XVII International Symposium
"ROAD ACCIDENTS PREVENTION 2026"
Novi Sad, Serbia, 14th and 15th October 2026.

https://doi.org/10.68515/RAP.2026.17.5

THE ROADS4ALL FRAMEWORK FOR TRAFFIC SAFETY CULTURE AND MULTILEVEL INTERVENTION DESIGN

Jens Schade[a], Tina Morgenstern[a], Markus Suren[a], Lazaros Giannakos[b], Evangelos Genitsaris[c]

[a] Technische Universität Dresden, Dresden, Germany
[b] Institute of Communication & Computer Systems, Athens, Greece
[c] Q-Plan International Advisors PC, Thessaloniki, Greece

jens.schade@tu-dresden.de – ORCID: 0000-0002-5404-9278
tina.morgenstern@tu-dresden.de – ORCID: 0009-0003-5940-873X
markus.suren@tu-dresden.de – ORCID: 0000-0002-9071-3164
lazaros.giannakos@iccs.gr – ORCID: 0000-0001-8111-0014
genitsaris@qplan-intl.gr – ORCID: 0000-0002-3905-3981

Abstract: Traffic safety culture offers a perspective on the shared values, beliefs, attitudes and norms through which actors understand and enact road safety. Translating this perspective into intervention design requires a clear connection between system conditions, cultural processes and road user behaviour. This paper presents the qualitative-integrative component of the Roads4All framework, developed through a synthesis of existing approaches and refined through an interdisciplinary expert consultation. The framework combines a multilevel system perspective with a behavioural pathway perspective. It distinguishes micro-, meso-, macro- and magna-level influences and treats shared safety-related cognitions as the cultural core, while recognising reciprocal relationships with behaviour and contextual conditions. A hypothetical fleet-speeding example illustrates how practitioners can identify intervention levels, formulate mechanisms and distinguish behavioural outcomes from cultural change. The framework provides a structure for developing context-sensitive intervention hypotheses and complementary measures. It does not establish causal effects or demonstrate intervention effectiveness. Future research should operationalise group-level cultural constructs and examine the proposed relationships through longitudinal and intervention studies.

Keywords: Traffic Safety Culture; Multilevel Framework; Road User Behaviour; Intervention Design; Expert Consultation

1. INTRODUCTION

Road traffic injuries remain a major public health and societal challenge (WHO, 2023). The Safe System Approach addresses this challenge through safe infrastructure, speeds, vehicles and road use, recognising human fallibility and shared responsibility for safety (ITF, 2022). Understanding how these principles are interpreted and enacted also requires attention to the social and cultural processes through which system conditions become relevant to everyday behaviour.

Traffic safety culture (TSC) directs attention to shared safety-related values, beliefs, attitudes, norms and practices within meaningful groups of actors in the transport system (Nævestad et al., 2026). Such groups may include road users, organisations or authorities. This broad

understanding links cultural orientations to their behavioural expression. For explanatory purposes, however, the present framework distinguishes shared cognitions from behaviour, allowing their relationships to be investigated empirically rather than assuming that behaviour is inherently part of TSC.

Existing approaches offer complementary perspectives on TSC, emphasising its multilevel organisation and the mechanisms linking cultural factors to road user behaviour (Özkan & Lajunen, 2015; Ward et al., 2019).

Despite these advances, an important challenge remains: How can the concept of TSC be translated into a structure that is useful for those who have to design, implement, and evaluate road safety measures? For researchers, conceptual frameworks can provide a basis for theory development. For road authorities, policymakers, transport organisations, and other practitioners, however, a framework also needs to answer a more practical question: Where can action be taken, and through which mechanisms could an intervention influence road user behaviour?

The Roads4All framework addresses this practical question by connecting a multilevel system perspective with a behavioural pathway perspective. Developed within the Horizon Europe project Roads4All, the framework was designed to support the project's aim of understanding and enabling cultural transformation towards safer road use. Its contribution is an integrative structure for relating intervention levels to hypothesised cultural mechanisms and behavioural outcomes. This structure supports the formulation of context-specific intervention hypotheses rather than prescribing a universally effective set of measures.

