

## Summary

Among the new challenges in road safety, driver distraction has emerged as one of the leading causes of crashes worldwide, accounting for more than 25% of all road accidents. Understanding the nature of distraction requires distinguishing between non-driving-related tasks (NDRTs, i.e., tasks unrelated to driving and vehicle operation that divert the driver's attention from the road) and driving-related tasks (DRTs, i.e., tasks that may divert the attention from the primary task of driving but are still directly related to the safe operation of the vehicle, e.g., adjusting the rear-view mirror, changing lanes, checking the speedometer).

While many DRTs are essential for safe driving, NDRTs are generally unnecessary and should be minimized to reduce risk and improve road safety. Various countermeasures, such as Driving Distraction Warning (DDW) systems, have been developed to address both types of distraction. However, improvements in technology and infrastructure alone cannot counteract the critical impact of human factors in crashes. Given the different nature of DRTs and NDRTs, they need to be addressed separately. NDRTs should be discouraged, and it is important to assess whether EU regulations can effectively reduce distraction-related accidents. Meanwhile, as DRTs become increasingly unavoidable due to technological advances, it is crucial to evaluate how effectively this information is conveyed to drivers to prevent inattention.

This thesis investigated the effect of in-vehicle technologies to improve road safety and reduce driver distraction for both NDRTs and DRTs in different road environments. Three driving simulation experiments with an NDRT were conducted to evaluate the effect of (i) cognitive distraction in motorway short-term work zones, and (ii) visual-physical distraction with the support of an auditory DDW device on motorway and on urban roads.

To investigate the more challenging DRTs, a fourth driving simulator experiment was designed to evaluate the best way to present basic DRT information to the driver through an innovative head-up display (HUD) based on the four main stages of human information processing (i.e., Information Acquisition, Information Analysis, Decision Selection and Action Implementation). The effects of such innovative HMIs on driving performance and safety have been evaluated in different road environments (i.e., urban, rural and motorway), considering their impact on the driver's mental workload and understanding user preferences.

The results indicate that both NDRTs and DRTs are difficult to mitigate in the urban environment due to numerous external stimuli and complex interactions with other road users. In contrast, in-vehicle systems such as HUDs and anti-distraction devices are more effective in rural or motorway contexts. This suggests that distraction countermeasures may be less effective in cognitively demanding environments.

Post-drive questionnaires also show that both the ADDW and the HUD can increase mental workload. Therefore, these measures should be designed to improve driving performance and road safety without leading to excessive cognitive demands.

Ultimately, driver distraction is not just a technological or regulatory issue. The human factor remains the most critical and challenging aspect of road safety. Effective solutions must consider the complexity of human behaviour and provide drivers with technologies that help them focus on the primary task of driving.

## **Keywords**

Road safety; Driving distraction; Driving simulation; Distraction countermeasures; Head-up display; Driving behaviour.