A review of anti-swooping trials

Prepared for Quality Services, Highways Agency

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Executive Summary

This report provides a summary of the studies that have been carried out by TRL Limited under a contract placed by the Highways Agency (HA), between 1995 and 2000, to investigate measures to reduce the occurrence of the practice of swooping at motorway diverges.

Swooping is defined as the following:

‘Vehicles moving directly from Lanes 2 or 3 of the mainline to exit at a diverge, typically within 500m of the diverge point.’

Within this study two different approaches to combating this problem have been considered:

- New lane separation markings.
- New ‘ghost’ island diverge layouts.

It was hoped that these measures would provide cost effective solutions to this problem of swooping. It was believed that high numbers of swooping manoeuvres were performed at diverges with high turning movements, or where there was queuing on the sliproad during peak periods.

Work within this study has included:

- Computer modelling of new diverge layouts using SISTM.
- Design of new markings including simulator and test track trials.
- Designing of appropriate signing for schemes.

Within this study five diverges have had anti-swooping measures installed and monitored, two sites have had new lane separation markings installed and at three diverges layouts have been modified to ‘ghost’ island layouts.

Whilst the solid white line lane separation marking trialed at the M27 J3 interchange proved to be unsuccessful in reducing the occurrence of swooping, the anti-swoop diamond markings installed at M6 J6 have proved to have had a significant effect on the number of swooping manoeuvres carried out during the morning peak hour. A 58% reduction in the average number of swoopers per hour was obtained, and as a result of this change in driver behaviour, flows on the sliproad increased by 23%.

Of the ‘ghost’ islands installed at the three diverges within this study, one was a standard ‘ghost’ island layout and the other two employed the lane drop ‘ghost’ island diverge layout. In all three cases significant reductions in the average number of swooping manoeuvres per hour have been recorded, 66% at the M20/M26, 80% at the M6 J4a and 39% at M27/M3. Through this improvement of driver behaviour in the vicinity of the diverge, disruption to the mainline traffic has been reduced and throughput through the section has increased.

The results of the monitoring within this study have highlighted that fact that it is not sufficient to install new markings or diverge layouts without informing drivers of the change to the layout and the expected modification of driver behaviour. As a part of the later schemes within this project, significant effort was devoted to ensuring that users of the diverges were informed of the new layouts through the design of appropriate signing for the schemes.

Before the installation of the schemes on the M6 and M27 there were features on local TV news about the problems the schemes were attempting to solve. It is believed that this high profile in the local press has meant that local regular users of the diverges in question were more willing to modify their behaviour to gain the expected benefits of the scheme. This has been demonstrated by the high conformance to the road markings observed.

Following the successes of the ‘ghost’ island diverge layouts at diverges with high turning movements in improving vehicle flows within this study, ‘ghost’ island diverges are already being installed on various parts of the network where there are high turning movements. It is believed that as more drivers become familiar with these layouts then the practice of swooping on the network will reduce, which in turn will bring safety benefits.

As an appendix to this document guidelines for designing ‘ghost’ island diverge layouts are included. Promoters of such schemes should be aware that at the time of publishing approval to a departure from standard needs to be obtained for ‘ghost’ island diverge layouts and in addition signs authorisation is required for non-standard signing including the vertical verge signing depicted in the appendix.
1 Introduction

Fast, safe and efficient communications are a prerequisite for any nation’s prosperity. In a compact, densely populated country such as Great Britain, motorways have proved to be a safe and effective means of providing short and predictable journey times, over long distances. Great Britain’s motorway network is having to cope with ever increasing traffic volumes. The motorway network accounts for 3,250 kilometres (2,019 miles), less than 1% of the total length of British roads. However, motorways carry 17% of all traffic. Traffic on motorways has been growing particularly quickly, rising by 57% between 1987 and 1997 to 78,500 million vehicle-kilometres, reflecting increases in motorway length as well as traffic flow (Department of the Environment, Transport and the Regions 1998). As a result, some sections of motorway experience regular stop-go driving conditions (known as flow breakdown).

The casualty rate (per 100 million vehicle-kilometres) is much lower for motorways than for other types of road. The figures for 1997 were 18 for motorways; 114 for urban roads and 50 for rural roads (Office for National Statistics 1998). However, there is a continuing need to seek ways of reducing the risk of those accidents that occur since they tend to involve serious injury.

A recent study looking into accidents on motorways found that the proximity to the nearest junction (merge or diverge) had an effect on injury accident numbers which was measurable, and extended as far as 3 km from the slip roads (Fletcher and Summersgill 1998). This is probably due to the increased lane changing and acceptance of shorter headways. It was also found that accident rates upstream of the diverges were higher than those downstream of the merges. The study involved the analysis of 92 merges (402.8 km) and 93 diverges (408 km) using injury accident records over a 15 year period from the beginning of 1980 to the end of 1994.

One potentially hazardous form of driver behaviour has become known as ‘swooping’; i.e. vehicles cutting directly into the slip road from lanes 2 or 3 in order to leave the mainline. Mr Robert Key MP, whilst Minister for Roads, requested that measures to control and reduce swooping should be investigated. It was thought that this behaviour had an adverse effect on capacity as well as safety.

This report describes part of the project commissioned by the Quality Services (Traffic, Safety and Environment) [QS(TSE)] Division of the Highways Agency to investigate increasing the capacity and safety of British motorway junctions at low cost. It includes a review of all research into reducing swooping at motorway diverges carried out within the project.