This paper presents the qualitative-integrative component documented in the Roads4All Deliverable D1.2 ((Giannakos et al., 2026), Section 4.1). The deliverable also contains a complementary semantic model intended for computational processing, which is outside the scope of this paper. We describe the conceptual foundations and development of the qualitative framework and illustrate its implications for intervention design through a hypothetical example. The framework is a basis for further operationalisation and empirical testing.

2. CONCEPTUAL DEVELOPMENT

The framework was developed through a literature-informed conceptual synthesis. The underpinning review covered the Safe System Approach, definitions of TSC, behavioural theories, existing safety culture models and intervention principles (Giannakos et al., 2026). These strands informed the integration described in Section 3. The emerging framework was subsequently discussed and iteratively refined through an online consultation workshop involving external experts and project partners from psychology, transport engineering and planning, road safety management, and related fields (Giannakos et al., 2026). The consultation highlighted, in particular, the need to account for reciprocal relationships between shared cognitions and behaviour and to avoid prematurely imposing causal ordering. These insights informed the representation of feedback relationships and the distinction between cultural and other intervention effects. The consultation served to support conceptual refinement rather than empirical validation.

3. THE ROADS4ALL QUALITATIVE-INTEGRATIVE FRAMEWORK

The Roads4All framework integrates two main approaches. The General Traffic (Safety) Culture System (G-TraSaCu-S; (Özkan & Lajunen, 2015)), grounded in systems and social-ecological theory (Bronfenbrenner, 1979; von Bertalanffy, 1968), provides the multilevel structure. It relates distal conditions, cultural components and proximal factors across micro-, meso-, macro- and magna-levels.

The Etiological Model of Road User Behaviour (Ward et al., 2019) provides the behavioural pathway perspective, identifying cognitive determinants through which physical, social and cultural conditions can influence risky or protective behaviour. Roads4All uses this perspective to connect its system levels to road user behaviour.

The Developmental Framework of Safety Culture (Bisbey et al., 2021) and the Egg Aggregated Model (Vierendeels et al., 2018) further inform the framework's treatment of cultural development and the distinction between underlying cultural processes and observable manifestations.

TSC is commonly described in broad terms, encompassing shared values, beliefs, attitudes, norms and practices (see Section 1). For the purposes of the present framework, this definition is narrowed to its cognitive core. Within the framework, TSC is conceptualised as an emergent system of shared safety-related cognitions. Emergence refers to the development and reinforcement of shared meanings through interaction, social learning and institutional or organisational practices over time. The framework identifies these processes as relationships to be investigated rather than specifying a formal model of their dynamics.

The narrower analytical focus on cognitions is compatible with recognising behaviour as a cultural manifestation in broader definitions. Separating the two avoids explaining behaviour using a measure of culture that already incorporates the behaviour itself. It also allows cultural and behavioural change to be assessed separately while retaining their reciprocal relationship.

3.1. System levels

The Roads4All framework distinguishes four interconnected levels of influence. These levels encompass both more distal conditions and more proximal factors or manifestations that interact with the shared cognitions underlying TSC.

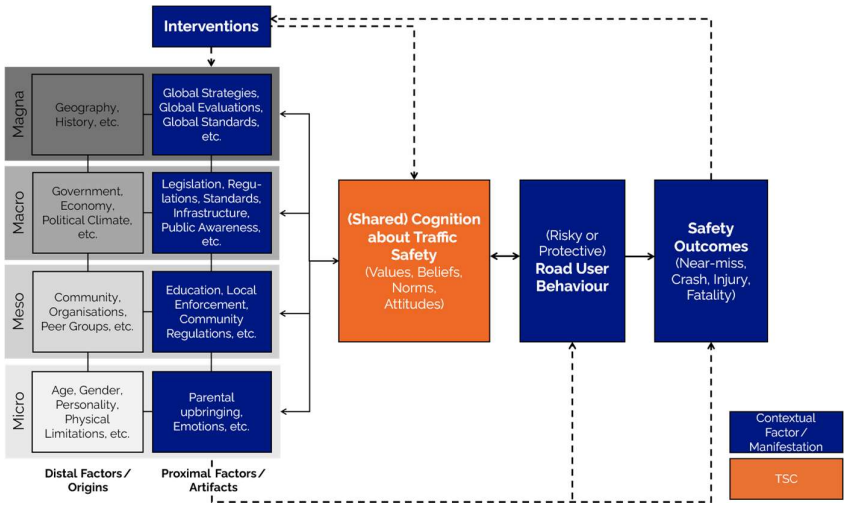


Fig. 1. The Roads4All qualitative-integrative framework ((Giannakos et al., 2026), Section 4.1). Arrows represent conceptual relationships requiring empirical specification and testing[1].

