Beyond the Self-Driven: Understanding User Acceptance of Cooperative Intelligent Transportation Systems in Automated Driving

Annika Stampf
annika.stampf@uni-ulm.de
Institute of Media Informatics, Ulm University
Ulm, Germany

Felix Reize
felix.reize@uni-ulm.de
Institute of Media Informatics, Ulm University
Ulm, Germany

Mark Colley
m.colley@ucl.ac.uk
UCL Interaction Centre
London, United Kingdom

Enrico Rukzio
enrico.rukzio@uni-ulm.de
Institute of Media Informatics, Ulm University
Ulm, Germany

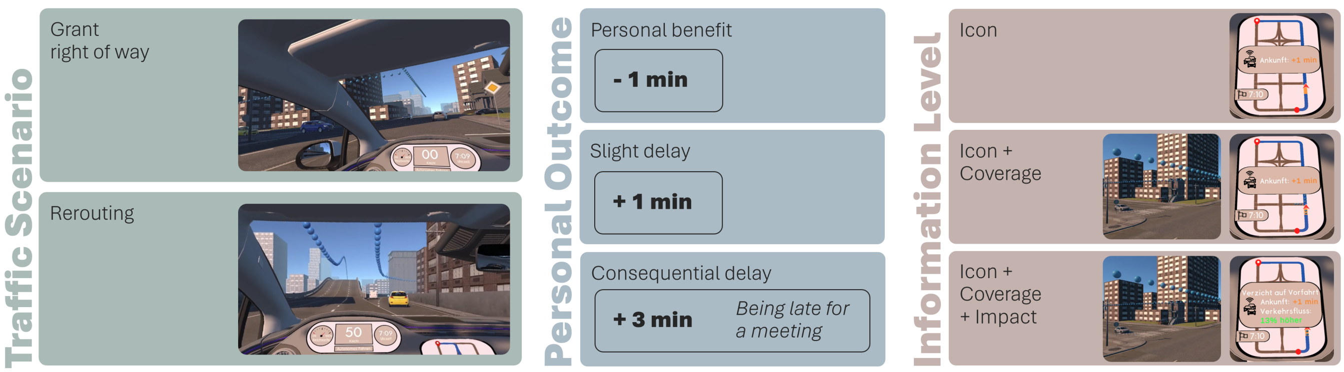

Figure 1: Overview of the study design: Participants experienced two Traffic Scenarios (Grant right of way and Rerouting), evaluated across three Personal Outcomes (Personal benefit, Slight delay, and Consequential delay), and three Information Levels (Icon, Icon+Coverage, and Icon+Coverage+Impact).

Abstract

Cooperative Intelligent Transportation Systems (C-ITS) leverage communication between intelligent vehicles and infrastructure (V2X) to address urban challenges, including congestion, delays, and safety, through advanced traffic planning. However, user acceptance—essential for real-world adoption—remains underexplored. Through an online survey (N=49), we investigated how Traffic Scenarios, Personal Outcomes, and Information Levels influence user acceptance. Our findings reveal that rerouting scenarios are perceived more positively than yielding scenarios, such as granting the right of way, while consequential delays increase conflict and frustration. Additionally, users showed similar acceptance ratings for the automated vehicle and the overarching C-ITS with differences emerging under consequential delays. We discuss implications for the design of user-centered C-ITS.

ACM ISBN 979-8-4007-1395-8/2025/04
https://doi.org/10.1145/3706599.3720260

CCS Concepts

• **Human-centered computing → HCI design and evaluation methods**; **Empirical studies in HCI**.

Keywords

cooperative intelligent transportation systems, automated vehicles, acceptance, V2X, traffic planning, traffic flow optimization

ACM Reference Format:
Annika Stampf, Felix Reize, Mark Colley, and Enrico Rukzio. 2025. Beyond the Self-Driven: Understanding User Acceptance of Cooperative Intelligent Transportation Systems in Automated Driving. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25), April 26-May 1, 2025, Yokohama, Japan.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3706599.3720260

1 Introduction

Cooperative Intelligent Transportation Systems (C-ITS) hold significant promise in addressing traffic challenges such as congestion, energy consumption, and emissions. By enabling communication among intelligent vehicles and with infrastructure (V2X), C-ITS facilitate real-time coordination, offering opportunities to improve road safety, reduce congestion, optimize efficiency, and minimize environmental impacts [21, 23]. Shifting from self-reliant automated vehicles (AVs) to a networked approach, C-ITS enable advanced traffic planning, such as negotiated right of way at intersections [7] or rerouting of AVs [36] to increase overall traffic flow.

While research largely focused on technological solutions (e.g., [8, 11, 23]), the human perspective remains unexplored. However, this perspective is important because the behavior of AVs integrated into C-ITS relies on information the user is unaware of, which could lead to a user not understanding why the AV behaves the way it does (e.g., yielding to grant other vehicles the right of way). Such unexpected AV behavior can lead to undertrust [4, 6, 31], which in turn can affect the acceptance of AVs and lead to not using the AVs [20]. Thus, it is important to present the user with information about AV behavior influenced by the C-ITS. This can range from minimal information (e.g. indicating that a C-ITS manages traffic) to very detailed information (e.g., visualizing areas that are covered by C-ITS traffic management and in what way it affects the users' AV behavior as well as its impact on the broader traffic). C-ITS not only provide additional information for individual (distributed) AV decision-making but also enable (de-)centralized decision-making to achieve collective traffic goals, directly influencing AV behavior [23]. This ability to prioritize traffic-wide efficiency over individual user goals presents novel Human-Computer Interaction (HCI) challenges in the mobility domain. To address this gap, we investigate the following research questions (RQs):

RQ1 *How do different Traffic Scenarios, Personal Outcomes, and Information Levels—from minimal information to detailed visualizations—influence user acceptance?*

RQ2 *What differences exist between user acceptance of the individual AV and the overarching C-ITS system?*

To answer the RQs, we conducted an online 360-degree video-based mixed-subjects study with 49 participants, analyzing the influence of Traffic Scenarios, Personal Outcomes, and Information Levels on Acceptance, Understanding & Predictability, Frustration, and Conflict towards the AV as well the overarching C-ITS.

Contribution Statement: This study examines C-ITS from an HCI perspective. Results show that *Rerouting* is perceived more positively than *Granting the right of way*, while *Consequential delays* induce conflicts and frustration. Moreover, users show similar ratings for the AV and the overarching C-ITS, with differences emerging under high negative personal outcomes. We discuss implications for the design of user-centered C-ITS.

