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Focus Group on Vehicular Multimedia (FG-VM)

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## **FGVM-01** **Use cases and requirements for the vehicular multimedia networks**

ITU-T



## **Summary**

This document is the output of the ITU-T Focus Group on Vehicular Multimedia. It has been prepared by FG-VM/WG1 during its working sessions of 2018-2019.

This Technical Report describes the use cases and requirements for vehicular multimedia networks (VMN).

## **Keywords**

ITS, multimedia, requirements, vehicle, use cases.

## **Change log**

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## Table of Contents

	<b>Page</b>
1	Scope..... 1
2	References..... 1
3	Definitions ..... 2
3.1	Terms defined elsewhere ..... 2
3.2	Terms defined in this Technical Report ..... 2
4	Abbreviations and acronyms ..... 2
5	Conventions ..... 4
6	Overview of the vehicular multimedia networks..... 4
6.1	Relationship with SAE J3016 levels of driving automation ..... 6
7	Connectivity..... 9
7.1	Distinction between brought-in, built-in and hybrid connectivity ..... 9
7.2	Multiple network connectivity in the vehicular multimedia context..... 10
7.3	Network convergence transmission and onboard terminal processing ..... 12
7.4	Networking connection among multiple terminals within the vehicle..... 14
7.5	Continuous and consistent services across various networks and environment (from/to VMS)..... 15
8	Intelligent human to machine interface) for VMS..... 17
8.1	The acoustic system in the vehicular multimedia..... 19
8.2	Gesture control in vehicular multimedia system ..... 21
8.3	Eye-movement control in vehicular multimedia system ..... 21
8.4	Data formats and storage ..... 22
9	Privacy considerations ..... 23
9.1	Background..... 23
9.2	General privacy requirements..... 24
9.3	Use case: Private vehicle with one single user ..... 24
9.4	Use case C– Long distance shared vehicle with multi users (shuttle all users are seated)..... 24
9.5	Use case – Public transportation shared vehicle with multi users (shuttle short distance trips – seated and standing users) ..... 25
10	Content rights protection in a converged network environment ..... 26
10.1	Background..... 26
10.2	Use cases ..... 27
10.3	Gap analysis..... 29
10.4	Content rights protection requirements for CA ..... 29
11	Copyright and rights management support for content delivery ..... 30
11.1	Content payment and copyright protection use case ..... 30
11.2	Privilege and account management ..... 30
11.3	Payment services in shared vehicle ..... 32

12	Security .....	33
12.1	User data protection.....	33
12.2	VMN application security .....	33
12.3	VMS security.....	33
13	Safety .....	34
13.1	Driving safety: Speed control.....	34
14	Requirement for defining vehicular multimedia profiles .....	34
14.1	Use case.....	34
14.2	Proposed profiles requirements .....	35
15	Vehicle domain service.....	35
15.1	General .....	35
15.2	Use case of vehicle domain service on vehicle multimedia service.....	36
15.3	Requirements of VDS use case in relation with VMS .....	38
Annex A	VDS requirements .....	39
A.1	Background.....	39
A.2	Proposed requirements .....	40



# Technical Report ITU-T FGVM-01

## Use cases and requirements for the vehicular multimedia networks

### 1 Scope

This document describes use-cases and requirements for converged network vehicular multimedia networks (VMNs), taking into account the autonomous levels defined by [SAE J3016] and used in conjunction with advanced driver assistance system (ADAS), automatic driving technologies, maps, voice commands or natural language processing.

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### 3 Definitions

#### 3.1 Terms defined elsewhere

None.

#### 3.2 Terms defined in this Technical Report

This Technical Report defines the following terms:

**3.2.1 vehicular multimedia networks (VMN):** The VMN consists of the vehicular multimedia service platform (VMSP), a variety of broadcast and communication networks and of the vehicle multimedia system (VMS) in the vehicle.

**3.2.2 vehicle multimedia system (VMS):** The VMS consists of vehicle multimedia system inputs (VM I/P), vehicle multimedia unit (VMU) and vehicle multimedia system outputs (VM O/P). It is also called an IVI.

**3.2.3 vehicular multimedia networks services (VMNS):** The VMNS are the services provided by service providers via the VMN.

**3.2.4 VMN application:** The VMN application uses the underlying VMS capabilities to consume and present a VMNS to end-user(s) in the vehicle.

### 4 Abbreviations and acronyms

This Technical Report uses the following abbreviations and acronyms:



ADAS	Advanced Driver Assistance System
AEC	Acoustic Echo Cancelation
AM	Amplitude Modulation
APP	Application
BCM	Body Control Module
CA	Conditional Access
CW	Control Word
CDR	China Digital Radio
DAB	Digital Audio Broadcast
DTMB	Digital Terrestrial Multimedia Broadcast
DVB	Digital Video Broadcasting
ECM	Entitlement Control Message
ECU	Electronic Control Unit
EMM	Entitlement Management Message
FG	Focus Group
FM	Frequency Modulation
GDPR	General Data Privacy Regulation
GNSS	Global Navigation Satellite System
HD	High Definition
HMI	Human Machine Interface
HUD	Heads Up Display
HUT	Infotainment Head Unit
ID	Identification
IVI	In Vehicle Infotainment
KWS	Keyword Spotter
LEO	Low Earth Orbit (Satellite)
PDK	Personal distribution key
PII	Personally Identifiable Information
PK	Personalisation Key
PK	Product Key
QoS	Quality of Service
RDS	Radio Data System
RF	Radio Frequency
T-Box	Telematics System
TM-Box	Telematics Multimedia System
TS	Transport Stream
VDS	Vehicle Domain System

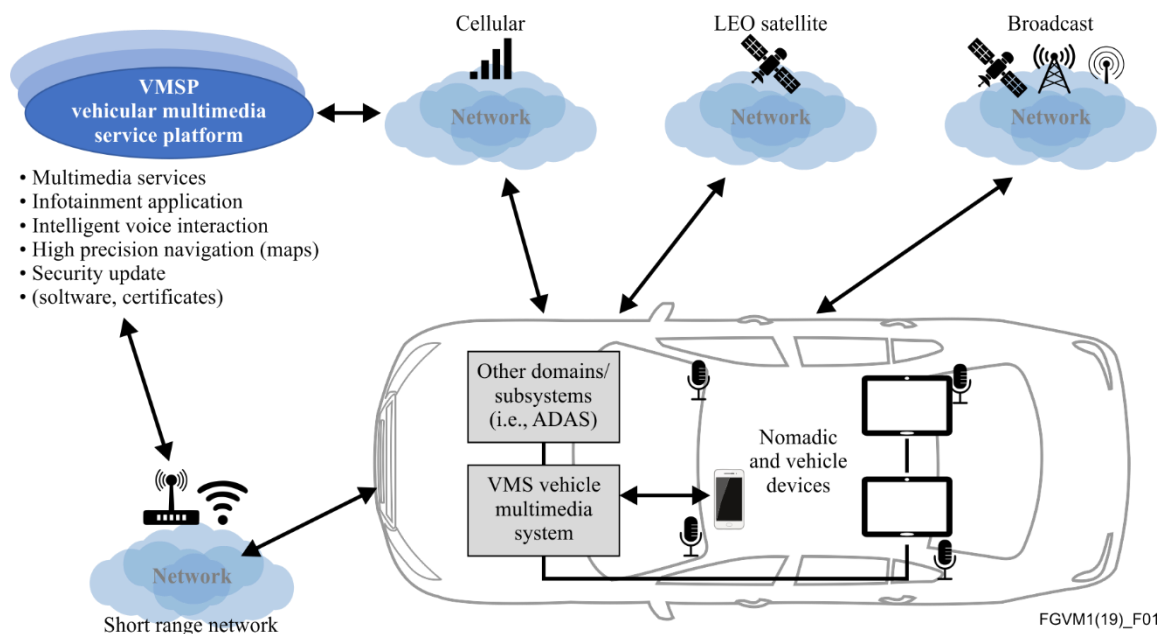
VDDM	Vehicle Domain Dynamic Map
VG	Vehicle Gateway
VGP	Vehicle Gateway Platform
VM I/P	Vehicle Multimedia System Inputs
VM O/P	Vehicle Multimedia System Outputs
VMN	Vehicular Multimedia Networks
VMNS	Vehicular Multimedia Networks Services
VMSP	Vehicular Multimedia Service Platform
VMS	Vehicle Multimedia System
VMU	Vehicle Multimedia Unit
WLAN	Wireless Local Area Network
WG	Working Group
ZIC	Zone Interference Cancellation

## 5 Conventions

None.

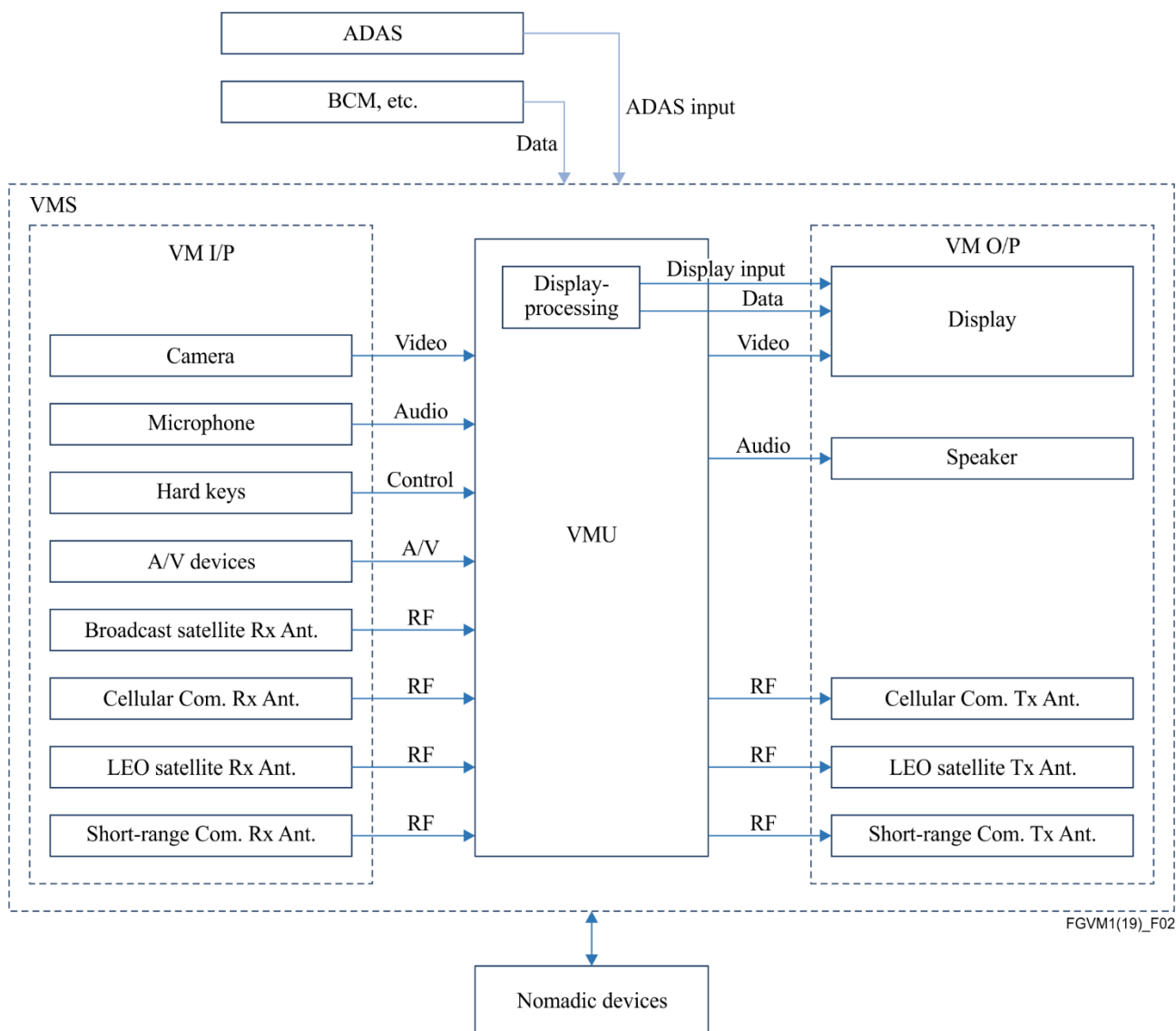
## 6 Overview of the vehicular multimedia networks

As shown in Figure 1, vehicle multimedia networks (VMN) consist of the vehicular multimedia service platform (VMSP) in the cloud, a variety of broadcast and communication networks, and the vehicle multimedia system (VMS) in the vehicle.



