# Context-Aware Take-Over Requests for Promoting Emergency Corridor Formation in Level 3 Automated Vehicles

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In some countries, emergency corridor formation is a legally mandated maneuver to enable emergency vehicle access during congestion. In countries such as Turkey, limited public awareness complicates compliance. As vehicles progress toward level 3 automation, Take-Over Requests (TORs) prompt humans to continue driving, but most designs lack cultural or contextual relevance. This study examines whether context-aware and multimodal TORs improve compliance of emergency corridor formation during take-over situations. Using video-based simulations with five licensed drivers experienced in Turkish traffic, participants responded to three TOR conditions varying in modality and contextual specificity. Measures included reaction time, compliance accuracy, and subjective ratings, complemented by semi-structured interviews. Results indicate that context-aware multimodal TORs led to higher compliance and were perceived as clearer and more trustworthy than generic prompts. Findings highlight the importance of adaptive TOR designs and inform future research on culturally sensitive automated vehicle interfaces.

CCS Concepts: • **Human-centered computing → User interface design**; *Empirical studies in accessibility*.

Additional Key Words and Phrases: Context-Awareness, Take-Over Requests, Emergency Corridor Formation, Level 3 Automated Vehicles, Human Factors, Driver Behavior

**ACM Reference Format:**
Tuğcan Önbaş, Michael A. Gerber, and Andreas Riener. 2025. Context-Aware Take-Over Requests for Promoting Emergency Corridor Formation in Level 3 Automated Vehicles. In *17th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI Adjunct '25), September 21–25, 2025, Brisbane, QLD, Australia.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3744335.3756855

## 1 INTRODUCTION

Level 3 automated vehicles (AVs) [12] permit driver disengagement but require timely resumption via Take-Over Requests (TORs) in specific scenarios. One such scenario involves forming an emergency corridor – a legally mandated maneuver in Germany known as the *Rettungsgasse*, strictly enforced through penalties and post-license training [3, 10, 11, 13]. In contrast, countries like Turkey exhibit limited public awareness and weak enforcement of this protocol [14], with multiple reports documenting driver noncompliance and ambulance obstruction [5, 7, 8]. In conditional automation, this gap becomes critical, as disengaged drivers may be unprepared for culturally unfamiliar or legally

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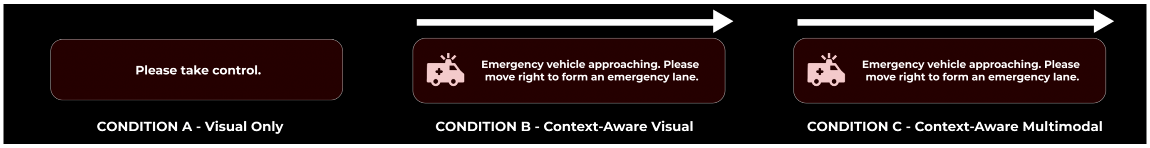


Fig. 1. Overview of the three Take-Over Request (TOR) conditions tested. Condition A shows a generic visual message: "Please take control.". Condition B displays a context-aware visual message with directional information and an icon indicating the approach of an emergency vehicle. Condition C combines the same context-aware visual message and icon as Condition B with additional auditory cues (e.g., siren and voice) to reinforce urgency.

specific maneuvers. To address this issue, this study explores (in a video-based simulation) whether context-aware, multimodal TORs can improve compliance and clarity.

## 2 RELATED WORK

TORs in Level 3 AVs have been widely studied with regard to modality, timing, and driver state. Eriksson and Stanton [2] found that TOR reaction times vary from 1.9 to 8.7 seconds depending on secondary task load and environment. Gold et al. [4] confirmed that cognitively demanding tasks delay responses, often beyond 5 seconds. Visual-auditory TORs consistently outperform single-modality alerts, with average take-over times between 3–7 seconds, and early warnings further improve response speed and accuracy [6].

Existing TOR designs often lack contextual relevance, leading to slower or incorrect responses. That's why recent work has shifted toward context-aware TORs [1, 9], focusing primarily on TOR timing and modality [2, 4]. As a result, most studies overlook the relevant aspect of culturally defined maneuvers (like Germany's *Rettungsgasse*), generalizing responses, and ignoring regional compliance challenges.

**This study fills that gap by examining how culturally adapted, multimodal TORs influence compliance with emergency corridor formation by investigating the following research question (RQ):** *How does the design of context-aware Take-Over Requests (TORs) influence drivers' compliance with emergency corridor formation during Level 3 automated driving?* Building on this, we expected that drivers would be more likely to correctly perform the maneuver in response to context-aware TORs compared to generic TORs, and that multimodal TORs (visual + auditory) would be perceived as clearer and more trustworthy than visual-only TORs.

## 3 METHODOLOGY

This study evaluated how different TOR designs support timely and compliant emergency corridor formation in Level 3 driving. A within-subjects video-based simulation was conducted with five licensed drivers holding or experienced with Turkish driving licenses. Each participant watched three congested highway scenarios where the AV issued a TOR: (A) generic visual, (B) context-aware visual, and (C) context-aware multimodal (see Fig. 1, Table1).