2 Initial studies

2.1 Junction layout simulation using ‘SISTM’

As part of an on-going programme of improving the design and operation of grade separated junctions, the TRL motorway simulation program SISTM was used to study different motorway merge and diverge layouts. SISTM (Simulation of Strategies for Traffic on Motorways) is a microscopic (i.e. vehicle by vehicle) simulation program designed to replicate in detail the behaviour of motorway traffic in congested conditions. Its main purpose is to help in the design and evaluation of traffic management measures designed to reduce motorway congestion. The car following and lane changing algorithms that it uses are based on observations of traffic under heavy flow conditions. SISTM has been tested extensively to ensure that it realistically reproduces traffic behaviour at the microscopic and macroscopic level. A real time representation of the vehicles on the motorway is shown on the computer display during a simulation. The software also produces a wide range of data for subsequent analysis.

Simulation runs were carried out separately on: (a) four types of merge, two with lane gain and two give-way merges and, (b) four types of diverge, two with lane drop, a standard diverge and a diverge with auxiliary lane. Each simulation represented 1 hour 35 minutes. In this time the amount of traffic on the motorway increased every 5 minutes by 200 vehicles per hour. Each layout was modelled twice, with a low and high demand. The low demand runs started at 2000 and ended at 5600 vehicles/hour, the high - 3800 and 7400 vehicles/hour respectively.

Separate simulation runs were carried out at different merge or diverge percentages from 0 to 70% in steps of 5%. Every simulation was carried out three times, each one with a different random number seed, which randomises the way vehicles are generated within the limits of the required demand. In total 1152 simulation runs were performed. SISTM completed the runs about nine times faster than real time. In addition, a further 54 simulation runs were carried out on the diverge layout with an auxiliary lane. These were done to investigate the effects of the different sign positioning and auxiliary lane length.

The results showed that two factors affected the capacity of a particular layout: the ease with which vehicles could change lanes to reach their destination and the number of lanes in the upstream and downstream section.

For merges, it was found that the design involving a conventional give-way merge without ghost island had the highest throughput at a wide range of merge percentages from 0% to 70%. The two layouts with a lane gain, as expected, operated poorly at low merge percentages, but at 35% or above the capacity was found to be equal to or slightly higher than the give-way merge. However this was the case only if it was the right hand lane of the slip road that continued into the main carriageway.

For diverges, the highest throughput - and lowest delays - were recorded for the diverge with a 550m auxiliary lane. There was an almost constant capacity over a range of diverges percentages from 0% to 55%. It was found that reducing the length of this auxiliary lane or moving the countdown markers to locations upstream of the beginning of the auxiliary lane reduced the effectiveness of this layout. It is believed that the reason for the good performance of the diverge with auxiliary lane is that it allows diverging vehicles to move into it and therefore out of the mainline flow at a convenient moment,
and so prevents them from causing further disturbance to main line traffic.

For the other diverge layouts tested, the standard diverge had a high capacity until the percentage diverging reached 20%. The diverses with lane drop performed better than the standard diverge when the percentage diverging was 30% to 40%, but even at these levels the maximum throughput was lower than for the diverge with the auxiliary lane.

The results suggest that the use of an auxiliary lane, before a diverge, would provide a low cost junction type able to deal effectively with a wide range of diverging proportions (0-55%). It is believed that the reason for the good performances of this type of diverge is that it allows diverging vehicles to move into the auxiliary lane and therefore out of the mainline flow at a convenient moment. This prevents the overloading of lane 1 as well as preventing further disturbance to the mainline. This new layout was used at the M20/M26 diverge (see Section 4.2).

2.2 Swooping trial at the Dartford Tunnel
A video survey was carried out on the Essex (north) side of the A282 Dartford Tunnel River Crossing for the four lanes of traffic heading northbound, emerging out of the twin tunnels (Harrison 1996). Figure 1 shows the layout of the survey site.

The twin tunnels accommodate two different types of traffic. The eastern tunnel contains two lanes of M25 bound traffic with the western tunnel containing a lane of slower vehicles and a slip road of traffic exiting at junction 31 immediately downstream. A double white line marking between lanes 1 and 2 stretches from the tunnel mouth to beyond the junction 31 exit. This was designed to discourage vehicles swooping into the slip road from lanes 2 and 3 across traffic emerging from the western tunnel.

Three hours of peak and off-peak traffic activity were recorded using a surveillance camera. From this video footage, it was possible to calculate the vehicle flows in each lane and the number of vehicles swooping.

Overall the trial showed that, with an average of 65 swoopers per hour in the peak and 55 swoopers per hour in the off-peak, the double white line marking did not prevent swooping. As no ‘Before’ trial was carried out, it is not known how many, if any, swoopers were prevented by the markings. It was intended that the markings would be interpreted differently from their normal application on single carriageway roads. Some drivers, therefore, may not fully understand their meaning.

3 Anti-swooping lane separation markings

3.1 Background
Mr Robert Key MP, whilst Minister for Roads, requested that measures to control and reduce swooping should be investigated. Swooping is a potentially hazardous form of driver behaviour where vehicles cut directly into the slip road from lanes 2 or 3 in order to leave the main carriageway.

In response to this, the Highways Agency commissioned TRL to investigate possible measures to discourage the practice of ‘swooping’.

It was thought that the introduction of a new carriageway marking between lanes 1 and 2 in the vicinity of the diverge area would reduce the occurrence of swooping. It was hoped that this would be a relatively simple and cost effective solution to this problem.

3.2 Use of a continuous white line on the M27 J3
A Before and After video survey in 1995 was carried out on the westbound junction 3 of the M27, near Southampton, to investigate the effectiveness of a new carriageway marking in discouraging swooping and thus modify driver behaviour (Wall 1996). Other contributory factors such as traffic flow, junction layout and the capacity of the slip road were also considered.

The marking took the form of a continuous solid white line painted from 100 metres before the start of the diverge area to 100 metres after the end of the merge area, between lanes 1 and 2. The line was intended to prevent movement...
from lane 2 to lane 1 over its entire length, whilst permitting movements out of lane 1. Figure 2 shows the M27 survey site.

Once motorists had learnt of the presence of the line, it was hoped that two main effects would be observed. These were that:

- all traffic intending to exit at the junction will enter lane 1 prior to the start of the line, thus eliminating swooping;
- vehicles continuing on the mainline, which temporarily move from lane 1 to lane 2 to avoid the congestion prior to the diverge, will now remain in lane 2 until after the subsequent merge instead of returning immediately to lane 1. It was hoped that this would make merging of entering traffic easier through lower flow in lane 1.

However, with no signs to inform motorists of its exact meaning, many perceived that the line should not be crossed in either direction.

From the results, there was more swooping in the After survey than in the Before. However, it became obvious that there was a link between the number of swoopers and the amount of time when lane 1 and/or the slip road were blocked with slow moving traffic. There was substantially more time in the after survey, when lane 1 was moving slowly (see Table 1).

### Table 1 Queuing and Swooping on each day of the survey at the junction exit

<table>
<thead>
<tr>
<th>Minutes of queuing on the left slip lane/lane 1</th>
<th>Number of swoopers</th>
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<tbody>
<tr>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Day 1</td>
<td>41</td>
</tr>
<tr>
<td>Day 2</td>
<td>58</td>
</tr>
<tr>
<td>Day 3</td>
<td>44</td>
</tr>
<tr>
<td>Day 4</td>
<td>43</td>
</tr>
<tr>
<td>Day 5</td>
<td>39</td>
</tr>
<tr>
<td>Average</td>
<td>45</td>
</tr>
</tbody>
</table>

The main result showed that a higher proportion of exiting traffic spent more time in lane 1 before entering the slip road as a result of the anti-swoop marking. This led to a significant increase in the amount of blocking in lane 1 and/or the slip road.

As almost half of the westbound traffic leaves the motorway at this junction, more congestion in the diverge area is inevitable. Also, the vast majorities of these vehicles are heading for Southampton and so need to be in the left-hand lane of the slip road. Therefore, the capacity of the slip road is a major factor in the efficiency of the junction. Recommendations such as installing signs or using the hard shoulder to increase capacity need to be studied carefully. It was recommended that left turning traffic uses the right hand slip road; this would involve some redesign of the junction at the head of the slip road, but the amount of queuing on the slip road and/or lane 1 should decrease significantly. This measure, if successful in reducing queuing in lane 1/slip road, should eliminate most of the swooping by removing the primary cause.

Due to the nature and layout of the junction, any extra line marking may have only a limited effect. It was recommended that similar trials be carried out at junctions where there is more even distribution of traffic at the head of the slip road, thus avoiding slip lane blockage as found here. The results of such trials should show more clearly how effective the anti-swoop line has been and be less affected by the particular junction characteristics.

However, the trial has highlighted that controlling swooping may not be achieved by a single blanket measure, but the application of appropriate measures according to the specific situation. In this particular case, the correct measure would appear to be alterations to traffic control off the mainline, as opposed to the expected on-mainline changes.

3.3 Anti-swooping diamond markings at the M6 J6 diverge

A ‘before’ survey was carried out at the diverge in order to quantify the perceived problem of swooping at this interchange, to assess whether the problem was serious enough to justify the design and installation of anti-swooping measures.

The survey was carried out during the morning peak period on 15/09/97 – 19/09/97. Seven video cameras, mounted on four overhead gantries, were used to provide complete coverage of the diverge area. From the videotapes, it was possible to measure the vehicle flows in each lane, the number of vehicles swooping and the number of vehicles crossing the nose area.

![Figure 2 The M27 Junction 3 survey site](image)
It was found that in the ‘before’ survey 34% of traffic diverged at this intersection. Due to congestion backing up on the slip road into the main carriageway, a significant number of swooping manoeuvres were observed. During the peak hour, swoopers accounted for 14% of traffic leaving the motorway.

Due to the elevation of the carriageway at this diverge, there was not sufficient room to install the previously successfully trialed ‘ghost’ island diverge layout. However it was decided to trial the use of a new anti-swoop lane separation marking.

Following the poor performance of the solid white line M27 J3, and the expressed wish of the HA not to use existing lane separation markings as anti-swoop markings, there was a need to design a new type of marking. For the new marking to be effective, it was decided that it must be instantly recognised by drivers at motorway speeds to be different from other lane separation markings.

Following discussions within the project team and with the HA, it was decided that a diamond would be the most suitable shape for the marking and initially 4 different diamond shapes were produced. Following trials on both the TRL simulator (see Figure 3) and the TRL test track (see Figure 4) the most suitable diamond shape was selected for the anti-swoop marking.

In addition to the new marking, new gantry based signing had to be designed and approved. Figure 5 shows the approved modified gantry signing in the vicinity of this junction which was associated with the new anti-swoop marking.

Following the approval of the complete scheme the new markings and signing were installed in July 1999. Prior to the installation of the scheme there were features on local TV, which attempted to raise awareness of the scheme and its objectives.