**Figure 1 – Vehicle multimedia networks**

A reference model of the VMS is shown in Figure 2, where the overall boundary of the VMS is given. The VMS consists of vehicle multimedia system inputs (VM I/P), vehicle multimedia unit (VMU) and vehicle multimedia system outputs (VM O/P).



**Figure 2 – A reference model for data input/output of the vehicle multimedia system**

System inputs may include audio and video signals from camera, microphone and audio/video devices such as USB devices, Bluetooth devices, SD-Cards, CD/DVD/Blu-ray and Aux-In, control signals from hard keys, and RF signals from reception antennas. Note that the connectivity functions and the related recommendations for intelligent transport systems have been discussed in ITU-T SG16 Question 27 (Q.27). These functions and recommendations, as defined in Q.27 may be reused for the connectivity in vehicle multimedia systems.

VMU is a central processing unit that processes the received input and output audio via the speakers, video via displays, etc.

Antenna systems for cellular communications, low earth orbit (LEO) satellites and short-range communications are used for reception and transmission.

VMU is not a single physical unit. It may consist of multiple electronic control units (ECUs). Options include either (a) infotainment head unit (HUT) and telematics system (T-Box), (b) telematics multimedia system (TM-Box), and (c) any other integrated solutions customized by automotive manufacturers such as just a HUT.

Note that a T-box alone as defined in Q.27 could not satisfy the requirements of a vehicle multimedia system, which include but is not limited to the connectivity requirements and the multimedia processing requirements. Nevertheless, the connectivity capability of the T-box could be used to

partially satisfy the connectivity requirements of the vehicle multimedia system. In such a case, option (a) as described above is a sound solution for the vehicle multimedia system, where HUT together with T-Box fulfils all the requirements of a vehicle multimedia system.

A VMN application is either a pre-installed or a downloaded application on the VMS available in the vehicle. The VMS application makes use of the VMS capabilities to present the VMNS to end-user(s) in the vehicle. The VMN application is configured to retrieve the VMS capabilities and connect to the VMNS. There may be multiple VMN applications in a vehicle and at different seat/screen positions.

Other system inputs such as those from the advanced driver assistance system (ADAS), body control module (BCM), etc., are processed by the VMU mainly for display. Nevertheless, for autonomous driving capable vehicles, the interaction between autonomous driving domains/function blocks or ADAS and the VMS need to be addressed in detail in the future. For example, the system could limit some VMS functions (e.g., no broadcasting or no conference calls) based on ADAS domain input that the vehicle is operating at level 3 or below, while it would be allowed for level 4/5 particularly for the driver's position.

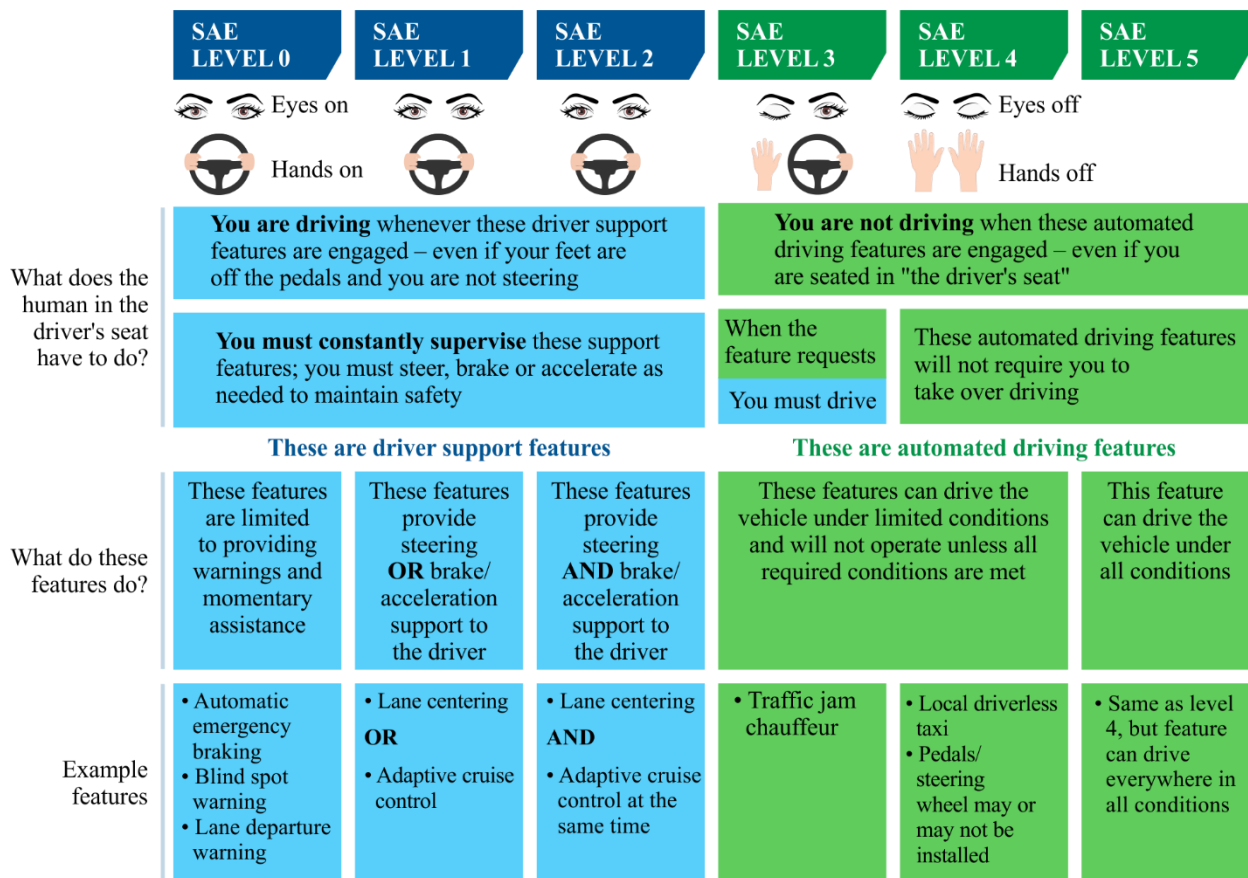
Nomadic devices such as mobile phones and handheld wireless devices are another group of devices whose data are processed by VMU for audio, video and control, but they are not part of the VMS.

With the development of ADAS and autonomous driving, the multimedia trend for a vehicular multimedia system includes:

- Multi-screens;
- Multi-instruments: e.g., glass to replace the screen of the in-vehicle infotainment;
- Multi-screen interaction;
- Multi-purpose: used for entertainment, official, social, gaming, etc;
- Holographic projection will be popular in the future.

## **6.1 Relationship with SAE J3016 levels of driving automation**

For the purpose of a common understanding the [SAE J3016] "Levels of Driving Automation" responsibilities of the driver per driving level are explained in this clause. See also Figure 3.



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**Figure 3 – SAE J3016 definition of driving levels**

(Sources: SAE International Release update (11.12.2018), illustration Mike Lemanski (TRW, ZF) (16.04.2017))

In levels 0, 1 and 2 the driver has to keep the eyes on the road and the hands on the steering wheel. The driver is fully in charge of the vehicle.

In level 2 driving, safety features will support the driver in his driving tasks and will make driving safer by intervening with corrective actions if necessary, e.g., emergency braking or lane keeping. However, at no time the vehicle will drive autonomously.

Level 3 driving is a first level of partly automated driving. Due to available driving features and legal constraints those automated driving features are allowed for use in limited or geofenced areas, such as on highways, or under a certain speed, e.g., in traffic jams with a speed up to 40 km/h (when speed gets faster driver is requested to take over control again). However, due to legislation the driver is still fully in charge for the vehicle even when driving in autonomous mode. This means that even if the driver take the hands off the steering wheel while driving autonomously, the driver still needs to keep the eyes on the road and be able to take over control from the vehicle at any time and within a very short timeframe in case of unexpected situations.

In driving levels 4 and 5 vehicles no longer need steering wheels or pedals. Vehicles drive autonomously. All persons in the vehicle become passengers. The vehicle has no driver.

Level 5 is the highest level of automation allowing vehicles to drive autonomously in any condition and every geographic area. The vehicle can drive fully autonomously without having any persons on board.

Driving levels mainly apply to the driver and make a difference for him being in charge of the vehicle or not. However, all other persons on board of a vehicle no matter if on the front passenger seat or on rear seats are passengers no matter which driving level applies.

### 6.1.1 Matching of generic multimedia use cases with driving levels

The following table matches available use cases and services that have been defined within the focus group with the driving levels. All activities that are mentioned in the table should be considered for a driving vehicle. When the vehicle parks or stands still, all services are available for the driver as well as for the passengers. Excluded in this case is a standing vehicle at traffic lights or other traffic signs as in this case the vehicle and the driver are still considered as active traffic participants similar to a driving car.

Within the driving levels a distinction on what drivers (D) and passengers (P) are allowed to do in the framework of these use cases and services is taken into consideration.

Use case	SAE LEVEL 0		SAE LEVEL 1		SAE LEVEL 2		SAE LEVEL 3		SAE LEVEL 4		SAE LEVEL 5	
	D	P	D	P	D	P	D	P	D	P	D	P
Listen to audio services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Use video, TV and gaming services		✓		✓		✓		✓	✓	✓	✓	✓
Use mobile devices		✓		✓		✓	(✓)	✓	✓	✓	✓	✓
Use mobile devices through VMS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Phone conferencing (handsfree)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Video conferencing		✓		✓		✓		✓	✓	✓	✓	✓
Reading in vehicle (books, mails, news, etc.)		✓		✓		✓		✓	✓	✓	✓	✓
Getting read content (text-to-speech)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Working in vehicle (office applications)		✓		✓		✓		✓	✓	✓	✓	✓

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- ✓ = Allowed
- (✓) = Partly allowed (in autonomous driving mode)

**Figure 4 – Matching of generic multimedia use cases with SAE driving levels**

The above table follows the guidelines of current legal framework in place in some jurisdiction. (e.g., US and EU. Note: Some other jurisdictions may use similar or different classifications than those in [SAE J3016]). However, from an ergonomic point of view phoning or getting read content while driving through text-to-speech can lead to a cognitive overload for the driver and can lead to critical driving situations. Therefore, for driving levels 0 to 3, it is suggested to integrate driver monitoring into the vehicle in order to measure the cognitive load of the driver and to adapt access and content to driving situations and distraction level.

