# Management of Connected and Automated Vehicle Disengagements in the Vicinity of Work Zones

Evangelos Mintsis[a*], Leonhard Luecken[b], Kallirroi N. Porfyri[a], Dimitris Koutras[a], Sven Maerivoet[c], Evangelos Mitsakis[a]

[a]Centre for Research and Technology Hellas, Hellenic Institute of Transport, 6th Km Charilaou - Thermi Rd., 57001 Thermi, Thessaloniki, Greece

[b]German Aerospace Center (DLR), Rutherfordstraße 2, 12489 Berlin, Germany

[c] Transport & Mobility Leuven, Diestsesteenweg 57, 3010 Leuven, Belgium

[*]Corresponding Author

## Abstract

The share of (connected) automated vehicles (CAVs) in the traffic mix is expected to increase significantly in the upcoming decade. Vehicles of different levels of driving automation will enter the public roads and will be capable to undertake different aspects of the dynamic driving task according to their features and capabilities. In this era prior to full autonomy when traffic will be mixed, (C)AVs will be confronted with challenging situations that might result in automation deactivation. In these cases either internal (system failure) or external (traffic complexity) reasons are going to induce system-initiated downward (from automated to manual driving) transitions of control (ToCs) that will require driver intervention to resume vehicle control. If the driver remains unresponsive to the take-over request (TOR) beyond a critical time window, the (C)AV can perform a Minimum Risk Manoeuver (MRM) that brings the vehicle to a stop as safely as possible. ToCs and MRMs are expected to have profound impacts on safety, traffic efficiency, and the environment.

This study introduces a centralised traffic management strategy that seeks to manage ToCs/MRMs in the vicinity of work zones, where complex traffic interactions and ambiguous lane markings are expected to generate a significant number of ToCs/MRMs. The goal of the traffic management strategy is to ensure that (C)AVs performing MRMs do not eventually block open lanes but are rather guided to safe spots upstream of the work zone. Namely, the traffic management centre is continuously aware of the (C)AV status and location information, and can guide it to a pre-determined safe spot with the use of infrastructure-to-vehicle (I2V) communication if MRM is foreseen or initiated. The safe spot is selected considering the optimal location for minimizing traffic disruption.

The performance of the proposed strategy is evaluated with the use of the microscopic traffic simulation tool SUMO. To this end, an existing ACC car-following model is integrated into SUMO, the default SUMO lane change model is parametrised to reflect (C)AV lane change behaviour, and a novel ToC/MRM model previously developed and incorporated into SUMO are used to emulate (C)AV motion in the microscopic traffic simulator. Simulation experiments encompass urban and motorway driving conditions, different traffic demand levels and various traffic mixes. Simulation results indicate that the proposed traffic management strategy can prevent the expected traffic disruption caused by ToCs/MRMs and yield significant benefits in terms of safety, traffic efficiency, and the environment.

***Keywords:*** Transition of Control; Minimum Risk Manoeuver; Work Zone; Centralised traffic management; Connected and Automated Vehicle; SUMO