

# Safeguarding Vulnerable Road Users: Summary Report of PRIME Road Trials 2020 to 2022

Prepared by

**Professor Alex Stedmon**

CPsychol CSci CIEHF AFBPsS FIEHF FRSA

31 January 2023

Open Road Simulation Ltd



## Abstract

Innovative road markings for motorcyclists, designed as Perceptual Rider Information for Maximising Expertise and Enjoyment (PRIMEs) were installed on the approach to demanding bends at 22 trial sites and two comparison sites across the West Highlands of Scotland. These road markings were presented as a series of 'gateways' to encourage safer riding. All sites were of similar standards in relation to road surface and environment. Video data were collected to measure motorcycle speed, lateral position, braking and use of the road markings, before and after the PRIME road markings were installed.

A total of 32,213 motorcyclists were observed. Across the trial sites, statistically significant reductions in speed were observed at 10 trial sites. Significant changes in lateral position were observed at the final PRIME gateway marking at 15 trial sites with motorcyclists riding in better positions on approach to the bend. Statistically significant changes in lateral position at the apex of the bend were observed at 13 trial sites. Statistically significant reductions in braking were observed at nine trial sites. There were statistically significant increases in the use of PRIME road markings across 18 of the 22 trial sites.

No statistically significant effects were observed at the comparison sites. These findings are discussed in relation to sustained effects, the 'Road Safety Framework to 2030' and the 'Safe System' approach to reducing motorcycle casualties.

## Highlights

- This research is a world-first and the largest road trial investigation of PRIME road markings involving 32,213 motorcyclists
- Unique PRIME road markings for motorcyclists produced statistically significant positive behavioural changes in speed, lateral lane position and braking at sites around the Scottish Highlands
- This in-depth study identifies important behavioural factors that support Transport Scotland's 'Road Safety Framework to 2030' and the 'Safe System' approach to motorcycle casualty reduction

## Prepared by Open Road Simulation Ltd

Open Road Simulation Ltd is an organisation providing high quality independent Human Factors and Applied Psychology consultancy services to a range of international clients.

Open Road Simulation Ltd has expertise across a range of specialist areas including transport (road safety, vulnerable road users, driver and rider behaviour), simulation solutions (driving and motorcycle simulation) and expert witness activities (driver and rider psychology).

For further information, please contact Alex using the information below.

e: [alex@openroadsim.com](mailto:alex@openroadsim.com)

www: <http://openroadsim.com>

## Executive summary

Motorcyclists account for only 2.2% of registered vehicles in Scotland but represented 14% of all Killed or Seriously Injured (KSI) casualties in 2019 (Transport Scotland, 2020). More generally, motorcyclists are around 51 times more likely to be killed on the road than car drivers. This makes them one of the most vulnerable road user groups on public roads (Stedmon, McKenzie, Langham, McKechnie, Perry and Wilson, 2021, 2022).

In response, the Scotland Road Safety Framework has identified motorcyclists as a Priority Focus Area with a target of 30% reduction in motorcyclists killed or seriously injured by 2030 (Transport Scotland, 2021).

### PRIMES for motorcycle casualty reduction

This report presents the results from a 3-year investigation of 'Perceptual Rider Information for Maximising Expertise and Enjoyment' (PRIMES) on Scotland's Trunk Road Network. This is a unique and innovative approach to casualty reduction that sets out to 'prime' rider behaviour by developing unique road markings for motorcyclists. The road markings provide a tool for riders to adapt their behaviour on approach to a potential hazard therefore optimising their expertise and enjoyment while remaining safe on the road.

The current work is focused on developing PRIMES to assist motorcyclists approaching demanding bends where it is important that:

- speed is suitable for the conditions
- lane position is optimised for negotiating the bend
- motorcyclists do not have to initiate braking whilst negotiating the bend

The PRIME road markings were designed as a set of three 'gateways' so that motorcyclists might ride 'through the gap' to put them in the correct position for the bend and allow them to adjust their speed and braking prior to the bend.