In addition, driver monitoring in driving level 3 facilitates tracking if the driver has taken back control when requested or if alternative actions need to be taken in order to bring the vehicle to a safe stop.

## 7 Connectivity

### 7.1 Distinction between brought-in, built-in and hybrid connectivity

In-vehicle connectivity can be distinguished in three connectivity cases, that is, brought-in, built-in and hybrid connectivity.

#### 7.1.1 Brought-in connectivity

The multi-media system of the vehicle is neither connected to the internet nor to other connected services and applications (maybe with the exception of radio FM). Due to legal requirements in certain jurisdictions the only VMS connectivity that is built-in might be for emergency calls. However, the limited bandwidth for emergency calls might not allow access or stream to any other connected services and apps.

The user can connect the VMS in this case through his mobile device that he brings into the vehicle. The mobile device will connect with the car through Bluetooth, USB or other connections.

Content of the mobile device like apps and mobile services will be displayed on the VMS through MirrorLink, Apple CarPlay or Android Auto, for example.

All connected apps and services are accessible through the VMS.

#### 7.1.2 Built-in connectivity

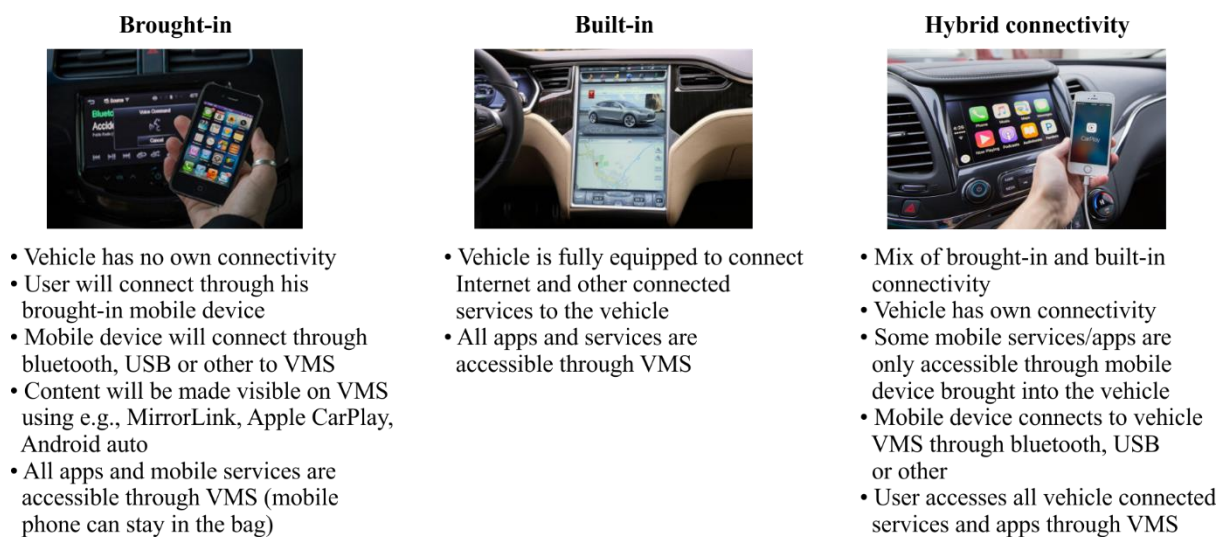
The vehicle is fully connected to the Internet, apps and connected services through its built-in connectivity.

All apps and services can be accessed through the VMS.

#### 7.1.3 Hybrid connectivity

Hybrid connectivity is a mixture of brought-in and built-in connectivity.

The vehicle has its own built-in connectivity. However, the user can bring-in additional connected services and apps through its mobile devices. As for the brought in connectivity, the mobile device connects to the vehicle through Bluetooth, USB or other types of connection and its services and apps can be displayed on the VMS through MirrorLink, Apple CarPlay, or Android Auto. The user accesses all vehicle connected services and apps through the VMS



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**Figure 5 – Vehicle connectivity (with credit to Tesla, GM)**

Ideally, in all the above cases, access to services, apps and content displayed are adapted to driving situations and to the location of users within the vehicle in order to minimize distraction for the driver.

## **7.2 Multiple network connectivity in the vehicular multimedia context**

### **7.2.1 Background**

Most vehicular audio/video entertainment systems have at least FM/AM radio functions, while digital radio and sound broadcasting receivers are becoming more common [ITU-R BS.2384], due particularly to the European Union mandating DAB+ receiver in all new cars. With the improvements of networking technologies, online radio and audio/video entertainment services in intelligent connected vehicles are becoming more and more popular.

On one hand, traditional one-way broadcasting systems, i.e., FM/AM, terrestrial digital broadcasting, and satellite broadcasting, only support one-way transmission mode. Hence, interactive and personalized services can hardly be achieved by such broadcasting networks.

On the other hand, mobile networks support two-way transmission modes. By using mobile network, online multimedia entertainment services can be provided to users to satisfy interactive and personalized demands. However, there are three drawbacks:

- 1) In certain situations, the cost of mobile Internet is an important factor impeding the wide deployment of VMNS in intelligent connected vehicles.
- 2) The wireless coverage of mobile networks is not fully guaranteed. For example, the signal strength can be limited or non-existent in certain locations, and, therefore, users may experience a poor connection and experience when at those locations.
- 3) The mobile network can be congested, which impacts the smoothness of online audio/video playback and degrades the user experience.

#### **7.2.1.1 Converged network empowers migration to more advanced services**

Network convergence transmission takes advantage of the complementary strengths of broadcasting and mobile Internet infrastructures to overcome their limitations. Based on the converged network transmission channels, the rich media contents and information can be delivered to all kinds of terminals in an efficient and timely manner, i.e., intelligent connected vehicles, personal mobile terminals, etc.

The VMS retrieves rich media contents from a VMSP through various networks and serves as a local infotainment centre. The VMS can not only play the contents locally on the built-in vehicle screens and speakers but can also share the contents with passengers' personal devices (for example, smartphones and tablets, using in-vehicle Wi-Fi connections).

The VMS seamlessly integrates the services received from various broadcasting networks and bi-directional networks. In particular, when the VMS is in-coverage of multiple broadcasting networks, it could intelligently select one of the broadcasting networks to receive the service. Such choice can be made based on various factors, such as network signal strength, terminal processing power, cost, etc.

### **7.2.2 Use-cases**

#### **7.2.2.1 In-city commuting/native life service as driving purpose (scenario A)**

1. Satisfy the needs of personalized and two-way interactions.
2. Provide undegraded quality of service (QoS) for audio/video streaming services.

The coverage of cellular mobile network in densely-populated city areas is fairly good. However, as more and more users are trying to access the cellular mobile network, the connection speed for each user becomes lower and lower. In such a case, mobile Internet by itself could not satisfy the user experience.



### 7.2.2.2 Out-city driving (scenario B)

Traveling for long distances away from cities using family cars or SUVs during weekends or holidays becomes a common trend. In some regions, large population lives outside of the cities and using a vehicle is a necessity. In environments such as mountain valleys, forests or deserts, the mobile network coverage could be much poorer than in cities, which in turn cause the degradation of multimedia services.

### 7.2.3 Characteristics of the VMN connectivity

The VMN could have the following characteristics:

- 1) Be available on a connected vehicle (or/and autonomous vehicle).
- 2) Includes a connectivity layer allowing services to seamlessly use multiple bearers and protocols (satellite, cellular, short range / broadcast, streaming, download). That connectivity layer is usable by various sub-systems and services such as infotainment, maps or ADAS.
- 3) The VMS may connect to one or more communication networks, in particular:
  - 3G/4G/5G cellular networks.
  - Low Earth Orbit (LEO) bi-directional communication networks (e.g., [Starlink], [Oneweb], [HongYan], [Hong Yun]).
  - Satellites (e.g., L Band Broadcast) with both broadcast and bi-directional communications.
  - Short range networks such as DSRC (e.g., IEEE 802.11p; 802.11bd), C-V2X (e.g., LTE-V (3GPP TS36.321), 5G PC5 (3GPPTR 38.885)).
  - Terrestrial broadcast networks (e.g., FM, DAB, HD Radio, CDR, DTMB, DVB-T2 and upcoming FeMBMS).

Further, the following scenarios should be envisaged for VMN:

- The vehicle drives away from the coverage area of the wireless local area network (WLAN), but access to services continue to be available via cellular network or satellite network.
- The vehicle drives away from the coverage area of the cellular network, but access to services continue to be available via satellite communication.
- The vehicle drives away from the coverage area of the satellite network, but access to services continue to be available via cellular communication (e.g., entering an underground parking).
- The vehicle drives away from the coverage area of the mobile network in a region where satellite broadcasting systems are not deployed, but access to service continue to be available via terrestrial broadcast communication.
- The VMS may prefer that large downloads such as map updates and security updates be performed only on higher bandwidth network such as WLAN.
- Network connectivity may be billed to the driver, or it may be billed to the vehicle manufacturer. In either case, the driver/manufacturer may want to limit types of data transmitted over higher-cost networks. For example, diagnostic data can be uploaded at a later time when WLAN is available, whereas safety related information may be downloaded via any means available.
- The VMS may receive indicators over a broadcast network (e.g., radio data system (RDS) program identifier) and connect to a server over a cellular or short-range data connection to download metadata about the program [radiodns].
- The VMS may transmit/receive multimedia information such as image/video, voice and broadcast messages (such as emergency messages received and retransmitted to nearby vehicles) through wireless short-range communication networks (e.g., DSRC, C-V2X).

### 7.2.4 VMS connectivity requirements

CR1: The VMS should be designed to allow access via multiple communication networks.

CR2: The VMS may connect via multiple communication networks simultaneously.

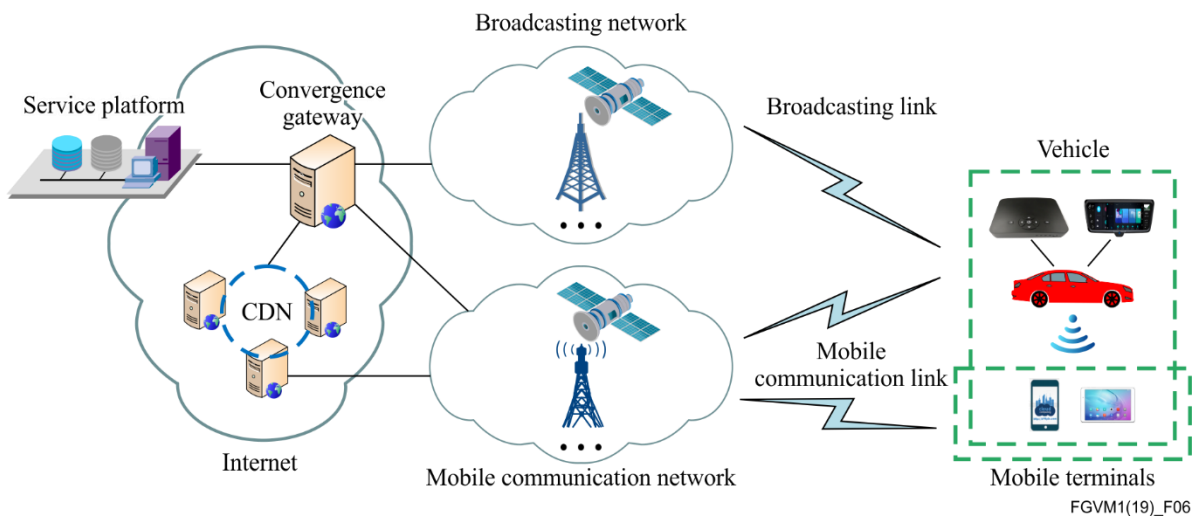
CR3: The VMS may provide seamless handoffs between communication networks.

