‘ATM TO MANAGED MOTORWAYS’ – DELIVERING OPERATIONAL BENEFITS TO ROAD USERS THROUGH THE INTRODUCTUION OF INNOVATIVE TECHNOLOGY SOLUTIONS

Authors:

Paul Unwin,
Senior Project Manager, Highways Agency
Highways Agency, 4 Broadway, Broad Street, Birmingham. B15 1BL
Tel: +44 (0) 121 6788180, Mobile: + 44 (0) 7766 794884

Paul Marsh,
Principal Consultant, Traffic Operations and Technology, Mouchel
Mouchel, Export House, Cawsey Way, Woking, Surrey, GU21 6QX
Mobile: +44 (0) 7976 456433

1. ABSTRACT

This paper considers the approach that is being developed to address the issues and challenges surrounding operational safety and network capacity in the UK. The Active Traffic Management (ATM) Pilot project on the M42 between Junctions 3A and 7 commenced operation in September 2006 and became the first motorway in the UK to dynamically use the hard shoulder as a ‘normal’ running lane. The ATM Pilot project has led the way in new approaches to address the issue of congestion and provides effective and innovative technology solutions. The Pilot has demonstrated that hard shoulder running is successful in reducing congestion, improving the predictability of journey times and increasing motorway capacity.

The success of the ATM Pilot has led to the UK Government announcing an additional 340 miles of hard shoulder running to be rolled out across the strategic road network, the concept has developed from ATM and is now known as ‘Managed Motorways’. The paper considers how the effective use of technology, to operate the network, can be balanced with the existing highway footprint in order to address congestion, safety and environmental concerns.

The paper focuses on the operational benefits that the introduction of Managed Motorways will bring to the network in order to meet customer needs for improved journey time reliability. Also, delivering Government targets for increased capacity, reduced environmental impact and maintaining, or improving where possible, the safety of all road user populations. Evidence is also provided to support these statements from the experience gained through the success of the ATM Pilot. The re-focusing of roads investment on the enhanced use of technology that will deliver tangible, value-for-money benefits to the travelling public is also reviewed. The paper demonstrates that the appropriate use and operation of technology can lead to compliant driver behaviour that will bring significant benefits to the network.

2. INTRODUCTION

Motorway traffic in the UK has been growing consistently at around 1.5% per annum. While high fuel prices and economic difficulties may slow this growth in the short term, it is likely that in the longer term traffic will continue to grow at a similar rate. While our motorways are increasingly congested, there remains the potential to unlock capacity in these roads – one method is through the use of the hard shoulder as a running lane.

It has long been recognised that stopping on the hard shoulder of a standard motorway involves considerable risk, and should therefore be discouraged in favour of more innovative and safer options.

Since the building of the first UK motorway in 1959 the provision of a hard shoulder has been considered a necessary feature and provides for lack of vehicle reliability. The hard shoulder is now seen as the only viable option for providing emergency vehicle and maintenance access; but with technology allowing better control of the motorway environment and improvements in vehicle reliability and performance, this concept can now be challenged.

Based on the lessons learnt from the M42 Active Traffic Management (ATM) Pilot, the UK government is now confidently focussed on making 'better use' of existing land within the current highways boundary before considering more expensive widening schemes that may have a greater and undesirable impact on the public and environment during construction and operational phases.

In beginning to better understand and address these issues the M25 Controlled Motorways scheme was developed on the M25 Motorway providing a simple technology solution that was delivered quickly. Evidence from the M25 Controlled Motorway informed the development of the concept of 'Active Traffic Management' and subsequently the 'Managed Motorways' concepts in order to deliver effective network operation balancing the use of technology and existing land with the recognised need to address congestion and safety concerns in a sustainable and managed way. The evolution of these schemes is shown below in Figure 2A.

This paper considers the approach that has been, and is continuing to be, developed to tackle the challenge of managing motorway capacity in the UK against ever increasing demand, and how this has paved the way for a new way of thinking, providing effective and innovative solutions.

