



Feature Document (FD)

Augmented Reality (AR)

(F003774)

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Important Note

You need to use the RE specification macros provided by the “RE_SpecificationMacroTemplate.dotm” (refer to “Utilities” on [page “Specification Templates” in the RE Wiki](#)) to allow seamless VSEM import of the specification content. **Use only these RE specification macros to create requirements** in this specification. Refer to [“How to use the Specification Templates”](#) on how to enable and use the macros and the requirements templates in this specification.



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1 INTRODUCTION

1.1 Document Purpose

A Feature Document (FD) document specifies **what** the feature shall do and how it shall behave from customer perspective. It should also provide reasoning and background **why** we have the feature in the vehicle.

The FD also serves as an Item Definition as defined by ISO26262 for those features, which follow the Ford Functional Safety process.

To get more information about the concept of feature, function and component level abstraction refer to the [Ford RE Wiki](#). For details on the Ford Functional Safety (ISO26262) process refer to the [Ford Functional Safety Sharepoint](#).

1.2 Document Scope

This Feature Document (FD) specifies the following features:

Feature ID	Feature Name	Owner	Reference
F003774	Augmented Reality	Mahmoud Abdelhamid	https://www.vsemweb.ford.com/tc/launchapp?-attach=true&-s=226TCSession&-o=yZa5vIx\$3NrTDAAAAAAAAAAAAAA&servername=Production_Server

Table 1: Features described in this FD

1.3 Document Audience

The FD is written by the feature owner of Augmented Reality / Occupant Engagement Features. All Stakeholders, i.e., all people who have a valid interest in the feature should read and, if possible, review the FD. It needs to be guaranteed, that all stakeholders have access to the currently valid version of the FD.

1.3.1 Stakeholder List

For the latest list of stakeholders of the feature and their influence refer to [<Put VSEM Link here>](#).

List of Stakeholders

Name	CDSID /phone	Stake	Contact date	Elicitation response	Review worksheet	Review meeting
Yousif, Meisam (M.L.)	myousif	Feature Owner Supervisor	11/23/2019	Accepted	Yes	Yes
Abdelhamid, Mahmoud (M.)	mabdelh1	Feature Owner Lead	11/23/2019	Accepted	Yes	Yes
Alsamarai, Ahmed (A.)	aalsamar	Feature Owner (co-lead)	8/17/2020	Accepted	Yes	Yes
Flores, Luis (L.A.)	lflore70	Feature Owner (co-lead)	8/17/2020	Accepted	Yes	Yes
Ahmed, Fahd	fahmed2	AR Feature Champion / AR Planning Lead	2/10/2021	Accepted	Yes	Yes
Kessler, Chris	ckessle8	Global AR Marketing Lead for Ford and Lincoln	01/25/2021	Accepted	Yes	Yes
King, Anthony (A.G.)	aking6	AR module Product owner Supervisor	8/17/2020	Accepted	Yes	Yes
Langkamp, Ulf (U.K.)	ulangkam	AR module Product owner Engineer	7/31/2020	Accepted	Yes	Yes
Nachtegall, Debbie (D.E.)	dnachte1	AR ECU D&R - Hardware	8/07/2020	Accepted	Yes	Yes



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List of Stakeholders

Name	CDSID /phone	Stake	Contact date	Elicitation response	Review worksheet	Review meeting
Keerthivasan, Venkataraman	vkeerth5	AR ECU D&R – Hardware	6/24/2021	Accepted	Yes	Yes
Vootkuri, ChandraSekhar (C.R.)	cvootkur	AR ECU D&R - Software	8/04/2020	Accepted	Yes	Yes
Lazalde, Eric (E.)	elazald1	HMI lead for the core interaction on the panoramic displays- HHDD	2/4/2021	Accepted	Yes	Yes
To, Curtis (C.S.)	cto3	HMI Supervisor, Customer Experience	8/26/2020	Accepted	Yes	Yes
Khanafer, Dima (D.)	dkhanafe	HMI Engineer, Customer Experience	8/26/2020	Accepted	Yes	Yes
Von hausen, Christian (C.)	cvonhaus	HMI Engineer, Customer Experience	8/26/2020	Accepted	Yes	Yes
Van Moen, Lidia	Ivanmoen	Core Hardware Engineer / ADAS FWC Camera	9/01/2020	Accepted	Yes	Yes
Zaragoza, Claudia	czarago1	Core Hardware Engineer / FIR Camera	10/29/2020	Accepted	Yes	Yes
Saini, Akriti (A.)	asaini10	Core Hardware Engineer / AR Camera	01/19, 2021	Accepted	Yes	Yes
Rahtz, Timothy (T.A.)	trahtz	AR Nav product owner	12/03/2020	Accepted	Yes	Yes
Check, Laura	lburek	IVI/Phoenix Product Owner	8/18/2020	Accepted	Yes	Yes
White, Melissa	mwhite35	Manufacturing point of contact	9/16/2020	Accepted	Yes	Yes
Civiero, Christian	ccivier1	ASO SME for AR	8/17/2020	Accepted	Yes	Yes
Gehrke, Mark	mgehrke2	GTDS #22423 Lead for FIR Camera Project	10/26/2020	Accepted	Yes	Yes
Hiskens, David	dhiskens	GTDS #22423 Co-Lead for FIR Camera Packaging	9/01/2020	Accepted	Yes	Yes
Diedrich, Jonathan (J.)	jdiedris	GTDS #22423 Co-Lead for FIR Camera Calibration	11/16/2020	Accepted	Yes	Yes
Cauvet, Colleen	ccaauvet	GTDS #30199 Lead for (Thermally Enhanced Night vision Features)	8/28/2020	Accepted	Yes	Yes
Dutta, Arun	adutta2	GTDS #30199 Engineer for (Thermally Enhanced Night vision Features)	9/10/2020	Accepted	Yes	Yes
Hurley, Collin	churle15	GTDS #30199 Engineer for (Thermally Enhanced Night vision Features)	9/11/2020	Accepted	Yes	Yes
Farrell, David (D.E.)	dfarre13	Functional Safety SE Lead	9/28/2020	Accepted	Yes	Yes
Dean, Shawn (S.)	sdean44	Functional Safety SE Engineer	9/28/2020	Accepted	Yes	Yes
Balachandran, Vignesh	vbalach4	Functional safety EESE Lead	1/14/2021	Accepted	Yes	Yes
Foresto, Marco (M.P.)	mforesto	Functional architecture	1/14/2021	Accepted	Yes	Yes
Perkins, Steve (S.)	sperki50	Functional architecture	10/21/2020	Accepted	Yes	Yes
Becerra, Alejandro (JABS.)	jbecer16	Feature MBSE Modeler	8/20/2020	Accepted	Yes	Yes
Ortiz Anguiano, Alejandro	aortizan	Feature MBSE Supervisor	8/17/2020	Accepted	Yes	Yes



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List of Stakeholders

Name	CDSID /phone	Stake	Contact date	Elicitation response	Review worksheet	Review meeting
Mahmood, Hamid	hmahmoo3	Pre-PS IVI – CoOps Supervisor	10/12/2020	Accepted	Yes	Yes
Rahman, Moshir	mrhama29	Pre-PS IVI – CoOps Engineer	8/20/2020	Accepted	Yes	Yes
Caballero, Fernando (F.)	fcabal11	FMA Coach Engineer	10/09/2020	Accepted	Yes	Yes
Buchanan, Alan (A.D.)	abuchan1	FMA Coach Lead	1/14/2021	Accepted	Yes	Yes
Fayad, Omar (O.)	ofayad	AR Cybersecurity Requirements	9/11/2020	Accepted	Yes	Yes
Raparathi, Satya (S)	srapart1	AR Cybersecurity Requirements	1/22/2021	Accepted	Yes	Yes
Childers, Chad (C.B)	cchilde1	AR Cybersecurity TARA modeling	9/21/2020	Accepted	Yes	Yes
Kalash, Mohammad (M.)	mkalash	ADAS customer experience	10/28/2020	Accepted	Yes	Yes
Aaron Mills	amills2	AR/DAT point of contact	11/04/2020	Accepted	Yes	Yes
Nath, Nitendra (N.)	nnath	AR/DAT point of contact	8/21/2020	Accepted	Yes	Yes
Sripinyo, Peter (P.P.)	psripiny	Power Mode - Software	2/26/2021	Accepted	Yes	Yes
Affeldt, Matthew (M.D.)	maffeldt	VSEM DAT point of contact	11/05/2020	Accepted	Yes	Yes
Cheng, Gail (L.G.)	gcheng	VSEM IVI point of contact	11/18/2020	Accepted	Yes	Yes
Sun, Jayla	Jsun55	IVI FVSS development engineer	1/17/2021	Accepted	Yes	Yes
Obeidat, Omar (O.A.)	oobeida2	AR GPS (GNSS) Location	10/20/2020	Accepted	Yes	Yes
Schein, Jamey (J.)	jschein2	AR Navigation point of contact	11/17/2020	Accepted	Yes	Yes
Medl, Chris (C.)	cmcdl	AR Phoenix Signals point of contact	1/19/2021	Accepted	Yes	Yes
Roseman, Matthew (M.)	mrosema8	AR Phoenix product owner	1/19/2021	Accepted	Yes	Yes
Olzewski, Chet	colzewsk	SIM Engineer	6/24/2021	Accepted	Yes	Yes
Rahtz, Timothy (T.A.)	trahtz	AR Navigation point of contact	11/17/2020	Accepted	Yes	Yes
Yu, Diven (D.W.)	dyu12	DuerOS module owner supervisor	6/08/2021			
Li, Qiyang (Q.)	QLI111	DuerOS module owner	6/08/2021			
Yang, Frank (F.)	FYANG36	PMT China	6/08/2021			
Ding, Sunny (X.)	XDING13	China local solution AR Nav Owner	6/08/2021			
Strackbein, Maria (M.)	mstrackb	E-Horizon Lead	6/24/2021			

1.4 Document Organization

1.4.1 Document Context

Refer to the [Specification Structure page](#) in the [Ford RE Wiki](#) to understand how the FD relates to other Ford Requirements Documents and Specifications.



1.4.2 Document Structure

The structure of this document is explained below:

Introduction	– Explains how to use this document including responsibilities and requisite documents. Explains the terminology. Gives a clarification of the definitions, concepts and abbreviations used in the document.
Feature Overview	– States briefly the background and the purpose of the feature, feature variants and corresponding regions and markets. Also includes input requirements, assumptions and constraints.
Feature Context	– describes all external entities, which have an influence on the feature.
Feature Modeling	– Contains Use Case, Driving Scenarios, State Charts to describe the functional behavior of the feature.
Feature Requirements	– Lists functional and non-functional requirements of the feature.
Functional Safety Cybersecurity	<ul style="list-style-type: none">– Lists System Behaviors, Safety Goals and Safety Requirements of the feature.– Lists Security Goals and Security Requirements of the feature.
Architecture	– Shows the coarse architecture, which the feature requirements are deployed to. Describes the elements and the boundary of the feature as well as the decomposition and distribution of associated functions.
Open Concerns	– List of Open Concerns
Revision History	– Document Change History including a list of new or modified requirements. The requirements in this document are tagged, and this section contains different types of tables listing all, new, or changed requirements by their title and page no.
Appendix	– Appendix

1.5 Document Conventions

1.5.1 Requirements Templates

Refer to [“How to use the Specification Templates”](#) on how to use the specification templates and the VBA macros to create/edit the requirements in the specifications.

The VBA macro enable the import of the specification to VSEM (refer to ["How to import specifications into VSEM as separate requirements"](#)).

1.5.1.1 Identification of requirements

The unique requirement ID given in the headline of any requirement follows the requirement throughout the development process. The requirement ID format follows a well-defined syntax.

All identifiers in a FD shall be composed of 4 parts:

- A leading prefix, which indicates the type of requirement (R=Requirement, UC=Use Case, SC=Scenario, ...)
- A prefix, which indicates the abstraction level (F=Feature, FNC=Function, CMP = component).
- Followed by a name, indicating the scope, which the requirement belongs to (e.g. feature or function name)
- Ending with the actual requirement number

Example:

R_F_AutoLamps_00004

This is the fourth requirement on feature level for the feature Autolamps.



1.5.1.2 Requirements Attributes

The templates provided by *Specification_Macros.dotm* define a list of attributes for each requirement. This helps to classify the requirement. The attributes are explained at [RE Wiki - Requirements Attributes](#).

1.6 References

1.6.1 Ford Documents

List here all Ford internal documents, which are directly related to the feature.

Reference	Title	Doc. ID	Document Location	Revision
N/A				

Table 2: Ford internal Documents

1.6.2 External Documents and Publications

The list of external documents could include books, reports and online sources.

Reference	Document / Publication	Document Location
N/A		

Table 3: External documents and publications

1.7 Glossary

1.7.1 Definitions

Definition	Description
Blending Capability	It is the ability of the system to combine the thermal (FIR-Cam) or night vision image with the standard video image from the augmented reality camera (visible) by highlighting the person or objects you cannot regularly see in dark or low light environments using the visible camera to provide a better driver experience.
Driver	Entity being presumed to drive the vehicle; target of this feature is to provide guidance/situational awareness

Table 4: Definitions used in this document

1.7.2 Abbreviations

Abbr.	Stands for	Description
ADAS	Advanced Driver Assistant System	
APIM	Accessory Protocol Interface Module,(Phoenix Domain Controller)	Phoenix
AR feature	Augmented Reality feature – Scope of this document	
AR-CAM	Augmented Reality Camera (visible)	
AR-ECU	Augmented Reality Electronic Control Unit (New Hardware)	
BCM	Body Control Module	
CAM	Camera	
TBT	Turn-by-Turn	
ECG	Enhanced Central Gateway	
FIR-CAM	Far Infrared Camera (Night Vision Camera)	



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Abbr.	Stands for	Description
FNV3	Fully Networked Vehicle-3; Allows different vehicle domains with a standard interface to allow them to work together.	
FOV	Field Of View	
GNSS	Global Navigation Satellite System	
GPS	Global Positioning System (the US GNSS system)	
HHDD	High Head Down Display (Panoramic Display), External display for AR content	
HMI	Human-Machine Interface	
MVP	Minimum Viable Product	
OEM	Original Equipment Manufacturer	
OTA	Over the Air updates	
PDB	Power Distribution Box	
POI	Point of Interest	
TCU	Telematics Control Unit	
DuerOS	China SYNC Operating System (equivalent to Phoenix in U.S)	
KOL	Key OFF Load	
EH	Electronic Horizon	

Table 5: Abbreviations

1.7.3 Parameters / Values

Name	Description	Range / Resolution
Augmented_Reality_Cfg	Configuration to denote feature enabled/disabled on the vehicle	0 x 0 == OFF 0 x 1 == ON; No FIR Camera (vehicle not equipped) 0 x 2 = ON; with FIR Camera (vehicle is equipped)

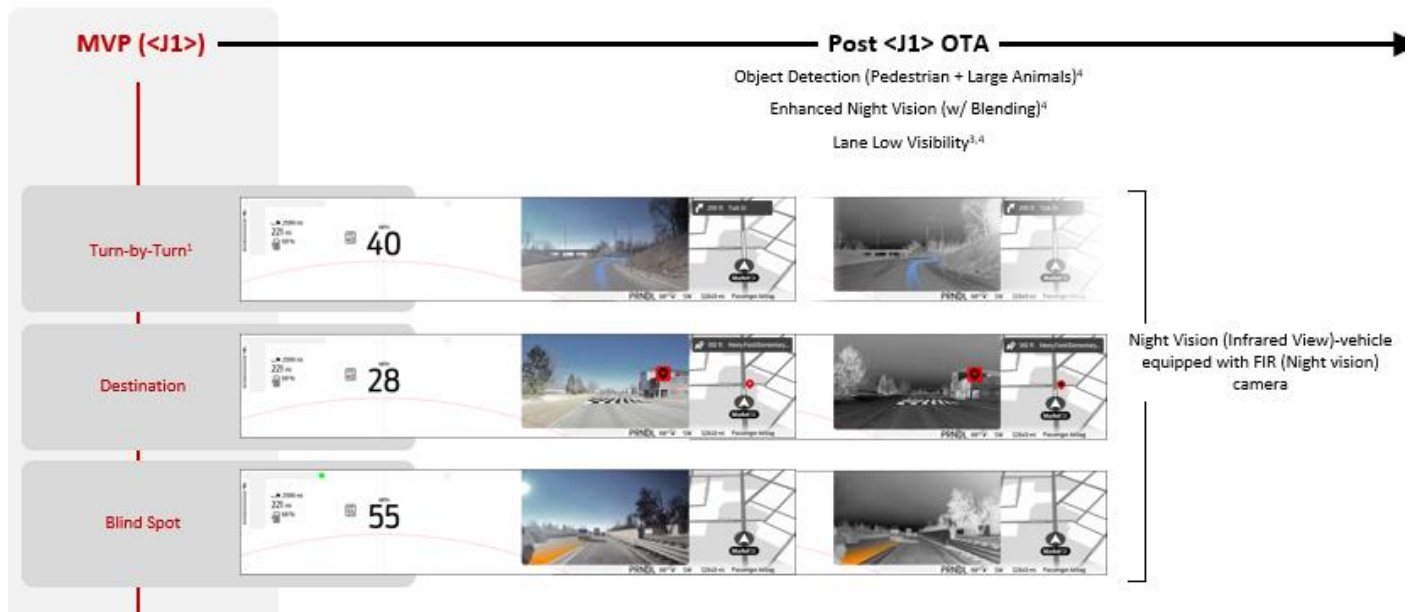
Table 6: Parameters / Values used in this document



2 FEATURE OVERVIEW

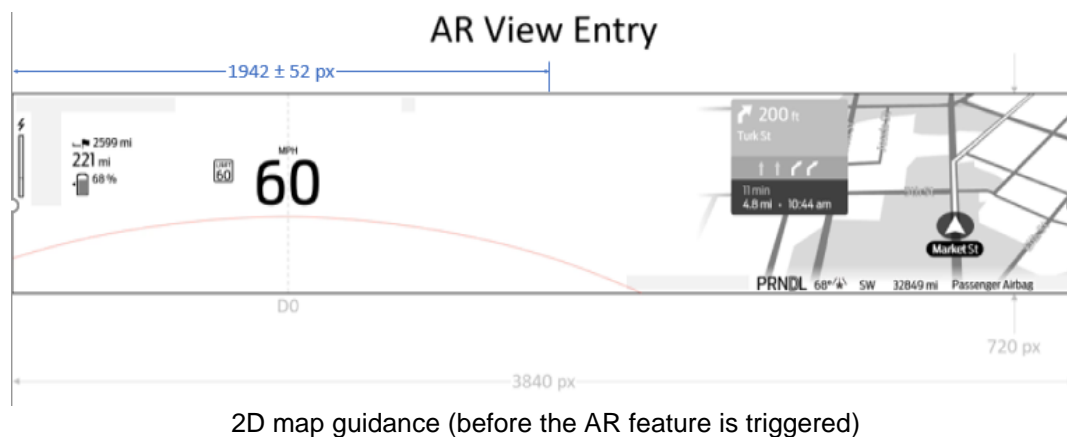
2.1 Purpose and Description of Feature

Augmented Reality (AR) feature displays virtual augmented information (Guide, Situational awareness, night vision capability) to the driver. Augmented Reality (AR) When target(s) in the environment may not be immediately obvious to the driver / passengers due to obstructions, information density, etc., the AR feature highlights or exposes the target(s) to the driver / passengers. This is a new feature to Ford but implemented in competitive vehicles as Mercedes, GM Cadillac, others.



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 feature is contextually triggered to optimize value and mitigate potential driver distraction, just the right content at the right moment.

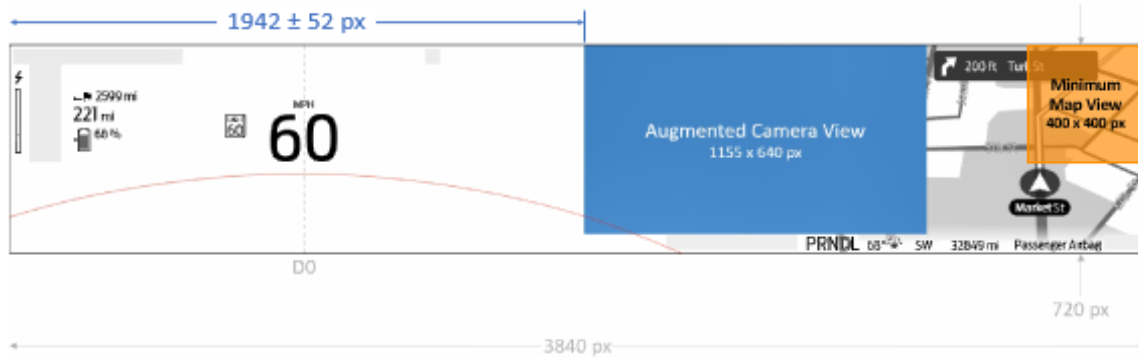
- The augmented camera view is contextually triggered to optimize value and mitigate potential driver distraction. This behavior will be consistent for all AR MVP features.
- The virtual imagery is purposefully concise, only showing what is necessary to mitigate driver distraction (i.e., cognitive capture) and facilitate feature interplay.
- AR is not presumed to be a complete environmental awareness solution to any situation. The augmented camera view works in concert with other information in the display to tell the entire story to the driver.



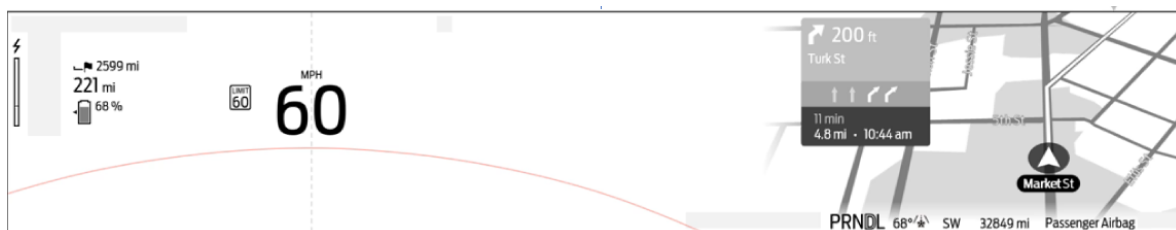


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AR View Entry



AR view Entry, when AR feature is triggered and active (Augmented Camera view is displayed and 2D map are shifted to the right and minimized)



Normal 2D map guidance resumes once AR camera window is closed

2.2 Feature Variants

Variant Name	Variant Description	Remarks
AR MVP <J1> – base “This variant” “Part of this document”	MVP- Feature Baseline: Provide navigation and situational awareness contents with high vision capability w/o blending. Include the following - <ul style="list-style-type: none">• Turn by Turn- MVP variant• Destination; - MVP variant• Blind Spot; - MVP variant• Night Vision Content: All above feature with Night Vision w/o Blending Capability between AR and FIR camera – if vehicle equipped with FIR camera - - MVP variant	Support MY24 Programs GE2 CDX746/747; U718; target for implementation is <J1> GE2. Night vision has GTDS 30199 & #22423
AR Near (Post <J1>- OTA) “NOT part of this document”	Enhance feature content by including: <ul style="list-style-type: none">• Object (Pedestrian/Large Animals) detection• Night vision with Blending capability between AR and FIR cameras• Lane Low Visibility	Target for implementation is post <J1> OTA; GTDS projects are: GTDS #30199 / GTDS #30242 / GTDS #30544

Table 7: Feature Variants



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Feature Owner:
M. Abdelhamid

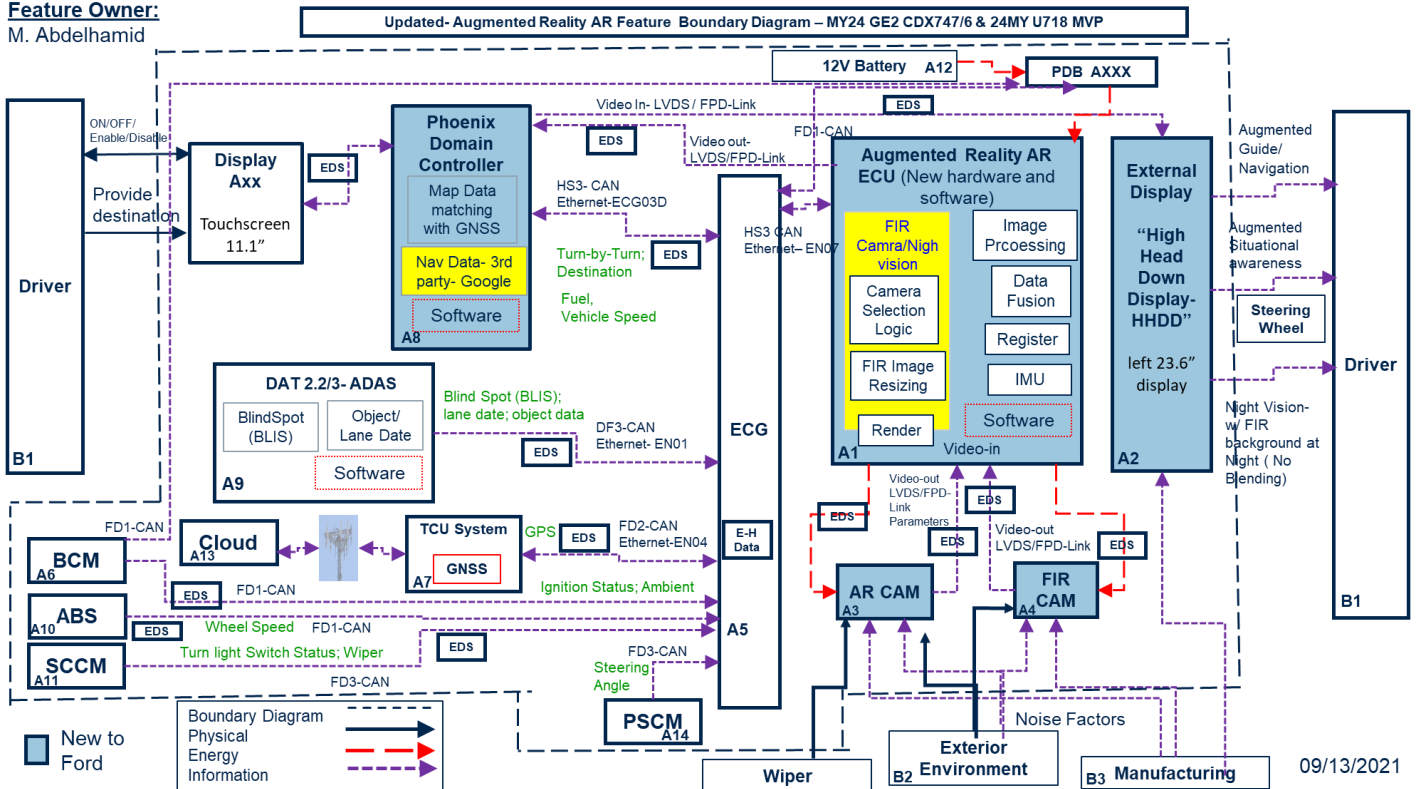


Figure- AR Feature Boundary Diagram

2.2.1 Regions & Markets

Market / Region	North America	South America	Europe	IMG	China
Variant Name					
AR CDX746 Enhanced Navigation System (MFAL code #HKCAT)	Yes BASE VERSION (In pack) PREMIUM VERSION (Standard)	-	Yes PREMIUM VERSION (In pack)	-	-
AR CDX747 Enhanced Navigation System (MFAL code #HKCAT) Camera Front Night Vision (MFAL code # J3QAE)	Yes <i>RESERVE VERSION HKCAT (In pack); J3QAE (In pack)</i> <i>BLACK LABEL VERSION</i>	-	TBD	-	Yes CDX747 – China Select Version : HKCAT (Standard); J3QAE (Not offered) CDX747 – China Reserve: HKCAT (Standard); J3QAE (Optional) CDX747 – China Precedential: HKCAT



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	<i>HKCAT (In pack); J3QAE (In pack)</i>				(Standard); J3QAE (Standard)
AR U718 Enhanced Navigation System (MFAL code #HKCAT) Camera Front Night Vision (MFAL code # J3QAE)	Yes	-	TBD	-	Yes U718- China LWB Ultra Presidential : HKCAT (Standard); J3QAE (Standard) U718- China SWB Presidential: HKCAT (Optional); J3QAE (Not offered)

Table 8: Regions & Markets (Note refer to program PDL for the latest offer: CDX747/6 PDL- 24MY CDX746/747 PDL Review & Sign-off and U718 PDL - link to iPDL.)

2.3 Input Requirements/Documents

Reference (Reference as listed in ch. "References")	Section/Requirement	Description	Derived Requirement (optional – reference to requirement in ch. "Feature Requirements")
Attribute Requirements			
N/A			
Ford Engineering Standards			
N/A			
Legal Regulations			
	FMVSS101		The Feature shall comply with FMVSS101.
Industry Standards			
	ISO 26262		The system should be developed according to Ford's implementation of Functional Safety.
Other Sources			
	None		



Table 9: Input Requirements/Documents

2.4 Lessons Learned

N/A first implementation.

2.5 Assumptions

- FNV3 architecture and above
- Vehicle equipped with new hardware and software for AR ECU module
- Vehicle equipped with Phoenix Domain Controller and above (for China DuerOS)
- Vehicle equipped with display for augmented reality (HHDD)
- Vehicle equipped with AR camera
- For night vision capability, vehicle equipped with FIR camera
- Vehicle equipped with navigation system, map data.
- Vehicle equipped with DAT 2.2 and above
- Connectivity/active modem subscription to support notification
- The FIR Camera (if vehicle is equipped) is packaged within the following packaging distance/position compared to AR Camera with enough FOV:
 - 6" in X and Y, and 2" in depth maximum separation for full blending.
 - If AR and FIR Camera packaging not within full blending, the FIR camera shall package TBD distance to allow for partial/selective blending.
- The AR Camera shall be packaged within a 6-inch distance and within a 5% FOV to the DAT (FWC) camera.
- AR camera is only offered with the 100 degree in same bracket as FWC ADAS camera (FWC offered with 100 degree).
- Vehicle equipped with ADAS feature (BLIS) to offer Augmented version of these features.
- Vehicle equipped with TCU (Gen5 and above) to support ethernet capabilities.
- Vehicle equipped with ECG2 and above with Electronic Horizon (EH) support.

3 FEATURE CONTEXT

3.1 Feature Context Diagram

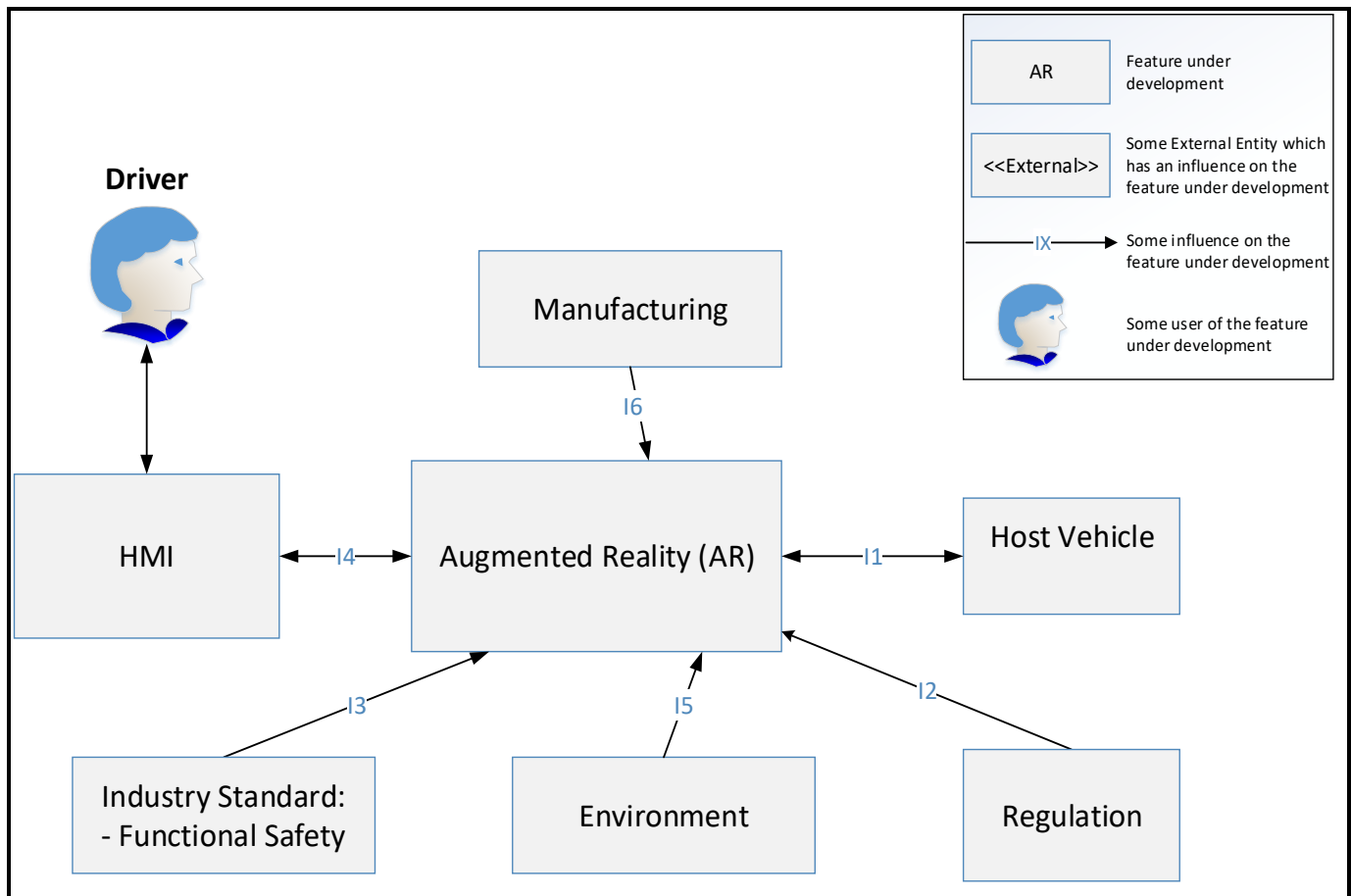


Figure 1: Context Diagram

3.2 List of Influences



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ID	External Entity	Influence Description
I1	Host vehicle	Host vehicle should have: <ul style="list-style-type: none">• AR ECU module software and hardware• Phoenix Domain Controller and above (for China DuerOS)• AR camera• For night vision capability, vehicle equipped with FIR camera• Navigation system, map data• DAT 2.2 or above• FNV3 electrical architecture or above• Vehicle equipped with display for augmented reality (HHDD)• Connectivity/active modem subscription to support notification• Turn signal indicator• Light sensor• ADAS feature (BLIS)• TCU (Gen5 and above) to support ethernet capabilities.• Vehicle equipped with ECG2 and above with Electronic Horizon (EH) support.
I2	Regulation	Meet the requirements called out in section 2.3
I3	Industry Standard	Meet any Functional Safety specific requirements/measures called out in section 6 and 7.
I4	HMI	1) Customer can select feature On/OFF and customize settings ii) Display of augmented reality feature output
I5	Environment	Other vehicles, surrounding, day/night, road condition, weather condition
I6	Manufacturing	Configuration and Calibration of Cameras and ECUs (i.e., AR-ECU, AR Camera, FIR Camera)

Table 10: List of Influences



4 FEATURE MODELING

4.1 Operation Modes and States

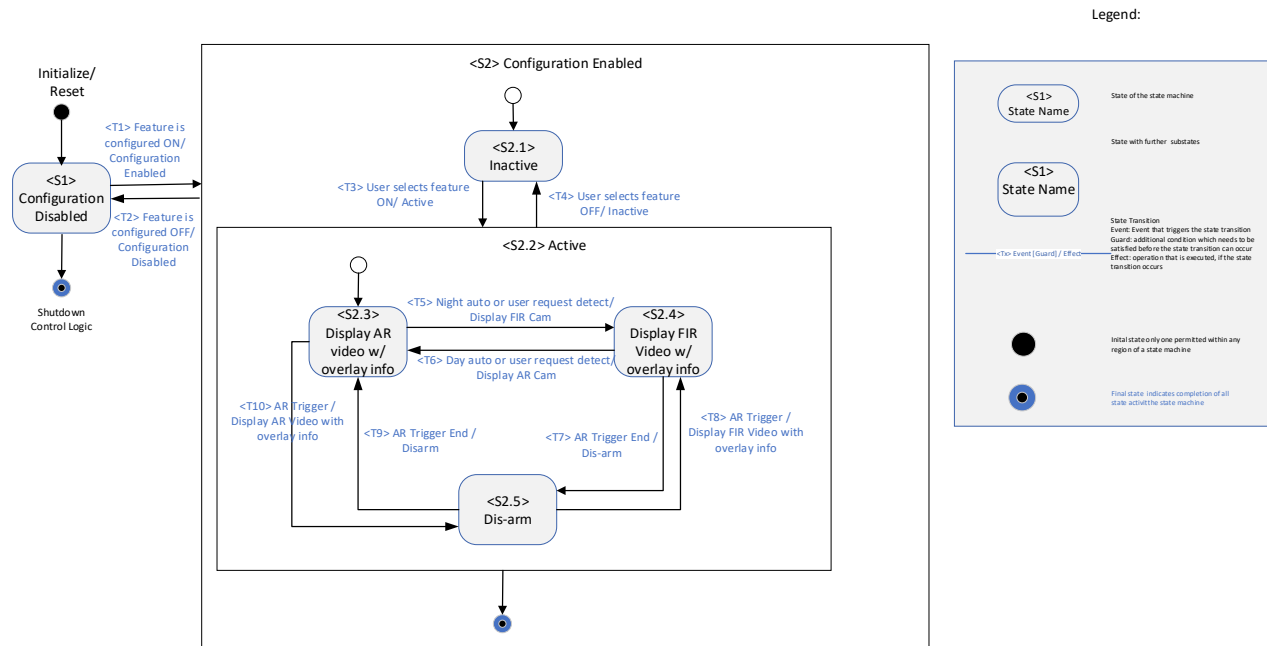


Figure 2: Feature Operation Modes and States

State	Description	Requirements Reference (optional)
S1	Configuration Disabled: Feature configuration Disabled by EOL/manufacture	
S2	Configuration Enabled: Feature configuration Enabled by EOL/manufacture	
S2.1	Inactive: User selects feature OFF	
S2.2	Active: User selects feature ON	
S2.3	Display Augmented reality AR video with overlay info	
S2.4	Display Augmented reality FIR video with overlay info	
S2.5	Disarm – stop display augmented reality once the event trigger completed	

Table 11: Operation Modes and States

Transition ID	Description	Requirements Reference (optional)
T1	Feature is configured ON/Configuration Enabled	
T2	Feature is configured OFF/Configuration Disabled	
T3	User selects feature ON	
T4	User selects feature OFF	
T5	Night auto or user request detect	
T6	Day auto or user request detect	
T7	AR Trigger End / Dis-arm	
T8	AR Trigger / Display FIR Video with overlay info	
T9	AR Trigger End / Disarm	
T10	AR Trigger / Display AR Video with overlay info	



Table 12: Transitions between Operational Modes and States

4.2 Use Cases

4.2.1 Use Case Diagram

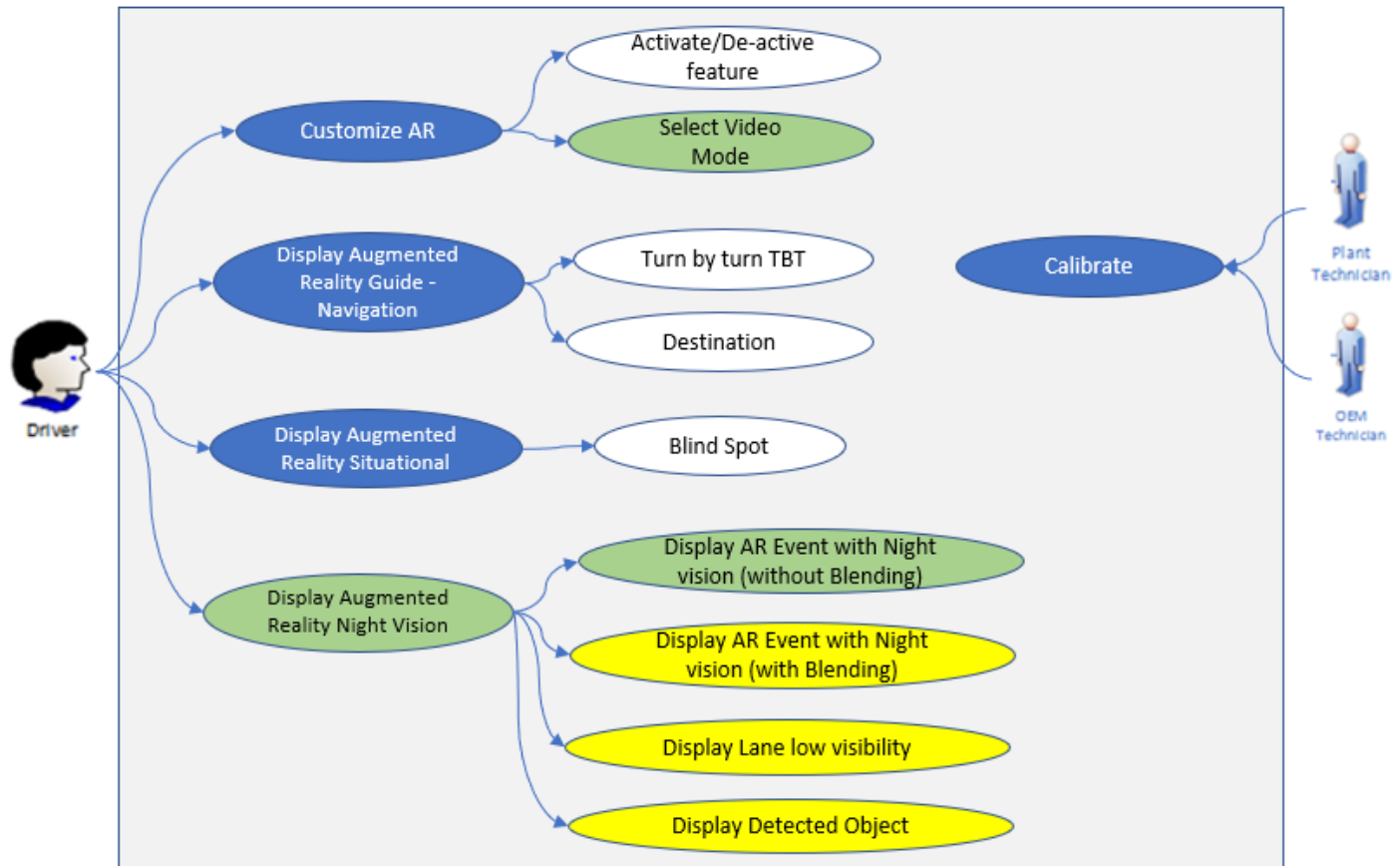


Figure 3: Use Case Diagram

(Note: use cases highlighted in Green – only if vehicle is equipped with FIR Camera; highlighted in Yellow is still WIP – target post <J1> OTA and only if vehicle is equipped with FIR camera)

4.2.2 Actors

Actor	Description
Driver	The customer interfaces with the AR-System over the displays (HHDD) in the vehicle where navigation guidance, driver assistant information and other information is provided. The customer shall be able to personalize the AR functionality, as well as activate/deactivate the visualization. Details will be provided through the UX specifications.
Plant Technician	The Ford Plant interacts with the system during vehicle assembly and sensor calibration. The sensors used by the AR-System require calibration in the Plant.
OEM Technician	Ford Service interacts with the system for fault diagnostics and re-calibration in case of a repair that led to a misalignment of the sensors. The sensors used by the AR-System require calibration in Service.

Table 13: List of Actors



Feature Document Augmented Reality (AR)

4.2.3 Use Case Descriptions

###UC_F_Augmented Reality_00001### AR On(default) / Off

Purpose		Provide the driver an HMI option (physical to turn On (default) or Off the AR feature.
Actors		Driver.
Precondition		AR is On (default) / Off.
Main Flow	M1	Driver selects the physical HMI option to turn Off the AR feature.
Alternate Flow	AF1	Driver selects the physical HMI option to turn On(default) the AR feature.
Post-condition	PC1	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.
	PC2	AR feature is On (default); augmented reality (AR) view will be presented to the Driver contextually during vehicle operation on the AR display.

###UC_F_Augmented Reality_00002### Select AR Video mode Enable(default) / Disable (If vehicle is equipped with FIR camera)

Purpose		Provide the driver an HMI option to select AR video mode (i.e., AR Night Vision) (physically) as: 1. Disable - Use visible camera only. When disabled, the RGB (AR) camera remains the AR view background regardless of whether the outside light levels. Note, this setting does not deactivate the FIR camera. If the vehicle is equipped with the FIR camera, it will be continuously active to monitor the environment and detect objects deemed a threat. 2. Enable (default) - Camera switches to FIR camera as the AR view background when "low" levels of light is detected, return to RGB camera as the AR view background when exterior light levels rise above "low" level thresholds.
Actors		Driver.
Precondition		AR feature is On. Vehicle is equipped with FIR camera AR video mode is Enable(default) / Disable
Main Flow	M1	Driver selects the physical HMI option to Disable the AR video mode (AR Night vision).
Alternate Flow	AF1	Driver selects the physical HMI option to Enable (default) the AR video mode (AR Night Vision).
Post-condition	PC1	AR video mode is Disable - Use visible camera only. When disabled, the RGB (AR) camera remains the AR view background regardless of whether the outside light levels. Note, this setting does not deactivate the FIR camera. If the vehicle is equipped with the FIR camera, it will be continuously active to monitor the environment and detect objects deemed a threat.
	PC2	AR video mode is Enable(default) - Camera switches to FIR camera as the AR view background when "low" levels of light is detected, return to RGB camera as the AR view background when exterior light levels rise above "low" level thresholds.



Feature Document Augmented Reality (AR)

###UC_F_Augmented Reality_00003### Display Augmented Reality Guide AG-Nav Turn-by-Turn

Purpose		Display the augmented reality Turn-by-Turn with a path/arrow on the road, with animation, and arrow color change according to the speed of the vehicle compared to speed limit while approaching the turn point
Actors		Driver
Precondition		AR feature is ON Navigation is ON Navigation with active route to destination. Driver selected AR Video Mode (AR Night vision) as: Enable(default) or Disable on the AR feature HMI
Main Flow	M1	Driver is driving to his/her destination actively using the Navigation system
	M2	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	M3	Vehicle approaches to the point of maneuver and the maneuver is within FoV of the camera
	M4	AR window is triggered
	M5	<ul style="list-style-type: none"> a) AR window show an AR real image as background depend on the AR video mode selection (AR night vision) <ul style="list-style-type: none"> i) Using the AR-Camera (visible) only as image background ii) or AR-Camera/FIR-Camera (automatic switch depends on light level detection) b) with overlay of the path/arrow to follow on the road, with animation, and color change according to the speed of the vehicle approaching to the point of maneuver. c) The 2D map resized and shift to the right of AR window to show 2D map guidance (along with the AR window).
	M6	Driver performs the maneuver following the guide on the AR display.
Post-condition	PC1	If the next maneuver is not within turn by turn distance of the current maneuver and turn is completed (trigger from NAV), the AR view closes 3 seconds after completing the maneuver per the specified exit animation treatment. Display shows the Navigation 2D map guidance resumes once the turn has been executed.
	PC2	Consecutive Maneuvers: If there is a consecutive maneuver immediately after the upcoming maneuver and this consecutive maneuver is within the camera FoV, then the consecutive maneuver is represented by a white path that extends from the upcoming turn path arrow.
	PC3	<i>Object Occlusion:</i> If the path arrow appears to be overlaying an object (e.g., other vehicles on the road) in the environment, the portion of the fill of the path arrow that is overlaying the object becomes transparent. The stroke of the path arrow shall stay the same.



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###UC_F_Augmented Reality_00004### Display Augmented Reality Guide AG-Nav Street Names, Note: Removed Not supported by Google

Purpose		Display the augmented reality Street Names by making real world elements pop by highlighting them in different sizes or colors. Street name is a subset of Turn by Turn, only showed when there is a trigger from NAV and when relative to route to destination.
Actors		Driver
Precondition		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.
Main Flow	M1	Driver is driving to his/her destination actively using the Navigation system.
	M2	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	M3	Vehicle approaches to the point of maneuver.
	M4	AR pinpoints exact turn location (Near Nav) and AR view is triggered by distance and speed relative to maneuver.
	M5	The display switches to show an AR real image as background, AR-Camera (visible) only or AR-Camera/FIR-Camera with light level detection, based on driver's AR Video Mode selection with augmented reality Street Names by making real world elements pop by highlighting them in different sizes or colors.
	M6	Driver performs the maneuver following the guide on the AR display
Post-condition		Display shows the Navigation 2D map guidance resumes, once the turn has been executed.

###UC_F_Augmented Reality_00005### Display Augmented Reality Guide AG-Nav House Number – Note-Removed – Not supported by Google

Purpose		AR system augments and overlays the numbers of the houses or building/landmark names by making real world elements pop by overlaying them on top of the objects and make them more visible and draw driver's attention to them.
Actors		Driver
Precondition		AR is ON Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display.
Main Flow	M1	Driver sets up a destination address (house number) on the Navigation, Navigation is turned On.
	M2	Driver is driving to his/her destination address actively using the Navigation
	M3	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	M4	Vehicle approaches to target address
	M5	AR view is triggered by distance (Near Nav) and speed relative to destination.
	M6	The display switches to show an AR real image as background, AR-Camera (visible) only or AR-Camera/FIR-Camera with light level detection, based on driver's AR Video Mode selection with augmented overlay of House Numbers on top of the objects and making them more visible to draw driver's attention to them.



Feature Document Augmented Reality (AR)

	M7	AR overlays the house number on the drive when approaching the target house. Final house number is treated like "Destination POI" and only 1 house number appears when approaching.
Alternate Flow 1	AF1	Driver is driving to his/her destination with Navigation without a set route, or Navigation is turned Off (Driver driving without a route)
	AF2	Driver speaks out Voice Command request (e.g. "Show me house numbers") to Navigation system or Via navigation predicted route (through adaptive vehicle workstream) and at current vehicle speed.
	AF3	If vehicle speed is below 25 mph or below current residential speed limit, then the AR view is triggered (Near Nav).
	AF4	The display switches to show an AR real image as background, AR-Camera (visible) only or AR-Camera/FIR-Camera with light level detection, based on driver's AR Video Mode selection with augmented overlay of House Numbers on top of the objects and making them more visible to draw driver's attention to them.
	AF5	AR overlays 4 house numbers on the drive of the vehicle at a time.
	AF6	AR highlights frequent destination points for the driver via "predicted route" from Navigation system.
	AF7	With navigation routing disabled, a series of 4 house numbers (matching the side of the specific destination house) appear on the drive when approaching target house at dTBT (NAV ON by setting house as destination or predicting the target house by getting the signal from Google)
Post-condition	PC1	AR identifies in plain sight the house number that is relevant to the driver at the address of destination.
	PC2	<ul style="list-style-type: none"> *—AR identifies in plain sight the house numbers that are relevant to the driver on his driving. AR view closes 4 seconds after last house number has been passed regardless of whether the maximum number of house numbers has been shown in series. *—AR view closes 4 seconds after no house number is displayed

###UC_F_Augmented Reality_00006### Display Augmented Reality Guide AG-Nav Points of Interest (POI)—Note – Removed not supported by Google

Purpose		AR system augments and overlays by highlighting those POIs that best align with driver's preference and identifies in plain sight the POIs that are relevant and preferred, driver can activate this functionality by both physical HMI or Voice Recognition Commands controls.
Actors		Driver
Precondition		AR is ON Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display.
Main Flow	M1	Driver selects the physical HMI option on the Navigation System to select the nearby POI or using Voice Recognition Command HMI option to speak out the POI voice command (e.g. "show me nearby restaurants")
	M2	Driver selects one POI from the list offered by the Navigation System ((Driver driving with active route)
	M3	Display shows AR view (Near Nav).
	M4	The display switches to show an AR real image as background, AR-Camera (visible) only or AR-Camera/FIR-Camera with light level detection, based on driver's AR Video Mode selection.



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	M5	AR can respond to the needs of the driver's current situation by identifying in-plain-sight the POIs that are relevant and preferred or history POIs, by utilizing augmented reality items/symbols overlaid on the real AR image on the display
Alternative Flow	AF1	Driver driving to his/her destination without active route
	AF2	Driver use Voice Recognition Command HMI option to speak out the (e.g. "show me nearby restaurants") or POI info categories that are required for the "smart selection" or personalization of POIs.
	AF3	Display shows AR view (Near Nav).
	AF4	The display switches to show an AR real image as background, AR-Camera (visible) only or AR-Camera/FIR-Camera with light level detection, based on driver's AR Video Mode selection.
	AF5	AR can respond to the needs of the driver's current situation by identifying in-plain-sight the POIs that are relevant and preferred, by utilizing augmented reality items/symbols overlaid on the real AR image on the display
Post-condition		<ul style="list-style-type: none"> • AR highlights those POIs that are highly rated and represent the Driver's familiarity and preferences. Every POI fades out after showing statically when it's outside the FOV. • No cropping of the POI (it sticks and then fade away—at less than 50% of POI showing within the location of the POI) • Starts appearing back when more than 50% of the actual POI showing fade-in

###UC_F_Augmented Reality_00007### Display Augmented Reality Guide AG-Nav Destination

Purpose		Display the augmented reality Destination to the driver once the request is received from navigation that the vehicle is approaching the destination. If the destination is within the camera FoV, then the destination icon appears based on the specified scaling dynamics. When a destination falls outside FoV, the AR view is still triggered. The destination icon is accompanied by a pointer that directs the driver to the destination that is just outside the FoV. A checkered pattern is applied on the roadway adjacent to the destination location.
Actors		Driver
Precondition		AR feature is ON Navigation is ON Navigation with active route to destination. Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display.
Main Flow	M1	Driver is driving to his/her destination actively using the Navigation system.
	M2	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	M3	Vehicle approaches to target destination and destination within AR camera FOV
	M4	AR window is triggered
	M5	<ul style="list-style-type: none"> a) AR window show an AR real image as background depend on the AR video mode selection (AR night vision) <ul style="list-style-type: none"> i) Using the AR-Camera (visible) only as image background ii) or AR-Camera/FIR-Camera (automatic switch depends on light level detection) b) with overlay symbol that start appearing on the target destination based on a specified scaling dynamics.



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		c) The 2D map resized and shift to the right of AR window to show 2D map guidance (along with the AR window). The accompanying 2D map will show the exact location of destination
	M6	A checkered pattern is applied on the roadway adjacent to the destination location.
Alternative Path	A1	Driver is driving to his/her destination actively using the Navigation system.
	A2	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	A3	Vehicle approaches to target destination and destination NOT within AR camera FOV
	A4	AR window is triggered
	A5	<ul style="list-style-type: none"> a) AR window show an AR real image as background depend on the AR video mode selection (AR night vision) <ul style="list-style-type: none"> i) Using the AR-Camera (visible) only as image background ii) or AR-Camera/FIR-Camera (automatic switch depends on light level detection) b) with overlay symbol that start appearing on the target destination based on a specified scaling dynamics. The destination icon is accompanied by a pointer that directs the driver to the destination that is just outside the FoV. c) The 2D map resized and shift to the right of AR window to show 2D map guidance (along with the AR window). The accompanying 2D map will show the exact location of destination
Post-condition	PC1	AR window closes 3 seconds after reaching the destination.

###UC_F_Augmented Reality_00008### Display Augmented Lines AL- Blind Spot Information System (BLIS)

Purpose		Display the augmented reality Blind Spot Information System (BLIS) to the driver as an highlight carpet on the AR HMI display when the driver has an object on the blind spot of his/her vehicle and has activated the turn signal indicator towards that direction.
Actors		Driver
Precondition		AR Feature is ON Blind Spot Indicator System (BLIS) is ON. Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display.
Main Flow	M1	Driver is driving
	M2	Driver activates the left (/right) turn signal indicator.
	M3	Driver has an object on the left (/right) blind spot of the vehicle (there is an obstacle is in specific blind spot)- BLIS is active
	M4	AR window is triggered through current BLIS system and turn indicator activity
	M5	<ul style="list-style-type: none"> a) AR window show an AR real image as background depend on the AR video mode selection (AR night vision) <ul style="list-style-type: none"> i) Using the AR-Camera (visible) only as image background ii) or AR-Camera/FIR-Camera (automatic switch depends on light level detection)



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		<ul style="list-style-type: none">b) with overlay “carpet” in the left (/right) lane (aligned with turn signal direction activity).c) The 2D map resized and shift to the right of AR window to show 2D map guidance (along with the AR window). The accompanying 2D map will show the exact location of destination
Post-condition	PC1	AR window closes when signal indicator is deactivated or when blind spot is clear of objects for greater than 3 seconds.

###UC_F_Augmented Reality_00009### Display Augmented Lines AL- Lane Low Visibility-

Note: post <J1> OTA feature – Still WIP

Purpose		Lane low visibility still WIP , this is part of post <J1> OTA, more details will be cascaded once it is ready. Below the 1-pager from CIED team.

Post <J1> OTA

Guide – Lane Low Visibility

Insights & User Goals

Moment Mapping

Nadine is nervous driving on the large expressways in low visibility morning fog on the California coast. She can barely make out lane lines and is worried about leaving her lane – or the roadway. As conditions worsen, an options pops up on her driver information display that allows her to turn on a “enhance vision” feature via her steering wheel controls. Once Nadine switches on this feature her display uses sensor, high-resolution location, image processing and map data to hint at a likely path without obstacles, helping her confidence in maintaining her lane.

Problem

Lane lines may be obscured or not visible in inclement conditions. This may include rain, fog, snow, dust, sun glare, and/or other debris that obstructs the actual lane markings and thus how to negotiate the vehicle. This increases driver workload / stress and reduces driver confidence.

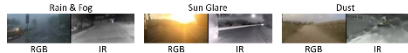
Human Goals Targeted

1. I know where I’m going next and how long it will take to get there.
2. The car informs me of changing conditions along my route.
3. I am a (more) confident driver in this car.
4. The right information is there when and where I need it.
5. The information the car gives me is relevant to the situation I am in.
6. The car makes me aware of things that might be difficult for me to see.
7. The car helps me maintain awareness of all important information.
8. I can handle changing situations with less effort when driving.
9. I do not need to learn anything to understand the interface information.
10. With this car, my vision is never impaired by environmental factors (e.g., sun, fog, night, etc.)

Concept Description

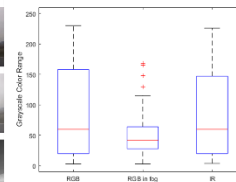
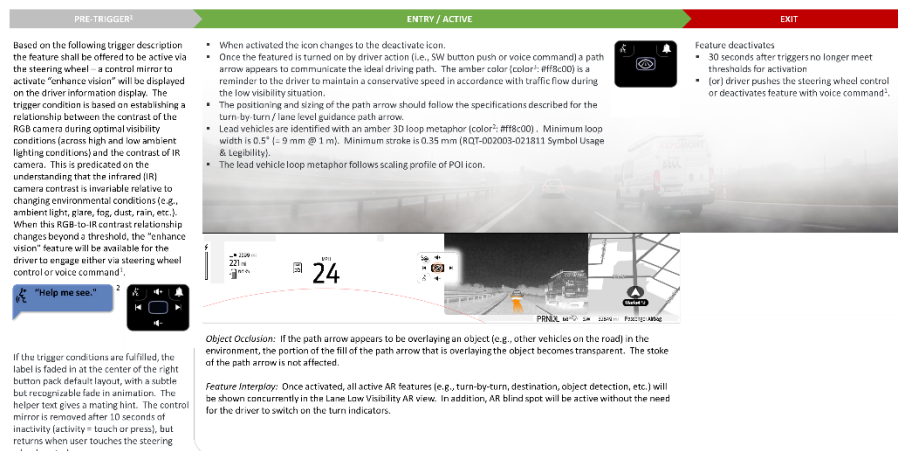
Visual Imagery to show the most probable path for the driver (i.e., navigation without an active route). Triggered by user because of following assumptions:

- System lack of knowledge about low visibility (what is considered low visibility).
- Augmented camera view provides improved benefit over existing enablers.
- Environmental context is important to communicate to the driver.
- Lane markers are not necessary - path showing where to go in the lane is enough (same as green NAV path; pointed arrow is always included).
- Function of speed – path starts at the bottom of the screen and extends as the speed increases; distance that is at a comfortable breaking speed.
- Occlusion needed – path still show and “box” around lead vehicle boundaries.



1 This strategy requires alignment and support from R&A to progress.
2 Voice commands not supported by Google for <J1>.
3 Final graphics and colors to be specified by Design Studio.

Triggers



This plot illustrates how the color range of the RGB camera degrades with fog. This represents a decrease in the overall contrast of the driving scene. This change in color range, as measured relative to the IR camera, can be used to trigger feature availability.



Feature Document Augmented Reality (AR)

###UC_F_Augmented Reality_00010### Display Augmented Lines AL- Lane Level Guidance - MVP+
Variant - Note: Removed not supported by Google

Purpose		Display the augmented reality AL-Lane Level Guidance with a path/arrow to follow rather than abstract instructions to the driver
Actors		Driver
Precondition		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.
Main Flow	M1	Driver is driving to his/her destination actively using the Navigation system
	M2	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	M3	Vehicle approaches to a point of maneuver
	M4	AR pinpoints exact turn location (Near Nav), It is shown to setup an upcoming maneuver (i.e., turn-by-turn) or a maneuver to evade an environmental object.
	M5	The display switches to show an AR real image as background, AR-Camera (visible) only or AR-Camera/FIR-Camera with light level detection, based on driver's AR Video Mode selection with overlay of the Blue path/arrow to follow on the road, with distance to maneuver, animation, and color change according to the speed of the vehicle approaching to the point of maneuver.
	M6	Driver performs the maneuver following the guide on the AR display.
Alternative Flow 1	AF1	Driver is driving to his/her destination actively using the Navigation
	AF2	Display is showing Navigation 2D map guidance (Far Nav) with route to follow
	AF3	The display shows an AR real image as background with overlay of Timely-Situational Guidance: Guide away from obstacle or hazards
	AF4	Driver performs the maneuver following the guide on the AR display
Post-condition		<p>If the next maneuver is not within lane level guidance distance of the current maneuver and turn is completed (trigger from NAV) and AR view closes 2-seconds after completing the maneuver per the specified exit animation-treatment.</p> <p><i>Consecutive Maneuvers:</i> If there is a consecutive maneuver immediately after the upcoming maneuver and this consecutive maneuver is within the FoV of the AR camera view, then the consecutive maneuver is represented by a white path that extends from the upcoming turn path arrow.</p> <p><i>Object Occlusion:</i> If the path arrow appears to be overlaying an object (e.g., other vehicles on the road) in the environment, the portion of the fill of the path arrow that is overlaying the object becomes transparent. The stroke of the path arrow shall stay the same.</p> <p>Display shows the Navigation 2D map guidance resumes, once the maneuver has been executed.</p>



Feature Document Augmented Reality (AR)

###UC_F_Augmented Reality_00011### Display Augmented Lines AL- Lane Biasing- MVP+ Variant
Note- Removed not recommended by CIED team for HHDD application-

Purpose		Display the augmented reality AL- Lane Biasing with a highlight of the object and correlate that object to the slight change in path to the left (/right) side of the road when the car is biasing to the left (/right) side of the lane because of an- encoming object on the right (/left) side of the vehicle.
Actors		Driver
Precondition		AR is ON Driver selected AR Video Mode Enable(default) / Disable for the AR HMI- display. Active Drive Assist System (ADAS) feature that allows driver for Hands-Off / Eyes-On Driving in Blue Zones is ON, i.e. when in ADA (Active Drive Assist= Highway Assist) or limited mode (ACC+Lane Centering)
Main-Flow	M1	Driver is driving actively using the Active Drive Assist (ADAS) feature that- allows driver for Hands-Off / Eyes-On Driving in Blue Zones
	M2	Another object is approaching the car through the right (/left) side of the vehicle
	M3	Lane Biasing signal triggers the AR display represents or highlights the object- and correlate that object to the slight change in path to the left (/right) side of the road to communicate the driver why the vehicle is deviating from the center- of the lane.
	M4	The car biases to the left (/right) side of the lane to give more space to the- encroaching object in the adjacent lane.
Post-condition		After the vehicle has completed the bias maneuver on trajectory the AR image- disappears from the AR display.

**###UC_F_Augmented Reality_00012### Highway Assist or called Active Drive Assist system or Blue
Cruise- Far Variant- need to be tied to Lane Biasing use Case)**
Note- Removed not recommended by CIED team for HHDD application

Purpose		Display the augmented reality Highway Assist with a highlighted representation- of the path of the Blue Zones on the highway. The metaphor is persistent until- the Blue Zone comes to an end.
Actors		Driver
Precondition		AR is ON Driver selected AR Video Mode Enable(default) / Disable for the AR HMI- display. ADA (Highway Assist) feature is On
Main-Flow	M1	Driver is on the Highway with his/her vehicle.
	M2	Driver activates the Highway Assist feature
	M3	AR screen is triggered when Highway Assist (ADA) is active. AR display shows- the highway lane marked to communicate the driver. The guidance metaphor is- the representation of the path of the Blue Zones on the highway.
Post-condition		The AR metaphor is persistent until the Blue Zone comes to an end. AR metaphor is ended



Feature Document Augmented Reality (AR)

~~###UC_F_Augmented Reality_00013### Assisted Lane Change or called Active Drive Assist system or Blue Cruise – Far Variant need to be tied to Lane Biasing use Case)~~
~~Note- Removed not recommended by CIED team for HHDD application~~

Purpose		Display the augmented reality Lane Change Assist with a highlighted representation of the proposed path for a lane change to be performed by the vehicle. The AR metaphor is persistent until the Lane Change Assists comes to an end.
Actors		Driver
Precondition		AR is ON Driver selected AR Video Mode Enable(default) / Disable for the AR HMI display. Vehicle is in a Blue Zone highway Highway Assist feature (ADAS) is active or limited mode (ACC plus Lane Centering)
Main Flow	M1	Driver is on the Highway with his/her vehicle.
	M2	Driver has activated the Highway Assist feature or limited mode (ACC plus Lane Centering)
	M3	The vehicle reaches to a front vehicle driving at a slower speed
	M4	The Assisted Lane Change from ADAS signals the driver that an Assisted Lane Change might be helpful to continue the trip at the previous speed
	M5	AR screen changes the position of the path that was showing him the lane he was in. Lane Guidance maneuver with metaphor to differentiate between suggestion versus action (i.e. color)
	M6	Driver accepts the prompt for Lane Change Assisted by activating the turn-signal switch
	M7	Vehicle performs maneuver when the lane is available
Post-condition		The AR metaphor is persistent until the Lane Change Assists comes to an end. AR metaphor is ended

###UC_F_Augmented Reality_00014### Calibration of Augmented Reality feature

Purpose		Allow the calibration of the Augmented Reality (AR) feature
Actors		Technician
Precondition		AR feature not calibrated Vehicle engine is ON
Main Flow	M1	Technician prepare the vehicle to follow calibration procedure
	M2	Technician follows calibration procedure for the vehicle
	M3	Technician verifies that calibration procedure has been successful
Post-condition		Vehicle AR feature is calibrated according to specifications and performs as indicated on the user's manual.

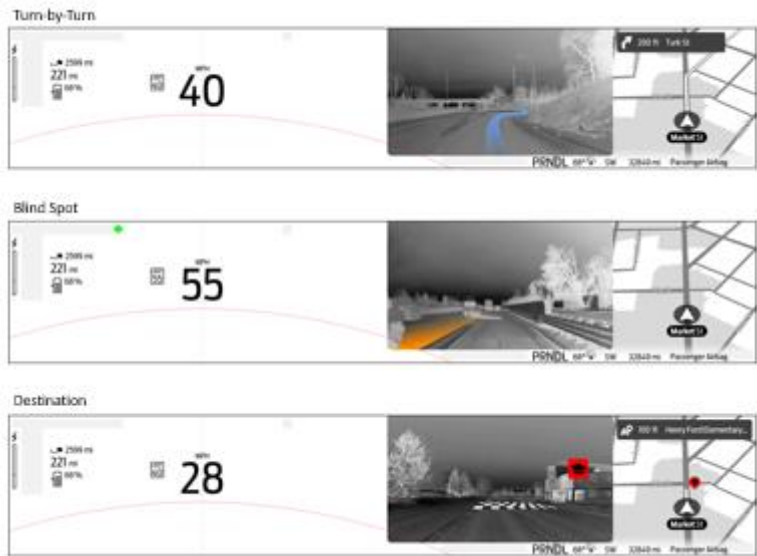


Feature Document Augmented Reality (AR)

###UC_F_Augmented Reality_00015### ~~Street Name – In-active route- WIP/Not defined yet, TBD for MVP variant, currently not available due to Google signal availability~~
Note- Removed not supported by Google-







Purpose		Street Name (Under Investigation for Route Inactive), triggered by voice-command-
Actors		
Precondition		
Main-Flow		
Post-condition		

###UC_F_Augmented Reality_00016### AR Event with Night Vision (Without Blending)

Purpose		Display all the augmented reality events (Turn by turn; destination; blind spot) at day and night
Actors		Driver
Precondition		AR Feature is ON Turn by turn; destination; or BLIS triggers are active
Main Flow	M1	Driver selects "Enable" in the AR Video mode (Night vision) setting – If vehicle is equipped with FIR camera
	M2	The AR feature switches to the FIR camera as the AR view background when "low" levels of light is detected
	M3	Display the AR Events using FIR camera as the AR view background 
Alternative Flow	A1	Driver selects "Enable" in the AR Video mode (Night vision) setting – If vehicle is equipped with FIR camera
	A2	The AR feature switches to the AR camera as the AR view background when "High" levels of light is detected
	A3	Display the AR Events using AR camera as the AR view background



Feature Document Augmented Reality (AR)


		<p>Turn by Turn</p>  <p>Destination</p>  <p>Blind Spot</p> 
Alternative Flow	B1	<p>Driver selects “Disable” in the AR Video mode (Night vision) setting, if the vehicle is equipped with FIR camera. Note: This is always the case if the vehicle does not equip with FIR camera</p>
	B2	<p>The AR feature uses visible camera only. When disabled, the RGB (AR) camera remains the AR view background regardless of whether the outside light levels. Note, this setting does not deactivate the FIR camera. If the vehicle is equipped with the FIR camera, it will be continuously active to monitor the environment and detect objects deemed a threat.</p>
	B3	<p>Display the AR Events using AR camera as the AR view background</p> <p>Turn by Turn</p>  <p>Destination</p>  <p>Blind Spot</p> 
Post-condition	PC1	<p>AR window closes when related events (turn by turn, destination, blind spot) ends.</p>



Feature Document Augmented Reality (AR)

###UC_F_Augmented Reality_00017### Enhanced AR Night vision with Blending (If vehicle is equipped with FIR Camera)-

Note: post <J1> OTA feature – Still WIP

Purpose	Enhanced Night Vision (w/ Blending) – Post <J1> OTA . When available, current assumption is for the blended RGB/IR view to replace the FIR view. More investigation is needed to understand how to leverage the blending technology in a way that highlights salient elements in the scene to the driver. Below 1-pager from CIED team
	<div><h4>Enhanced Night Vision (w/ Blending) – Post <J1> OTA</h4><p>When available, current assumption is for the blended RGB/IR view to replace the IR view. More investigation is needed to understand how to leverage the blending technology in a way that highlights salient elements in the scene to the driver.</p></div>
Note	<p>See Table 2.5 assumptions for the blending. There are multiple R&A GTDS projects: #30199 / GTDS #30242 / GTDS #30544 in progress.</p> <ul style="list-style-type: none">i) The current R&A work highlighted that in order to do full blending, the FIR Camera shall be packaged within 6" in X and Y, and 2" in depth maximum separation distance/position compared to AR camera with enough FOV.ii) The current lead program 24MY CDX747 is NOT meet this packaging requirement, hence other R&A current work is to (Partial blending) based on current FIR/AR camera location. This is still WIP and no requirements currently availableiii) For 24MY U718, the packaging is still under way and no conclusion yet about latest FIR camera location.



Feature Document Augmented Reality (AR)

###UC_F_Augmented Reality_00018### Object Detection with Infrared Camera (If vehicle is equipped with FIR Camera)-

Note: post <J1> OTA feature – Still WIP

Purpose	Object detection– Post <J1> OTA . Below 1-pager from CIED team Note: There are multiple R&A GTDS projects: #30199 / GTDS #30242 / GTDS #30544 in progress. More details are not ready yet.
---------	---

Post <J1> OTA

Object Detection with Infrared Camera

Insights & User Goals

Moment Mapping

Nadine is nervous driving on the large expressways in low visibility morning fog on the California coast. She can barely make out lane lines and is worried about not being able to see potential hazards on the roadway along her path. Her vehicle uses the infrared camera as a sensor by processing the real-time IR video and highlighting objects that may pose a threat to her.

Problem

Inconsistent weather condition (e.g., fog, rain, sun glare, snow, etc.) and changing road conditions (e.g., dust, debris, etc.) impair the driver's visibility of the forward road scene. This may diminish the driver's ability to discern objects, such as pedestrian and large animals, that may enter the vehicle's path.

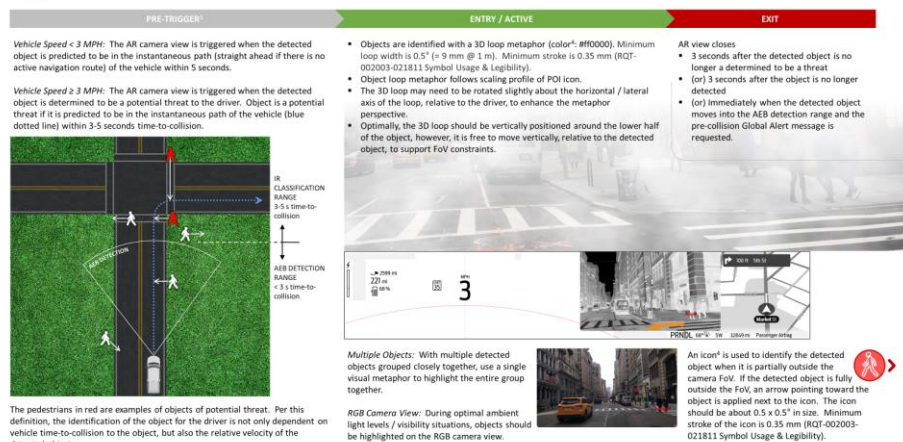
Human Goals Targeted

1. I am a [more] confident driver in this car.
2. The right information is there when and where I need it.
3. The information the car gives me is relevant to the situation I am in.
4. The car makes me aware of things that might be difficult for me to see.
5. The car helps me maintain awareness of all important information.
6. I can handle changing situations with less effort when driving.
7. I do not need to learn anything to understand the interface information.
8. With this car, my vision is never impaired by environmental factors (e.g., sun, fog, night, etc.)

Concept Description

Visual imagery to highlight pedestrian and large animals that may be a potential threat to the driver.

Triggers



The pedestrians in red are examples of objects of potential threat. Per this definition, the identification of the object for the driver is not only dependent on vehicle time-to-collision to the object, but also the relative velocity of the detected object.

At less than 3 seconds time-to-collision, the AEB system would detect and react to nearby objects. When AEB is active, the pre-collision assist popup message, a Global Alert message, would override any AR camera view. Pre-collision assist is active at approximately 3 MPH¹.

RGB vs. IR Camera FoV Differences & Transition



In the case that the FoV of the IR camera is smaller than that of the RGB camera, prescribe a zoom in animation when transitioning from the RGB camera to IR camera view to leverage the pixel density of the IR camera view. At the start of the animation, the IR camera view should be scaled such that environmental elements are 1:1 relative to those seen in the RGB camera view.

¹ This strategy requires alignment and support from R&A to progress.

² For Collision Avoidance with Automatic Emergency Braking, I Ford Note To I Ford

³ Wang L, Dixon KK, Li H, Ogilvie J. Normal Acceleration Behavior of Passenger Vehicles Starting from Rest at All-Way Stop-Controlled Intersections. *Transp Res Rec: Journal of the Transportation Research Board*. 2004; 1883(1):158-166.

⁴ Final graphics and colors to be specified by Design Studio.



4.3 Driving and Operation Scenarios

None.

4.4 Decision Tables

None.



5 FEATURE REQUIREMENTS

5.1 Functional Requirements

~~###R_F_Augmented Reality_00001### Augmented Reality feature to work on Run ignition status-~~

~~The Augmented Reality (AR) feature shall be able to operate while the ignition is on Run status-~~

Note- This requirement is replaced by new requirement "R_F_Augmented Reality_00146### AR feature to be powered only on Normal and Factory KOL modes"

End-of-Requirement

###R_F_Augmented Reality_00002### Augmented Reality AR feature to be powered only on Normal and Factory KOL modes

The Augmented Reality feature shall NOT be powered unless the last known Key OFF Load (KOL) modes value of the vehicle is "Normal" or "Factory", followed table below.

3.4.5 Determine KOL Mode

KOL Mode is a simple combination of Ignition Status, LifeCvcMde D Actl and Sleep Mode.

<u>Rqm't Num.</u>	<u>Ignition Status</u>	<u>LifeCvcMde D Actl</u>	<u>Sleep Mode</u>	<u>KOL Mode</u>
R: 3.4.2-1	RUN START ACC	Don't care	Don't care	NORMAL
R: 3.4.2-2	OFF	FACTORY	Don't care	FACTORY
R: 3.4.2-3	OFF	TRANSPORT	Don't care	TRANSPORT
R: 3.4.2-4	OFF	NORMAL	NORMAL	NORMAL
R: 3.4.2-5	OFF	NORMAL	HIBERNATE	HIBERNATE
R: 3.4.2-6	OFF	NORMAL	CRITICAL_BATT	CRITICAL_BATT

End of Requirement

###R_F_Augmented Reality_00003### Turn AR On / Off by physical control

The Augmented Reality (AR) feature shall provide the driver an HMI physical control to turn feature On/OFF

End of Requirement

~~###R_F_Augmented Reality_00004### Turn AR On / Off by voice command control-~~

~~Note: Removed voice commands NOT supported by Google~~

~~The Augmented Reality (AR) feature shall provide the driver an HMI Voice Recognition Command control to turn feature On/OFF, i.e. "Turn ON AR"~~

~~Note: Deleted, voice command not supported by Google~~

End-of-Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00005### AR default state is On

The augmented reality feature shall have the default state of being turned On.

End of Requirement

###R_F_Augmented Reality_00006### AR Video Mode (AR Night Vision) selection by physical control – Only if vehicle is equipped with FIR Camera

The augmented reality feature shall provide the driver an HMI physical control to select AR Video mode (AR Night vision) as:

1. Enable: The AR feature switches automatically between the AR vs FIR camera based on the AR Outside Light Level Adaptation.
2. Disable: The AR feature uses AR visible camera only

End of Requirement

###R_F_Augmented Reality_00007### AR Video selection by voice command control-

Note: Removed voice commands NOT supported by Google

The augmented reality feature shall provide the driver an HMI Voice Recognition Command control to select AR Video mode – AR Outside Light Level Adaptation

1. "Turn ON night vision"=Enable – The AR feature switches automatically between the AR vs FIR camera based on the AR Outside Light Level Adaptation.
2. "Turn OFF night vision"=Disable: The AR feature uses AR visible camera only

End of Requirement

###R_F_Augmented Reality_00008### AR Video mode (AR Night vision) default selection is Enable – Only if vehicle is equipped with FIR camera

The augmented reality feature shall provide the driver with the AR video mode (AR Night vision) default selection of Enable.

End of Requirement

###R_F_Augmented Reality_00009### AR selection memory

The following customer selection AR settings shall stay as individual driver preference for the upcoming ignition key cycles unless the driver overwrites it on the HMI settings:

- AR status ON/OFF
- AR video mode selection Enable/Disable

End of Requirement

###R_F_Augmented Reality_00010### AR detection of Navigation status



Feature Document Augmented Reality (AR)

The AR feature shall detect the navigation status Active/Inactive route

End of Requirement

###R_F_Augmented Reality_00011### AR receiver of Navigation information

The AR feature shall be able to receive from navigation the turn by turn and destination related information.

End of Requirement

###R_F_Augmented Reality_00012### AR Trigger by Event

The augmented reality AR feature shall be:

- 1) Request start show AR window in the HMI when triggered by related events (i.e., Navigation system, ADAS system, or environmental conditions)
- 2) Request stop show AR window in the HMI when the related AR duration are completed (see requirement #15).

End of Requirement

###R_F_Augmented Reality_00013### Augmented Reality Display

The Augmented Reality (AR) feature shall provide an adequate display to show the driver the AR window. The display of augmented reality feature shall be located with minimal interface with steering wheel location and positioned in such a way that avoids impairment of the windshield or the driver line of sight to avoid any driver distraction and vehicle controllability issues

End of Requirement

###R_F_Augmented Reality_00014### Augmented Reality Video Feed Background

The Augmented Reality (AR) feature shall be able to display the AR event with AR or FIR view background depending on the AR night vision selection by the driver and availability of FIR camera in the vehicle as below:

- a) If the vehicle is equipped with FIR camera AND driver selects setting for "AR Night Vision (AR video Mode) Enable (default) – The Camera shall switch to FIR camera as the AR view background when "low" levels of light is detected, return to AR (RGB) camera as the AR view background when exterior light levels rise above "low" level thresholds.
- b) If vehicle is equipped with FIR camera AND driver selects setting for "AR Night Vision (AR video Mode) Disable, then the AR (RGB) camera shall be only use as the AR view background regardless of the outside light levels.
 - This "Disable" setting shall keep the FIR camera active to continuously monitor the environment and detect objects (once available).
- c) If the vehicle is NOT equipped with FIR camera, then the AR (RGB) camera shall be only use as the AR view background regardless of the outside light levels.

- | |
|---|
| a) If the vehicle is equipped with FIR camera AND driver selects setting for "AR Night Vision (AR video Mode) Enable (default) – The Camera switches to FIR camera as |
|---|



Feature Document Augmented Reality (AR)

the AR view background when "low" levels of light is detected, return to AR (RGB) camera as the AR view background when exterior light levels rise above "low" level thresholds.

- b) If vehicle is equipped with FIR camera AND driver selects setting for "AR Night Vision (AR video Mode) Disable, then the AR (RGB) camera will be only use as the AR view background regardless of the outside light levels.
- c) If the vehicle is NOT equipped with FIR camera, then the AR (RGB) camera will be only use as the AR view background regardless of the outside light levels.

End of Requirement

###R_F_Augmented Reality_00015### AR view duration

The Augmented Reality (AR) feature shall stop displaying the AR view/content after the AR event ends as below:

Guide – Turn-by-Turn:

- If the next maneuver is not within turn by turn distance of the current maneuver and turn is completed (trigger from NAV), the AR view closes 3 seconds after completing the maneuver per the specified exit animation treatment.

- Guide – Destination:

- AR view closes 3 seconds after reaching the destination.

- Blind Spot:

- AR view closes when signal indicator is deactivated or when blind spot is clear of objects for greater than 3 seconds.

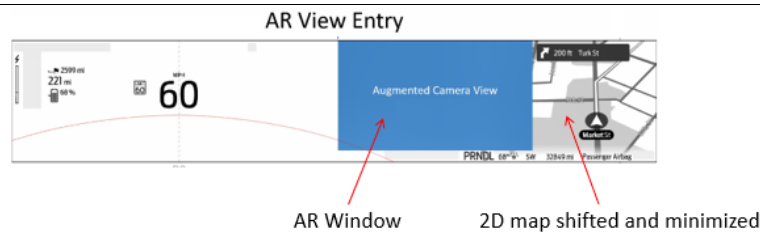
End of Requirement

###R_F_Augmented Reality_00153### AR Window vs Minimized and Shift the 2D Map

If the AR event is triggered, the Augmented Reality (AR) feature shall show the AR window in the HMI and the 2D map is minimized and shift to the right of the AR window.



Feature Document Augmented Reality (AR)



If the AR event is triggered, the Augmented Reality (AR) feature shall show the AR window in the HMI and the 2D map is minimized and shift to the right of the AR window.

End of Requirement

####R_F_Augmented Reality_00016#### Overlay AG-Nav Turn-by-Turn

The Augmented Reality feature shall overlay rendered augmented Turn-by-Turn advise with overlay of the path/arrow to follow on the road when the Navigation system triggers the next maneuver for the driver to reach its destination, if maneuver is within AR camera FoV.

End of Requirement

####R_F_Augmented Reality_00017#### Guidance Path with Pointed Arrow (Maneuver Type Available)

If the maneuver type is available at the maneuver point, the augmented reality AR feature shall provide a guidance path with pointed arrow depending on the maneuver type to communicate an upcoming maneuver to the driver.

End of Requirement

####R_F_Augmented Reality_00018#### Pointed Blue Arrow laid down on the road

The augmented reality AR feature shall provide a pointed arrow with Blue color (color: #669df6) laid down on the road/street as below

- The pointed arrow shall extent from the bottom of the camera view or fade into view to guide the path of maneuver for the driver.
- The entire arrowhead of the path arrow shall be always be visible in the FoV (so that the arrowhead is clearly visible at far distances)
- On turns (i.e., if the arrowhead is not pointed forward), the arrowhead shall be rotated to face the camera instead of lie flat on the road

End of Requirement

####R_F_Augmented Reality_00019#### Center the pointed arrow to the Vehicle

The augmented reality AR feature shall display the tale of the turn by turn path arrow centered to the vehicle and extend as far as possible within the FoV.

End of Requirement

####R_F_Augmented Reality_00020#### No AR view if coming maneuver is Not within FOV



Feature Document Augmented Reality (AR)

The augmented reality AR feature shall show no AR camera view, if the turn is not within the FoV.

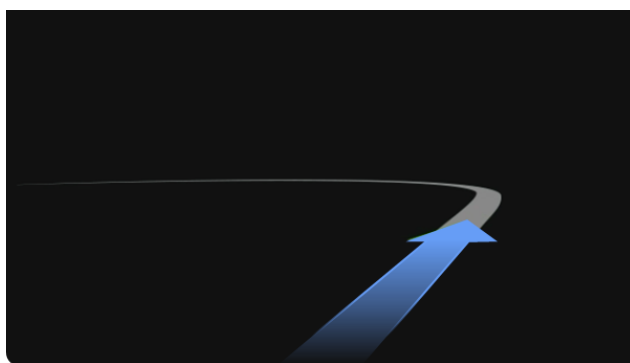
The augmented reality AR feature shall show no AR camera view, if the turn is not within the FoV.

End of Requirement

###R_F_Augmented Reality_00147### Consecutive Maneuvers in Turn-by-turn

When there is a consecutive maneuver immediately after the upcoming maneuver and this consecutive maneuver is within the FoV of the AR camera view, the AR feature shall display turn by turn arrow as below:

- The consecutive maneuver shall be represented by a white path that extends from the upcoming turn path arrow.
- The consecutive maneuver shall start 10 m after the immediate maneuver coordinate.



End of Requirement

###R_F_Augmented Reality_00148### Object Occlusion of laid down Turn by Turn arrow on road

If the turn by turn path arrow appears to be overlaying an object (e.g., other vehicles on the road) in the environment, the portion of the fill of the path arrow that is overlaying the object shall become transparent. The stroke of the path arrow shall stay the same.



Feature Document Augmented Reality (AR)



End of Requirement

~~###R_F_Augmented Reality_00021### Transition to show street name on AR display~~

~~Note: Removed Not supported by Google~~

~~The augmented reality AR feature shall display the street name on the top of the screen when the driver is at the following distances from the maneuver point:~~

~~City: $d_{LLG} = 0.25$ mi, $d_{TBT} = 0.1$ mi~~

~~Highway: $d_{LLG} = 1$ mi, $d_{TBT} = 0.2$ mi~~

~~Where:~~

~~LLG = lane change path arrow + 2D static Info (2D street name + distance to maneuver + turn icon)~~

~~TBT = turn path arrow + 2D Static Info (2D street name + distance to maneuver + turn icon)~~

End of Requirement

~~###R_F_Augmented Reality_00022### Activate AR Display at following distances from maneuver point~~

~~Note: Removed Not supported by Google~~

~~The augmented reality AR feature shall display AR image on the AR display starting from the following distances when it receives a trigger from Navigation system:~~

~~City: $d_{LLG} = 0.25$ mi, $d_{TBT} = 0.1$ mi~~

~~Highway: $d_{LLG} = 1$ mi, $d_{TBT} = 0.2$ mi~~

~~Where:~~

~~LLG = lane change path arrow + 2D static Info (2D street name + distance to maneuver + turn icon)~~

~~TBT = turn path arrow + 2D Static Info (2D street name + distance to maneuver + turn icon)~~

End of Requirement

~~###R_F_Augmented Reality_00023### Pointed Arrow color change if speed approaching the maneuver point is higher than speed limit~~



Feature Document Augmented Reality (AR)

The augmented reality AR feature shall monitor the vehicle speed during the turn sequence for the pointed arrow to change color property from “Blue” (color: #669df6) to “Amber (color: #ff8c00)” when the approaching speed is higher than the speed limit to communicate the need to reduce speed to comfortable complete the maneuver or check speed relative to a detected object (e.g., pedestrian)



End of Requirement

~~###R_F_Augmented Reality_00024### Pointed Arrow animation~~

~~The augmented reality AR feature shall show the turn arrow pointing towards the direction of turn through some animation to enhance lane marking biased towards the turn to show which lane to be at.~~

End of Requirement

###R_F_Augmented Reality_00025### Pointed Arrow angled/biased toward the line (road curvature data available)

If the road curvature data available at the time of maneuver, the augmented reality AR feature shall visibly enhance lane marking on the road/street by make it biased/angled towards the turn to show which lane to be at.

End of Requirement

###R_F_Augmented Reality_00154### Pointed Turn Arrow angled/biased toward the line (road curvature data Unavailable)

If the road curvature data and the maneuver type are unavailable at the time of maneuver, the length of the tail of the Turn by turn arrow at the end of the animation should be short to mitigate any perceived discrepancy between the arrow direction and the actual course of the maneuver.

End of Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00026### Representation of turn by turn depending on maneuver Type (maneuver type is available)

If the maneuver type is available at the maneuver point, the arrow of turn by turn at the maneuver coordinate shall be shaped to the appropriate maneuver type (Data for both right and left maneuver types are available) as below:

- Depart
- Name Change
- Straight
- Lane Change
- U-turn
- On-ramp
- Off ramp
- Fork
- Merge
- Ferry
- Ferry Train
- Roundabout Enter
- Roundabout Exit
- Destination
- Turn: Slight (10-45° turn); Normal (45-135° turn); Sharp (135-175° turn); Keep
- Unspecified

Note: A maneuver point is usually a junction between two [path] segments, but some maneuvers like destination may be part way along a segment and associated with only one segment.

the arrow of turn by turn at the maneuver coordinate based on the appropriate maneuver type

End of Requirement

###R_F_Augmented Reality_00027### U-turn display and guidance (maneuver type is available)

Note: Replaced with Requirement #26

If the maneuver type is available at the maneuver point, the augmented reality AR feature shall show the pointed arrow with the desired angle of turn for safe distance from curb when approaching to a U turn signal triggered by Navigation.

End of Requirement

###R_F_Augmented Reality_00028### Lane change requirement and display (maneuver type is available)

Note: Replaced with Requirement #26

If the maneuver type is available at the maneuver point, the augmented reality AR feature shall show the pointed arrow pointing towards the desired lane using angled guided path if there is a lane change required by the road/street (i.e. entry/exit to/from highway) (Example is below in the picture).

End of Requirement

###R_F_Augmented Reality_00029### Acceptance of Audio/Visual prompts from Navigation

The augmented reality AR feature shall block no visual/audio alerts to the driver that prompting by the NAV system when turn point of maneuver is approaching



Feature Document Augmented Reality (AR)

End of Requirement

###R_F_Augmented Reality_00155### Complex Maneuvers Representation with Limited Data

In complex maneuvers situations, the augmented reality feature shall trigger no AR related turn by turn metaphor, if the maneuver coordinate cannot accurately describe the geo location of the maneuver (e.g., roundabouts) and the road curvature cannot be determined. In this case, route guidance will depend on the 2D navigation map.

The augmented reality feature shall trigger no AR related turn by turn metaphor, if the maneuver coordinate cannot accurately describe the geo location of the maneuver (e.g., roundabouts) and the road curvature cannot be determined.

End of Requirement

###R_F_Augmented Reality_00030### Overlay AG-Nav Street Names -

Note: Removed, Not Support by Google

The Augmented Reality feature shall overlay rendered augmented Street Names on the HMI display when the Navigation system has an active destination route that triggers the next maneuver for the driver.

End of Requirement

###R_F_Augmented Reality_00031### Street Name highlighting for driver awareness -

Note: Removed, Not Supported by Google

The augmented reality AR feature shall highlight the street name to the driver by providing a flying flag or rectangular shape with the street name on the AR display when AR feature receives a trigger from the Navigation system.

End of Requirement

###R_F_Augmented Reality_00032### Positioning of Street Name -

Note: Removed, Not Supported by Google

The augmented reality AR feature shall provide a colored flying rectangular flag on the top center part of the AR display to communicate an upcoming street to the driver.

End of Requirement

###R_F_Augmented Reality_00033### Transition 3D property of Street Name flying flag -

Note: Removed, Not Supported by Google

The augmented reality AR feature shall provide a flying rectangular flag having a 3D transition property to meet such alignment upon the street on the drive route.

End of Requirement

###R_F_Augmented Reality_00034### Show Street Names as a subset of Turn by Turn -

Note: Removed, Not Supported by Google



Feature Document Augmented Reality (AR)

End-of-Requirement

~~###R_F_Augmented Reality_00035### Display House Numbers like a POI when there is route on-NAV system~~

Note: Removed, Not Supported by Google

The augmented reality AR feature shall display House Numbers like a destination location point of interest (POI) when triggered by Navigation route as with any other destination.

End-of-Requirement

~~###R_F_Augmented Reality_00036### Display House Numbers with highlighted icons~~

Note: Removed, Not Supported by Google

The augmented reality AR feature shall display the House Numbers more visible with highlighted icons in Yellow color to draw driver's attention.

End-of-Requirement

~~###R_F_Augmented Reality_00037### Activate Navigation via predicted route to display 4 House Numbers when approaching target house~~

Note: Removed, Not Supported by Google

The augmented reality AR feature shall display on AR view a series of 4 House Numbers, matching the side of the specific destination house, on the drive triggered via a navigation predicted route (through adaptive vehicle-workstream), if it is available, when approaching target house with navigation routing disabled.

End-of-Requirement

~~###R_F_Augmented Reality_00038### Prioritize the name of the building/business~~

Note: Removed, Not supported by Google

The augmented reality AR feature shall prioritize the display of the name of building/business (i.e. mall, restaurant...), if this is available, instead of the house number on address.

End-of-Requirement

~~###R_F_Augmented Reality_00039### Display Navigation directory name if available~~

Note: Removed Not supported by Google

The augmented reality AR feature shall display available data from Navigation directory for defined addresses instead of house numbers like: "friend's house", if this is available.

End-of-Requirement



Feature Document Augmented Reality (AR)

~~###R_F_Augmented Reality_00040### Activate Navigation via voice command to display 4 House Numbers-~~

Note: Removed, Not supported by Google

The augmented reality AR feature shall display on AR view a series of 4 House Numbers on the drive triggered by the driver via a voice command like "Show me house numbers".

End of Requirement

~~###R_F_Augmented Reality_00041### Vehicle speed restriction to show House Numbers~~

Note: Removed, Not supported by Google

The augmented reality AR feature shall trigger the AR view of House Numbers only when the vehicle speed is to be below 25 MPH or below current residential speed limit.

End of Requirement

~~###R_F_Augmented Reality_00042### Display of House Numbers within the proximity of the vehicle~~

Note: Removed, Not supported by Google

The augmented reality AR feature shall display to the driver the House Numbers that are within the proximity of the vehicle location.

End of Requirement

~~###R_F_Augmented Reality_00043### Show POIs as received from Navigation system -~~

Note- Removed Not Supported by Google

The augmented reality AR feature shall display the AR view of any POIs active in the navigation system.

End of Requirement

~~###R_F_Augmented Reality_00044### AR view to Driver's voice commands for POI-~~

Note: Removed Not Supported by Google

The augmented reality AR feature shall display the AR view of any POIs active in the navigation system triggered by a voice command (e.g., show me gas station).

End of Requirement

~~###R_F_Augmented Reality_00045### AR view of driver personalization setting for POIs-~~

Note: Removed, Not supported by Google

The augmented reality AR feature shall display on the AR view the POIs based on the available user personalized preferences/activities.

End of Requirement



Feature Document Augmented Reality (AR)

~~###R_F_Augmented Reality_00046### POIs Icons shown accordingly to the category selected — Removed, Not Supported by Google~~

The augmented reality AR feature shall display on the AR view the POI Icons based on their category on the navigation system list.

End of Requirement

~~###R_F_Augmented Reality_00047### Distance from the ground level to show the POI Icons on the AR display~~

~~Note: Removed Not supported by Google~~

The augmented reality AR feature shall display on the AR view the POI Icons placed vertically centered with the horizon as positioned in the camera FoV, as vehicle approaches the POI, the vertical position of the POI icon translates relative to the camera FoV perspective.

End of Requirement

~~###R_F_Augmented Reality_00048### POI location/placement on the AR view~~

~~Note: Removed, Not Supported by Google~~

The augmented reality AR feature shall display on the AR view the POI location pointing at the exact location or drivable path of the POIs existence.

End of Requirement

~~###R_F_Augmented Reality_00049### AR view capability to show destination inputted by user~~

The augmented reality AR feature shall trigger the AR window once the request is received from navigation that the vehicle is approaching the inputted destination by the user.

End of Requirement

~~###R_F_Augmented Reality_00149### AR to show only the closest POI text label to driver~~

~~Note: Removed, Not Supported by Google~~

When showing a POI text label, the Augmented Reality (AR) feature shall use the following strategy:

- ~~a) One text label will be shown~~
- ~~b) If multiple POI icons are on screen, the POI closest to the driver should be labeled~~
- ~~c) Once the closest POI icon leaves the FoV, the next closest POI icon will be labeled with text~~

End of Requirement

~~###R_F_Augmented Reality_00150### POI icon labeled with specific company name~~

~~Note: Removed, Not Supported by Google~~



Feature Document Augmented Reality (AR)

When the POI icon has scaled to a size equal to or greater than the specified minimum, the Augmented Reality (AR) feature shall add a text label with the specific company name if this is available.

End of Requirement

###R_F_Augmented Reality_00050### Overlay AG-Nav Destination Icon

The Augmented Reality feature shall show the rendered augmented destination icon as below:

- 1) If the destination is within AR camera FOV, the icon size shall change based on the remaining distance to the destination location.
- 2) If the destination falls outside camera FoV, the AR view shall still be triggered but the destination icon shall be accompanied by a pointer that directs the driver to the destination that is just outside the FoV.

Note: Refer to function document for icon/pointer scaling description

Icon Scaling

Greater than 0.5 miles away from POI, the Starter icon is $0.25^\circ \times 0.25^\circ$. Minimum stroke of the Starter icon is 0.35 mm (RQT-002003-021811 Symbol Usage & Legibility). The Starter icon starts scaling larger at a distance 0.5 miles away from the destination. The Starter icon transitions into the destination icon once it is scaled to $0.5^\circ \times 0.5^\circ$ in size. Closer than 0.02 miles from the destination, the destination icon stops scaling up.

Pointer appears with icon if destination is outside the display FoV.

Recommended icon background color²: #fff000

Converting icon size for HHDD @ 1 m

- $0.25^\circ = 4.5 \text{ mm}$
- $0.5^\circ = 9 \text{ mm}$
- $1.0^\circ = 18 \text{ mm}$



End of Requirement

###R_F_Augmented Reality_00051### Display address upon reaching Destination

Note: Removed, Not Supported by Google

The Augmented Reality feature shall overlay rendered augmented street address with destination icon on HMI display upon reaching Destination.

End of Requirement

###R_F_Augmented Reality_00052### Highlighting of destination buildings on AR view

Note: Removed, Not Supported by Google

The augmented reality AR feature shall highlight on the AR view the destination buildings (final and/or waypoint) that were inputted by the user on the Navigation system.

End of Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00053### Mark of destination with Checkered Pattern

The augmented reality AR feature shall mark the destination by showing a checkered pattern to apply on the roadway adjacent to the destination location.



End of Requirement

###R_F_Augmented Reality_00054### Allow Navigation audio prompts at destination arrival

The augmented reality AR feature shall block no audio prompts if they are produced by the Navigation system when destination is approaching. The Augmented reality feature shall not produce any audio prompt.

End of Requirement

~~###R_F_Augmented Reality_00055### Provide Destination address and Icon at point of arrival — Note: Removed Not Supported by Google~~

~~The augmented reality AR feature shall provide an AR view of the destination street address with Destination POI icon displayed upon reaching the destination.~~

End of Requirement

~~###R_F_Augmented Reality_00056### Show pointed arrow as Lane guidance to destination house entry or driveway Note: Removed, Not Supported by Google~~

~~The augmented reality AR feature shall show a pointed arrow (or carpet) as Lane guidance starting to merge (e.g. reduced arrow size) with the house entry or driveway as House or Destination is starting to show on the AR view.~~

End of Requirement

###R_F_Augmented Reality_00057### Destination Icon Symbol/Color

The augmented reality AR feature shall display a Destination icon as:

- 1) The background of the icon shall be Red color (#ff0000).
- 2) The icon symbol shall be general destination icon, if data is available from the Nav system to support destination specific icons.

End of Requirement

~~###R_F_Augmented Reality_00058### Stop showing House Number/ POI when reaching point of Destination~~

~~Note: Removed, Not Supported by Google~~



Feature Document Augmented Reality (AR)

The augmented reality AR feature shall stop showing the House number POI to allow the AR display to go back to normal state when the destination has been reached as follows:

- AR view closes 4 seconds after no house number has been displayed regardless of whether the maximum number of house numbers has been shown in series.
- If the set or predicted destination house is approached and/or reached, add checkered pattern near the house when reaching the destination, and the AR view closes after 4 seconds.

End of Requirement

###R_F_Augmented Reality_00156### Object Occlusion of destination icon/checkerboard on road

If the destination icon/checkerboard location appears to be overlaying an object (e.g., other vehicles on the road, trees, etc.) in the environment, below shall use for display destination:

- For the checkerboard pattern, the portion of the texture that is overlaying the object becomes transparent. And the stroke of the checkered pattern shall show as normal.
- For the display destination icon, the icon shall be placed on the top of overlaying object and shall become visible.



If the destination icon/checkerboard location appears to be overlaying an object (e.g., other vehicles on the road, trees, etc.) in the environment, below shall use for display destination:

- For the checkerboard pattern, the portion of the texture that is overlaying the object becomes transparent. And the stroke of the checkered pattern shall show as normal.
- For the display destination icon, the icon shall be placed on the top of overlaying object and shall become visible.

End of Requirement

###R_F_Augmented Reality_00059### AR Blind Spot Carpet Trigger

The Augmented Reality AR feature shall display blind spot (BLIS) carpet on the AR screen when user turns signal indicators ON AND there is an object is in specific blind spot (i.e., BLIS ADAS system is active in same direction of turn signal).

In case of lane low visibility (see requirement # 162) trigger is active, the AR blind spot will be active without the need for the driver to switch on the turn indicators.

End of Requirement

###R_F_Augmented Reality_00060### No activation of AR BLIS window.

The augmented reality AR feature shall trigger no BLIS carpet when:

- BLIS (ADAS) is not active (i.e., no object is detected in blind spot)
- No turn Signal is activated by the user (except when lane low visibility is triggered- see requirement #162)
- Turn signals is activated but not in the same direction of the activated BLIS signal

End of Requirement



Feature Document Augmented Reality (AR)

~~###R_F_Augmented Reality_00061### Display of BLIS Symbol/Icon on top of Amber carpet~~ ~~Note: Removed per CIED team~~

~~The augmented reality AR feature shall display on the AR view a BLIS icon/symbol over the Amber "carpet" when it is shown on the AR display.~~

End of Requirement

~~###R_F_Augmented Reality_00062### Stop displaying the Amber carpet and BLIS symbol/icon when clear to maneuver~~ ~~Note: Removed, Replaced with Requirement #15~~

~~The augmented reality AR feature shall stop displaying the Amber "carpet" with the BLIS symbol/icon on top of it on the AR view when driver can make the turn or lane change with no object in its blind spot or if the turn signal indicator is deactivated:~~

- ~~• AR view closes when signal indicator is deactivated or when blind spot is clear of objects for more than 2 seconds.~~

End of Requirement

###R_F_Augmented Reality_00157### AR Blind Spot Carpet Color

The Augmented Reality AR feature shall display blind spot (BLIS) highlight in Amber (#ff8c00) color carpet on the AR screen in the right or left lane (aligned with turn signal direction activity).

The Augmented Reality AR feature shall display blind spot (BLIS) highlight in Amber (#ff8c00) color carpet on the AR screen in the right or left lane (aligned with turn signal direction activity).

End of Requirement

###R_F_Augmented Reality_00158### AR Blind Spot Carpet Characteristic – If Road Curvature Available

The Augmented Reality AR feature shall display blind spot (BLIS) carper within the following characteristics:

- The carpet shall project out as far as possible (at least 100 m) and shall accommodate any curvature in the roadway.
- The carpet shall have a gradient that reduces in fill opacity with lateral and longitudinal distance from driver.
- The carpet shall quickly fade out (within 250 ms) when AR blind spot trigger ends.

- The carpet shall project out as far as possible (at least 100 m) and shall accommodate any curvature in the roadway.
- The carpet shall have a gradient that reduces in fill opacity with lateral and longitudinal distance from driver.
- The carpet shall quickly fade out (within 250 ms) when AR blind spot trigger ends.

End of Requirement

###R_F_Augmented Reality_00159### AR Blind Spot with Object Occlusion

If the AR blind spot carpet appears to be overlaying an object (e.g., other vehicles on the road) in the environment, the portion of the fill of the carpet that is overlaying the object shall become transparent.



Feature Document Augmented Reality (AR)



The portion of the fill of the carpet that is overlaying the object shall become transparent, If the AR blind spot carpet appears to be overlaying an object (e.g., other vehicles on the road) in the environment

End of Requirement

###R_F_Augmented Reality_00160### AR Blind Spot Carpet Characteristic – If Road Curvature Unavailable

If the road curvature unavailable in the event of display AR blind spot, the blind spot carpet shall approximately extend 10 m (approximately the length of two average size vehicles) out on the adjacent lane, instead of projecting out to fill the adjacent lane.



the blind spot carpet shall approximately extend 10 m (approximately the length of two average size vehicles) out on the adjacent lane, instead of projecting out to fill the adjacent lane, If the road curvature unavailable in the event of display AR blind spot

End of Requirement

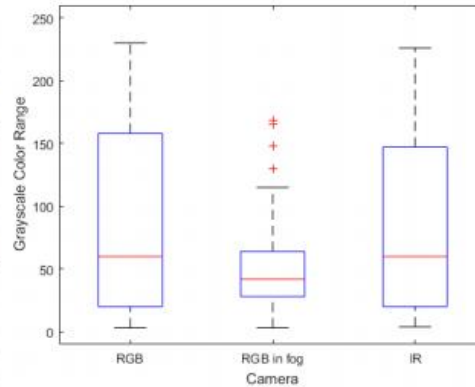
###R_F_Augmented Reality_00064### Lane Low Visibility (Post <J1> OTA – Still WIP) Trigger – If vehicle is equipped with FIR camera

The augmented reality feature shall offer the lane low visibility activation based on below trigger:

- 1) The trigger condition shall be based on establishing a relationship between the contrast of the RGB (AR camera) during optimal visibility conditions (across high and low ambient lighting conditions) and the contrast of FIR camera.
- 2) This is predicated shall be based on the understanding that the infrared (IR) camera contrast is invariable relative to changing environmental conditions (e.g., ambient light, glare, fog, dust, rain, etc.).
- 3) When this RGB-to-IR contrast relationship changes beyond a threshold, the lane low visibility “enhance vision” feature shall be available for the driver to engage either via steering wheel control or voice command



Feature Document Augmented Reality (AR)



This plot illustrates how the color range of the RGB camera degrades with fog. This represents a decrease in the overall contrast of the driving scene. This change in color range, as measured relative to the IR camera, can be used to trigger feature availability.

End of Requirement

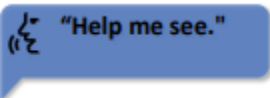
####R_F_Augmented Reality_00063#### Lane Low Visibility (Post <J1> OTA – Still WIP) Activation – If vehicle is equipped with FIR camera

If lane low visibility (enhanced vision) event triggers are active, the augmented reality AR feature shall offer to be active using:

- 1) The steering wheel: (i.e., a control mirror to activate “enhance vision” will be displayed on the driver information display)



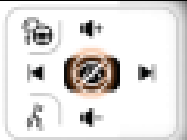
- 2) Or, driver voice command (i.e., help me see) – if voice command is supported by navigation provider.



- 3) The label shall be faded in at the center of the right button pack default layout, with a subtle but recognizable fade in animation. The helper text shall give a mating hint.
- 4) The control mirror shall be removed after 10 seconds of inactivity (activity = touch or press) but returns when user touches the steering wheel controls.
- 5) When the driver activates the lane low visibility status icon, the icon shall change to the deactivate icon status.



Feature Document Augmented Reality (AR)



When, lane low visibility (enhanced vision) event triggers are active, the augmented reality AR feature shall offer to be active using: The steering wheel or through driver's voice command (i.e., help me see).

End of Requirement

###R_F_Augmented Reality_00065### Lane Low visibility (Post <J1> OTA- Still WIP – Carpet characteristic – if vehicle is equipped with FIR camera

Once the lane low visibly (enhanced vision) if activated by the driver, a path arrow shall appear to communicate the ideal driving path as below:

- 1) Using an amber color (color: #ff8c00) to remind the driver to maintain a conservative speed in accordance with traffic flow during the low visibility situation.
- 2) The positioning and sizing of the path arrow shall follow the specifications described for the turn-by-turn guidance path arrow.
- 3) Lead vehicles are identified with an amber 3D loop metaphor (color: #ff8c00). Minimum loop width is 0.5° (= 9 mm @ 1 m). Minimum stroke is 0.35 mm (RQT-002003-021811 Symbol Usage & Legibility).
- 4) The lead vehicle loop metaphor shall follow scaling profile of destination icon.



End of Requirement

###R_F_Augmented Reality_00161## Lane Low Visibility – Post <J1> OTA – Still WIP – Carpet characteristic with Object Occlusion – If vehicle is equipped with FIR camera

If the path arrow of lane low visibly (enhanced vision) appears to be overlaying an object (e.g., other vehicles on the road) in the environment, the portion of the fill of the path arrow that is overlaying the object shall become transparent and the stroke of the path arrow shall stay the same.

End of Requirement

###R_F_Augmented Reality_00162## Lane Low Visibility – Post <J1> OTA – Still WIP – with Other features interaction - If vehicle is equipped with FIR camera

Once the lane low visibility is activated, all active AR features (e.g., turn-by-turn, destination, object detection, etc.) shall be shown concurrently in the Lane Low Visibility AR view. In addition, AR blind spot shall be active without the need for the driver to switch on the turn indicators.

End of Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00151### Lane Low Visibility – Post <J1> OTA – Still WIP – De-activation – If vehicle is equipped with FIR camera

The Augmented Reality (AR) feature shall deactivate the lane low visibility carpet if the lane low visibility triggers no longer meet thresholds for activation within 30 seconds or driver pushes the steering wheel control or deactivates feature with voice command.

End of Requirement

###R_F_Augmented Reality_00066### Display Augmented Lines AL- Lane Level Guidance-

Note: Removed. Not Supported by Google

The Augmented Reality feature shall display rendered augmented Lane Level Guidance with a blue path/arrow to follow rather than abstract instructions to the driver for situational awareness of the driver to show the preferred lane (entry, exit, machine learning...), guide away from obstacle or hazards that will determine if it is clear and do the lateral motion to move into the desired lane.

End of Requirement

###R_F_Augmented Reality_00067### Lane Level Guidance – evade an environmental object –

Note: Removed, Not Supported by Google

The augmented reality AR feature shall provide the driver on the AR view a visual image of the preferred line to follow on the road/street by showing a blue pointed arrow (carpet) lay down on the road/street to guide the path when an upcoming maneuver (i.e. turn by turn) is set up to evade an environmental object.

End of Requirement

###R_F_Augmented Reality_00068### Lane Level Guidance – same attributes as Guide – Turn by turn

Note: Removed, Not Supported by Google

The augmented reality AR feature shall provide the driver with the same AR attributes for Lane Level Guidance as for Guide – Turn by Turn.

End of Requirement

###R_F_Augmented Reality_00152### Lane Level Guidance distance threshold triggers

Note: Removed, Not Supported by Google

When maneuver is within FoV, the Augmented Reality (AR) feature shall show the augmented camera view at d_{LLG} distance at the specified entry animation treatment:

- a) City near nav distance threshold: d_{LLG} = 0.25 mi
- b) Highway near nav distance threshold: d_{LLG} = 1 mi

Exact values are subject to change in accordance with embedded navigation triggers. If turn is not within the FoV, the AR camera view is not shown.

End of Requirement

###R_F_Augmented Reality_00069### Overlay Augmented Lines AL- Lane Biasing

Note: Removed not recommended per CIED for HHDD application



Feature Document Augmented Reality (AR)

The Augmented Reality feature shall display visualized rendered augmented Lane Biasing with a highlight of the object and correlate that object to the slight change in path to the right (/left) side of the road when the car is biasing to the right (/left) side of the lane because of an oncoming object on the left (/right) side of the vehicle.

End of Requirement

~~###R_F_Augmented Reality_00070### Lane Biasing of path to follow —~~

Note: Removed not recommended per CIED for HHDD application

The augmented reality AR feature shall provide on the AR view a visual image of the guidance path the vehicle will follow on the road/street by showing a pointed arrow (carpet) lay down on the road/street biased to the left (/right) of the lane due to an incoming object on the right (/left) prior to the vehicle performing the maneuver within the road/street lane when the vehicle is in a Blue zone and driving using the ADAS system.

End of Requirement

~~###R_F_Augmented Reality_00071### Lane Biasing show on AR view with same requirements as Turn by Turn —~~

Note: Removed not recommended per CIED for HHDD application

The augmented reality AR feature shall provide the driver with a Lane Biasing visual treatment with the same requirements as Guide Turn by Turn.

End of Requirement

~~###R_F_Augmented Reality_00072### Lane Biasing to be perform when vehicle is operating with ADAS system~~

Note: Removed not recommended per CIED for HHDD application

The augmented reality AR feature shall perform the Lane Biasing when the vehicle is operating with the Active Drive Assist System (ADAS).

End of Requirement

~~###R_F_Augmented Reality_00073### Lane Biasing to be shown on AR view until the end of the maneuver~~

Note: Removed not recommended per CIED for HHDD application

The augmented reality AR feature shall maintain the AR view of the Lane Biasing event until the maneuver is completed.

End of Requirement

~~###R_F_Augmented Reality_00074### Lane Biasing to be triggered coincidentally with ADAS event - Note: Removed not recommended per CIED for HHDD application~~

The augmented reality AR feature shall trigger the AR view of the Lane Biasing event coincidentally to the original lane biasing signal from ADAS system.

End of Requirement

~~###R_F_Augmented Reality_00075### Highway Assist/ Active Drive Assist~~

Note: Removed not recommended per CIED for HHDD application



Feature Document Augmented Reality (AR)

The augmented reality AR feature shall display the augmented reality Highway Assist with a highlighted representation of the path of the Blue Zones on the highway until the Blue Zone comes to an end.

End of Requirement

###R_F_Augmented Reality_00076### Perform calibration of the Augmented Reality (AR) feature

The augmented reality AR feature shall allow a qualified Technician to perform a Calibration procedure/process to verify/adjust the AR vehicle parameters and Augmented Reality Cameras (AR and FIR) for the AR feature to perform to manufacturer's specifications.

End of Requirement

###R_F_Augmented Reality_00077### AR night driving capability – if Vehicle is equipped with FIR Note: Deleted and merged with requirement # 00014

The Augmented Reality (AR) feature shall be able to display the AR content during night/dark environment when an AR event is triggered switching the AR display from 2D navigation HMI to real-time AR view with the night image capturing device as the background image presented to the driver

End of Requirement

###R_F_Augmented Reality_00078### AR night/dark environment during AR Event - if Vehicle is equipped with FIR Note: Deleted and merged with requirement # 00014

The Augmented Reality (AR) feature shall be able to display the AR content during night/dark environment when the AR event is triggered with the night image capturing device as the background image with the proper AR overlays for the AR events.

End of Requirement

###R_F_Augmented Reality_00079### Provide driver with the same user experience with FIR camera as background as with AR visible camera

The augmented reality AR feature shall provide the driver with the same user experience when using the AR night vision (FIR) camera as a background as with the AR visible camera for the AR Events (FIR camera as background. Same use cases to visible camera but overlaid on top of infrared camera)

End of Requirement

###R_F_Augmented Reality_00080### FIR Camera – Monitoring - If vehicle is equipped with FIR camera

The augmented reality AR feature shall be continuously using FIR camera to monitor the environment and detect objects deemed a threat, even if the customer disables the FIR camera night vision HMI setting (i.e., Select Disable for AR night vision HMI option).

The augmented reality AR feature shall be continuously using FIR camera to monitor the environment and detect objects deemed a threat, even if the customer disables the FIR camera night vision HMI setting.

End of Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00081### AR and FIR Camera for image processing

The augmented reality AR feature shall use the AR camera and FIR camera (if vehicle is equipped) for image processing to determine the geometry of environmental objects for AR event overlay, in case more accurate data is available (e.g., ADAS FWC camera), the AR feature shall leverage it as well.

End of Requirement

~~###R_F_Augmented Reality_00082### Triggering AR event – if Vehicle Not equipped with FIR Camera~~

~~Note: Deleted and merged with requirement # 00014~~

~~The Augmented Reality (AR) feature shall be able to display the visible real-time AR view as the background image with the proper AR overlays when an AR view triggering event switches the AR display from 2D navigation HMI to real-time AR view for the dark/night environments events and the vehicle is Not equipped with FIR camera.~~

End of Requirement

~~###R_F_Augmented Reality_00083### Night image FIR capturing device not available on triggering AR event – if Vehicle is equipped with FIR Camera~~

~~Note: Deleted and merged with requirement # 00014~~

~~The Augmented Reality (AR) feature shall be able to display the visible real-time AR view as the background image with the proper AR overlays when an AR view triggering event switches the AR display from 2D navigation HMI to real-time AR view for dark/night environment and the night image FIR capturing device is not available.~~

End of Requirement

###R_F_Augmented Reality_00084### Detect FIR camera failure (not operational) and Report Feature is Not available to the HMI

The augmented reality feature shall:

- 1) detect that the night image FIR camera is not operational (fail)
- 2) report to the driver on the HMI display a fault message that the AR feature is not available.
- 3) display no AR functionality once a fault message has been triggered and until the fault has been resolved.

End of Requirement

~~###R_F_Augmented Reality_00085### Visible image capturing device not available on triggering AR event~~

~~Note: Deleted and merged with requirement # 00084~~

~~The Augmented Reality (AR) feature shall be able to display the night image real-time AR view as the background image (if vehicle is equipped with FIR camera) with the proper AR overlays when an AR view triggering event switches the AR display from 2D navigation HMI to real-time AR view and the visible image capturing device is not available.~~

End of Requirement

###R_F_Augmented Reality_00086### Detect AR camera failure (Not operational) and Report Feature is Not available to the HMI

The augmented reality feature shall:

- 1) detect that the visual image AR camera is not operational (fail)
- 2) report to the driver on the HMI display a fault message that the AR feature is not available.



Feature Document Augmented Reality (AR)

- 3) display no AR functionality once a fault message has been triggered and until the fault has been resolved.

End of Requirement

####R_F_Augmented Reality_00087#### AR Camera video feed / Cropping AR Camera FOV Due Minification

The Augmented Reality (AR) feature shall be able to:

- 1) receive a video feed from the AR camera with native AR camera FOV
- 2) provide cropping capability to AR camera native FOV (due to minification) before display the AR event.
- 3) crop the AR camera native FOV view to 85% (this is default value) such that the proximity of environmental objects would appear more realistic to the driver.
- 4) have the cropping amount value of AR camera native FOV as configurable parameter.



Cropping of RGB camera native FoV: Minification (i.e., objects in the camera view are perceived as further away than reality due to the lens of the camera having a wider FoV than the human eye) is reduced by cropping the RGB camera FoV to 85% of the native view such that the proximity of environmental objects would appear more realistic to the driver.

End of Requirement

####R_F_Augmented Reality_00088#### FIR Camera video feed – If Vehicle is equipped

The Augmented Reality (AR) feature shall be able to:

- 1) receive a video feed from the FIR camera with native FIR camera FOV
- 2) provide no crop to FIR camera FOV as a default, unless it is approved based on target vehicle mounting.
- 3) provide cropping amount capability to FIR camera native FOV (amount of cropping from the top of the image shall be configurable between 0 and 200 pixels and from the bottom of the image shall also be configurable between a configurable 0 to 200 rows of pixels)



Feature Document Augmented Reality (AR)

Since the infrared (IR) camera already has a lower FoV than the cropped RGB camera, the IR camera FoV should not be cropped.

End of Requirement

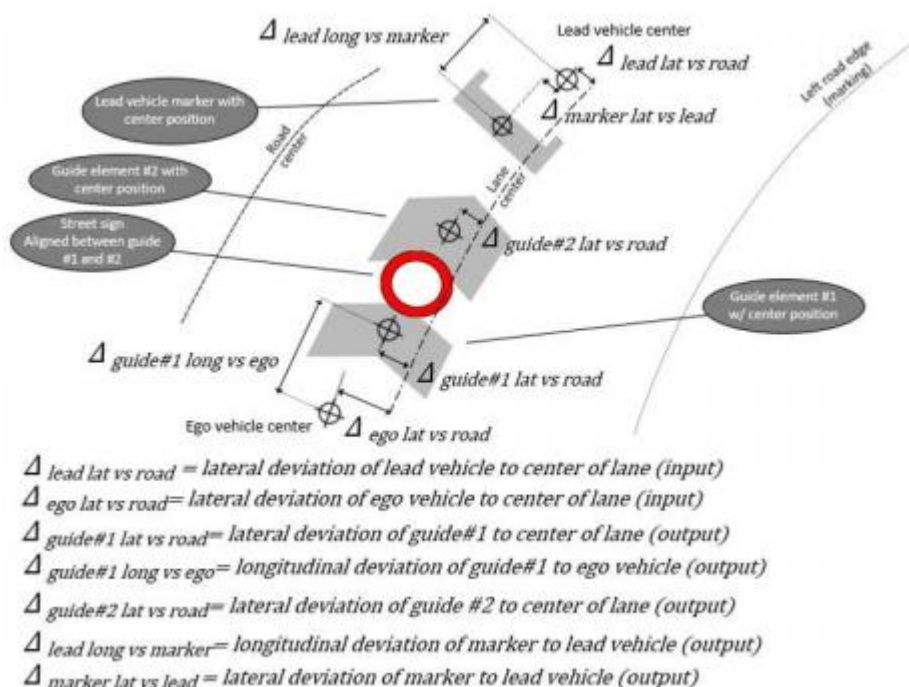
###R_F_Augmented Reality_00089### OTA capability

The Augmented Reality (AR) feature shall be able to receive fast over the air (OTA) software updates.

End of Requirement

###R_F_Augmented Reality_00090### Overlay Accuracy

The Augmented Reality (AR) feature shall be able to provide overlay data to the driver within below accuracy:



The accuracy with below limits forward up to 50m:

- $\Delta \text{guide\#1 lat vs road} < 200\text{mm}$
- $\Delta \text{guide\#1 long vs ego} < 500\text{mm}$
- $\Delta \text{guide\#2 lat vs road} < 300\text{mm}$
- $\Delta \text{lead long vs marker} < 500\text{mm}$
- $\Delta \text{marker lat vs lead} < 300\text{mm}$

End of Requirement

###R_F_Augmented Reality_00091### Glass-to-Glass Latency

The Augmented Reality (AR) feature shall be able to provide the AR view (video overlay) to the driver at a maximum glass-to-glass latency of 100 ms.

End of Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00092### Rendering priority control

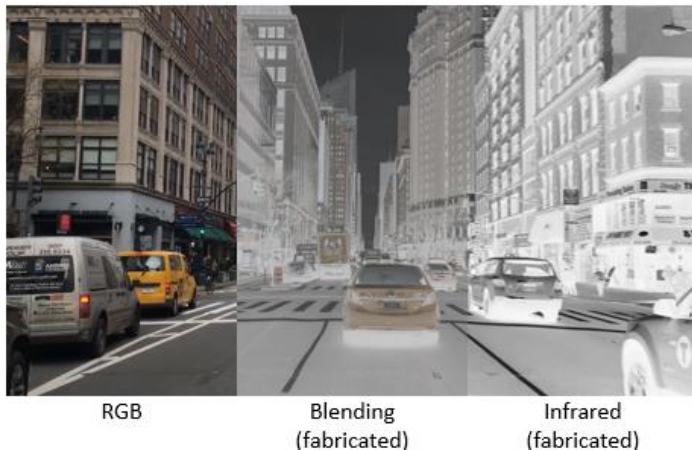
The concurrent display of AR features shall be allowed and integral to the system communication to the driver (e.g., show turn-by-turn maneuver with blind spot), the AR view shall remain if at least one feature metaphor is active. Once removed, feature metaphors shall expire with a 250 ms fade out animation

The concurrent display of AR features shall be allowed and integral to the system communication to the driver

End of Requirement

###R_F_Augmented Reality_00163### AR Night Vision View with AR/FIR blending – Still WIP (Blending is post <J1> OTA) – if vehicle is equipped with FIR camera

When the AR/FIR camera blending capability is available, the Augmented Reality (AR) feature shall replace the FIR camera view with the blended AR/FIR view.



Note: This is still WIP, and part of post <J1> OTA. This is the current assumption. More investigation is needed to understand how to leverage the blending technology in a way that highlights salient elements in the scene to the driver

the Augmented Reality (AR) feature shall replace the FIR camera view with the blended AR/FIR view.

End of Requirement

###R_F_Augmented Reality_00164### Object detection with FIR Camera – Still WIP (Object Detection is post <J1> OTA) – if vehicle is equipped with FIR camera



Feature Document Augmented Reality (AR)

When the object detection is available, the augmented reality feature shall detect object (pedestrian, large animal, etc.) using FIR camera (Note- refer to FIR Pedestrian Detection and Classification Functional and Performance Specification for Augmented Display for details).

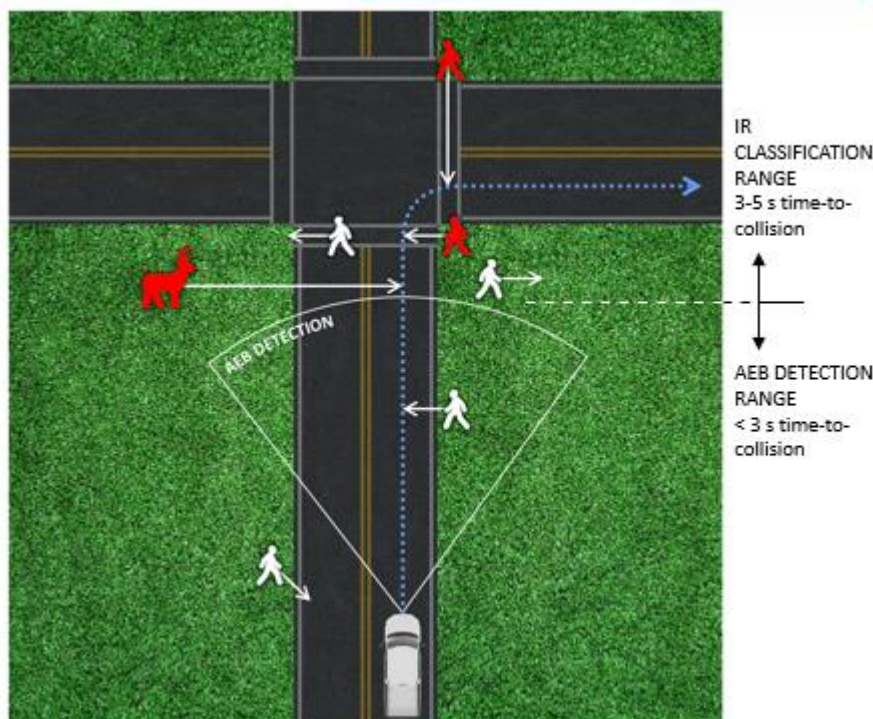
the augmented reality feature shall detect object (pedestrian, large animal, etc.) using FIR camera.

End of Requirement

###R_F_Augmented Reality_00165### Object detection Trigger – Still WIP (Object Detection is post <J1> OTA) – if vehicle is equipped with FIR camera

When the object detection (pedestrian, large animal) is available, the augmented reality feature shall trigger object detection AR view, when the objects (pedestrian, large animal) are considered as potential threat (The pedestrians/large animal in red in picture below are examples of objects of potential threat). Per this definition, the identification of the object for the driver is not only dependent on vehicle time-to-collision to the object, but also the relative velocity of the detected object. As below

- 1) When Vehicle Speed < 3 MPH: The AR camera view shall be triggered when the detected object is predicted to be in the instantaneous path (straight ahead if there is no active navigation route) of the vehicle within TBD (i.e., 5 seconds).
- 2) When Vehicle Speed ≥ 3 MPH: The AR camera view shall be triggered when the detected object is determined to be a potential threat to the driver. Object is a potential threat if it is predicted to be in the instantaneous path of the vehicle (blue dotted line) within time-to-collision TBD (i.e., 3-5 seconds).



the augmented reality feature shall trigger object detection AR view based on vehicle speed

End of Requirement



###R_F_Augmented Reality_00166### Object detection AR metaphor – Still WIP (Object Detection is post <J1> OTA) – if vehicle is equipped with FIR camera

When the object detection is available, the augmented reality feature shall show the AR view of the object detection as below:

- 1) Visual imagery to highlight pedestrian and large animals that may be a potential threat to the driver (refer to previous requirement for definition of objects of potential threat)
- 2) Detected objects shall be identified with a 3D loop metaphor with color (#ff0000). Minimum loop width is 0.5° (= 9 mm @ 1 m). Minimum stroke is 0.35 mm (RQT#002003-021811 Symbol Usage & Legibility).
- 3) Object loop metaphor shall follow the scaling profile of destination icon (the 3D loop may need to be rotated slightly about the horizontal / lateral axis of the loop, relative to the driver, to enhance the metaphor perspective. Optimally, the 3D loop should be vertically positioned around the lower half of the object, however, it is free to move vertically, relative to the detected object, to support FoV constraints.



- 4) If multiple objects are detected and grouped closely together, a single visual metaphor shall be used to highlight the entire group together.



- 5) An icon shall be used to identify the detected object when it is partially outside the camera FoV. If the detected object is fully outside the FoV, an arrow pointing toward the object is applied next to the icon. The icon should be about 0.5 x 0.5° in size. Minimum stroke of the icon is 0.35 mm (RQT-002003- 021811 Symbol Usage & Legibility).



- 6) During optimal ambient light levels / visibility situations, detected objects shall be highlighted on the RGB camera view, in other situations detected objects shall be highlighted on FIR camera view (with or without blended AR/FIR).

	The augmented reality feature shall display AR visual imagery to highlight pedestrian and large animals that may be a potential threat to the driver
End of Requirement	

###R_F_Augmented Reality_00167### Object detection AR Trigger End – Still WIP (Object Detection is post <J1> OTA) – if vehicle is equipped with FIR camera



Feature Document Augmented Reality (AR)

When the object detection is available, the augmented reality feature shall close the AR view of the object detection as below:

- 1) 3 seconds after the detected object is no longer a determined to be a threat
- 2) (or) 3 seconds after the object is no longer detected
- 3) (or) Immediately when the detected object moves into the AEB (Automatic emergency braking) detection range and the pre-collision Global Alert message is requested.

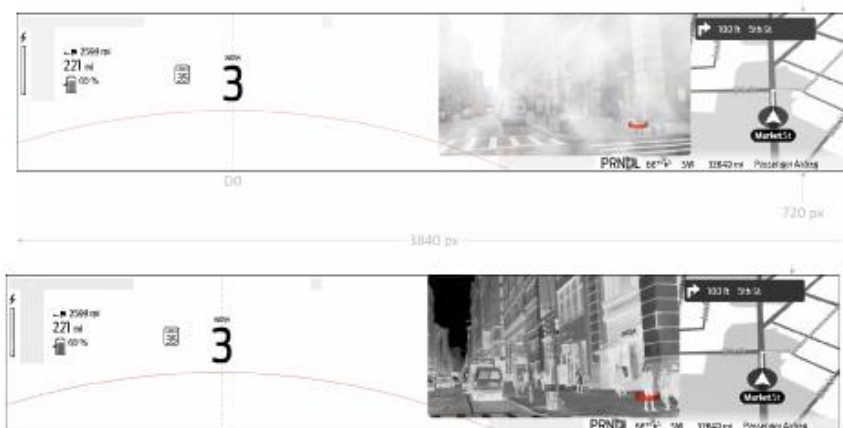
The augmented reality feature shall close the AR view of the object detection as below:

- 1) 3 seconds after the detected object is no longer a determined to be a threat
- 2) (or) 3 seconds after the object is no longer detected
- 3) (or) Immediately when the detected object moves into the AEB (Automatic emergency braking) detection range and the pre-collision Global Alert message is requested.

End of Requirement

###R_F_Augmented Reality_00168### Object detection AR vs. FIR Camera FoV Differences & Transition– Still WIP (Object Detection is post <J1> OTA) – if vehicle is equipped with FIR camera

When the object detection is available, the augmented reality feature (In the case that the FoV of the FIR camera is smaller than that of the AR camera) shall use prescribe a zoom in animation when transitioning from the AR camera to FIR camera view (native 640 x 360 px resolution) to maximize the size of the FIR camera view to the set frame of the AR view on the display. At the start of the animation, the FIR camera view shall be scaled such that environmental elements are 1:1 relative to those seen in the RGB camera view.



When the object detection is available, the augmented reality feature (In the case that the FoV of the IR camera is smaller than that of the AR camera) shall use prescribe a zoom in animation when transitioning from the AR camera to FIR camera view to leverage the pixel density of the IR camera view. At the start of the animation, the IR camera view shall be scaled such that environmental elements are 1:1 relative to those seen in the RGB camera view

End of Requirement

###R_F_Augmented Reality_00169### AR View when Wiper motion in the view

In case the wiper motion is active/moving and within the AR camera FOV, the augmented reality feature shall digitally remove the wiper motion from the AR view with minimal noticeable lag for the driver.

Since the AR camera is mounted on the inside of the vehicle windshield, wiper motion should be digitally removed (requires testing) from the AR camera view

The augmented reality feature shall digitally remove the wiper motion from the AR view with minimal noticeable lag for the driver

End of Requirement



5.2 Non-Functional Requirements

5.2.1 Safety

None.

5.2.2 Security

None.

5.2.3 Reliability

The feature shall comply with the expected life of the vehicle of 15 years or 150,000 miles, whichever occurs first.

5.3 HMI Requirements

###R_F_Augmented Reality_00093### HMI option to turn AR feature On/Off though a physical control

The Augmented Reality (AR) feature shall provide an HMI option to turn AR feature ON or OFF though a physical control and visual impact are shown based on the driver selection.

Off - no augmented camera view will be presented to the driver at any time during vehicle operation.

On (default) - augmented camera view will be presented to the driver contextually during vehicle operation.

- Off - no augmented camera view will be presented to the driver at anytime during vehicle operation.
- On (default) - augmented camera view will be presented to the driver contextually during vehicle operation.

End of Requirement

###R_F_Augmented Reality_00094### HMI option to turn AR On/Off though a voice command control

Note: Removed, Voice command not supported by Google

The Augmented Reality (AR) feature shall provide an HMI option to turn AR feature ON or OFF through HMI voice command control, i.e. "Turn ON AR"

End of Requirement

###R_F_Augmented Reality_00095### Default status for AR feature is On

The augmented reality feature shall have the default status of ON.

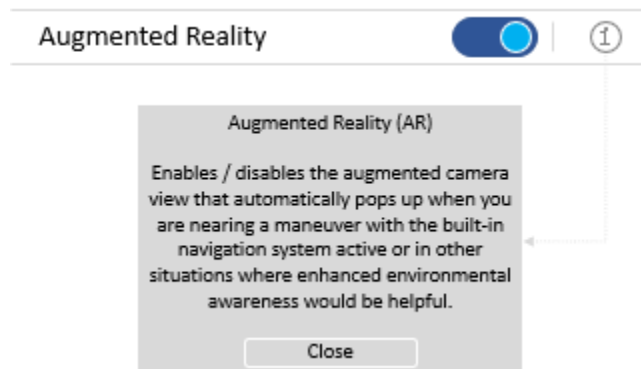
End of Requirement



Feature Document Augmented Reality (AR)

####R_F_Augmented Reality_00096#### AR Feature Status HMI information icon “i”

The Augmented Reality (AR) feature shall provide an HMI info icon “i” to educate the driver about what this feature selections and options to choose from on the menu:



End of Requirement

####R_F_Augmented Reality_00097#### HMI physical control to select AR Video Mode (AR Night Vision) Enable/Disable – If vehicle is equipped with FIR Camera

The augmented reality feature shall provide an HMI option to select AR video background mode (AR Night vision) by a physical control.

Select AR Video mode - AR Outside Light Level Adaptation

1. Disable - Use AR (visible) camera only. When disabled, the RGB camera remains the AR view background regardless of whether the outside light levels.
2. Enable (default) - Camera switches to FIR camera as the AR view background when "low" levels of light is detected, return to AR (visible) camera as the AR view background

End of Requirement

~~####R_F_Augmented Reality_00098#### HMI voice command control to select AR Video Mode- Enable/Disable – If vehicle is equipped with FIR Camera- Note: Removed, Voice Command Not Supported by Google~~

~~The augmented reality feature shall provide an HMI voice command control to select AR video background mode to-
Select AR Video mode with AR Outside Light Level Adaptation~~

- ~~1. "Turn OFF night vision"– Disable – the AR feature shall use AR-visible camera only~~
- ~~2. "Turn ON night vision"– Enable (default) – The AR feature shall switch automatically between the AR and FIR-camera based on the level of environmental lights.~~

End of Requirement

####R_F_Augmented Reality_00099#### HMI selection Setting through key ignition start cycles

The following customer HMI selection AR settings shall stay as individual driver preference for the upcoming ignition key cycles unless the driver overwrites it on the HMI settings:

- AR status ON/OFF
- AR video mode selection Enable/Disable



Feature Document Augmented Reality (AR)

End of Requirement

####R_F_Augmented Reality_00100#### Default selection of AR Video Mode as Enable – If vehicle is equipped with FIR Camera

The augmented reality feature shall provide an HMI default option for selection of AR video background mode as Enable:

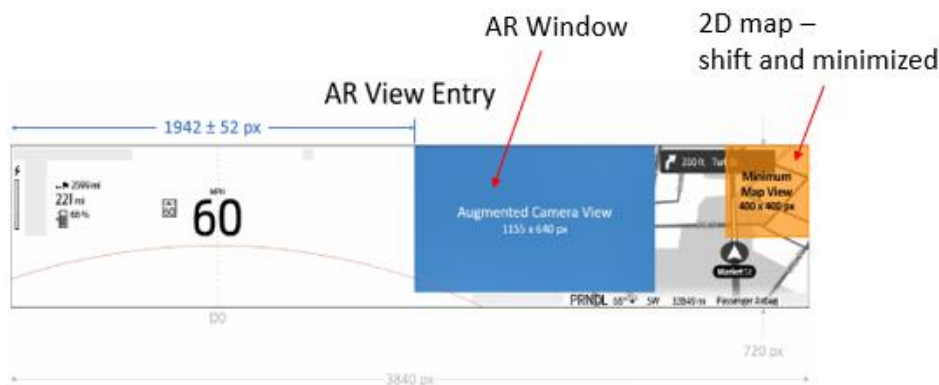
- The AR feature shall switch automatically between the AR and FIR camera based on the level of environmental lights.

End of Requirement

####R_F_Augmented Reality_00101#### Augmented Reality Display

When AR event is triggered, the Augmented Reality (AR) feature shall display AR camera view that located with minimal interface with steering wheel location as below:

- 1) The resolution of AR view screen size shall be as close as possible to 1155 x 640 pixels
- 2) The left edge of the AR view should be 1942 ± 52 pixels from the left edge of the display.
- 3) The 2D map is shifted to the right of AR view and minimized to at least 400 x 400 dp (Note the 'dp' rather than 'px' - 1 dp is about 1px for a 160 dpi display)".



End of Requirement

####R_F_Augmented Reality_00102#### Augmented Reality Display adjustment of FOV

The AR display shall provide different corresponding FOV in the display depending on AR/FIR/Auto camera capabilities.

End of Requirement

####R_F_Augmented Reality_00103#### Augmented Reality camera video feed remains until AR event has finished

The Augmented Reality (AR) feature shall provide a driver experience where the camera video feed is kept until the AR event being shown has finished, prohibiting the change of camera video feed during AR events.

End of Requirement



Feature Document Augmented Reality (AR)

###R_F_Augmented Reality_00104### AR contextually triggering by Event

The Augmented Reality (AR) feature shall provide a contextually triggered environment on the AR display between 2D map guidance (Far Nav) to AR exact turn location (Near Nav) and back to 2D map guidance once the maneuver has been executed by the driver to optimize value and mitigate potential driver distractions.

End of Requirement

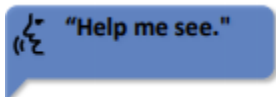
###R_F_Augmented Reality_00105### Select- Lane Low Visibility HMI options – Post <J1> OTA - WIP

If lane low visibility (enhanced vision) event triggers are active, the augmented reality AR feature shall offer HMI option to be active using:

- 1) The steering wheel: (i.e., a control mirror to activate “enhance vision” will be displayed on the driver information display)



- 2) Or, driver voice command (i.e., help me see) – if voice command is supported by navigation provider.



- 3) The label shall be faded in at the center of the right button pack default layout, with a subtle but recognizable fade in animation. The helper text shall give a mating hint.
- 4) The control mirror shall be removed after 10 seconds of inactivity (activity = touch or press) but returns when user touches the steering wheel controls.
- 5) When the driver activates the lane low visibility status icon, the icon shall change to the deactivate icon status.



Feature Document Augmented Reality (AR)



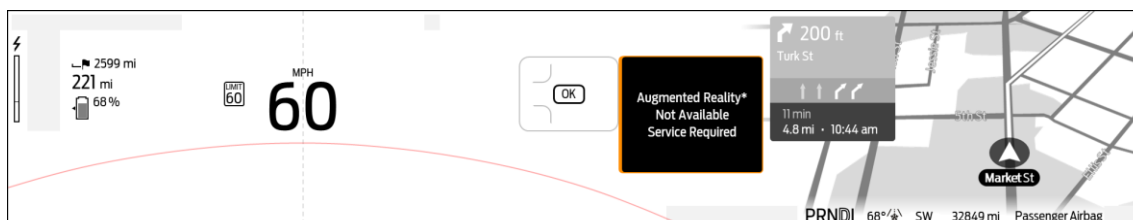
When, lane low visibility (enhanced vision) event triggers are active, the augmented reality AR feature shall offer to be active using: The steering wheel or through driver's voice command (i.e., help me see).

End of Requirement

###R_F_Augmented Reality_00106### Fault Message

The Augmented Reality (AR) feature shall display fault text message (i.e., Augmented Reality Not Available Service Required) on the HMI display when there is a fault or lack of normal operation due to:

- 1) AR camera
- 2) FIR camera – if vehicle is equipped with FIR camera
- 3) Loss of communication between components and invalid data (e.g., Phoenix gets stuck image from AR ECU. Video feed not updated).
- 4) The fault message behavior shall follow messaging strategy for designated vehicle program and shall give the HMI option to driver to acknowledge the message to disappear.



Message Attributes

Warning Type: single cycle – SC*

Time Out: N/A

Icon: N/A

Color: Amber

Chime: No

Due Care: No



Feature Document Augmented Reality (AR)

End of Requirement

###R_F_Augmented Reality_00107### AR Feature behavior when AR Fault Message is Requested

The Augmented Reality (AR) feature shall display NO AR functionality, once a AR fault message has been triggered and until the fault has been resolved

(AR) feature shall display NO AR functionality, once a fault message has been requested and until the fault has been resolved

End of Requirement

~~###R_F_Augmented Reality_00108### AR Camera Fault Message — If Vehicle is NOT equipped with FIR Camera~~

~~Note: Removed, replaced with Requirement # 107~~

~~The Augmented Reality (AR) feature shall display an AR Camera fault text message with feature Not available text (TBD) on the HMI display when there is a fault or lack of normal operation of the visible AR Camera and the vehicle is not equipped with night vision FIR Camera.~~

End of Requirement

###R_F_Augmented Reality_00109### AR Display HMI positioning

The Augmented Reality (AR) feature shall provide an AR display HMI to play the augmented reality images positioned in such a way that avoids impairment of the windshield or the driver line of sight to avoid any driver distraction and vehicle controllability issues. The display of augmented reality feature HMI shall be located with minimal interface with steering wheel location

End of Requirement

~~###R_F_Augmented Reality_00145### No AR operation on Transportation and Low Battery modes~~

~~Note: Removed / Replaced by #146~~

~~The Augmented Reality (AR) feature shall stay not operational during the following modes of the vehicle:~~

- ~~a) Transportation Life Cycle mode~~
- ~~b) Low Battery mode~~

End of Requirement



Feature Document Augmented Reality (AR)

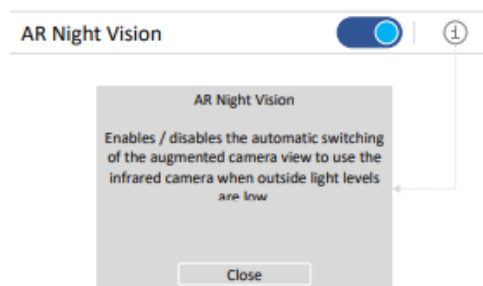
###R_F_Augmented Reality_00146### Augmented Reality HMI settings availability in Normal and Factory KOL Modes

The Augmented Reality (AR) feature shall allow the driver to select the AR settings in Normal and factory key-Off-load (KOL) modes.

End of Requirement

###R_F_Augmented Reality_00170### AR Night Vision Settings HMI information icon “i” – if vehicle is equipped with FIR camera

The Augmented Reality (AR) feature shall provide an HMI info icon “i” to educate the driver about Enable/Disable AR video mode (AR Night vision) options to choose from on the menu:



End of Requirement

###R_F_Augmented Reality_00171### AR Feature Settings Access

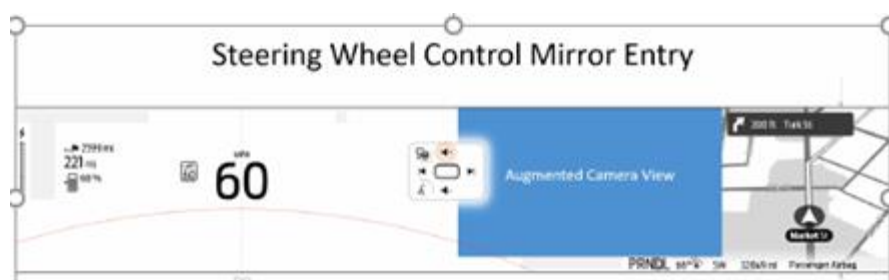
The Augmented Reality (AR) feature HMI settings shall be accessible in the SYNC center touchscreen in the Panoramic Configuration App.

End of Requirement

###R_F_Augmented Reality_00172### AR Feature – Steering Wheel Control Mirror Entry

When the AR view is triggered, the Augmented Reality (AR) feature shall:

- 1) hide the augmented camera view, once there is a use action that result in information being presented in the area of the AR camera view (e.g., accommodations menu).
- 2) show the control mirror overlaps the AR view, once there is action that only add the control mirror on the screen (e.g., touching the steering wheel controls, volume control)



User actions that result in information being presented in the area of the AR camera view (e.g., accommodations menu) will hide the augmented camera view. For actions that only add the control mirror on the screen (e.g., touching the steering wheel controls, volume control), the control mirror overlaps the AR camera view



Feature Document Augmented Reality (AR)

End of Requirement

####R_F_Augmented Reality_00173#### AR Feature vs Global Alert

When a global alert is requested, the Augmented Reality view shall be hidden by all Global Alert popup message (in the LINE OF SIGHT location of the display (the global alert override the AR feature display)).



When a global alert is requested, the Augmented Reality view shall be hidden by all Global Alert popup message (in the LINE OF SIGHT location of the display (the global alert override the AR feature display)).

End of Requirement

####R_F_Augmented Reality_00174#### AR Feature vs Warning Popup

When a warning popup message is requested, the Augmented Reality view shall be hidden by warning popup messages (in the PERIPHERAL location of the display) to promote visual priority.



When a warning popup message is requested, the Augmented Reality view shall be hidden by warning popup messages (in the PERIPHERAL location of the display) to promote visual priority.

End of Requirement

5.4 Other Requirements

5.4.1 Design Requirements

####R_F_Augmented Reality_00110#### AR vs FIR Camera packaging



Feature Document Augmented Reality (AR)

The FIR Camera (if vehicle is equipped) shall be packaged within the following packaging distance/position compared to AR Camera with enough FOV:

- 6" in X and Y, and 2" in depth maximum separation for full blending.
- If AR and FIR Camera packaging not within full blending, the FIR camera shall package TBD distance to allow for partial/selective blending.

End of Requirement

###R_F_Augmented Reality_00111### AR Camera Packaging

The AR Camera shall be packaged within a 6-inch distance and within a 5% FOV to the DAT (FWC) camera.

End of Requirement

5.4.2 Manufacturing Requirements

###R_F_Augmented Reality_00112### AR feature EOL Configuration/Calibration

The Augmented Reality feature shall:

- a) be configurable at the End Of Line (EOL) test at the manufacturing plant as below values. This mean all related DIDs shall be matched at EOL.

Name	Description	Range / Resolution
Augmented_Reality_Cfg	Configuration to denote feature enabled/disabled on the vehicle	0 x 0 == OFF 0 x 1 == ON; No FIR Camera (vehicle not equipped) 0 x 2 = ON; with FIR Camera (vehicle is equipped)

- b) be able to perform EOL calibration to the AR and FIR camera

End of Requirement



5.4.3 Service Requirements

###R_F_Augmented Reality_00113### Service Calibration for AR camera

The Augmented Reality feature shall be able to perform service calibration to the AR Camera.

The Augmented Reality feature shall be able to perform service calibration to the AR Camera

End of Requirement

###R_F_Augmented Reality_00114### Service Calibration for FIR camera (if vehicle is equipped with FIR camera)

The Augmented Reality feature shall be able to perform service calibration to the FIR Camera.

The Augmented Reality feature shall be able to perform service calibration to the FIR Camera.

End of Requirement

5.4.3.1 Cloud Connectivity Data Analytics Requirements

###R_F_Augmented Reality_00115### AR data analytics to turn feature On/Off though physical interface

When the driver turns the AR feature On/Off on the physical HMI the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:

- How many users are still in the default state (AR feature status ON)?
- How many users that changed the default feature setting status from ON to Off
- How many users that changed the feature setting status from OFF to ON
- How many users push the info icon of AR feature setting to learn about the feature status settings

End of Requirement

~~###R_F_Augmented Reality_00116### AR data analytics to turn feature On/Off though voice-command interface—~~ ~~Note: Removed not Supported by Google~~

~~When the driver turns the AR feature On/Off using the voice command HMI the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:~~

- ~~● How often does the driver turn On/Off the feature using the voice command interface?~~



Feature Document Augmented Reality (AR)

- How many times per drive cycle, hours in operation, per week, month, year, etc.?

End of Requirement

###R_F_Augmented Reality_00117### AR data analytics to turn feature AR video mode (AR Night Vision) Enable/Disable though physical interface – if vehicle is equipped with FIR camera

When the driver turns the AR video mode (AR night vision) Enable/Disable on the physical HMI the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:

- How many users are still in the default state (AR video mode status Enable)?
- How many users that changed the default AR video mode setting status from Enable to Disable
- How many users that changed the AR video mode setting status from Disable to Enable
- How many users push the info icon of AR video mode setting to learn about the AR video setting

End of Requirement

~~###R_F_Augmented Reality_00118### AR data analytics to turn feature mode Enable/Disable though voice command interface~~

~~Note: Removed, Not Supported by Google~~

~~When the driver turns the AR feature mode Enable/Disable using the voice command HMI the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:~~

- ~~• How often does the driver turn Enable/Disable the feature mode using the voice command interface?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

###R_F_Augmented Reality_00119### AR data analytics to turn Low Lane Visibility On/Off though push button on steering wheel – post <J1 feature>

When the driver turns the AR Lane Low Visibility On/Off using the push button HMI on the steering wheel the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:

- How often does the driver turn AR Lane Low Visibility On/Off using the push button on the steering wheel?
- How many times per drive cycle, hours in operation, per week, month, year, etc.?

End of Requirement

###R_F_Augmented Reality_00120### AR data analytics to turn Low Lane Visibility On/Off though voice command interface

When the driver turns the AR Lane Low Visibility On/Off using the voice command HMI the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:

- How often does the driver turn AR Lane Low Visibility On/Off using the voice command interface?
- How many times per drive cycle, hours in operation, per week, month, year, etc.?

End of Requirement



Feature Document Augmented Reality (AR)

####R_F_Augmented Reality_00121#### AR data analytics to turn Low Lane Visibility On/Off though contextually triggered menu – post <J1> feature

When the driver turns the AR Lane Low Visibility On/Off using the contextually triggered menu on the dashboard HMI the AR feature shall provide the data analytics of this action through the connected vehicle services to have data analysis throughout the following timelines:

- How often does the driver turn AR Lane Low Visibility On/Off responding to the contextually triggered option offered on the cluster?
- How many times per drive cycle, hours in operation, per week, month, year, etc.?

End of Requirement

####R_F_Augmented Reality_00122#### AR data analytics for output to HHDD when Turn by turn triggered

When the AR turn by turn as triggered, the AR feature shall provide the data analytics of the AR turn by turn and record the turn by turn event through the connected vehicle services to have data analysis throughout the following:

- When AR turn by turn is requested, how long it takes to appear in AR window
- When AR turn by turn window is displayed on HHDD, how often does the 2D map is shifted to the right and minimized?
- When AR turn by turn shown in AR view, how long it stays before AR window ends and no other AR trigger is active
- How often does the 2D map audio chime for turn by turn is Not synchronized when AR turn by turn window is displayed on HHDD (e.g., time differences when AR turn by turn appear on the HHDD vs time when turn by turn 2D map chime is generated by nav system)

When the AR turn by turn as triggered, the AR feature shall provide the data analytics of the AR turn by turn and record the turn by turn event through the connected vehicle services to have data analysis throughout the following:

- When AR turn by turn is requested, how long it takes to appear in AR window
- When AR turn by turn window is displayed on HHDD, how often does the 2D map is shifted to the right and minimized?
- When AR turn by turn shown in AR view, how long it stays before AR window ends and no other AR trigger is active
- How often does the 2D map audio chime for turn by turn is Not synchronized when AR turn by turn window is displayed on HHDD (e.g., time differences when AR turn by turn appear on the HHDD vs time when turn by turn 2D map chime is generated by nav system)

End of Requirement

~~####R_F_Augmented Reality_00123#### AR data analytics for output to HHDD when triggered by Lane Biasing~~

~~Note: Removed, Not Supported by Google~~

~~When the driver has the AR feature On using the ADAS system the AR feature shall provide the data analytics of the Lane Biasing prompts and record the number of AR feature outputs to the HHDD through the connected vehicle services to have data analysis throughout the following timelines:~~

- ~~• How often does the AR feature was On while the vehicle system had prompts from the ADAS system for Lane Biasing?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

~~####R_F_Augmented Reality_00124#### AR data analytics for output to HHDD when triggered by Highway Assist~~

~~Note: Removed, Not Supported by Google~~

~~When the driver has the AR feature On using the ADAS system the AR feature shall provide the data analytics of the Highway Assist prompts and record the number of AR feature outputs to the HHDD through the connected vehicle services to have data analysis throughout the following timelines:~~



Feature Document Augmented Reality (AR)

- How often does the AR feature was On while the vehicle system had prompts from the ADAS system for Highway Assist?
- How many times per drive cycle, hours in operation, per week, month, year, etc.?

End of Requirement

###R_F_Augmented Reality_00175### AR data analytics for output to HHDD when triggered by Destination

When the AR destination is triggered, the AR feature shall provide the data analytics of the AR destination and record the destination event through the connected vehicle services to have data analysis throughout the following:

- When AR destination is requested, how long it takes to appear in AR window
- When AR destination is shown on the HHDD, how long it takes to end the AR view after reaching the destination
- When destination AR window is displayed on HHDD, how often does the 2D map is shifted to the right and minimized?
- How often does the 2D map audio chime for destination is Not synchronized when AR destination window is displayed on HHDD (e.g., time differences when AR destination appear on the HHDD vs time when turn by turn 2D map chime is generated by nav system)

When the AR destination is triggered, the AR feature shall provide the data analytics of the AR destination and record the destination event through the connected vehicle services to have data analysis throughout the following:

- When AR destination is requested, how long it takes to appear in AR window
- When AR destination is shown on the HHDD, how long it takes to end the AR view after reaching the destination
- When destination AR window is displayed on HHDD, how often does the 2D map is shifted to the right and minimized?
- How often does the 2D map audio chime for destination is Not synchronized when AR destination window is displayed on HHDD (e.g., time differences when AR destination appear on the HHDD vs time when turn by turn 2D map chime is generated by nav system)

End of Requirement

###R_F_Augmented Reality_00125### AR data analytics for output to HHDD when triggered by Blind Spot

When the AR blind spot is triggered, the AR feature shall provide the data analytics of the AR blind spot and record the blind spot event through the connected vehicle services to have data analysis throughout the following:

- When AR blind spot is requested, how long it takes to appear in AR window
- When AR blind spot window is displayed on HHDD, how often does the 2D map is shifted to the right and minimized?
- When AR blind spot shown in AR view, how long it stays before AR window ends and no other AR trigger is active

The AR feature shall provide the data analytics of the AR blind spot and record the blind spot event through the connected vehicle services to have data analysis throughout the following:

- When AR blind spot is requested, how long it takes to appear in AR window
- When AR blind spot window is displayed on HHDD, how often does the 2D map is shifted to the right and minimized?
- When AR blind spot shown in AR view, how long it stays before AR window ends and no other AR trigger is active

End of Requirement

###R_F_Augmented Reality_00126### AR Feature Status HMI Setting through physical option-failure mode

The failure mode of AR feature HMI setting shall record the data analytics based on below events:



Feature Document Augmented Reality (AR)

- When customer turn AR feature status OFF, how often per vehicle, days, etc. the feature still ON and display AR event?
- When customer turn AR feature status ON, how often per vehicle, days, etc. the feature still OFF and display no AR event?
- When customer press to display AR feature status info icon, how often per vehicle, days, etc. the info icon not shown?
- When customer press to close AR feature status info icon, how often per vehicle, days, etc. the info icon still shown?

The failure mode of AR feature HMI setting ON/OFF shall record the data analytics

- When customer turn AR feature status OFF, how often per vehicle, days, etc. the feature still ON and display AR event?
- When customer turn AR feature status ON, how often per vehicle, days, etc. the feature still OFF and display no AR event?
- When customer press to display AR feature status info icon, how often per vehicle, days, etc. the info icon not shown?
- When customer press to close AR feature status info icon, how often per vehicle, days, etc. the info icon still shown?

End of Requirement

###R_F_Augmented Reality_00176### AR Video Mode Status HMI Setting through physical option-failure mode

The failure mode of AR video mode HMI setting shall record the data analytics based on below events:

- When customer turn AR video mode status Disable, how often per vehicle, days, etc. the video mode setting still Enable and display AR event using FIR camera background?
- When customer turn AR video mode status Enable, how often per vehicle, days, etc. the video mode setting still disable and not shown the AR display event using FIR camera background when low light threshold is detected?
- When customer turn AR video mode status Enable, how often per vehicle, days, etc. the video mode setting still disable and not shown the AR display event using AR camera background when high light threshold is detected?
- When customer press to display AR video mode setting info icon, how often per vehicle, days, etc. the info icon not shown?
- When customer press to close AR video mode setting info icon, how often per vehicle, days, etc. the info icon still shown?

The failure mode of AR video mode HMI setting shall record the data analytics based on below events:

- When customer turn AR video mode status Disable, how often per vehicle, days, etc. the video mode setting still Enable and display AR event using FIR camera background?
- When customer turn AR video mode status Enable, how often per vehicle, days, etc. the video mode setting still disable and not shown the AR display event using FIR camera background when low light threshold is detected?
- When customer turn AR video mode status Enable, how often per vehicle, days, etc. the video mode setting still disable and not shown the AR display event using AR camera background when high light threshold is detected?
- When customer press to display AR video mode setting info icon, how often per vehicle, days, etc. the info icon not shown?
- When customer press to close AR video mode setting info icon, how often per vehicle, days, etc. the info icon still shown?
- When customer turn AR feature status ON, how often per vehicle, days, etc. the feature still OFF and display no AR event?
- When customer press to display AR feature status info icon, how often per vehicle, days, etc. the info icon not shown?
- When customer press to close AR feature status info icon, how often per vehicle, days, etc. the info icon still shown?

End of Requirement



Feature Document Augmented Reality (AR)

~~###R_F_Augmented Reality_00127### AR On through physical HMI option and AR stays Off failure mode~~

Note: Removed, Replaced with Requirement #126

~~When the driver selects to turn the AR feature On through the physical HMI option the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature stays Off.~~

End-of-Requirement

~~###R_F_Augmented Reality_00128### AR On/Off through physical HMI option and no visual feedback failure mode~~

Note: Removed, Replaced with Requirement #126

~~When the driver selects to turn the AR feature On/Off through the physical HMI option the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature feedback to the driver stays in the same state without clear indication of the change.~~

End-of-Requirement

###R_F_Augmented Reality_00129### AR Turn by Turn- failure mode

The failure mode of AR turn by turn shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR turn by turn is requested when maneuver trigger > 0.1 for city and >0.2 for highway received from navigation system
- How often does the AR turn by turn is requested without a user set a destination in navigation system
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR turn by turn are shown with blue turn by turn arrow when speed of the vehicle is higher than speed limit?
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR turn by turn are shown with Amber turn by turn arrow when speed of the vehicle is below speed limit?
- When AR turn by turn shown in AR view, how long it stays before AR window ends (in scenario no other AR trigger is active).
- How often does the AR turn by turn display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)
- How often does the AR turn by turn display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?

The failure mode of AR turn by turn shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR turn by turn is requested when maneuver trigger > 0.1 for city and >0.2 for highway received from navigation system
- How often does the AR turn by turn is requested without a use set a destination in navigation system
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR turn by turn are shown with blue turn by turn arrow when speed of the vehicle is higher than speed limit?
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR turn by turn are shown with Amber turn by turn arrow when speed of the vehicle is below speed limit?
- When AR turn by turn shown in AR view, how long it stays before AR window ends (in scenario no other AR trigger is active).
- How often does the AR turn by turn display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)
- How often does the AR turn by turn display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?



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End of Requirement

~~###R_F_Augmented Reality_00130### AR Street Name failure mode~~

~~Note- Removed Not Supported by Google~~

~~When the driver selects to turn the AR feature On with a Destination or route set in the Navigation System the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to present to the driver the correct Street Names on the AR HMI according to the prompts provided by the Navigation System per the following timelines:~~

- ~~• How often does the AR feature was On with a Destination or route set in the Navigation System that provided prompts to the AR feature to display Street Name while the AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

~~###R_F_Augmented Reality_00131### AR House Number failure mode~~

~~Note- Removed Not Supported by Google~~

~~When the driver selects to turn the AR feature On with a Destination or route set in the Navigation System the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to present to the driver the correct House Number on the AR HMI according to the prompts provided by the Navigation System per the following timelines:~~

- ~~• How often does the AR feature was On with a Destination or route set in the Navigation System that provided prompts to the AR feature to display House Number while the AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

~~###R_F_Augmented Reality_00132### AR House Numbers voice command failure mode~~

~~Note- Removed Not Supported by Google~~

~~When the driver speaks the voice command to show house numbers (i.e. "Show me House Numbers") the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to present to the driver the correct House Numbers near the vehicle vicinity on the AR HMI per the following timelines:~~

- ~~• How often does the driver spoke the voice command to show house numbers and AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement



Feature Document Augmented Reality (AR)

####R_F_Augmented Reality_00133#### AR Destination- failure mode

The failure mode of AR destination shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR destination is requested when user does not set a destination in navigation system (No active route)
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol are shown without show checkboard.
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol are not shown but the checkboard is shown.
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol and checkerboard are not shown after reaching destination
- How often does the AR destination display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)
- How often does the AR destination display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?

The failure mode of AR destination shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR destination is requested when user does not set a destination in navigation system (No active route)
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol are shown without show checkboard.
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol are not shown but the checkboard is shown.
- How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol and checkerboard are not shown after reaching destination
- How often does the AR destination display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)
- How often does the AR destination display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?

End of Requirement

####R_F_Augmented Reality_00134#### AR Point of Interest failure mode Note- Removed, Not Supported by Google

When the driver selects a Point Of Interest (POI) through the physical or spoken HMI option the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to present to the driver the correct directions with augmented reality symbols/icons to follow to reach/show the POI on the AR HMI according to the prompts provided by the Navigation System per the following timelines:

- How often does the AR feature was On with a POI in the Navigation System that provided prompts to the AR feature to display the correct directions with augmented reality symbols/icons to follow to reach to his/her POI while the AR feature output to the HMI stayed without change?
- How many times per drive cycle, hours in operation, per week, month, year, etc.?

End of Requirement

####R_F_Augmented Reality_00135#### AR Blind Spot - failure mode

The failure mode of AR blind spot shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR blind spot is requested when ADAS blind spot is not active?



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- How often does the AR blind spot is requested when ADAS left blind spot is active and customer does not activate left turn signal
- How often does the AR blind spot is requested when ADAS right blind spot is active and customer does not activate right turn signal
- How often does the AR blind spot display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)
- How often does the AR blind spot display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?

The failure mode of AR blind spot shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR blind spot is requested when ADAS blind spot is not active?
- How often does the AR blind spot is requested when ADAS left blind spot is active and customer does not activate left turn signal
- How often does the AR blind spot is requested when ADAS right blind spot is active and customer does not activate right turn signal
- How often does the AR blind spot display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)
- How often does the AR blind spot display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?

End of Requirement

###R_F_Augmented Reality_00177### AR Night Vision - failure mode

The failure mode of AR night vision shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR window is shown with FIR image background, when user select AR select mode (AR night vision) setting Disable.
- How often does the AR window is shown with FIR image background, when user select AR select mode (AR night vision) setting Enable but light threshold (AR camera gain threshold) is < threshold (TBD)
- How often does the AR window is shown with AR image background, when user select AR select mode (AR night vision) setting Enable but light threshold (AR camera gain threshold) is >= threshold (TBD)
- How often does the AR window is transition between AR image background to FIR image background (or opposite), while current AR event is active

The failure mode of AR night vision shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following:

- How often does the AR window is shown with FIR image background, when user select AR select mode (AR night vision) setting Disable.
- How often does the AR window is shown with FIR image background, when user select AR select mode (AR night vision) setting Enable but light threshold (AR camera gain threshold) is < threshold (TBD)
- How often does the AR window is shown with AR image background, when user select AR select mode (AR night vision) setting Enable but light threshold (AR camera gain threshold) is >= threshold (TBD)
- How often does the AR window is transition between AR image background to FIR image background (or opposite), while current AR event is active

End of Requirement

###R_F_Augmented Reality_00136### AR Lane Low Visibility failure mode

When the driver selects to turn the AR feature for Lane Low Visibility through the physical or spoken HMI option the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to show the driver the correct road lines to follow on the AR HMI per the following timelines:

- How often does the driver activated the driver activated the AR feature for Lane Low Visibility through the physical or spoken HMI option and AR feature output to the HMI stayed without change?
- How many times per drive cycle, hours in operation, per week, month, year, etc.?



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End of Requirement

~~###R_F_Augmented Reality_00137### AR Lane Level Navigation failure mode~~

~~Note- Removed Not Supported by Google~~

~~When the driver selects to turn the AR feature On and the Navigation system in combination with the ADAS system provides prompts for a Lane Level Navigation the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to present to the driver the correct augmented reality arrow to follow to show to the driver the correct road line the vehicle should be going into per the following timelines:~~

- ~~• How often does the Navigation and ADAS system triggered the Lane Level Navigation for the vehicle to move to the correct lane to continue with its trip and AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

~~###R_F_Augmented Reality_00138### AR Lane Biasing failure mode~~

~~Note- Removed Not recommend per CIED for HHDD Application~~

~~When the driver selects to turn the AR feature On with the ADAS system turned On in a blue zone, the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to show the Lane Biasing metaphor on the AR HMI when the ADAS system triggers any lane biasing command of the vehicle within the same road lines due to an oncoming object from behind the vehicle that persist until the ADAS command finishes per the following timelines:~~

- ~~• How often does the ADAS system triggered the Lane Biasing for the vehicle to bias toward one side within the same road lines and AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

~~###R_F_Augmented Reality_00139### AR Highway Assist failure mode~~

Note-

~~Removed Not recommend per CIED for HHDD Application~~

~~When the driver selects to turn the AR feature On with the ADAS system turned On, the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to show the Highway Assist metaphor on the AR HMI when the ADAS system triggers any Highway Assist command of the vehicle that persist until the ADAS command finishes per the following timelines:~~

- ~~• How often does the ADAS system triggered the Highway Assist for the vehicle to be driven Hands Off the wheel within a Blue Zone or requested the driver to take control of the vehicle wheel and AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~

End of Requirement

~~###R_F_Augmented Reality_00140### AR Assisted Lane Change failure mode~~

~~Note- Removed Not recommend per CIED for HHDD Application~~

~~When the driver selects to turn the AR feature On with the ADAS system turned On, the Augmented Reality feature shall provide the necessary diagnostics for data analytics if the AR feature fails to show the Assisted Lane Change requested metaphor on the AR HMI when the ADAS system triggers any Assisted Lane Change command of the vehicle that persist until the ADAS command finishes per the following timelines:~~

- ~~• How often does the ADAS system triggered the Assisted Lane Change for the vehicle to perform an overpass of another vehicle in front of it with the acknowledgement of the driver with the turn signal indicator and the AR feature output to the HMI stayed without change?~~
- ~~• How many times per drive cycle, hours in operation, per week, month, year, etc.?~~



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End of Requirement

###R_F_Augmented Reality_00178### AR failure messages

The AR feature data analytics shall record the faults messages appear on the HMI and the reason of the faults based on below events through the connected vehicle services to have data analysis throughout the following:

- How many times the fault messages are due to fault in AR camera
- How many times the fault messages are due to fault in FIR camera
- How many times the fault messages are due to miss communication between components or invalid data

The AR feature data analytics shall record the faults messages appear on the HMI and the reason of the faults based on below events through the connected vehicle services to have data analysis throughout the following:

- How many times the fault messages are due to fault in AR camera
- How many times the fault messages are due to fault in FIR camera
- How many times the fault messages are due to miss communication between components or invalid data

End of Requirement

###R_F_Augmented Reality_00144### Data Analytics Table

Data Gathering/Brainstorm/Analysis Worksheet

Purpose: To gather information and Data elements for feature development in support of Data Analytics in order to understand the value and opportunities gained. In addition, this will also help prioritize the opportunities to focus on which will be investigated in more detail in the "Data Elements for FIS" worksheet.

Data Element (Variable)	Data Element Description	Purpose	Value / Opportunity	Current Data Type (If known)	Current Data Source (If known)	Priority
Data Elements for Customer Outputs						
AR Feature Status Button Pressed	AR Feature on/off status To tell if the customer is pressing the AR feature on/off button	<ul style="list-style-type: none">- If many customers use this feature often, then we can make the feature standard on luxury vehicles, which increases customer satisfaction.- If customers always go into this mode, then we can make the menu selection easier to get to, or we could have as default to off, as part of reductive design- to turn the feature off before stopping the use of the Augmented Reality feature for Navigation and situational awareness, for reductive design	<ul style="list-style-type: none">- reductive design- customer satisfaction	Ethernet	APIM, ARM	High



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AR Feature Mode Button Pressed – if vehicle is equipped with FIR camera	AR feature Enable/Disable of automatic camera selection	<ul style="list-style-type: none"> - If many customers use Enable to keep AR-Camera always On, then we can make this the default mode, which increases customer satisfaction. - If customers always go into this mode, then we can make the menu selection easier to get to, or we could have as default to Enable (always AR-Camera), as part of reductive design - to turn the feature to Enable before starting the use of the Augmented Reality feature for Navigation and situational awareness, for reductive design 	<ul style="list-style-type: none"> - reductive design - customer satisfaction 	Ethernet	APIM, ARM	High
Guide - Turn by Turn	To tell if the AR feature function turn-by-turn is activated by the Navigation system prompts	- See if the AR display is activated with the prompts from Navigation System, to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	<ul style="list-style-type: none"> - customer satisfaction - warranty 	Ethernet	ARM	Medium
Overlay Destination	To tell if the AR feature function Destination is activated by the Navigation system prompts	- See if the AR feature is activated with the prompts from Navigation System, to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	<ul style="list-style-type: none"> - customer satisfaction - warranty 	CAN signal (TBD)	ARM	Medium
Overlay Blind Spot (BLIS)	To tell if the AR feature function BLIS is activated by the ADAS system prompts and turn signals	- See if the AR feature is activated with the prompts from Navigation System, to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	<ul style="list-style-type: none"> - customer satisfaction - warranty 	CAN signal (TBD)	ARM, DAT, SCCM	Medium
Night vision AR overlay	To tell if the AR feature night vision background appear as requested	- See if the AR feature night vision appear based on AR camera gain threshold to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	<ul style="list-style-type: none"> - customer satisfaction - warranty 	Ethernet	ARM,	Medium
Overlay Lane Biasing – MVP+	To tell if the AR feature function Lane Biasing is activated by the ADAS system prompts	- See if the AR feature is activated with the prompts from ADAS System, to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	<ul style="list-style-type: none"> - customer satisfaction - warranty 	CAN signal (TBD)	ARM, DAT	Low
Data Elements for Customer Inputs						
AR Menu Active	AR menu Activate/Deactivate signal	- See how often the customer goes into the AR menu, if very often, then make the menu easier to use, i.e. higher level, less button presses, etc. as part	<ul style="list-style-type: none"> - reductive design - customer satisfaction 	Ethernet	APIM, ARM	High



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		of the reductive design to improve customer satisfaction				
AR Mode Menu Enable/Disable	AR menu Enable/Disable automatic camera selection signal	- See how often the customer goes into the AR menu, if very often, then make the menu easier to use, i.e. higher level, less button presses, etc. as part of the reductive design to improve customer satisfaction	- reductive design - customer satisfaction	Ethernet	APIM, ARM	High
AR Low Lane Visibility push button	Activate AR road lanes visibility by push button on steering wheel	- See how often the customer uses the AR push button on steering wheel, if not often, then we can consider the removal of it as part of the reductive design	- reductive design - material cost	Ethernet	APIM, ARM, ADAS	High
AR Low Lane Visibility contextually triggered	Activate AR road lanes visibility by contextually triggered menu help on dashboard according to weather conditions or wiper high speed	- See how often the customer uses the AR contextually triggered menu, if not often, then we can consider the removal of it as part of the reductive design	- reductive design - material cost	Ethernet	APIM, ARM, ADAS	High
Data Elements for Customer Level Failure Modes						
AR feature Off/ON	Unintended function - Feature is activated when setting = OFF Feature is deactivated when setting = ON	When customer turn AR feature status OFF, how often per vehicle, days, etc. the feature still ON and display AR event? When customer turn AR feature status ON, how often per vehicle, days, etc. the feature still OFF and display no AR event? When customer press to display AR feature status info icon, how often per vehicle, days, etc. the info icon not shown? When customer press to close AR feature status info icon, how often per vehicle, days, etc. the info icon still shown?	- Reduce Warranty	Ethernet	APIM, ARM	High
AR feature mode Enable /Disable	Unintended /No function	When customer turn AR video mode status Disable, how often per vehicle, days, etc. the video mode setting still Enable and display AR event using FIR camera background? When customer turn AR video mode status Enable, how often per vehicle, days, etc. the video mode setting still disable and not shown the AR display event using FIR camera background	- Reduce Warranty	Ethernet	APIM, ARM	High



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		<p>when low light threshold is detected?</p> <p>When customer turn AR video mode status Enable, how often per vehicle, days, etc. the video mode setting still disable and not shown the AR display event using AR camera background when high light threshold is detected?</p> <p>When customer press to display AR video mode setting info icon, how often per vehicle, days, etc. the info icon not shown?</p> <p>When customer press to close AR video mode setting info icon, how often per vehicle, days, etc. the info icon still shown?</p>				
Guide - Turn by Turn not responding	To tell if the AR feature function turn-by-turn is activated by the Navigation system prompts	<p>How often does the AR turn by turn is requested when maneuver trigger > 0.1 for city and >0.2 for highway received from navigation system</p> <p>How often does the AR turn by turn is requested without a user set a destination in navigation system</p> <p>How many times per drive cycle, hours in operation, per week, month, year, etc. AR turn by turn are shown with blue turn by turn arrow when speed of the vehicle is higher than speed limit?</p> <p>How many times per drive cycle, hours in operation, per week, month, year, etc. AR turn by turn are shown with Amber turn by turn arrow when speed of the vehicle is below speed limit?</p> <p>When AR turn by turn shown in AR view, how long it stays before AR window ends (in scenario no other AR trigger is active).</p> <p>How often does the AR turn by turn display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)</p> <p>How often does the AR turn by turn display on AR window show a wiper motion? What</p>	- customer satisfaction - warranty	Ethernet	ARM APIM	High



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		<p>was the wiper motion speed when AR view is triggered? How often does the 2D map is Not shifted to the right and/or Not minimized, when AR turn by turn window is displayed on HHDD</p> <p>How often does the 2D map audio chime for turn by turn is Not synchronized when AR turn by turn window is displayed on HHDD (e.g., time differences when AR turn by turn appear on the HHDD vs time when turn by turn 2D map chime is generated by nav system)</p> <p>to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature</p>				
Overlay Destination not responding	To tell if the AR feature function Destination is activated by the Navigation system prompts	<p>- See if the AR feature is activated with the prompts from Navigation System,</p> <p>How often does the AR destination is requested when user does not set a destination in navigation system (No active route)</p> <p>How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol are shown without show checkboard.</p> <p>How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol are not shown but the checkboard is shown.</p> <p>How many times per drive cycle, hours in operation, per week, month, year, etc. AR destination symbol and checkerboard are not shown after reaching destination</p> <p>How often does the AR destination display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)</p> <p>How often does the AR destination display on AR window show a wiper motion?</p> <p>What was the wiper motion</p>	- customer satisfaction - warranty	Ethernet	ARM APIM	High



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		<p>speed when AR view is triggered?</p> <p>How often does the 2D map is Not shifted to the right and/or Not minimized, when AR destination window is displayed on HHDD</p> <p>How often does the 2D map audio chime for destination is Not synchronized when AR destination window is displayed on HHDD (e.g., time differences when AR destination appears on the HHDD vs time when destination 2D map chime is generated by nav system)</p> <p>How long does it take for AR destination window to close, after driver arrive destination?</p> <p>to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature</p>				
Overlay Blind Spot (BLIS) not responding	To tell if the AR feature function BLIS is activated by the ADAS system prompts and turn signals	<p>- See if the AR feature is activated with the prompts from Navigation System,</p> <p>How often does the AR blind spot is requested when ADAS blind spot is not active?</p> <p>How often does the AR blind spot is requested when ADAS left blind spot is active and customer does not activate left turn signal</p> <p>How often does the AR blind spot is requested when ADAS right blind spot is active and customer does not activate right turn signal</p> <p>How often does the AR blind spot display on AR window show overlap with an object in front of the host vehicle (car, pedestrian, bike, motorcycle, etc.)</p> <p>How often does the AR blind spot display on AR window show a wiper motion? What was the wiper motion speed when AR view is triggered?</p> <p>How often does the 2D map is Not shifted to the right and/or Not minimized, when AR blind spot window is displayed on HHDD</p>	- customer satisfaction - warranty	Ethernet CAN	ARM, DAT, SCCM APIM	High



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		<p>How long does it take for AR blind spot window to close, after driver deactivates turn signal or ADAS blind spot is clear?</p> <p>to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature</p>				
AR night vision	To tell if the AR feature function night vision	<p>- See if the AR feature is activated with the prompts from Navigation System,</p> <p>The failure mode of AR night vision shall record the data analytics based on below events through the connected vehicle services to have data analysis throughout the following: How often does the AR window is shown with FIR image background, when user select AR select mode (AR night vision) setting Disable. How often does the AR window is shown with FIR image background, when user select AR select mode (AR night vision) setting Enable but light threshold (AR camera gain threshold) is < threshold (TBD) How often does the AR window is shown with AR image background, when user select AR select mode (AR night vision) setting Enable but light threshold (AR camera gain threshold) is >= threshold (TBD) How often does the AR window is transition between AR image background to FIR image background (or opposite), while current AR event is active to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature</p>	<p>- customer satisfaction</p> <p>- warranty</p>	Ethernet	ARM, APIM	High
Overlay Lane Low Visibility– not responding	To tell if the AR feature function Lane Low Visibility is activated by the AR system menu buttons	<p>- See if the AR feature is activated with the prompts from Navigation System, to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature</p>	<p>- customer satisfaction</p> <p>- warranty</p>	Ethernet CAN	APIM, ARM, DAT, SCCM	High



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Overlay Lane Low Visibility – not responding	To tell if the AR feature function Lane Low Visibility is activated through the Steering Wheel acceptance of Contextual Virtual Option on HHDD	- See if the AR feature is prompted by the contextually option for Virtual selection, to improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	- customer satisfaction - warranty	Ethernet CAN	APIM, ARM, DAT, SCCM	High
Fault messages	To tell if the AR feature has any fault messages and what reason of the fault	See if the AR feature has any fault messages, not available How many times the fault messages are due to fault in AR camera How many times the fault messages are due to fault in FIR camera How many times the fault messages are due to miss communication between components or invalid data improve customer satisfaction and reduce warranty claims, we can verify the correct operation of the AR feature	- customer satisfaction - warranty	Ethernet CAN	APIM, ARM,	High

End of Requirement



5.4.4 After Sales Requirements

None

5.4.5 Process requirements

None



6 FUNCTIONAL SAFETY

6.1 System Behaviors for HARA

System Behaviours of Augmented Reality

ID	Name	Description
System Behavior 1	Disable Augmented Reality applicable information to the driver on HHDD	Display the forward looking camera image on the AR display, to provide a background to overlay the AR data onto screen
System Behavior 2	Display Augmented Cruise (AC) information to the driver on HHDD	Display information from the navigation system on the AR display, as an overlay onto the base camera image, in the relevant part of the base image: <ul style="list-style-type: none">- Turn-by-Turn direction arrows- Address numbers- Street names- Point-of-Interest information- Destination Beacon/pointer
System Behavior 3	Display Augmented Guide (AG) information to the driver on HHDD	Display information from the Active drive assist system on the AR display, as an overlay onto the base camera image, in the relevant part of the base image: <ul style="list-style-type: none">- Lane Biasing - MVP+- Highway Assist - TBD if part of MVP+- Assisted Lane Change - TBD if part of MVP+
System Behavior 4	Display Augmented Lanes (AL) information to the driver on HHDD	Display information from the DAT/Navigation system on the AR display, as an overlay onto the base camera image, in the relevant part of the base image: <ul style="list-style-type: none">- Blind Spot Information System Notification – MVP- Lane guide (Lane Level Guidance), navigation - MVP+- Lane low visibility - MVP+
System Behavior 5:	Display Augmented Visibility (AV) information to the driver on HHDD	Display the forward-looking FIR camera image on the AR display, to provide a background at night to overlay the AR data onto <ul style="list-style-type: none">- Night vision- FIR camera will use as background to AR camera when display at night, enhance image quality

Table 14: System Behaviors for HARA



6.2 Safety Assumptions

None.

6.3 Safety Goals

Not applicable for Augmented Reality feature. Feature is QM per HARA document.

6.4 Functional Safety Requirements

Not applicable for Augmented Reality feature. Feature is QM per HARA document.

6.4.1 <Goal 1 Name>

Not applicable for Augmented Reality feature. Feature is QM per HARA document.

6.4.2 <Goal n Name>

Not applicable for Augmented Reality feature. Feature is QM per HARA document.

6.4.3 Derivation of Functional Safety Requirements on Assumptions

Not applicable for Augmented Reality feature. Feature is QM per HARA document.

6.4.4 ASIL Decomposition of Functional Safety Requirements

Not applicable for Augmented Reality feature. Feature is QM per HARA document.



7 CYBERSECURITY

7.1 Security Goals

ID	Goal	
1	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Data Repudiation by AR ECU
	Description	AR ECU may not have sufficient logging for forensic purposes after an incident occurs. May not have appropriate DTCs.
	CAL	
	Related CSR IDs	Mitigation Implemented - Planning diagnostics for lost comm and invalid data. Covered in functional requirements, NETCOM has lost comm, may need to add additional ones.
2	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Information Disclosure on ECU
	Description	CAN data may be disclosed including vehicle dynamics. XYZ of eye gaze.
	CAL	
	Related CSR IDs	Mitigation Implemented - Not storing or recording any driver behavior, messages already broadcast on CAN, normal NETCOM requirements. On die Hardware Security Module (HSM) may be included depending on spoofing above. Display adjustment.
3	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - CAN bus interruption
	Description	An external agent interrupts data flowing across a bus to AR ECU or floods the bus, not able to provide correct rendering of information.
	CAL	
	Related CSR IDs	Mitigation Implemented - Normal NETCOM requirements, lost comm DTC.
4	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - ECU elevation of privilege
	Description	Attacker may be able to change application, configuration, or calibration. Stop AR functionality or display wrong data.
	CAL	
	Related CSR IDs	Mitigation Implemented - Firmware updates following Ford standard requirements, supplier to perform TARA and rest of cyber eSOW when selected. If supplier has HSM, secure boot may help.
5	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing CAN ECU
	Description	TCU may be spoofed by an attacker and this may lead to unauthorized access to AR ECU to provide GNSS data. Used to calculate vehicle position. Attacker with physical access to CAN sends improper messages, causing unauthorized behavior.
	CAL	
	Related CSR IDs	Mitigation Implemented - GNSS data is often inaccurate, uses default assumptions and GNSS to calculate. will ignore if it decides it is wrong. TCU currently using CAN, plan to move to SOA GNSS platform when available, China TCU is different, may have different controls.
6	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Lack of Input Validation for AR ECU
	Description	GNSS data from TCU to AR ECU may be tampered with by an attacker. Data or command tampering impact is ____
	CAL	
	Related CSR IDs	Mitigation Implemented
7	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Information Disclosure on ECU
	Description	GNSS data disclosed on vehicle bus.



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	CAL	
	Related CSR IDs	Mitigation Implemented - Existing signal, see above, mTLS in future.
8	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - ECU elevation of privilege
	Description	Attacker may be able to change application, configuration, or calibration. What is the worst potential impact?
	CAL	
	Related CSR IDs	Mitigation Implemented - Will have supplier TARA, cover there.
9	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Lack of Input Validation for AR HUD
	Description	LVDS from AR ECU to AR HUD may be tampered with by an attacker. Data or command tampering impact is garbled or incorrect image.
	CAL	
	Related CSR IDs	Mitigation Implemented - Delivered on an FPD3 link with an I2C back channel. same questions for supplier as for camera. AR HUD is responsible for adjusting brightness, has its own light and rain sensor inputs over CAN.
10	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Data Repudiation by AR HUD
	Description	AR HUD may not have sufficient logging for forensic purposes after an incident occurs. Data integrity failure.
	CAL	
	Related CSR IDs	Mitigation Implemented - If this is primary display, may need lost comm strategy, same as for AR ECU and DAT. Part of functional spec.
11	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Process Crash or Stop for AR HUD
	Description	AR HUD crashes, halts, stops or runs slowly; in all cases violating an availability metric.
	CAL	
	Related CSR IDs	Mitigation Implemented - Covered in functional spec.
12	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing CAN ECU
	Description	AR ECU may be spoofed by an attacker and this may lead to unauthorized access to Phoenix or above for LVDS. Attacker with physical access to hardwired coax data cable sends improper video stream.
	CAL	
	Related CSR IDs	Mitigation Implemented - Hardwired physical connection. Attacker would need to set up data stream and connect a new device, as soon as connection is broken would not have image.
13	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Lack of Input Validation for SYNC 4.2 or above
	Description	LVDS from AR ECU to Phoenix may be tampered with by an attacker. Data or command tampering impact is wrong video displayed, wire cut.
	CAL	
	Related CSR IDs	Mitigation Implemented - A requirement is in place to determine if there is a stuck image, this requirement will be cascaded to the Phoenix controller via the feature owner.
14	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing the AR-CAM Process
	Description	AR-CAM, other thermal cam may be spoofed by an attacker and this may lead to unauthorized video signal delivered to AR ECU for LVDS or other video or I2C connection from AR-CAM to AR ECU.
	CAL	
	Related CSR IDs	Mitigation Implemented - Physical attack if this is hardwired coax connection, how camera malfunctions or other data are communicated to AR-ECU, I2C, may require additional micro on AR-CAM if it needs to be responsible for diagnostics, Debbie to investigate how it happens. Authentication not technically possible over I2C. Diagnostics to set a DTC if



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		communication is broken. AR ECU will set stuck images and gambled images.
15	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Lack of Input Validation for AR ECU
	Description	LVDS or other video from AR-CAM or other thermal cam to AR ECU may be tampered with by an attacker. AR functionality will be incorrect, corrupt, or missing.
	CAL	
	Related CSR IDs	Mitigation Implemented - A requirement is in place to determine if camera has been swapped or if there is a stuck image
16	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Data Repudiation by AR ECU
	Description	AR ECU may not have sufficient logging for forensic purposes after a failure occurs. DTC not present when required.
	CAL	
	Related CSR IDs	Mitigation Implemented - Need DTC for calibration failure, end of line test, any failures reported by camera, covered in issue 2.
17	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - CAN bus interruption
	Description	An external agent interrupts data flowing across a bus to AR ECU or cuts the wire.
	CAL	
	Related CSR IDs	Mitigation Implemented - Monitors on power, see DTCs in 2 above.
18	Goal Name	Prevent compromise of a single vehicle or vehicle system from propagating to other vehicles or fleets - Spoofing AR ECU
	Description	AR ECU may be spoofed by an attacker and this may lead to unauthorized access to AR-CAM over LVDS or other video.
	CAL	
	Related CSR IDs	Mitigation Implemented - AR ECU sends i2c commands to camera, hardwired connection. Consider follow up with Cheri Hansen on Sensing System Architecture Platform for future camera services. Hardwired controls sufficient for current vehicle program but consider for long term strategy. Diagnostics to set a DTC if communication is broken. AR ECU will set stuck images and gambled images
19	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Lack of Input Validation for AR ECU
	Description	Display control, Map, nav data from SYNC 4.2 or above to AR ECU may be tampered with by an attacker. Data or command tampering impact is
	CAL	
	Related CSR IDs	Mitigation Implemented - See above, mTLS.
20	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing CAN ECU
	Description	Phoenix may be spoofed by an attacker and this may lead to unauthorized access to AR ECU for Display control, Map, nav data. GNSS antenna may come through SYNC for older modules, if so, that data will go over CAN.
	CAL	
	Related CSR IDs	Mitigation Implemented - If GNSS, covered under GNSS data same as TCU. Phoenix ethernet authenticates using SOA, mTLS. Can signals rated are C5. If the controller does not get any response Phoenix should enter DTC
21	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Information Disclosure on ECU
	Description	Map, nav data disclosed, route, POI, street name from SYNC to AR ECU
	CAL	
	Related CSR IDs	Mitigation Implemented - mTLS over ethernet. Nav data may be stored, either get all maneuvers or send each maneuver and then display. Will



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		delete every time, have functional spec for delete command, not retain after arrived to destination. Does not store for long time and keeps refreshing.
22	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - CAN bus interruption
	Description	If no nav data cannot display directions.
	CAL	
	Related CSR IDs	Mitigation Implemented - Nav team has 2D map already whenever the signals are present then the AR navigation pops up.
23	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - ECU elevation of privilege
	Description	Attacker may be able to change application, configuration, or calibration. This would stop AR functionality or display wrong data.
	CAL	
	Related CSR IDs	Mitigation Implemented - JTAG port is locked, Software signing is integrated as part of the requirement
24	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing AR ECU
	Description	AR ECU may be spoofed by an attacker and this may lead to unauthorized access to Phoenix domain controller over Map, nav data. Attacker with physical access to CAN sends improper messages, causing unauthorized behavior.
	CAL	
	Related CSR IDs	Mitigation Implemented - AR signal ratings completed, C5, CMA not required, also have Ethernet which has SOA authentication.
25	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing the TCU Process
	Description	Cloud POI data may be spoofed by an attacker and this may lead to incorrect POI information displayed on AR ECU.
	CAL	
	Related CSR IDs	Mitigation Implemented - Points of Interest will be displayed to customer, pushed from the cloud, open item, no use cases yet defined. Very high level use cases defined from SYNC. If using standard FTCP and SYNC encryption, via Ford cloud, do not need additional investigation, if going to third party cloud or WIR IP Passthrough, cover under a new threat model.
26	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Spoofing CAN ECU
	Description	DAT 2.X may be spoofed by an attacker and this may lead to unauthorized access to AR ECU for Position, object, lane over ethernet. Attacker with physical access to CAN sends improper messages, either no function or wrong information provided.
	CAL	
	Related CSR IDs	Mitigation Implemented - DAT 2.X authenticates using SOA mTLS cert.
27	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Lack of Input Validation for AR ECU
	Description	Position, object, lane over ethernet from DAT 2.X to AR ECU may be tampered with by an attacker. Data or command tampering impact is wrong or no AR display.
	CAL	
	Related CSR IDs	Mitigation Implemented - Ethernet, mTLS Encryption in transit.
28	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Potential Data Repudiation by AR ECU
	Description	AR ECU may not have sufficient logging for forensic purposes after an incident occurs. Data integrity failure.
	CAL	
	Related CSR IDs	Mitigation Implemented - Yes requirements for Lost comm and invalid data is captured through the diag requirements DiagFaultCovAndDTCNmbrsDesignConsid_00.06.15.601-003



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		ECUs would set U-Codes - loss of communications DTCs against all the ECUs that they are expecting messages from but are unable to transmit due to loss of arbitration.
29	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - Information Disclosure on ECU
	Description	Position, object, lane data disclosed.
	CAL	
	Related CSR IDs	Mitigation Implemented - Encrypted in transit.
30	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - CAN bus interruption
	Description	An external agent interrupts data flowing across a bus to AR ECU or floods the bus, will not show anything related to DAT.
	CAL	
	Related CSR IDs	Mitigation Implemented - Need to define lost comms strategy from DAT. Within certain amount of time if the DAT is not broadcasting the message then the feature will not be displayed, CAN Message arbitration is used to prioritize CAN messages. Higher priority messages will be sent within 1 frame length even under 100% bus utilization. Message filtering on receiving ECUs will ignore unwanted message IDs
31	Goal Name	Prevent unauthorized remote access and control of the vehicle and vehicle systems - ECU elevation of privilege
	Description	Attacker may be able to change application, configuration, or calibration. What is the worst potential impact?
	CAL	
	Related CSR IDs	Mitigation Implemented

Table 15: Cybersecurity Goals

7.2 Cybersecurity Requirements

###R_F_Augmented Reality_00141### Camera Swapped

AR Feature shall be able to detect any augmented reality camera swap.

End of Requirement

###R_F_Augmented Reality_00142### Stuck Image

AR Feature shall be able to detect any stuck image coming from the feed of any of the augmented reality cameras.

End of Requirement

###R_F_Augmented Reality_00143### Unauthorized Remote Access

AR Feature shall be able to detect any unauthorized remote access to the augmented reality system to report it for cybersecurity concerns.

End of Requirement



8 ARCHITECTURE

8.1 Functional Architecture

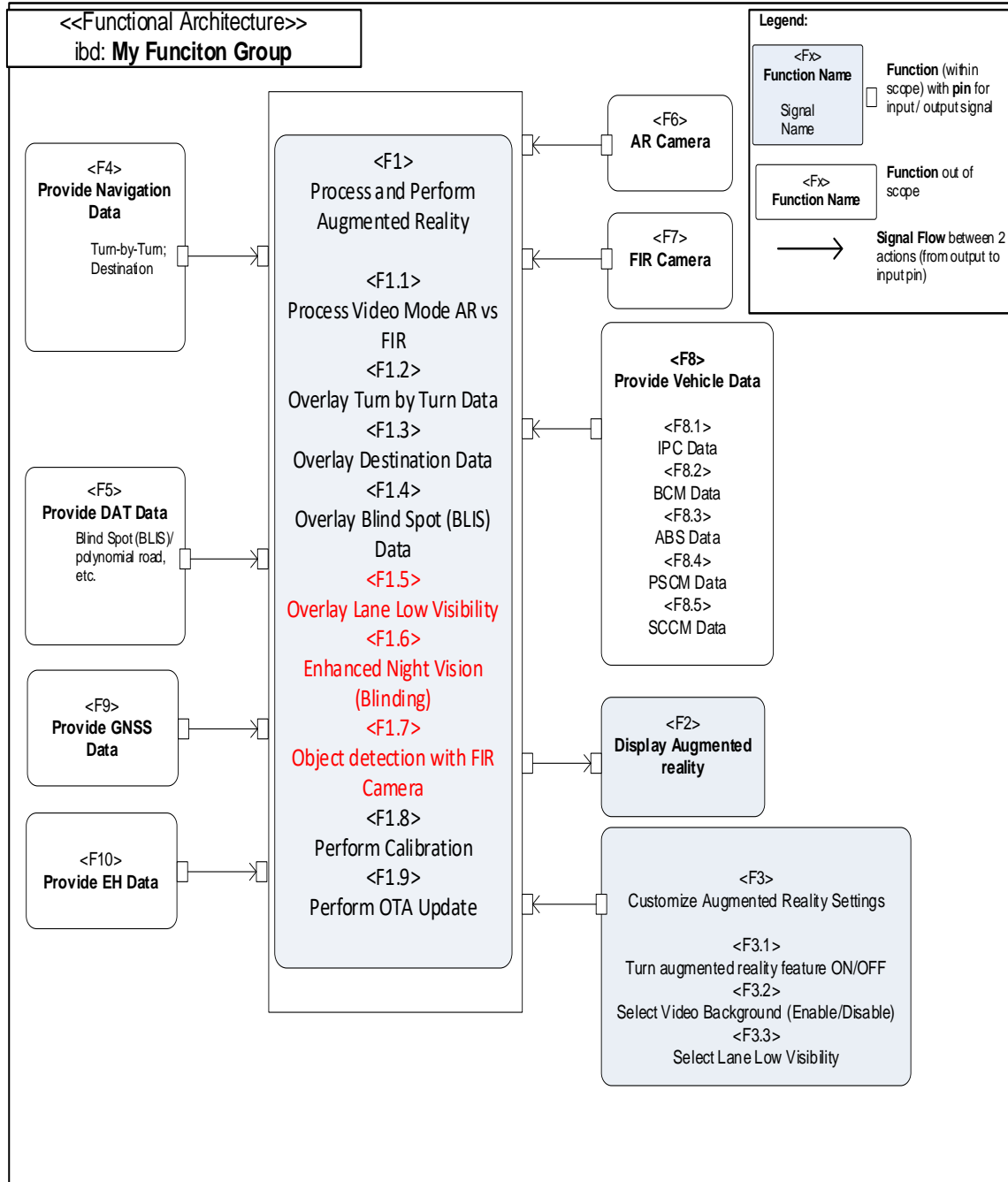


Figure 4: Functional Boundary Diagram



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8.1.1 Logical Functions

Function ID	Function Name	Function Description	ASIL
F1	Process and Perform Augmented Reality	Process the received data and Perform the AR overlay functions required by the feature.	QM
F1.1	Process Video Mode	Process video mode AR camera vs FIR camera	QM
F1.2	Overlay Turn by Turn Data	Turn by turn Data received from NAV will be overlaid on the video feed from the cameras.	QM
F1.3	Overlay Destination Data	Destination icons Data received from NAV will be overlaid on the video feed from the cameras.	QM
F1.4	Overlay Blind Spot Data	BLIS warning will be rendered spatially correct to the neighboring lane.	QM
F1.5	Overlay Lane Low Visibility	Lane Low Visibility Data received will be overlaid on the video feed from the cameras.	TBD
F1.6	Enhanced Night Vision (Blinding).	Enhanced Night Vision (Blinding) data will be overlaid on the video feed from both AR and FIR cameras.	TBD
F1.7	Object Detection with FIR Camera	Object detection with FIR Camera data will be overlaid on the FIR camera video feed.	TBD
F1.8	Perform Calibration	Perform calibration for AR/FIR cameras.	QM
F1.9	Perform OTA Update	Receive and perform OTA updates.	QM
F2	Display Augmented Reality	Display the AR video to the HHDD display (TBT, POI, Street Name, House Number, Destination, and Blind Spot)	QM
F3	Customize AR Settings	Provide the user the ability to customize the feature.	QM
F3.1	Select AR Feature	Turn AR feature (ON/OFF)	QM
F3.2	Select Video background	Select video background (Enable/Disable)	QM
F3.3	Select Lane Low Visibility	Turn Lane Low Visibility feature (ON/OFF)	TBD
F4	Provide Navigation Data	Provide the required data from NAV to support the overlay functions.	QM
F5	Provide DAT Data	Provide the required data from DAT to support the overlay functions.	QM
F6	Provide AR Camera Data	Provide the video feed from AR camera.	QM
F7	Provide FIR Camera Data	Provide the video feed from FIR camera.	QM
F8	Provide Vehicle Data	Provide the required vehicle data from different ECUs.	QM
F8.1	Provide IPC Data	Provide fuel level status	QM
F8.2	Provide BCM Data	Provide ignition status	QM
F8.3	Provide ABS Data	Provide vehicle speed status	QM
F8.4	Provide PSCM Data	Provide steering angle status	QM
F8.5	Provide SCCM Data	Provide turn light signal status	QM
F9	Provide GNSS Data	Provide GNSS data	QM
F10	Provide EH Data	Provide Electronic Horizon data	QM

Table 16: List of Functions

8.2 Logical Architecture



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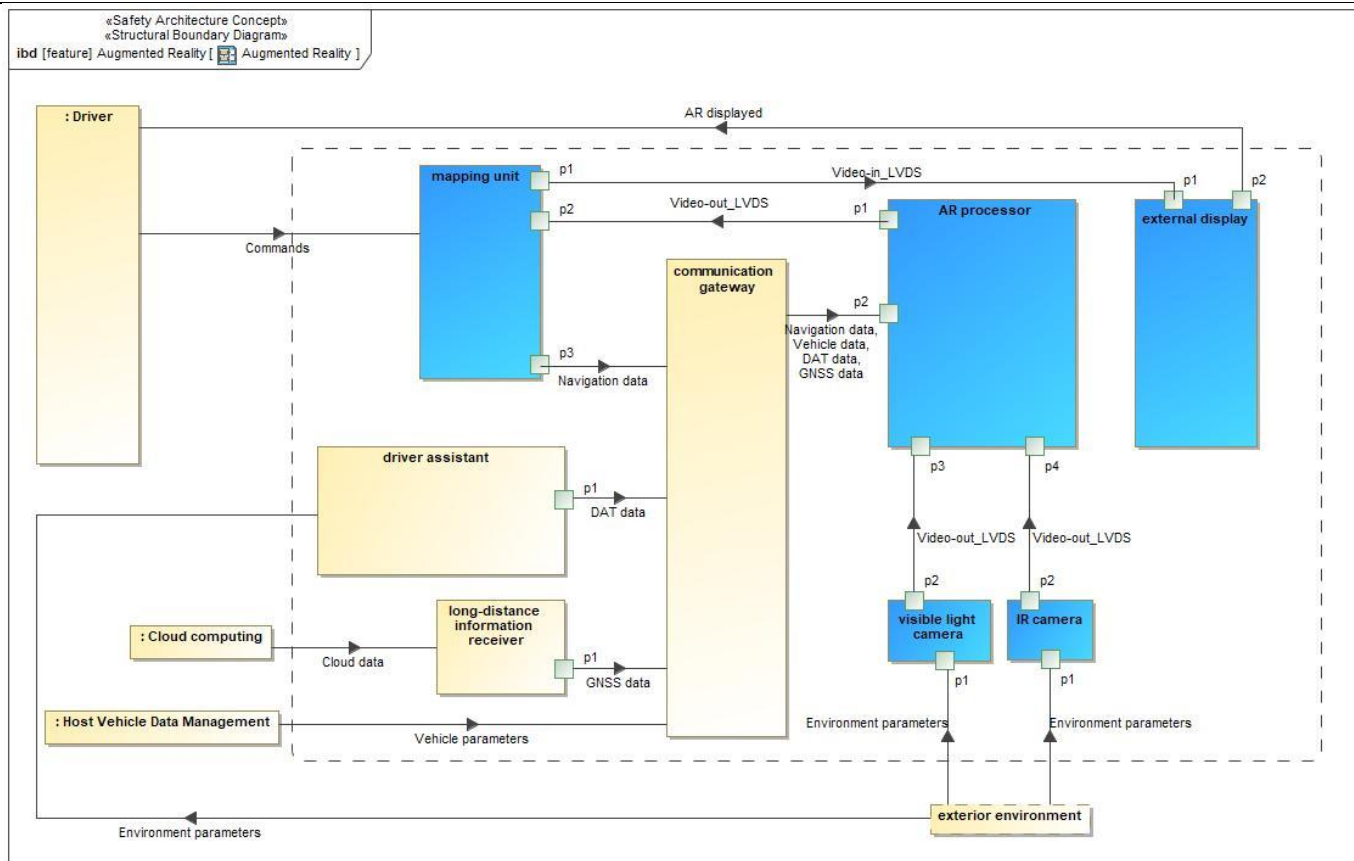


Figure 5: Logical Boundary Diagram

8.2.1 Logical Elements

Element Name	Description	Allocated Functions	Comments
A1 AR processor	The ECU module dedicated to the AR feature.	<ul style="list-style-type: none"> F1.1 Process and Perform Augmented Reality 	
A2 External display	A horizontal display HHDD.	<ul style="list-style-type: none"> F1.2 Display Augmented Reality 	
A3 Visible camera	The type of camera that sense the visible spectrum.	<ul style="list-style-type: none"> F1.6 Provide AR Camera Data 	
A4 FIR camera	A type of camera that uses the IR spectrum.	<ul style="list-style-type: none"> F1.7 Provide FIR Camera Data 	
A6 Communication gateway			
A7 Long-distance information receiver	ECU that deals with telematics	<ul style="list-style-type: none"> F1.8 Provide GNSS data 	
A8 Mapping unit	ECU that deals with navigation data.	<ul style="list-style-type: none"> F1.4 Provide Navigation Data 	
A9 Driver assistant	The ECU that deals with the Advance Driving Assistance Technologies.	<ul style="list-style-type: none"> F1.5 Provide DAT Data 	
Cloud computing	Servers that are accessed over the Internet, and the software and databases that run on those servers. It also includes telematics.		
Driver	The customer interfaces with the AR-System over the displays (AR-HUD or AR-SCREEN) in the vehicle where		



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	navigation guidance, Points-of-Interests, driver assistant information and other information is provided. The customer shall be able to personalize the AR functionality, as well as activate/deactivate the visualization. Details will be provided through the UX specifications.		
Host Vehicle Data Management	The vehicle electronic components that are outside the feature boundary but will provide signals to the feature.		
Physical environment			

Table 17: Logical Elements

8.2.2 Logical Interfaces

Interface	Direction	Description	Value Range
AR displayed	p2 To Driver		
Cloud data	Cloud computing To A7 Long-distance information receiver	Input source for TCU GNSS	
Commands	Driver To A8 Mapping unit	Commands can be sent through HMI Phoenix Domain Controller, customer can select feature On/OFF and customize settings for example. Voice commands are other type of commands the feature will be able to process.	
Vehicle parameters	Host Vehicle Data Management To A6 Communication gateway	Data from modules like BCM, ABS, SCCM, etc.	

Table 18: Logical Interfaces



9 OPEN CONCERNS

ID	Concern Description	e-Tracker / Reference	Responsible	Status	Solution
1	Use cases/Requirements for Highway Assist / Active Drive Assist system/ Assisted Lane Change/Lane Biasing			Closed	Removed per CIED recommendation for HHDD application
2	Use Cases / requirements for Inactive navigation route / POI / Street Name/ House Number			Closed	Removed, Not Supported by Google
3	Use cases / requirements for voice command			Closed	Removed, Not Supported by Google
4	Detailed Use case for Blending / Partial – Post <J1> OTA			Open	Pending R&A requirements
5	Detailed Use case for Object detection– Post <J1> OTA			Open	Pending R&A requirements
6	Detailed Use case for Lane low visibility - Post <J1> OTA			Open	Pending R&A requirements

Table 19: Open Concerns



10 REVISION HISTORY

Revision	Date	Description	Approved by	Responsible
1.0	10-7-20	Initial Release / <PSC>		mabdelh1
2.0	4-21-21	<p>The following changes were performed:</p> <ul style="list-style-type: none"> Updated Stakeholder list 1.3.1 1.4.2 Document Structure updated to reflect the correct section names Included additional abbreviations to 1.7.2 Updated 1.7.3 Parameters / Values Updated 2.1 Purpose and Description of Feature Updated Boundary Diagram in 2.2 Updated 2.5 Assumptions Updated 3.1 Feature Context Diagram to add Manufacturing Updated 3.2 List of Influences to add Manufacturing 4.1 Operation Modes and States, Figure 2: Feature Operation Modes and States updated by swapping T9 and T10 Updated all descriptions for Use Cases on 4.2.3 and included: Added Logical Boundary Diagram on 8.2 Logical Architecture Added 8.2.2 Logical interfaces Included information on section 9 Open Concerns 		mabdelh1
2.1	7-08-21	<p>The following section were updated on the document:</p> <ul style="list-style-type: none"> 1.3.1 Stakeholder List 1.7.2 Abbreviations 2.1 Feature Overview 2.2 Feature Variants – AR Feature Boundary Diagram 2.2.1 Regions & Markets 4.2.3 Use Case Descriptions: #3, #4, #5, #6, #7, #8, #9, #10, #12, #13, and #15 4.3 Driving and Operation Scenarios 5.1 Functional Requirements: <ul style="list-style-type: none"> Deleted/replaced requirement- #1, #56, #61, #145 Modified requirement: #2, #4, #7, #9, #11, #13, #15, #17, #18, #19, #21, #22, #23, #24, #26, #27, #28, #30, #31, #32, #33, #34, #36, #37, #38, #39, #40, #41, #42, #43, #44, #45, #46, #47, #48, #51, #52, #53, #55, , #57, #58, #59, #62, #63, #64, #65, #66, #67, #68, #69, #70, #71, #72, #73, #74, #75, #92, #94, #98, #99, #101, #105, #110, #111, #125, #130, #131, #132, #134, #135 New: #144, , #146, #147, #148, #149, #150, #151, #152 9 Open Concerns 10 Revision History 		mabdelh1
2.2	09-17-21	<p>The following section were updated on the document:</p> <ul style="list-style-type: none"> 1.7.2 Abbreviations 		mabdelh1



Feature Document Augmented Reality (AR)

Revision	Date	Description	Approved by	Responsible
		<ul style="list-style-type: none"> 2.1 Feature Overview Purpose and Description of Feature 2.2 Feature Variants 2.2.1 Regions & Markets 2.5 Assumptions 4.2.1 Use Case Diagram 4.2.3 Use Case Descriptions: Updated <p>#1 – updated to remove voice command, not support by Google</p> <p>#2 - Added precondition vehicle equipped with FIR and remove voice command not supported by Google</p> <p>#3, #7, #8, #9 – updated per latest CIED</p> <p>#4, #5, #6, #10, #15- Removed not supported by Google</p> <p>#11, #12, #13 – Removed not recommended by CIED team for HHDD application</p> <p>#16 – New Use case – was included in other use cases already but it is separated now for more clarity</p> <p>#17, #18 – New Use case for post <J1> OTA</p> <ul style="list-style-type: none"> 4.3 Driving and Operation Scenarios 5.1 Functional Requirements: <p>Removed/ replaced- #1, #24, #25, #27, #61, #62, #69, #70, #71, #72, #73, #74, #75, #77, #78, #82, #83, #85, #145, #123, #124, #127, #128, #138, #139, #140</p> <p>modified to re-order #2 – (original was #146)</p> <p>Removed- Not supported by Google- #4, #7, #21, #22, #30, #31, #32, #33, #34, #35, #36, #37, #38, #39, #40, #41, #42, #43, #44, #45, #46, #47, #48, #149, #150, #51, #52, #55, #56, #58, #66, #67, #68, #152, #94, #98, #116, #118, #130, #131, #132, #134, #137,</p> <p>Updated- #11, #12, #13, #14, #15, #16, #17, #18, #19, #20, #147, #148, #23, #26, #29, #50, #53, #57, #59, #60, #64, #63, #65, #151, #79, #80, #81, #84, #86, #87, #88, #92, #96, #97, #99, #100, #101, #105, #106, #107, #146, #115, #117, #122, #125, #126, #129, #133, #135, #144</p> <p>New- #153, #154, #155, #156, #157, #158, #159, #160, #161, #162, #163, #164, #165, #166, #167, #168, #169, #170, #171, #172, #173, #174, #175, #176, #177, #178</p> <ul style="list-style-type: none"> 8.1 Functional Architecture 9 Open Concerns 10 Revision History 		



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11 APPENDIX

11.1 Definitions

Definition	Description
AR-ECU	Augmented Reality Electronic Control Unit
AR-HHDD	Augmented Reality High Head-Down Display
AR-System	Augmented Reality System
DAT2.2	Ford ADAS ECU Version 2.2
Phoenix	Ford Communication and Infotainment System – Domain Controller

Table 20: Definitions used in this document

11.2 Abbreviations

Abbr.	Stands for
ADAS	Advanced Driver Assistant System
AR	Augmented Reality feature
DAT	Driver Assistance Technologies Module
ECG	Enhanced Central Gateway
GNSS	Global Navigation Satellite System
HMI	Human-Machine Interface
OTA	Over-The-Air
TCU	Telematics Control Unit

Table 21: Abbreviations used in this document



Document ends here.