CR4: The VMS shall be inclusive of both bi-directional and broadcast communication networks.

CR5: The VMS shall allow the user to configure or limit types of data transmission over various communication networks.

### 7.3 Network convergence transmission and onboard terminal processing

The network architecture of convergence transmission, as shown in Figure 6, illustrates how the network convergence greatly improves system efficiency and user experience.



**Figure 6 – The network architecture of convergence transmission**

#### 7.3.1 Use cases

Scenario 1: Vehicle A commutes in metropolitan areas with satellite broadcasting signal being intermittently blocked by high-rise buildings; Vehicle B takes a weekend excursion to remote areas where 4G/5G cellular coverage is limited; Vehicle C is on a long road trip across country during which favorite channels from home city are played throughout the whole trip. In either of the above cases, as long as one bearer of the converged networks has signal coverage, the services available are uninterrupted while the overall data charges are kept at minimum;

Scenario 2: Users enjoy rich media content and various services, such as live/on-demand audios and videos, pushed data, on-the-go Internet, emergency alert, global navigation satellite system (GNSS) etc., on one unified in-vehicle infotainment platform over converged networks, without having to care about the actual bearer that carries the service;

Scenario 3: The driver in a vehicle equipped with vehicular multimedia system can enjoy high-quality audio, videos and other value-added services through in-vehicle screen and speakers;

Scenario 4: Each passenger inside a vehicle equipped with VM system can enjoy their own choice of high-quality audio, video, and other value-added services on their personal smartphones or tablets through Wi-Fi access;

Scenario 5: Users who have downloaded the APP on their mobile phones/pads can continue enjoying the same program at the same quality of service using their own internet connections, when out of the vehicle Wi-Fi coverage.

### 7.3.2 Gap analysis

Various media services, i.e., live/on-demand audio/video service, pushed data service, on-the-go Internet service, shall be supported by the VMN and the vehicle VMS over a variety of underlying broadcast and communication networks. In order to guarantee the QoS of these services and improve the network efficiency, carefully designed transmission protocols and reception methods shall be pursued. Firstly, the transmission protocols and reception methods shall support various underlying physical-layer transmission standards, i.e., various wireless broadcast standards and wireless access standards, so that the QoS of these media services can be guaranteed while the vehicle is roaming across different networks. Secondly, service providers may use different application layer protocols to support similar media services, i.e., either MPEG-DASH or HLS can be used to support streaming services. Therefore, the transmission protocols and reception methods shall be transparent to the upper layer protocols so that the vehicle multimedia network can be used by various service providers to run their own services. Thirdly, the transmission protocols and reception method shall be able to take full advantage of the characteristics of various wireless networks to improve the QoS of these media services, or to optimize the overall network efficiency.

At present, ITU-T SG16/Q27 has achieved important progress in the standardization of vehicle gateway (VG) and vehicle gateway platform (VGP). In the related Recommendations [ITU-T F.749.1] and [ITU-T H.560], functional requirements for VGs, service requirements for VGPs, architecture and functional entities of VGPs, and communications interface between external applications and VGPs are well defined with a focus on intelligent transportation services. However, none of these Recommendations provides transmission protocols or reception methods that can fulfill the vehicle media service requirements of clause 7.3.

- 1) Recommendation [ITU-T F.749.1], Functional Requirements for Vehicle Gateways.
- 2) Recommendation [ITU-T F.749.2], Service Requirements for Vehicle Gateway Platforms.
- 3) Recommendation [ITU-T H.550], Architecture and Functional Entities of Vehicle Gateway Platforms.
- 4) Recommendation [ITU-T H.560], Communications Interface between External Applications and a Vehicle Gateway Platform [ITU-T H.560].

### 7.3.3 VMS converged network requirements

The requirements on network convergence transmission and onboard terminal processing are listed as follows:

R1: Convergence network transmission and reception function of the VMS shall be agnostic to the underlying physical layer transmission standards and be transparent to the upper layer applications.

R2: The VMS should take full advantage of different network characteristics to ensure uninterrupted and seamless services (e.g., to keep the overall network costs minimum).

R3: The increase in the end-to-end system converged network transmission delays due to the VMS should be minimized.

R4: The increase in the overall system start-up and channel switching time due to the convergence network transmission and reception function of the VMS shall be minimized.

R5: The VMS shall require none or minimum modifications to the existing broadcasting and mobile communication infrastructures and shall be compatible with major media streaming and broadcasting protocols.

## **7.4 Networking connection among multiple terminals within the vehicle**

### **7.4.1 Scenario A: Nomadic device connectivity**

The VMS provides in-vehicle media content distribution over a local wireless network (e.g., Wi-Fi, Bluetooth, etc.) Various types of terminal (such as various types of IVI screens, mobile phones, tablets, etc.) can connect to the vehicular multimedia system and receive content adapted to the characteristics of the different terminals.

### **7.4.2 Scenario B: Screen casting**

Support the interactive connection between the VMS and a user's mobile device. Mobile devices use a variety of existing screen casting systems, a non-exhaustive list includes technologies such as Wi-Fi Alliance Miracast, CCC MirrorLink, Huawei Welink, Apple CarPlay, Baidu CarLife, Android Auto, etc.

### **7.4.3 Display Screens and terminals connectivity requirements**

R1: The VMS should be able to connect to various terminals (such as different types of IVI screens, mobiles, tablets, etc.) based on their capabilities.

R2: The VMS should support the interactive connection with mobile devices.

### **7.4.4 Scenario C: Comfort and well-being on board**

The emotional and physical conditions of driver and passengers are measured either through smart watches connected with the VMS, through scanning of facial expressions and postures with cameras or other sensors on board (e.g., sensors integrated in steering wheel or seats) that are connected to the VMS. In order to stimulate the comfort and well-being of all passengers on board and to ensure the non-drowsiness and attentiveness of the driver, the senses of persons on board are stimulated through display content, ambient light, sound, scents, as well as air distribution and flow.

In case of critical situations, such as drowsiness or distraction of the driver, VMS displays alert messages, gives audible alerts or shuts down displays in case the driver is looking away from the road for a considerable long period of time.

The information collected for each passenger is integrated in each personal profile, possibly along with other environmental information (localization, number of persons aboard, air condition, temperature, vehicle telemetry etc.).

Over time, an individual evolution measured per passenger as well as an individual profile for well-being will be created with the help of artificial intelligence running in the background of the VMS and be deposited in the cloud.

The information collected by the vehicle VMS regarding the emotional and physical status of the users, can be made available to other well-being and health related value-added services to which the user has subscribed. These services can provide information on user well-being and health needs to the vehicle VMS.

#### **7.4.4.1 Proposed requirements**

R1: VMS should have or should be connected to sensors sensing the cognitive load of the driver, and the emotional and physical conditions of all vehicle users.

R2: VMS should have or be connected to all features that can change the ambience in the vehicle such as a library of music and messages, lighting, perfume deodorizer, etc.

R3: VMS should have integrated algorithms that react to and initiate actions instantaneously including outside of network coverage.

R4: VMS should be able to connect to external well-being and health services and transmit information collected regarding each user.

R5: VMS must have storage space to save each user profile data and to send them to the cloud when network coverage becomes available.

R6: Each individual user should have the possibility to shut down or unsubscribe the function at any time temporarily or irrevocably.

#### **7.4.5 Scenario D: On-demand functions for privately owned vehicle**

Through vehicle apps available on smart devices and on the VMS, the vehicle user can demand vehicle functions that he can subscribe to against a fee for one-time use, a certain duration or over the vehicle's lifetime. Examples for such functions could be premium on-demand autonomous driving functions, longer battery range, on-demand navigation, 3D video, AR/VR games, digital radio, etc. The requirement is that safety functions should not be part of such on-demand functions.

Based on user interests, services can be proposed to the customer actively through the app. Some of these on-demand functions will be directly displayed or linked to the VMS.

In the vehicle the VMS displays a choice of on-demand functions. The passenger can choose a function and the duration of the subscription through interaction with the VMS. Based on the VMS payment profile for that user deposited in the cloud, a passenger can pay after secure identification through the VMS. Alternatively, payment may not require a user profile and/or an in-app payment could be used. VMS confirms the purchase and displays the chosen function that is ready for use.

##### **7.4.5.1 Requirements**

R1: The VMS should enable a centralized or individual access in a multi-passenger vehicle to the cloud with app for on-demand functions and payment functions.

R2: For on-demand functions and payment functions, the VMS in a multi-passenger vehicle should have access to the VMS user profiles at a centralized or individual position.

R3: VMS should be equipped with sensors allowing the identification passenger(s) at different positions for usage and payment functions or with an input function allowing the user to identify himself through a password.

R4: VMS should support on-demand functions that are meant to run locally on VMS such as on-demand navigation, 3D video, AR/VR games, digital radio, etc.

- VMS must have enough storage space
- VMS must have enough calculation power
- For multi-passenger vehicles individual VMS at each passenger seat should respond to these prerequisites.

#### **7.5 Continuous and consistent services across various networks and environment (from/to VMS)**

##### **7.5.1 Use case A: continuity of service**

During breakfast, a person starts to watch a live streaming of a basketball game using an App on a tablet through the Wi-Fi network at home. After breakfast, the video of the basketball game is paused. Meanwhile, the viewing records (i.e., the program that is being watched, the time when the video is paused, the preferred audio commentary track, etc.) are uploaded to a cloud database automatically. The individual steps into a waiting vehicle and subsequently decides to continue to watch the live broadcasting of the basketball game en route to the office with the in-vehicle display or windshield display through the converged network. In the vehicle, the individual may log into an application in the VMS with the same user account to continue viewing. Meanwhile, the viewing records are downloaded from the cloud database to the VMS. In such a case, the account information and viewing records can be used to support continuous and consistent services across various networks and on multiple screens providing an improved viewing experience. For example,

- 1) Suppose the live streaming of the basketball game is available on both satellite broadcast networks and cellular communication networks. If the person has a premium subscription, then the high-definition (HD) live broadcasting of the basketball game with HD surround sound available on the satellite broadcast network may be enjoyed. If the person has a non-premium subscription, then the service could be a best-effort live streaming of the basketball game available on the cellular communication network.
- 2) If the person decides to resume the play of the basketball game from the time that the video was paused previously, then the buffered recording of the basketball game on the cellular communication network should be supported. Meanwhile, the live stream of the basketball game on the satellite network may be available in a picture-in-picture mode.
- 3) When the person resumes the video of the basketball game on the application in the VMS, it should automatically choose the preferred audio commentary track based on the viewing records.

#### **7.5.1.1 Requirements**

To support continuous and consistent services across various networks and on multiple screens, the following requirements are proposed:

R1: The VMSP and the VMS should allow a user to log in with the same user account by using various devices, i.e., VMS itself, mobile phones, tablets, etc.