2 Related Work

This work builds upon research investigating trade-offs in C-ITS decision-making and the role of visualizations in fostering trust and acceptance of automated systems.

2.1 Trade-offs in C-ITS Decision-Making

C-ITS often require AVs to prioritize the overall traffic flow by, for example, yielding to other vehicles [7] or rerouting to avoid congestion [2]. Thus, they may result in personal negative consequences like increased travel time or reduced convenience. Previous studies on social routing in the manual driving context investigated factors influencing driver decisions [13] and modeled the cooperative behavior of drivers [10, 27] showing that drivers develop individual cooperative strategies over time while hesitant to use social-optimizing navigation systems. In AVs, users additionally experience a loss of control over driving decisions, which can lead to conflicts between the AV's cooperative behavior and the user's individual intentions. This conflict can result in frustration and reduced acceptance [24–26]. Still, to the best of our knowledge, the influence of personal negative consequences, due to traffic management, on user trust and acceptance towards the AV, as well as the broader C-ITS, has not yet been examined.

2.2 Visualizations to Support Trust in Automated Driving

Trust directly relates to users' acceptance and usage of automation [18]. Trust is defined as "the attitude that an agent will help achieve an individual's goal in a situation characterized by uncertainty and vulnerability" [16, p. 51]. Visualizations play a critical role in fostering trust by enhancing users' understanding and predictability of AV behavior [14]. This subscale of trust is particularly important in the context of C-ITS, where decisions rely on data shared invisibly between AVs and with the infrastructure [19]. Without clear explanations, users may experience automation surprises, where decisions appear unjustified or unpredictable, reducing trust and acceptance [4, 17, 22]. Müller, Colley et al. [19] identified three key information types to visualize V2X information: *action-related* (e.g., showing planned maneuvers), *location-specific* (e.g., visualization of V2X coverage area), and *dynamic environment* (e.g., highlighting other road users). Their study found that visualizations incorporating all three types significantly increased understanding and, thus, trust in the AV. However, there is a lack of research on how C-ITS level decisions should be visualized and how users perceive such visualizations in scenarios where pursuing collective goals can lead to personal negative consequences.

3 Online Study

To investigate **RQ1** and **RQ2**, a 2 (Traffic Scenario) × 3 (Personal Outcome) × 3 (Information Level) mixed-subject study design was employed (see Figure 1). *Traffic Scenario* and *Personal Outcome* were varied within subjects, while *Information Level* was a between-subjects factor. This study design resulted in a total of 18 conditions (6 per participant).

3.1 Traffic Scenarios

Depending on the scenario, personal outcomes can be influenced by C-ITS level decisions in a way that is more or less visible to the user. Thus, two scenarios were designed. Both depict a commute to work with the same initial route, focusing on the common optimization approaches of allocating the right of way and rerouting.

Grant Right of Way. A platoon of AVs coming from the left is granted priority at a T-intersection (to minimize vehicle stops and prevent platoon interruption; see, e.g., [35]), even though the formal right of way, according to traffic rules, belongs to the vehicles coming from the right. Participants experience the scenario either from the perspective of an AV user who yields to the platoon or as a user within the platoon of AVs who receives priority depending on the Personal Outcome (see below). Users can observe if they are favored or disadvantaged by C-ITS decisions.

Rerouting. To optimize traffic flow, AVs are rerouted in this scenario to distribute traffic more evenly and prevent congestion (see e.g., [36]). Participants experience this either from the viewpoint of a user who, because other AVs are being rerouted, can continue on the original route without encountering congestion or from the perspective of a user whose AV is being rerouted. Users cannot determine whether they are favored or disadvantaged by C-ITS decisions, as the other route is not observable.

3.2 Impact of Traffic Planning on Personal Outcome.

Various arrival time advantages and disadvantages were compared, ranging from -1 minute to +3 minutes, in order to show noticeable differences while still being able to show the entire journey. *Personal benefit.* The participant arrives 1 minute earlier (also indicated in the estimated time of arrival).

Slight delay. The participant experiences a minor delay (1 minute) without consequences.

Consequential delay. The participant experiences a 3-minute delay, resulting in being late for a scheduled meeting.

3.3 Information Level

We implemented three incremental visualizations, each adding another layer of detail about C-ITS that influences AV behavior and the broader traffic. *Icon.* The center display shows an icon as implemented by [19] to indicate *that* C-ITS decisions influence the AV driving behavior to optimize traffic flow.

Icon+Coverage. The icon is complemented by a visual overlay that responds to *what* is being optimized, i.e. showing areas that are included in the optimization process. Blue spheres represent this overlay, projected as augmented reality (AR) elements on the AV windshield and blue dots on the navigation map in the center stack (see [19]).

Icon+Coverage+Impact. To explain *how* and *why* the C-ITS makes decisions, this visualization additionally indicates the effect on the AV's behavior (e.g., "Waiving the right of way") and the impact on the traffic flow (displayed as a percentage, as many traffic optimization approaches rely on predicted traffic flow (e.g., [2, 3, 12]), allowing also to predict the improvements while making complex C-ITS decisions more assessable for users).

3.4 Apparatus

The scenarios were modeled in Unity version 2022.3.48f1 [28]. The urban environment, the traffic, and vehicle automation were implemented using the Mobile Traffic System. Further, CiDy was used for the buildings and environmental objects. As we simulated mixed traffic, the rear-view mirrors of other AVs were highlighted in cyan (as done by Colley et al. [5]). Equirectangular 360-degree videos were recorded from the user's point of view in Unity with a resolution of 4096 × 2028 pixels and hosted on Vimeo. A background script ensured that the videos played in full-screen mode and full resolution, prevented skipping or replaying, and automatically paused the video if full-screen mode was exited. Study participation was restricted to desktop users (smartphone or tablet users were excluded). However, while this was a participation requirement, actual hardware configurations could not be fully controlled. The survey interface followed standard 360-degree video interaction mechanics, allowing participants to explore the environment by clicking and dragging with the mouse.

