



Auto Sphere

A
human-vehicle interface

For
L3/L4 self-driving vehicles

To
control or change vehicle automation



An interface that is closely tied to human desires and the unpredictable nature of road adventures.

Auto Sphere prioritizes the human experience. It simplifies decision-making by allowing the driver to manage unexpected scenarios during automated journeys through a controller and a graphical user interface.

Automation is more than just following a mapped route

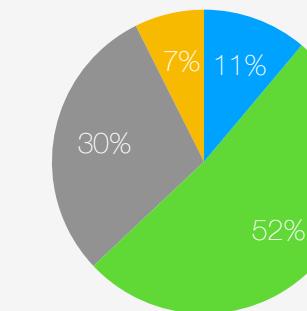
Admiring the scenery as your car navigates through the national park, you decide to pause your vehicle and take a walk, **but how?**



Visionaries from modern automakers reflect a desire for humans to yield active driving duties, letting the car take complete control.



However, unforeseen events during the trip may require us to take a detour or change our route, like stopping for refresh or taking a walk.

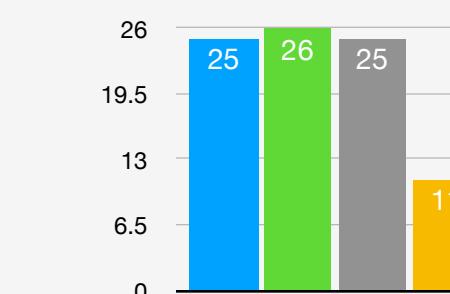
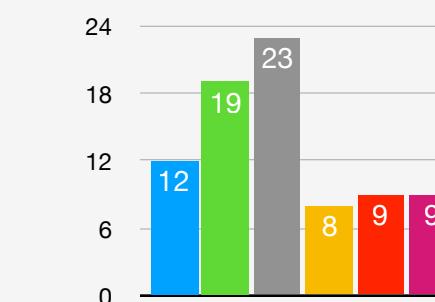


Will you enable vehicle automation?

- Yes, let the machine take complete control.
- Yes, but supervise and intervene.
- Only when road conditions are clear
- Never

Expectations of infotainment system:

- Larger display, more content
- Display trip-related info
- More effective input instead of touching
- Smaller display for safety info only
- Voice command
- Connect and control with a phone



What will you do?

- Non-Visual Task (Leaning)
- Regular Task (Normal position)
- Productivity (Further from the dash)
- Eat

The trip plan's unpredictability is supported by interviewing five experienced drivers:

- All took rest or meals during the trip.
- Four had driven in a national park and took unplanned roadside parking.
- None of them specified places for rest and meals before trips in most cases.

A survey involving 26 participants provided valuable insights into people's preferences and demands for interaction during a trip in an automation-capable vehicle.