[1] The figure emphasises the culturally mediated pathway. System and contextual conditions may also influence road user behaviour and safety outcomes through non-culturally mediated mechanisms; these additional pathways are discussed in Section 3.3 and are not exhaustively represented.

- **Micro-level**: The micro-level concerns characteristics, experiences, and circumstances of individual road users that may shape their understanding of traffic safety. Individual socialisation, for example, may influence whether caution and compliance are regarded as important or whether risk-taking is perceived as acceptable.
- **Meso-level**: The meso-level captures the role of social groups, local communities, and organisations. Organisational practices, peer influences, community expectations, and local enforcement can contribute to the development of shared understandings of traffic safety within a particular social context.
- **Macro-level:** The macro-level encompasses broader societal and institutional conditions, including legislation, traffic regulations, safety standards, infrastructure, and other national or systemic arrangements. These conditions establish the formal and environmental context within traffic safety is understood and enacted.
- **Magna-level**: The magna-level refers to influences that extend beyond the national context, including international strategies, standards, evaluations, and transnational developments. These may shape how traffic safety is approached and prioritised at national and lower levels.

The levels are interconnected analytical domains, not independent or exclusively top-down sources of influence. Their classification depends on the scope and authority of the actor or arrangement concerned: A municipal enforcement practice may be meso-level, whereas the national enforcement regime is macro-level. Similarly, infrastructure may be examined as a local condition or as part of national standards and investment decisions. The relevant unit should therefore be specified for each application.

3.2. Shared cognitions and their reference groups

Shared cognitions comprise safety-related values, beliefs, attitudes and norms within a defined reference group. A relevant group may be a fleet organisation, a peer network or a local community. Membership of a country or road user category does not in itself imply a shared safety culture. Different groups may maintain competing expectations, and individuals may belong to several groups whose norms conflict.

Individual perceptions of norms, personal motivation and decision-making are distinguished from the collective cultural patterns to which they may relate. An individual survey response is therefore an indicator of an individual's perspective, not sufficient evidence of a shared group property. Empirical applications should justify the reference group and examine the extent of agreement and variation before interpreting aggregated responses as cultural characteristics.

Shared meanings may be reinforced or revised through interaction, observed practices and institutional responses. They can influence how road users interpret situations and evaluate behavioural options. Behaviour and safety outcomes can, in turn, prompt organisational learning or policy changes. These feedback processes should be examined over time rather than inferred from cross-sectional associations alone.

3.3. Behaviour and other pathways to safety

Behaviour is treated as a potential consequence and contributor to TSC, but is not a specific measure of culture by itself. The same observed behaviour may reflect shared norms, immediate incentives, physical constraints or a combination of influences. Practitioners should therefore investigate both cultural and contextual explanations for an observed safety problem.

The Roads4All framework does not assume that all effects of system conditions are mediated by shared cognitions. Enforcement can alter immediate incentives, road design can constrain speed, and vehicle protection can reduce injury severity without prior cultural change. The cultural pathway complements these mechanisms. An intervention may influence shared meanings as well, but this requires separate evidence.

The relationship is nevertheless not exclusively one-directional. Behaviour can also contribute to the development and reinforcement of TSC. For example, repeatedly observing other road users speeding may influence perceptions of what constitutes normal or socially acceptable behaviour. In this way, observed behaviour can reinforce shared expectations and norms, creating a feedback loop between culture and behaviour.

For operational purposes, risky and protective road user behaviour can therefore be treated as a distinct analytical layer between shared safety-related cognitions and safety outcomes. This preserves behaviour as an observable expression and potential feedback source of TSC without defining culture by behaviour itself.