In the ‘after’ survey (04/11/99 – 05/11/99 and 08/11/99 – 10/11/99) it was found that while the level of swooping had fallen by 54% during the peak hour, the traffic flows on the slip road have increased by 23%. This increase in throughput on the slip road has meant that there is less disruption to traffic on the main carriageway.

This trial has shown that the new anti-swoop diamond marking has been successful at modifying driver behaviour in the vicinity of the diverge at this junction. During periods of high turning movements, the layout acts as a virtual lane drop diverge layout whilst retaining the capacity of the main carriageway when there are lower turning movements.

4 ‘Ghost’ island / ‘Tiger Tail’ diverge layouts

4.1 Background
It was hypothesised that high proportions of swooping manoeuvres carried out by diverging traffic indicated that the diverge layout was not operating optimally. It was thought that the factors affecting the number of swooping manoeuvres at a diverge, were the turning movement at that diverge and the capacity of the sliproad. Both these factors have the greatest effects during the peak periods.

Initial modelling work using SISTM had predicted that diverge layouts encompassing an auxiliary lane performed better than conventional diverge layouts when high turning movements were combined with high vehicle flows.

Following the success of the ‘ghost’ island merge layout at improving merge performance at a number of locations on the motorway network, it was decided to trial the installation of ‘ghost’ island diverge layouts at locations where specific problems had been identified. It was hoped that the new layout would modify diverging driver behaviour and as a result improve the performance of the diverge both on and off the mainline.

4.2 The first trial at the M20/M26 interchange (Use of carriageway markings only)
The first before and after video survey was carried out at the M20/M26 interchange at Wrotham, in Kent in 1995, during the morning peak period. The diverging area was approximately 1 km long with two slip lanes leading to the M26 alongside the three mainline lanes of the M20. There was considerable weaving between slip lanes 1 and 2 and the mainline with considerable speed differentials between vehicles. This provided ample opportunity for the swooping manoeuvre. Figure 6 shows the Before M20/M26 survey site.

From the results from the SISTM simulation trials (see Section 2), a new layout combining an auxiliary lane with a ‘tiger-tailed’ marked ‘ghost’ island was designed to allow easier departure from lane 2 of the mainline without the need for a last minute swoop. It was also hoped that the movement of diverging traffic would be regulated into a safer and more orderly stream. In order to leave the mainline in the new layout (see Figure 7), vehicles needed to be in lane 1 and use either the first exit to join slip lane 1 or second exit to join slip lane 2.

Table 2 shows the average number of swoopers on each day of the Before and After surveys.

<table>
<thead>
<tr>
<th>Average number of swoopers per hour</th>
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<tbody>
<tr>
<td><strong>Before</strong></td>
</tr>
<tr>
<td>Day 1</td>
</tr>
<tr>
<td>Day 2</td>
</tr>
<tr>
<td>Day 3</td>
</tr>
<tr>
<td>Day 4</td>
</tr>
<tr>
<td>Day 5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
</tr>
</tbody>
</table>

As seen from Table 2, the average number of swoopers decreased significantly in the After survey from an average of 709 to 239 swoopers per hour, despite a small increase in traffic flow in the After survey. The difference in the average was found to be statistically significant. The remaining numbers of swoopers in the after survey were concentrated at the two exit points (90% of all swoopers) with a noticeable proportion of drivers crossing the ‘ghost’ island markings (an average of 94 vehicles an hour).
Figure 3 Simulator screen capture

Figure 4 Selected anti-swoop marking on TRL test track
Figure 5 Modified gantry signing at M6 J6
The relatively large number of swoopers at the first exit was thought due in part to the lack of a vertical sign clearly showing drivers that there is another opportunity to leave the mainline. This could also explain why drivers cross the ‘ghost’ island in order to leave the mainline. After the installation of the ‘ghost’ island, slip lane 1 was found to carry about 440 vehicles per hour more than slip lane 2.

Overall, the trial was a success. Swooping was substantially reduced and the exit now runs in a more orderly fashion than before, with lower speeds on both slip lanes. It was recommended that installing a suitable sign informing drivers of the new junction layout, might have made the trial even more successful. One of the effects of adding a new sign was expected to be a more equal balance of flow between the two slip lanes, as well as reducing swooping and the numbers crossing the ‘ghost’ island. Vehicles essentially now leave the mainline either by slip lane 1 or slip lane 2, and having once entered a lane, remain in it until away from the junction area.

4.3 The second trial at the M20/M26 interchange (Installation of vertical signing)

A second Before and After video survey was carried out on the M20/M26 interchange at Wrotham in Kent in 1997. The layout remained unchanged from the original After survey in the first trial (see Figure 7). The purpose of the second trial was to evaluate what effect installing a new vertical sign showing the new layout, had on swooping and the numbers crossing the ‘ghost’ island. The new vertical sign (see Figure 8) shows drivers that in order to leave the mainline they need to be in lane 1, and that there are two equally usable exits.

Between the first and second trial, swooping had again fallen considerably (from 239 to 120 vehicles an hour) as
well as fewer vehicles crossing the ‘ghost’ island (from 94 to 23 an hour), presumably due to drivers’ increased familiarity with the layout. These were much greater decreases than the 10% reduction in the total traffic flow observed. The new trial showed a marginal increase in swooping (120 to 148 per hour) but no change in vehicles crossing the ‘ghost’ island (remaining at 23 an hour). This minor increase in swooping needs to be considered in the context of a 10% increase in flow between the second before and after surveys. Following the ‘ghost’ island installation, the flows in the slip lanes were unbalanced (slip lane 1 with 61% and slip lane 2 with 39% of diverging traffic). By the time the new sign was introduced, these slip lane flows had evened out at 54% and 46%, presumably due to driver familiarity. In the After survey, the slip lane flows were at 53% and 47%, showing that the sign had made little additional effect.