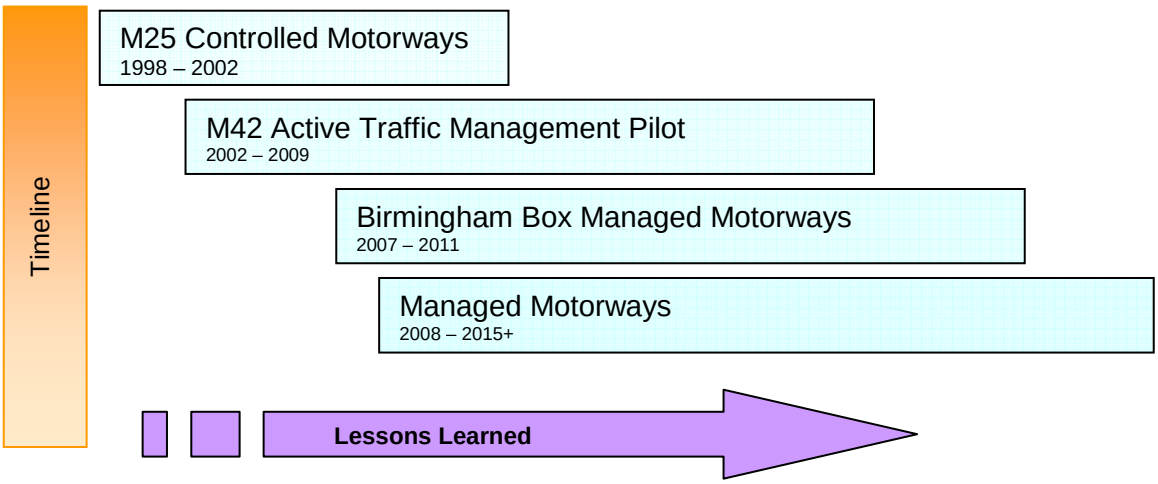


Figure 2A – Evolution of Managed Motorways

Prior to implementation, each of the schemes discussed in this paper had one or more of the following attributes that resulted in the need for the improvements:

- Regular congestion;
- Insufficient capacity;
- Poor or inconsistent journey times and / or journey time reliability; and
- Poor safety record.

Building on the M25 Controlled Motorways project, the concept of Active Traffic Management has been developed through a comprehensive trial. The objectives of the trial were to prove the business case and technology for rollout elsewhere on the network and to demonstrate that, through the use of technology, the concept could provide a cost effective alternative to conventional widening schemes. The concept of using the hard shoulder as a dynamic running lane for the first time on the UK network was initially controversial with many stakeholders; however through robust safety and operational design management the scheme has proven a great success and is the foundation for the current Managed Motorways thinking.

The paper considers the operational benefits that the introduction of Managed Motorways will bring to the network in order to meet customer needs for improved journey time reliability whilst also delivering Government targets for increased capacity, reduced environmental impact and maintaining, or improving where possible, the safety of all road user populations.

3. THE JOURNEY SO FAR

An overview of some of the key influential technology projects is provided below demonstrating how, through innovative thinking, the use of the latest technology and by challenging industry standards, new benchmarks can be set that offer efficiencies and tangible benefits to the road user.

3.1 M25 Controlled Motorways – 1998 to 2002

Controlled Motorways (now known as Variable Mandatory Speed Limits – VMSL) was designed to provide additional control over traffic in a known congestion hotspot on the M25. By installing gantries at a nominal 1000m spacing (supporting lane signalling with the facility to set mandatory speed limits and carriageway message signs) in conjunction with an inductive loop detection system, traffic speeds could be controlled and 'start-stop' behaviour reduced. Through the reduction in flow breakdown an increase in capacity was also created, with reduced headways between vehicles. Mouchel designed and implemented the scheme and positive results were achieved, including a 15% reduction in personal injury accidents, while it was recognised that the concept could be further developed to offer improved solutions.

3.2 M42 Active Traffic Management Pilot – 2002 to 2009

There was a realisation within the Highways Agency towards the end of the 1990s that for congestion to be effectively addressed without invoking traditional major project widening schemes, alternative methods that made better use of the existing road spaces would have to be found. Such alternative methods would need to offer better value for money than traditional more expensive widening schemes that may have a greater and undesirable impact on the public and environment, particularly during construction. It was as a result of this realisation and subsequent innovative design concepts that the M42 ATM Pilot was developed, to test for the first time in the UK utilisation of the motorway hard shoulder as an additional running lane during peak periods.