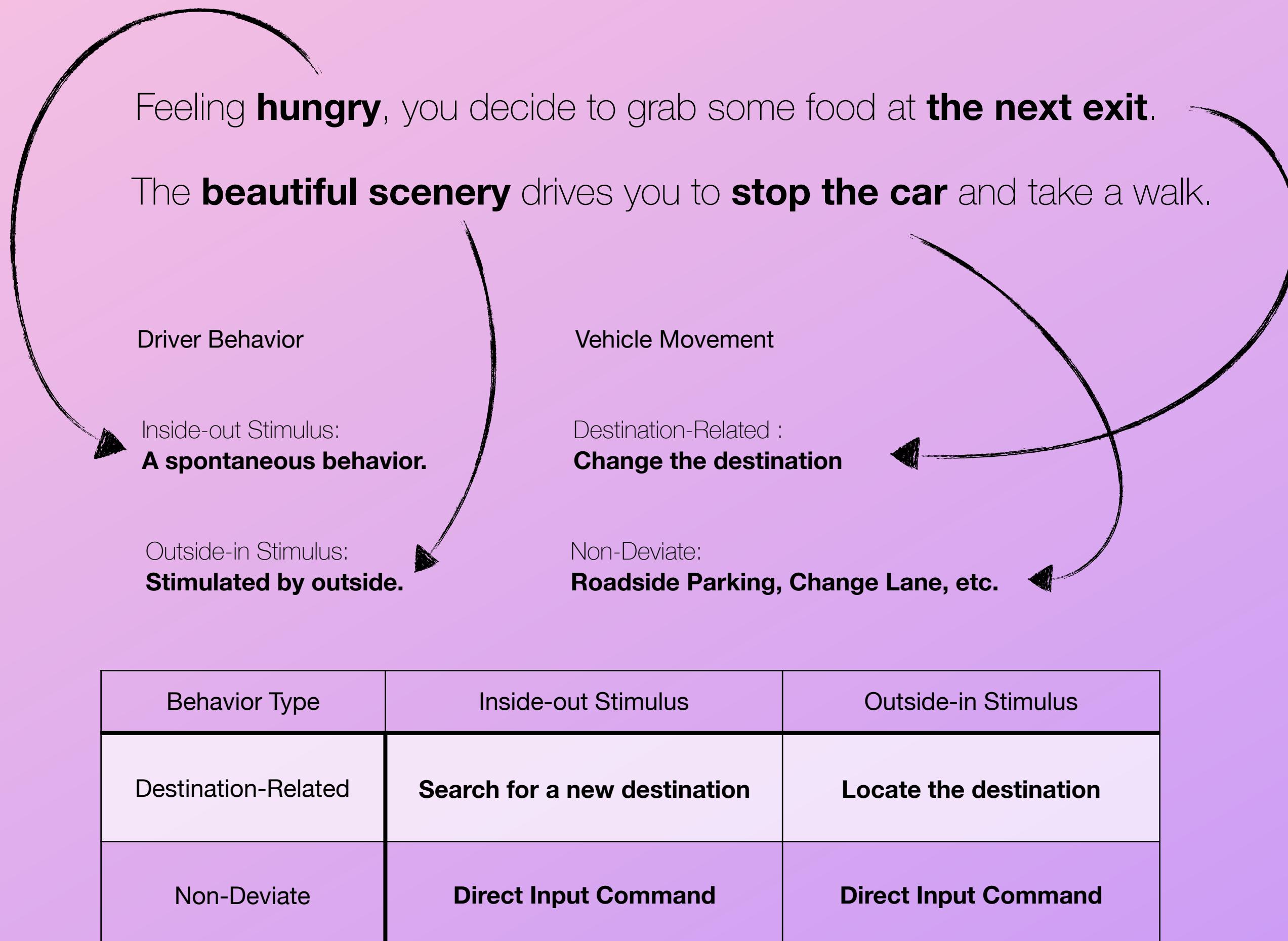
Drivers need **information accessible**

at any time in the car for **automation intervention**

through an **effective interface**

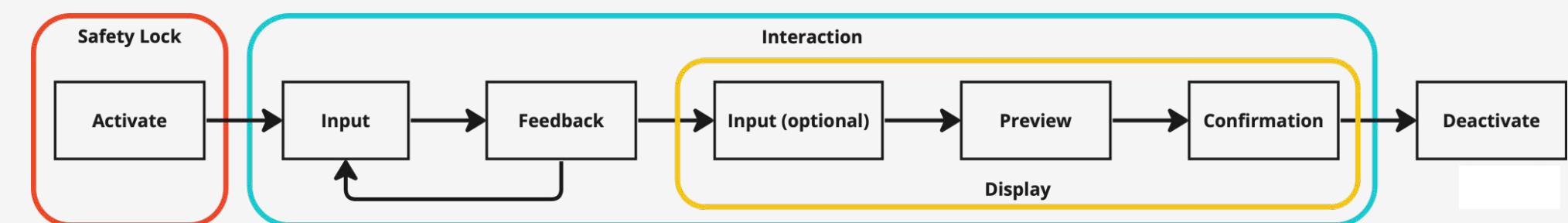
when **sitting or reclining.**

Driver behavior + vehicle movement



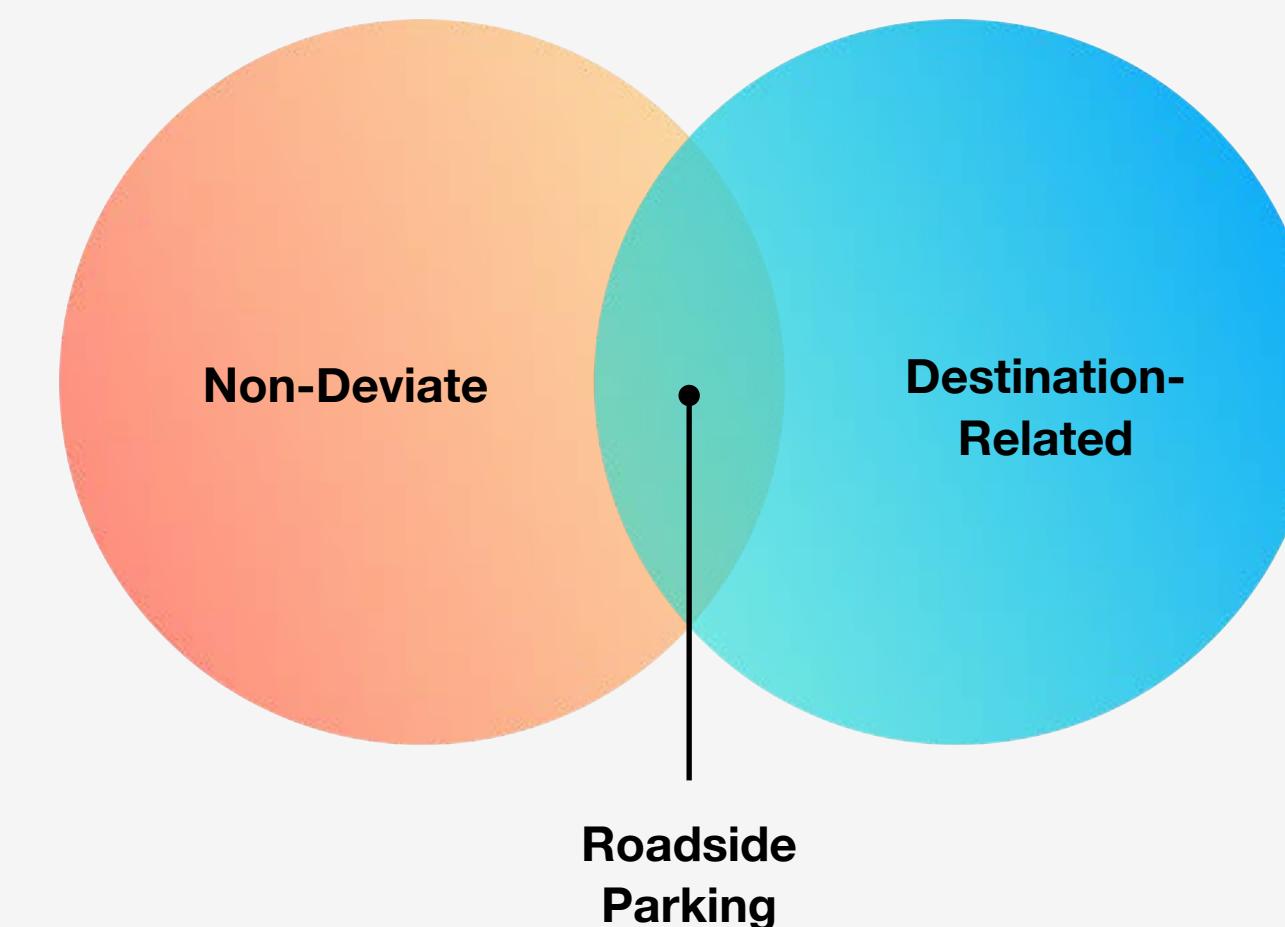
The driver's interventions are categorized as "externally stimulated" or "internally stimulated," leading to different levels of urgency based on their motivation. The vehicle's movement is classified into two sections: destination-related and non-deviated, based on whether or not the motion deviates from the planned route. By organizing the driver's behaviors and the vehicle's movements into a 2x2 matrix, we can understand the required information and interaction for each combination, systematically identifying the different needs based on varying driver behaviors and vehicle responses.

An input device and an information display



The interface should address the user's demands from two stimuli and display feedback. As a result, we need an input device and an information display to support users following tasks:

1. **Locate a new/adjacent destination**
2. **Input non-deviated moving command**
3. **Provide feedback**



Roadside parking is an exception to both patterns. While the vehicle remains on the planned route, it ceases driving, requiring users to choose a parking spot manually in certain situations. Such behavior can be spontaneous during a road trip while dropping off, picking up people, or in emergencies. Therefore, they require an efficient method to specify the parking location.

Change lane
Roadside parking
Spot a new destination

Summarized from driver behavior and vehicle movement, the interface should allow users to promptly input movement commands, view nearby options, and designate a parking spot alongside other essential interactions.

Input Device test: Touchpad, knob, and joystick

The test aims to evaluate and rank user experience with three proposed interaction devices: **touchpad**, **knob**, and **joystick**, commonly used in automotive and informatics systems.



Simulation Environment



First Person Perspective

A virtual environment simulating a self-driving scenario is built. In this simulation, the car moves on a four-lane road, and tester can change lanes using one of the three input devices being evaluated (touchpad, knob, or joystick), all while experiencing the driving from a first-person perspective.

