How to fight wrong way driving accidents

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Abstract

Road accidents due to wrong way driving on a motorway or a dual two-lane road may be a relatively low-priority issue. However, although such accidents are few in number (only 1% of the total number of accidents on these types of road in France), they tend to be very serious (accounting for about 4% of the total number of fatal accidents). Moreover, from a road safety point of view, the matter is considered intolerable in the eyes of the public and the media. Whilst all neighbouring European countries seem to be confronted with these "ghost drivers", they have yet to find an ideal solution.

The issue of wrong-way driving was first dealt with by French legislation in 2000, with the update of the technical directive on design requirements of rural motorways. Several means of intervention were identified: modifying road geometry so as to deter wrong way movements, reinforcing static traffic signs, implementing dynamic detection and alarm signs, and finally physical prevention systems coupled or not to detection systems. This present document takes a closer look at these different means.

The paper analyses possible over-signing, detection, alarm and information systems. The possibilities of existing equipment (counting stations) have been analysed so as to acquire data to better understand and handle the phenomenon of wrong-way driving. An international bibliography has been compiled, and assessment methodologies have been implemented on experimental systems: luminous no-entry sign controlled by radar (a Doppler radar has been experimented), luminous studs and innovative signing ("raised hand").

An international literature study highlighted that efforts are currently chiefly concentrated on reinforcing traffic signs on the exit slip roads of motorways or on their approach. Indeed several studies have demonstrated that incidents involving "ghost drivers" are most often caused by entry to a freeway via an exit ramp, leading to continued wrong-way driving on a link section.

These works are being finalized in a document ([1]) shortly to be published. This document does not form a technical guide but a current state of knowledge on the issue of wrong-way driving, and gives advice and recommendations on dealing with this type of traffic violation, on related road geometry and junction signing, the use of additional innovative equipment, and measures to take in the event of confirmed wrong way driving incidents.

Sétra plans to continue monitoring technical developments so as to provide future updates on this topic, and will explore other issues such as simulation, required time and funding for various measures, technical improvements of vehicle stopping systems, experimentation assessments and further developments in legislation.
1. Wrong-way driving accident figures

In France, wrong-way driving accidents represent approximately 1% of the total number of personal injury accidents occurring on divided carriageway roads. In fact, from 2001 to 2005, 427 personal injury accidents were listed on this type of road. Moreover, the severity is higher than the average severity of accidents, and wrong-way driving accidents represent 4% of the total number of fatal accidents. Another feature is the important impact on the population due to the media. The general public consider each wrong-way driving accident as intolerable.

In Switzerland, from 2000 to 2004, 21 wrong-way accidents occurred on average every year, causing 3 fatalities and 21 injured persons. In Belgium, from 1991 to 2001, 78 persons lost their life in 204 wrong-way accidents. Whilst all neighbouring European countries seem to be confronted with these "ghost drivers", none has yet found an ideal solution.

2. Main accident features

The French motorway concessionary companies association (ASFA) studied all wrong-way driving accidents on their network from 1999 to 2003 and highlighted the main features of these accidents.

A lower occurrence was highlighted on toll road areas than on free roads. This can partly be explained by the fact that the density of entry or exit slip roads is lower on a toll road network. In addition, a higher occurrence in areas without any toll plazas was identified. Nearly 60% of these wrong-way driving accidents took place during the night. A lower legibility of the motorway interchanges and road signs, the low traffic and the road users’ tiredness are usually more probable during the night.

Regarding the type of population mostly concerned with wrong-way driving, drivers with an illegal alcohol level, the elderly and people who have suffered from major emotional shocks are over represented.

Links with road infrastructure design have also been highlighted, for example the poor legibility of motorway interchanges or poor road geometry. Geometry-related problems on the entry or exit slip roads, the lack of traffic signs and poor perception of the junction between the slip road and the link section are important factors. Two-way slip roads are problematic because of the possibility that drivers may decide to change their direction and consequently drive the wrong way.

After having exposed some general features of wrong-way driving accidents, in the next chapters we will explain possible concrete measures.

3. What can be done

The problem of wrong-way driving was first dealt with by French legislation with the update of the technical directive on design requirements of rural motorways ([17]), which rapidly confirmed existing and other conceivable means of intervention:

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1 This chapter takes up the conclusions of document [1], which is not a technical guide but a state of knowledge on wrong way driving.
• **Modify road geometry so as to deter wrong way movements**

This approach conveys two complementary ideas. On the one hand, the legibility of motorway interchanges should be improved with the aim of ensuring that road users easily understand the different possible routes they can follow. Indeed, the misunderstanding of the different routes proposed by the interchange may perturb drivers and cause wrong way driving. On the other hand, the geometry of slip roads, and more specifically their intersection with a junction, should be designed in order to make wrong-way driving physically difficult.

• **Reinforce static traffic signs (mandatory or experimental)**

Efficiency criteria of road signing have been identified. Firstly, the uniformity of road signing implies that only the use of signs in conformity with regulations is allowed. Secondly, homogeneity requirements imply that, in the same conditions, road users will find traffic signs with the same value and the same meaning, located according to the same regulations. Thirdly, simplicity: it is important to avoid the overabundance of road signs that tires drivers. Lastly, the continuity of the indicated directions should be consolidated on the road network.

The French road-signing directive defines three principles in terms of road signing perception by drivers who have their attention focused on the driving task.

Firstly, is the principle of "added value". Road signs should only be used where they are considered useful. Secondly, is the principle of grouping. When it is essential to have several signs visible at the same location, traffic signs should be positioned so that road users can see them at the same time. However, grouping traffic signs will be limited by the next principle, legibility. The reading effort or the understanding effort of the traffic signs should not be too hard for road users. The information should be simplified and that is why different signs should preferably be spread over different locations.

• **Implement dynamic detection and alarm signs**

The main goal is to detect wrong-way driving as early as possible in order to inform not only the ghost drivers, through lighted signs and alarms, but also “right-way” drivers. Still problematic is the question of what “right-way” drivers should be told to do when they meet ghost drivers. What message should be displayed on variable message signs, for example?

• **Develop vehicle stopping systems coupled or not with detection devices**

The main goal of this last idea is to prevent ghost drivers from entering the motorway through the use of vehicle stopping systems such as barriers.

For the two last intervention means, the interest is also to inform "normal" users about the existence of a vehicle driving the wrong way, provided signs or messages are understood without ambiguity.

In the next chapters of this paper, we will detail the first, second and third actions.

4. **Modifying the geometry of motorway interchanges**

Geometrical modifications primarily involve improving the legibility of motorway interchanges and making it physical difficult to take the exit slip road in the wrong direction.

In order to improve the legibility of motorway interchanges, the complexity of the intersection should be reduced. One way of achieving this is to reduce the number of traffic islands, as their multiplicity could perturb drivers and lead to wrong way driving. It is therefore preferable to have only one island. Moreover, the remaining islands should be designed in order to make wrong way driving on the slip road difficult. Nevertheless, truck traffic should be taken into
consideration at the moment of design. The use of roundabouts could solve many of these problems.

Figure 1. Existing situation and advocated solution for traffic islands ([1], p 24)

To prevent wrong-way driving which begins at the junction between the entry slip road and the link section, a common practice is still to reinforce the guidance of the road users entering the link section by putting road marker posts at the end of the entry slip road. However, the guidance of the road users located on the slip road should not reduce visibility of the junction. On the slip road, the removal of the no-entry road signs allows wrong-way drivers already located on the link section to exit the motorway by using the entry ramp. The idea is that the risk is less important if wrong-way drivers are on the slip road in comparison to the fact that they are on the link section.

Figure 2. Existing situation and advocated solution for the entry to the link section ([1], p 28)

5. Reinforce traffic signs

The international literature study highlighted that efforts currently chiefly focus on reinforcing traffic signs on motorway exit slip roads or on the approach to them. Indeed several studies have demonstrated that the incidents involving "ghost drivers" are more often caused by entry to a freeway via an exit ramp, which leads to wrong-way driving on the link section.

These signs show a raised hand on which figures a no entry sign, above which can be seen the word "STOP". In addition, painted arrows on the exit slip roads (exit ramps) clearly indicate the traffic direction.
In the United States, reinforcing traffic signs primarily involves enlarging and lowering the “do not enter” signs at the intersection of the exit slip road and the crossroads, using signs with text e.g. "wrong way", painted arrows on the ground indicating the traffic direction and continuous lines along the edge of the exit ramp.

In Europe, “no entry” signs are systematically used on the left and the right of the carriageway on the exit ramp, with possible additional wrong way signs further along the ramp. Some countries place the no entry symbol on a sign with a florescent background, systematically positioned at the end of the exit ramps or on the exit ramps where accidents have occurred.
Reinforcing traffic signs is not the only action undertaken by road authorities. In France, for example, the motorway concessionary companies use road marker posts in order to visually guide the drivers coming from the entry slip roads to the link section. The aim is to provide visual guidance without impairing visibility of the junction. Painted directional arrows on the carriageway appear to be another action implemented to reinforce the guidance.

The luminous barrier consists in reinforcing two “no-entry” signs and a directional arrow on the ground by additional luminous studs. It is cheap equipment that can be used on a large scale. Experimentation is currently underway in France on the RN171 highway from Nantes to Saint Nazaire, the RN165 from Brest to Nantes and the A154 motorway from Rouen to Evreux.
6. Implement detection systems: two experiments in France

There appears to be little use of detection and alarm systems at present, either in the United States or in Europe, mainly because of their cost. In the event of confirmed wrong-way driving incidents, several countries (Austria, Switzerland, Denmark) use the radio to warn drivers of the presence of a ghost driver.

An international bibliography has been compiled and assessment methodologies have been implemented on experimental systems: luminous wrong way signs controlled by radar, luminous studs, innovative signs ("hand up"). Among the experimental systems, two systems providing a solution to identified problems may be quoted: an AID system for a suspected incident on an exit slip road and luminous barriers for a whole network.

A wrong-way vehicle detection system controlled by a Doppler radar, which lights up two “no-entry” signs, has been installed at the toll plaza of a motorway interchange.

Within two months of use, three wrong-way driving incidents were detected. Out of these three incidents, two users changed back to the normal traffic direction, and only one continued on his course to the link section and then changed to the normal traffic direction.

It can therefore be assumed that this last wrong-way driving incident was voluntary.

![Figure 8. Detection by a Doppler radar ([3], p 36)](image)

The detection and alarm-triggering possibilities of other existing equipment (counting stations) have also been analysed so as to data better understand and handle the phenomenon of wrong-way driving.

If a vehicle goes through loop B₁ before the loop B₀, whatever the speed, an alarm is generated. This alarm will allow the activation of a luminous traffic sign, and the activation of a sonorous alarm.

The goal is to warn the wrong-way driver as early as possible, which is why the system is automatic.

![Figure 9. Detection using two traffic counting stations ([3], p 37)](image)
7. Conclusion and Perspectives

The ideas exposed in this paper summarize the ideas of a document to be published, which does not form a technical guide but rather a state of knowledge on the issue of wrong-way driving. This document gives advice and recommendations on dealing with this type of violation, on road geometry and junction signing, additional innovative equipment and the measures to be taken in the event of confirmed wrong-way driving incidents.

Sétra plans to continue monitoring technical developments so as to provide future updates and will explore other issues such as simulation, required time and funding for various measures, technical improvements of vehicle stopping systems, experimentation assessments, and developments in terms of legislation.

These possible actions will be further studied and experimented before being integrated into national road geometry and signing directives.

8. References

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2 Most of the French publication are available at www.setra.equipement.gouv.fr