The results for both trials were for peak period operation, when most drivers are very familiar with the junction layout; the fact that both swooping and ‘ghost’ island violations have dropped significantly between the first After and the second Before survey indicates that increased familiarity has improved driver behaviour. Although the sign has had no noticeable effect in the AM peak period, it is reasonable to assume that drivers unfamiliar with the layout will be assisted by the new sign, reducing the perceived need to swoop and/or cross the ‘ghost’ island.

4.4 The M6 J4a intersection: trial of a ‘ghost’ island diverge layout

Following the success of the trials of the ‘ghost’ island diverge layout with a lane drop and without a lane drop at the M3/M25 and M20/M26 intersections, there was potential for identifying other sites which could benefit from these measures. The M6 J4a site was suggested by the Highways Agency as it had high traffic flows and a significant diverge proportion.

A Before and After video survey was carried out in November 1997 and October 1998 respectively for the evening peak period using seven video cameras. The new ghost island layout was installed in June 1998. Figure 9 and Figure 10 show the Before and After layouts.

In the Before survey, it was found that during the evening peak hour, 47% of traffic diverged at the junction. This meant that lane 1 could not provide the required capacity for the exiting traffic and so there was a high occurrence of the practice of swooping, especially during the peak hour, when 14% of exiting vehicles performed swooping manoeuvres. Over 50% of swooping manoeuvres occurred once the slip road had sufficient width for two lanes of traffic. Also, flow breakdown occurred on the slip road, which caused queues of slow moving traffic to form in the slip road, which on occasions extended back onto the mainline.

Due to the above reasons, it was decided that the most appropriate ‘ghost’ island layout would incorporate a lane drop, but in order not to reduce the capacity of the mainline the lane is regained immediately after the diverge has ended. (Figure 11).

The existing large diverge area allowed the ‘ghost’ island to be introduced with little impact on the hard shoulder of the diverge area. As well as modifying the diverge layout, the signing at 1 mile, 2/3 mile and 1/3 mile was altered informing drivers of the new layout (Figure 12, Figure 13 and Figure 14 respectively).

In the After survey, it was found that the level of swooping had fallen by 77% despite increases in vehicle flow of 4% during the survey period and 12% during the peak hour. The new layout effectively allowed the driver to retain the perceived personal benefits of swooping, but without the safety hazards to other drivers associated with last minute lane changing.
Figure 9 The Before M6 J4a survey site

Figure 10 The After M6 J4a survey site
Figure 11 Schematic diagram of the After M6 J4a southbound survey site

Figure 12 New verge mounted sign at 1m
**Figure 13** New gantry mounted sign at 2/3m

**Figure 14** New gantry mounted sign at 1/3m
At present, the second exit lane is under utilised with only 22% of diverging vehicles using it. This means that once the ‘ghost’ island has ended, there was a large number of lane changing manoeuvres on the slip road. Also, there are approximately 25 vehicles an hour crossing the ‘ghost’ island. It is hoped that as drivers become more familiar with the new layout (as with the M20/M26 study), the two exit lanes will be more equally utilised along with a reduction in vehicles crossing the ghost island.

4.5 The M27/M3 eastbound diverge: trial of a ‘ghost’ island diverge layout

A Before and After video survey was carried out on the M27/M3 eastbound diverge during the morning peak period, near Southampton, in November 1998 and June 2000 respectively. In between the two surveys, a ‘tiger-tail’ ‘ghost’ island lane drop was installed at the site. Figure 15 and Figure 16 show the Before and After survey site at the M27/M3 eastbound diverge. The new layout replaced the previous standard lane drop arrangement.

With the original layout, vehicles wishing to diverge onto the M3 needed to be in lane 1. It was estimated that about 50% of traffic diverged onto the M3. This meant that lane 1 could not provide the required capacity for the exiting traffic, resulting in queues of slow moving traffic in some of the peak periods, with a high occurrence of swooping (vehicles moving into the slip road directly from lane 3,

![Figure 15 The Before survey site](image1.png)

![Figure 16 The After survey site](image2.png)
within 1500m from the exit, in order to leave the mainline) and potentially dangerous manoeuvres (sudden lane changes into or out of the slip road/lane within 1100m of the exit). It was hoped that the installation of the new ‘ghost’ island would allow easier departure onto the M3 from lane 1 and lane 2 reducing the need of drivers to swoop. It was also hoped that the movement of diverging traffic would be regulated into a safer and more orderly stream.

New gantry and vertical signing (shown in Figure 17), informing drivers of the new junction layout, were also installed. With the new layout, vehicles wishing to diverge onto the M3 need to be in either lane 1 and use the first exit to join slip lane 1, or lane 2 and use the second exit to join slip lane 2. Vehicles wishing to continue on the M27 still needed to be in either lane 2 or lane 3.

Annex 4

Accident statistics for the approaches to the M27/M3 eastbound diverge were analysed for the period from 1st January 1994 to 31st October 1999, prior to the installation of the new layout. There were 4 accidents in this period, but only one was attributable to changing lane carelessly (driver lost control whilst diverging over nose). It is unclear from the accident data whether this involved a swooping manoeuvre into the slip road but it was certainly a last moment departure and therefore very likely to be potentially dangerous. It is hoped that the installation of the new ‘ghost’ island layout will lead to safer driver behaviour.

