Hard Shoulder Running
Fact Sheet v2.0

Introduction

The first version of the CEDR TNM WG Fact Sheet on Hard Shoulder Running (HSR), produced in 2018, is based on the proceedings and outputs of the 2nd CEDR Traffic & Network Management (TNM) Working Group Workshop under the CEDR FA3: SAFETY, OPERATIONS, MOBILITY & PERFORMANCE held in the National Traffic Management Center at Utrecht on 16-17 May 2018.

Since 2018, a number of countries have further developed the concept of HSR as a way to increase highway capacity and safety. However, despite clear evidence of the effectiveness of the HSR concept, some vocal concerns amongst the public and professional drivers' groups remain. In this context, CEDR's TNM WG aim objective is to update the 2018 HSR Fact Sheet to reflect new experiences and best practice.

In February 2021, CEDR launched a survey among its members to update views, assessments and best practice requirements for HSR deployment. This Fact Sheet is an update of the 2018 HSR Fact Sheet integrating the results of the survey.

Scope of the HSR fact sheet is limited to the needs and requirements of NRAs towards HSR planning and deployment highlighting the main relevant issues and best-practice assessment results discussed in the working group. The aim is to summarize experiences with focus on impacts and factors related to HSR and give recommendations and arguments for NRAs to implement and operate HSR.

The Fact Sheet will not cover physical design requirements for Hard Shoulders nor managing stopped vehicles on motorways but rather the requirements, best practice and impacts of deploying dynamic hard shoulder running on motorways to increase road capacity in specific conditions.

The Fact Sheet will not include basic concepts or technical deployment guidelines, as these guidelines are well known and published, e.g. the EasyWay HSR Deployment Guideline (http://dg.its-platform.eu/DGs2012). A good overview of HSR basic concepts and definitions can be found in CEDR Task Group T12 report Traffic Management to reduce congestion (http://www.cedr.eu/download/Publications/2013/T12_Traffic_management.pdf).

The CEDR TNM WG HSR Workshop minutes and presentations are available on the CEDR website in the members' area (www.cedr.eu).

Definition of Hard Shoulder Running

Hard shoulder running (HSR) enables dynamic use of hard shoulders as an extra driving lane with the aim to increase road capacity in times of high traffic demand (see CEDR T12 report). This is different from the All Lane Running Systems where hard shoulder is permanently operating as a normal additional lane.

Conclusion and Main Position of WG TNM on HSR

Based on the previous experiences of countries where HSR has been in operation for several years, **HSR could be recommended as useful measure** to (temporarily) increase capacity on sections of the road

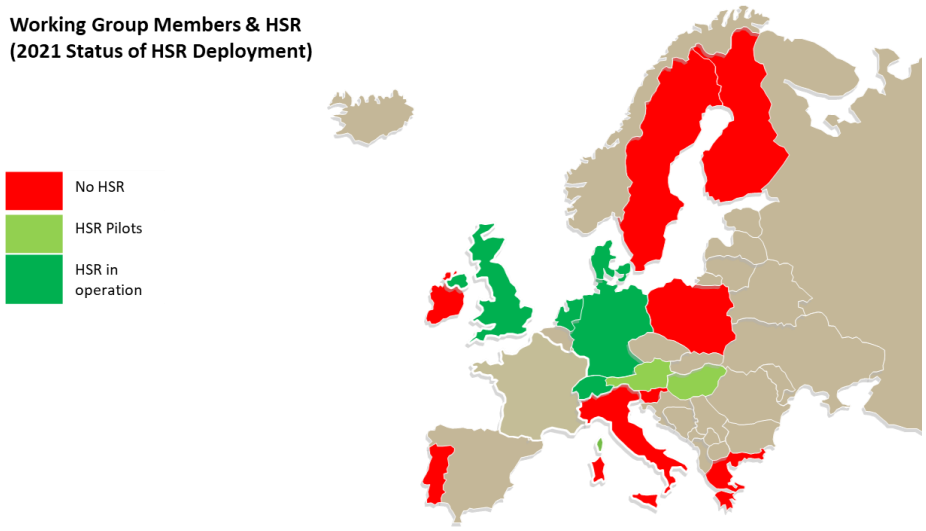
network to avoid or reduce (heavy) congestion and to reduce the probability of incidents, especially rear-end collisions.

