Mitigating Motorway Congestion via Hard Shoulder Running

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1. Introduction

Hard Shoulder Running (HSR) is a scheme that uses the motorway shoulder as a general-purpose lane. HSR produces significant increase in capacity and reduction in travel times under acceptable safety conditions

Limitations of existing systems:

- HSR gives the hard shoulder an ambiguous character, leading to confusing situations for road users;
- All Lane Running (ALR) causes the loss of a continuous emergency refuge area.

Objectives:

- Develop a truck-only HSR strategy to increase the operational benefits and user acceptance of HSR;
- Analyse the impact of HSR on emission reduction using micro-simulation.

2. Truck-only HSR (T-HSR) Strategy

Features:

- Determine HSR actions based on the real-time traffic volume and the truck proportion (see Fig.1);
- Can be integrated with Variable Speed Limit (VSL) to ensure safety.
- Can be used directly with existing motorway Active Traffic Management (ATM) facilities (see Fig.2);
- Can improve user acceptance via opening the hard shoulder as a truck-only lane.

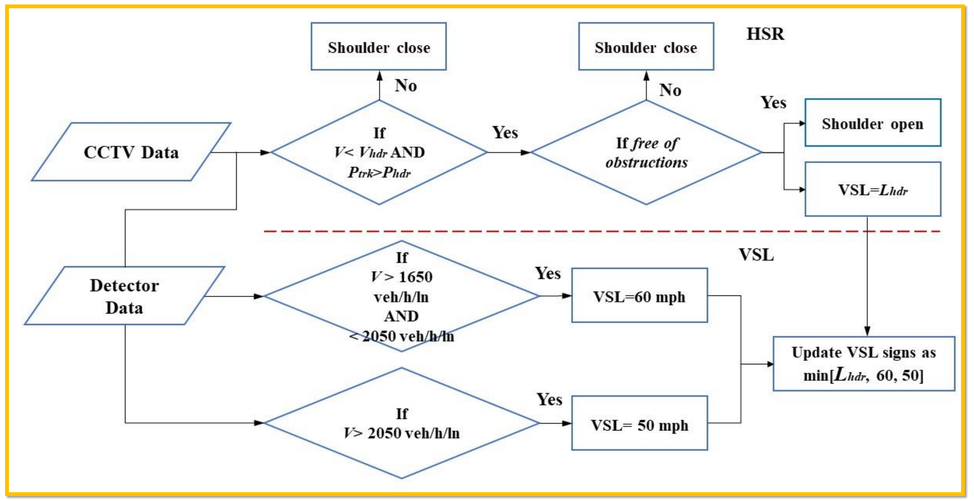

Fig. 1 Flow chart of T-HSR strategy - $Vhdr$ and $Phdr$ are pre-determined thresholds; V and $Ptrk$ are real-time traffic volume and truck proportion data; and $Lhdr$ is speed limit for HSR.

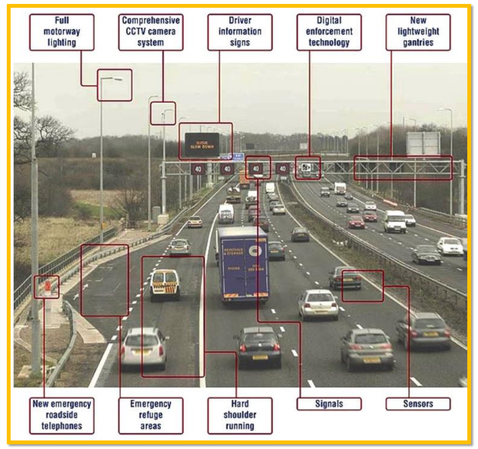

Fig. 2 ATM facilities in the UK (source: [1])

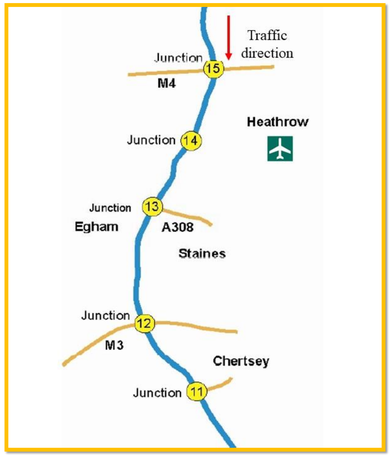

Fig. 3 Layout of test bed

3. Case Study

Simulation in AIMSUN [2]

Test bed: a 12-mile (19.3-km) stretch of motorway M25 with 5 Junctions was selected as the test bed (see Fig 3).
Field data: obtained from Highways England, including traffic volumes of different types of vehicles.
Simulation period: 6:30-9:30 AM on June 3, 2019
Emission model: London Emission Model (LEM) [2]

Results

Table 1 Simulation results

Performance Measures	Base	HSR	T-HSR
Total Travel Time (sec)	1.1E+07	**8.3E+06**	8.7E+06
# of Stops per vehicle	15.5	**5.8**	9.7
NOx (g/km)	3.0E+05	**1.5E+05**	2.2E+05
CO2 (g/km)	1.1E+08	**5.3E+07**	6.3E+07
Total # of Lane Changes	**1.3E+05**	1.4E+05	1.6E+05

4. Conclusions and Future Work

Results shows that the proposed T-HSR strategy

- mitigates congestions via increasing road capacity;
- decreases emissions by reducing stop-go conditions;
- provides a cost-effective solution to balance user acceptance and operational benefits of HSR

In the future, a deep-reinforcement-learning-based control strategy will be developed to enhance HSR.

Reference
[1] HA, "Active traffic management (atm) project m42 junctions 3a-7," tech. rep., UK Highways Agency, 2004.
[2] AIMSUN, "Aimsun next 20 user's manual," tech. rep., TSS-Transport Simulation Systems, Barcelona, Spain, 2020.

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