4. FROM FRAMEWORK TO INTERVENTION DESIGN

The Roads4All framework supports a structured diagnosis of a safety problem: Identify the relevant behaviour and actors, define the reference group, examine contextual constraints and shared cognitions, and formulate plausible mechanisms of change. The resulting intervention hypotheses should specify both the intended outcomes and the evidence needed to evaluate them.

4.1. Identifying intervention levels

The four levels of the framework provide an initial structure for locating potential intervention points. At the micro-level, interventions may address individual values, beliefs, or motivation. Examples include targeted education, or interventions designed to modify specific behavioural beliefs.

At the meso-level, interventions may focus on shared norms and beliefs among peer groups, communities, organisations, or transport providers. Relevant measures may include organisational safety policies, peer-based (school) interventions, local campaigns, community initiatives, or changes in organisational practices.

At the macro-level, potential intervention levers include legislation, enforcement systems, infrastructure, vehicle standards, licensing systems, and national road safety strategies. Such measures may shape the social and institutional conditions under which safety-related cognitions develop.

At the magna-level, international strategies, standards, cross-national initiatives, and transnational knowledge exchange may influence national and local approaches to traffic safety.

The framework therefore does not assume that a given road safety problem has a single intervention point. Instead, the relevant question is which level or combination of levels contributes to the cognitions and behaviours associated with the specific safety problem.

4.2. Specifying mechanisms and outcomes

Identifying an intervention level is only a first step. For each proposed measure, practitioners should specify how it is expected to work. A regulation may change behaviour through perceived sanction risk, while also signalling a collective safety priority. A campaign may seek to correct misperceptions about peer approval. These are different hypotheses, requiring different measures. A diagnostic sequence is:

Safety problem → relevant behaviour and group → contextual and cultural diagnosis → intervention mechanism → expected outcomes and evaluation

This sequence orders the diagnostic steps for practical purposes; it is a planning aid, not a causal model, and the steps are typically revisited iteratively as new information emerges, rather than completed once in strict order. It should remain open to evidence that cultural mechanisms are not central to the problem, or that practical constraints prevent the intended change. Behavioural indicators and indicators of shared values, beliefs or norms should be assessed separately.

4.3. Combining measures in a hypothetical fleet example

Consider a hypothetical delivery fleet in which repeated speeding is observed. This example illustrates the framework; it does not report Roads4All intervention findings. The initial diagnosis would examine route schedules, incentives, enforcement exposure and drivers' accounts of supervisory and peer expectations. A candidate cultural hypothesis is that drivers perceive timely delivery as more highly valued than speed compliance, even where the formal policy prioritises safety.

At the meso-level, the operator could revise unrealistic schedules and performance incentives, align supervisors' instructions with its safety policy and involve drivers in discussing acceptable practice. At the micro-level, feedback and discussion could address beliefs that speeding is necessary or approved by colleagues. The macro-level legal and enforcement context would remain relevant to the diagnosis. International guidance at the magna-level could inform organisational policy, but need not itself be an intervention target. The combination should follow the diagnosed problem rather than a requirement to intervene at every level.

The proposed mechanisms must be distinguished. More realistic schedules may reduce time pressure directly, whereas consistent supervisory practices and peer discussion may also change expectations about what the organisation values and what colleagues approve. Evaluation could combine repeated speed measurements, records of scheduling and implementation, and repeated surveys or interviews on perceived priorities and group norms. Exposure and route conditions should be considered, with a comparison group where feasible. Reduced speeding would indicate behavioural change; evidence of cultural change would additionally require changes in shared meanings and their persistence over time.

5. DISCUSSION

The Roads4All framework's contribution lies in connecting the location of potential intervention levers with hypothesised cultural and behavioural processes. Its value is therefore both analytical and practical: It provides a common structure for asking which actors and conditions matter, what mechanism a measure is intended to change, and how complementary measures might work together. The fleet example illustrates this use without establishing that the proposed combination is effective.

Several limitations remain. The framework is a high-level conceptual synthesis, and the expert consultation was exploratory and involved a substantial proportion of project partners. It does not establish independent consensus or causal validity. The relative importance, direction and timing of the proposed relationships remain to be specified. The framework also does not yet provide an operational measurement model for distinguishing shared cultural patterns from individual perceptions across different groups and contexts.

