



HUD Based Augmented Reality

Version 00

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FORD CONFIDENTIAL



Revision History

Date	Version	Notes	
6 / 7 / 2021	0.0	Rough Unreleased	



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1 Introduction

1.1 Purpose

- The AR navigation is designed to provide user Augmented Reality display on HUD. It visualizes the route to get people to his/her destination in augmented reality with 3D arrows, and overlays of information related to user's location (streets and POI) where is projected on objectives.
- Potentially AR can increase rapid information recognition and decrease a drivers' cognitive workload. It is important to determine to what extent AR provides an advantage compared to presenting driver information through 2D unregistered symbols.
- AR supports the development of a winning portfolio by guiding the driver in the most natural and intuitive way, which presents a competitive advantage for a mobility company.
- AR augments the user's view of the world like an "invisible friend" who is always with you, pointing out the way.
- Displaying virtually augmented information to the driver, aligned with natural human behaviour and performance this will change the stressful act of following screen/HUD 2D directions.

1.2 Scope

- AR HUD

1.3 Audience

- Core engineering / supplier responsible for developing the AR navigation and its subsystems.
- Supplier responsible for providing AR navigation data.
- Core engineering responsible for developing customer functions that use the AR navigation.

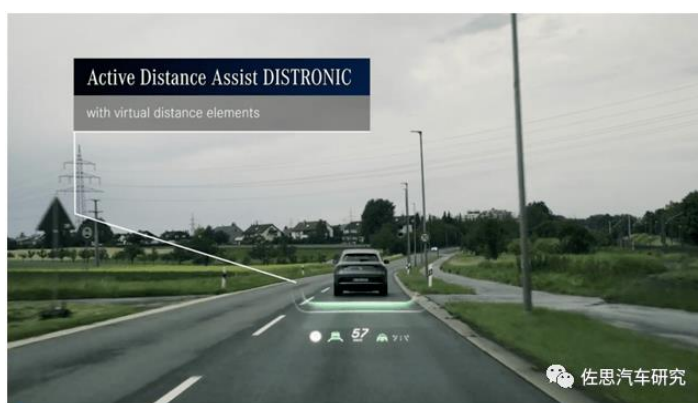
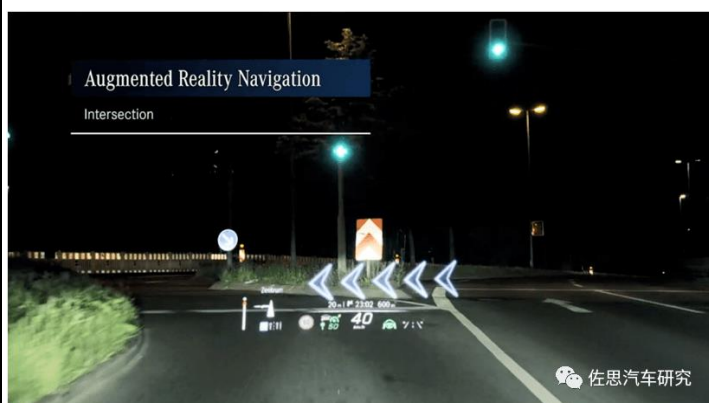
2 Feature Description

2.1 Feature Overview

Augmented Reality (AR) feature displays virtual augmented information (Guide, Situational awareness) to the driver. It aligns with natural human performance to reduce cognitive workload, enhance the information perception and reaction times for the driver.

Other than, in the often-stressful act of following screen 2D directions, the AR technology renders virtual objects near relevant objects in the real environment. AR technology should visualize the driver information not only in real time but also correctly aligned (even in focal depth), meaning in a tight connection to the physical space. AR is contextually triggered to optimize value and mitigate potential driver distraction, just the right content at the right moment.

This is a AR HUD feature that user could have navigation guide arrow visualized and have enhance information of street .AR HUD notifies user of potential hazards on road via ADAS system



2.2 Implementation Principle

- Camera capture the live video stream of the road in front of the vehicle.
- Then feed this video stream into IVI (DuerOS system) via LVDS cable.
- The ADAS provide the horizon of the road in front of the vehicle
- AR image algorithm was deployed in DuerOS doing image identification, render and merge, etc.
- DuerOS feed completed video stream AR HUD for display via LVDS cable.