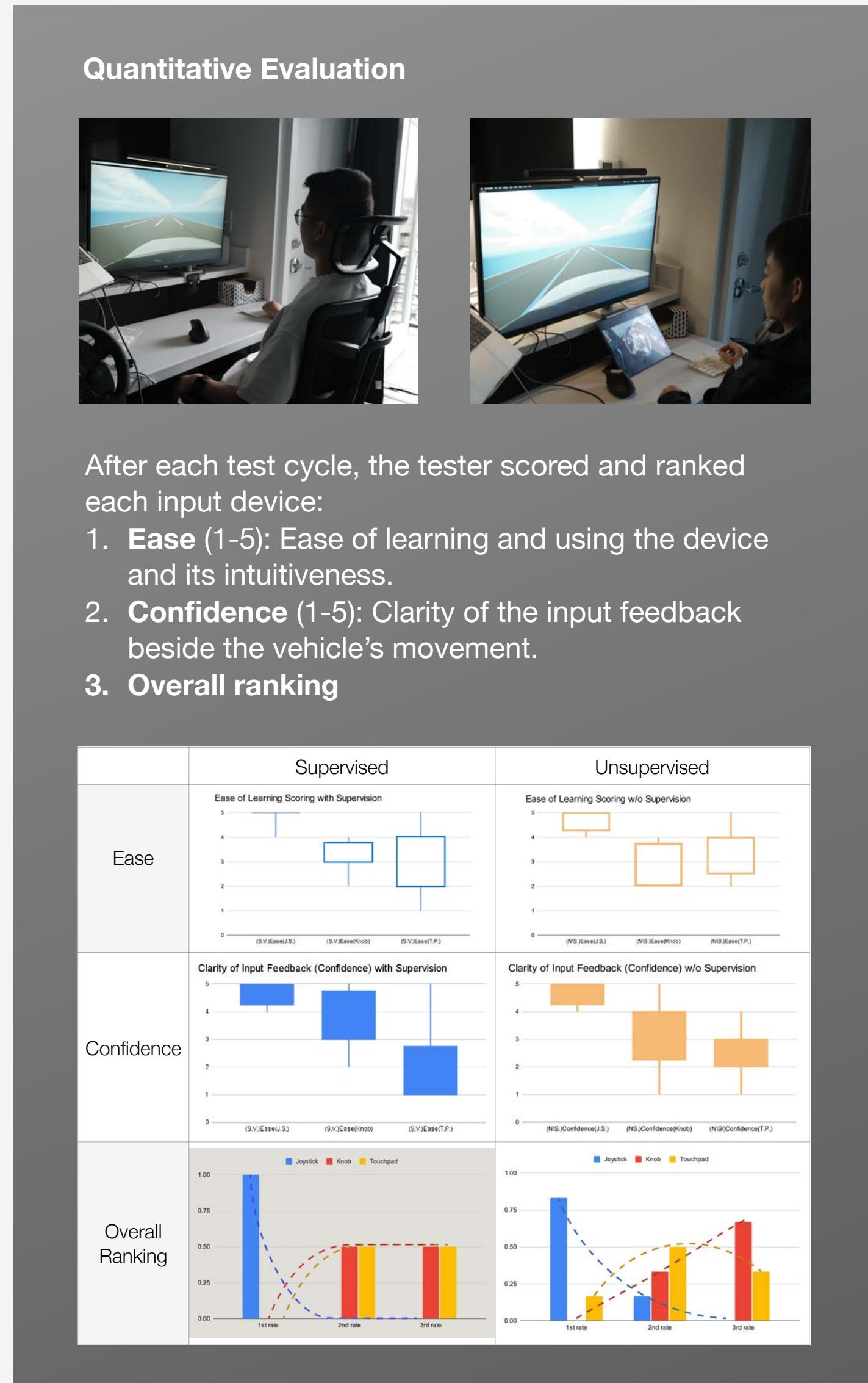
Test Design

```

graph LR
    Instruction([Instruction]) --> TestSupervised[Test (Supervised Cycle)]
    TestSupervised --> Score1[Score Ease Score Confidence Rank Preference]
    Score1 --> TestUnsupervised[Test (Unsupervised Cycle)]
    TestUnsupervised --> Score2[Score Ease Score Confidence Rank Preference]
    Score2 --> End([End])
  
```

Testers were asked to use each of the three input devices in random order for 30 seconds to switch lanes in the simulation. The test consists of two cycles: supervised and unsupervised.

3D printed knob and joystick, attached to the keyboard, along with the touchpad, enabled participants to input commands in the simulated environment built with UE5.



The **joystick** outperform the knob and touchpad as an input device for the interface in all tests and evaluations, indicated by the scores of six participants.

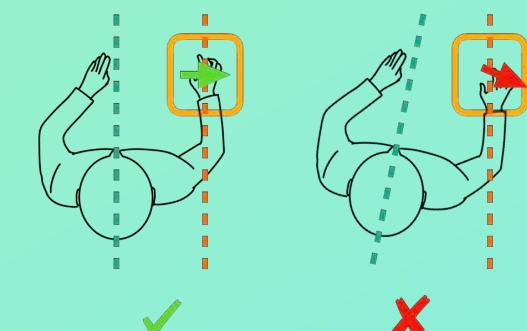
Besides the scoring, several issues were spotted when using the knob or the touchpad in the qualitative evaluation:

Knob:

- Using counter-clockwise poses a challenge for some users, increasing learning costs and a higher risk of potential input errors.
- Half testers found the knob less comfortable to operate than the other two options.