### Unique research in the West Highlands

Based on formal reviews and analyses of collision data, 22 sites were identified in the West Highlands ranging from Glencoe, Oban, Inveraray, Loch Lomond and towards Stirling and Crieff. Two comparison sites were also included where data were collected but PRIME road markings were not installed. Where necessary, all sites had been brought up to similar standards prior to data collection.

This research followed a conventional 'pre- and post-intervention' paradigm, where baseline data were compared with data collected once the PRIME road markings had been installed. Data were captured at each site using small and inconspicuous roadside video cameras in order to analyse speed, lateral position, braking behaviour and use of the PRIME road markings.

The PRIME road markings were installed using 3M™ Stamark™ High Performance permanent tape. They underwent a range of design specification, user acceptance, evaluation, and non-prescribed road sign application activities prior to being installed on public roads for the trials. Independent road safety audits were also conducted before and after the PRIME road markings were installed.

### Over 30,000 motorcycles observed

In total 32,213 motorcycles were manually counted and coded across all the trial sites. Motorcycles carrying a passenger/pillion (N= 3,281) represented 10.19% of the total sample of motorcycles. The largest proportion of motorcycles were classified as being part of a group (N=19,568), accounting for 60.75% of the total sample of motorcycles. This would indicate that while motorcyclists did not generally carry a passenger/pillion they were likely to be riding with other motorcyclists, reinforcing the social aspect of motorcycling.

Lead motorcycles (N=9,919) accounted for 30.79% of the total sample of motorcycles and were analysed in more detail. Results across the 22 trial sites are summarised below:

- **Speed** – statistically significant reductions in speed were observed at 10 trial sites. Trends were observed at four other sites
- **Lateral position at the final PRIME road marking** – statistically significant changes in lateral position were observed at 15 trial sites with motorcyclists riding in better positions on approach to the bend. Trends were observed at three other sites.
- **Lateral position at the apex of the bend** – statistically significant changes in lateral position were observed at 13 trial sites. A trends was observed at one other site.
- **Braking behaviour** – statistically significant reductions in braking were observed at nine trial sites. Trends were observed at 15 other sites.
- **Use of the PRIME road markings** – statistically significant increases of PRIMEs were observed at 18 trial sites. Trends were observed at three other sites.

At the comparison sites as expected, no differences in rider behaviour were observed. At one site a trend for reduced braking was observed but this was due to temporary traffic management in the area affecting traffic flow on specific data collections periods.

Rider interviews indicated that the majority of motorcyclists were supportive of PRIME road markings and felt they could be particularly useful to inexperienced motorcyclists or tourists with many riders stating that “anything that makes the roads safer is a good thing”. Almost two-thirds of the motorcyclists interviewed did not remember seeing the PRIMEs and, in most cases, they did not feel the PRIMEs would have influenced their riding. Taking these two observations together, this could indicate an unconscious or implicit influence of PRIMEs in the behaviours observed across the trial sites.

### **Long-term effects of PRIMEs**

Additional research was conducted to investigate rider behaviour changes over one-year and two-year periods. At the one-year review site the same results were observed in 2021 and 2022 indicating that behavioural effects of PRIMEs remained constant. At the two-year review site the same results were observed in 2020 and 2022 for speed reduction and position changes at the final PRIME road marking and apex of the bend indicating that behavioural effects of PRIMEs were still apparent two-years later. The only difference was that trends for reduced braking that were present in 2020 were not apparent in 2022.