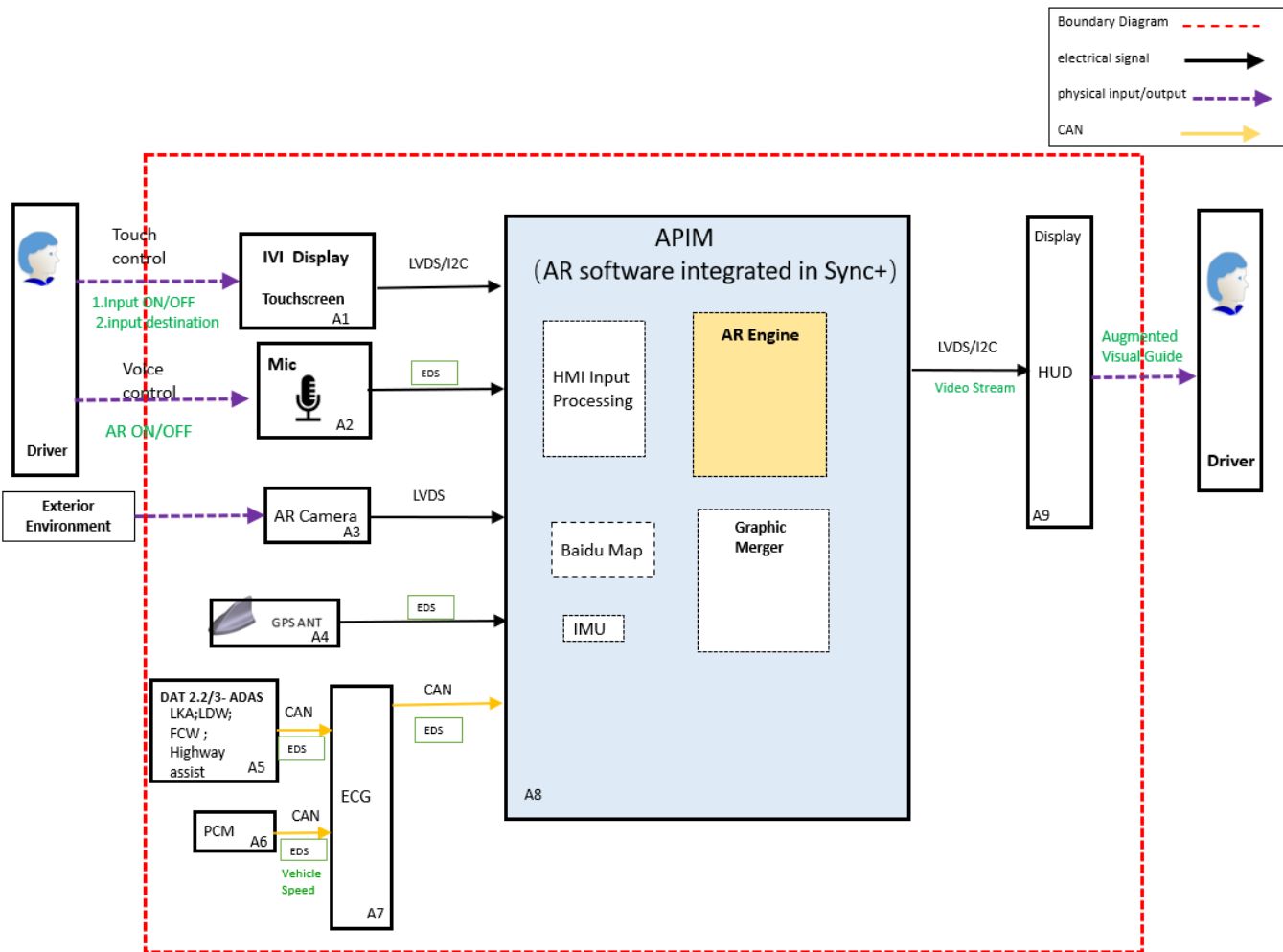


2.3 Feature list

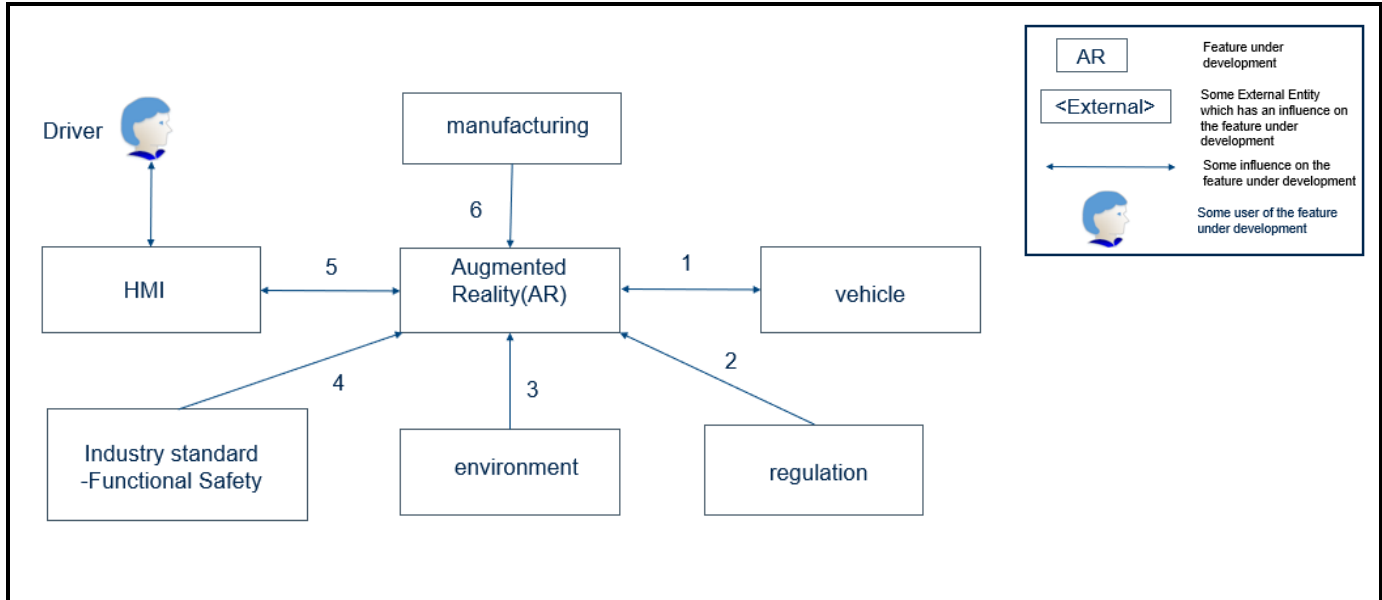
Feature type	Description	Comments
AR	<ul style="list-style-type: none">• AR guide arrow• Destination• Forward Collision Warning (FCW)• LDW/LKA• FVDW 前车启动提示	
voice command/Soft button control	<ul style="list-style-type: none">• AR ON• AR OFF	

3 Architectural Design

3.1 Boundary Diagram

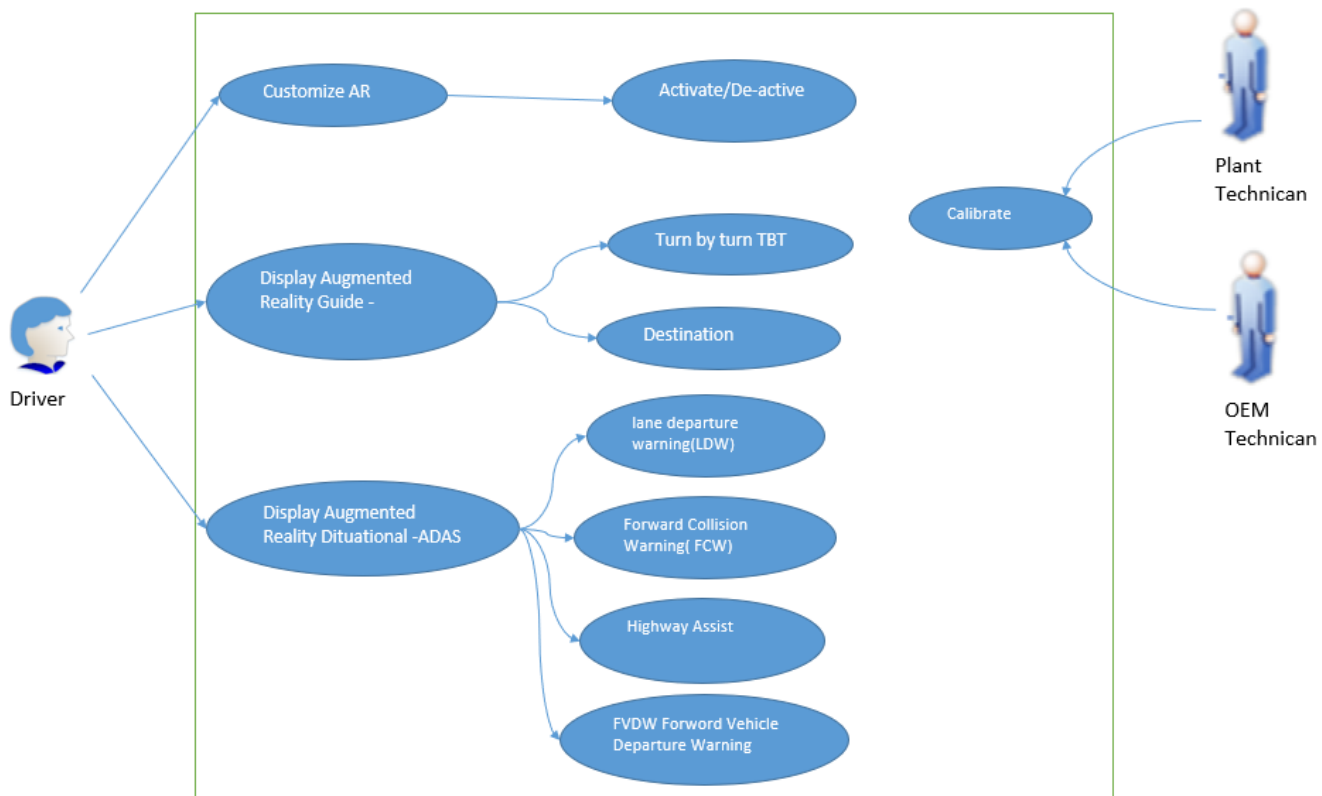


3.2 Context Diagram



ID	External Entity	Influence Description
1	Vehicle	vehicle should have: <ul style="list-style-type: none"> • sync+ • IVI (phase4/5) • AR camera • navigation system, map data, • Vehicle equipped with display for augmented reality (HUD) • DAT2.0 or above
2	Regulation	Meet the requirements called out in section 2.3
3	Environment	Other vehicles, surrounding, day/night, road condition, weather condition
4	Industry Standard	/
5	HMI	HMI contains two ways of driver interaction with the augmented reality feature: <ul style="list-style-type: none"> i) through HMI IVI- customer can select feature On/OFF and customize settings ii) Augmented reality output is display through HUD
6	Manufacturing	Configuration and Calibration of Cameras and ECUs.(ie., AR HUD ,AR Camera, AR ECU)

3.3 Use case Diagram





4 Functional Definition

4.1 AR ON/OFF

4.1.1 Description

- Provide the driver an HMI option, both button and through spoken Voice Recognition Commands, to turn On(default) or Off the AR feature

4.1.2 Use Case

Actors	- User
Pre-conditions	- HUD / IVI are both initialized completed
Scenario Description	- Driver selects the physical HMI option or the Voice Recognition Command HMI option to speak out the voice command to turn Off the AR feature.
Post-conditions	- AR feature is Off; no augmented reality (AR) view will be presented to the Driver at any time during vehicle operation on the AR display.
List of Exception Use Cases	- N/A
Interfaces	-

4.1.3 要求

1.AR 的功能可以通过软开关开启和关闭。

2.AR 增强显示开关位于 HUD 调节子菜单。



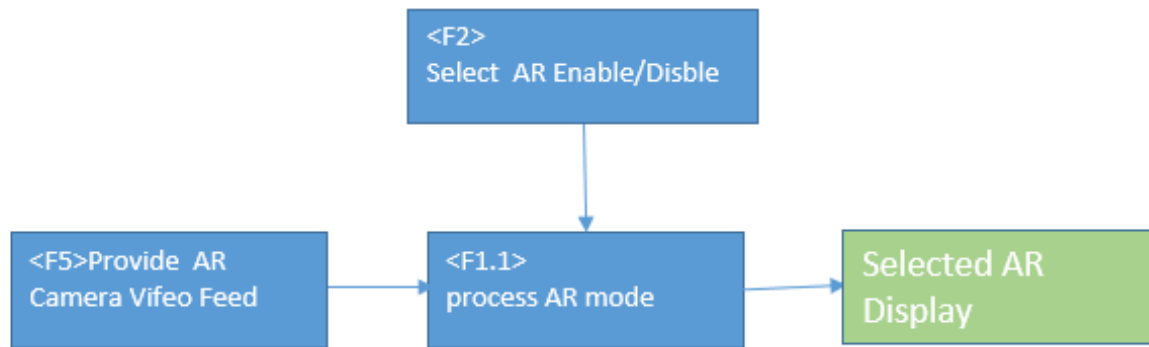
3.AR 开关可以通过语音控制实现开启和关闭。“打开 AR 增强显示”、“打开增强显示”（具体见语音指令。）

4.AR 关闭时，HUD 中以下显示关闭，不影响其他系统显示：

AR 箭头显示，AR 目的地显示，AR 车道线显示，AR 前车标记，前车启动提示。

5.AR 开关记忆顾客操作。

6.AR 开关默认为开。





4.2 AR guide arrow

4.2.1 Description

- Display the augmented reality Turn-by-Turn with a path/arrow on the road, with distance to maneuver, animation, and color change according to the speed of the vehicle approaching the turn point, to follow rather than abstract instructions to the driver.

4.2.2 Use Case

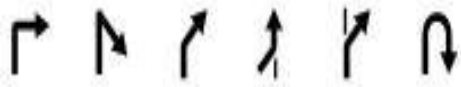
Actors	- User
Pre-conditions	- AR is ON - Navigation is ON - Navigation with active route to destination. - Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display.
Scenario Description	- Vehicle approaches to the point of maneuver - AR pinpoints exact turn location (Near Nav)
Post-conditions	- Road guide arrow is displayed and guide user driving.
List of Exception Use Cases	- N/A
Interfaces	-

4.2.3 要求

1.在距离机动点 100m(城市)/200m（高速）触发箭头指示（距离可实际配置）。

2.机动点通常是两个路径段之间的交汇点，主要包含以下：

直行、变道、掉头、岔路口、合流、环路、转弯（轻微 10-45°、正常 45-135°、大转弯 135-175°）等。



3. 箭头从预备触发到路口指示，动画要流畅过渡。

4.箭头指示准确显示导航信息，符合实际道路信息，不能偏出实际道路。

5.在接收到机动点完成信号，箭头 3s 内消失。

6.箭头显示不能影响顾客的正常驾驶视角。

7.箭头触发到显示的软件延时<100ms。

8.增强现实 AR 功能将不会阻止导航系统在机动转弯点接近时向驾驶员发出的视觉/音频警报。



4.3 Destination

4.3.1 Description

- Display the augmented reality Destination to the driver by adding an overlay symbol to the AR image that starts appearing on the target destination by highlighting the building to help driver locate the specific location of the place

4.3.2 Use Case

Actors	- User
Pre-conditions	- AR is ON - Navigation is ON - Navigation with active route to destination. - Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display.
Scenario Description	- Driver is driving to his/her destination actively using the Navigation system. - Vehicle approaches to target address
Post-conditions	- AR identifies destination by highlighting destination address or Building/landmark name inputted by user (final or/and waypoint).
List of Exception Use Cases	- N/A
Interfaces	- CAN, LVDS, I2C

4.3.3 要求

- 从导航接收到车辆正在接近用户输入的目的地请求，增强现实 AR 功能将触发 AR 窗口。触发距离 d=60m(待定)
- 如果目的地在 HUD FOV 内，目的地图标指示在道路边缘位置。(由于目前导航系统无法将建筑物标定)

如果目的地显示图标超出 HUD FOV，仍应触发 AR 视图，目的地以最邻近的视图进行显示，但目的地图标应附有一个指针，将驾驶员引导至刚好在 FOV 之外的目的地。

- 在导航到达目的地后图标 3 秒后消失。

- 目的地触发到显示的延时 $\leq 100\text{ms}$



4.4 Forward Collision Warning

4.4.1 Description

- Possible collision, vehicle identification, marking and warning, combined with real scene to provide intuitive warning.

4.4.2 Use Case

Actors	- User
Pre-conditions	- AR is ON - Active Drive Assist system (FCW) feature is On
Scenario Description	- Driver activates the FCW feature - FCW function work
Post-conditions	- The vehicle in front is marked and highlighted
List of Exception Use Cases	- N/A
Interfaces	- CAN, LVDS, I2C

4.4.3 要求

- 在 HUD 上标记前方车辆，标记的颜色随着 FCW 系统发送的信号变化。识别车辆使用蓝色，预警黄色，警示显示红色。具体见 HMI。在没有 ADAS 信号时，使用百度识别报警。
- 标记车辆准确，标记要位于车身上。
- 前车标记的延时 $\leq 100\text{ms}$ 。



4.5 LDW

4.5.1 Description

- For the driver's autonomous or involuntary lane departure behavior, through the combination of visual and sound prompts, to inform the user to pay attention to driving safety.

4.5.2 Use Case

Actors	- User
Pre-conditions	- AR is ON - Active Drive Assist system (LDW) feature is On
Scenario Description	- Driver activates the LDW feature - lane departure
Post-conditions	- Off-side lane highlighted
List of Exception Use Cases	- N/A
Interfaces	- TBD

4.5.3 要求

- 车道偏移的信号来自于 ADAS 车道偏移系统。在没有 ADAS 信号时使用百度信号。
- 在接收到车道偏移预警信息时，偏移侧车道显示为黄色，在接收到车道偏移报警时，偏移车车道显示为红色（实际根据 HMI 定义）。具体参考下方信号。
- HUD 中绘制的车道线，要在视觉上与实际车道线贴合，不能有偏移。
- 车道偏移的延时 $\leq 100\text{ms}$ 。



LaActvStats_D2_Dsply Signal	HUD 显示	
0x0 No left - No right 灰	无显示	
0x1 Available left - no right 灰	不显示	
0x2 Suppress left - no right 灰	不显示	
0x3 Warn left - no right 红	左边红色	
0x4 intervene left - Available right 黄	左边黄色	
0x5 no left - Available right 灰	不显示	
0x6 Available left - Available right 白	不显示	
0x7 suppress left - Available right 白	不显示	
0x8 warning left - Available right 红	左边红色	
0x9 intervene left - Available right 黄	左边黄色	
0xA no left - suppress right 灰	不显示	
0xB Available left - suppress right 白	不显示	
0xC suppress left - suppress right 灰	不显示	
0xD warning left - suppress right 红	左边红色	



0xE intervene left - suppress right 黄	左边黄色	
0xF no left - warn right 红	右边红色	
0x10 Available left - warn right 红	右边红色	
0x12 warn left - warn right 红 - 不会出现	不显示	
0x13 intervene left - warn right 红 - 不会出现	不显示	
0x14 no left - intervene right 黄	右边黄色	
0x15 Available left - intervene right 黄	右边黄色	
0x16 suppress left - intervene right 黄	右边黄色	
0x17 warn left - intervene right 红 - 不会出现	不显示	
0x18 intervene left - intervene right 黄 - 不会出现	不显示	



4.6 FVDW

4.6.1 Description

- Through the detection of the front vehicle, the front vehicle is identified. Combined with the judgment of the speed, the vehicle is always in its original state, then the vehicle in front of the vehicle starts the warning.

4.6.2 Use Case

Actors	- User
Pre-conditions	- AR is ON
Scenario Description	- The in front vehicle is identified and go forward. - the vehicle is always in its original state.
Post-conditions	- Pop-up text warning
List of Exception Use Cases	- N/A
Interfaces	- TBD

4.6.3 要求

- 前车启动时显示弹窗提示。
- TTS 播报: 前车已启动。
- 前车识别的延时 $\leq 100\text{ms}$ 。