Touchpad

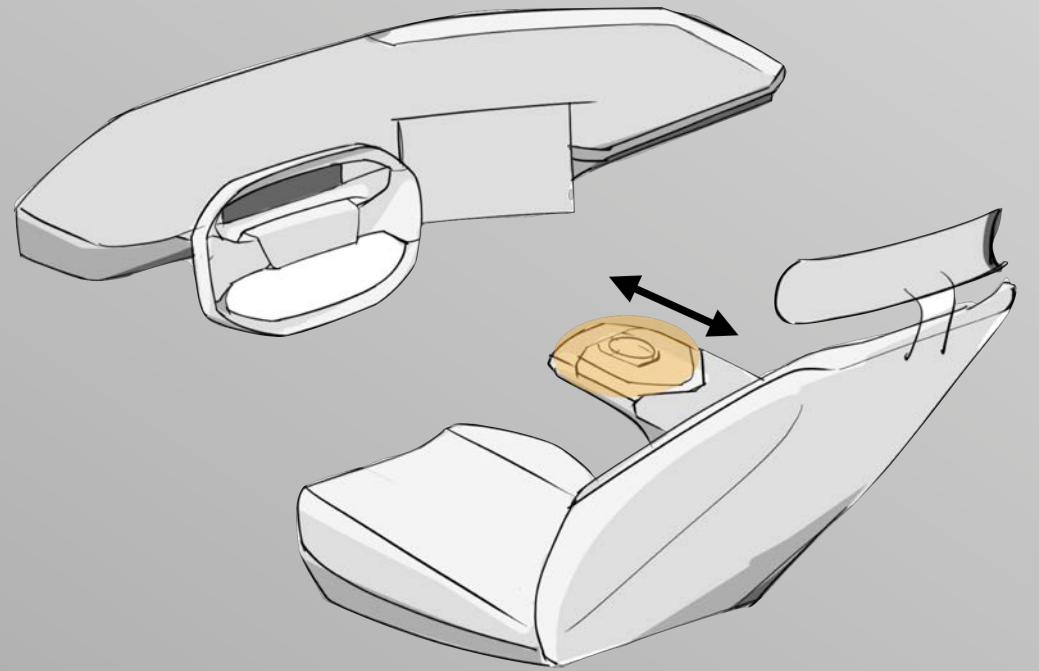
- When the driver's position is offset from the touchpad's centerline, the system is prone to misinterpreting the direction of gestures, resulting in low accuracy.
- Despite the strong vibration feedback when touched, most testers found the touchpad's physical feedback to be the least perceptible, and they were uncertain about the accuracy of their input.



Design a joystick controller

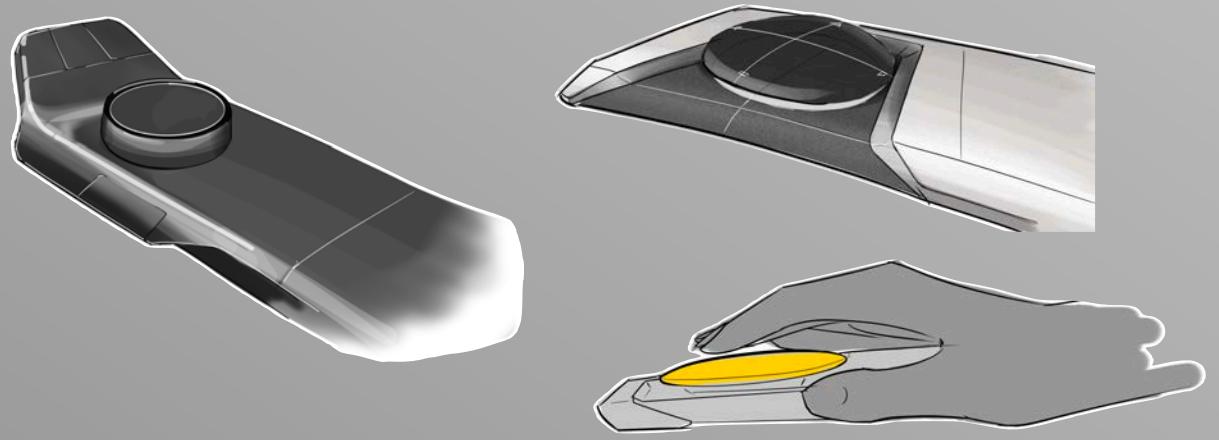
The joystick controller is designed to help users with the following tasks:

1. Entering two types of commands: deviated and non-deviated.
2. Selecting options and confirming them.
3. Navigating back and forth.

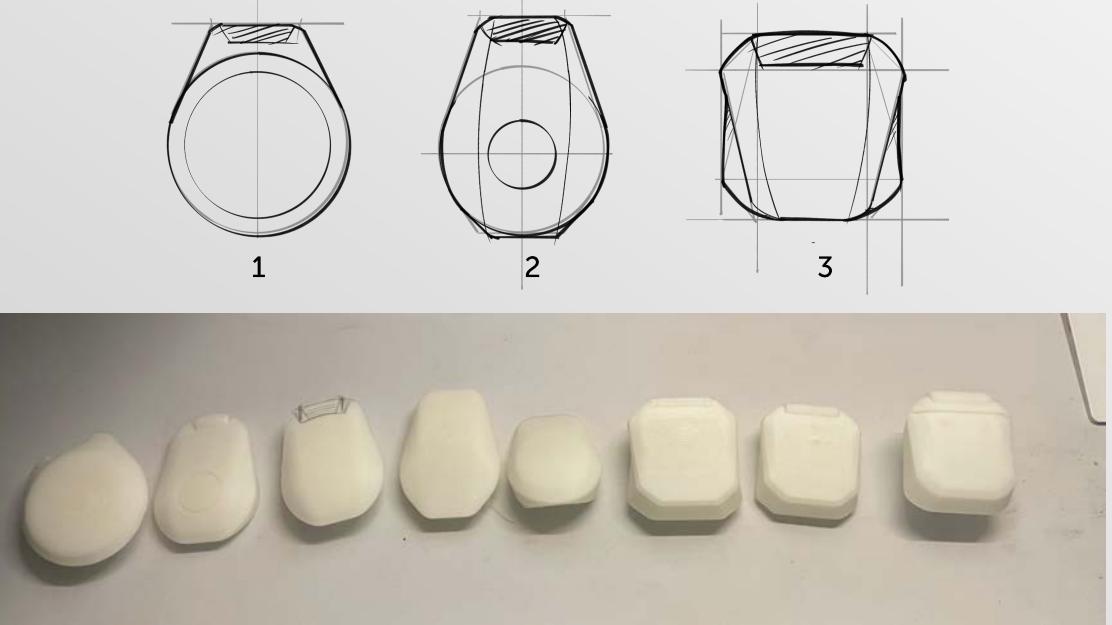


Operator is able to input commands comfortably at a wide range of seat's position.

