Use Case Implementations for Sensor Data Sharing

5GAA Automotive Association
Technical Report

CONTACT INFORMATION:

Executive Manager – Thomas Linget
Email: liaison@5gaa.org

MAILING ADDRESS:

5GAA c/o MCI Munich
Neumarkter Str. 2181673 München, Germany
www.5gaa.org

VERSION:	Version 1
DATE OF PUBLICATION:	6 February, 2023
DOCUMENT TYPE:	Technical Report
EXTERNAL PUBLICATION:	Yes
DATE OF APPROVAL BY 5GAA BOARD:	19 September, 2022

Contents

Foreword

This Technical Report has been produced by 5GAA.

The contents of the present document are subject to continuing work within the Working Groups (WG) and may change following formal WG approval. Should the WG modify the contents of the present document, it will be re-released by the WG with an identifying change of the consistent numbering that all WG meeting documents and files should follow (according to 5GAA Rules of Procedure):

x-nnzzzz

(1) This numbering system has six logical elements:

(a) x: a single letter corresponding to the working group:

where x =

T (Use cases and Technical Requirements)

A (System Architecture and Solution Development)

P (Evaluation, Testbed and Pilots)

S (Standards and Spectrum)

B (Business Models and Go-To-Market Strategies)

(b) nn: two digits to indicate the year. i.e. ,17,18 19, etc

(c) zzzz: unique number of the document

(2) No provision is made for the use of revision numbers. Documents which are a revision of a previous version should indicate the document number of that previous version

(3) The file name of documents shall be the document number. For example, document S-160357 will be contained in file S-160357.doc

1 Scope

This report presents the Use Case Implementation Descriptions (UCIDs) [1],[2] for the three sensor data sharing use cases introduced in the Use Case Description Technical Reports Vol. 2 [3] and Vol. 3 [4], as well as shown on the C-V2X Roadmap [5].

2 References

[1] 5GAA WG1 T-210014, Use Cases Implementation Descriptions (UCID) Phase II work item description

[2] 5GAA WG1, Use Case Implementation Description, available online at https://5gaa.org/wp-content/uploads/2021/04/use-case-t21001.pdf

[3] 5GAA, WG1 T-200116, C-V2X Use Cases and Service Level Requirements Volume II, available online at https://5gaa.org/wp-content/uploads/2021/01/5GAA_T-200116_TR_C-V2X_Use_Cases_and_Service_Level_Requirements_Vol_II_V2.1.pdf

[4] 5GAA WG1 T-210022, C-V2X Use Cases and Service Level Requirements Volume III, available online at https://5gaa.org/c-v2x-use-cases-and-service-level-requirements-volume-iii/

[5] C-V2X Roadmap TR

[6] 5GAA WG2, V2X Application Layer Reference Architecture, available online at https://5gaa.org/news/v2x-application-layer-reference-architecture/

[7] ETSI EN 302 890-1, Intelligent Transport Systems (ITS); Facilities layer function; Part 1: Services Announcement (SA) specification

[8] IEEE 1609.3: Networking Services

3 Abbreviations

For the purposes of the present document, the following acronyms apply:

AS Application Server

BSM Basic Safety Messages

CAM Cooperative Awareness Message

CPM Collective Perception Message

DL Downlink

HD High Definition

HV Host Vehicle

MQTT Message Queuing Telemetry Transport

OEM Original Equipment Manufacturer

OEM AS Original Equipment Manufacturer Application Server

RV Remote Vehicle

SLR Service Level Requirements

UC Use Case

UCID Use Case Implementation Description

UL Uplink

4 Introduction

As part of the 5GAA XWI C-V2X Roadmap, multiple variations of sensor sharing use cases were identified as key milestones. The 5GAA technical reports on C-V2X Use Cases and Service Level Requirements (SLRs) [3,4] describe these use cases in a technology agnostic manner. The present document complements these descriptions with technology dependent Use Case Implementation Descriptions (UCIDs) fulfilling the SLRs and, where applicable, available standards or standards under development are referred to. If no suitable standards are available, the resulting need for standardisation is highlighted as one prerequisite for deployment.

It is noted that issues of trust in – and functional safety treatment of – received object data and non-analysed data may are not fully represented in the UCIDs in this document.

5 Use Case Implementation Descriptions

In this section the use cases (UCs) are mapped to the communication architecture and illustrated with sequence diagrams including the main parameters conveyed.

5.1 Data Collection and Sharing for HD Maps

Vehicles equipped with multiple sensors can collect environmental data around themselves, and share the precise position and 3D geometry of so-called collected ‘objects, including temporary and variable road signs, road conditions, etc., with a HD map provider who analyses the information and merges or combines it to build a regional HD map. This helps to generate more dynamic, up-to-date and accurate HD maps to reflect the actual environment or road/driving conditions. Dynamic information on moving vehicles and vulnerable road users (VRUs) not related to the map is not gathered or shared.

5.1.1 Direct Connection with HD Map Provider

In this scenario, the vehicles interact directly with the HD map provider.

Assumptions:

- Vehicles are equipped with sensors, and they can share processed sensor data as object information.
- Vehicles can communicate and have established connection with HD map provider.
- Vehicles can share the object information directly with the HD map provider.
- The HD map provider can collect (and merge) sensor information from different sources to build the HD map in a verified and proven manner.

The table below summarises the main properties and requirements for this UC realisation:

Category	Item	Description
	Use case name	Data collection and sharing for HD Maps [3]
	Relation to other use cases	Use cases based on cooperative awareness/information from basic safety messages Data sharing of dynamic objects [4] Non-analysed sensor data sharing [4]

	Actors and roles	Host Vehicle (HV): collect object information with onboard sensors and share with HD map provider HD map provider: receive, collect, and merge object information from vehicles, and provide resulting information to vehicles Remote Vehicle (RV): receive and consume HD map data
	Information classification	Up to transient dynamic object information from HV provided to HD map provider
Standards and technology	Access layer technology/ies	Cellular: 3GPP LTE Uu or NR Uu
	Network and Transport layer technologies	Cellular: UDP/TCP/Ipv4/v6
	Message standards	Cellular: proprietary and/or industry standards (e.g. SENSORIS)
	Framework	V2XSRA, in simplest form directly connecting vehicles with AS (other architectures with multiple AS possible as well)
Application requirements	Use case triggers	Proprietary (data collection application in vehicle or trigger from HD map provider)
	Required information in the vehicles	Detected objects
Network layer requirements	Required coverage	Cellular network coverage of road network
	Required availability	Medium (data transfer can be asynchronous)

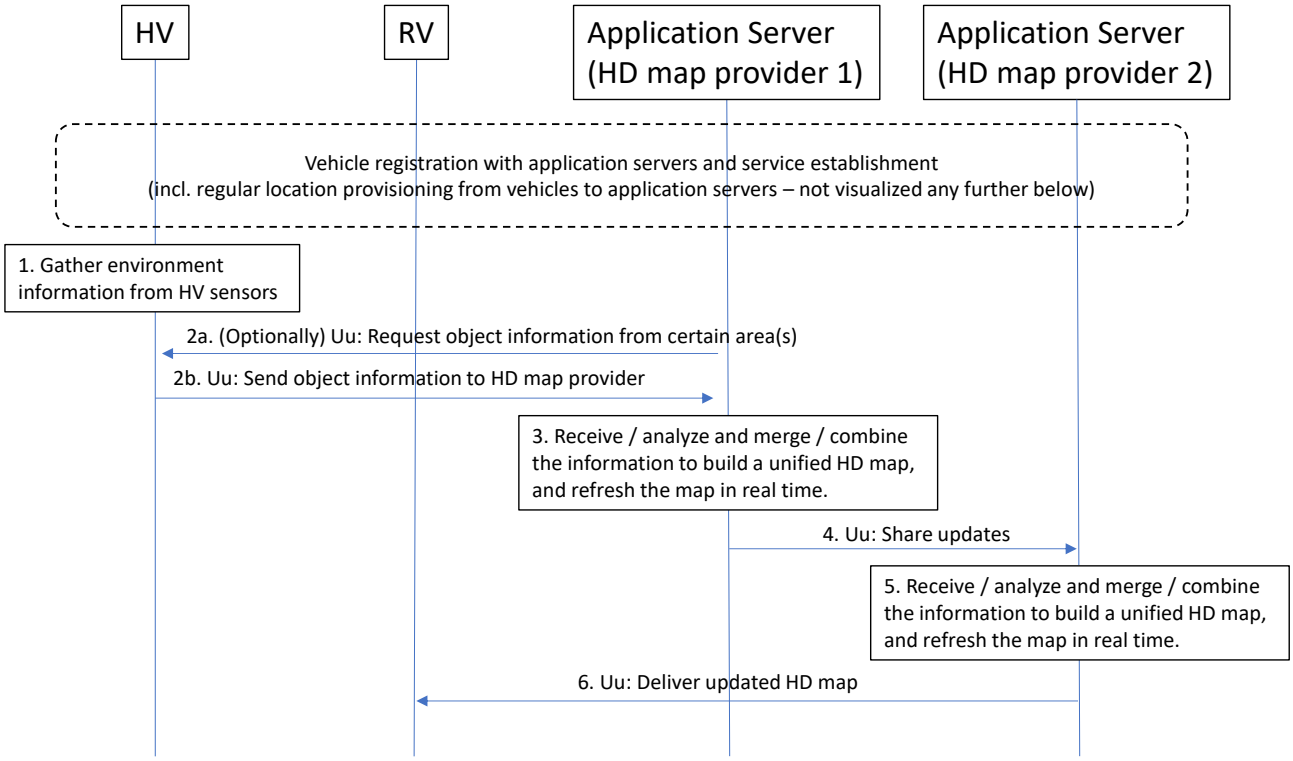

Figure 1 – Data collection and sharing for HD maps – Direct connection with HD map provider

1. HV gathers environment information from its own sensors and creates object information from the perceived environment.
2. a) Optionally, HD map provider requests object information in certain area(s) from HV.
   b) HV sends object information to the HD map provider, either based on the HV's estimation which objects/areas are required by the HD map provider, or based on the request from step 2a).
3. HD map provider receives object information from multiple vehicles, and then analyses and combines the information; the results are merged into a unified HD map.
4. HD map provider shares resulting updates with other HD map provider(s).
5. Other HD map providers receive object information which they can then analyse and combine as well; again, the results are merged into a unified HD map.
6. RV HD map provider delivers updated HD map information to RVs.

The following table provides a matching of the above-described solution to SLRs defined as part of the user stories in [3]. SLRs highlighted in green are expected to be fulfilled according to comments given in the last column.

User story	Range [m]	Information requested/ generated	Service level latency [ms]	Service level reliability	Vehicle density [vehicle/km^2]	Comments
#1	1 000	UL: 5kb DL: 500kb	1 000	99	12 000	Assuming provisioning of processed sensor data

5.1.2 HD Map Through OEM Backend

In this scenario the vehicles interact indirectly with the HD map provider through their OEM backends.

Assumptions:

- Vehicles are equipped with sensors, and they can share processed sensor data as object information.
- Vehicles can communicate and have established connection with their OEM backends.
- Vehicles are indirectly connected with HD map provider (through OEM backend).
- Connection between different ASs (HD map provider and OEM backends) already established.

- HD map provider issues updated HD map information to OEM backends.
- OEM backends provide HD map information to their vehicles.

The table below summarises the main properties and requirements for this UC realisation:

Category	Item	Description
	Use case name	Data collection and sharing for HD Maps [3]
	Relation to other use cases	Use cases based on cooperative awareness/information from basic safety messages Data sharing of dynamic objects [4] Non-analysed sensor data sharing [4]
	Actors and roles	Host Vehicle (HV): collect object information with onboard sensors and share with OEM AS (OEM backend) OEM backend act as intermediate between vehicles and HD map provider(s) HD map provider: receive, collect, and merge object information from OEM backends, and provide resulting information to OEM backends Remote Vehicle (RV): receive and consume HD map data
	Information classification	Up to transient dynamic object information from HV provided to OEM backend/HD map provider
Standards and technology	Access layer technology/ies	Cellular: 3GPP LTE Uu or NR Uu
	Network and transport layer technologies	Cellular: UDP/TCP/Ipv4/v6
	Message standards	Cellular: Proprietary and/or industry standards (e.g. SENSORIS)
	Framework	V2XSRA, connection vehicles with the OEM ASs, and the OEM ASs with the map provider AS
Application requirements	Use case triggers	Proprietary (data collection application in vehicle or triggered by OEM backend)
	Required information in the vehicles	Detected objects
Network layer requirements	Required coverage	Cellular network coverage of road network
	Required availability	Medium (data transfer can be asynchronous)

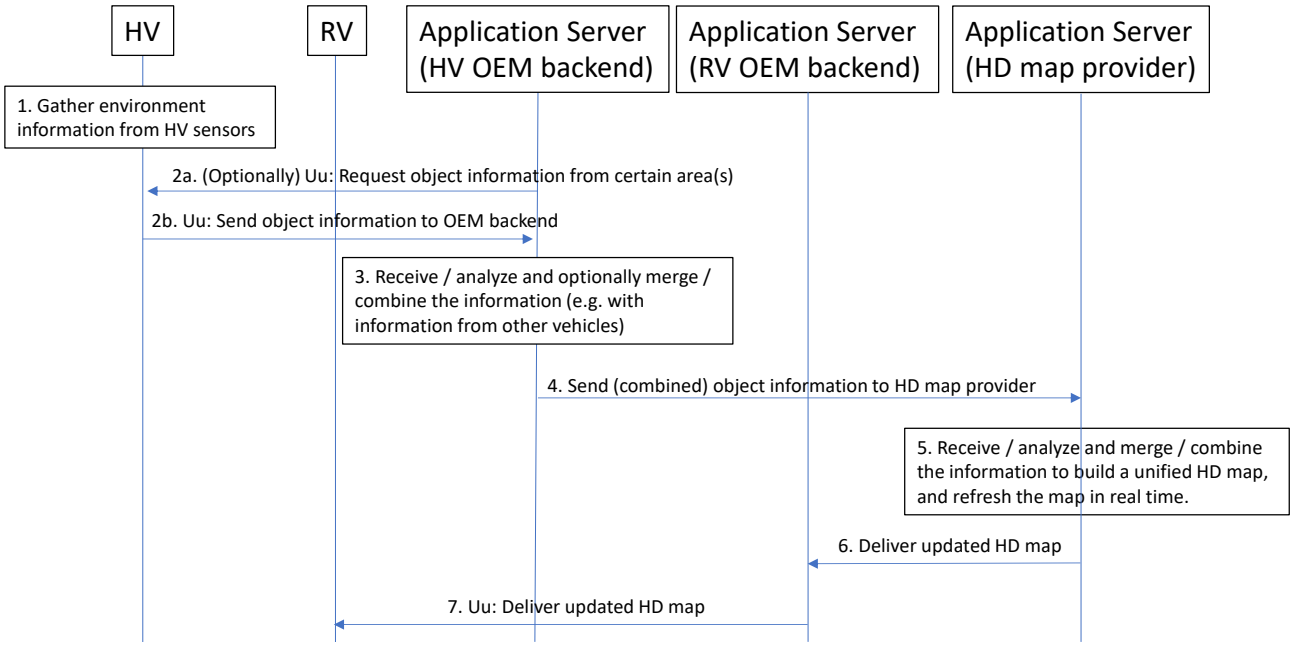

Figure 2 – Data collection and sharing for HD maps – connection through OEM backends

1. HV gathers environment information from its own sensors and creates object information from the perceived environment.
2. a) Optionally: HV OEM backend requests object information from certain area(s) from HV.
   b) HV sends object information to its HV OEM backend, either based on the HV's estimation which objects / areas are required by the OEM backend, or based on the request from step 2a).
3. HV OEM backend receives and processes the information and combines it with information from other vehicles.
4. HV OEM backend sends combined object information to HD map provider.
5. HD map provider receives object information from multiple OEMs, then analyses and combines the information; the results are merged into a unified HD map.
6. HD map provider delivers updated HD map information to RV OEM backend.
7. RV OEM backend delivers updated HD map information to RV.

The following table provides a matching of the above-described solution to SLRs defined as part of the user stories in [3]. SLRs highlighted in green are expected to be fulfilled according to comments given in the last column.

User story	Range [m]	Information requested/ generated	Service level latency [ms]	Service level reliability	Vehicle density [vehicle/km^2]	Comments
#1	1 000	UL: 5kb DL: 500kb	1 000	99	12 000	Assuming provisioning of processed sensor data

5.2 Data Sharing of Dynamic Objects

Vehicles (host vehicles) or roadside infrastructure detect dynamic objects and or road participants and share information on the detections.

5.2.1 Sharing Using Direct Communication

In this scenario the detected dynamic objects/road participants are shared using direct communication.

Assumptions:

- The HV/roadside infrastructure uses its sensors to detect dynamic objects and/or road-participants.
- The HV/roadside infrastructure sends out (broadcasts) processed information.
- The RV receives the information directly from the HV/roadside infrastructure

The table below summarises the main properties and requirements for this UC realisation:

Category	Item	Description
	Use case name	Data sharing of dynamic objects [4]
	Relation to other use cases	Use cases based on cooperative awareness/information from basic safety messages Data collection and sharing for HD maps [3] Non-analysed sensor data sharing [4]
	Actors and roles	Host Vehicle (HV)/roadside infrastructure: collect dynamic object information with onboard sensors and share object information with remote vehicle(s) Remote Vehicle (RV)/roadside infrastructure: receive and consume dynamic object information from HV
	Information classification	Dynamic object information from HV/roadside infrastructure provided to RV/roadside infrastructure
Standards and technology	Access layer technology/ies	Short range: PC5
	Network and transport layer technologies	Short range: GNW with BTP or WSMP
	Message standards	Short range: ETSI CPM/SAE J3224
	Framework	n/a
Application requirements	Use case triggers	Periodic transmission of detected dynamic objects according to CPM transmission rules
	Required information in the vehicles	Detected objects
Network layer requirements	Required coverage	n/a
	Required availability	Provide all PC5 equipped vehicles in communication range with dynamic object information

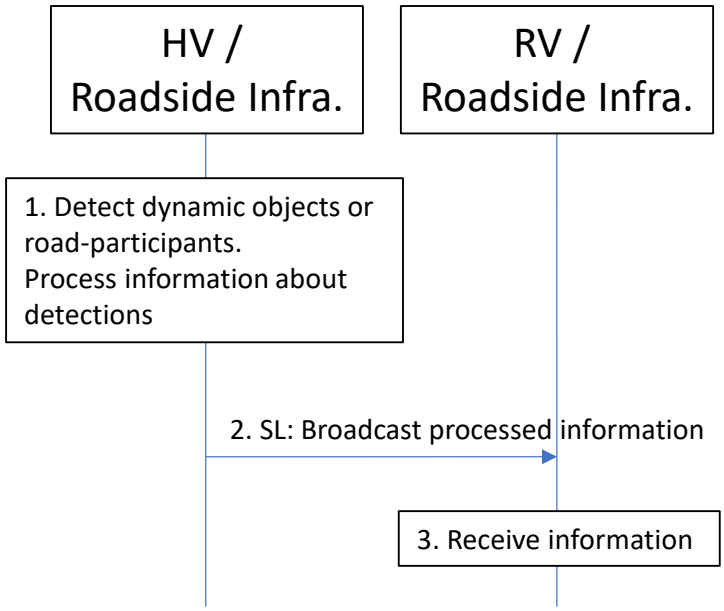

Figure 3 – Data sharing of dynamic objects – using direct communication

1. HV/roadside infrastructure uses its sensor to detect dynamic objects/road participants (within its sensing range); sensor detections are processed, and corresponding object data is derived.
2. The processed information (object data) is broadcasted.
3. RVs/roadside infrastructure in communication range receive the broadcasted object data.

The following table provides a matching of the above-described solution to SLRs defined as part of the user stories in [4]. SLRs highlighted in green are expected to be fulfilled according to comments given in the last column.

User story	Range [m]	Information requested/ generated	Service level latency [ms]	Service level reliability	Vehicle density [vehicle/km^2]	Comments
#1	300	300 bytes/message – 1 400 bytes/message	100	99.9	12 000	Similar requirements as CAM/BSM, and feasibility confirmed in multiple research projects

5.2.2 Sharing Through a Data Provider

In this scenario the detected dynamic objects/road users are shared through a data provider.

Assumptions:

- HV/roadside infrastructure uses its sensors to detect dynamic objects and/or road-participants.
- HV/roadside infrastructure and RV/roadside infrastructure have established relationships/registrations with the data provider.
- Data provider appears as a single point of contact to the vehicles, independent of whether it is located in the cloud or the edge (data provider is capable of guaranteeing latency requirements for dynamic object sharing).
- The HV/roadside infrastructure sends processed information to the data provider who is capable of detecting when a RV is entering the ‘scenario application zone’.
- The RV can receive the information from the data provider.

The table below summarises the main properties and requirements for this UC realisation:

Category	Item	Description
	Use case name	Data sharing of dynamic objects [4]
	Relation to other use cases	Use cases based on cooperative awareness / information from basic safety messages Data collection and sharing for HD Maps [3] Non-analysed sensor data sharing [4]
	Actors and roles	Host Vehicle (HV)/roadside infrastructure: collect dynamic object information with onboard sensors and share object information with application server (AS) Application Server (AS): receives dynamic object information from HV/roadside infrastructure and provides it to relevant RV/roadside infrastructure Remote Vehicle (RV)/Roadside Infrastructure: receive and consume dynamic object information from AS
	Information classification	Dynamic object information from HV/roadside infrastructure provided to RV/roadside infrastructure over AS
Standards and technology	Access layer technology/ies	Cellular: 3GPP LTE Uu or NR Uu
	Network and transport layer technologies	Cellular: UDP/TCP/Ipv4/v6
	Message standards	ETSI CPM/SAE J3224
	Framework	V2XSRA, connection vehicles/roadside infrastructure with the AS
Application requirements	Use case triggers	Periodic transmission of detected dynamic objects according to CPM transmission rules
	Required information in the vehicles	Detected objects
Network layer requirements	Required coverage	Cellular network coverage of road network
	Required availability	Coverage for all equipped vehicles/roadside infrastructure subscribed to the service

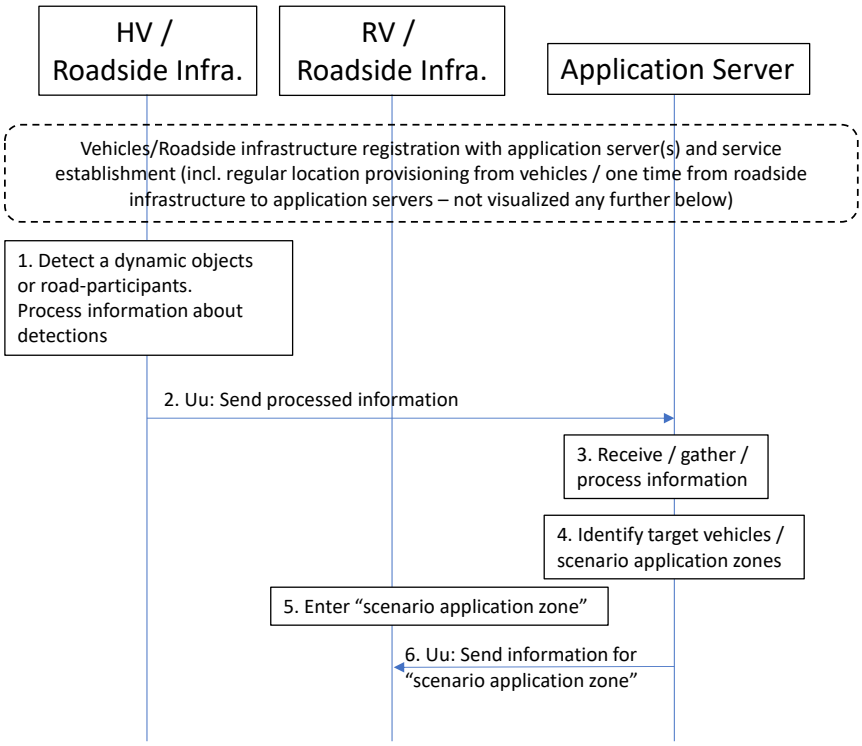

Figure 4 – Data sharing of dynamic objects – through application server

1. HV/roadside infrastructure uses its sensor to detect dynamic objects/road participants (within its sensing range); sensor detections are processed, and corresponding object data is derived.
2. HV sends processed information (object data) from its sensors to AS.
3. AS receives, gathers, and processes the object information.
4. AS identifies target vehicles/roadside infrastructure/'scenario application zones'.
5. RV enters/roadside infrastructure is in 'scenario application zone'.
6. AS sends relevant information to RV/roadside infrastructure.

The following table provides a matching of the above-described solution to SLRs defined as part of the user stories in [4]. SLRs highlighted in green are expected to be fulfilled according to comments given in the last column.

User story	Range [m]	Information requested/ generated	Service level latency [ms]	Service level reliability	Vehicle density [vehicle/km^2]	Comments
#1	300	300 bytes/message – 1 400 bytes/message	100	99.9	12 000	

5.3 Non-analysed Sensor Signal Sharing

Entering an area covered by sensors including a non-analysed sensor data sharing service provided by other road users (e.g. other vehicles, VRUs) on the road and/or road infrastructure, the HV and said road users or road infrastructure share non-analysed sensor data (e.g. compressed video streams).

5.3.1 Sharing Using Direct Communication

In this scenario the information is shared using direct communication between the involved actors.

Assumptions:

- Vehicles (HV) can detect that they enter/leave an area where non-analysed sensor data sharing is available (either from a RV or roadside infrastructure); this might be realised through service advertisement.
- HV and RV/roadside infrastructure can negotiate the parameters for the non-analysed sensor data sharing.

The table below summarises the properties and requirements for this UC realisation:

Category	Item	Description
	Use case name	Non-analysed sensor data sharing [4]
	Relation to other use cases	Use cases based on cooperative awareness/information from basic safety messages Data collection and sharing for HD maps [3] Data sharing of dynamic objects [4]
	Actors and roles	Host Vehicle (HV): subscribe to, receive, and consume non-analysed sensor data from RV Remote Vehicle (RV) / roadside infrastructure: announce non-analysed sensor data sharing service and provide requested non-analysed sensor data to HV after registration
	Information classification	Non-analysed sensor data provided from RV/roadside infrastructure to HV
Standards and technology	Access layer technology/ies	Short range: PC5
	Network and Transport layer technologies	Short range: GNW with BTP or WSMP
	Message standards	Short range: a) Service announcement/registration: ETSI SA [7]/IEEE WSA [8] b) sensor data stream: to be standardised
	Framework	n/a
Application requirements	Use case triggers	Service registration in response to received service announcement
	Required information in the vehicles	Non-analysed sensor data
Network layer requirements	Required coverage	n/a
	Required availability	Provide all PC5 equipped vehicles in communication range with option to register for service

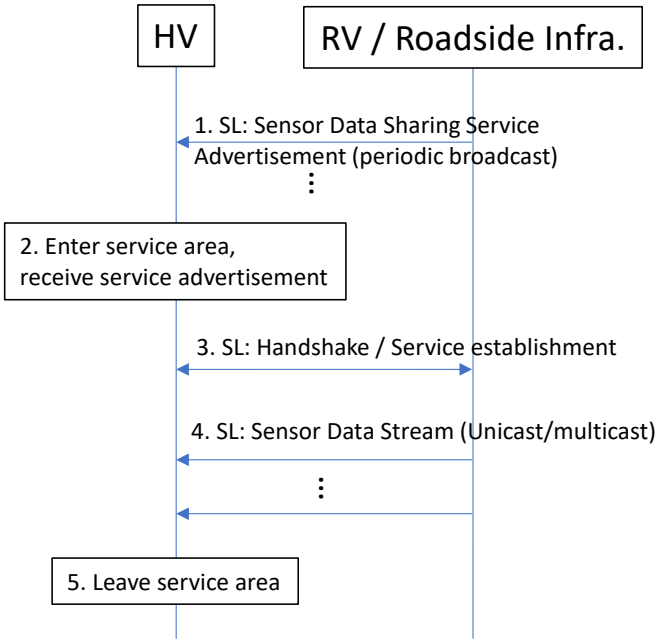

Figure 5 – Non-analysed sensor data sharing using direct communication

1. RV/roadside infrastructure periodically broadcasts service advertisements for the non-analysed sensor data sharing (note that as an alternative, HV might broadcast a service request upon entering the service area and RV would respond accordingly).
2. HV enters service area and receives service advertisement.
3. HV and RV/roadside infrastructure perform handshake/service establishment; this includes the exchange and agreement on basic specific meta-data (e.g. technical capabilities, location of the camera, codec,…).
4. HV receives the HD data stream, either as unicast or multicast (in case multiple HVs are registered for the same HD sensor data stream).
5. HV leaves the area covered by the service; streaming stops if no other vehicles are subscribed to the HD sensor data stream.

The following table provides a matching of the above-described solution to SLRs defined as part of the user stories in [4]. SLRs highlighted in green are expected to be fulfilled according to comments given in the last column.

User story	Range [m]	Information requested/ generated	Service level latency [ms]	Service level reliability	Vehicle density [vehicle/km^2]	Comments
#1	300	8 Mbps (Video) 35 Mbps (Lidar)	50	99	1 500	

5.3.2 Sharing Through Data Provider

In this scenario the information is shared using a server between the involved actors.

Assumptions:

- HV and RV/roadside infrastructure have established relationships/registrations with the data provider.
- Data provider appears as a single point of contact to the vehicles, independent of whether it is located in the cloud or the edge (data provider is capable of guaranteeing latency requirements for non-analysed sensor data sharing service).
- Data provider will offer service if HV is entering the service area.
- HV, RV/roadside infrastructure, and data provider negotiate the parameters for the HD sensor data sharing.

The table below summarises the properties and requirements for this UC realisation:

Category	Item	Description
	Use case name	Non-analysed sensor data sharing for AVs [4]
	Relation to other use cases	Use cases based on cooperative awareness/information from basic safety messages Data collection and sharing for HD Maps [3] Data sharing of dynamic objects [4]
	Actors and roles	Host Vehicle (HV): subscribe to, receive, and consume non-analysed sensor data from RV Application Server (AS): register sources (RV/roadside infrastructure) for non-analysed sensor data; offer and provide non-analysed sensor data to HV Remote Vehicle (RV)/Roadside infrastructure: announce non-analysed sensor data sharing service to AS, and provide requested non-analysed sensor data to application server on request
	Information classification	Non-analysed sensor data provided from RV/roadside infrastructure to HV through AS
Standards and technology	Access layer technology/ies	Cellular: 3GPP LTE Uu or NR Uu
	Network and transport layer technologies	Cellular: UDP/TCP/Ipv4/v6
	Message standards	To be defined/standardised protocol, e.g. using MQTT
	Framework	V2XSRA, connection vehicles/roadside infrastructure with AS
Application requirements	Use case triggers	Service registration/offer/request with AS
	Required information in the vehicles	Non-analysed sensor data
Network layer requirements	Required coverage	Cellular network coverage of road network
	Required availability	Coverage for all equipped vehicles/roadside infrastructure subscribed to the service

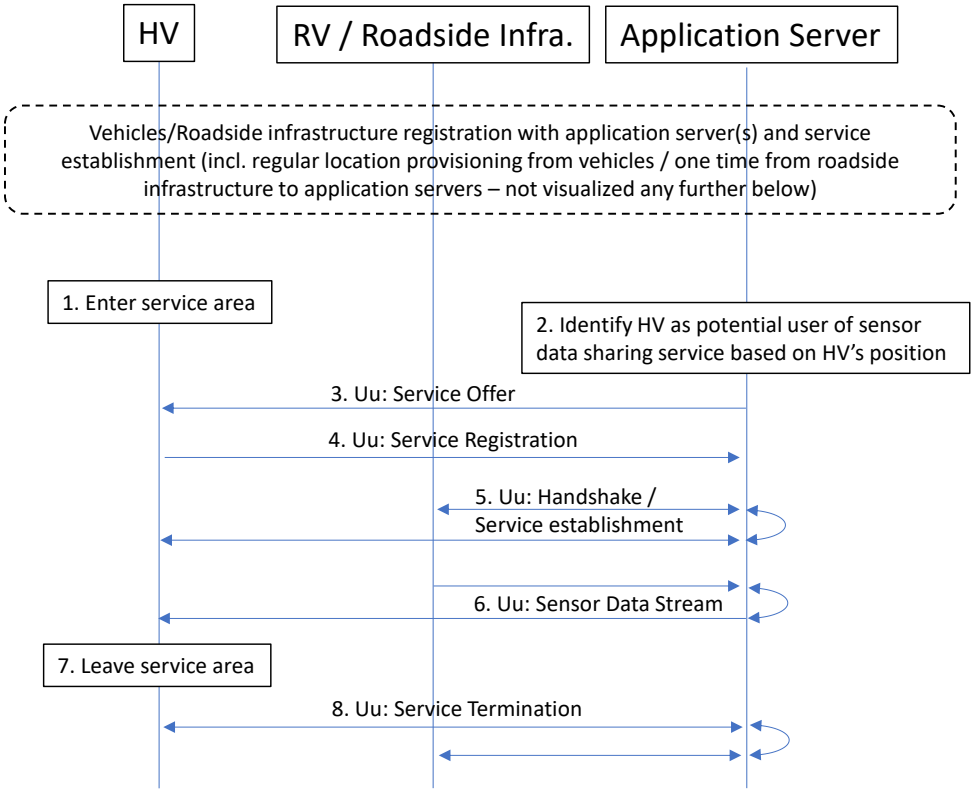

Figure 6 – Non-analysed sensor data sharing – through data provider

1. HV enters service area covered by non-analysed sensor data sharing service.
2. AS identifies HV as potential user of sensor data sharing service.
3. AS sends service offer to HV.
4. HV replies with service registration.
5. RV/roadside infrastructure, AS, and HV perform handshake procedure and service establishment.
6. RV/roadside infrastructure is providing HV with the sensor data stream through AS.
7. HV leaves the area covered by the sensor data sharing service.
8. HV, AS, and RV/roadside infrastructure perform the service termination procedure.

The following table provides a matching of the above-described solution to SLRs defined as part of the user stories in [4]. SLRs highlighted in green are expected to be fulfilled according to comments given in the last column.

User story	Range [m]	Information requested/ generated	Service level latency [ms]	Service level reliability	Vehicle density [vehicle/km^2]	Comments
#1	300	8 Mbps (Video) 35 Mbps (Lidar)	50	99	1 500	

6 Summary and Conclusions

The present document describes initial Use Case Implementation Descriptions (UCIDs) for three sensor data sharing use cases:

1. Data Collection and Sharing for HD maps,
2. Data Sharing of Dynamic Objects, and

3. Non-analysed Sensor Data Sharing.

Every use case is provided in different implementation options, e.g. one option using direct communication, the other option using a service provider. Note that different options might also be combined.

Visualisation of mechanisms to create trust in – and cover functional safety treatment for – received object data and non-analysed data are subject to future work.