Evaluation studies in the UK, Germany and the Netherlands reveal that with proper design and deployment of HSR can temporarily increase capacity by up to 25% and network performance up to 20%. Because of the reduced probability of congestion related incidents, the impact to road safety is rather positive and not negative when HSR is operated in an appropriate way. During the pilot phase, impact assessment studies in the UK on the M42 show a reduction of personal injury accidents of up to 20% after implementation of HSR on heavy congested sections. Such positive safety impacts of HSR deployment are supported by evaluation results in the Netherlands where significant improvements of more than 25% were seen in several HSR deployment locations evaluated over a period between 2000 and 2014. In stocktaking report conducted by the UK Department of Transport in 2019, positive safety impacts of HSR deployment were reported in terms of lower fatality rate than conventional motorways, provided stopped vehicles are timely detected. However in the UK, it was reported from experience gained through operating HSR over a number of years that several issues and challenges in operating HSR were found including:

- HSR introduces the rare situation of drivers being instructed to cross a solid white line onto the hard shoulder;
- HSR can have the potential for confusion as to whether or not the hard shoulder is open to traffic;
- HSR provides extra lane capacity, but only at a reduced 60mph speed limit;
- HSR is resource-intensive as it requires the hard shoulder to be opened and closed twice daily, which required Regional Operations Centre (ROC) operators to check every camera for obstructions prior to opening; and
- Technology faults can prevent the hard shoulder from being opened (if an Advanced Motorway Indicator (AMI) above the hard shoulder became faulty then the hard shoulder cannot be opened to traffic).

HSR provides a valuable tool to react on traffic problems in a fast way. While the construction of an additional lane takes several years on average, the deployment of HSR normally can be realized in a relative short space of time, with a more smooth-running planning process and normally without making the traditional environmental impact assessment. HSR could be the first step in solving capacity problems and help NRAs as a temporary solution until traditional lane widening are decided, financed and constructed.

A summary of the main results of the CEDR 2021 HSR survey, as identified by TNM WG members, can be seen in Annex 1 of the Fact Sheet.



Working Group Members:

Austria, Belgium, Cyprus, Denmark, Finland, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Portugal, Slovenia, Sweden, Switzerland,

Additional Participation or Support to HSR WS:

Germany, Ireland, United Kingdom

HSR Planning & Deployment Recommendations

Hard shoulder running is usually triggered by traffic demand or at fixed times, and applied for bottlenecks or problem stretches with recurrent – but not constant – lack of capacity (see CEDR T12 final report). For road operators and NRAs this traffic management measure is a feasible option to react on temporary traffic problems (peak hours) in short space of time. Nevertheless, not every stakeholder is convinced of the benefits of HSR, amongst others because of reservations in the field of traffic & road safety. The use of the hard shoulder as a temporary lane means less space for broken down vehicles, and rescue and emergency service vehicles may also require additional measures to access the incident location.

For a successful introduction and operation of HSR the following issues should be considered by NRAs as they are identified as important by the CEDR working group for the planning and deployment stage (without claim of completeness).

For HSR planning, the following issues are identified as important by CEDR TNM WG members:

- Clarity about the legal framework is necessary to enable HSR deployment
- Involvement and engagement from all stakeholders from the start is crucial to ensure effective implementation
- Assessment studies are useful for ex-post and ex-ante stages of HSR deployment to gain knowledge and fine-tune deployments
- Organizational resources need to be ensured prior to deployment
- Liability issues for HSR operation should be clarified in advance
- HSR needs to be viewed not only from a local scale but also from a network-scale to enable proper delivery and assessment.
- Driver awareness campaigns are necessary to decrease confusion on whether or not the hard shoulder is open for traffic.

For HSR deployment, the following issues were identified as important to consider by TNM WG members:

- Adequate lane widths need to be ensured for trucks and buses

- Adequate number of refuge areas per Km (500m average spacing) with adequate lengths of 80-100m per refuge to enable effective HSR operation.
- Adequate capacity should be ensured for downstream sections of the HSR deployment area
- Debris clearing is essential prior to activation. Debris is defined and communicated according to DATEX II safety related message sets as general or environmental obstructions and obstacles on the road are posing a danger to drivers (DATEX II CEN/TS 16157)
- 100% CCTV coverage and continuous monitoring of hard shoulder during operation to detect incidents and stopped vehicles is needed
- Effective automatic incident detection methods could improve HSR operation (but is no "must" criteria)
- Proper delivery of emergency corridor when needed during HSR activation must be ensured
- Adequate Lane Control Systems (LCS) using VMS are necessary to indicate whether hard shoulder could be used or not (opened / closed)
- Hard shoulder should be considered and treated as normal lane in case it is opened. Speed limits or overtaking bans for trucks could be appropriate but it depends on the actual situation on the HSR section. Several countries reported in special cases the need to operate the hard shoulder running at reduced speed limits.
- In the UK, according to the Department for Transport stocktaking and action plan report in 2020, to provide a more consistent experience to smart motorways' users, all HSR deployed sections will be converted to all lane running (ALR) operations by 2025[1]. Austria and Denmark have noted that this conversion from HSR into ALR might cause safety and environmental issues in non-overloaded situations or causing speed reduction in low traffic times and increasing the probability of stopped vehicles occurring in off-peak/free flow speed conditions and hence needs to be verified for necessary operational conditions and to assess safety and sustainability impacts. Netherlands assessed All Lane Running systems and found that possible negative environmental impacts will occur due to attracting additional traffic due to increased capacities at all times. Denmark noted concern in providing safe access to road maintenance works and emergency services access in case of all lane running conditions.
- Continuous training of operation staff is required.
- Continuous monitoring of HSR operation is required to fine-tune operation protocols
- In the winter time it is important to handle salting and snow removal on the hard shoulder with the right timing.

Many of the above issues are handled in detail in the EasyWay HSR deployment guidelines that can be used as good starting point for planning deployment of HSR along European harmonised framework (See link: http://dg.its-platform.eu/DGs2012). In addition, a useful source for HSR deployment requirements can be found in Highways Agency Implementation Guidance for Hard Shoulder Running (Interim Advice Note 111/09): See link: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian111_09.pdf)

To counter reservations regarding traffic safety, NRAs should identify possible risk situations of hard shoulder usage and define additional safety measures. Possible risk situations and relevant safety measures are for instance:

[1] A recent notice on the UK Department for Transport website noted that the recommendation to pause the rollout of future ALR smart motorway schemes, including converting HSR into ALR, until a full 5 years' worth of safety data is available.

Possible risk situation	Safety measure	Implementation NL	Implementation BE
Accidents - occur mostly due to congestion • HSR to prevent congestion, but accidents still possible	Informing road users of traffic jam	Implementation of overhead signals	LCS for closing hard shoulder and other lanes quickly
Inaccessible accident location • HS not available for emergency vehicles • Safety and traffic flow risk	Possibility to quickly clear a lane	Implementation of overhead signals	LCS incl. induction loops Local specific arrangements with emergency services
Vehicle breakdown • No refuge for breakdown vehicle	Create new refuge area; Informing road users of traffic jam	Emergency refuge areas every 1000 m Overhead signals	Emergency refuge areas every 500 m LCS incl. induction loops
Unclear status of the hard shoulder lane • Closed -> misusage -> possible accidents with breakdown vehicle • Open -> less utilization -> decrease of capacity	Clear design & good communication. Only activate HSR when extra capacity is actually needed	Solid line to emphasize closed situation Red cross on overhead signal above hard shoulder (whenever closed)	Red cross on overhead signal above hard shoulder (whenever closed)

Closed HS in Belgium

Opened HS in the Netherlands

Benefits - Best Practice Assessment

During the workshop, assessment results were found in several ex-ante and ex-post HSR deployment reports. In general, hard shoulder running offers advantages for a better network performance due to

- Increase of capacity
- Decrease of congestion
- Reduction of delays
- Shorter travel times
- Benefits on traffic safety
- Positive impacts to secondary road network

Netherlands:

When properly implemented and according to several evaluation results in the Netherlands, HSR deployment benefits include up to 20% improvement of overall traffic performance and up to 80% reduction

of delays as well as a 25% reduction of overall congestion. By elimination of upstream congestion, HSR can result in significant improvement of traffic safety (25 - 85% reduction of accidents on several sections). The benefits for traffic safety mostly comes from the reduction of congestion related incidents (elimination of upstream congestion). A 2015 safety impact study was conducted with/without HSR at varying traffic volumes and found no significant safety impact differences at medium traffic congestion and slightly higher rates for HSR at high traffic volumes, indicating the need for extensive monitoring and incident detection and management in congested motorway section during HSR deployment.

Belgium, Flanders

The ex-post evaluation of HSR in Flanders confirms effective and significant decrease in lost vehicle hours and a perceptible decrease of travel times. Furthermore, positive impacts to the secondary road network could be observed due to a relocation of traffic from secondary roads to motorways. In some cases, there was an increase of congestion downstream latent bottlenecks. Therefore, the whole framework of HSR is important for the overall success. Regarding road safety, no significant change has been observed after HSR was introduced.

Germany, Bavaria

Using hard shoulder as a lane can temporarily increase capacity up to 25%. On some stretches positive impacts to road safety resulting in a reduction of accidents up to 20% were possible. In general, no serious impairments to road safety has been established.

Denmark

In Denmark one pilot of HSR has been implemented in December 2013 and since evaluated. Considering all the analyses performed the overall key result of the pilot trial is that use of the hard shoulder as a traffic lane in the morning rush hour has generally improved traffic flow, increased capacity, reduced travel times, reduced the variation in travel times, resulted in shorter queues and shorter duration of queues. Further, it has reduced traffic on the local roads along the M13. A study was recently finalized after 5 years of operation of the above-mentioned trial. It shows neither a positive nor negative effect of HSR. The section is 2 km long and there are no exits/access ramps in the section with HSR. The number of incidents was low both before and after the introduction of HSR. In addition, the road users are in general satisfied with the introduction of hard shoulder running in Denmark and feels comfortable driving on the hard shoulder.

A socio-economic assessment conducted according to the national guidelines and model for cost-benefit analysis of ITS systems with a 10-year time frame gave positive results and an internal rate of return of 26.8 %. Note that the assessment includes effects on traffic flow only. Safety and environmental effects are not included.

United Kingdom

In a stocktaking report on smart highways conducted by the Department of Transport in 2019, high level statistics show that HSL motorways, compared to conventional motorways, have a lower rate of fatal casualties and a higher rate of slight casualties, while serious casualty rates are slightly higher. Before and after collision data for HSL schemes suggested that personal injury collisions reduced.

Switzerland

Overall experience with the deployment of HSR positive. In a 2018 assessment exercise on a pilot 3.7Km section on A1 motorway, a decrease in accidents and incidents was observed. Nevertheless, there were still potential conflict areas (lane changes). Assessment results also showed that the implementation of the active hard shoulder lane system offers significant advantages in terms of traffic conditions, particularly with an increase in flow, a stabilisation of speeds, a reduction in traffic jams and shorter journey times.

Austria

A first pilot has started in July 2018 in Vienna and recently closed due to road works in the particular section. Within the HSR pilot (just a short section) the impact to safety when using hard shoulder running was analysed: there was no impact to safety detected.. General studies are not available and larger HSR deployments are needed to assess properly.

More information on case studies can be found in the following links:

- http://www.verkeerscentrum.be/verkeersinfo/studies/overzicht (in Flemish)
- Annex of the EasyWay HSR Deployment Guidelines. See link: http://dg.its-platform.eu/DGs2012
- HSR Fact Sheet from CEDR Working Group T12 “Traffic Management to reduce congestion” Final Report (http://www.cedr.eu/download/Publications/2013/T12_Traffic_management.pdf)
- Highways Agency Implementation Guidance for Hard Shoulder Running (Interim Advice Note 111/09): See link: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian111_09.pdf)
- Danish Road Directorate. Evaluation summary of “Pilot trial with Hard Shoulder Running on the Hillerød Motorway” in English and full evaluation report in Danish. See links: http://www.vejdirektoratet.dk/DA/viden_og_data/temaer/its/Documents/Summary%20af%20Hard%20Shoulder%20Running%20evalueringsrapport.pdf and http://www.vejdirektoratet.dk/DA/viden_og_data/publikationer/_layouts/delegate/pages/GetPublication.ashx?id=1292381633
- Grontmij Nederland B.V. , Differentiatie Verkeersveiligheid Spitsstroken- Hoofdrapport, Project No. 339843, Rijkswaterstaat, June 2015 (Report in Dutch).
- EU EIP Evaluation Report on Hard shoulder running (BAU) at A1 Morges-Ecublens, version 1.0, URSA MAJOR Group, 2018.
- UK Government’s smart motorways stocktake report published in March 2020: https://www.gov.uk/government/publications/smart-motorway-evidence-stocktake-and-action-plan
- UK Highways Agency First year progress report 2021: https://highwaysengland.co.uk/media/bb4lpkcp/smart-motorways-stocktake-first-year-progress-report-2021.pdf

Recommendations and Next Steps

It is of value for NRAs/CEDR countries to continue and expand on exchange and discuss HSR deployment experiences, partly to learn from each other and partly to get closer to a more harmonised approach that will benefit all NRAs.

The workshop on hard shoulder running and the 2021 CEDR Survey showed the necessity, advantages and the success of sharing, exchanging and discussing experience, knowledge and best practice examples in a specific field of traffic management measures. The mix of participants from experts having years of operational experience, countries with first experience from pilots to countries with interests in introducing the measure ensures a fruitful discussion of the overall process from planning, deploying to operating and therefor a useful output for several members of CEDR. It has also strengthened the network between the involved experts, which is expected to make it easier to keep in touch and share knowledge in the future.

As added value to the thematic recommendations regarding hard shoulder running, the necessity and the benefit of having workshops on specific topics like HSR were confirmed and the structure of the workshop was established as successful. Existing guidelines, assessment studies and best practice examples including lessons learnt are very useful and helpful in order to avoid unnecessary mistakes and introduce new measures efficiently. For that reason, such guidelines and documents should further be established and updated.

The following recommendations for continuing the work were developed in the CEDR TNM HSR Workshop by the workshop participants and the 2021 CEDR HSR survey coupled with the TNM WG Meeting on 9.May 2022:

- Develop a Knowledge Base of best-practice HSR deployment case studies building on the CEDR members' HSR evaluation reports and international deployment reports, as well as the Knowledge Base of European best-practice HSR deployments. An interesting case to monitor is the current conversion of all HSR deployment into all lane running deployments in all UK smart motorways by 2025. Such a scheme might conflict with current best practice in several European countries where, in case of permanent conversion of HSR into all lane running systems, safety and environmental issues can occur in non-overloaded situations or speed reduction in low traffic periods and could cause emergency/road maintenance access issues.
- In coordination with EU ITS Platform, CEDR members to set up a mechanism and resources to update existing Guidelines, e.g. the EasyWay HSR Deployment Guidelines, in line with latest developments and evaluation reports in HSR deployments.
- Based on the KPIs agreed in the last TNM WG Workshop on KPIs and to be used for annual reporting of TNM deployment by TNM WG members, the following KPIs are proposed for reporting HSR deployment and impact of operations:
    - Level of HSR Deployment:
        - Number of HSR deployments categorised according to length of section on which the HSR is being deployed (< 2 km, section length and more than 2 km)
        - % of road network length covered by HSR preferably measured against number of motorway km with peak hour congestion
    - Congestion/Incident Impact: of HSR
        - No. of incidents by type per km of corridor
        - Average delay per veh. km. of corridor (hours/veh.km.)
        - Average travel time variation per corridor
    - TM Efficiency:
        - Average Incident Response/Clearance/Duration per km of corridor by type of incident
        - Average TMC ticket resolution time by ticket type

- Safety Impact:
  - Number of accidents by type per veh.km. of corridor
- User Satisfaction:
  - Measure of user satisfaction levels and safety perception levels after HSR deployment on motorways

Contribution

This position paper was compiled by CEDR WG Traffic and Network Management.

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In addition to the above, contributions were made by the United Kingdom and Ireland through the 2021 HSR Survey initiated by the CEDR General Secreteriat.

CEDR HSR Utrecht Workshop minutes and presentation are available in the Members' Area under FA3.3 on the CEDR website (www.cedr.eu).

Annex 1:

Table 1. Summary of CEDR 2021 HSR Survey Results (updated in TNM WG Meeting on 9.May 2022)

Issue	Austria	Belgium-Flanders	Denmark	Finland/ Poland/ Portugal/Ireland/Slovenia	Hungary	Netherlands	Switzerland	United Kingdom
HSR Deployment Status Change since 2018	No change. Decision to expand beyond the limited Vienna HSR pilot on hold	3 additional stretches with planning of further deployments	2-3 further stretches are being considered	No HSR deployed	Pilot HSR on M2 motorway under development	Not significant change	3 HSR in operation and 2 HSR under construction	HSR is no longer a standard for smart motorways in England, the Smart Motorway Stocktake (2020) included plans to convert all existing HSR motorways to All Lane Running (ALR) thus providing a single, consistent form of smart motorway. In 2011, it was decided not to build any further HSR motorway, instead implementing ALR motorways.
HSR for specific vehicles or all vehicles in current deployments	All vehicles in Vienna Pilot	All vehicles and specific vehicles	All vehicles	NA IR: Considering buses only for HSR	All vehicles	All vehicles except 1 HSR section for trucks and buses	All vehicles	All vehicles
Length/capacity requirements for refuges	2 refuges per Km with 90m length	2 refuges per Km with 100m length	1 refuge per Km with 100m length	NA	NA	Generally 2 refuges per Km with 100m length	In average, 1 refuge per 500-800m, with length of 60-80m	The design standards for DHS have been withdrawn as all new smart motorways will

Issue	Austria	Belgium-Flanders	Denmark	Finland/ Poland/ Portugal/Ireland/Slovenia	Hungary	Netherlands	Switzerland	United Kingdom
when HSR is active								be All Lane Running motorways. The maximum distance between emergency areas on HSR contained in the 2009 standard was 1km with 100m length
Safety impacts with/without HSR	No impact detected in pilot	No significant impacts	HSR deployed in stretches with low incidents, hence no significant safety impacts	NA	NA	Yes		The Government's smart motorways stocktake published in March 2020 discusses safety performance: https://www.gov.uk/government/publications/smart-motorway-evidence-stocktake-and-action-plan High level statistics show that HSR motorways, compared to conventional motorways, have a lower rate of fatal casualties and a higher rate of slight casualties,

Issue	Austria	Belgium-Flanders	Denmark	Finland/ Poland/ Portugal/Ireland/Slovenia	Hungary	Netherlands	Switzerland	United Kingdom
								while serious casualty rates are slightly higher. Before and after collision data for HSR schemes suggested that personal injury collisions reduced Further data is contained in the Smart motorways Stocktake, First year progress report 2021: https://highwaysengland.co.uk/media/bb4lpkcp/smart-motorways-stocktake-first-year-progress-report-2021.pdf
Signaling requirements in HSR operation	EasyWay Deployment Guidelines	Lane Signals and special road markings	VMS on sides	NA	NA	Overhead VMS with speed limit on side	In accordance with FEDRO directive s 15002 and 15019	Lane Signals
Detection and management of stopped vehicles in HSR	CCTV/AID cameras	CCTV and loops	CCTV and loops	NA	NA	CCTV, Loops and user notifications	Radar speed detection and CCTV	CCTV and Queue Detection Side Radar. All HSR schemes will have radar-based Stopped Vehicle

Issue	Austria	Belgium-Flanders	Denmark	Finland/ Poland/ Portugal/Ireland/Slovenia	Hungary	Netherlands	Switzerland	United Kingdom
								Detection installed when they are converted to ALR.
Additional Comments		HSR used mostly in fixed time periods and can be used dyanmically outside this fixed time	3-hour fixed day operation. Recommended to lower speed limits when HSR in operation	FIN: Hard shoulders should be marked as normal lane when used POL: Implementation of a wider scope of the HSR in Poland may be problematic due to the obligation to provide additional areas for road users.		The implementation of HSR is efficient and effective to de-crease or eliminate congestion on sections where road expansion is not possible or take too long to realize.	Overall experience with HSR are so far positive	HSR (DHS) motorways do exist in England (63 miles in total) but no more are planned and the existing HSR (DHS) motorways will be converted to All Lane Running in the current Roads Investment Period (by March 2025). From experience gained through operating HSR (DHS) over a number of years, it was found to have several issues and challenges including: • it introduces the rare situation of drivers being instructed to cross a solid white line onto the hard shoulder; • there is the potential for

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								confusion as to whether or not the hard shoulder is open to traffic; • it provides extra lane capacity, but only at a reduced 60mph speed limit; • it is resource-intensive as it requires the hard shoulder to be opened and closed twice daily, which required Regional Operations Centre (ROC) operators to check every camera for obstructions prior to opening; and • technology faults can prevent the hard shoulder from being opened (if an Advanced Motorway Indicator (AMI) above the hard shoulder became faulty then the

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								hard shoulder cannot be opened to traffic).