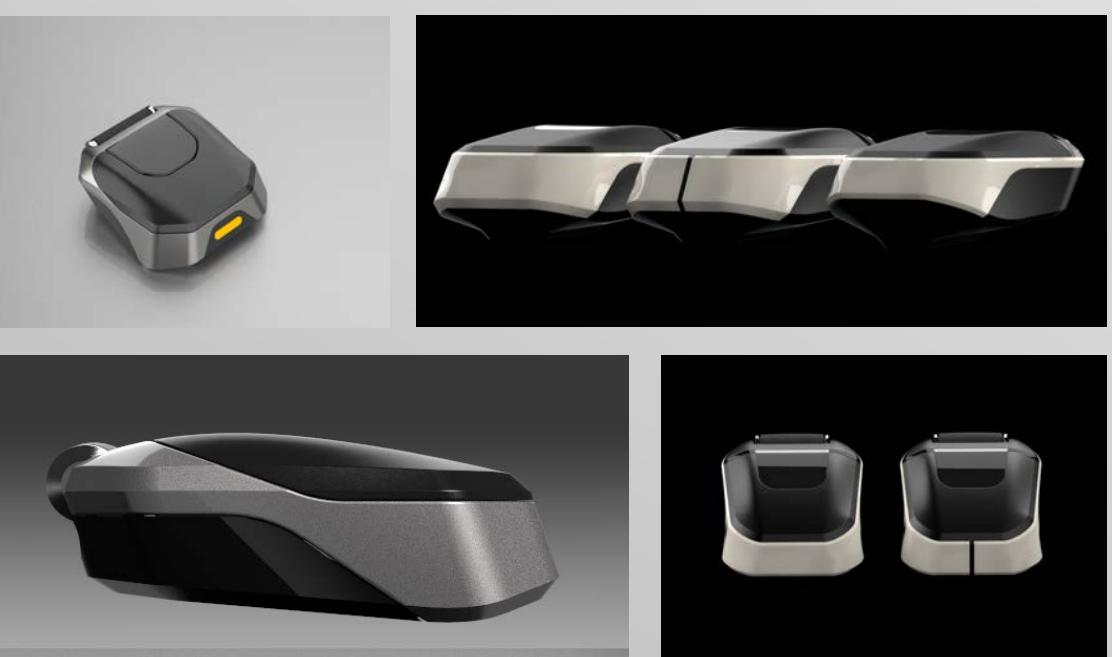
1. Concept Design



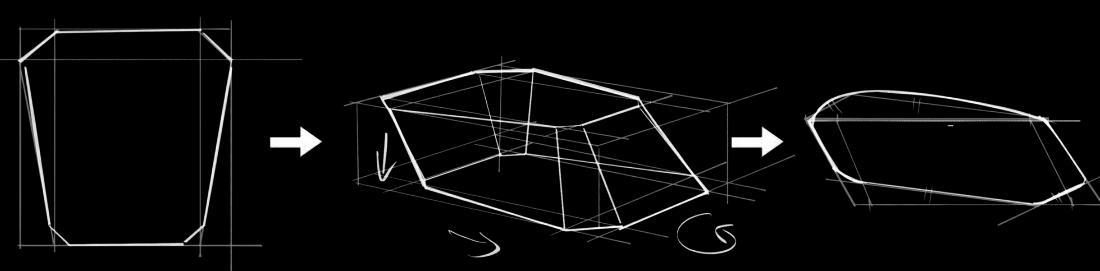
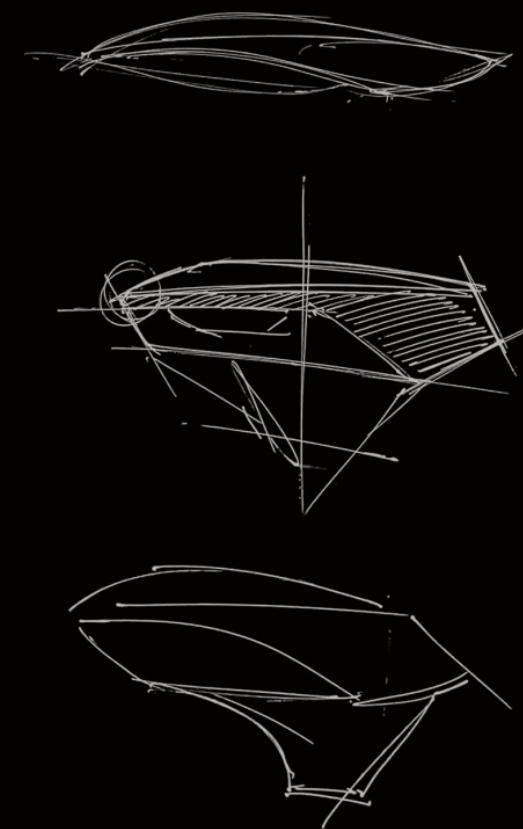
2. Iteration and refinement