R2: The VMSP and the VMS should support the uploading of the user's viewing records to the VMSP.

R2.1: The VMSP and the VMS should support the configuration, by the user, of the scope of his/her viewing records that are to be uploaded.

R2.2: The VMSP and the VMS should support the configuration, by the user, of the frequency of his/her viewing records that are to be uploaded.

R3: The VMSP and the VMS should support the download of the user's viewing records to various devices.

R3.1: The VMSP and the VMS should support the configuration, by the user, of the frequency of his/her viewing records that are to be downloaded.

R4: The VMS should support the reception, processing, and display of multiple media channels from various networks and on different screens simultaneously.

#### **7.5.2 Use case B: Cloud based services**

Seamless connectivity between home, office and in-vehicle services will allow users to always find the same software applications, user interfaces, language, etc., regardless of their location (home, in the vehicle or at the office). Multimedia content, office applications and services will be the same. However, for security and confidentiality reasons corporate data will not be made available or be transferred to a VMS centrally managed user profile.

The VMS displays this content once the user is identified and allows access to individual data from the cloud or from the user's mobile phone.

##### **7.5.2.1 Proposed requirements**

R1: A central user profile with content, applications and services excluding any corporate data is deposited in the cloud or locally in the user's mobile phone. Each user can have different profile versions, depending on the roles he can assume (on business, on leisure, family, etc.).

R2: VMS will identify driver/passenger(s) through its mobile phone (NFC, Bluetooth, other) or cameras or sensors (scan of fingerprint, iris, face, other).

R3: VMS will identify which seat in the vehicle passenger has occupied in order to display the right content at the right place.

R4: VMS accesses cloud content of passenger or the user provided profile of the mobile phone, displays it at the place user is occupying in the vehicle and adapts the passenger comfort of the specific place (seat and screen positioning, audio levels, temperature etc.). In case of multiple user profiles, the user will be asked to choose the profile to apply or the VMS will choose the one that corresponds to the current situation.

- Changes made to the profile on the VMS within the vehicle, e.g., new applications, user surfaces, comfort choices etc. will be sent back from the VMS to the cloud, or stored to the user's mobile phone, where they will be saved and are accessible later from any other vehicle, at home or at work.
- Access of VMS to passenger specific cloud data from anywhere must be secured against intrusion and cyber attacks.
- VMS must have storage space to save profile data and to send them to the cloud when network coverage becomes available.

## 8 Intelligent human to machine interface) for VMS

In keeping with current development trends of intelligent vehicles, the integration of various interactive control schemes for safe driving such as voice control, gesture control, eye movement control, etc., will become mainstream in the future.

When interacting with the VMS there should be a distinction between input and output devices. All input and output devices should be intuitive, easy to use and be placed preferably in ergonomically areas so that they are easy to reach and allow simple interaction. Especially in driving levels 0 to 3 driver distraction and cognitive overload for the driver should be avoided so that the driver can safely operate the vehicle in all driving situations (hands on the steering wheel and eyes on the road) [SAE J3016].

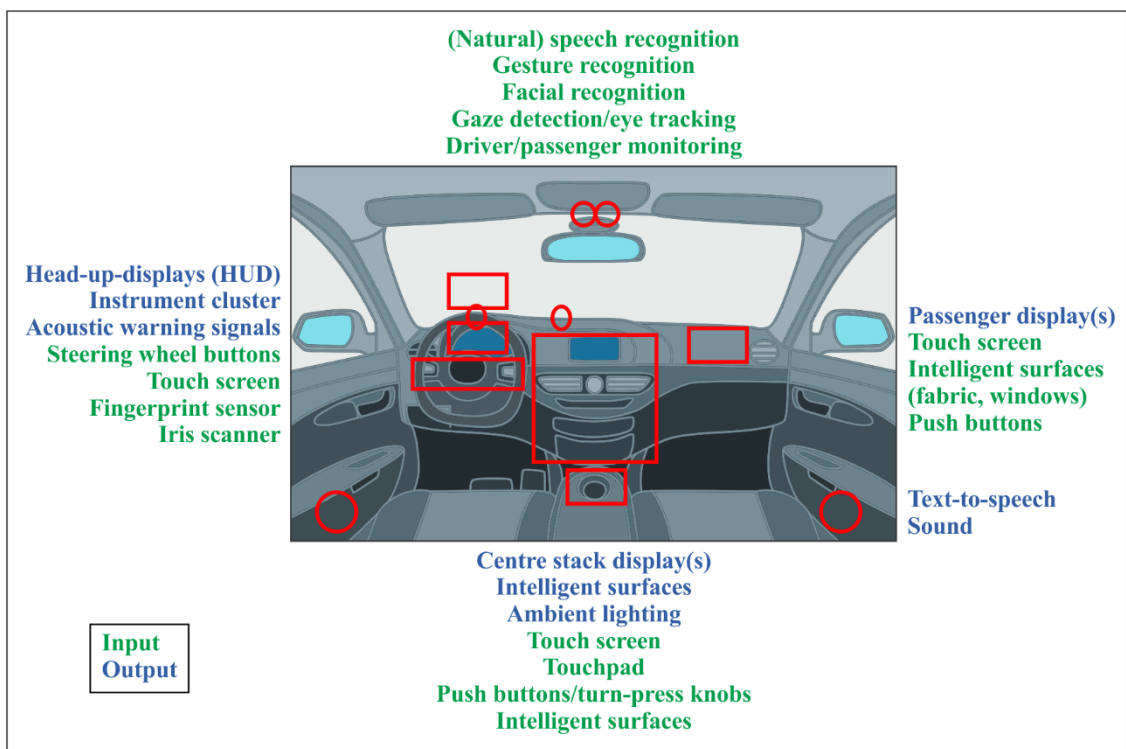
**Input devices** allow the driver and passengers to input data and information into the VMS by directly interacting with the vehicle. The following input devices can be distinguished:

- Center stack and tunnel area
  - Touch screen(s)
  - Touchpad
  - Push buttons
  - Turn-press-knob
- Interior camera(s) for
  - Person identification (e.g., eye scanner, facial recognition)
  - Gesture control
  - Gaze detection/eye tracking
  - Driver and passenger monitoring (sensing, e.g., of drowsiness, distraction, emotional state, etc.)
- (Natural) Speech recognition
- Driver area
  - Steering wheel buttons
  - Touch screen on steering wheel
  - Fingerprint sensor

- Passenger areas
  - Touch screens
  - Push buttons
- Intelligent surfaces (e.g., fabrics, cockpit surface, windows)

**Output devices** can give information specific to the driver as well as for all other passengers on board the vehicle:

- Driver area
  - Head-up display (HUD) (limited to driver, or augmented over a big part or the whole windshield)
  - Instrument cluster (numeric, or digital display)
  - Touch screen in the steering wheel
- Loudspeakers either in doors, or passenger specific for individual sound bubbles in headrests
  - Acoustic warning signals
  - Text-to-speech (e.g., reading of messages, mails, other information)
  - Sound (e.g., multimedia content, phone/video conferencing)
- Center stack display(s)
- Passenger displays
- Intelligent surfaces (e.g., fabrics, cockpit surface, windows)
- Ambient lighting (light integrated, e.g., around steering wheel, in cockpit, doors, etc.)



FGVM1(19)\_F07

**Figure 7 – VMS input and output devices, cockpit view**



## 8.1 The acoustic system in the vehicular multimedia

### 8.1.1 Background

As stated in the terms of reference of the FG-VM, a vehicle may become a user's third entertainment space, and could be highly personalized. A VMS may support multiple screens and may be used not only to listen to radio but also possibly to watch television, movies, play games, either collectively or individually. At the same time a vehicle may comprise a voice recognition or natural language processing system. It is expected that one or more multimedia sources and users interacting with one another or with a multimedia system will interfere with the voice commands.

It becomes apparent that the determination of the location (zone) of the various emitting sources (talkers) in the cabin and the acoustic treatment of each transmitted signal (voice command) from each location (zone) will facilitate the correct processing of voice commands by the voice recognition system.

### 8.1.2 Use-cases

#### 8.1.2.1 Initiating a voice recognition session (scenario A)

A person in a vehicle containing multiple occupants wishes to initiate a voice recognition session by uttering a keyword, such as "Hey Siri", "Alexa" or "Okay Google". Each occupant is in a separate zone of the cabin. The cabin may contain one or more microphones which may or may not be dedicated for each zone. Each microphone picks up the voice of the occupant, but also the voices of other occupants, or "interference speech". One or more multiple microphone signals (or audio channels) may be available to a keyword spotter (KWS), which must decide not only whether/when the keyword was spoken, but also from which zone the keyword was spoken.

The following problem scenarios may result in inadequate behavior of the KWS:

- A-1 If there is no dedicated microphone for each zone, or no means to identify the zone of the target talker, the command may not be detected, may be rejected or wrongly executed.
- A-2 Otherwise:
  - A-2-A Interfering speech may cause a KWS to fail to detect (false reject) the keyword spoken by the target talker in the target zone microphone.
  - A-2-B Concurrent sources (e.g., music, video) played into the vehicle, resulting in echo on the microphones, may cause a KWS to fail to detect (false reject) the keyword spoken by the target talker in the target zone microphone.
  - A-2-C Interference of the target talker onto microphones outside of the target zone may cause the KWS to detect the keyword but from the wrong zone.

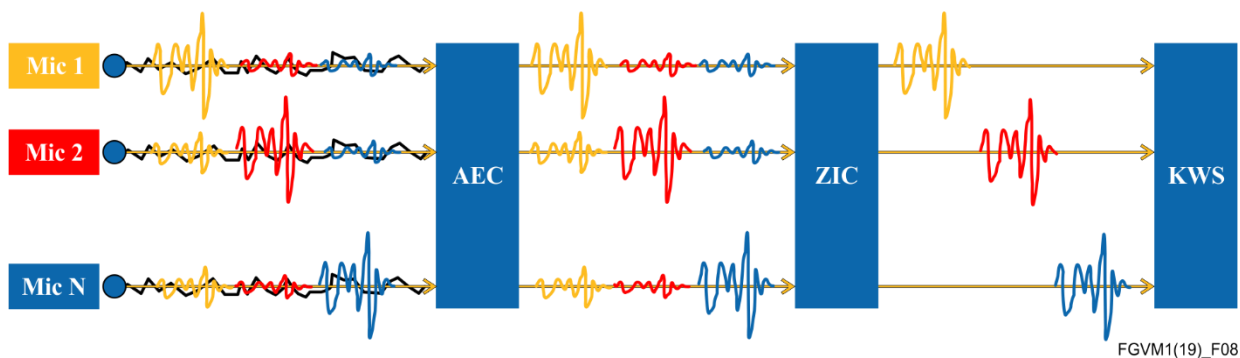


Figure 8 – Acoustic processing (AEC and ZIC) on each zone dedicated microphone

Figure 2 is an illustration of use case A-2 involving KWS with N microphones/zones in a vehicle, depicting the waveforms. Each microphone contains target speech, interfering speech and echo (black). Talker in zone 1 is yellow, talker in zone 2 is red and talker in zone 3 is blue. Acoustic echo cancellation (AEC) is used to subtract the echo from each microphone, and zone interference cancellation (ZIC) is used to isolate the target speech from interfering speech in each microphone.

