Centralized Infrastructure-Assisted Management for Mixed Traffic at Transition Areas

A. Wijbenga [a], J. Vreeswijk [a,*], J. Schindler [b], E. Mintsis [c], M. Rondinone [d], A. Correa [e], M. Sepulcre [e], S. Maerivoet [f], R. Blokpoel [g], E. Mitsakis [c]

[a] *MAP Traffic Management, The Netherlands*

[b] *German Aerospace Center (DLR)*

[c] *Centre for Research and Technology Hellas (CERTH), Greece*

[d] *Hyundai Motor Europe Technical Center, Germany*

[e] *University Miguel Hernandez de Elche, Spain*

[f] *Transport & Mobility Leuven, Belgium*

[g] *Dynniq, The Netherlands*

The advent of connected and automated vehicles (CAVs) is expected to challenge mixed traffic operations on the way to full automation on the roads [1]. Market penetration of CAVs with varying level of automation and connectivity capabilities generates a complex road environment where vehicular interactions might become less smooth in the absence of infrastructure-assisted traffic management. CAVs are not expected to be fully automated in the near future [2]. Therefore, there might be situations on the road when drivers are requested to resume vehicle control due to complex traffic situations, adverse weather conditions, system failures, unexpected events, external disturbance to automation decisions or executions, or other possible sources of disturbance [3]. Moreover, there might be cases when drivers fail to take-over control from automation, and thus CAVs execute Minimum Risk Manoeuvres (MRMs) according to their capabilities to reach a safe stop [4]. Geographical areas where Transitions of Control (ToCs) (or consequently MRMs) are induced due to internal or external reasons are characterized as "Transition Areas" (Figure 1).

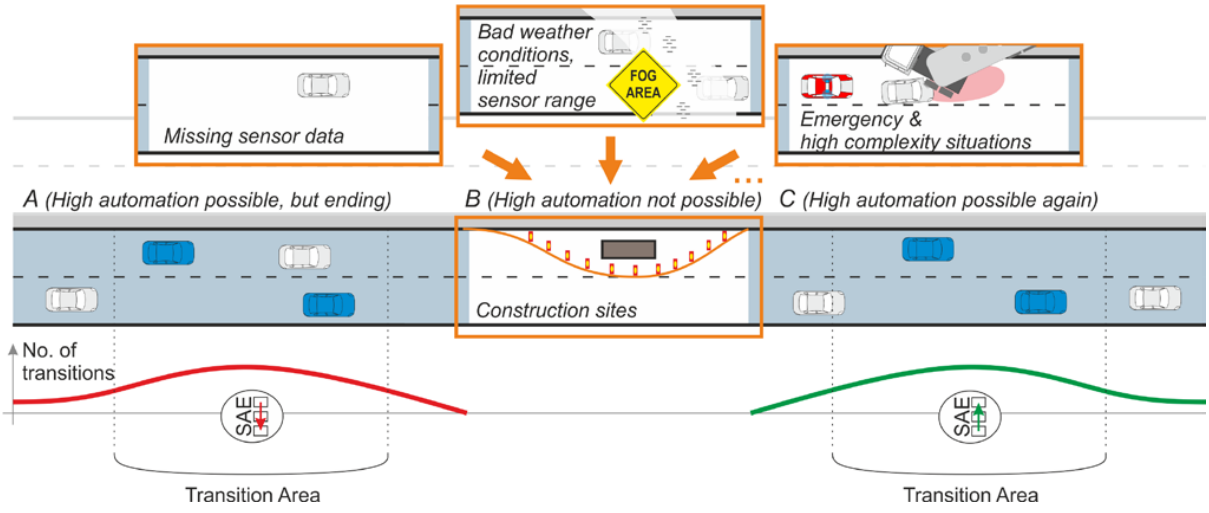

Figure 1. Transition Areas are characterized by vehicle automation level changes due to various reasons

The H2020 European Project TransAID (Transition Areas for Infrastructure-Assisted Driving) identifies triggering conditions (where, when, why, and how) for ToCs and thus determines "Transition Areas" based on the examination of the following factors and their interrelations: i) the environment, ii) the

* J. Vreeswijk (jaap.vreeswijk@maptm.nl)

automated driving (AD) functions, and iii) the ToC process. Infrastructure-assisted traffic management procedures using V2X and conventional signalling are subsequently designed both for urban and highway driving, focusing on the realization of the following objectives: i) prevent ToC or MRM (suggest manoeuvres, speed, headway and/or lane advice), ii) manage or support ToC or MRM (indicate safe spot, inform vehicles to give way, etc.), and iii) distribute ToC or MRM (spatially and temporally). Six services encapsulating the three aforementioned objectives were designed to improve traffic operations at transition areas for the upcoming 15 years (Table 1).

Table 2. Description of the proposed traffic management services

Service No.	Service Name	Service Description
S1	Prevent ToC/MRM by providing vehicle path information.	Provide path information to CAVs that cannot continue driving due to inherent logic limitations.
S2	Prevent ToC/MRM by providing speed, headway and/or lane advice.	Provide designated speed, headway and/or lane advisory to facilitate highway merging traffic and obstacle avoidance.
S3	Prevent ToC/MRM by traffic separation.	Guide CAVs to CAV dedicated lanes to limit vehicle interaction and prevent ToC/MRM.
S4	Manage ToC/MRM through cooperative perception.	Provide environmental information to CAV to avoid a risky MRM and allow a safe execution of a ToC.
S5	Manage MRM by guidance to safe spot.	Guide CAVs to safe stop spot where traffic flow and safety are minimally impacted.
S6	Distribute ToCs by scheduling ToCs.	ToCs are distributed in time and space to prevent traffic disturbance due to collective ToCs.

Several use cases were selected to study the effect of the six services. Through these use cases the proposed infrastructure-assisted traffic management schemes will be evaluated with the use of the simulation and later in the project by conducting real-world feasibility assessments. Traffic models for automated driving, and V2X communication protocols for CAVs will be developed and integrated into the open source simulation platform iTETRIS [5] that will assess safety, traffic and energy efficiency in the presence of hierarchical and centralized infrastructure-assisted traffic management. Real world experiments will show the feasibility of the simulation prototypes. Based on the project findings guidelines for infrastructure-assisted management of mixed traffic streams will be developed that will also include a roadmap defining future actions and needed upgrades of road infrastructure in the upcoming 15 years in order to guarantee a smooth coexistence of conventional, connected and automated vehicles.

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