3. Design language and CMF



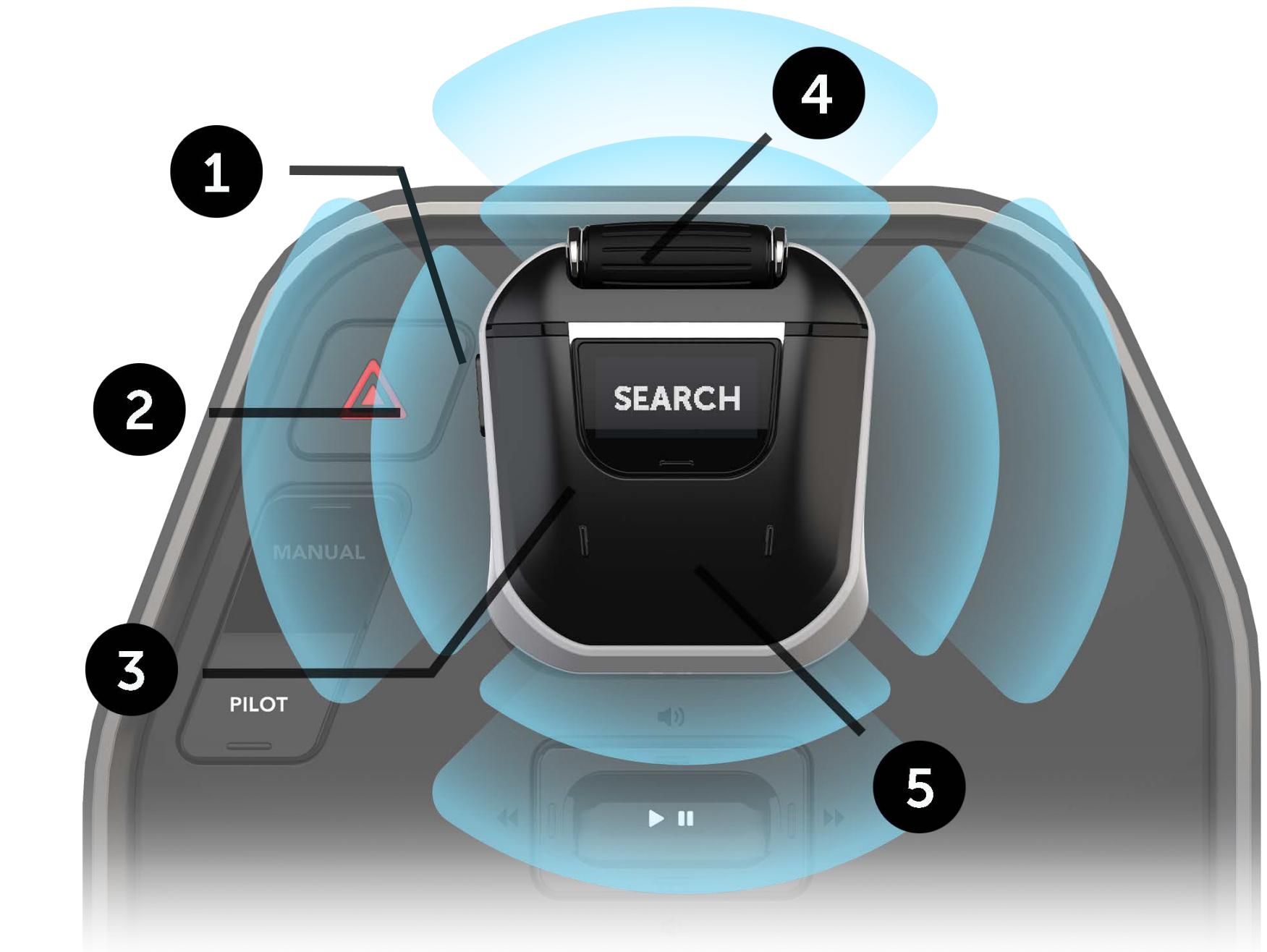
4. Final prototype



The raw shape of the joystick is the result of the loft between two opposite trapezoids. The top surface is extruded and the bottom is trimmed to create a smooth, streamlined shape that fits naturally and securely in the palm, allowing for comfortable use.



A controller that is versatile, highly integrated, and fits comfortably in your palm.



① Activation button

When the lock is not pressed, the joystick becomes fixed, allowing users to control the common infotainment system with the controller.

② Two Travel Stage Joystick



Once the activation button is pressed, the joystick mode will be activated. The joystick features two travel stops:

- **First travel stage** by pushing the joystick to the first stop: instant vehicle behaviors that do not deviate from the planned route, such as changing lanes, decelerating, overtaking, etc.
- **Second travel stage** by pushing the joystick further to the second stop: instant instructions for changing the destination.

③ Adaptive Fn Key

The adaptive function key allows users to input conditional shortcuts or commands. For example:



Search for adjunct destination, or music and video.



Cancel a progressing movement input such as overtake.



Long press to switch between jobs through app dock.

④ Scroll Wheel

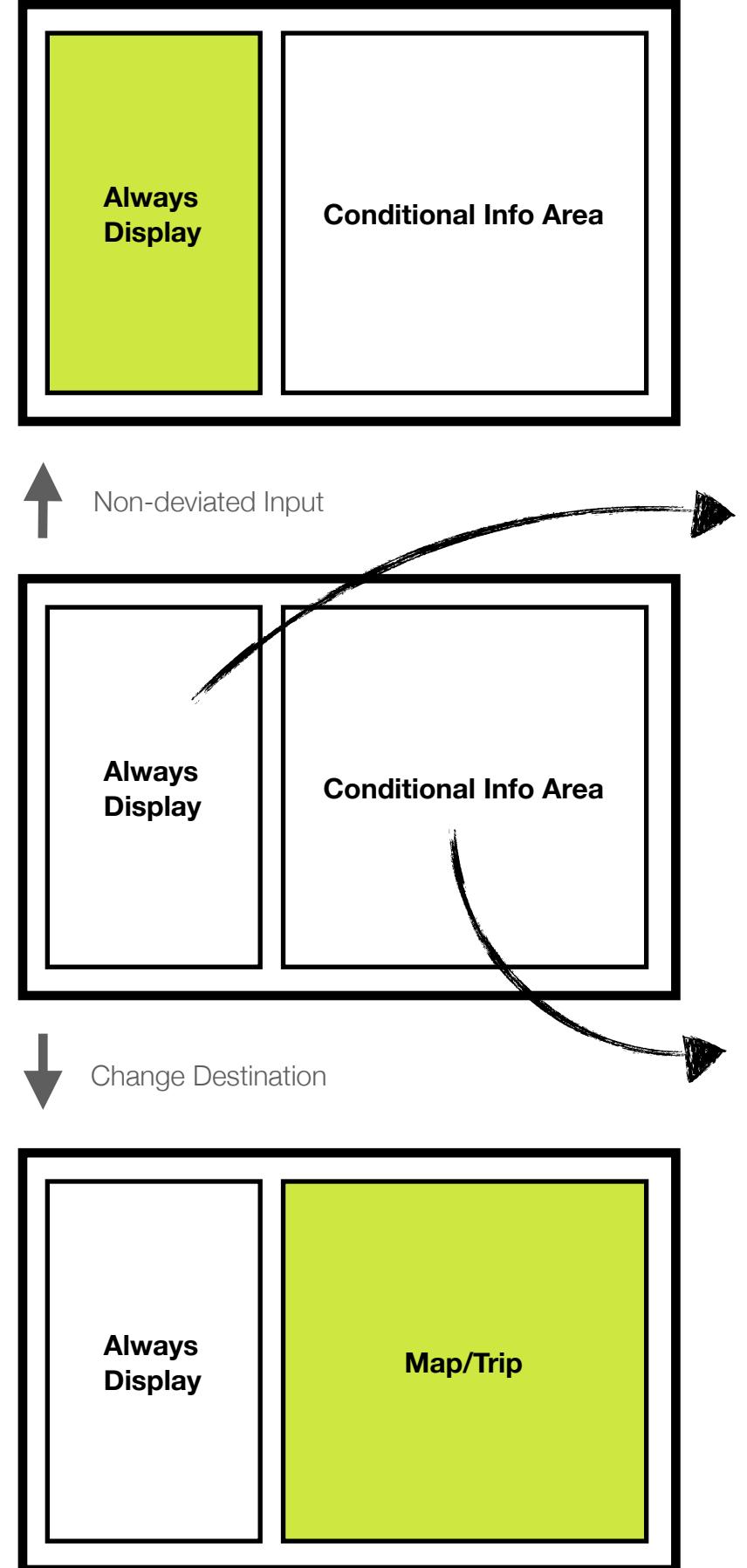
Easily navigate to options with the scroll wheel. Scroll the wheel to select, and then press the wheel to confirm.

⑤ Touch Capacitive Pad

The pad is comfortably shaped and curved. Users can wipe left/right with the palm to go back/forward without adjusting the hand's position.

Graphical user interface

The screen is split into two areas: always-on and conditional content. The size and layout of the two sections can be adjusted based on the specific input and the driver's preferences. This adaptability ensures that the most relevant information is prominently displayed.