The UK Highways Agency appointed Mouchel as Managing Consultant to develop the concept of Active Traffic Management (ATM) and deliver hard shoulder running for the first time in the UK.

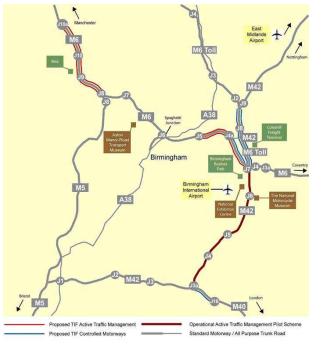
The ATM trial provided gantries at a nominal 500m spacing to improve the control of traffic and introduced technology to the network including advanced lane based indicators (AMIs) and the latest Message Signs (MS4s) combined with 100m Motorway Incident Detection and Automatic Signalling (MIDAS) technology to provide a unique driving environment.

The spacing of gantries at 500m enabled the "intervisibility" of the signs and signals on the overhead gantries. After passing a gantry displaying a speed limit the road user can see the next gantry with a speed limit displayed. It is now safe to say that the success of Managed Motorway schemes is highly

dependant on compliant driver behaviour in relation to speed limits and appropriate and relevant information being delivered to the driver at a timely rate so as not to cause overload or leave the driver in doubt as to what to do. This has led to the development of the concept of “intervisibility” of signals and message signs. By consistently keeping the driver informed of speed limits and a message stating the reason for the limit, a high level of compliance has been obtained, which has led to a reduction in casualties.

A hard shoulder management system was developed, enabling control centre operators to open the hard shoulder to traffic during congested periods and incidents. The project became fully operational, with a maximum speed of 50mph during hard shoulder running, in September 2006. The scheme has proved a great success in the UK, showing considerable benefits and meeting all its objectives, leading to the UK Government reconsidering its approach to the entire road building and widening programme. The benefits achieved are reported in the 12 Month Monitoring and Evaluation report [3]. ATM provided the additional capacity at around one fifth of the cost of widening.

3.3 Birmingham Box Managed Motorways – 2007 to 2011



In 2007 funding was secured to expand the project around the Birmingham Motorway Box. The technology and infrastructure design was further developed using lessons learned from the Pilot, leading to an increased gantry spacing of nominal 800m with MIDAS provision at 400m intervals either side of the gantries. The “intervisibility” of the signs and signals was a key feature on the ATM Pilot that was considered essential tor the successful operation of the Birmingham Box Managed Motorways scheme. Construction commenced on site in summer 2008 and the first phase is programmed to become operational by the end of 2009 – only two years after the project design contract was awarded.

3.4 Managed Motorways – 2008 to 2015+

In October 2007, the UK Transport Secretary announced that a comprehensive review of the roads improvement programme was to be undertaken. Managed Motorways builds on the lessons learned from the Pilot and Birmingham Box schemes to feed into a full review of the roads improvement programme. In July 2008 a £6bn programme was announced to fund improvements to national strategic roads in England in the period up to 2014. The Department for Transport (DfT) Command Paper [6] considered key aspects of the roads improvement programme, with considerable merit being given to the Managed Motorways.

Since the issue of the DfT Command Paper, the DfT and Highways Agency have undertaken detailed development of the design, costs and benefits of hard shoulder running when compared to traditional motorway widening. In January 2009 the DfT study [7] considered how the concept of hard shoulder running can be developed for more widespread use across the network and looked at how the 'Managed Motorways' concept will be introduced to the network. The study also set out the programme of other capacity enhancements on the national network.

4. OPERATIONAL & TECHNICAL INNOVATION

The success of the ATM concept has only been possible through operational and technical innovation while utilising best practice from the latest international scheme developments. There was no control system capable of delivering the requirements, so this had to be developed. The message sign and signal technology was not fully proven, and significant hurdles had to be overcome to improve reliability and create robust performance. From day one the scheme was led by network operational and safety requirements, and not limited by technology frailties.