Swooping at the diverge decreased significantly from an average of 69 to 44 swoopers per hour (approximately a 36% reduction). Although the level of swooping observed at the site was relatively low compared to for example the M20/M26 diverge, this was still an encouraging result. Potentially dangerous manoeuvres decreased significantly from an average of 399 to 81 an hour (an 80% reduction). The new ghost island layout was particularly successful in reducing the number of these potentially dangerous manoeuvres by regulating the diverging flow into a more orderly stream, eliminating many potential conflict opportunities.

The average number of vehicles crossing the nose reduced from 3 to 1 vehicle an hour. A small number of drivers drove over the ‘ghost’ island markings (an average of 17 an hour which is less than 0.8%) and changed from either slip lane 1 to slip lane 2 (8 vehicles an hour) or slip lane 2 to slip lane 1 (9 vehicles an hour). The number of vehicles crossing the ‘ghost’ island is expected to reduce to close to zero once drivers are more familiar with the new layout.

The average number of vehicles changing from the slip road/slip lane 1 to slip lane 2 reduced dramatically from 835 to just 8 vehicles per hour. In the Before survey, there was potential conflict between vehicles changing from the slip road/slip lane 1 to slip lane 2 (835 vehicles per hour) and those vehicles changing from lane 2 to slip lane 2 (215 vehicles per hour). Changing from lane 2 to slip lane 2 in the Before layout was not illegal but could still be dangerous. This potential conflict involving last minute departures from lane 2 was almost eliminated in the after survey. Drivers were now able to change safely from lane 2 to slip lane 2 and did so in increased numbers (1022 vehicles per hour compared to 215 vehicles per hour in the Before survey).

Overall, the trial was a success. Swooping and potentially dangerous manoeuvres were substantially reduced, with the exit running in a more orderly fashion with lower average speeds on both slip lanes. Vehicles essentially now leave the mainline by either slip lane 1 (from lane 1) or slip lane 2 (from lane 2) and having once entered a slip lane, remain in it until away from the junction vicinity.

5 Summary of swooping results

Table 3 shows a summary of the monitored anti-swooping trials.
### Table 3 Summary of monitored swooping trials

<table>
<thead>
<tr>
<th>Location</th>
<th>Scheme</th>
<th>Before/After</th>
<th>Date of survey</th>
<th>Time period</th>
<th>Average flow per hour</th>
<th>Average number of swoopers per hour</th>
<th>Average flow on Slip</th>
<th>% of swoopers</th>
<th>% crossing nose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dartford Tunnel</td>
<td>N/A</td>
<td>Before</td>
<td>1995</td>
<td>07:30-08:30</td>
<td>4783 N/A</td>
<td>65</td>
<td>872-2044</td>
<td>3.2%-7.5%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>M27 J3</td>
<td>Solid white line</td>
<td>Before</td>
<td>May 1995</td>
<td>07:30-09:00</td>
<td>4316 46%</td>
<td>218</td>
<td>1977</td>
<td>11.0%</td>
<td>–</td>
<td>Not successful in reducing swooping, (A relationship between swooping and queuing on the slip was found).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After</td>
<td>July 1995</td>
<td></td>
<td>4365 47%</td>
<td>238</td>
<td>2032</td>
<td>11.7%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>M20/M26</td>
<td>Ghost Island</td>
<td>Before</td>
<td>July 1995</td>
<td>06:45-09:00</td>
<td>4641 48%</td>
<td>709</td>
<td>2211</td>
<td>32.1%</td>
<td>0.2%</td>
<td>Successful in reducing swooping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After</td>
<td>Oct 1995</td>
<td></td>
<td>4824 42%</td>
<td>239</td>
<td>2039</td>
<td>11.7%</td>
<td>0.8%</td>
<td>–</td>
</tr>
<tr>
<td>M20/M26</td>
<td>Ghost Island</td>
<td>Before</td>
<td>Feb 1997</td>
<td>06:45-09:00</td>
<td>4511 50%</td>
<td>120</td>
<td>2242</td>
<td>5.4%</td>
<td>0.2%</td>
<td>Usage of slip lanes evened out due to new sign.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After</td>
<td>May 1997</td>
<td></td>
<td>4735 49%</td>
<td>148</td>
<td>2304</td>
<td>6.4%</td>
<td>0.3%</td>
<td>–</td>
</tr>
<tr>
<td>M25/M20</td>
<td></td>
<td>Before</td>
<td>Dec 1997</td>
<td>17:30-18:30</td>
<td>4603 27%</td>
<td>46</td>
<td>1227</td>
<td>3.7%</td>
<td>0.6%</td>
<td>No scheme was installed following before survey.</td>
</tr>
<tr>
<td>M6 J6</td>
<td>Diamond markings</td>
<td>Before</td>
<td>Sept 1997</td>
<td>08:00-09:00</td>
<td>4455 36%</td>
<td>291</td>
<td>1599</td>
<td>18.2%</td>
<td>0.1%</td>
<td>Successful in reducing swooping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After</td>
<td>Nov 1999</td>
<td></td>
<td>4659 42%</td>
<td>122</td>
<td>1963</td>
<td>6.2%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>M6 J4a</td>
<td>Ghost Island</td>
<td>Before</td>
<td>Nov 1997</td>
<td>17:30-18:30</td>
<td>5332 47%</td>
<td>354</td>
<td>2496</td>
<td>14.2%</td>
<td>0.2%</td>
<td>Successful in reducing swooping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After</td>
<td>Oct 1998</td>
<td></td>
<td>5896 46%</td>
<td>71</td>
<td>2723</td>
<td>2.6%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>M27/M3</td>
<td>Ghost Island</td>
<td>Before</td>
<td>Nov 1998</td>
<td>06:30-10:30</td>
<td>4488 49%</td>
<td>71</td>
<td>2221</td>
<td>3.2%</td>
<td>0.1%</td>
<td>Successful in reducing swooping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After</td>
<td>Jan 2000</td>
<td></td>
<td>4444 49%</td>
<td>44</td>
<td>2165</td>
<td>2.0%</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
6 Locations of existing ‘ghost’ island diverges