3.5 Procedure and Measurements

The study was conducted online via LimeSurvey [1]. Participants were first introduced to the study's procedure and provided informed consent. Then, participants were exposed to the 6 condition videos. The videos were randomized to account for learning effects. After each condition, Acceptance following Van Der Laan et al. [29], The Conflict subscale of the Human-Machine-Interaction-Interdependence Questionnaire (HMII) [34], and Understanding & Predictability using the Trust in Automation (TiA) subscale [14] were measured on 5-point scales. These variables were assessed for both the AV and the C-ITS, with participants informed that "system" referred to either. Frustration was measured using the NASA-TLX [9]. The study concluded with a demographic questionnaire.

3.6 Participants

We evaluated 49 participants from Germany, Switzerland, and Austria: 8 manually recruited personally and via the mailing list and 41 via Prolific. Manually recruited participants were eligible to win one of three 30€ Amazon vouchers. Prolific participants were compensated with 9£. The sample included 25 males, 23 females, and 1 diverse participant, aged 19–74 (*M*=34.22, *SD*=13.19). Residency distribution was 22.4% rural, 61.2% urban, and 16.4% suburban. Driving experience ranged from less than one year to 56 years (*M*=14.12, *SD*=13.08). Interest in automated driving (5-point Likert scale) averaged 3.65 (*SD*=1.13).

4 Results

4.1 Data Analysis

Before every statistical test, we checked the required assumptions (normal distribution and homogeneity of variance assumption). In cases where the data did not follow a normal distribution, we utilized the ARTool package [32] to conduct a non-parametric factorial ANOVA. Subsequently, Dunn's test with Holm correction was applied for post-hoc analyses. R in version 4.4.2 and RStudio in version 2024.09.1 were used. All packages were up to date in November 2024.

4.2 Acceptance

The ART found significant main effects of *Scenario* ($F(1, 46) = 21.58$, p<0.001) and *Personal Outcome* ($F(2, 92) = 35.11$, p<0.001) on AV Acceptance (see Figure 2. AV Acceptance was rated significantly higher for the Rerouting scenario (*M*=3.78, *SD*=0.96) than for the Grant right of way scenario (*M*=3.32, *SD*=1.07). A post-hoc test revealed that AV Acceptance was significantly higher for Personal benefit (*M*=4.03, *SD*=0.82) compared to both Slight delay (*M*=3.54, *SD*=0.96; p_{adj} <0.001) and Consequential delay (*M*=3.07, *SD*=1.09;

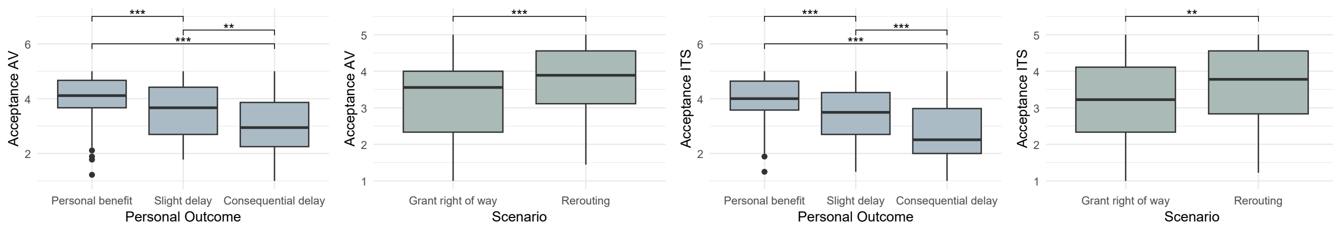

Figure 2: Main effects of Personal Outcome (first and third from left) and Scenario (second and fourth from left) on Acceptance with AV (left two) and C-ITS (right two).

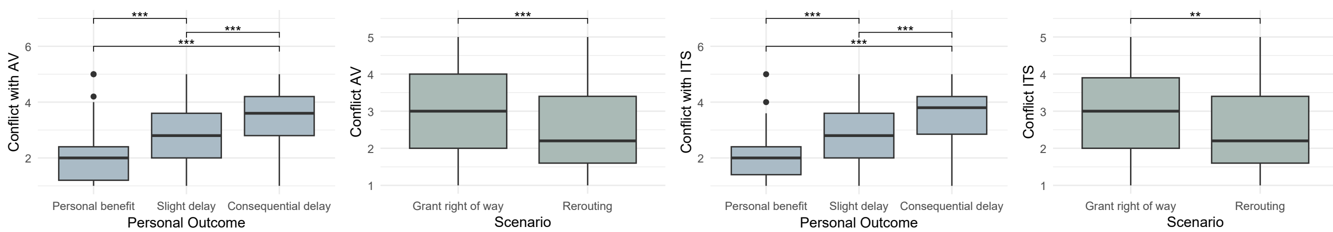

Figure 3: Main effects of Personal Outcome (first and third from left) and Scenario (second and fourth from left) on Conflict with AV (left two) and C-ITS (right two).

p_{adj} <0.001). Additionally, Slight delay was rated significantly higher than Consequential delay (p_{adj}=0.005).

The ART found significant main effects of *Scenario* ($F(1, 46) = 18.06$, p<0.001) and *Personal Outcome* ($F(2, 92) = 49.80$, p<0.001) on C-ITS Acceptance (see Figure 2). C-ITS Acceptance was rated significantly higher for the Rerouting scenario (M=3.63, SD=1.06) than for the Grant right of way scenario (M=3.23, SD=1.10). A post-hoc test further revealed that Personal benefit (M=4.03, SD=0.81) was rated significantly higher than Consequential delay (M=2.79, SD=1.13; p_{adj} <0.001) and Slight delay (M=3.48, SD=0.96; p_{adj} <0.001). Additionally, Slight delay (M=3.48, SD=0.96) was rated significantly higher than Consequential delay (M=2.79, SD=1.13; p_{adj} <0.001).

4.3 Conflict

The ART found significant main effects of *Scenario* ($F(1, 46) = 16.78$, p<0.001) and *Personal Outcome* ($F(2, 92) = 49.33$, p<0.001) on Conflict with AV. Conflict with AV was rated significantly higher in the Grant right of way scenario (M=2.96, SD=1.15) than in the Rerouting scenario (M=2.49, SD=1.13). A post-hoc test further found that Conflict with AV was significantly higher with Consequential delay (M=3.36, SD=1.10) than with Personal benefit (M=2.06, SD=0.93; p_{adj} <0.001) and Slight delay (M=2.76, SD=1.09; p_{adj} <0.001). Additionally, Conflict with AV was significantly higher with Slight delay compared to Personal benefit (p_{adj} <0.001).