The Success Factors are considered to be as follows:

- Operations led design process
- Stakeholder management
- Robust safety management
- Design for Maintenance
- Challenge the standards

The key elements of these success factors are explained in Table 4A below:

Key Success Factor	**Explanation**
Operations led design process	• Start by developing a robust understanding of your network. • Understand operational objectives of a project before the design can begin. • Applying standard rules to any area of the network and assuming one solution fits all can lead to an incorrect design solution
Stakeholder management	• Stakeholders need to be managed appropriately depending on the likely impact a scheme will have on them • Stakeholders can be major allies, their views and feedback should be fed into the design process from the start and their ongoing engagement can be very useful to feed into design decisions.
Robust safety management	• Any scheme that challenges standards and uses unproven systems or operational methods is going to be challenged.

	• Robust safety management is critical to success and again can prove extremely beneficial in informing decision making throughout the design process, and in providing an auditable and defendable solution. • The safety management should allow the capability to assess any individual element, and understand what the impact of this is on the scheme.
Design for Maintenance	• In the UK, Construction Design Management (CDM) regulations place major emphasis on designing for maintenance after implementation – and also considers the longer term design life of the scheme. • Consider the design from a whole life maintenance perspective, the use of technology as an alternative to widening will encounters a number of challenges. • Road worker and road user safety is clearly paramount and must be a key consideration when designing for maintenance.
Challenge the standards	• Traditional standards may not be applicable to meet operational requirements - challenging the standards does not mean that the standards are disregarded, but where suitable mitigation is in place and where robust analysis has been undertaken, this should be considered a positive and necessary move.

Table 4A: Key Success Factors

The key success factors need to be fed into the design process. It may seem an obvious starting point but the operational objectives of a project must be clearly understood before the design process can begin. The diagram below gives an indication of the thinking process that should be undertaken in order to identify and agree the operational approach to be taken to deliver the expected outcome.

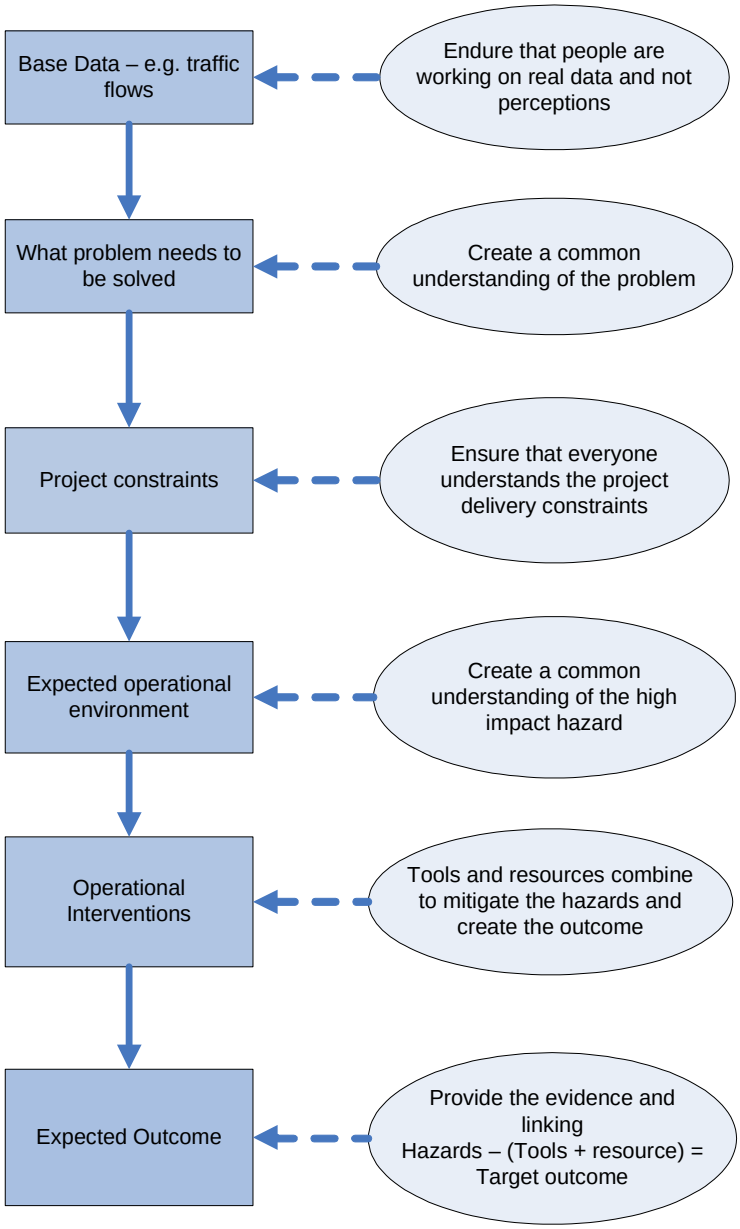


Figure 4B: Process to Agree Operational Approach

5. OPERATIONAL BENEFITS OF MANAGED MOTORWAYS

The introduction of the ATM concept on the M42 has resulted in a number of Operational Benefits. These include the improvement in Journey Time reliability and increased throughput of traffic as a result of the additional capacity through opening the hard shoulder. It is anticipated that the introduction of Managed Motorways on sections of congested motorways around the UK will see similar benefits to those found on the ATM Pilot. The development of Managed Motorway has opened the thinking on what can be achieved with the network, allowing the Highways Agency to consider how the network can be managed as a whole, rather than as individual elements. Flows on local roads can be fed into systems enabling predictive signal setting, preventing the congestion from occurring in the first place rather than dealing with it once it appears – this is perhaps the greatest area for future

advances in technology and operational management to tackle, and that thinking has started.

Analysis of several types of traffic data was undertaken on the ATM Pilot and from this analysis the impact on the key government targets can be assessed.

5.1 Journey Time Reliability

This is a key consideration for the driving public as surveys have indicated that 'not knowing' the time a journey is going to take is a major frustration. Therefore making Journey Times reliable day in, day out – even if the average journey time increases by a small percentage – is a key benefit that Managed Motorways will bring to the road user.

Analysis of traffic data for the initial 12 months after the ATM Pilot became operational showed that journey time variability decreased by an average of nearly 16% over all links for all days when the system was operational, with a drop of 60% for the Friday PM peak, which is often the busiest period of the week, and hence the period which suffered the most from congestion [3].

Customer surveys have shown that a small increase in average journey time was acceptable, given the significant increase in Journey Time reliability which was seen as key in giving a relaxing journey. In October 2008 the Pilot scheme increased the hard shoulder operational speed from 50mph to 60mph, so as to maximise the benefits in terms of traffic conditions, and especially those of journey time and journey time reliability. The HSR60 (hard shoulder running at 60mph) scheme built upon the benefits of the initial Pilot scheme by being less restrictive to drivers at the start and end of peak periods, where traffic conditions warranted hard shoulder running, but could accommodate the higher speed.

Another good indicator of this more reliable journey that Managed Motorways aims to provide to the driver is that of the frequency of the traffic dropping below 25mph, thus resembling total flow breakdown. Prior to the implementation of the ATM Pilot scheme this was averaging approximately 0.4 instances per hour during the peak periods. This has now decreased to almost no instances per hour. This is despite the fact that traffic flows have increased by around 7% during the period of comparison [3].

5.2 Increased Capacity

A great deal of the improved Journey Time reliability above comes from the increased capacity that a Managed Motorway can promote. That the traffic is speed and lane controlled (thus reducing weaving which reduces capacity) helps increase the road's potential capacity. Having a highly controlled speed environment means that headways can be safely reduced as unpredictable braking from drivers is very much reduced.

The traditional value for mid-link per-lane capacity is 1800vph, based on a 2 second headway. Flows of in excess of 2000vph per-lane were regularly seen

on the ATM Plot section. With the introduction of hard shoulder running the overall capacity of the motorway increases significantly, even if the hard shoulder is not fully, or evenly, utilised when compared to the standard three lanes.

4 lane Variable Mandatory Speed Limits have improved the distribution of traffic by reducing the differences in lane utilisation percentage between lanes. On average, the operating regime has improved the lane utilisation (i.e. becomes closer to uniform distribution of traffic between lanes) by a small percentage.

The average utilisation of the hard shoulder is approximately 12% [3] which is likely to be due to the messages displayed on the overhead gantries advising that the hard shoulder is for exiting traffic only. This gives a good distribution between lanes reducing the likelihood of flow breakdown occurring.

More research is needed to realise exact figures for capacity but it is clear that Managed Motorways does lead to an increase in capacity and throughput.

5.3 Safety

Analysis of speed differential between lanes and the lane utilisation analysis has shown that four lane variable mandatory speed limits smoothes the traffic operation on the ATM section and this has been reflected in safety related statistics seen so far. The M42 ATM Pilot is now considered to be one of the safest sections of motorways in Europe (albeit based on limited data).

Analysis (again based on very limited data) on the Pilot scheme has shown that the average number of Personal Injury Accidents has reduced from 5.08/month to 1.83/month when compared to the before ATM scenario [3].

The analysis of speed differential between lanes demonstrated the benefit of 4 lane Variable Mandatory Speed Limits in keeping traffic conditions consistent between lanes and therefore potentially improving safety. Additional analysis has confirmed that Variable Mandatory Speed Limits have reduced the speed differential between lanes. Generally, the average speed profile on the hard shoulder is comparable to other lanes. This is an indication that there are no major safety concerns with regard to the usage of the hard shoulder.

5.4 Compliance

The level of speed compliance on the ATM Pilot has resulted in the safe and successful operation of the scheme where controlling the speed and behaviour of traffic has enabled the realisation of traffic benefits.

Figure 5A below shows the compliance since the Pilot scheme went live three years ago:

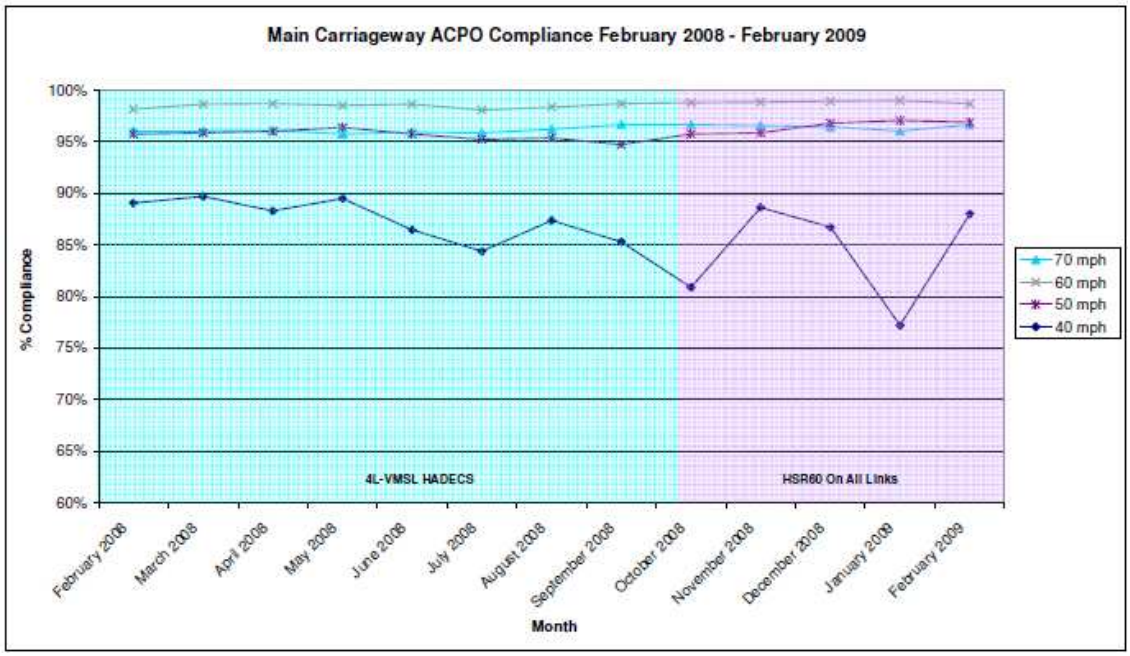


Figure 5A – Monthly compliance on the main carriageway at the ACPO threshold. Source: 'HA M42 ATM Monitoring Compliance with VMSL, Lane Closures & Hard Shoulder Operation January – February 2009'

As can be seen above, the compliance at 70mph to 50mph has remained consistently high, with the compliance at 40mph more variable, but still averaging around 85%. This variation is mainly due to occasional high non-compliance with 40mph limits set for overnight road works [3].

One of the key reasons for this high compliance is the implementation of a well designed signalling regime which promotes compliant driver behaviour together with driver education, demonstrating the benefits of obeying the overhead signals displaying the varying speed limits. A key element of why compliance is high is due to the "intervisibility" of the signs and signals on the overhead gantries. The "intervisbility" between gantries allows drivers to experience driving through a unique highly controlled environment.

5.5 Environmental Benefits

The key environmental benefit from implementing a Managed Motorway is that the scheme is making best use out of the existing road space and therefore when compared to traditional widening schemes there is less impact on the environment, particularly through the construction phase. It should also be recognised that traffic flows are smoother with less stop-start conditions. ATM has resulted in a small reduction in emissions and also a reduction in noise levels. The reductions in emissions are similar to those obtained from two studies of the impact of Variable Speed Limits on the M25.

6. WHERE NEXT

Managed Motorways is an approach that will address the problems and issues surrounding network capacity in the UK whilst maintaining or improving the safety of the core motorway network.

Congestion on the UK network particularly around major conurbations, has presented a major challenge to the countries economy specifically in the area of transport logistics.

The ATM Pilot has demonstrated that hard shoulder running is a viable alternative option to widening and indeed can bring benefits that widening in isolation without the application of additional technology can ever achieve. The ATM Pilot has bought success in reducing congestion, improving the predictability of journey times and increasing motorway capacity. Additional benefits have been achieved in environmental gains and early indications are that the design of the scheme has led to realistic and sustainable reductions in the numbers of killed and seriously injured.

The interactive nature of the speed limits, the “intervisibility” of gantries and speed limit signals throughout a driver’s journey along the M42 ATM Pilot means that they are continually faced with a posted mandatory speed limit - this is unlike any other motorway in the country including the M25 Controlled Motorway.

The schemes discussed within this paper provide examples of how the road improvement programme has been affected by a successful Pilot project that challenged standards and introduced significant innovation into the design process. This interest is growing internationally, as increasingly robust and beneficial technical solutions are available to the market. Provided these solutions meet type approval or equivalent standards and, most importantly, are aligned to the operational and safety requirements of the project, they should be included in the option assessment process.

Huge opportunities exist to provide a joined up network where the impact of an ‘incident‘ (any event affecting local or strategic road users) is communicated in real time to all concerned. The concept of Managed Motorways, utilising the ATM tool box of operational regimes along with more traditional solutions, provides an ideal platform on which to build a joined up network. There are still challenges that remain including the methods by which vehicles are detected on the motorway – whether it be in-road technology or radar solutions. An effective risk profile is key to the delivery of future schemes – there is a need to access each individual scheme balancing the risks to the various stakeholders that will be affected by the scheme.

Through robust management following some of the principles discussed within this paper these can become a reality. The associated risks surrounding any new technology or operational solution need to be robustly understood and challenged. Technology has moved on immeasurably over the last 15 years, and based on this trend some significant changes are likely in the short term

future, and the motorway and local networks, like any other part of communities, need to move forward with them.

7. REFERENCES

Ref	Title	Reference
[1]	Controlled Motorways – Highways Agency Web Site	http://www.highways.gov.uk/knowledge/14329.aspx
[2]	ATM / BBMM– Highways Agency Web Site	http://www.highways.gov.uk/knowledge/1334.aspx
[3]	M42 ATM 12 Month Monitoring and Evaluation Report	http://www.dft.gov.uk/pgr/roads/tpm/m42activetrafficmanagement/atm12mthsumrep.pdf
[4]	Managed Motorways Design Guidance	http://www.standardsforhighways.co.uk/ians/pdfs/ian111.pdf
[5]	Advanced Motorway Signaling and Traffic Management Feasibility Study – Report to the Secretary of State – March 2008	http://www.dft.gov.uk/pgr/roads/network/policy/mtorsigntrafmanagement/advancedmotorwaysignal.pdf
[6]	DfT Command Paper (Roads – Delivering Choice and Reliability) – July 2008	http://www.dft.gov.uk/pgr/roads/introtoroads/roadcongestion/roadscommandpaper1.pdf
[7]	Britain's Transport Infrastructure Motorways and Major Trunk Roads January 2009	http://www.dft.gov.uk/pgr/roads/network/policy/motorways/motorways.pdf
[8]	HA ATM Monitoring and Evaluation 4L VMSL HSR60 3 Month Operation Report	
[9]	HA M42 ATM Monitoring Compliance with VMSL, Lane Closures & Hard Shoulder Operation January – February 2009	

Table 7A – References