### 8.1.2.2 Interference during a voice recognition session (scenario B)

Once a voice recognition session has been initiated and the target zone has been identified (e.g., using KWS or push-to-talk), an occupant in the target zone will use voice commands to interact with the voice recognition system. The target speech in the target zone will potentially be mixed with interfering speech from other zones, and echo from media sources playing into the cabin. These may result in incorrectly detected speech and difficulties in accomplishing the voice command.

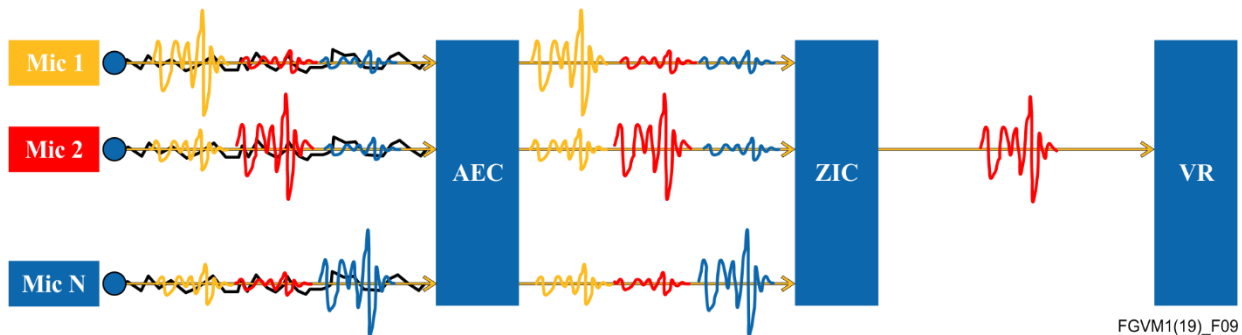


Figure 9 – Illustration of use case B, where zone 2 has been identified as the target zone

### 8.1.3 Gap analysis

ITU-T SG12 is currently working on a set of recommendations relevant for VMS:

- In car communication (P.ICC). P.ICC utilizes the integrated microphones and speakers in the motor vehicle cabin to amplify conversation to provide an improved communication between all occupants in a motor vehicle. Furthermore, it ensures the quality of voice such that the motor vehicle driver does not feel it necessary to turn their head to amplify their voice when talking to other passengers. However, it is not immediately apparent that P.ICC addresses the requirements associated with the use of voice recognition in a vehicular multimedia context.
- P11xx -00,10,20,30 series. Hands-free communications in vehicles for narrowband, wideband, super-wideband and full-band and associated subsystems provides useful conformance points to improve signal processing for hands-free communication within a vehicle. However, it is not immediately apparent that the P11xx series can address the use cases and requirements for multiple talkers, KWS, voice commands and voice recognition sessions.

### 8.1.4 Acoustic requirements

In order for a KWS, a voice recognition or natural language processing solution to operate effectively in a multiple-talker scenario with background media in a vehicle, the following requirements are proposed:

R1: It shall be possible to initiate a voice recognition session from any zone in the vehicle.

AR1.1: It shall be possible to initiate a voice recognition session from any zone in presence of speech interference and noise interference from the same or a different zone.

R2: The VMS or vehicle should provide at least one voice/speech/audio channel per zone (e.g., one microphone per zone).

R3: It shall be possible to process each channel/zone independently.

R4: It shall be possible to identify a target zone/target speech (e.g., scenario A-1).

R5: ZIC shall be performed to suppress interfering speech from a zone whilst preserving the target speech in that zone. (scenarios A-2-A, A-2-C and B).

R6: AEC shall be performed on each channel to suppress the echo of media sources that are picked up in each zone (scenario A-2-B).

R7: When interfacing with cloud recognition services that are not trained specifically with vehicle noise, it should be possible to perform noise reduction in the target zone to suppress road noise or wind noise.

## **8.2 Gesture control in vehicular multimedia system**

Applying gesture recognition as part of intelligent human to machine interface (HMI) and of ADAS can improve driving safety. Drivers can use gesture to control various functions, including in-vehicular multi-media functions, or change various settings, such as the temperature of air-conditioners or sound volume in the vehicle, thus paying more attention to the road and reducing the occurrence of traffic accidents.

Through a simple and easy to use gesture control system, drivers can interact with multimedia system functions while looking directly at the road ahead.

## **8.3 Eye-movement control in vehicular multimedia system**

### **8.3.1 Real time eye gaze tracking scenario**

Eye gaze tracking is the process of measuring either the point of gaze (where one is looking) or the motion of an eye relative to the head. An eye tracker is a device for measuring eye positions and eye movement. With the progress in processor speed and image processing algorithms, it is now also possible to use the gaze tracking technology in real time to control a screen pointer in a direct manipulation interface. Eye gaze tracking technology is well explored for consumer electronics and gradually making way to the automotive and aviation sector. It has already been explored for the attention analysis of drivers and pilots and designing cockpits to minimize eye gaze movement, highlighting critical elements and so on. The following use cases emphasize real time use of eye tracking in a moving vehicle as a direct controller of electronic displays inside a car and to analyse drivers' cognitive load while driving.

- Driver wants to change radio channel or accept a call. He does not need to take his eyes off the road nor look down at the dashboard, and neither to take his hands off the steering wheel. The whole dashboard is reflected on a heads up display and he operates the display just like any graphical user interface through fixating attention on the required icons. The fixation duration is less than 2 seconds and even when he is operating the display, he can use his peripheral vision to observe the road.  
[https://en.wikipedia.org/wiki/Two-second\\_rule](https://en.wikipedia.org/wiki/Two-second_rule)
- Driver is distracted, feeling stressed or bored, eye tracker detects driver's state from ocular parameters like pupil dilation or fixation rate. Based on the gaze tracker inputs the ADAS system that will trigger the VMS to reduce secondary task load (e.g., VMS media playback) and alerts driver and passengers.
- Eye tracker tracks eyes of passengers of an autonomous vehicle. The VMS uses it to operate entertainment systems on back seats and can be used to alerts passengers if the passenger in driver's seat is distracted or stressed.

#### **8.3.1.1 Gap analysis**

Required improvement for the use of eye gaze trackers in automotive environment includes:

- Commercial eye gaze trackers which have not yet been tested for automotive compliance

- Robust algorithm for affective state detection
- Improving accuracy and latency of commercial eye gaze trackers in automotive environment
- Combining eye gaze control system with other existing modalities
- Testing the accuracy of driver distraction and affective state detection system in automotive environment.

### **8.3.2 Use case**

A dynamic HMI responds to the user's gaze. Elements of the UI can be configured to change based on whether or not the user is looking at them. For example, an element on the screen can be set to be transparent when the user is not looking at it, and immediately return to the visible state once the user is looking at it.

Controlling the vehicle multimedia by eye movement can be implemented to improve driving safety.

### **8.3.3 Requirements**

R1: Accuracy and latency requirement for gaze control system integrated for use in the HMI of a VMS shall not require fixating attention for more than 2 seconds or the maximum time defined by local regulations in automotive environment on the HMI.

### **8.3.4 Controllable camera**

Users can also control an external camera through their eyes, which is similar to the head-tracking camera.

NOTE – This is not a DVR camera which is mandated in certain country to record. DVR camera are not user controllable.

## **8.4 Data formats and storage**

### **8.4.1 Use case and considerations**

There is a need to define a minimum set of data formats to be supported by a VMS to allow for interoperability between different VMS and different VMNS providers. The following aspects should be considered:

- Codecs (and protocols) used by broadcast and interactive systems to and from a VMS.
- Contents on nomadic devices (mobile phones) when connecting to the VMS (e.g., to share content via the VMU).
- Existing codecs usually supported by current infotainment solution.
- Additional sensors and their storage/compression requirements for VM system services (e.g., maps, AR, telematics).

The main ECU may be built on a powerful processor, while processors with lower capabilities (e.g., limited set of codecs) may be available in the vehicle (e.g., with mounted display in back seat positions). As such, it can be desirable to transcode content received at the main ECU in formats supported throughout the vehicle.

Further, as the amount of data exchanged between device and infrastructure is becoming a bottleneck, evaluation of codec performances (compression, lossless/lossy capabilities) should be taken in account when deciding on codec support. In the context of a VMS, this data comprises at least audio, video, images and point-cloud (such as lidar) which can be used both for entertainment and safety purposes.

In addition, VMS and VMU will need to support software updates. These updates and software codecs should be securely provided. Their use and access by different VMNS may be restricted.

## 8.4.2 Data format requirements

For multimedia broadcasting services provided by a VMNS service provider, the media types, content navigation methods and interactivity methods supported by a VMS and VMNP shall be selected from the recommended format in [ITU-T BT.2055-1].

Additional media types may be supported by the VMS and the VMNP to address some regional requirements (e.g., support of AVS2 codecs in China).

A VMN application may support additional software codecs to address the need of a VMNS service provider.

For interactive, and non-broadcasted VMNS, the VMNP and VMS:

- Should support the same multimedia broadcast media types
- May support JPEG-XS
- May support MPEG-H 3D audio

NOTE – The selection of media types and transmission protocol formats (e.g., MPEG-DASH, MBMS, etc.) will be refined after the architecture phase.

## 9 Privacy considerations

### 9.1 Background

A VMS could have the following characteristics:

- 1) Be available on a connected vehicle (or/and autonomous vehicle)
- 2) Be personalizable, like a phone, a subscription or a service tailored to the user and to the user's interests

Countries and states have started to regulate connected vehicles or release broad privacy regulations. Among them:

- The US Department of Transport requires, among other things, that connected vehicle safety applications messages shall not contain any personally identifying information (PII). [DoT PII-1]
- In Europe, the general data privacy regulation (GDPR) came into effect in May 2018 and requires, among other things, that only the minimum necessary personal information are collected, consent shall be obtained in a clear manner, collected data shall be accessible by the user and data shall be deleted when no longer relevant or when consent is withdrawn [DoT PII-2]
- In China, the Cybersecurity Law of the People's Republic of China came into effect in June 2017 and requires that network operators collecting and using personal information shall abide by the principles of legality, propriety, and necessity. Besides, a guideline for Internet personal information security protection is being formulated to ensure that the rights of data subjects are not to be violated.

Further, the following scenario should be envisaged:

- The vehicle is owned by the user of the VMS
- The VMS may be temporarily used by different individuals (driver or passenger) of the vehicle, for instance in a family, shared car, rental car, or taxi model.
- The personalization of a VMS may be provided by a centralized service provider.

In network communication protocols, at various layers identifiers are used to identify software and hardware (e.g., IP address, MAC address, E.164 "phone number", etc.). Some of these identifiers constitute PII in some instances, and protocol designers in the past did not always take this into

account. In the design of systems and protocols today, there needs to be intentional separation of PII identities (e.g., username, email address [IETF email] and [ITU-T E.164]) and non-PII identities (e.g., IP address, MAC address, etc.) used at various layers in the communication stack.

Further, user's privacy and PII (such as viewing history, history of interactions, profiles and preferences) needs also to be protected in interactive broadcasting system, both at the broadcast receiver (e.g., the VMS or VMS application), on the interactive link and at the service provider level as highlighted in [ITU-R BT.2052].

From the above it becomes apparent that VMNS needs to allow for different use cases under different regulatory requirements. The high-level privacy requirements in clause 9.2 are proposed:

## **9.2 General privacy requirements**

R1: The VMN and VMS shall be designed to allow for its use under different privacy regulatory environments.