The ART found significant main effects of *Scenario* ($F(1, 46) = 11.65$, p=0.001) and *Personal Outcome* ($F(2, 92) = 57.78$, p<0.001) on Conflict with C-ITS (see Figure 3). Conflict with the C-ITS was rated significantly higher in the Grant right of way (M=2.89, SD=1.14) than in the Rerouting scenario (M=2.52, SD=1.15). A post-hoc test further revealed that Conflict with C-ITS was significantly higher for Consequential delay (M=3.39, SD=1.11) compared to both Personal benefit (M=2.00, SD=0.82; p_{adj} <0.001) and Slight delay (M=2.73, SD=1.07; p_{adj} <0.001), while Slight delay also showed significantly higher Conflict than Personal benefit (p_{adj} <0.001).

4.4 Understanding & Predictability

The ART found a significant main effect of *Scenario* on Understanding & Predictability of the AV ($F(1, 46) = 7.42$, p=0.009) (see Figure 4; left). Understanding & Predictability of the AV was rated significantly lower for the Grant right of way scenario (M=3.45, SD=1.02) than for the Rerouting scenario (M=3.79, SD=0.81).

The ART found a significant main effect of *Personal Outcome* on Understanding & Predictability of the C-ITS ($F(2, 92) = 6.08$, p=0.003) (see Figure 4; right). A post-hoc test found that the Understanding & Predictability of the C-ITS was significantly higher when having a Personal benefit (M=3.64, SD=0.91) compared to having a Consequential delay (M=3.25, SD=1.01; p_{adj}=0.017).

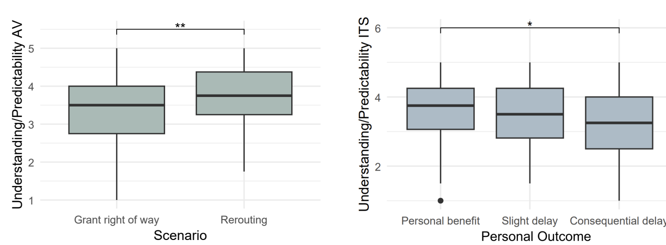

Figure 4: Main effects on Understanding & Predictability of the AV (left) and C-ITS (right).

4.5 Frustration

The ART found significant main effects of *Scenario* ($F(1, 46) = 13.23$, p<0.001) and *Personal Outcome* ($F(2, 92) = 30.78$, p<0.001) on

Frustration. Additionally, a significant interaction effect of *Scenario* × *Personal Outcome* × *Information Level* was found ($F(4, 92) = 2.97$, p=0.023; see Figure 5). A post-hoc test revealed significant differences in Frustration scores between various conditions. In the Grant right of way scenario with Icon+Coverage visualization and a Consequential delay, participants reported significantly higher Frustration scores (*M*=6.90, *SD*=1.94) compared to:

- the Rerouting scenario with Icon+Coverage+Impact visualization and a Personal benefit (*M*=2.21, *SD*=1.53; p_{adj} <0.001).
- the Grant right of way scenario with Icon+Coverage visualization and a Personal benefit (*M*=3.15, *SD*=1.73; p_{adj}=0.002).
- the Rerouting scenario with Icon+Coverage visualization and a Personal benefit (*M*=2.85, *SD*=1.69; p_{adj} <0.001).
- the Rerouting scenario with Icon visualization and a Personal benefit (*M*=3.13, *SD*=2.53; p_{adj}=0.003).
- the Rerouting scenario with Icon+Coverage+Impact visualization and a Slight delay (*M*=3.07, *SD*=2.30; p_{adj}=0.004).

Additionally, Frustration was rated higher in the Rerouting scenario with Icon visualization and a Consequential delay (*M*=6.20, *SD*=3.08) compared to the Rerouting scenario with Icon+Coverage+Impact visualization and a Personal benefit (*M*=2.21, *SD*=1.53; p_{adj}=0.010).

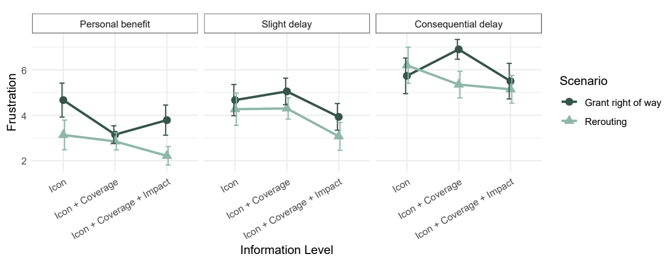

Figure 5: Interaction effect on Frustration.

4.6 Difference between AV and C-ITS

Since the AV is a component of the C-ITS and the ratings for the two systems are not statistically independent, we focused on descriptive statistics. A comparison of the AV and C-ITS (see Table 1) reveals slightly higher values for Acceptance and Understanding & Predictability for the AV compared to the C-ITS. This shows up almost across all conditions (see Table 3). The largest differences (up to a mean difference of 0.58 for Understanding & Predictability) can be seen in the Consequential delay conditions additionally reinforced with decreasing Information Level. However, in general, differences are minor (with Understanding & Predictability ranging from -0.19 to 0.58; Acceptance ranging from -0.61 to 0.51; and Conflict ranging from -0.35 to 0.27).

System	Count	Acceptance		Conflict		Und. & Pred.	
		M	SD	M	SD	M	SD
AV	294	3.55	1.04	2.72	1.16	3.62	0.938
C-ITS	294	3.43	1.10	2.71	1.15	3.47	0.977

Table 1: Descriptive statistics for Acceptance, Conflict, and Understanding & Predictability by system.

5 Discussion

This study investigated the development of self-relying AVs to C-ITS from an HCI perspective. Our results show that Personal Outcomes and Traffic Scenarios significantly influence user Acceptance, Conflict, and Understanding & Predictability. Additionally, the influences of C-ITS on AV behavior were perceived more positively in the Rerouting scenario compared to Grant right of way. With the increase of negative personal outcomes, Acceptance and Understanding & Predictability decreased, while Conflict increased. For the Information Level, no main effects were found; however, Frustration was highest in the Grant right of way scenario under the Icon+Coverage condition and showed interaction effects with all three factors. In the following, we discuss our findings based on the RQs.

RQ1 User perception is more positive for the Rerouting scenario than scenarios involving yielding, such as Granting right of way. One reason could be that in the Grant right of way scenario, users can see that the C-ITS puts them at a disadvantage compared to other vehicles, reflecting how fairness perceptions play a critical role in the trust development process [15]. If expectations are not met, AV behavior can appear unpredictable [4, 6, 31], leading to lower acceptance [20]. Thus, another reason could be that users may not anticipate the AV stopping or driving on a priority road when it does not have the right of way. This suggests that C-ITS designs should prioritize strategies that minimize visible disadvantages to individual users and align AV behavior with established traffic norms to enhance predictability.

The decrease in Understanding & Predictability with longer delays, even when the situation remains unchanged, highlights the need for clearer explanations of extended trade-offs. In the Grant right of way scenario, users might expect only a few vehicles to be prioritized, leading to Frustration. Thus, emphasizing the user's long-term benefits of traffic optimization, particularly for users who frequently travel the same routes, could help them better appreciate how the C-ITS decisions align with their broader interests.

No main effects were found for the Information Level. However, an interaction effect on Frustration suggests that its impact depends on the Scenario and Personal Outcome. Frustration is highest in the Grant right of way scenario when Icon+Coverage is displayed, while in Rerouting, Frustration peaks when only the Icon is shown. One possible reason is that in Grant right of way, the disadvantage compared to other vehicles becomes visible. When Coverage information is provided, it makes clear that this disadvantage is system-intended. In the Personal Benefit condition, Frustration arises in Grant right of way when only the Icon is displayed, likely because the vehicle appears to act against traffic regulations without an explanation, contradicting expectations. This aligns partially with findings by Müller, Colley et al. [19], who demonstrated that location-specific elements, such as icons and coverage visualizations, had a limited impact on Understanding & Predictability compared to action-related information and visualizations of dynamic environment objects, both of which significantly influenced trust. In our study, we included both location- and action-specific information, supplemented by additional C-ITS-level details. Those results raise the question of additional information, e.g., about long-term benefits, could enhance Understanding & Predictability and, in turn, overall acceptance.

RQ2 The AV was introduced as part of the C-ITS, with its behavior being influenced by C-ITS-level decisions to optimize traffic flow (see subsection A.1). Our findings show that users perceive the AV and the C-ITS similarly, except when it leads to Consequential delay, Acceptance and Understanding & Predictability of C-ITS decreases more compared to AV, especially when only the Icon is shown. This highlights the importance of visualizing the overall impact on the traffic. Previous research has shown that conflicts with AVs often lead to user takeovers (if allowed) [26, 33]. This presumably extends to C-ITS conflicts (but should be investigated further), which could undermine the collective goals of C-ITS. This indicates that C-ITS decisions may fall back on the AV, effectively requiring it to "bear the burden" of C-ITS trade-offs. Thus, as already suggested above, it speaks in favor of displaying additional information on how the user benefits from it in the long term. For C-ITS solutions, it is recommended to use approaches that take into account incentive/pricing strategies (see e.g., [30]).

Summarizing, some user-centered design recommendations can be derived for the implementation of C-ITS:

- AV behaviors should be adjusted to avoid making prioritization too obvious, reducing frustration.
- Adhering to traffic regulations and shifting negotiations to intersections with traffic lights—while influencing the signal timing or providing an external human-machine interface (eHMI) on the other AVs could support users in recognizing that right of way has been granted rather than taken.
- Providing additional information on personal long-term benefits could improve user understanding and acceptance.
- Implementing incentive mechanisms could help ensure that individual AVs are not disproportionately disadvantaged within a single trip.

5.1 Limitations

Our study focused on short-term user perceptions, missing long-term effects such as evolving trust and perceived fairness in C-ITS usage. Further, the video-based survey lacked real-world consequences, potentially limiting external validity. Lastly, the participant sample was restricted to German-speaking countries, limiting cultural generalizability.

6 Conclusion

This study investigated user acceptance of C-ITS, focusing on Traffic Optimization Scenarios, Personal Outcomes, and Information Levels. Results indicate that the Rerouting scenario was perceived more positively than Grant right of way, highlighting the importance of minimizing perceived disadvantages and aligning system behavior with traffic norms. While users showed similar ratings for AVs and C-ITS overall, differences became evident under conditions with high negative personal outcomes. Future research should explore how clearer communication of long-term user benefits can improve the perception and acceptance of C-ITS.

Open Science

All anonymized data and the complete survey questionnaire will be available upon request.

Acknowledgments

We thank all study participants. This work was supported by the start-up funding grant of the Graduate & Professional Training Center Ulm (ProTrainU) to Annika Stampf.

References

[1] [n. d.]. *LimeSurvey – Kostenloses Online-Umfrage-Tool.* Retrieved 3 September, 2023 from https://www.limesurvey.org/de

[2] Christian Backfrieder, Gerald Ostermayer, and Christoph F. Mecklenbräuker. 2017. Increased Traffic Flow Through Node-Based Bottleneck Prediction and V2X Communication. *IEEE Transactions on Intelligent Transportation Systems* 18, 2 (Feb. 2017), 349–363. doi:10.1109/TITS.2016.2573292 https://ieeexplore.ieee.org/abstract/document/7514969.

[3] Azzedine Boukerche, Yanjie Tao, and Peng Sun. 2020. Artificial Intelligence-Based Vehicular Traffic Flow Prediction Methods for Supporting Intelligent Transportation Systems. *Computer Networks* 182 (Dec. 2020), 107484. doi:10.1016/j.comnet.2020.107484 https://www.sciencedirect.com/science/article/pii/S1389128620311567.

[4] Mark Colley, Benjamin Eder, Jan Ole Rixen, and Enrico Rukzio. 2021. Effects of Semantic Segmentation Visualization on Trust, Situation Awareness, and Cognitive Load in Highly Automated Vehicles. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21).* Association for Computing Machinery, New York, NY, USA, 1–11. doi:10.1145/3411764.3445351 https://doi.org/10.1145/3411764.3445351.

[5] Mark Colley, Christian Hummler, and Enrico Rukzio. 2022. Effects of Mode Distinction, User Visibility, and Vehicle Appearance on Mode Confusion When Interacting with Highly Automated Vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour* 89 (Aug. 2022), 303–316. doi:10.1016/j.trf.2022.06.020 https://www.sciencedirect.com/science/article/pii/S1369847822001498.

[6] Mark Colley, Max Rädler, Jonas Glimmann, and Enrico Rukzio. 2022. Effects of Scene Detection, Scene Prediction, and Maneuver Planning Visualizations on Trust, Situation Awareness, and Cognitive Load in Highly Automated Vehicles. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 6, 2 (July 2022), 49:1–49:21. doi:10.1145/3534609 https://dl.acm.org/doi/10.1145/3534609.

[7] Yang Guan, Yangang Ren, Shengbo Eben Li, Qi Sun, Laiquan Luo, and Keqiang Li. 2020. Centralized Cooperation for Connected and Automated Vehicles at Intersections by Proximal Policy Optimization. *IEEE Transactions on Vehicular Technology* 69, 11 (Nov. 2020), 12597–12608. doi:10.1109/TVT.2020.3026111 https://ieeexplore.ieee.org/abstract/document/9204585.

[8] Sohan Gyawali, Shengjie Xu, Yi Qian, and Rose Qingyang Hu. 2021. Challenges and Solutions for Cellular Based V2X Communications. *IEEE Communications Surveys & Tutorials* 23, 1 (2021), 222–255. doi:10.1109/COMST.2020.3029723 https://ieeexplore.ieee.org/abstract/document/9217500.

[9] Sandra G. Hart and Lowell E. Staveland. 1988. Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In *Advances in Psychology*, Peter A. Hancock and Najmedin Meshkati (Eds.). Human Mental Workload, Vol. 52. North-Holland, 139–183. doi:10.1016/S0166-4115(08)62386-9 https://www.sciencedirect.com/science/article/pii/S0166411508623869.

[10] Dirk Helbing, Martin Schönhof, Hans-Ulrich Stark, and Janusz A. Hołyst. 2005. How Individuals Learn to Take Turns: Emergence of Alternating Cooperation in a Congestion Game and the Prisoner's Dilemma. *Advances in Complex Systems* 08, 01 (March 2005), 87–116. doi:10.1142/S0219525905000361 https://www.worldscientific.com/doi/abs/10.1142/S0219525905000361.

[11] Rateb Jabbar, Eya Dhib, Ahmed Ben Said, Moez Krichen, Noora Fetais, Esmat Zaidan, and Kamel Barkaoui. 2022. Blockchain Technology for Intelligent Transportation Systems: A Systematic Literature Review. *IEEE Access* 10 (2022), 20995–21031. doi:10.1109/ACCESS.2022.3149958 https://ieeexplore.ieee.org/abstract/document/9706476.

[12] Muhammad Awais Javed, Sherali Zeadally, and Elyes Ben Hamida. 2019. Data Analytics for Cooperative Intelligent Transport Systems. *Vehicular Communications* 15 (Jan. 2019), 63–72. doi:10.1016/j.vehcom.2018.10.004 https://www.sciencedirect.com/science/article/pii/S221420961830192X.

[13] Florian Koller. 2021. What Determines the Acceptance of Socially Optimal Traffic Coordination?: A Scenario-Based Examination in Germany. *Transportation Research Part A: Policy and Practice* 149 (July 2021), 62–75. doi:10.1016/j.tra.2021.04.004 https://www.sciencedirect.com/science/article/pii/S0965856421001026.

[14] Moritz Körber. 2018. *Theoretical Considerations and Development of a Questionnaire to Measure Trust in Automation.*

[15] Markus Langer, Cornelius J. König, Caroline Back, and Victoria Hemsing. 2023. Trust in Artificial Intelligence: Comparing Trust Processes Between Human and Automated Trustees in Light of Unfair Bias. *Journal of Business and Psychology* 38, 3 (June 2023), 493–508. doi:10.1007/s10869-022-09829-9 https://doi.org/10.1007/s10869-022-09829-9.

[16] John D. Lee and Katrina A. See. 2004. Trust in Automation: Designing for Appropriate Reliance. *Human Factors* 46, 1 (March 2004), 50–80. doi:10.1518/hfes.46.1.50_30392 https://journals.sagepub.com/doi/abs/10.1518/hfes.46.1.50_30392.

[17] Chenchang Li, Zheng Wang, Bo Yang, Muhua Guan, Chao Huang, and Kimihiko Nakano. 2023. The Impact of System Transparency on Passenger's Quality of Experience in Highly Automated Driving. In *2023 IEEE Intelligent Vehicles Symposium (IV)*. 1–7. doi:10.1109/IV55152.2023.10186700

[18] Bonnie M. Muir. 1994. Trust in Automation: Part I. Theoretical Issues in the Study of Trust and Human Intervention in Automated Systems. *Ergonomics* 37, 11 (Nov. 1994), 1905–1922. doi:10.1080/00140139408964957 https://doi.org/10.1080/00140139408964957.

[19] Tobias Müller, Mark Colley, Gülsemin Dogru, and Enrico Rukzio. 2022. AR4CAD: Creation and Exploration of a Taxonomy of Augmented Reality Visualization for Connected Automated Driving. *Proceedings of the ACM on Human-Computer Interaction* 6, MHCI (Sept. 2022), 177:1–177:27. doi:10.1145/3546712 https://doi.org/10.1145/3546712.

[20] Raja Parasuraman and Victor Riley. 1997. Humans and Automation: Use, Misuse, Disuse, Abuse. *Human Factors* 39, 2 (June 1997), 230–253. doi:10.1518/001872097778543886 https://doi.org/10.1518/001872097778543886.

[21] Ramin Ranjbar Motlagh, Omid Ameri Sianaki, and Himanshu Shee. 2024. A Survey on Cooperative Intelligent Transportation Systems (C-ITS): Opportunities and Challenges. In *Complex, Intelligent and Software Intensive Systems*, Leonard Barolli (Ed.). Springer Nature Switzerland, Cham, 253–260. doi:10.1007/978-3-031-70011-8_23

[22] Tobias Schneider, Joana Hois, Alischa Rosenstein, Sabiha Ghellal, Dimitra Theofanou-Fülbier, and Ansgar R.S. Gerlicher. 2021. ExplAIn Yourself! Transparency for Positive UX in Autonomous Driving. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 161. doi:10.1145/3411764.3446647 https://doi.org/10.1145/3411764.3446647.

[23] Katrin Sjoberg, Peter Andres, Teodor Buburuzan, and Achim Brakemeier. 2017. Cooperative Intelligent Transport Systems in Europe: Current Deployment Status and Outlook. *IEEE Vehicular Technology Magazine* 12, 2 (June 2017), 89–97. doi:10.1109/MVT.2017.2670018 https://ieeexplore.ieee.org/document/7911287/?arnumber=7911287.

[24] Annika Stampf, Mark Colley, Bettina Girst, and Enrico Rukzio. 2024. Exploring Passenger-Automated Vehicle Negotiation Utilizing Large Language Models for Natural Interaction. In *Proceedings of the 16th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '24)*. Association for Computing Machinery, New York, NY, USA, 350–362. doi:10.1145/3640792.3675725 https://dl.acm.org/doi/10.1145/3640792.3675725.

[25] Annika Stampf, Mark Colley, Ann-Kathrin Knuth, Cagla Tasci, and Enrico Rukzio. 2024. Examining Psychological Conflict-Handling Strategies for Highly Automated Vehicles to Resolve Legal User-Vehicle Conflicts. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 8, 3 (Aug. 2024), 1–25. doi:10.1145/3678511 https://dl.acm.org/doi/10.1145/3678511.

[26] Annika Stampf, Ann-Kathrin Knuth, Mark Colley, and Enrico Rukzio. 2024. Law and Order: Investigating the Effects of Conflictual Situations in Manual and Automated Driving in a German Sample. *International Journal of Human-Computer Studies* 187 (July 2024), 103260. doi:10.1016/j.ijhcs.2024.103260 https://www.sciencedirect.com/science/article/pii/S1071581924000442.

[27] Hans-Ulrich Stark, Dirk Helbing, Martin Schonhof, and Janusz A Holyst. [n. d.]. Alternating Cooperation Strategies in a Route Choice Game: Theory, Experiments, and Effects of a Learning Scenario. ([n. d.]).

[28] Unity Technologies. 2022. Unity. Unity Technologies. https://unity.com/.

[29] Jinke D. Van Der Laan, Adriaan Heino, and Dick De Waard. 1997. A Simple Procedure for the Assessment of Acceptance of Advanced Transport Telematics. *Transportation Research Part C: Emerging Technologies* 5, 1 (Feb. 1997), 1–10. doi:10.1016/S0968-090X(96)00025-3 https://www.sciencedirect.com/science/article/pii/S0968090X96000253.

[30] Chaojie Wang, Srinivas Peeta, and Jian Wang. 2021. Incentive-Based Decentralized Routing for Connected and Autonomous Vehicles Using Information Propagation. *Transportation Research Part B: Methodological* 149 (July 2021), 138–161. doi:10.1016/j.trb.2021.05.004 https://www.sciencedirect.com/science/article/pii/S0191261521000837.

[31] Philipp Wintersberger, Anna-Katharina Frison, Andreas Riener, and Tamara von Sawitzky. 2018. Fostering User Acceptance and Trust in Fully Automated Vehicles: Evaluating the Potential of Augmented Reality. *Presence: Teleoperators and Virtual Environments* 27, 1 (Feb. 2018), 46–62. doi:10.1162/pres_a_00320 https://doi.org/10.1162/pres_a_00320.

[32] Jacob O. Wobbrock, Leah Findlater, Darren Gergle, and James J. Higgins. 2011. The Aligned Rank Transform for Nonparametric Factorial Analyses Using Only Anova Procedures. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada) *(CHI '11)*. Association for Computing Machinery, New York, NY, USA, 143–146. doi:10.1145/1978942.1978963

[33] Marcel Woide, Dina Stiegemeier, and Martin Baumann. 2019. *A Methodical Approach to Examine Conflicts in Context of Driver - Autonomous Vehicle - Interaction*. doi:10.17077/drivingassessment.1712

[34] Marcel Woide, Dina Stiegemeier, Stefan Pfattheicher, and Martin Baumann. 2021. Measuring Driver-Vehicle Cooperation: Development and Validation of the Human-Machine-Interaction-Interdependence Questionnaire (HMII). *Transportation Research Part F: Traffic Psychology and Behaviour* 83 (Nov. 2021), 424–439. doi:10.1016/j.trf.2021.11.003 https://www.sciencedirect.com/science/article/pii/S1369847821002539.

[35] Zongyuan Wu and Ben Waterson. 2022. Urban Intersection Management Strategies for Autonomous/Connected/Conventional Vehicle Fleet Mixtures. *IEEE Transactions on Intelligent Transportation Systems* 23, 8 (Aug. 2022), 12084–12093. doi:10.1109/TITS.2021.3109783 https://ieeexplore.ieee.org/document/9535372/?arnumber=9535372.

[36] Jorge Luis Zambrano-Martinez, Carlos T. Calafate, David Soler, Lenin-Guillermo Lemus-Zúñiga, Juan-Carlos Cano, Pietro Manzoni, and Thierry Gayraud. 2019. A Centralized Route-Management Solution for Autonomous Vehicles in Urban Areas. *Electronics* 8, 7 (July 2019), 722. doi:10.3390/electronics8070722 https://www.mdpi.com/2079-9292/8/7/722.

A Supplementary Materials

A.1 Introduction into the AV and the C-ITS

The introduction was as follows: "The videos show the journey in an autonomous vehicle from the passenger's perspective. The vehicle is capable of performing all driving tasks successfully and completely autonomously. It also communicates with other road users, vehicles, and the local infrastructure and is integrated into a central traffic planning system. Please imagine that you are the driver of this vehicle [...]. In the scenarios shown, both your journey and that of other road users is influenced by the traffic planning system in order to optimize the flow of traffic in the respective situation. For example, priority rules or routes are adjusted at short notice. This can affect your arrival time both positively and negatively. The vehicle shows you how these adjustments affect your journey on the display in the center console. " (Translated from German)

