to minimise the amount of traffic using the northbound section of the M42.

09:15 **CMPG** Officers in attendance securing the site and checking for casualties. Lane and speed restrictions remain in place. Traffic begins to build up behind incident. Ambulance arrives on site shortly afterwards and takes single casualty with minor injuries to hospital.

09:20 **MAC** recovery crew arrives on site and following approval of **CMPG** officers commences removal of damaged vehicle. Further **MAC** resources arrive on-site to affect repairs.

09:45 Damaged vehicle removed, carriageway cleared of debris and the necessary repairs completed to roadside infrastructure. Operators advised that it is safe to re-open lanes 2 and 3 to traffic. Operators commence the procedure for re-opening the lanes and closing the hard shoulder.

10:00 Traffic flows back to normal with traffic moving freely. Motoring organisation arrives on-site to provide assistance to driver that ran out of fuel earlier in the morning peak.

14:30 Alarm sounds in the **ICO** advising Operator that a vehicle has been detected in an **ERA**. CCTV automatically zooms in on **ERA** and images displayed on Operator console. Shortly afterwards, alert call received from the motorist broken down in **ERA**. Breakdown service dispatched.

15:00 **Variable Speed Limits** activated by rising flows and reducing speeds. 60mph limit set to control flow of traffic and delay or prevent on-set of flow breakdown in critical areas.

15:10 Alarm sound in **ICO** advising Operator of AMI fault, failure of an LED array has resulted in the signal auto-switching to a fall-back mode in which signal displays requested signal setting but not to the agreed standard required for enforcement. Drivers are unaware of the problem due to the fault tolerance built into the equipment however enforcement is suspended on this site until the fault has been rectified. **ICO** Operator raises a fault report for the repair of the faulty signal outside of the peak period when access can be gained to the signal without disrupting traffic flow (after 00:30).

15:45 60mph **Variable Speed Limits** extends along whole length of Pilot site.

16:00 – 19:15 Similar combination of **Variable Speed Limits**, **Extra Lane and Access Management** implemented as for morning peak (in response to local conditions). No incident so all measures removed by 19:15.

23:15 Procedures implemented to open **Extra Lane** joining (north and southbound) at Junction 6 for **Buses** as part of pre-planned **Operational Regime** to allow easy flow of buses and coaches leaving a concert at the NEC. **Lane Marshalling** implemented to clear lane 1 of mainline traffic to allow easy merging by joining (bus and non-bus) traffic.

00:30 Bus levels reduce and therefore procedures implemented to close both **Bus Lanes** at Junction 6. ATM system remains operational. Arrangement made for the repair of the faulty AMI sign. **ICO** operators continue to monitor situation.