The always-display section presents information that must be constantly visible, such as:

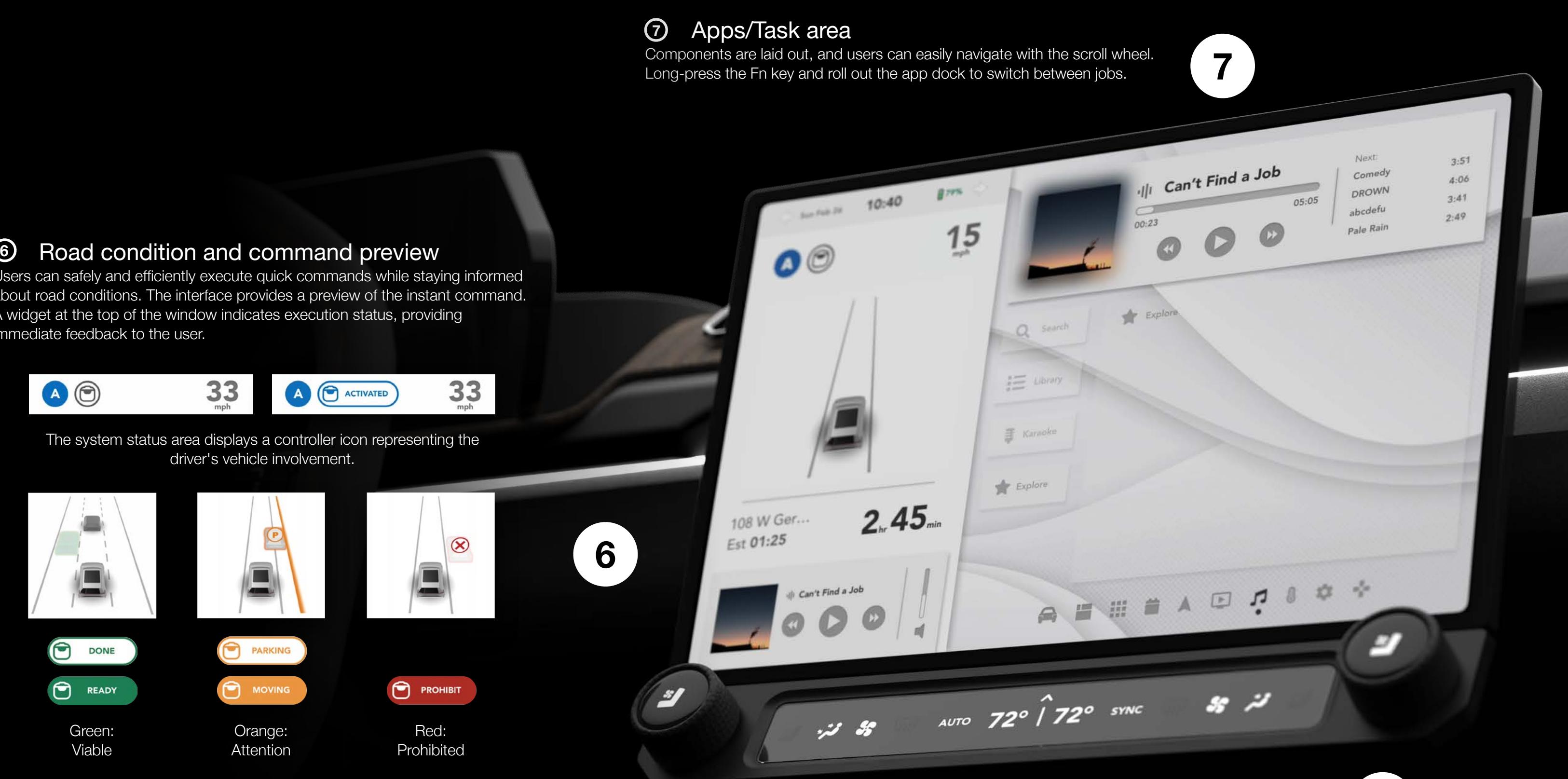
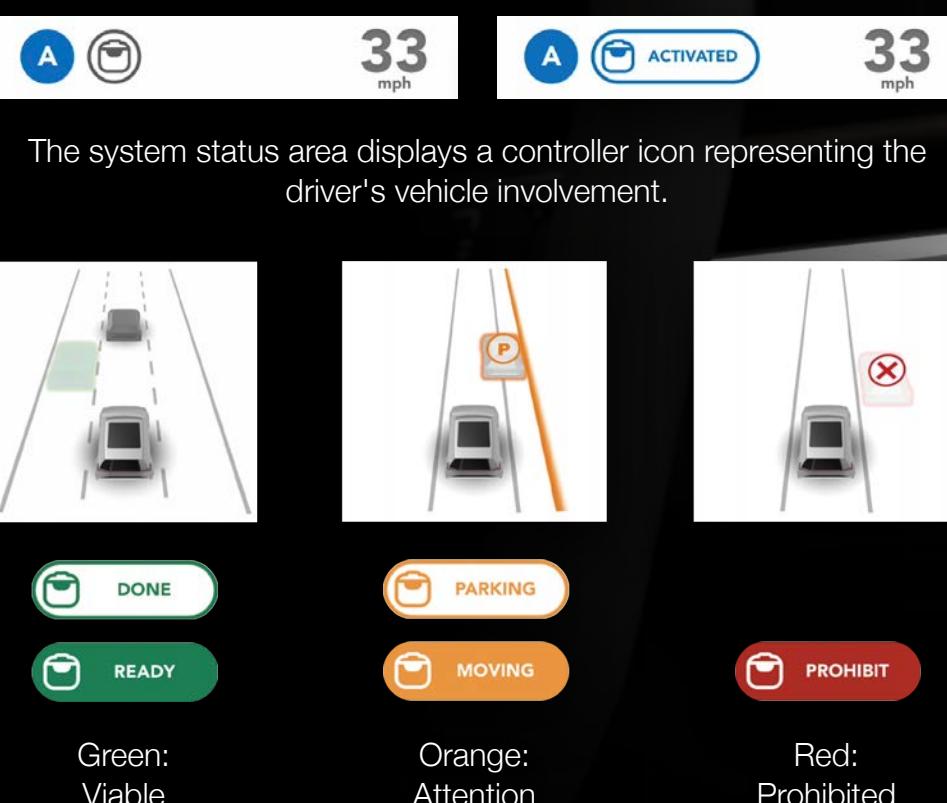
1. Road condition for manual driving and non-deviated input
2. Trip and time information
3. Ongoing tasks include system status and media playing.

The conditional section exhibits information that is not necessary to display at all times and is based on user input, for example:

1. Map/Trip for editing the trip
2. Entertainment Content

⑥ Road condition and command preview

Users can safely and efficiently execute quick commands while staying informed about road conditions. The interface provides a preview of the instant command. A widget at the top of the window indicates execution status, providing immediate feedback to the user.



⑦ Apps/Task area

Components are laid out, and users can easily navigate with the scroll wheel. Long-press the Fn key and roll out the app dock to switch between jobs.