6.1 Sites where ‘ghost’ island diverges are known to exist
1 M3/M25 northbound (M3 J2).
2 M20/M26*.
3 M6 J4a*.
4 M23/M25.
5 M42 J3a.
6 M6/M61 southbound.
7 M27/M3* eastbound and westbound.

6.2 Potential sites where ‘ghost’ island layouts are being considered
1 M5 J4a northbound.
2 M5 J4a southbound.
3 M1/M45.
4 M1/M6.
5 M25 J2 and J3.
6 M6 J6 southbound.
7 M60 ‘A’ carriageway J15 exit to M61.
8 M56 J3 eastbound to Sharston Bypass.
9 M25/M40 eastbound and westbound (after widening).

7 Discussion

7.1 Anti-swooping lane separation markings
Within this study two different types of markings have been trialed and monitored with different degrees of success.

The solid white line which was installed on the M27 J3 was found not to be successful in reducing the occurrence of swooping, however, there are a number of factors which may have contributed to this failure.

The anti-swoop marking was installed as a stand-alone measure and there were no associated signing to inform drivers of the expected behaviour. The marking was effective in encouraging drivers who wished to turn left at the head of the slip road to get into lane one before the start of the marking. However, as the majority of traffic needs to turn left at the head of the sliproad towards Southampton this modification of driver behaviour had an adverse effect on the capacity of the sliproad.

This meant that queues of traffic formed on lane 1 of the sliproad, which encroached back onto the mainline. By performing a swooping manoeuvre drivers were able to perform queue jumping. It was recommended to modify the layout at the head of the sliproad so the right-hand lane could also be used by vehicles wishing to head into Southampton; this measure would effectively double the queuing capacity on the sliproad.

There may have also been a visibility problem; the M27 at this point is a concrete road, and the solid anti-swooping line did not stand out clearly against this surface. It was not possible to say whether this contributed significantly to the ineffectiveness of the marking.

This study highlighted the fact that anti-swoop markings may not be successful if installed as a standalone measure or if the cause of the problem stems from capacity bottlenecks on the sliproad.

In contrast, the diamond markings installed on the M6 J6 were shown to be successful in reducing the occurrence of swooping at this particular diverge. The reduction in the amount of swooping at this diverge increased the capacity of the sliproad as previously, as swooping vehicles caused a bottleneck where the two slip lanes merged into one.

The aim of the marking design was to provide a marking whose shape and size was recognisably different from all other road markings. The diamond shape was chosen as the best to fulfil this requirement, and its size and spacing were determined by tests on the TRL driving simulator, and then by practical trials between the two best layouts on the TRL test track.

In contrast to the trial on the M27, the markings were installed as part of a package, along with new gantry based signing which informed drivers of their expected behaviour in the vicinity of the markings. In addition, before the installation of the scheme, there were features on local news programmes informing viewers of the expected results of the scheme. As a result it is believed that regular users of this diverge were more willing to change their driving behaviour to gain the expected benefits.

This first trial of the diamond markings has shown that with effective signing and publicity, driver behaviour can be modified with the introduction of a lane separation marking. During periods of high turning movements, the layout acts as a virtual lane drop layout whilst retaining the capacity of the mainline when there are lower turning movements.

This measure can be employed at diverges where it is not possible to install a ‘ghost’ island diverge layout or where it is desirable to limit the diverging traffic to one lane on the sliproad without using a lane drop diverge layout which reduces the capacity of the mainline.

7.2 ‘Ghost’ Island / ‘Tiger Tail’ diverge layouts
Within this study ‘ghost’ island diverge layouts have been installed and monitored at three diverges either as stand-alone measure or as part of wider junction layout improvements.

- M20/M26 Interchange - standard ‘ghost’ island layout.
- M6 J4a - Lane drop ‘ghost’ island diverge.
- M27/M3 Interchange - lane drop ‘ghost’ island diverge.

When the ‘ghost’ island diverge layout was installed on the M20/M26 it was found that whilst the occurrence of swooping had reduced, initially that there was an uneven distribution in the use of the two exit points. In an attempt to even the usage of the exits a vertical sign was installed displaying the new layout of the junction. It was hoped
that infrequent users of the junction would be made aware of the second exit point on the diverge.

In subsequent trials ‘ghost’ island diverge layouts have been accompanied by associated vertical signing, it is believed that this signing has encouraged drivers to more readily use the second exit point at the diverge.

The second and third trials in this study have used the ‘ghost’ island lane drop layout; the M6 J4a was converted from a standard auxiliary lane diverge layout and the M27/ M3 already encompassed a lane drop layout. Both of these diverges have high turning movements ~ 50%, and the new layouts have improved driver behaviour in the vicinity of the diverges. As well as reducing swooping manoeuvres at the diverge point, there have been a significant reduction in the number of lane changing manoeuvres carried out on the slip roads. The diverge layout enables the separation of traffic which heads in different directions at the head of the sliproad.