Future studies should combine qualitative identification of meaningful groups and locally relevant constructs with quantitative assessment of within-group agreement and between-group variation. Longitudinal and intervention designs are needed to examine reciprocal relationships and distinguish cultural change from responses to incentives or physical constraints. Evaluation should assess implementation, behavioural outcomes and cultural indicators separately. A measure that improves safety without changing culture can still be valuable; a claim of cultural transformation requires additional evidence.

Future operationalisation should preserve the multilevel structure of the framework rather than collapsing heterogeneous indicators into a single composite score. Separate indicators or subscores for magna-, macro-, meso-, micro- and behavioural domains may provide a diagnostically useful multilevel profile related to TSC. Safety outcomes, including fatalities and serious injuries, should be reported as contextual and external validation criteria rather than as constitutive elements of a culture score. Such a profile-based approach would make it possible to identify level-specific strengths, weaknesses and implementation gaps while retaining the distinction between system conditions, cultural processes, behavioural expression and safety performance.

6. CONCLUSION

The qualitative-integrative Roads4All framework connects multilevel system conditions, shared safety-related cognitions and road user behaviour. Developed through conceptual synthesis and expert consultation, it provides a structure for identifying intervention levers and formulating context-sensitive mechanisms of change. Its practical use is illustrated through a hypothetical fleet-speeding example. The framework supports intervention planning and empirical hypothesis development, while leaving the effectiveness of specific measures and the validity of proposed pathways to further research. Its multilevel architecture also provides a basis for future profile-based operationalisation in which system-level, cultural and behavioural indicators are assessed separately and related to safety outcomes as external criteria.

ACKNOWLEDGMENTS

This work was conducted within the Roads4All project, funded by the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No. 101203314 and by the Swiss State Secretariat for Education, Research and Innovation (SERI).

REFERENCES

[1] Bisbey, T. M., Kilcullen, M. P., Thomas, E. J., Ottosen, M. J., Tsao, K., & Salas, E. (2021). Safety culture: An integration of existing models and a framework for understanding its development. Human Factors, 63(1), 88–110. https://doi.org/10.1177/0018720819868878

[2] Bronfenbrenner, U. (1979). The ecology of human development: Experiments by nature and design. Harvard University Press.

[3] Giannakos, L., Fokeas, K., Alexiou, P., Antonakopoulou, A., Morgenstern, T., Suren, M., & Schade, J. (2026). D1.2 Knowledge Elicitation (Version 1.0, 31 March 2026). Roads4All, Horizon Europe project 101203314.

[4] International Transport Forum. (2022). The Safe System Approach in Action. OECD Publishing. https://doi.org/10.1787/ad5d82f0-en

[5] Nævestad, T.-O., Meesmann, U., Wallén Warner, H., Kaiser, S., Hesjevoll, I. S., Milch, V., Forward, S., De Roeck, M., Schachner, M., Nikolaou, D., Björklund, G., Laiou, A., Wennberg, H., Aigner-Breuss, E., & Eichhorn, A. (2026). Traffic safety culture within the safe system: Developing a common definition of traffic safety culture. Frontiers in Sustainable Cities, 8, 1819840. https://doi.org/10.3389/frsc.2026.1819840

[6] Özkan, T., & Lajunen, T. (2015). A General Traffic (Safety) Culture System (G-TraSaCu-S). TraSaCu project, Deliverable D2.1, 4 December 2015.
[7] Vierendeels, G., Reniers, G., Van Nunen, K., & Ponnet, K. (2018). An integrative conceptual framework for safety culture: The Egg Aggregated Model (TEAM) of safety culture. Safety Science, 103, 323–339. https://doi.org/10.1016/j.ssci.2017.12.021
[8] von Bertalanffy, L. (1968). General system theory: Foundations, development, applications. George Braziller.
[9] Ward, N. J., Otto, J., & Finley, K. (2019). Ten principles of traffic safety culture. In N. J. Ward, B. Watson, & K. Fleming-Vogl (Eds.), Traffic Safety Culture (pp. 21–39). Emerald Publishing. https://doi.org/10.1108/978-1-78714-617-420191004
[10] World Health Organization. (2023). Road traffic injuries. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries