Project Report

The Part 1 report should be in a document in PDF format (Max 35 pages excluding appendix) named `inf2002-team<number>-2025-part1report.pdf` and submitted to the **team document repo** in a folder named "part1_report"

INF2002 Human Computer Interaction

TEAM 41

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1. Introduction

Our project addresses a fundamental challenge in the evolution of private autonomous vehicles (AVs): the critical handover period during accident-handling scenarios. As the automotive industry advances towards Level 3 (L3) automation, where vehicles manage all driving tasks under specific conditions but require human intervention when encountering limitations, we face a crucial safety paradox. While AVs capably handle routine driving, the human driver's attention inevitably wanes during extended automation. A phenomenon known as automation complacency. This creates a dangerous situation where drivers experience out-of-loop performance degradation, significantly delaying their response when the system encounters an unmanageable situation and requests intervention. Research by Vlakveld et al. (2018) [9] demonstrates this critical safety gap, documenting take-over request response times as long as 8-10 seconds. At highway speeds, this delay represents hundreds of meters of uncontrolled travel, posing severe risks to vehicle occupants and all road users. Our project directly confronts this human-factor crisis by investigating how the Human-Machine Interface (HMI), specifically through integrated multi-sensory cues (visual, audio, and physical feedback) can be designed to bridge the awareness gap, rebuild situational understanding, and ensure swift, safe driver intervention when the vehicle's automation fails during Minimum Risk Conditions (MRCs).

2. Needfinding & Task Analysis

Understanding User needs in AV Emergency Scenarios

2.1. Research Methodology

2.1.1. Survey and Questionnaire (Direct Observation):

- Uses Microsoft Forms which is easy to create. Surveys offers flexibility and fast method in gathering insights on AV functionalities. It can collect both qualitative and quantitative data and useful in capturing user experience with AVs, confidence and perceptions
- Conducted through Microsoft Forms to create questionnaires for users via an URL to gather both qualitative and quantitative data
- Target people: Private Car owners with AV functionalities
- What were the goals of the survey?
    - Find out overall experience with Autonomous Vehicles features such as smart features, near miss accidents
    - Find out how confident users were with the current AV system
- Number of participants/response gathered was 10
- There is 6 participants aged between 18 to 24 years old and 4 participants aged between 25 to 34 years old
- The form was put online for three days

2.1.2. Document mining (Indirect Observation):

- Document mining through analysing video/articles(discussions, crash/incident report). It gave valuable information by revealing current real-world issues, anomalies and perception of current AV systems. These information may not be captured from our survey so it helps us to gather comprehensive information on current AV system
- Reviewed multiple autonomous vehicle crash/incident or anomaly in United States and China over 3 days through Youtube videos, Reddit and articles
- Video and Article analysed:
    - 3 videos from youtube, 3 articles and 2 article/video from reddit
- This method was critical for capturing **behavioral and contextual data** from real-world scenarios that are difficult to replicate in a survey. By analyzing actual incident reports and user discussions from platforms like Reddit and YouTube, we gained unfiltered insight into the systemic failures, edge cases, and human factors that lead to accidents. Which provides a vital reality check against the self-reported survey data, revealing the actual challenges AVs face (e.g., sensor malfunctions, misjudgments) and the genuine anxieties users express in informal settings.

2.2. Results Presentation

2.2.1. Quantitative Data (Pie Charts)

We utilised pie charts as our main visualisation tool for displaying the distribution of responses across all survey questions. These charts effectively showed proportional relationships.

- 60% of respondents were aged 18 to 24 years old and 40% is were aged 24 to 34 years old (Fig 1.1)
- 60% of respondents have not used AV features before, but they are interested in the features (Fig 1.2) and 50% have not experienced any near miss/accidents from AV as they have never used it (Fig 1.7)
- There is mixed level of trust in AV in handling emergencies (Fig 1.8) and it leans towards lower level of trust as 70% of respondents would rather have the AV alert them before they take control over the vehicle(Fig 1.9)
- The features that user wants when the AV wants to hand over the control is through voice, dashboard warning and seat/steering wheel vibration (Fig 1.4) and 80% wants the AV to automatically contact emergency contact (Fig 1.3)
- 70% will trust the AV to handle emergencies if it were explained to them (Fig 1.10)

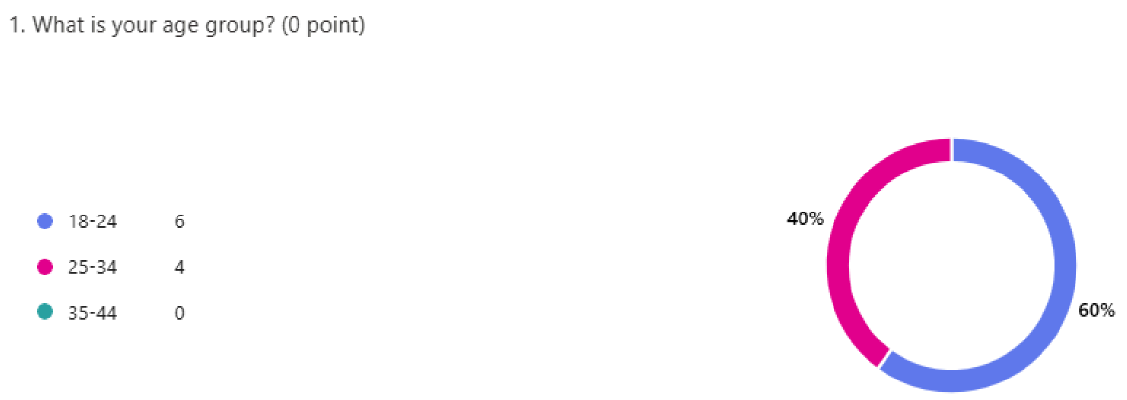


Figure 1.1

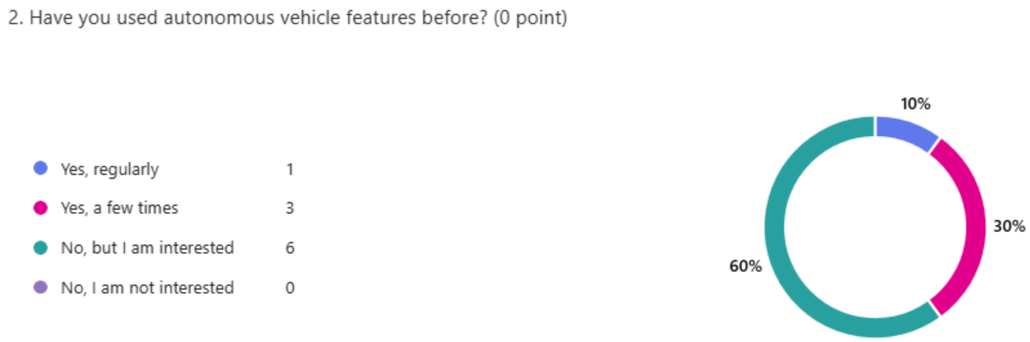


Figure 1.2

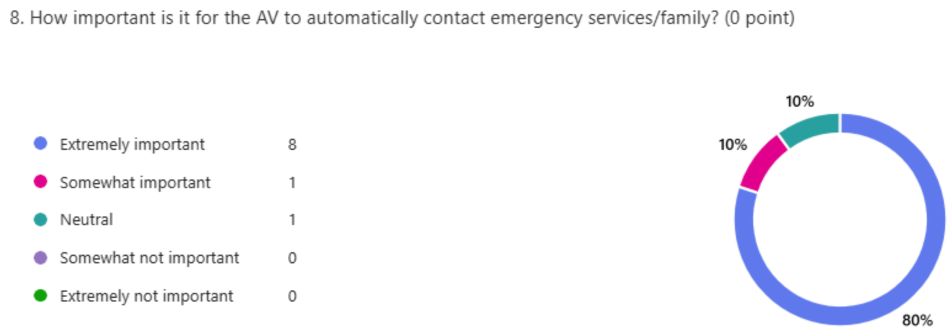


Figure 1.3

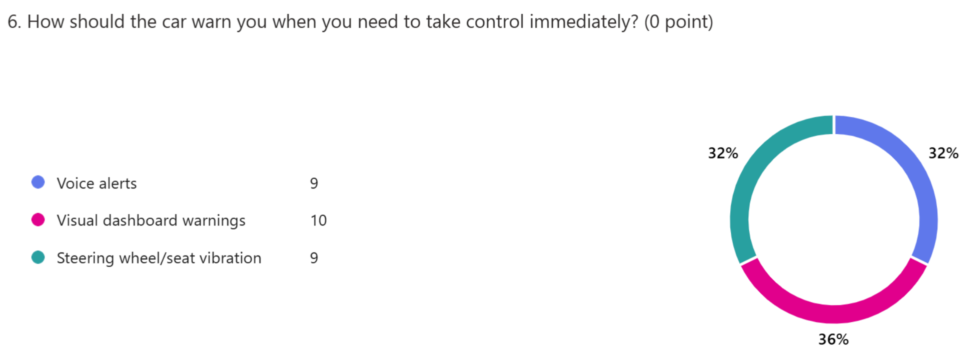


Figure 1.4

2.2.2. Qualitative Data (Data Tables)

We implemented tables for the open-ended questions to present detailed qualitative responses. This includes clear documentation of individual responses such as AV Secureness (Figure 1.5), and concerns on accident scenarios (Figure 1.10).

AV Secureness (Figure 1.5):

Respondents will feel secure in AV if

1. They know when the AV is changing lane
2. They know when the AV wants to increase speed or if it is speeding
3. Consistent throttle control (no jerking, sudden stopping)

Concerns on accident scenarios (Figure 1.6):

However, respondents also have worries on accidents while using AV

1. AV misjudges the scenario and cause accidents instead
2. AV sensors malfunction
3. AV makes the wrong prediction

9. What would make you feel most secure during autonomous driving?

8 Responses

ID ↑	Name	Responses
1	anonymous	nil
2	anonymous	When they are able to show on the small TV if we are speeding or not
3	anonymous	at least let me know where the car is going and its predictions
4	anonymous	There will always be some sort of risk involved
5	anonymous	Distancing
6	anonymous	Update everytime when it is going to turn or change lane or increase speed
7	anonymous	Consistent throttle control with no sudden stopping
8	anonymous	When I visited the US, and my Uber driver used Tesla's FSD.

Figure 1.5

10. What kind of accident or emergency scenarios worry you most while using AVs?

9 Responses

ID ↑	Name	Responses
1	anonymous	nil
2	anonymous	Lost of control
3	anonymous	pregnancy
4	anonymous	wrong predictions
5	anonymous	when the sensors stop working or is malfunctioning during drives
6	anonymous	Lorry coming from behind
7	anonymous	bang into cars
8	anonymous	The AV misjudges the scenario and causes an accident instead
9	anonymous	sensor failure leading to accident

Figure 1.6

2.2.3 Task Analysis

Our task analysis have presented us with:

Mixed levels of trust in AV

- Users will want to know what exactly the AV will do in emergency situations to decide when to take control
  - In case of emergencies, they would want to be the one making decisions instead of the AV
- Some argue that AVs are safer than human drivers as they eliminate human error (drunk driving, sleeping behind the wheel, etc.)
- Concerns about ability to react quick enough to unexpected situations that may not be in their knowledge base (e.g. New construction sites, lesser known animals or objects when driving in the suburbs)
- Some concerns over how AVs are unable to provide cues to other drivers or vehicles such as bicycles on the road, thus some preferring distance or a separate lane for AVs
- Concerns over loss of control or computer manipulation
- Nordhoff et al. (2020) conducted a study and found that more than half (51.9%) of the professionals surveyed believe that keeping the steering wheels will guarantee safer operation (as a safety driver can take control in critical situations)

<u>HTA on handling of emergencies in AV:</u>

Goal: To handle emergencies in AV

Plan 0: Do 1, 2, 3 concurrently, if alert received, go to 4, then 5, then 6.

1. Monitor road situation: Vehicle is on autopilot, driver will scan traffic condition manually
2. Driver glances periodically at the car dashboard for any alerts
3. Driver seat in ready position in order to take control of vehicle(hands on wheels, feet near throttle)
4. Take notice of the alerts shown in dashboard/steering wheel
   4.1. Seat/Steering wheel vibration
   4.2. Dashboard alerts with sound
5. Driver assess the alerts
   5.1. Check mirrors
   5.2. Check surrounding for hazards
6. Driver takes control over vehicle
   6.1. Grab steering wheel and feet on throttle
   6.2. Maneuver vehicle safely

2.2.4 Conclusion

From our needfinding and task analysis, firstly, users want to know and understand what the AV is doing while autopilot is on. Secondly, users want active feedback(voice, dashboard warning and seat/steering wheel vibration) in emergencies. Thirdly, users wants the AV to immediately contact their emergency contact in emergencies. Lastly, users want insight and explanations on AV decisions while handling emergency situations before having more trust in it.

2.3 Identified User Needs (5)

1. Need for Immediate and Intuitive Manual Override

- **Description:** Users need to regain immediate manual control of the vehicle in an intuitive, reliable, and panic-proof way when they feel the autonomous system is failing or in an emergency.
- **Justification:** The task analysis shows the final step is "Driver takes control," but current systems lack a guaranteed "emergency exit." This is supported by the heuristic evaluation (H3), which flagged the lack of a manual override as a severity-4 "Usability Catastrophe." Furthermore, user concerns about "loss of control" and the finding from Nordhoff et al. (2020) that 51.9% of professionals believe steering wheels guarantee safety, directly validate this need for a reliable fallback.
- **Design Implications:** The final design must include a highly visible, always-accessible, and physically distinct control (e.g., a large, red button on the steering wheel or console) that instantly returns full command to the driver, bypassing any automated processes.

2. Need for Unambiguous, Multi-Sensory Emergency Alerts

- **Description:** Users need to be made aware of an imminent danger or system failure through clear, multi-sensory alerts that effectively cut through distraction and complacency.
- **Justification:** The HTA specifies that the user must first "Take notice of the alerts" through "Seat/Steering wheel vibration" and "Dashboard alerts with sound." User feedback explicitly calls for "active feedback (voice, dashboard warning and seat/steering wheel vibration)." This multi-layered approach is crucial to combat automation complacency and ensure the alert is perceived even if the user is not looking directly at the dashboard.
- **Design Implications:** The alert system cannot rely on a single modality. It must integrate visual (flashing lights on the dashboard/HUD), auditory (distinct, escalating sounds), and haptic (steering wheel or seat vibration) cues simultaneously to guarantee recognition.

3. Need for Automated Emergency Communication

- **Description:** Users need assurance that their emergency contacts will be notified automatically and immediately in the event of a serious accident, without relying on their own physical or mental ability to act.

- **Justification:** This need was explicitly stated in the conclusion: "users want the AV to immediately contact their emergency contact in emergencies." In a high-stress or post-crash scenario, the user may be incapacitated or disoriented. Automating this process provides significant peace of mind and addresses a critical safety concern beyond the immediate driving task.
- **Design Implications:** The vehicle system must have a feature to detect a severe collision or emergency state and automatically send a pre-configured alert (with location and incident details) to designated emergency contacts via a connected network.

4. Need for Transparent System Intent and Status

- **Description:** Users need to understand the current status, perceptions, and intentions of the autonomous driving system to build appropriate trust and maintain situational awareness.
- **Justification:** The conclusion states that "users want to know and understand what the AV is doing" and want "insight and explanations on AV decisions." The task analysis shows the user is stuck in a passive "monitoring" role with limited information. Without this transparency, trust erodes, as seen in user concerns about the AV's ability to handle "new construction sites" or "lesser known animals."
- **Design Implications:** The interface must move beyond simple alerts. It should provide a real-time visualization of what the car "sees" (e.g., highlighted pedestrians, vehicles) and clearly communicate its planned action (e.g., "Stopping for obstacle," "Changing lanes to the left in 3 seconds").

5. Need for Confident and Accurate Hazard Detection

- **Description:** Users need to feel confident that the autonomous system can accurately, reliably, and consistently identify potential hazards on the road.
- **Justification:** This is the foundational need upon which all else is built. User concerns about the AV's ability to react to "unexpected situations" and its inability to "provide cues to other drivers" indicate a core lack of trust in the system's core perceptual capabilities. Until users believe the car can see and identify hazards as well as or better than a human, they will not feel safe.
- **Design Implications:** The vehicle's sensing and AI systems must be robust. From an interface perspective, the design can foster this confidence by providing clear feedback when it detects and classifies objects correctly, thereby demonstrating its competence and building user trust over time.

2.4 Needfinding Conclusions and Design Implications

This comprehensive needfinding process, integrating surveys, document mining, and task analysis, has yielded critical insights into user requirements for autonomous vehicle handover scenarios. The data reveals a user base with significant interest in AV technology but tempered by substantial trust issues, primarily stemming from a lack of transparency and control. Key results confirm that users demand a reliable, multi-sensory alert system (voice, visual, haptic) to capture their attention, an immediate and intuitive manual override to reclaim control, and automated emergency communication for post-incident safety. Furthermore, building long-term trust is contingent on the system's ability to demonstrate its hazard detection capabilities and clearly communicate its real-time status and intentions. These findings provide a robust, evidence-based foundation for designing an HMI that directly addresses the critical human factors of safety, trust, and control in Level 3 autonomous vehicles.

3. Storyboards & Prototypes

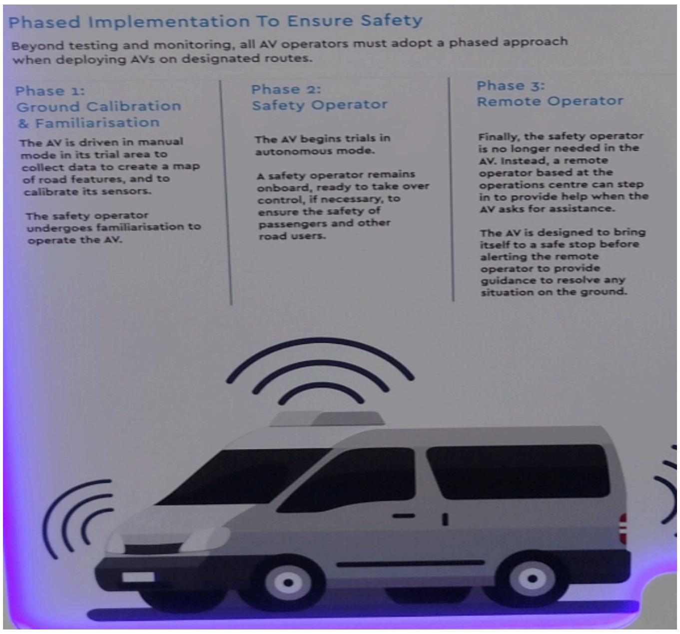
From Concepts to Interactive Prototypes

3.1 Design Process

Our team conducted the “**crazy 8**” brainstorming method to rapidly generate a wide range of design concepts focused on multisensor alerts and handover procedures.

1. Phase Implementation to ensure safety picture

The picture shows a phased safety model with multi-stage. Firstly, the system calibrates, the car will highlight areas of uncertainty using sensors for the driver to monitor manually. Secondly, there is a copilot mode where the driver is asked to confirm decisions or keep hands near the wheel. Lastly, there is a direct handover mode where the driver takes control, with a safe stop protocol as last resort if the driver doesn’t respond.

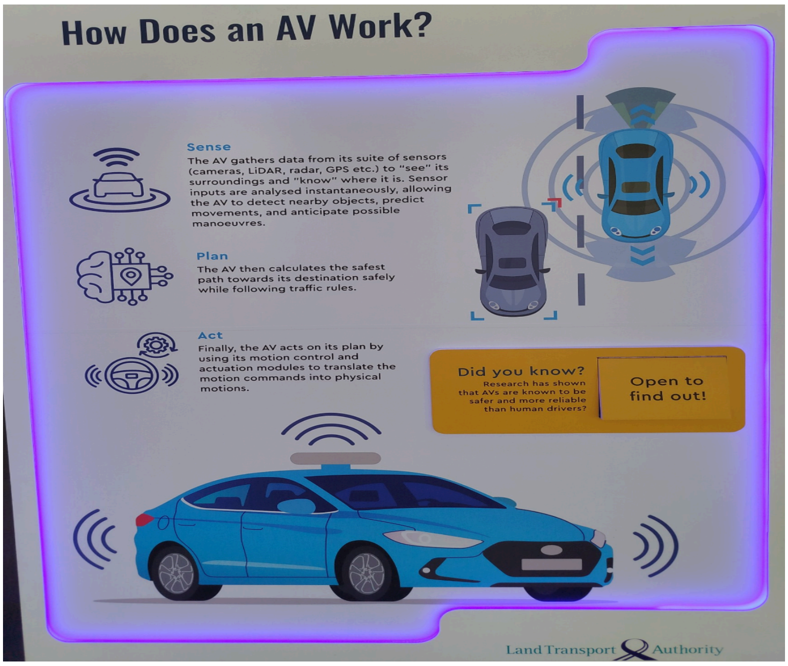


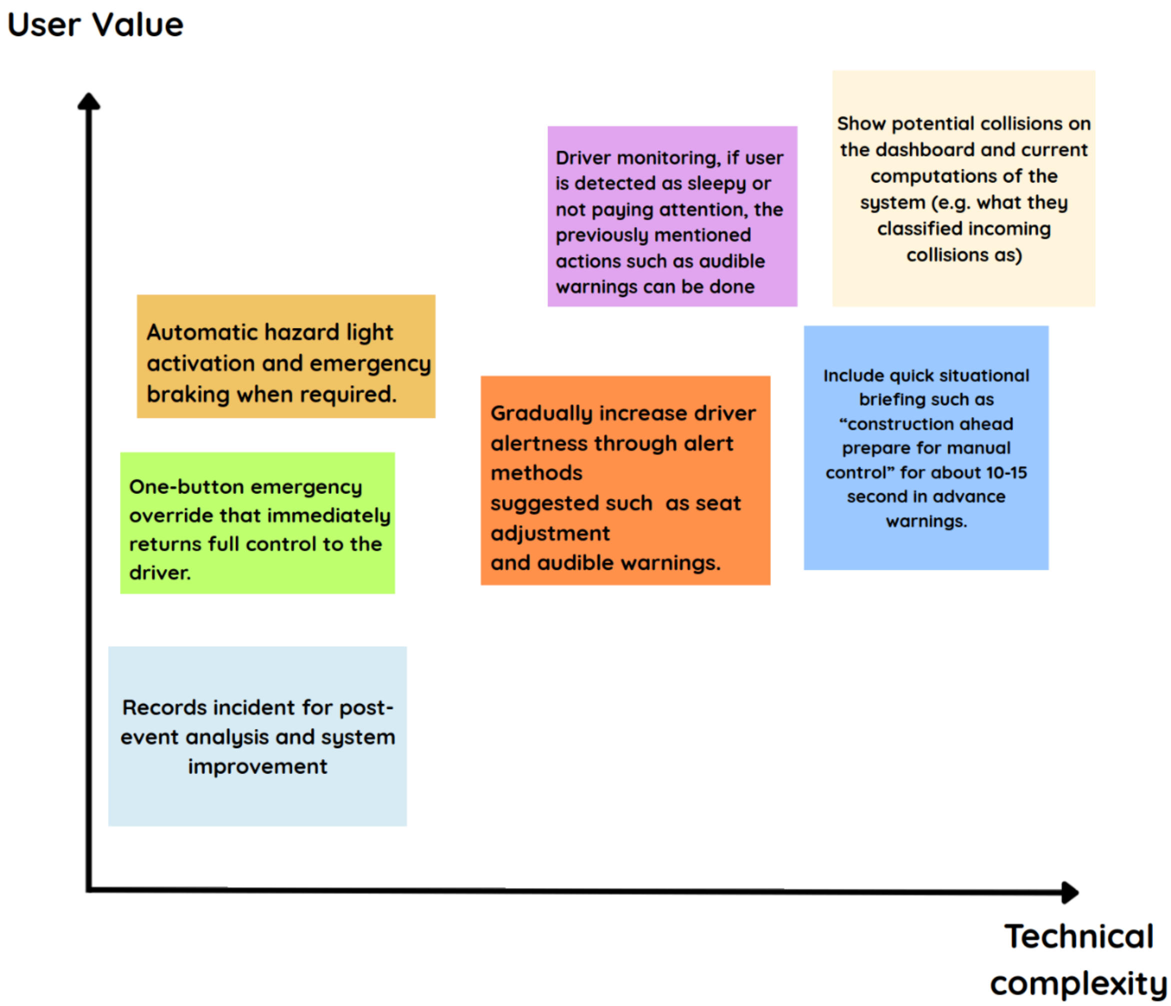
2. AV sensor system graphic

The picture shows a detailed role of each sensor. An alert system that shows which sensor(whether the camera or LiDAR) is compromised and why, and explanation on handing over

3. How does AV work picture on Sense, Plan, Act

The picture help us to design alert that corresponds to any AV decision making



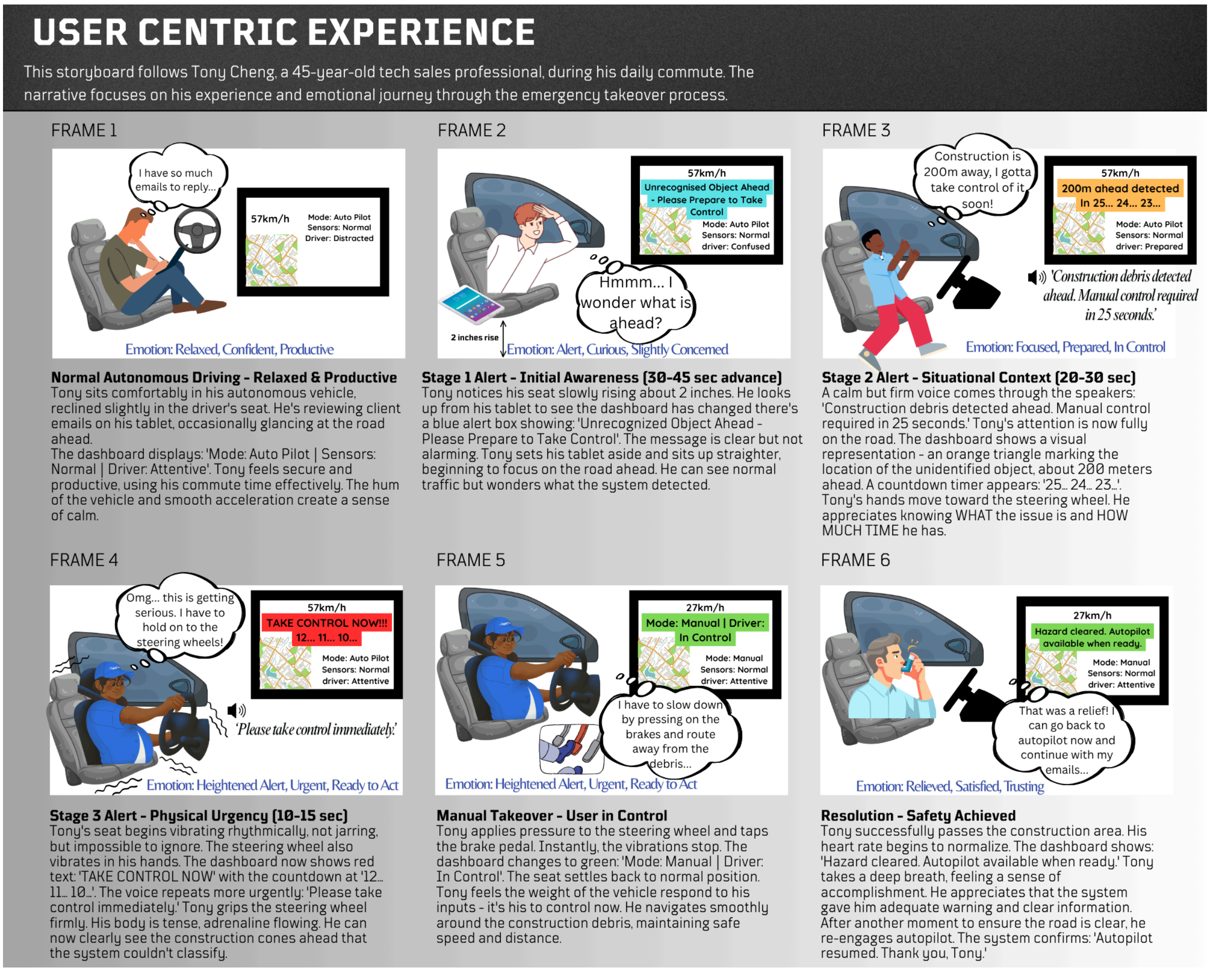


Autonomous Vehicle Safety System: Proposed Features

Name	Description	Matches User Need
Automatic Hazard Response	The vehicle automatically activates hazard lights and initiates emergency braking when an imminent collision is detected.	Need **5**: Confident and Accurate Hazard Detection
One-Button Emergency Override	A single, prominent button allows the driver to instantly bypass all autonomous functions and reclaim full manual control.	Need **1**: Immediate and Intuitive Manual Override
Incident Data Recording	Continuously logs sensor data, vehicle responses, and driver actions during incidents for post-event analysis and system improvement.	Need **5:** Confident and Accurate Hazard Detection
Driver Monitoring	Uses interior sensors to detect driver	Need **2:** Unambiguous,

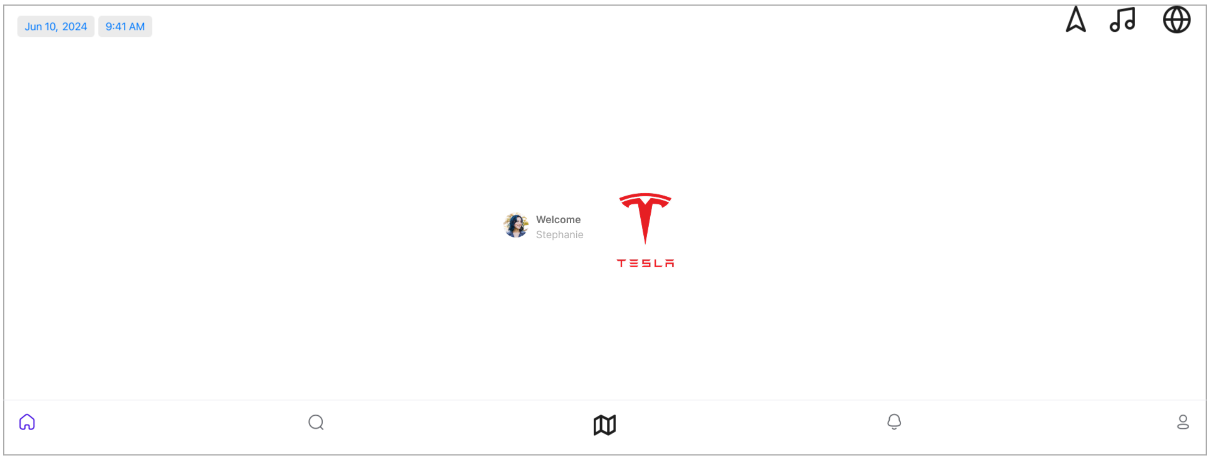
System	drowsiness or inattention and triggers appropriate warnings (e.g., audible alerts) to re-engage them.	Multi-Sensory Alerts
Gradual alert Escalation	Increases driver alertness through a tiered system of warnings, starting with subtle seat adjustments and escalating to more pronounced cues.	Need **2:** Unambiguous, Multi-Sensory Alerts
Visual Situation Display	Shows potential collisions on the dashboard and the system's real-time computations, such as how it has classified detected objects.	Need **4:** Transparent System Intent and Status
Advanced Situational briefing	Provides early (10-15 second) verbal warnings for upcoming events (e.g., "construction ahead") to prepare the driver for a smooth handover.	Need **4:** Transparent System Intent and Status Need **2:** Unambiguous Alerts

3.2 Storyboards



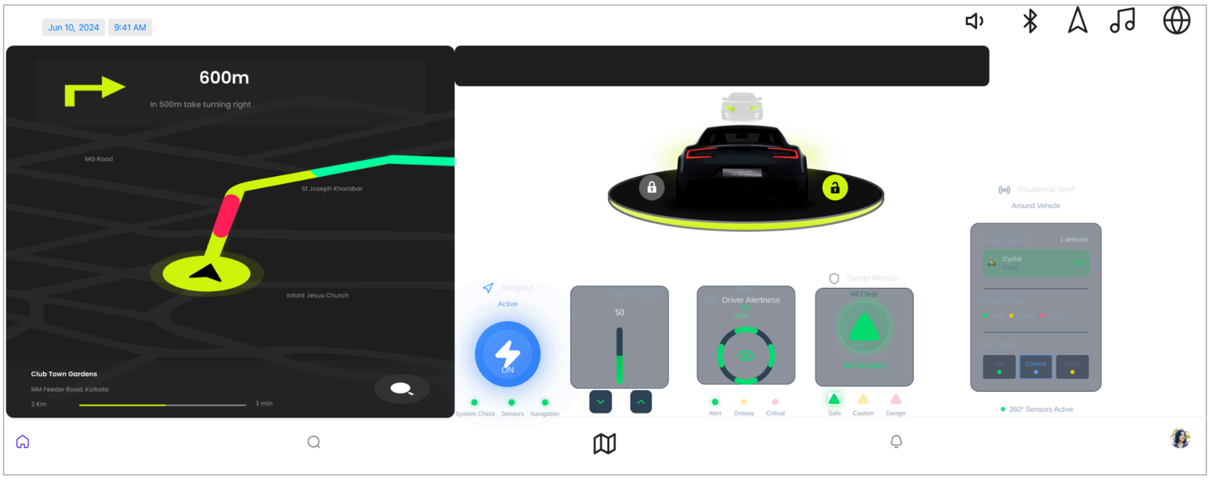
3.3 Low-fidelity Prototype

Screen 1: Welcome Screen



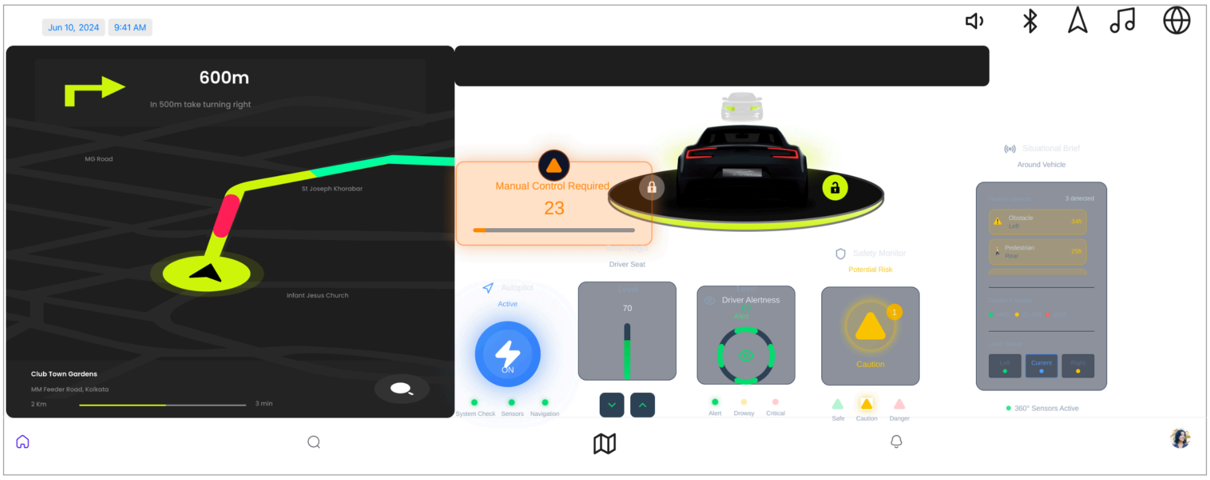
- **Caption:** This is the initial loading or welcome screen displayed when the system starts up. It personalizes the experience by greeting the driver ("Stephanie") and reinforces the brand (Tesla).

Screen 2: Autopilot Active (All Clear)



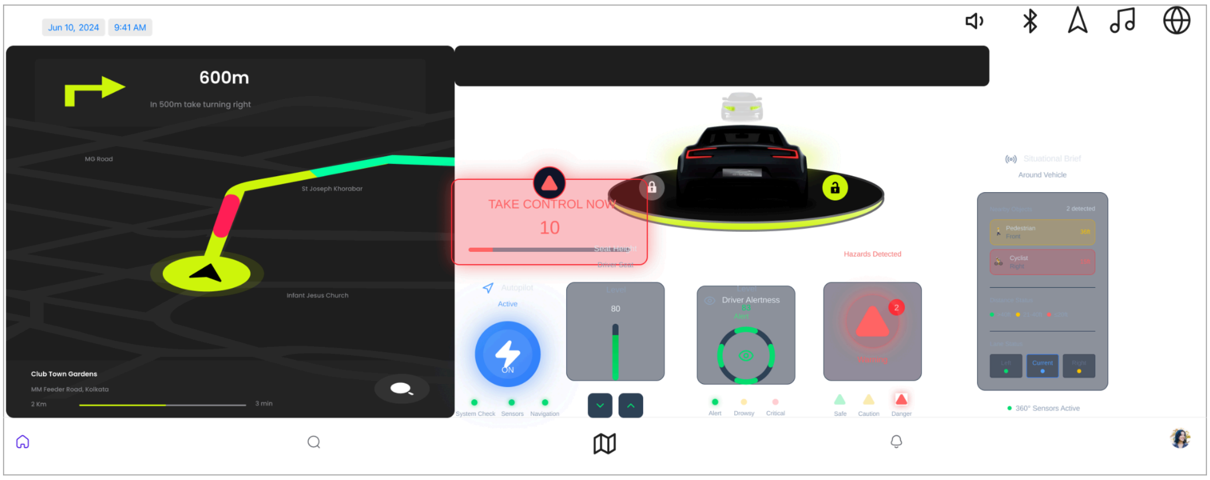
- **Caption:** This screen represents the default state during an active Autopilot session. The system is in control, all monitors show a safe status ("All Clear," "No Hazards"), and the map provides navigation.

Screen 3: Autopilot Warning (Manual Control Required)



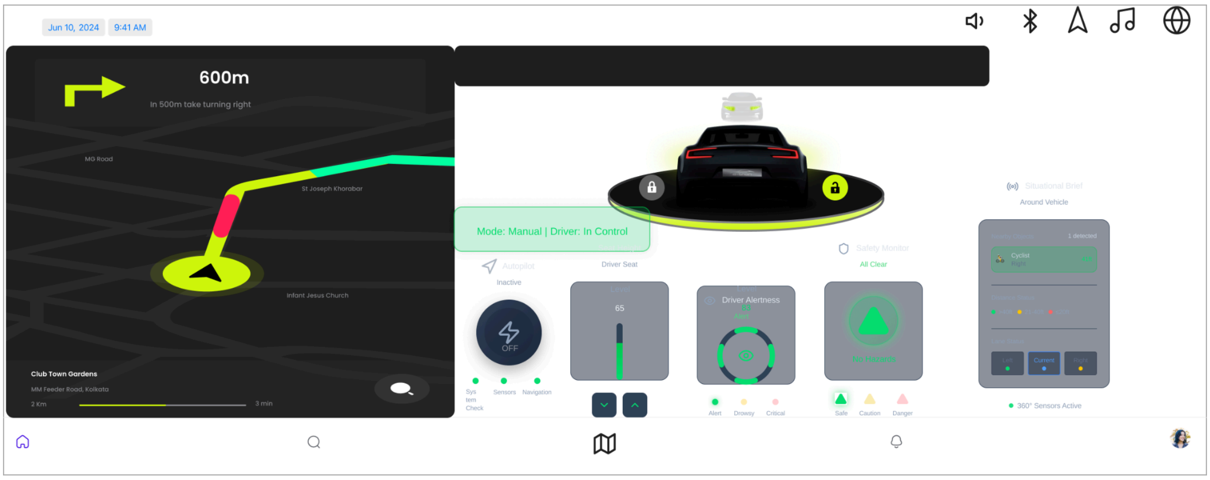
- **Caption:** This screen shows a non-critical alert. The system has detected a situation that may soon require driver intervention. It provides a countdown timer (23 seconds) for the driver to prepare to take over.

Screen 4: Autopilot Critical Alert (Take Control Now)



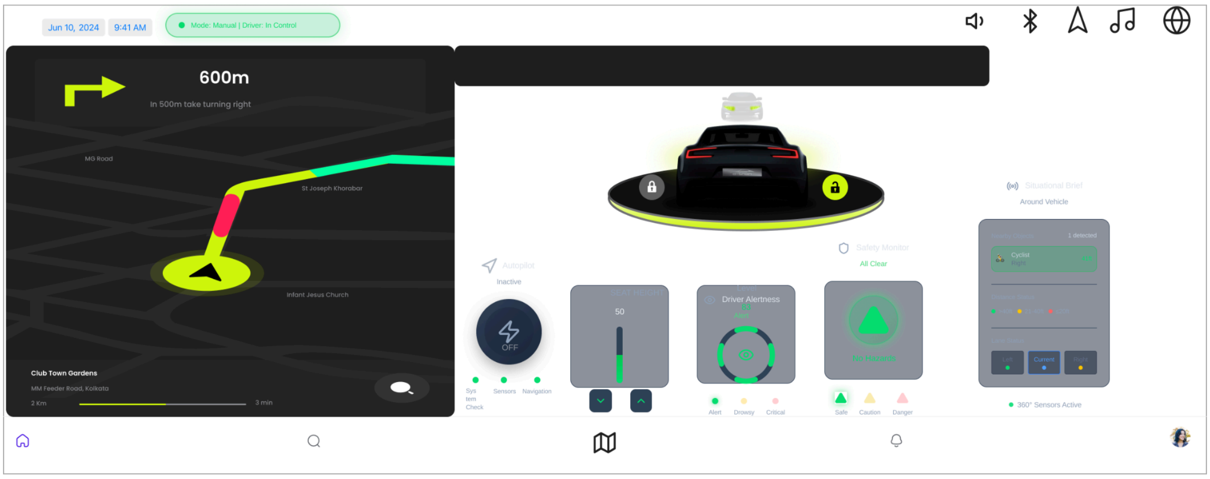
- **Caption:** This is a critical, high-priority alert. A hazard has been detected, and the system is urgently demanding the driver take immediate manual control. The alert is prominent and uses a red color scheme to signify danger.

Screen 5: Manual Mode (Driver in Control)



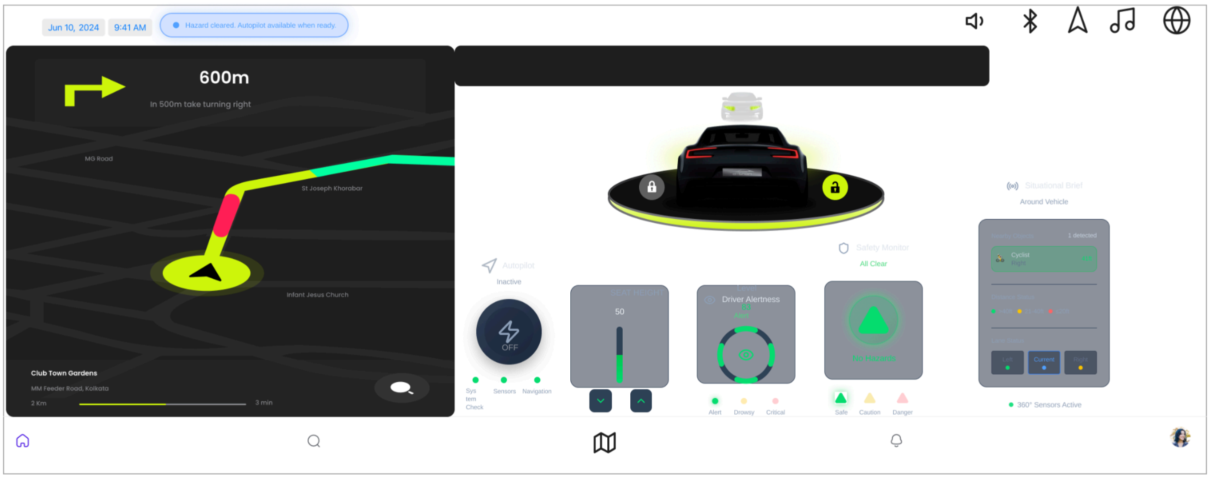
- **Caption:** This screen confirms that the driver has successfully taken control of the vehicle. Autopilot is now "Inactive," and a clear status message "Mode: Manual | Driver: In Control" is displayed.

Screen 6: Manual Mode (Hazard Detected)



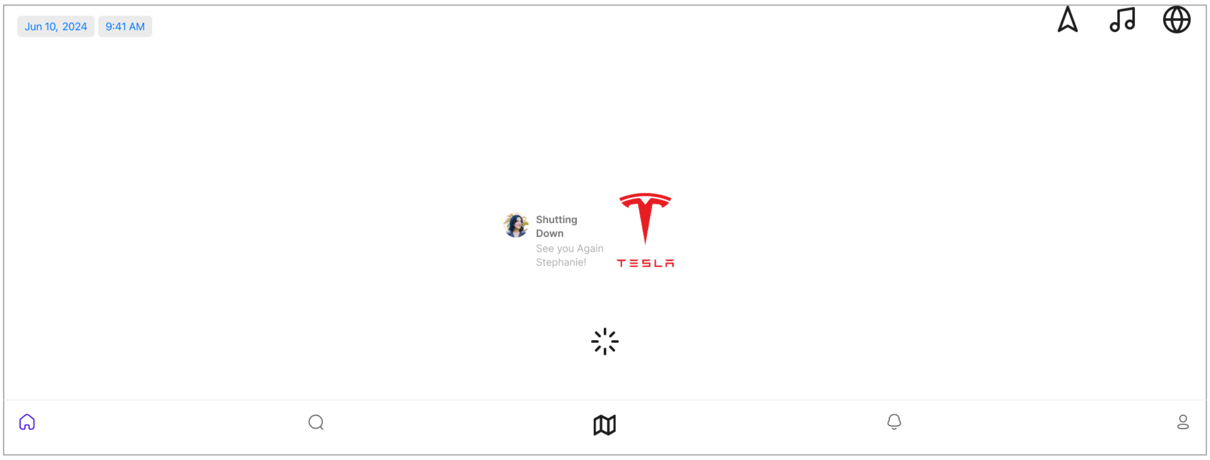
- **Caption:** This screen shows the system operating in manual mode while continuing to provide situational awareness. It has identified a specific nearby object ("Cyclist" on the right) and is notifying the driver.

Screen 7: Hazard Cleared (Autopilot Ready)



- **Caption:** This screen is shown after a hazard has passed. It informs the driver that the situation is now safe and that Autopilot is available to be re-engaged whenever the driver is ready.

Screen 8: Shutdown Screen



- **Caption:** This is the final screen displayed when the system is shutting down. Like the welcome screen, it offers a personalized farewell message.

3.4 UI Screen Flow and Design Concepts

3.4.1. UI Screen Flow

The prototypes illustrate a complete user journey for engaging with and disengaging from the vehicle's Autopilot system in response to road conditions.

1. **Startup:** The user journey begins with the **Welcome Screen (1)**, which boots up and personalizes the interface.
2. **Normal Operation:** The driver engages Autopilot, leading to the **Autopilot Active (2)** screen. This is the ideal state where the car is driving itself under safe conditions.
3. **Warning State:** If the system anticipates a complex situation, it transitions to the **Manual Control Required (3)**screen, giving the driver a countdown to prepare.
4. **Critical Alert:** If a sudden hazard appears, the system escalates to the **Take Control Now (4)** screen, demanding immediate user action.
5. **Driver Takeover:** In response to the alert, the driver takes the wheel, and the system confirms this by switching to the **Manual Mode (5)** screen. While in manual mode, the system continues to scan and display potential hazards, such as a cyclist in **Screen 6**.
6. **Return to Normal:** Once the hazard is no longer a threat, the system displays the **Hazard Cleared (7)** screen, inviting the driver to re-engage Autopilot at their convenience.
7. **Shutdown:** Finally, when the trip is over, the system displays the personalized **Shutdown Screen (8)**.

3.4.2. Design Concepts Used

- **Modular Layout:** The interface uses a clear, three-column modular layout.
  - **Left Module:** Dedicated to navigation and trip details.
  - **Center Module:** Focuses on the primary vehicle status and core driving controls (Autopilot, seat, driver alertness).
  - **Right Module:** Serves as a "Situational Brief," providing real-time data from the car's sensors about surrounding objects and lane status.
- **Visual Hierarchy:** The design effectively directs the user's attention. Critical alerts (Screens 3 and 4) use large, centrally-located modal windows that overlay other information, ensuring they are not missed. The most important control, the Autopilot button, is large and centrally located in its module.
- **Color-Coding for Status:** The design uses an intuitive color scheme based on the universal traffic light metaphor:
  - **Green/Blue:** Indicates a safe, active, or "all clear" status.
  - **Yellow/Orange:** Serves as a caution or warning.
  - **Red:** Signifies danger, a critical alert, or an error state.

3.5. Analysis based on HCI Principles and Conceptual Models

The design demonstrates a strong application of fundamental Human-Computer Interaction (HCI) principles.

3.5.1. Merits of the Design

- **Visibility of System Status:** This is a core strength of the UI. The system constantly communicates what it's doing. Whether Autopilot is "Active" or "Inactive," whether hazards are detected or the scene is "All Clear," the user is always informed. This builds trust and reduces uncertainty.
- **Feedback:** The system provides immediate and clear feedback for every state change. When a hazard is detected, an alert appears instantly. When the driver takes control, the UI confirms "Mode: Manual." This responsiveness is crucial for a time-sensitive task like driving.
- **Mapping:** The design features excellent mapping between the interface and the real world.
    - The central car graphic is a direct representation of the user's vehicle.
    - The "Situational Brief" on the right maps sensor data to a simple, understandable list of detected objects (e.g., "Cyclist," "Pedestrian").
    - The color-coding maps directly to the user's mental model of urgency and safety.
- **Metaphors:** The design leverages powerful metaphors to make complex information easy to grasp.
    - **Digital Avatar:** The car graphic acts as a digital twin, showing its lock status and serving as the focal point for system status. The glowing ring around it acts as a metaphorical **"safety shield,"** changing color to reflect the current risk level.
    - **Dashboard/Cockpit:** The overall layout mimics a traditional dashboard, placing critical information within the driver's natural field of view.
- **Affordances and Constraints:**
    - **Affordance:** The large "ON/OFF" button for Autopilot clearly *affords* being tapped to change the state. The up/down arrows for the seat heater clearly afford adjustment.
    - **Constraints:** The system smartly constrains the user's actions for safety. For example, the message "Autopilot available *when ready*" on Screen 7 implies that the system will not allow Autopilot to be re-engaged until all safety parameters are met, thus preventing user error.
- **Consistency:** The design is highly consistent. The layout of the three modules remains the same across all screens, which reduces the user's cognitive load. They always know where to look for navigation, vehicle status, or sensor information, regardless of the driving mode.

4. Heuristic & Think Aloud Evaluation

Usability Testing and Design Refinement

Video Link to Think-Aloud-Protocol

4.1 Heuristic Evaluation Results

To empirically validate the effectiveness of our multi-modal emergency handover system, we will employ a **Think-Aloud Protocol (TAP)** using a simulated environment with a collaborating team. This process is designed to capture not only the quantitative aspects of the driver's response (e.g., Takeover Time) but also the qualitative user experience (cognitive load, confusion, trust) as the emergency alert escalates.

The evaluation requires collaboration with another team, the participant team (Team 39). Our team (Team 41) will staff the functional roles necessary for running the simulation, while the participant from the collaborating team will act as the driver.

Team 41 Role	**Responsibility**
Facilitator	Read the Introduction Script and Task Instructions. Manages the session flow, ensures the participant is continuously verbalizing their thoughts, and prompts them gently when they fall silent.
Simulator Operator	Executes the multi-modal system response in real time. This includes manually triggering the physical feedback (lifting/shaking the chair), changing the paper prototype dashboard overlays, and playing the specific audio files for each stage.
Observer/Note-taker	Focuses solely on recording the participant's verbal comments, physical actions, and emotional reactions against the structured checklist, paying close attention to the time it takes for the participant to notice and respond to each cue.
Participant	**(From team 39)** Performs the simulated driving tasks while continuously verbalising all thoughts, feelings, and decision-making processes.

4.2. Think-Aloud Analysis

The evaluation is structured into a warm-up scenario followed by four distinct, escalating stages of the emergency takeover.

A. Scenario Setup (Automation Complacency Induction): The facilitator first establishes the context, asking the participant to imagine being relaxed and engaged in a non-driving related task (reading emails). This is a crucial step to induce a state of automation complacency, directly addressing the project's design theme of driver distraction.

B. Stage 1: Initial Alert (30-45 second window): The simulation begins with the lowest-salience alert: a slow, subtle physical cue (chair lift/shake) combined with a dashboard message. The primary goal is to measure how long the participant takes to notice this mild haptic stimulus and shift their attention from the tablet to the HMI.

C. Stage 2: Contextual Information (20-30 second window): Upon initial driver re-engagement, the system escalates by providing critical contextual information through audio (hazard description, e.g., 'Construction debris') and visual cues (countdown timer). The focus shifts to measuring the participant's cognitive preparation, specifically tracking if they understand the hazard and move their hands toward the steering wheel.

D. Stage 3: Urgent Physical Warning (10-15 second window): To break deep distraction, this stage employs the highest-salience, rhythmic, multi-modal feedback (continuous chair and steering wheel vibration, urgent audio, and a flashing red 'TAKE CONTROL NOW' message). The objective here is to evaluate if the combined intensity is sufficient to provoke immediate action without causing excessive panic or stress.

E. Stage 4: Take Manual Control & Confirmation: The operator immediately ceases all alerts and feedback once the participant takes the steering wheel or performs a simulated brake action. The focus is on the intuitiveness of the takeover action and the clarity of the system confirmation (green dashboard display).

4.3. Post-Task Analysis

After the simulation, the facilitator conducts a structured debriefing using the Post-Task Discussion Questions. These questions are essential for gathering subjective, qualitative data on the participant’s perceived trust, confusion, effectiveness of specific alerts, and overall satisfaction. The Observer’s notes and the video recording will be cross-referenced with this qualitative feedback to identify key usability issues and inform the final design refinement.

4.4. Issues Identified in the Think-Aloud Process

4.4.1 Cognitive Awareness Without Physical Action

Severity: 4

The transition to the visual/auditory countdown (Stage 2: 45-15 seconds remaining) successfully grabs the driver's cognitive attention but **fails to prompt physical readiness.**

- **Failure Point: No Call to Physical Action.** Participants verbalized the countdown and understood the timeline, but in every single case, they **k**ept their hands in their lap or on the distraction device until the countdown reached the final, critical stage. Cognitive recognition does not translate to the necessary motor action.
- **Result:** The driver remains physically unready to take control for over 75% of the total available handover time.

4.4.2 High Post-Takeover Complacency (Violation: Flexibility and Efficiency of Use)

Severity: 3

The emergency event did not deter the user from immediate reversion to the distracted state.

- **Observation:** After successfully clearing the hazard and seeing the "Autopilot available when ready" message, the user immediately verbalized their intention to "go back to the email".
- **Problem:** The system successfully handled the emergency but failed to enforce a period of post-takeover hyper-vigilance. Returning immediately to deep distraction after a near-miss maintains the high-risk L3 complacency loop.
- **Recommendation:** Implement a temporary system-imposed cool-down period. After the hazard is cleared, the system should prevent autopilot resumption for a set time (e.g., 60 seconds), showing a message like, "Manual Control Recommended for Next 60 Seconds: Re-establishing Situational Awareness." The car should only return to autopilot if the driver actively requests it *after* this timer expires.

4.4.3 Induced Panic in the Critical Window

Severity: 4

The final, abrupt escalation to the aggressive haptic and loud audio alerts (Stage 3: 15 seconds remaining) forces a panicked, high-stress response.

- **Failure Point: Abrupt Severity Mismatch.** The sudden, jarring nature of the final alert causes participants to **snatch or violently grip the wheel**, indicating a panic response rather than a controlled, measured one.
- **Result:** The takeover maneuver is initiated under extreme stress, jeopardizing the safety and stability of the vehicle control inputs.

4.5 Issues Identified in the Heuristic Evaluation

Based on the six heuristic evaluations, the system has several critical issues, primarily related to Visibility of System Status (H1) and User Control and Freedom (H3) during emergency handovers.

The core problem is that the critical alert is visually too small for a high-stress scenario, and the system traps the user in the alert sequence without a clear way to cancel it or acknowledge control.

Summary of Critical Issues (Severity 3-4)

Heuristic	Severity (Avg.)	Description of Major Issues	Evaluators Highlighting Issue
H1: Visibility of System Status	**4.0**	The critical warning message or pop-up is too small relative to the screen size, making the information difficult to process quickly during an emergency. The wordings are slightly small.	Darren Khong Wai Kidd, Nabil Bin Noor Azlan, He Yezi, [Anonymous]
H3: User Control and Freedom	**4.0**	The system lacks a clear "emergency exit," cancel function, or acknowledgment button to stop the escalating alerts or exit the screen, trapping the user.	Nabil Bin Noor Azlan, He Yezi, Voo Zong Yang, Lim Zong Wei Glenn
H7: Flexibility and Efficiency of Use	**3.0**	The handover process is **rigid and lacks flexibility/customization** for experienced users to expedite, shorten, or customize the alert intensity or sequence.	Darren Khong Wai Kidd, He Yezi, [Anonymous], Voo Zong Yang, Nabil Bin Noor Azlan
H5: Error Prevention	**3.0**	Poor error prevention, such as the inability to exit the alert screen once it's up, or allowing the driver to change settings while the car is moving.	Voo Zong Yang, Nabil Bin Noor Azlan, Lim Zong Wei Glenn
H9: Help Users Recover from Errors	**3.0**	The system fails to clearly communicate the reason for the takeover request or only shows a small icon without explaining the problem or what to do next.	Voo Zong Yang, Nabil Bin Noor Azlan, Lim Zong Wei Glenn

Consolidated Issues Table

Evaluator Name	Issue Description	Heuristic Violated	Severity (0-4)
Darren Khong Wai Kidd	Critical warning messages do not command enough screen real estate, which could lead to them being overlooked.	H1: Visibility of System Status	4
Nabil Bin Noor Azlan	The wordings on the alert are slightly small to discern what is written.	H1: Visibility of System Status	4
Beatrice Tan Jie Ting	The emergency alert pop-up is too small relative to the total screen size, making critical information difficult to process quickly.	H1: Visibility of System Status	4
Nabil Bin Noor Azlan	There is no back or similar functionality (emergency exit/cancel) in the dashboard when there is an emergency.	H3: User Control and Freedom	4
He Yezi	The user is trapped in an automated process with no "emergency exit." System lacks a cancel function or user-initiated way to dismiss the alert.	H3: User Control and Freedom	4
Darren Khong Wai Kidd	The handover process is one-size-fits-all, lacking customizable options for different user experience levels.	H7: Flexibility and Efficiency of Use	3

He Yezi	System provides no flexibility for user preference or control, and no shortcuts to expedite handling frequent events like obstacle alerts.	H7: Flexibility and Efficiency of Use	3
Beatrice Tan Jie Ting	The overall system lacks features (like shortcuts or user preferences) to allow experienced users to accelerate or dismiss non-critical alerts.	H7: Flexibility and Efficiency of Use	3
Voo Zong Yang	No immediate "I am in control" acknowledgment button to stop escalating alerts.	H3: User Control and Freedom	3
Voo Zong Yang	False positive handover triggers from unrecognized roadside objects may occur, distracting drivers unnecessarily.	H5: Error Prevention	3
Nabil Bin Noor Azlan	Cannot exit once alert message is up, so if the automated system has an error, the user cannot exit.	H5: Error Prevention	3
Lim Zong Wei Glenn	The system allows the driver to change settings while the car is moving, which can lead to driver distraction or input errors.	H5: Error Prevention	3
Voo Zong Yang	System does not clearly communicate the reason for takeover requests, leaving drivers uncertain.	H9: Help Users Recognize, Diagnose, and Recover from Errors	3

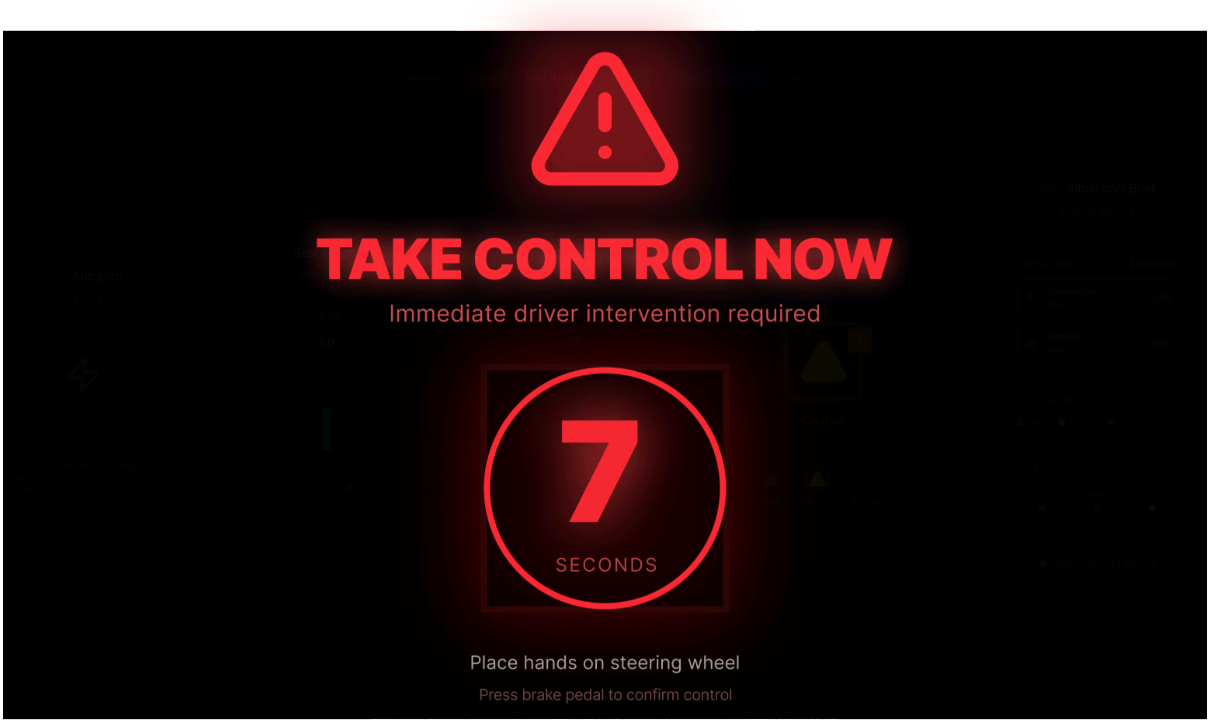
Nabil Bin Noor Azlan	Since there is no exit from the automated alerts, the system cannot recover/diagnose errors.	H9: Help Users Recognize, Diagnose, and Recover from Errors	3
Lim Zong Wei Glenn	When an error occurs, the system only shows a small icon without explaining the problem or what to do.	H9: Help Users Recognize, Diagnose, and Recover from Errors	3
Lim Zong Wei Glenn	Users have limited control and can't easily undo mistakes.	H3: User Control and Freedom	3
Lim Zong Wei Glenn	Some icons look similar (e.g., in the climate control section), making it unclear which function is active.	H4: Consistency and Standards	3
Voo Zong Yang	No interactive tutorial to familiarize users with the multi-sensor alerts.	H10: Help and Documentation	3
Beatrice Tan Jie Ting	The system offers no readily available on-demand documentation to explain the alert stages or the mechanics of the takeover.	H10: Help and Documentation	3
He Yezi	The alert popup is too small relative to total screen size for easy reading.	H1: Visibility of System Status	3
Voo Zong Yang	Experienced drivers may prefer customizable alert intensity or shorter warning intervals.	H7: Flexibility and Efficiency of Use	2

Lim Zong Wei Glenn	Reasonably clear feedback but can be improved with more visual or text indicators.	H1: Visibility of System Status	2

4.5 Solutions to Address Issues Identified in Paper Prototype Evaluation

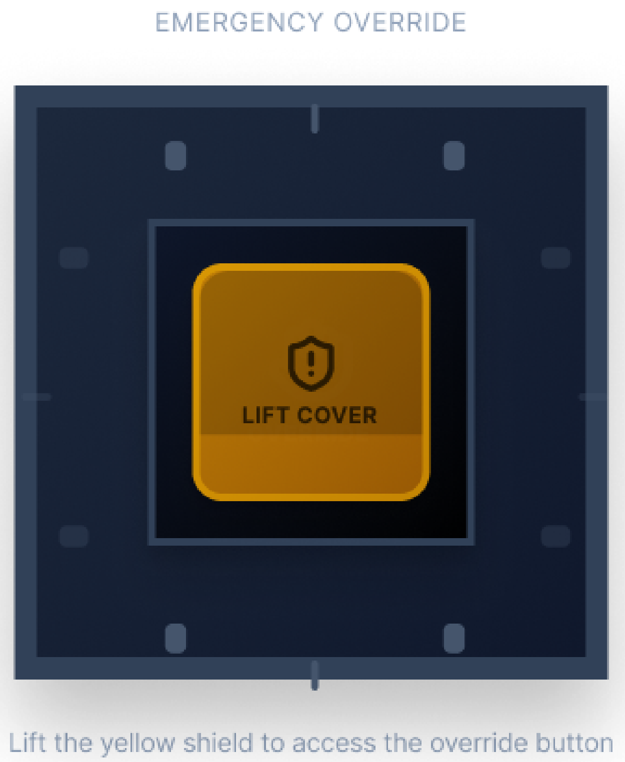
Based on the think-aloud protocols and heuristic evaluations, here are specific solutions to address the identified issues:

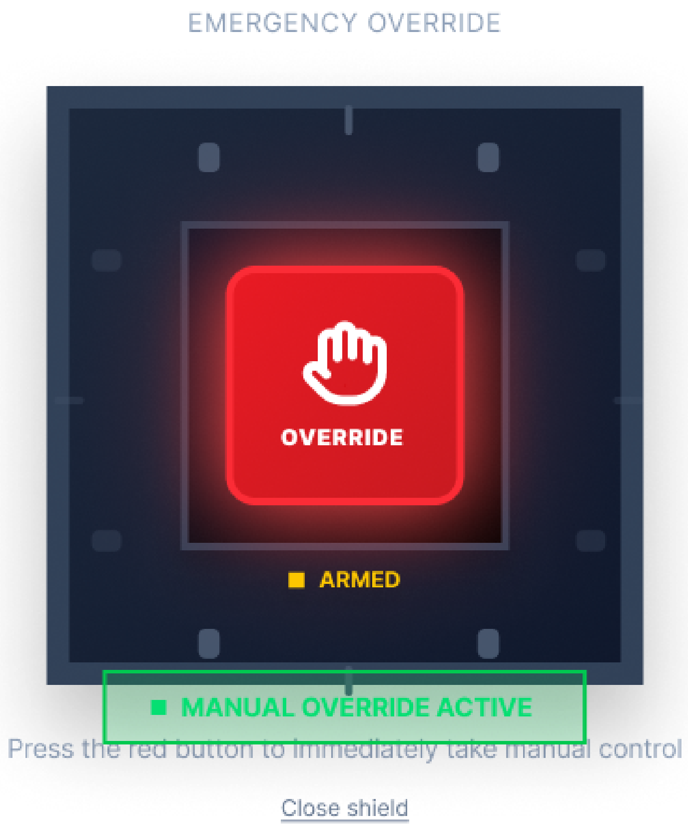
4.5.1. Issue: Critical Visibility Failure (Small Alert Size)



- **Solution:** Implement a full-screen or dominant overlay alert system. The warning should cover at least 50% of the main display, with high-contrast colors (red/black) and large, bold typography that can be read instantly from the driver's position. The countdown timer should be the most prominent visual element.

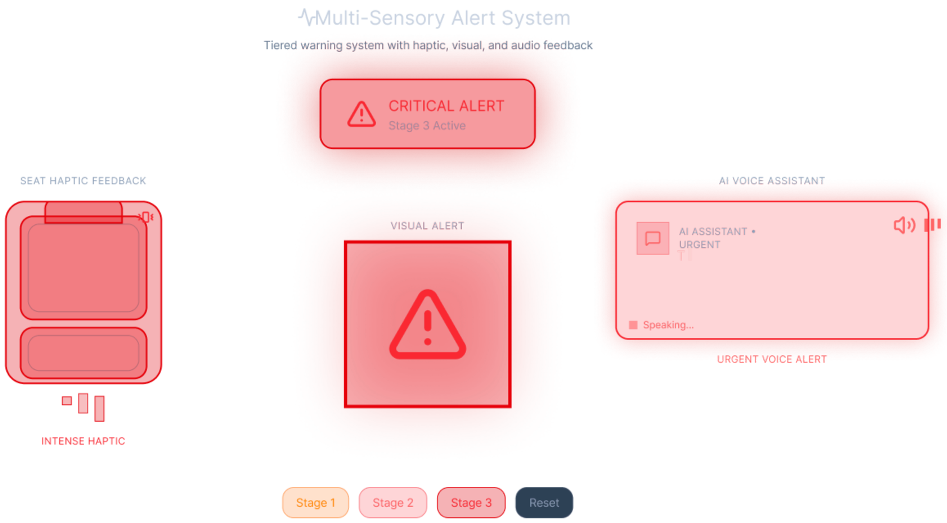
4.5.2. Issue: Lack of Immediate Manual Override





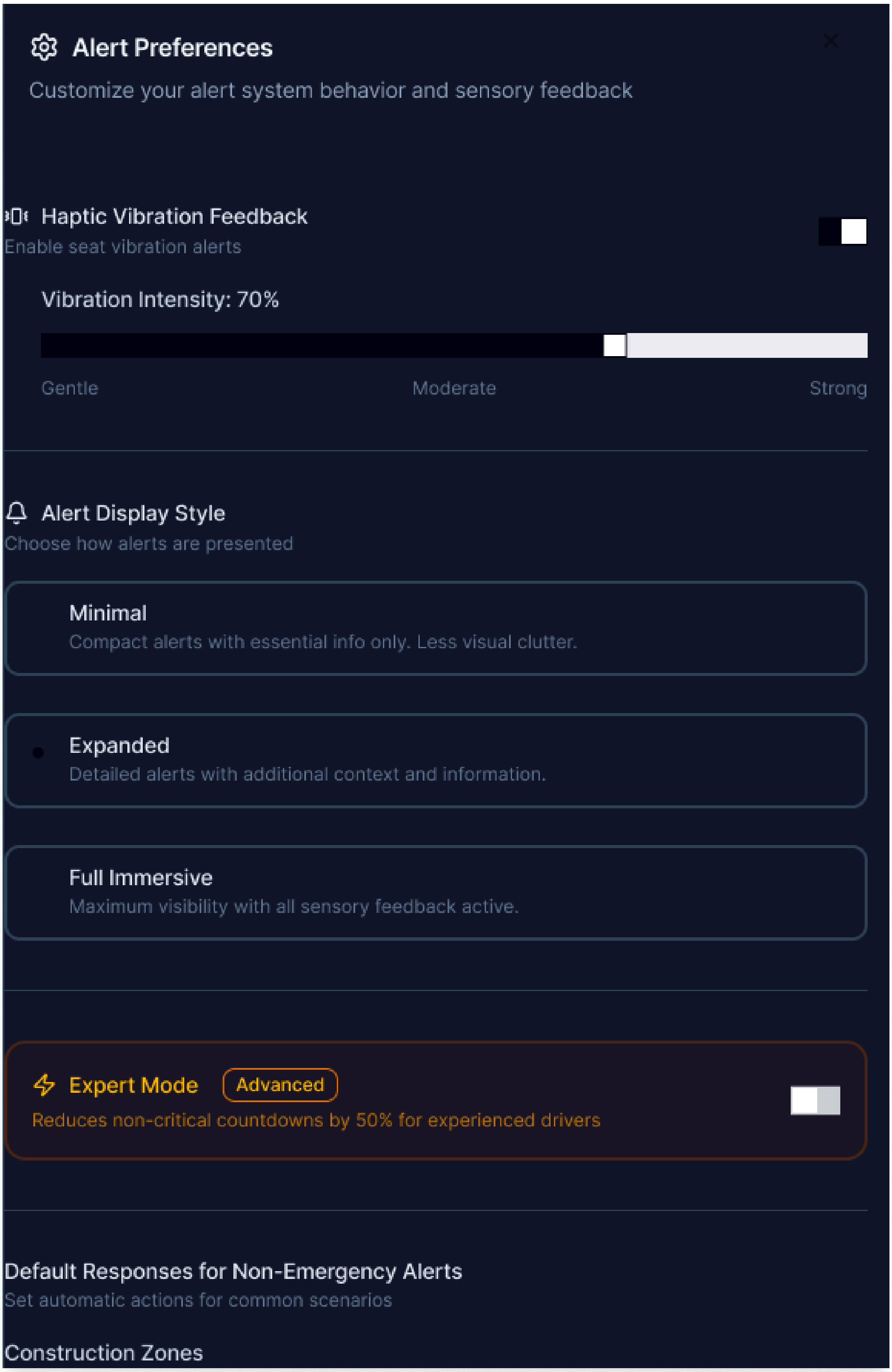
- **Solution:** Add a large, backlit physical "OVERRIDE" button on the steering wheel and a matching touch target on the main interface. When pressed, this immediately cancels all autonomous functions and returns full control to the driver, bypassing any countdown sequences. The button should be shielded to prevent accidental activation.

4.5.3. Issue: Insufficient Multi-Sensory Alert Integration



- **Solution:** Create a tiered alert system where:
  - **Stage 1:** Subtle seat vibration + orange visual warning
  - **Stage 2:** Stronger vibration + red visual + calm AI voice stating "Construction ahead, manual control required in 25 seconds"
  - **Stage 3:** Intensified vibration + flashing red visual + urgent AI voice repeating "Take control immediately!"

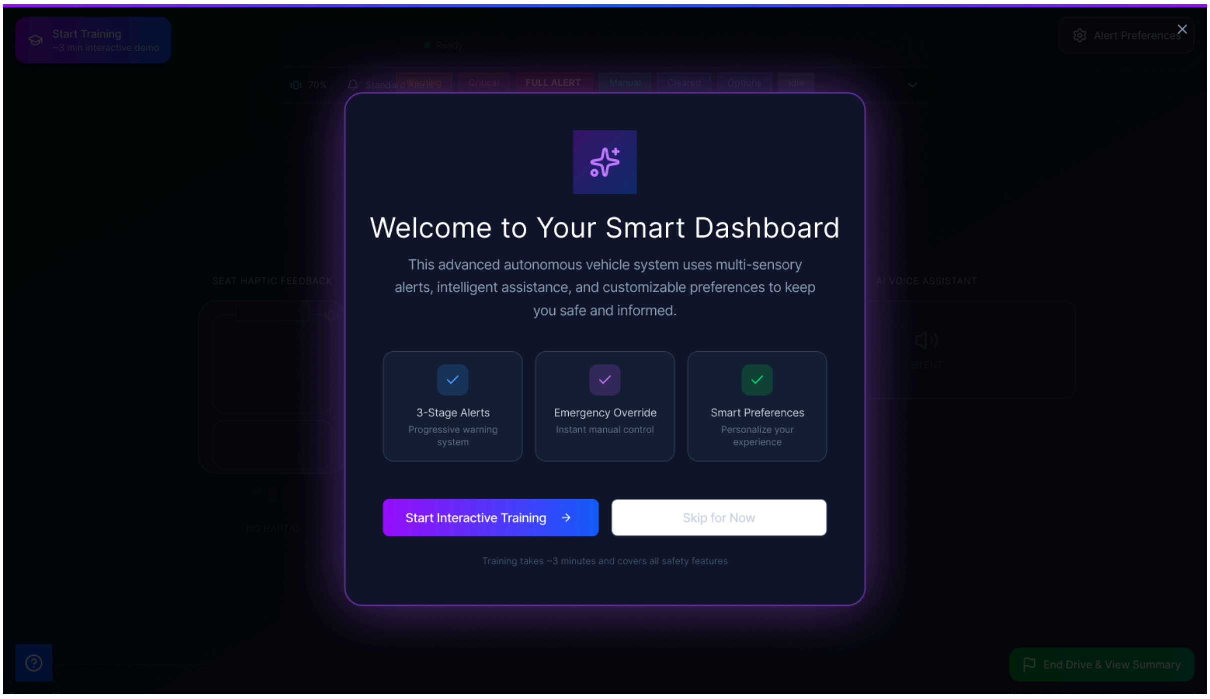
4.5.4. Issue: No Customization or Efficiency Feature



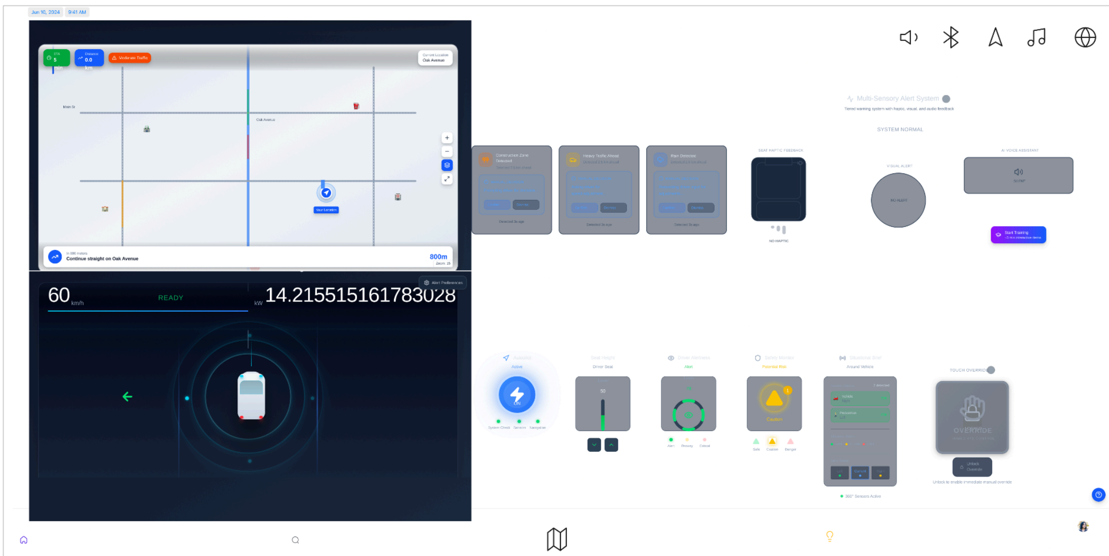
- **Solution:** Create a "Alert Preferences" menu allowing users to:
  - Adjust vibration intensity or disable it
  - Choose between different alert styles (minimal/expanded)

    - Set default responses for recurring non-emergency alerts
    - Enable an "expert mode" that shortens non-critical countdowns
    -

4.5.5. Issue: Lack of On-Demand Help and Training



- **Solution:**
    - Add a "What's This?" help feature accessible during any alert
    - Include a demo mode that walks new users through alert scenarios
    - Provide post-drive summaries explaining system actions and decisions



4.6 Summary of Evaluation

The evaluation combining Think-Aloud Protocols (TAP) and an Heuristic Evaluation, clearly highlighted a severe and consistent safety problem with our Level 3 emergency handover prototype. The main issue, rated at a Catastrophic Severity 5, is that the system doesn't force the driver to get ready early enough. While the informational countdown in Stage 2 successfully grabbed their attention (participants knew the hazard was coming), it completely failed to prompt the necessary physical readiness of putting hands on the steering wheel. Because of this, drivers remained deeply distracted until the final, jarring Stage 3 alert at 15 seconds. This abrupt escalation resulted in a panic response in every test, causing users to violently snatch the wheel, which is obviously a serious risk for vehicle stability.

Beyond the panic issue, the evaluation uncovered crucial usability flaws that need urgent fixing. The Heuristic Review showed that the critical alerts are visually too small to process quickly in an emergency, violating Visibility of System Status (H1). Furthermore, users felt trapped in the escalating alarm sequence because there wasn't a prominent physical or touch override button to stop the alerts and confirm they were taking control, which is a big breach of User Control and Freedom (H3). To close this dangerous complacency loop, we must introduce directional physical cues to get hands back on the wheel, add a clear manual OVERRIDE button, and, critically, implement a mandatory 60-second cool-down period after a manual takeover. These changes are essential to make the L3 handover process safe and usable, rather than just an automated trigger for panic.

5. Conclusion

This project set out to design a Human-Machine Interface (HMI) to address the critical safety challenge of the driver handover period in Level 3 autonomous vehicles, where automation complacency creates significant risk. Through a comprehensive process of needfinding, including surveys and document analysis, we identified key user requirements centered on trust, control, and clear, multi-sensory communication. These insights guided the development of a multi-stage paper prototype designed to manage a driver's transition from a passive state to active control.

The most critical phase of our project was the Heuristic and Think-Aloud evaluation. This user testing revealed a severe and fundamental flaw in our initial design concept. While our prototype successfully captured the driver's cognitive attention during the early warning stages, it critically failed to induce the necessary physical readiness—specifically, prompting the driver to place their hands on the steering wheel *before* the situation became urgent. This gap between awareness and action consistently led to a panic response and unsafe behavior during the final, high-intensity alert.

In response to these evidence-based findings, we have proposed a series of concrete design improvements. Key solutions include implementing a full-screen, high-visibility alert system to address the visibility flaw, incorporating a physical "OVERRIDE" button to give users an immediate sense of control, and refining the alert system to better manage the escalation of warnings.

In conclusion, our work demonstrates that designing for a safe AV handover is not merely about conveying information. The system must actively guide the driver back into the control loop, managing both their situational awareness and their physical preparedness. While our initial prototype failed in this regard, our rigorous evaluation process has successfully identified this critical distinction and has provided a clear, user-centered path forward to create an HMI that effectively bridges the human-factor gap in autonomous driving.

Appendix

Use the Appendix to add figures/tables which are not necessary to be included in the main report but will be useful for the reader to refer to.

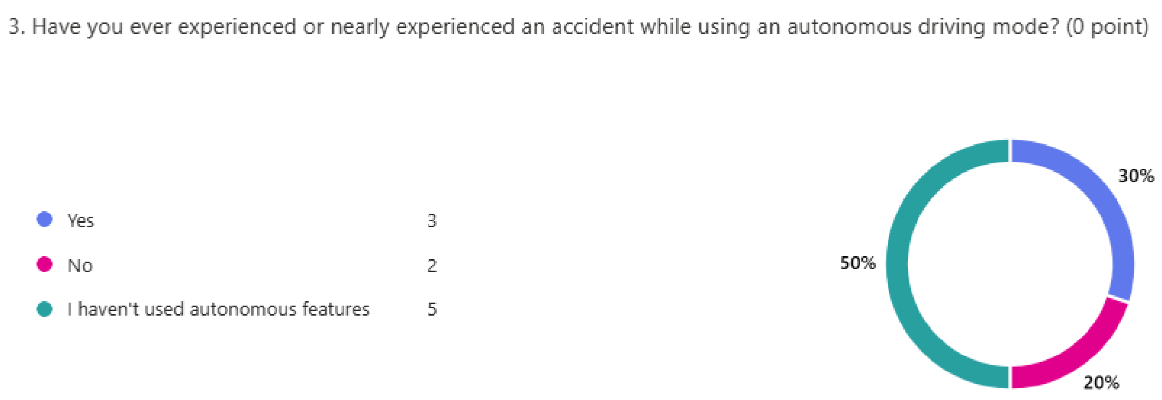


Figure 1.7

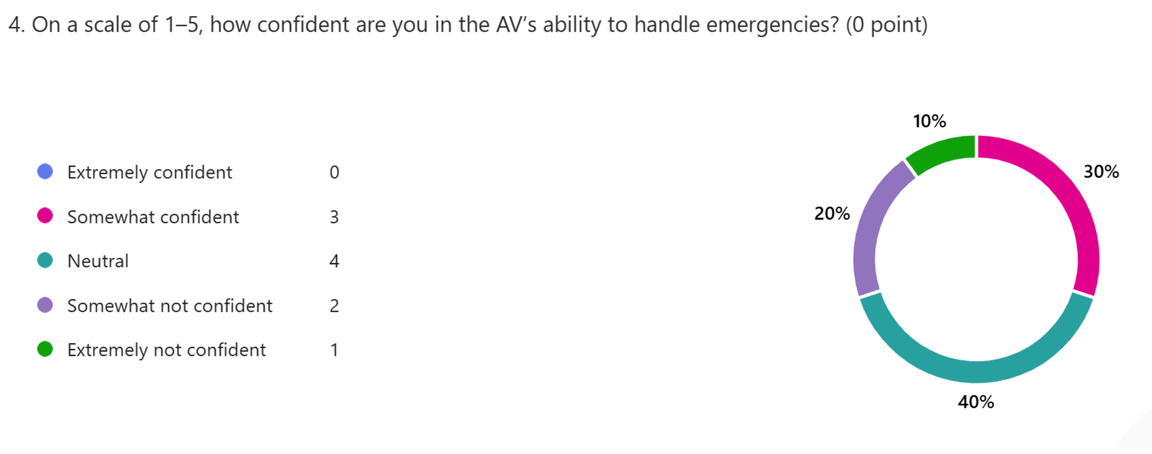


Figure 1.8

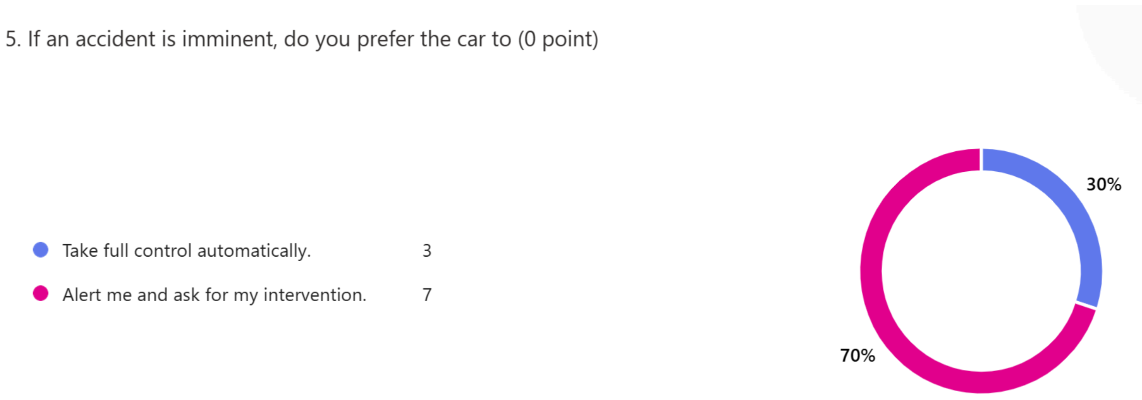


Figure 1.9

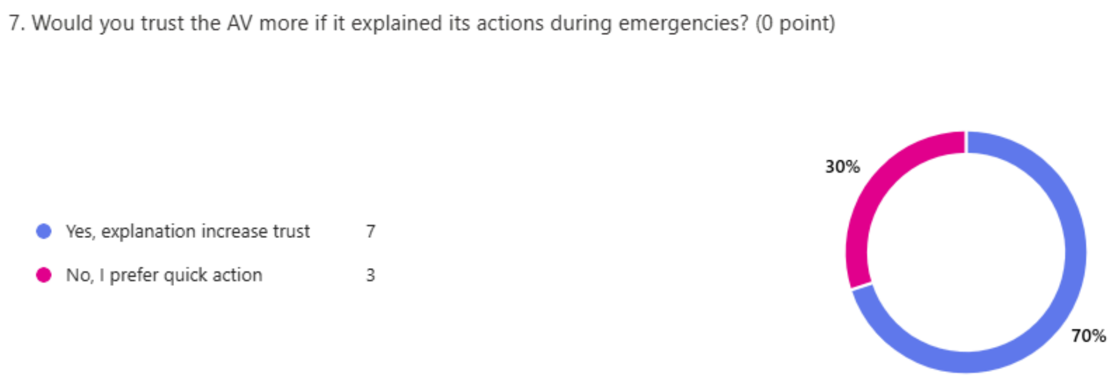


Figure 1.10

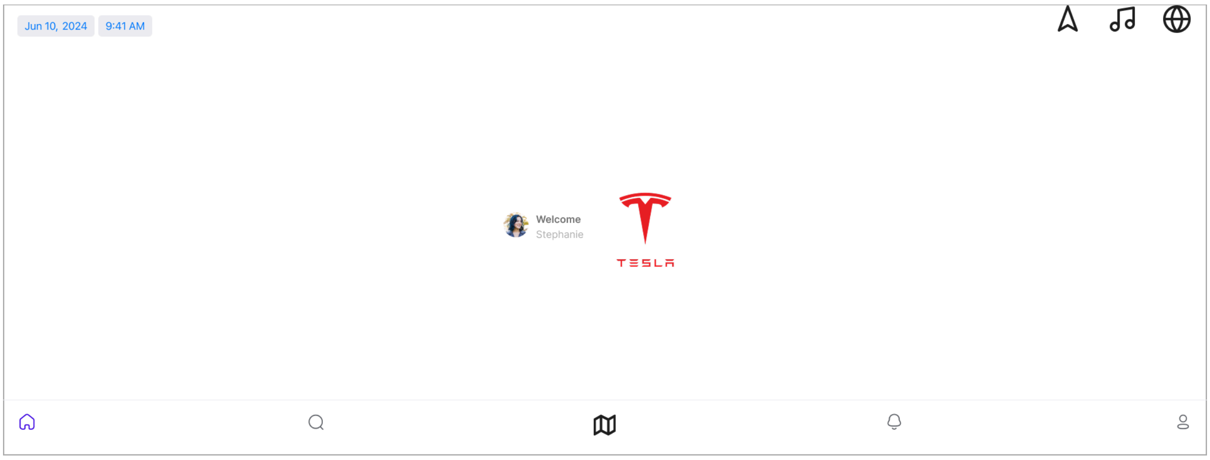


Figure 1.11

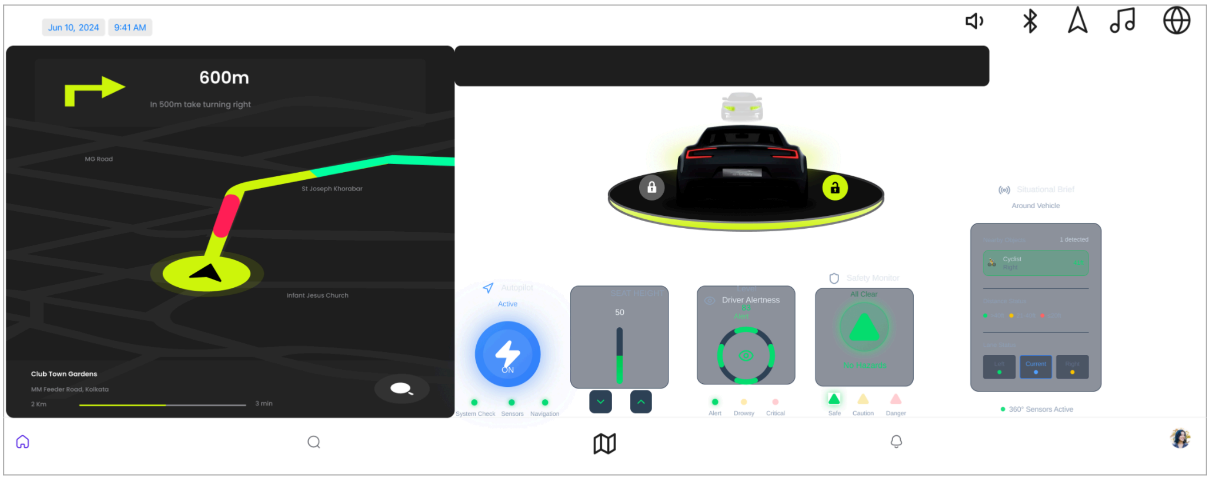


Figure 1.12

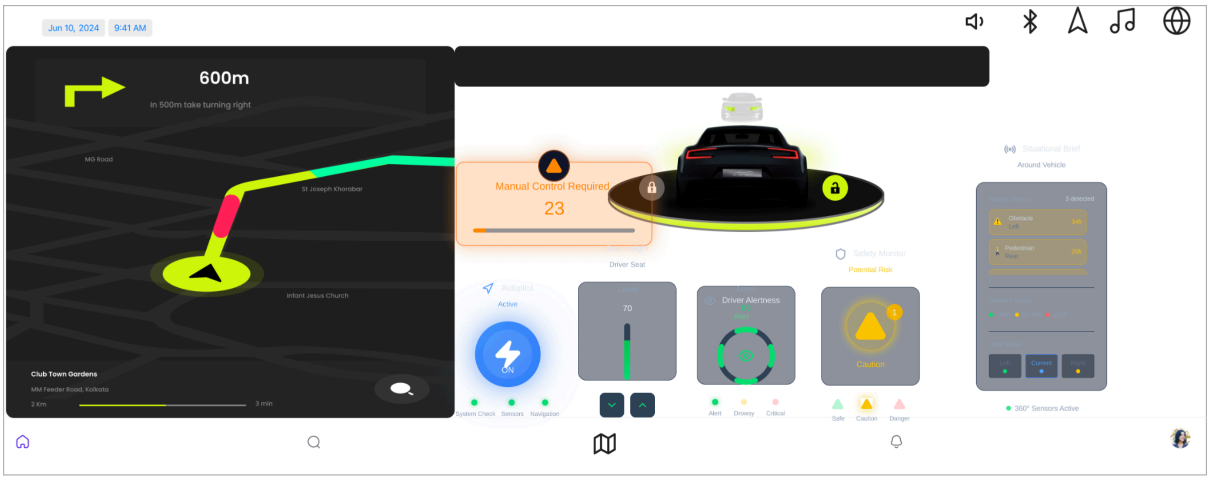


Figure 1.13

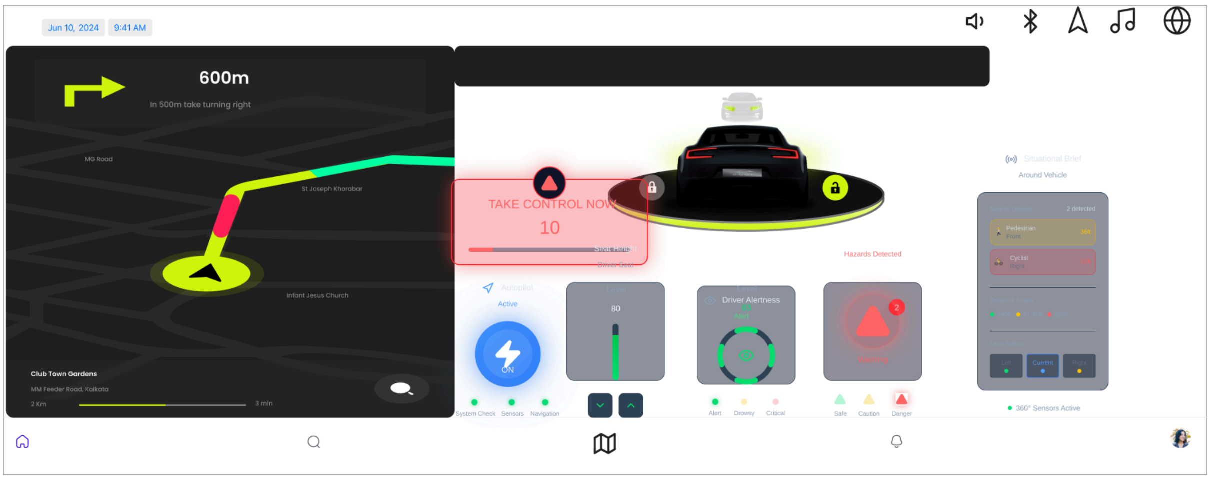


Figure 1.14

Think-Aloud Protocol Script

Emergency Takeover System for Autonomous Vehicles

Team 41 | INF2002 Human Computer Interaction

Usability Script for Think-Aloud Overview

This think-aloud protocol is designed to evaluate the usability of our emergency takeover system through realistic scenario simulation. Participants will verbalize their thoughts, feelings, and decision-making processes as they experience the progressive alert system during a simulated emergency handover situation.