R2: The VMN and VMS shall prevent network-layer identifiers (such as MAC address) to be used as personally identifying information.

R3: The VMS shall protect any permanent hardware identifiers and only allow access for authentication purposes.

R4: In addition to the specified requirements for in-vehicle entertainment and multimedia systems, it is required that users' (driver, passengers) privacy be protected, and that private conversations not be directed to the voice-recognition system, be protected and that un-authorized sharing of such conversations be hindered.

R5: Consideration should be given to the case where the voice recognition system is in-vehicle or is cloud-based.

## **9.3 Use case: Private vehicle with one single user**

The end user is identified when entering his privately-owned vehicle. VMS cloud platform has access to the agenda of vehicle owner. It therefore knows if the user is driving to a meeting, a birthday party, a restaurant, etc., and the time of arrival at the destination. Based on the time of day and geo-localization of the vehicle, the platform sends proposals to the VMS that are displayed on the VMS or read to the end user through the VMS (text-to-speech) e.g., restaurant reservation before a meeting, buying flowers on the way to a dinner or a gift on the way to a birthday party, etc. The vehicle user can through direct interaction (voice recognition, touch screen, other) with the VMS make use of these proposals or deny proposals. Furthermore, having deposited payment preferences in the cloud, the vehicle owner can directly pay through the VMS. Based on the inputs into the VMS, the vehicle might be rerouted to another itinerary in order to pick up the goods or to go to the restaurant chosen during the ride.

### **9.3.1 Requirements**

R1: VMSP should have access to a commercial platform linking location-based data with the information of shops, restaurants and current commercial offers.

R2: VMS should have access to personal payment data that are deposited in the cloud.

R3: VMS should have a feature for secure identification of the user before payment process (e.g., fingerprint sensor, iris scanner).

## **9.4 Use case C– Long distance shared vehicle with multi users (shuttle all users are seated)**

End users are identified when entering the shuttle. Each user of the shuttle has his own seat in the vehicle. VMS identifies where they are seated within the shuttle in order to adapt content, based on

the capabilities of each seated position (some might have screen, some just audio, the possibility of seat comfort adaptation etc.). VMS has access to agenda or agenda parts of each shuttle user (either from the cloud, following authorization from the user, or from the user's mobile phone). The itinerary has been optimized in order to bring each vehicle user on an optimized route within the shortest time to its destination. In addition, due to the link of the cloud platform with the agenda of the multiple users, the VMS knows for each single user if he drives to a meeting, birthday party, etc. Based on optimization algorithms the VMS proposes services (restaurant reservations, buying flowers or a gift) to each individual shuttle user based on his respective agenda. Each vehicle user can pay through direct interaction with its VMS within the shuttle.

#### **9.4.1 Requirements**

R1: VMS should have the ability to identify the different users and retrieve their personal and payment data.

R2: VMS should support receiving agenda and personal information from user mobile devices.

R3: VMS can allow the user to enter destination without revealing his agenda and other personal information (via dedicated application, or in-vehicle screen with coordination and synchronization with user mobile phone).

R4: The VMSP with data concerning destination and agenda of all users of the shuttle and the commercial decisions all users take, should provide these data to the cloud navigation application and receive from it, an optimized proposal for the different users and for the routing of the shuttle.

R5: User can at any time change itinerary, overwriting agenda information and previous instructions in the VMS.

#### **9.5 Use case – Public transportation shared vehicle with multi users (shuttle short distance trips – seated and standing users)**

End users are identified when entering the shuttle (via RFID, mobile phone NFC, or face recognition for registered users). VMS identifies the position of the user in the vehicle.

VMS has access to agenda or agenda parts of each shuttle user (either from the cloud, following authorization from the user, or from the user's mobile phone). The itinerary has been optimized in order to bring each vehicle user on an optimized route within the shortest time to its destination.

VMS provides personalized information on the public display in the bus informing users when approaching their bus stop (by preserving their privacy). VMS can send messages to mobile or wearable devices of user with more private information, if this is authorized by the user.

VMS presents infotainment information on the public screens, based on interests of the user and their proximity to the screen. As the journey progress, information about the city, about events near to the route, about special offers of shops in the trajectory and other interesting information that are displayed on the public screen. User can also ask to send this information directly on their smart device while on board the vehicle.

#### **9.5.1 Requirements**

R1: VMSP should be able to push non- personalized messages on VMS or directly on user's mobile devices when users have opted in to the service.

R2: Connectivity from mobile devices to VMS is possible.

R3: VMS can receive agenda and personal information from user mobile devices.

R4: VMS can allow the user to enter destination without revealing his agenda and other personal information (via dedicated application, or in-vehicle screen with coordination and synchronization with user mobile phone).

R5: VMSP with data concerning the destination and agenda of all users of the shuttle must optimize content proposals to the different users and the routing of the shuttle.

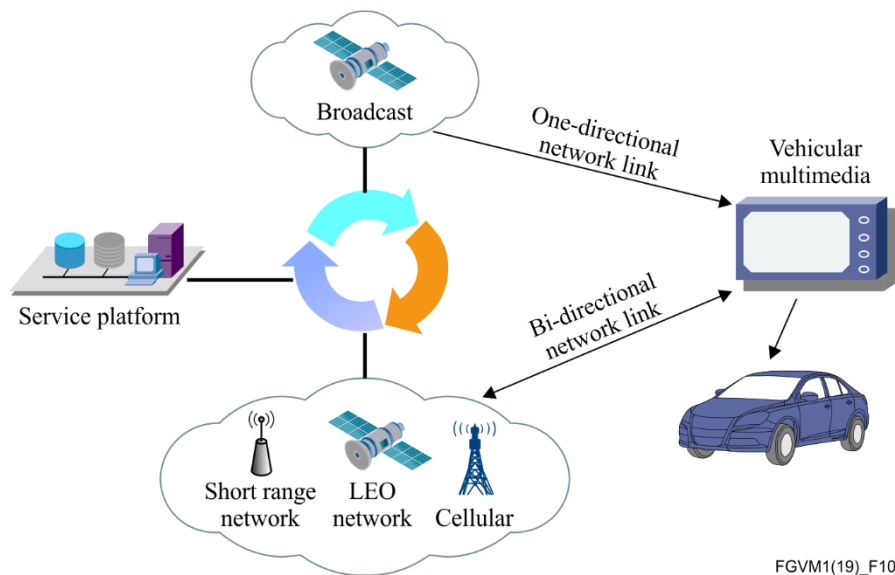
R6: User can at any time change itinerary, overwriting agenda information and previous instructions via VMS or via their mobile phone.

R7: User should have the possibility to opt-in or opt-out of the service at any time either through an interface of the VMS or through its mobile device.

## 10 Content rights protection in a converged network environment

### 10.1 Background

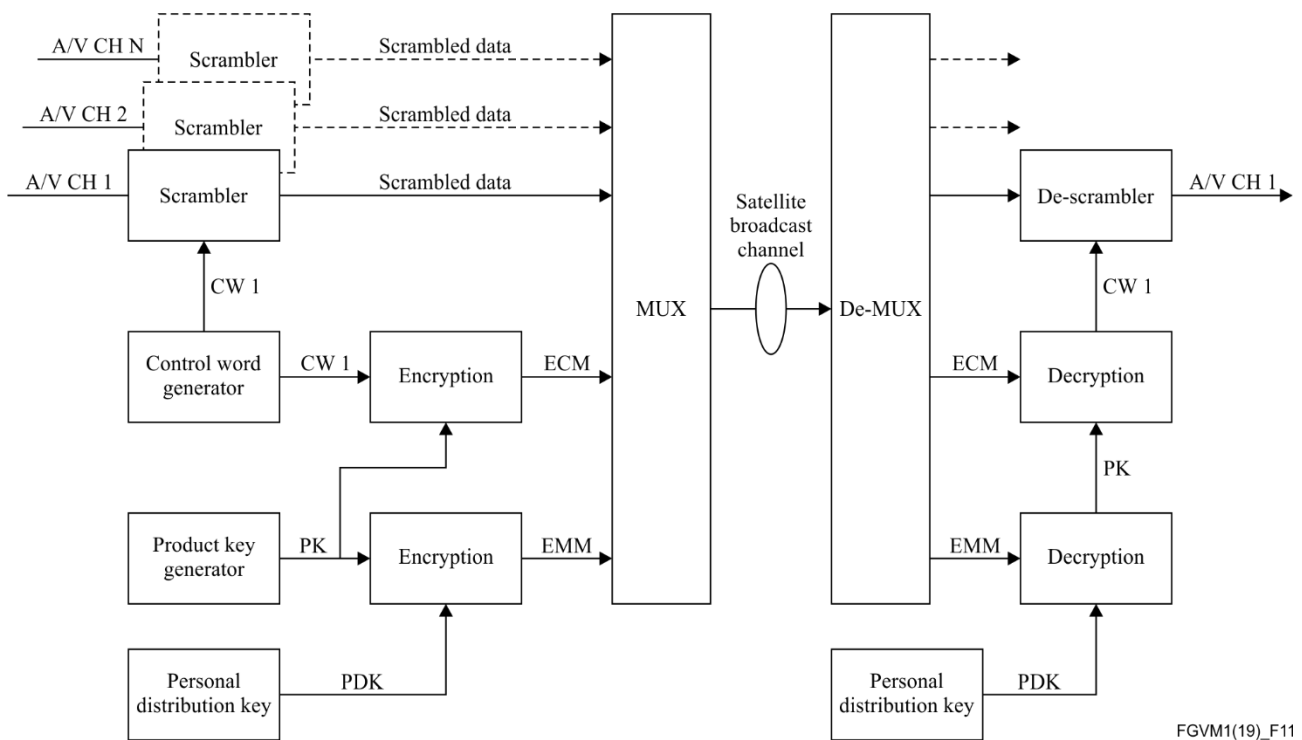
The convergence of different networks combines features of uni-directional networks and bi-directional networks. Such converged networks provide a variety of advanced multimedia information services to vehicle terminals, i.e., live television service, online video streaming service, multimedia content delivery service, etc. The architecture of the converged networks is illustrated in Figure 10.



**Figure 10 – Convergence of different networks for vehicular multimedia content**

Consider live television service as an example. Currently, live television service is delivered solely by satellite broadcast network. To protect the television video content from being received at unauthorized terminals, the following conditional access (CA) technique is applied. The architecture of the satellite broadcast system with CA support is illustrated in Figure 11. At the head end, the multimedia stream for each channel is scrambled by a control word (CW). The CW is encrypted by the product key (PK) to obtain the entitlement control message (ECM). The PK is encrypted by the personal distribution key (PDK) to obtain the entitlement management message (EMM). Scrambled data, ECMs, and EMMs are multiplexed into a transport stream (TS) before it is transmitted over satellite broadcast channels. At the terminal, the transport stream is demultiplexed to recover the scrambled data, ECMs, and EMMs. Then, the PK is decrypted from the EMM by the PDK stored at the CA terminal. Next, the CW 1 for channel 1 is decrypted from the ECM by the PK. Finally, the multimedia stream for channel 1 can be obtained by descrambling the data for channel 1 with CW 1. Note that PDK is unique for each terminal, and, therefore, the EMM for a terminal would be different from those for other terminals. By using the above CA technique, for each terminal the access to the live television service can be controlled (i.e., access to the content is either allowed or denied).