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The GUI accommodates different input commands under a unified visual language and similar information architecture to maximize user experience by minimizing learning costs and workflow differences.

⑧ Comfort Control

Comfort control is separated from the main display. Users can easily read the info and control it anytime. Two physical knobs and buttons enable fast adjustment and shortcuts.

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Switch lane



Step 1: Unlock the joystick

Press the activation button to unlock the joystick. The controller icon on the display will turn from grey to blue and show 'ACTIVATED'.

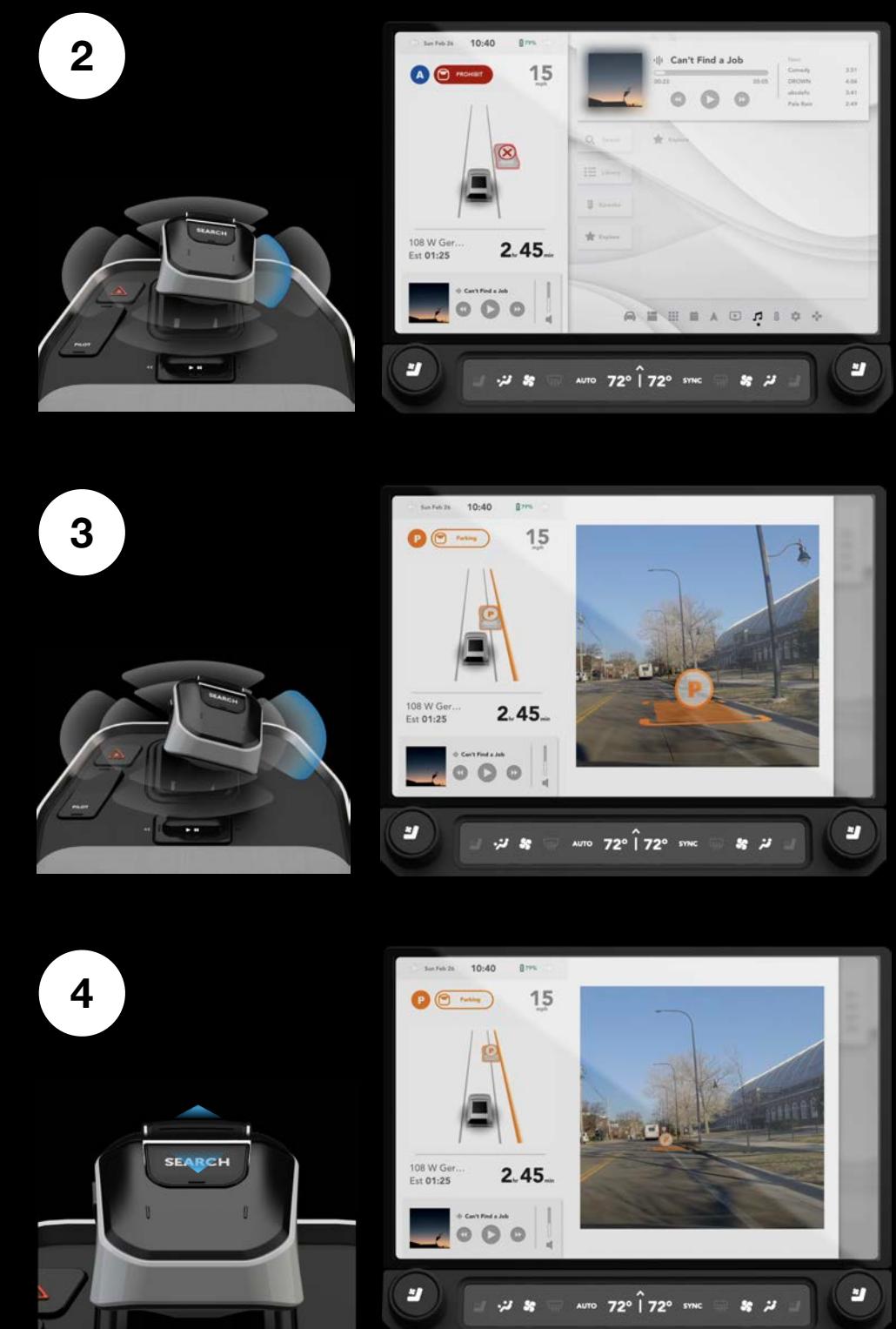
Step 2: Shift to stage one

Move the joystick towards the desired orientation to its first travel stage. The vehicle preview icon will turn green, and the indicator widget will display the word 'READY' if the clearance is allowed.

Step 3: Complete

The car will automatically change the lane. The preview and the indicator will turn orange, notifying the driver to be attentive. The driver can cancel and return to the original lane by pressing the CANCEL (as displayed on the adaptive function key) at any time during the movement.

Roadside parking



Switch lane



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Step 1: Unlock the joystick

Step 2: Shift to stage one

Move the joystick towards the orientation of the desired parking spot until it reaches the joystick's first travel stage. In the preview of the car's movement, the vehicle will turn red, and the indicator widget will display the word 'PROHIBITED' because no other lane is available.

Step 3: Shift to stage two

Move the joystick again to the joystick's second travel stop. The system will enter roadside parking mode with a spot selector overlayed on the AR viewport. The indicator will turn orange-stroked, waiting for further instruction from the driver.

Step 4: Select and confirm

Move the spot selector back and forth with the scroll wheel to assign the parking spot, then press the scroll to confirm. Upon confirmation, the car will travel to (as the indicator showing 'MOVING') and stop at (as the indicator showing 'DONE') the desired spot.



Step 1: Unlock the joystick

Step 2: Shift to stage one

Move the joystick to the second stop stage; the interface will show the exits ahead along the route.

Step 3: Select

Select the Exit using the scroll wheel. The driver can select the point of interest (if applicable) and search by pressing the adaptive Fn key. The driver can also take over the driving after exiting the highway.

Step 4: Confirm

Upon confirmation from the driver, the vehicle will reroute to the new destination or hand over the control to the driver after reaching the exit.

Instant reroute (highway)



Instant reroute (urban)



Step 2: Shift to stage two

Move the joystick to the second stop stage on the right/left, depending on the orientation of the point of interest. The interface will display the available options on the assigned side.

Step 3: Select

Move the area selector with the scroll wheel to confirm and zoom in on the covered area.

Step 4 (Optional): Adjust

The driver can adjust the covered area on the UI by scrolling while pressing and holding the scroll wheel.

Step 5: Confirm

After zooming in the area, the driver can select the destination in the list on the left. The driver can always search for the destination by pressing the SEARCH anytime during the workflow if the desired destination is not listed.

Other commands



A: Speedup/slow down

Move the joystick forward/backward to the first stop.

B: Overtake

Move the joystick forward to the first stop.

C: Comfort control page

Swipe up