### **Largest motorcycle study of its kind**

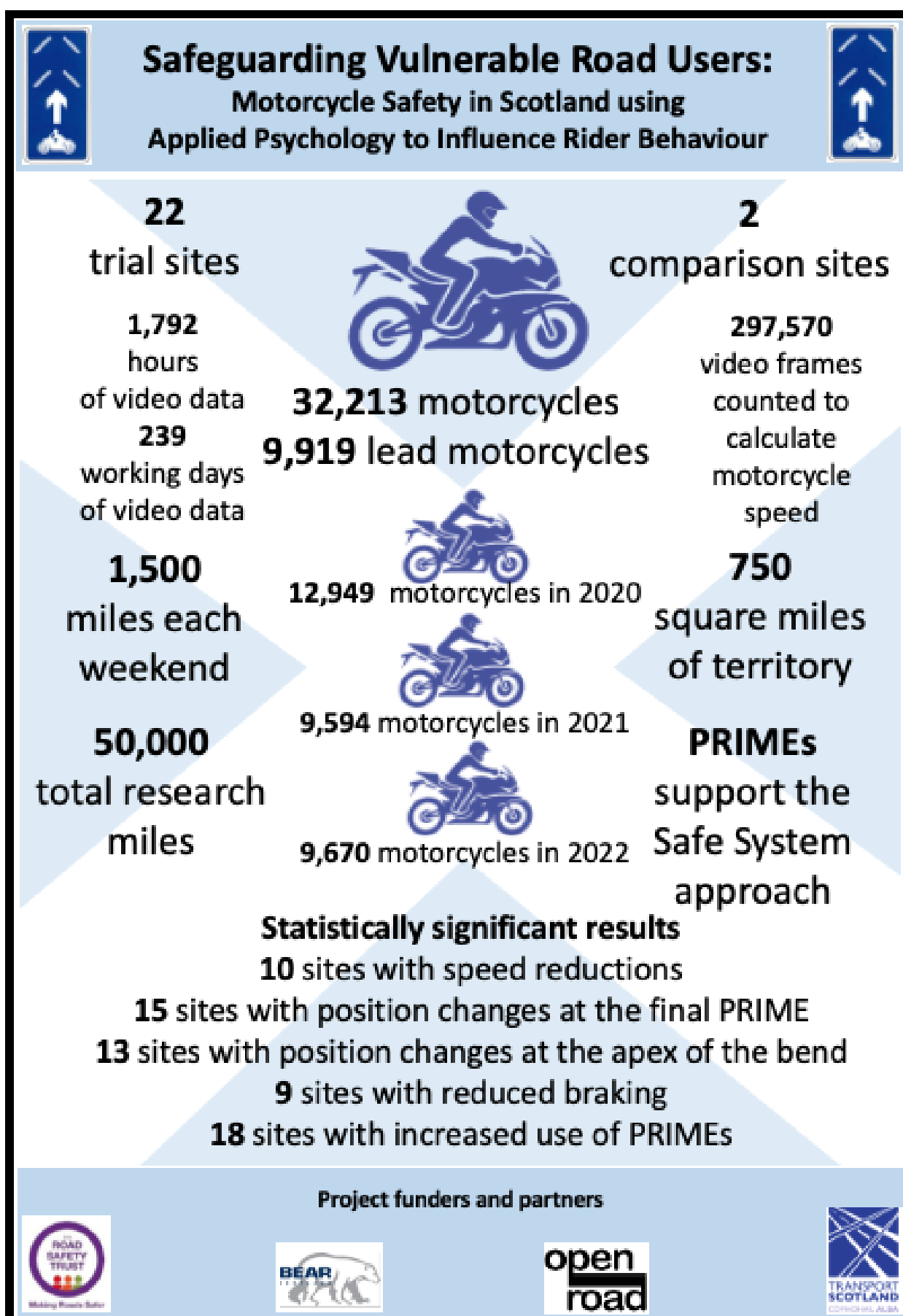
As far as the research consortium are aware, this is the most in-depth investigation of motorcycle rider behaviour to date. With 32,213 motorcycles manually counted, coded and analysed, the results provide substantial evidence that PRIME road markings had strong, sustained, and long-term effects on speed, position and braking. There was no evidence that PRIMEs had a detrimental effect on rider behaviour. In addition, while the collision data are low and not always known for each site, since the start of the trials there have been no motorcycle injury collisions at any of the previously identified cluster sites.

### **Transport Scotland pioneering world-leading and world-class research**

This research underpins the development of bespoke motorcycle road safety measures by Transport Scotland and an important step in reducing motorcyclist road casualties.

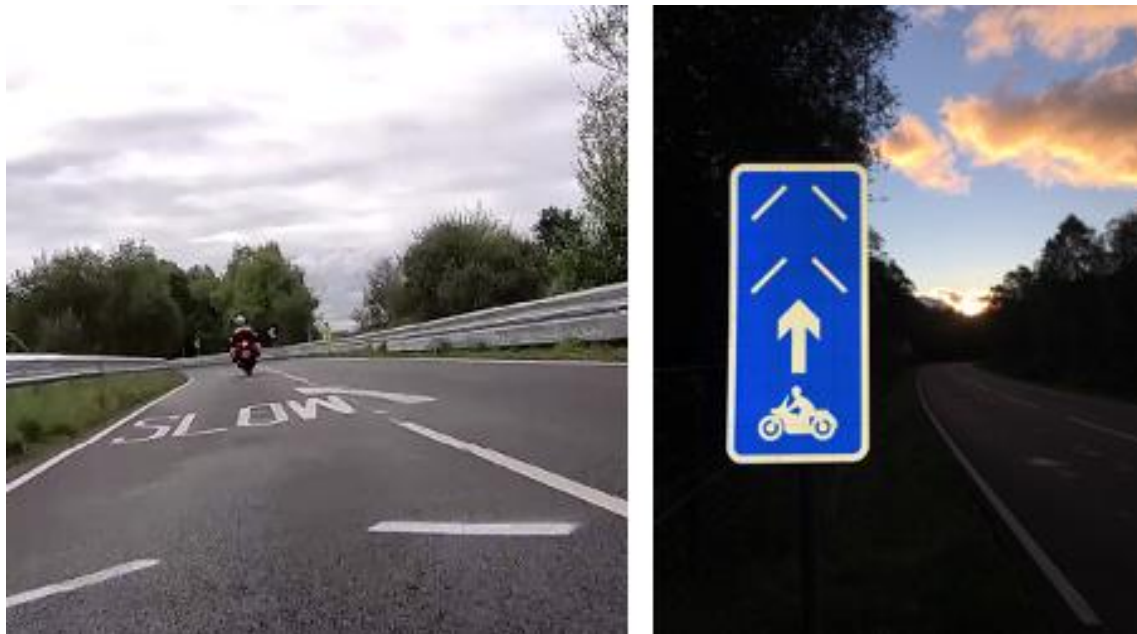
To date, the work has been published twice in the world-leading scientific journal ‘Transportation Research Part F: Traffic Psychology and Behaviour’ meaning that this research has been peer-reviewed to the highest standard by the academic community.

By demonstrating the positive influence of PRIMEs on rider behaviour and rider safety, this work showcases Transport Scotland as a leader in this initiative for the UK and the world. It highlights the important role of employing Human Factors expertise in road safety initiatives beyond the current work and in casualty reduction and road user behaviour more widely.



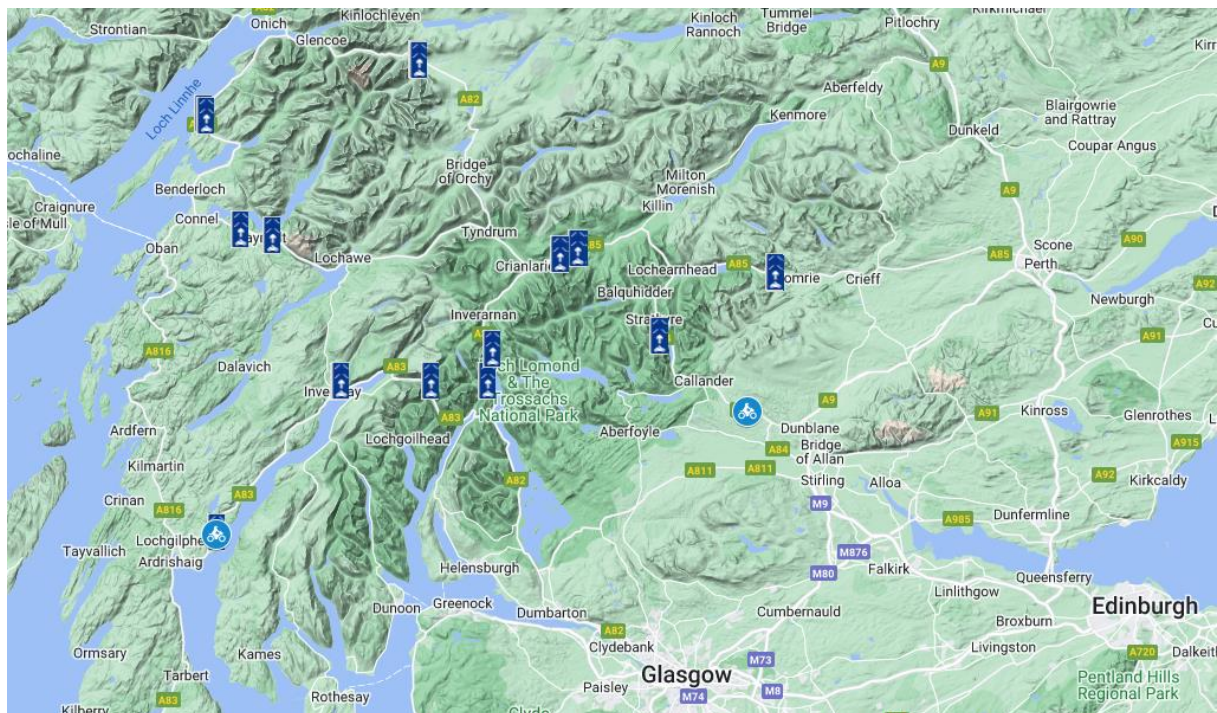


The PRIME road marking used in this research road marking was designed to potentially influence speed, position, and braking on approach to a bend (Figure 1).



**Figure 1: PRIMEs 'gateway' design**  
PRIME road marking (left) and PRIME road sign (right)

With a focus on the A82, A85 and A83, sites were identified in the region ranging from Glencoe, Oban, Inveraray, Loch Lomond and towards Stirling and Crieff (Figure 2).



**Figure 2: PRIMEs trial sites**



These images illustrate some of the left-hand and right-hand bend trials sites where PRIME road markings were installed throughout 2020 to 2022 (Figure 3).



**Figure 3: Selection of trial site images**



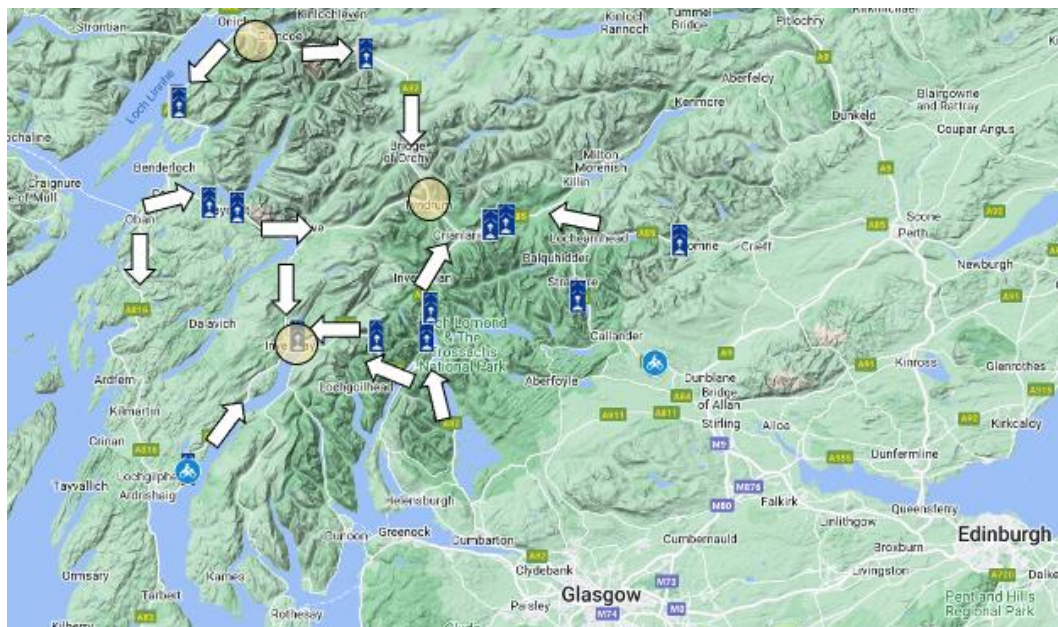
A selection of bends illustrate the changes in road position due to PRIMEs (Figure 4).



**Figure 4: Changes in road position**  
(left-hand images = without PRIMEs installed, right-hand images = with PRIMEs installed)

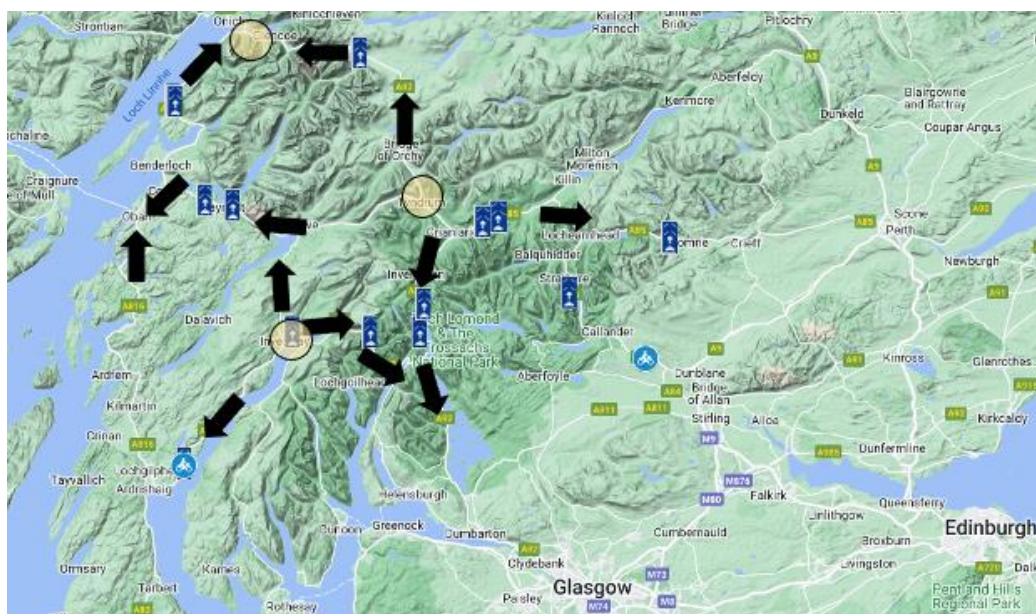


When the distributions are plotted on the map of the PRIME road trial sites, it is possible to identify typical routes that riders might take in this area earlier in the day (Figure 5).



**Figure 5: Flow of motorcyclists on the Trunk Road Network**  
(arrows indicate direction of travel in the morning)

The yellow circles indicate popular motorcycle meeting points (Glencoe, Tyndrum and Inveraray) and it is apparent from the motorcycle distributions that motorcyclists tend to ride out to these locations during the day and then return later in the day (Figure 6).



**Figure 6: Flow of motorcyclists on the Trunk Road Network**  
(arrows indicate direction of travel in the afternoon)

From the analyses specific motorcycle flow patterns were identified in the West Highlands. Clear directional effects exist in motorcycle traffic throughout the day. For any given location it is even possible to pin-point which hour of the day most motorcycles are expected to pass by, and typical numbers. This information could be invaluable for emergency response logistics, enforcement/education initiatives, pop-up road safety campaigns, etc.