Significant modifications in driver behaviour have been recorded at each of these diverges following the installation of the schemes. This modification of driver behaviour has resulted in a decrease in swooping manoeuvres, higher capacity for through traffic and improved flow distributions on the slip road.

These trials have confirmed the predictions made by the initial work using SISTM that this type of layout would perform well at diverges with high turning movements i.e. over 40%. There is now sound backing for the inclusion of ‘ghost’ island diverges as approved standard layouts, both with and without a lane drop.

7.3 Conclusions

This review of the anti-swooping trials shows that effective measures to combat the problems of swooping at diverges have been found. Where these have been trialed successfully by reducing the occurrence of swooping and modifying driver behaviour in the vicinity of the diverge area, there have been benefits in terms of capacity and average vehicle speeds through the section. Vehicles are now able to diverge in a more controlled manner and as a result this has a benefit for through traffic on the mainline.

The three monitored trials within this study have proved that ‘ghost’ island diverge layouts can be used to good effect at diverges where there is a significant turning movement. During the study period these layouts have been installed at a number of other locations on the motorway network. The results suggest that ‘ghost’ island layouts, with and without lane drops, could be added to the approved standard layouts.

Further trials of the diamond anti swoop marking are required before it can be confirmed that they are an effective measure, which can be used on the network to combat swooping.

The later trials conducted within this study have been accompanied by a high profile in the local news coverage. It is thought that this publicity prior to the installation of a scheme has contributed to the immediate success of the schemes by educating drivers.

8 Acknowledgements

The authors would like to acknowledge the help provided by TRL Visual Media Centre in carrying out the video filming and the Transportation Project Support Unit for analysing the video tapes.

The authors would also acknowledge the help and support provided by the HA staff involved in the schemes and their respective agents.

9 References


Appendix A: Recommendations for ‘ghost’ island diverge layouts

The aim of this appendix is to provide guidance for designers who are considering the installation of ‘ghost’ island diverge layouts. These layouts can be considered when the diverge flow is high (more than about 1600 vehicles per hour), leading to queues of slow-moving traffic in Lane 1 together with ‘swooping’ movements (late manoeuvres from Lane 2 or 3 to the slip road). By providing two entry points to a 2-lane off-slip road, the capacity of the slip road is increased, congestion on the mainline is reduced and swooping movements are discouraged.

‘Ghost’ island layouts (otherwise known as ‘tiger tails’) have been successfully installed as trials at several locations on the motorway network. They have proved particularly effective at improving traffic flow at sites where there is a high diverging flow i.e. greater than 40% of the total upstream flow. Depending on the space available and the required mainline capacity these layouts can be used either with or without a lane drop.

Figure A1, Figure A2 and Figure A3 show examples of recommended layouts for ‘ghost’ island diverges. The dimensions shown are all for rural motorways. For the possible application of ‘ghost’ island diverge layouts to other roads, guidance should be sought from the relevant Overseeing Organisation. There may be constraints at a particular site which prevent the dimensions of the recommended layouts from being achieved. Designers may need to consider amendments to the lengths and widths of the various elements of the layouts. Where there are land constraints, for example, encroaching on the hardshoulder may be considered an acceptable means of achieving the additional capacity and safety offered by a ‘ghost’ island diverge layout.

It is essential when installing a new layout that drivers are informed of the behaviour expected at the modified layout. Figure A4 shows three advanced direction signs which have been installed in conjunction with the trials summarised in this report. The main objective of the signs is to highlight to the driver the existence of the second diverge point and encourage its use. It has been found that the installation of such signing improves the utilisation of the second exit with the effect of balancing the vehicle flows on the slip road lanes. Signs authorisation will be required for the non-standard signs designed for a particular site.

At present, ‘ghost’ island diverge layouts require the agreement of the relevant Overseeing Organisation as a departure from standard.
1. ‘Ghost’ island and nose markings to Traffic Signs Regulations and General Directions diagram 1042
2. ‘Ghost’ island width 2m minimum when fully developed
3. Lane widths for slip roads as required by TD 22/92
Abstract

This report provides a summary of the trials, conducted between 1995 and 2000, which have attempted to combat the problem of ‘swooping’ at diverge areas. Two different approaches to solving this problem have been employed within this study: new lane separation markings and ‘ghost’ island diverge layouts. The trials have shown that reducing swooping manoeuvres during peak periods increases both the capacities of the mainline and of the slip road through the smoothing of vehicle flows through the section. The ‘ghost’ island diverge layout has been particularly successful in modifying diverging driver behaviour and has been used in both auxiliary lane and lane drop layouts. The study has also highlighted that for a scheme to be successful the modified layout should be accompanied by appropriate signing to inform drivers of the expected behaviour. The promotion of the scheme through local media prior to the installation, encourages regular users of the diverge to adapt their behaviour in order that the expected benefits can be experienced.

Related publications

TRL332 Road layout design standards and driver behaviour by G Maycock, P J Brocklebank and R D Hall. 1998 (price £35, code H)

PR49 Yellow bar marking on motorway slip-roads by J Haynes, G Copley, S Farmer and R D Hellier-Symons. 1993 (price £25, code E)

RR342 Analysis of accidents before and after implementation of improved motorway signalling by B R Cooper, H E Sawyer and K S Rutley. 1992 (price £35, code H)

CR338 An investigation of flow breakdown and merge capacity on motorways by N B Hounsell, S R Barnard, M McDonald and D Owens. 1992 (price £50, code L)

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