Session Information

Evaluator Team: Team 39

Participant (User) Team: Team 41

Date: ____

Video Recording Started: ☐ Yes Time: ______________________

Note: All teams must be visible in the video recording throughout the simulation.

Setup Requirements

Physical Setup:

- Chair that can be shaken/vibrated (manually or mechanically) to simulate seat movement and vibration
- Paper prototype dashboard display mounted in clear view of participant
- Steering wheel prop (or representation)
- Audio playback device for voice alerts
- Video camera positioned to capture participant, facilitator, and prototype

Team Roles:

- **Facilitator:** Guides the participant through tasks, manages simulation timing
- **Simulator Operator:** Controls physical feedback (shakes chair), changes dashboard overlays, plays audio
- **Observer/Note-taker:** Records participant comments, reactions, and usability issues
- **Participant (from another team):** Performs tasks while thinking aloud

Introduction Script for Facilitator

Read this to the participant before beginning:

"Thank you for participating in our usability evaluation. Today you'll be testing an emergency takeover system for autonomous vehicles. I'll ask you to complete a series of tasks while thinking aloud - that means verbalizing your thoughts, feelings, and decision-making process as you go.

There are no right or wrong responses. We're testing the system, not you. If something is confusing or doesn't work as expected, that's valuable feedback for us. Please be as honest as possible.

The session will be video recorded for analysis purposes. During the simulation, we'll use various methods to represent the system's feedback - I'll shake the chair to simulate seat movement and vibration, we'll show you dashboard changes on paper, and play audio alerts.

Do you have any questions before we begin?"

Task Scenarios

Present these tasks to the participant one at a time. After each task, allow time for questions and discussion before moving to the next.

Scenario Setup

"Imagine you're commuting to work in your Level 3 autonomous vehicle. You've been reading emails on your tablet for the past 15 minutes while the car drives itself. The car has been handling everything smoothly, and you're comfortable and relaxed."

1. Experience the Initial Alert (Stage 1 - 30-45 sec advance)

Instructions to Participant:

"You're reading an important email on your tablet. Suddenly, you notice something different about your seat. Think aloud: What do you notice? How do you feel? What do you do?"

Simulation Steps for Operator:

1. Slowly lift the chair 2 inches (or gently shake upward to simulate rising)
2. Change dashboard overlay to: 'Mode: Auto Pilot' with blue alert box: 'Unrecognized Object Ahead - Please Prepare to Take Control'
3. Wait for participant to notice and respond (give 10-15 seconds)

Observer Notes to Record:

- How quickly did participant notice the seat movement?
- What was their immediate reaction? (verbal and physical)
- Did they look at the dashboard? How long did it take?
- Did they understand the alert message?
- What emotions did they express? (confusion, concern, alertness, etc.)

2. **Respond to Contextual Information (Stage 2 - 20-30 sec)**

Instructions to Participant:

"Now you're more alert. The system provides you with more information. Think aloud: What information do you receive? Is it helpful? How are you preparing?"

Simulation Steps for Operator:

4. Play audio: 'Construction debris detected ahead. Manual control required in 25 seconds.' (calm but clear voice)
5. Change dashboard overlay to show: hazard visual (orange triangle icon) + countdown timer starting at '25... 24... 23...' + text 'Manual Control Required'
6. Count down verbally or point to decreasing numbers

Observer Notes to Record:

- Did the participant understand what the hazard was?
- How did they react to the countdown timer?
- Did they move their hands toward the steering wheel?
- What did they verbalize about preparation or readiness?
- Did they seem confident or anxious?

3. **React to Urgent Physical Warning (Stage 3 - 10-15 sec)**

Instructions to Participant:

"The situation is becoming more urgent. Think aloud: What's happening now? How does it make you feel? What action are you taking?"

Simulation Steps for Operator:

7. Shake/vibrate the chair rhythmically (moderate intensity, continuous)
8. Shake or tap the steering wheel prop to simulate vibration
9. Change dashboard overlay to RED text: 'TAKE CONTROL NOW' + countdown showing '12... 11... 10...'
10. Play audio: 'Please take control immediately.' (more urgent tone)

Observer Notes to Record:

- How did participant react to combined physical feedback (seat + wheel vibration)?
- Was the urgency level appropriate or overwhelming?
- Did they grip the steering wheel? When?
- What words did they use to describe their emotional state?
- Did they appear ready to take control?

4. Take Manual Control

Instructions to Participant:

"It's time to take control. Show me how you would take over the vehicle. Think aloud: What do you do? How do you know you're in control?"

Simulation Steps for Operator:

11. Wait for participant to grab steering wheel and/or tap brake (simulated action)
12. IMMEDIATELY stop all vibrations when participant indicates takeover
13. Lower seat back to normal position
14. Change dashboard overlay to GREEN: 'Mode: Manual | Driver: In Control'

Observer Notes to Record:

- What physical action did participant take to indicate control?
- Was it intuitive/natural?
- How did they react when vibrations stopped?
- Did they understand the confirmation (green dashboard)?
- What was their emotional state after takeover? (relief, confidence, stress, etc.)

5. Navigate and Resume Autopilot

Instructions to Participant:

"You've successfully passed the construction debris. Think aloud: What would you do next? How do you feel about the experience? Would you trust the system to resume autopilot?"

Simulation Steps for Operator:

15. Allow participant to 'navigate' (mime steering around hazard)
16. After 10-15 seconds, change dashboard overlay to: 'Hazard cleared. Autopilot available when ready.'
17. If participant chooses to resume autopilot, show: 'Autopilot resumed. Thank you, [Name].'

Observer Notes to Record:

- How long did participant stay in manual control?
- Did they express trust or hesitation about resuming autopilot?
- What feedback did they give about the overall experience?

- How satisfied did they seem with the system's performance?

Post-Task Discussion Questions

After completing all tasks, ask the participant these follow-up questions:

18. How would you describe the overall experience of the emergency takeover system?

Response: ____

_

19. Which alert stage was most effective in getting your attention? Why?

Response: ____

_

20. Was there any point where you felt confused or overwhelmed? Please describe.

Response: ____

_

21. Did you feel you had enough time to safely take control? Was 30-45 seconds adequate preparation?

Response: ____

_

22. How helpful was the information provided (hazard type, location, countdown timer)?

Response: ____

_

23. What would you change or improve about the system?

Response: ____

_

24. On a scale of 1-10, how much would you trust this system in a real autonomous vehicle?

Rating: ______ Reason:
____

Observation Checklist

Use this checklist during the session to ensure comprehensive evaluation:

Observation Point	Observed? (✓)
Participant noticed seat movement within 5 seconds	
Participant looked at dashboard after alert	
Participant understood the hazard type from audio/visual	
Participant moved hands toward steering wheel at Stage 2	
Vibrations got participant's full attention at Stage 3	
Takeover action was intuitive and natural	
Participant understood control transition confirmation	
Participant expressed confidence/trust after experience	
No excessive stress or panic observed	

Video clearly captured all participants and interactions	

Key Usability Issues Identified:

1. ____

2. ____

3. ____

4. ____

Thank you for conducting this evaluation!

Remember to save the video recording for final report analysis.

Heuristic Evaluation Form - Task List

Emergency Takeover System for Autonomous Vehicles

Team 41 | INF2002 Human Computer Interaction

Evaluator Information

Evaluator Name: ____

Team/Group Number: 50

Date of Evaluation:

System Overview

Problem: Emergency handover in Level 3 autonomous vehicles when the system encounters unrecognized objects and requires human takeover.

Solution: Progressive multi-sensory alert system using physical feedback (seat movement/vibration), visual dashboard displays, and audio warnings over 30-45 seconds.

Evaluation Instructions

For each heuristic below:

1. Review the prototype components and alert stages
2. Rate the system on a scale of 1-5
3. Document specific usability issues found
4. Assign severity ratings to each issue (0-4)

Rating Scale:

1 = Major usability problems

2 = Significant issues

3 = Moderate (acceptable)

4 = Good (minor issues)

5 = Excellent

Heuristic Evaluations

H1: Visibility of System Status

Definition: *The design should always keep users informed about what is going on through appropriate feedback within a reasonable time.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

H2: Match Between System and Real World

Definition: *The design should speak the users' language, with words, phrases, and concepts familiar to the user, rather than internal technical terminology. (Choose words that users already know and use in daily lives, rather than technical terms that developers or designers knows.)*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

H3: User Control and Freedom

Definition: *Users often perform actions by mistake. They need a clearly marked 'emergency exit' to leave the unwanted action without having to go through an extended process.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

H4: Consistency and Standards

Definition: *Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform and industry conventions.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____
____

____
____

____
____

Severity (0-4): _______

H5: Error Prevention

Definition: *Good error messages are important, but the best designs carefully prevent problems from occurring in the first place.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____
____

____
____

____
____

Severity (0-4): _______

H6: Recognition Rather Than Recall

Definition: *Minimize the user's memory load by making elements, actions, and options visible. The user should not have to remember information from one part of the interface to another.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____
____

____
____

____
____

Severity (0-4): _______

H7: Flexibility and Efficiency of Use

Definition: *Shortcuts may speed up the interaction for the expert user so that the design can cater to both inexperienced and experienced users.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

H8: Aesthetic and Minimalist Design

Definition: *Interfaces should not contain information which is irrelevant or rarely needed. Every extra unit of information in an interface competes with the relevant units of information.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

H9: Help Users Recognize, Diagnose, and Recover from Errors

Definition: *Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

H10: Help and Documentation

Definition: *It's best if the system doesn't need any additional explanation. However, it may be necessary to provide documentation to help users understand how to complete their tasks.*

Rating (circle one): 1 2 3 4 5

Issues identified:

____

____

____

Severity (0-4): ________

Severity Rating Reference

Severity	Description
0 - Cosmetic	Not a usability problem
1 - Minor	Low priority fix
2 - Moderate	Medium priority fix
3 - Major	High priority fix
4 - Critical	Immediate fix required

Summary of Critical Issues

List all issues with severity 3 or 4:

Issue 1:
Description:
____

Heuristic: ____________________ Severity: _______ Location:
____

Recommendation:
____

Issue 2:
Description:
____

Heuristic: ____________________ Severity: _______ Location:
____

Recommendation:
____

Issue 3:
Description:
____

Heuristic: ____________________ Severity: _______ Location:
____

Recommendation:
____

Issue 4:
Description:
____

Heuristic: ____________________ Severity: _______ Location:
____

Recommendation:
____

Overall Assessment

Strengths of the design:

____
____
____
____
____
____

Main areas for improvement:

____
____

____
____

____
____

Overall usability rating (1-5): ________

Additional comments:

____
____

____
____

____
____

Thank you for your evaluation!

____
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This is the link to the team's think aloud evaluation

https://www.youtube.com/watch?v=0giI3_1E7Xk

References

[1] u/sizzsling. “Self driving car fail to stop at stop sign and run over mannequin”, Reddit. Available:https://www.reddit.com/r/interestingasfuck/comments/1lb4cs7/self_driving_car_fail_to_stop_at_stop_sign_and/

[2] u/skydivingdutch. “Video compilation of Waymo near-misses, avoiding accidents”, Reddit. Available:https://www.reddit.com/r/SelfDrivingCars/comments/1f9sng8/video_compilation_of_waymo_nearmisses_avoiding/

[3] NBCNews. “Passenger got stuck in driverless car going in circles”. [Video]. Available:https://www.youtube.com/shorts/YwN5hU5PYWs

[4] CNBC Television. “Viral videos and trusting self-driving tech”. [Video]. Available:https://www.youtube.com/watch?v=RHDWQQDiZEY

[5] S.Nordhoff, J. Stapel, B. van Arem and R. Happee, “Passenger opinions of the perceived safety and interaction with automated shuttles: A test ride study with ‘hidden’ safety steward,**”** *Transportation Research Part A: Policy and Practice,* vol. 138, pp 508-524, Jul 2020, https://www.sciencedirect.com/science/article/pii/S0965856420305917

[6] K. Othman, “Exploring the implications of autonomous vehicles: a comprehensive review**”,** *Innovative Infrastructure Solutions,* vol. 7, no. 2, Mar. 2022, doi:https://doi.org/10.1007/s41062-022-00763-6

[7] A. Rezaei, B. Caulfield, “Safety of autonomous vehicles: what are the insights from experienced industry professionals?,” *Transportation Research Part F: Traffic Psychology and Behaviour,* vol. 81, pp. 472-489, Jul. 2021, doi: https://doi.org/10.1016/j.trf.2021.07.005

[8] D. Omeiza, R. Bhattacharyya, M. Jirotka, N. Hawes, L. Kunze, “A transparency paradox? Investigating the impact of explanation specificity and autonomous vehicle imperfect detection capabilities on passengers,” *Transportation Research Part F: Traffic Psychology and Behaviour,* vol. 109, pp. 1275-1292, Feb. 2025, doi: https://doi.org/10.1016/j.trf.2025.01.015

[9] W. Vlakveld, N. van Nes, J. de Bruin, L. Vissers, M. van der Kroft, “Situation awareness increases when drivers have more time to take over the wheel in a Level 3 automated car: A simulator study,”, *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 58, 2018, pp. 917-929, doi: https://doi.org/10.1016/j.trf.2018.07.025. (https://www.sciencedirect.com/science/article/pii/S1369847818300603)