A.2 Descriptive Study Results

Traffic Scenario	Information Level	Personal Outcome	System	Count	Acceptance		Conflict		Trust	
					M	SD	M	SD	M	SD
Grant right of way	Icon	Personal benefit	AV	15	3.44	1.38	2.73	1.34	3.25	1.08
Grant right of way	Icon	Personal benefit	C-ITS	15	3.50	1.05	2.47	1.15	3.30	1.01
Grant right of way	Icon	Slight delay	AV	15	3.32	1.15	2.99	1.22	3.63	1.03
Grant right of way	Icon	Slight delay	C-ITS	15	3.24	1.22	2.95	1.25	3.47	1.22
Grant right of way	Icon	Consequential delay	AV	15	3.12	1.40	3.09	1.31	3.43	1.02
Grant right of way	Icon	Consequential delay	C-ITS	15	2.87	1.44	3.19	1.35	3.30	1.11
Grant right of way	Icon+Coverage	Personal benefit	AV	20	3.92	0.63	2.30	0.88	3.45	0.98
Grant right of way	Icon+Coverage	Personal benefit	C-ITS	20	3.93	0.87	2.21	0.71	3.64	0.96
Grant right of way	Icon+Coverage	Slight delay	AV	20	3.17	0.80	3.25	0.95	3.30	1.04
Grant right of way	Icon+Coverage	Slight delay	C-ITS	20	3.22	0.75	3.08	0.93	3.34	0.87
Grant right of way	Icon+Coverage	Consequential delay	AV	20	2.62	0.80	3.74	0.78	3.25	0.90
Grant right of way	Icon+Coverage	Consequential delay	C-ITS	20	2.37	0.90	3.62	0.70	3.18	0.89
Grant right of way	Icon+Coverage+Impact	Personal benefit	AV	14	4.02	0.73	2.01	0.51	3.79	1.03
Grant right of way	Icon+Coverage+Impact	Personal benefit	C-ITS	14	3.72	0.78	2.09	0.78	3.46	1.02
Grant right of way	Icon+Coverage+Impact	Slight delay	AV	14	3.50	0.93	2.83	1.19	3.77	0.99
Grant right of way	Icon+Coverage+Impact	Slight delay	C-ITS	14	3.52	0.94	2.83	1.14	3.29	1.04
Grant right of way	Icon+Coverage+Impact	Consequential delay	AV	14	2.90	1.08	3.54	1.18	3.36	1.26
Grant right of way	Icon+Coverage+Impact	Consequential delay	C-ITS	14	2.80	1.17	3.53	1.33	3.36	1.11
Rerouting	Icon	Personal benefit	AV	15	4.42	0.63	1.63	0.87	3.90	0.67
Rerouting	Icon	Personal benefit	C-ITS	15	4.44	0.66	1.79	0.86	3.92	0.76
Rerouting	Icon	Slight delay	AV	15	4.13	0.93	2.03	0.92	4.27	0.74
Rerouting	Icon	Slight delay	C-ITS	15	3.82	1.03	2.29	0.98	3.85	1.03
Rerouting	Icon	Consequential delay	AV	15	3.48	1.16	2.96	1.13	3.83	1.07
Rerouting	Icon	Consequential delay	C-ITS	15	2.97	1.15	3.31	1.17	3.25	1.08
Rerouting	Icon+Coverage	Personal benefit	AV	20	4.17	0.55	2.04	0.75	3.81	0.62
Rerouting	Icon+Coverage	Personal benefit	C-ITS	20	4.23	0.51	1.90	0.59	3.88	0.72
Rerouting	Icon+Coverage	Slight delay	AV	20	3.41	0.88	2.87	1.01	3.51	0.76
Rerouting	Icon+Coverage	Slight delay	C-ITS	20	3.39	0.88	2.88	0.99	3.40	0.85
Rerouting	Icon+Coverage	Consequential delay	AV	20	3.14	1.05	3.31	1.02	3.49	0.94
Rerouting	Icon+Coverage	Consequential delay	C-ITS	20	2.78	1.17	3.30	1.06	3.32	1.02
Rerouting	Icon+Coverage+Impact	Personal benefit	AV	14	4.23	0.60	1.56	0.60	3.93	0.49
Rerouting	Icon+Coverage+Impact	Personal benefit	C-ITS	14	4.28	0.62	1.49	0.53	3.54	0.98
Rerouting	Icon+Coverage+Impact	Slight delay	AV	14	3.91	0.87	2.34	0.91	4.04	0.67
Rerouting	Icon+Coverage+Impact	Slight delay	C-ITS	14	3.84	0.89	2.19	1.01	3.86	0.87
Rerouting	Icon+Coverage+Impact	Consequential delay	AV	14	3.31	1.00	3.39	1.22	3.54	1.02
Rerouting	Icon+Coverage+Impact	Consequential delay	C-ITS	14	3.10	0.98	3.34	1.21	3.09	1.02

Table 2: Descriptive statistics for Acceptance, Conflict, and Understanding & Predictability across all conditions.

Traffic Scenario	Information Level	Personal Outcome	Count	Diff Acceptance	Diff Conflict	Diff Und. & Pred.
Grant right of way	Icon	Personal benefit	30	-0.06	0.27	-0.05
Grant right of way	Icon	Slight delay	30	0.08	0.04	0.17
Grant right of way	Icon	Consequential delay	30	0.24	-0.09	0.13
Grant right of way	Icon + Coverage	Personal benefit	40	-0.017	0.09	-0.19
Grant right of way	Icon + Coverage	Slight delay	40	-0.05	0.17	-0.04
Grant right of way	Icon + Coverage	Consequential delay	40	0.25	0.12	0.08
Grant right of way	Icon + Coverage + Impact	Personal benefit	28	0.30	-0.07	0.32
Grant right of way	Icon + Coverage + Impact	Slight delay	28	-0.02	0	0.48
Grant right of way	Icon + Coverage + Impact	Consequential delay	28	0.10	0.01	0
Rerouting	Icon	Personal benefit	30	-0.02	-0.16	-0.02
Rerouting	Icon	Slight delay	30	0.31	-0.27	0.42
Rerouting	Icon	Consequential delay	30	0.51	-0.35	0.58
Rerouting	Icon + Coverage	Personal benefit	40	-0.06	0.14	-0.06
Rerouting	Icon + Coverage	Slight delay	40	0.017	-0.01	0.11
Rerouting	Icon + Coverage	Consequential delay	40	0.36	0.01	0.16
Rerouting	Icon + Coverage + Impact	Personal benefit	28	-0.05	0.07	0.40
Rerouting	Icon + Coverage + Impact	Slight delay	28	0.07	0.157	0.18
Rerouting	Icon + Coverage + Impact	Consequential delay	28	0.21	0.04	0.45

Table 3: Differences in Acceptance, Conflict, and Understanding & Predictability across all conditions, calculated by subtracting C-ITS ratings from AV ratings. Thus, values greater than zero indicate higher ratings for the AV compared to the C-ITS and vice versa.