Table 1. Overview of Experimental Conditions by Context and Modality

| Cond. | Context-Aware | Modality | TOR Message / Cue |
|---|---|---|---|
| A | ✗ No | Visual only | "Please take control." |
| B | ✓ Yes | Visual only | "Emergency vehicle approaching. Please move right/left to form an emergency lane." |
| C | ✓ Yes | Visual + Auditory | Same as B + auditory cues (e.g., siren, voice) |

During each condition (i.e., video), participants verbally stated their intended action (e.g., "I would steer right now"), recorded as behavioral proxies. After each scenario, they completed a short questionnaire assessing clarity, urgency, and trust. A final semi-structured interview gathered perceptions and preferences. A custom web platform handled video delivery, time-stamped logging, and questionnaire submission.

**Quantitative measures** included reaction time (the interval between TOR onset and verbal response, extracted from recordings), compliance accuracy (correctly identifying the legally mandated maneuver), perceived workload (NASA-TLX), and Likert-scale ratings of trust, usefulness, urgency, and clarity. **Qualitative data** from interviews explored the clarity and interpretability of each TOR, perceived urgency, ease of understanding the required action, and overall trust. All sessions were screen-recorded, including camera and audio, to enable precise timestamp extraction and analysis.

## 4 RESULTS AND DISCUSSION

This section presents quantitative and qualitative findings from five participants, showing how TOR designs influenced reaction time, compliance, clarity, urgency, and trust.

### 4.1 Quantitative Findings

Condition A elicited the fastest reactions (mean 2.6 s) but less consistent compliance (4/5). Conditions B and C were slightly slower (3.8 s and 3.6 s) yet achieved full compliance, suggesting contextual cues promote accurate responses even with brief delays (see Tables 2, 3).

Table 2. Reaction Time and Compliance Accuracy (N=5)

| Metric | A | B | C |
|---|---|---|---|
| Mean RT (s) | 2.6 | 3.8 | 3.6 |
| Median RT (s) | 2.0 | 3.0 | 4.0 |
| SD RT | 0.89 | 1.30 | 0.55 |
| Compliance | 4/5 | 5/5 | 5/5 |

Table 3. Average Likert Ratings (N=5)

| Measure | A | B | C |
|---|---|---|---|
| Clarity | 4.2 | 4.4 | 5.0 |
| Urgency | 3.6 | 4.4 | 4.4 |
| Trust | 3.8 | 4.4 | 4.2 |
| Confidence | 3.4 | 4.6 | 5.0 |
| Helpfulness | 3.6 | 4.8 | 4.6 |
| Sound clarity | – | – | 5.0 |
| Natural feel | – | – | 4.8 |

Subjective ratings reinforced the benefits of context-aware and multimodal designs. Condition C scored highest overall, with clarity and confidence rated 5.0 and audio unanimously improving understanding (5.0) and naturalness (4.8). Condition B also outperformed A, especially in trust and urgency. In multiple-choice responses, correct action reporting reached 100% in B and C but fell to 80% in A. All participants confirmed that audio clarified the intended maneuver.

### 4.2 Qualitative Insights

Participants preferred the multimodal TOR (C), describing it as intuitive and trustworthy. Sound was seen as essential for clarity and urgency. While B improved clarity, only C felt fully "natural" and supportive, increasing confidence.

Cultural background also shaped perceptions: all participants noted the difficulty of forming emergency corridors in Turkey and viewed context-aware TORs as valuable. Suggestions focused on tone, visual contrast, and voice style. No participant found C confusing, supporting its usability when designed carefully.

### 4.3 Interpretation and Implications

Context-aware TORs substantially improved compliance: B and C achieved 100% correct maneuvers, compared to 80% in A. Even brief contextual information enhanced performance. Multimodal TORs were rated clearest and most trustworthy. Interviews confirmed that combining visual and auditory cues increased confidence and responsiveness.

These results align with prior research on takeover timing and modality [2, 4, 9] while emphasizing the added value of legal and cultural adaptation. They highlight the need for interfaces that address road conditions and regional laws to help AVs close the gap between actual driver behavior and ideal protocols.

### 4.4 Limitations

This study offers initial insights into context-aware and multimodal TORs but has limitations. The small, culturally specific sample of five Turkish drivers limits generalizability. The video-based simulation lacked real driving stressors, which could affect perceived urgency. Only a single emergency scenario was tested, while real-world situations are more varied. The multimodal cues used fixed voice and language; exploring different tones, languages, or haptic feedback could enhance effectiveness. Finally, immediate reactions were measured without assessing learning effects or long-term trust. Implementing such TORs will also require addressing regulatory and technical challenges.

## 5 CONCLUSION

This study examined how context-aware and multimodal TORs affect driver behavior during emergency corridor formation in Level 3 automation. In video-based trials, generic TORs led to faster but less clear and less compliant responses. Context-aware TORs, especially multimodal prompts, achieved perfect compliance and the highest clarity and confidence ratings, underscoring the benefits of multimodal, context-specific messaging.

Participants stressed the importance of legal context and cultural familiarity, particularly in regions where emergency protocols are less established. Voice prompts were seen as essential for conveying urgency and guiding action.

Future work should develop adaptive TOR systems that adjust modality and content based on driver state, urgency, and local laws. High-fidelity simulators or on-road studies are needed to validate these findings under realistic conditions. Research should also explore personalization strategies to support diverse driver needs, and collaboration with regulators will be key to aligning TOR messaging with legal requirements.

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