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**Figure 11 – Diagram of the satellite broadcast system with CA support**

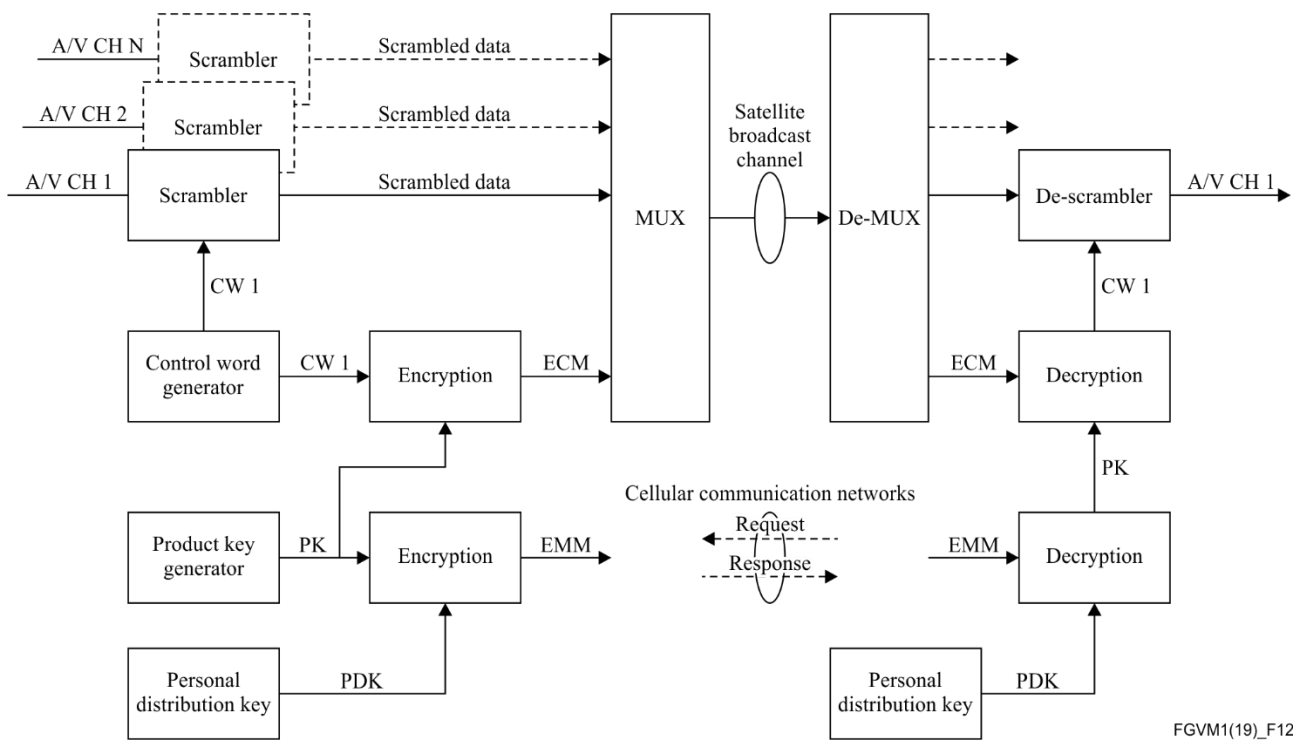
## 10.2 Use cases

The conditional access system shown in Figure 11 has several drawbacks. In the following use cases, the limits of the above conditional access system are analysed and solutions to improve the system performance with converged networks are described.

### 10.2.1 Use case A

Consider a live television broadcast service delivered solely by satellite networks. In such a case, the scrambled multimedia data for each channel, ECM for each channel, and EMM for each terminal should be transmitted over the satellite broadcast channel. Typically, the size of an EMM is about dozens of bytes. If tens of thousands of new users are trying to activate their devices in a short period of time, then the bandwidth required for the transmission of the EMMs for these new devices may not be available in a satellite broadcast channel. As a result, some of these users may experience service activation delay or failure.

For a service operator with access to converged networks, such circumstance could be avoided by offloading the EMM transmission to the cellular communication network. The architecture of the multimedia system with flexible EMM transmission is illustrated in Figure 12, where the scrambled data and ECMs are transmitted over satellite broadcast channel and the EMMs are transmitted over cellular communication networks.



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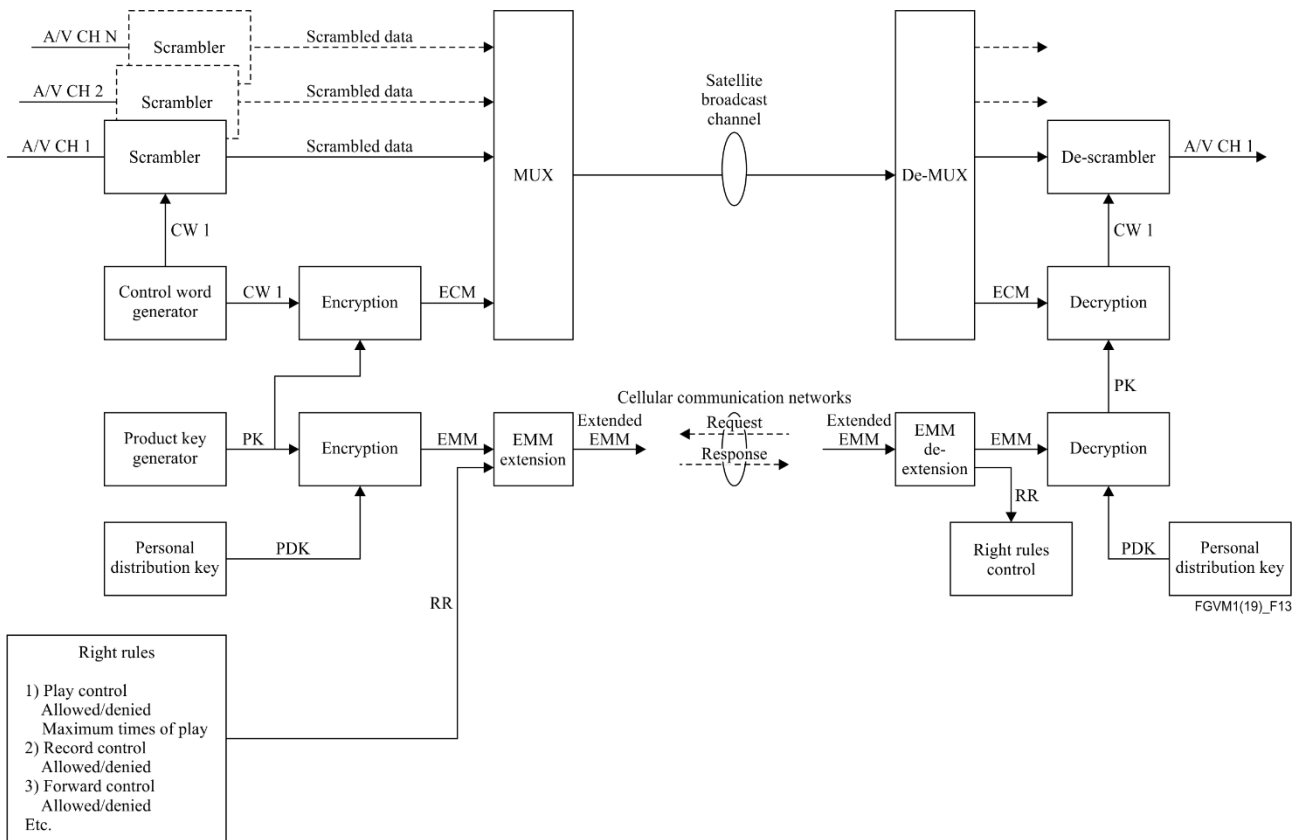
**Figure 12 – Diagram of the multimedia system with flexible EMM transmission**

### 10.2.2 Use case B

Bearing in mind that the conventional conditional access system could support simple access control at terminals, i.e., the play of multimedia streams can be either allowed or denied at a terminal. However, for vehicle multimedia service operator, more rights control options shall be available. The following should be noted for a live television programme:

- 1) the reception of this live television program should be controlled (i.e., allowed or denied);
- 2) the recording and local storage of this live television program should be controlled (i.e., allowed or denied);
- 3) if the recording and local storage of this live television program is allowed, then a maximum number of plays of the recorded video can be set;
- 4) the forwarding of this live television program to other nomadic devices in vehicle should be controlled (i.e., allowed or denied).

To support the above rights control options, rules shall be delivered from the head end to the terminals. For each terminal, specific rights rules may be applied. For example, specific to each terminal, the rights rules can be delivered together with the EMM over the cellular communication networks. A diagram of the multimedia system with extended EMM to support more rights control options is shown in Figure 13, where the scrambled data and ECMs are transmitted over satellite broadcast channel and the extended EMMs are transmitted over cellular communication networks. Note that this is a general framework and the specific scheme to achieve rights rule control at terminals is an implementation issue.



**Figure 13 – Diagram of the multimedia system with extended EMM to support more rights control options**

### 10.3 Gap analysis

At present, multimedia information service is mainly based on either the unidirectional network or bidirectional networks.

For multimedia information system based on unidirectional networks, the following conventional CA schemes can be applied to provide simple access control at terminals. Two major drawbacks for such systems have been analysed in clause 10.2.

- 1) ETSI Standard: Support for use of scrambling and Conditional Access (CA) within digital broadcasting systems ETSI ETR 289 ed.1 (1996-10) [ETSI ETR 289]
- 2) ATSC Standard: Conditional Access System for Terrestrial Broadcast (A/70 Part 1:2010) [ATSC]
- 3) China's Radio and television industry standard: Specification of Conditional Access System for Digital Television Broadcasting GY/Z 175-2001 [CN-CAS]

For multimedia information system based on bi-directional networks, the following conventional digital rights management (DRM) schemes can be applied. A major drawback of such schemes is that they cannot be seamlessly integrated with conventional conditional access schemes. Nevertheless, the concept of rights rules in these DRM schemes can be used to enhance the conventional CA schemes.

- 1) Open Mobile Alliance: OMA Digital rights management (DRM) [OMA DRM]
- 2) ChinaDRM: Technical specification of digital rights management for internet television, GY/Z 277-2014 [ChinaDRM]

### 10.4 Content rights protection requirements for CA

The requirements for the content rights protection in converged networks are as follows.

- R1: Conventional conditional access schemes for unidirectional networks may be supported.
- R2: Entitlement management messages in conventional CA schemes may be delivered over bidirectional networks.
- a) A CA agent on the VMS should support transmitting a request of its EMM to the head-end.
  - b) The head-end should support transmitting a response with the EMM to a terminal.
  - c) The head-end may push the EMM to a VMS without being requested.
- R3: Rights rules for a terminal may be transmitted along with the EMM to the terminal.
- R4: Rights rules for a terminal may be transmitted in an independent message to the terminal.
- R5: The integrity of rights rules for a terminal shall be guaranteed during its transmission from the head-end to the terminal.
- R6: The rights control options shall be extensible for additional rules to be added in the future.

## **11 Copyright and rights management support for content delivery**

### **11.1 Content payment and copyright protection use case**

For some content providers the in-vehicle-screen and mobile phones are two different distribution channels with different service cost and price offering. The price for an end-user to receive content in a vehicle can be different on a mobile phone than on the in-vehicle-screen. Sometimes the end-user should pay again to enjoy the same content in a vehicle while the content was already paid for by mobile phone consumption. Alternatively, a content provider may allow its users to enjoy the same content freely in vehicle if users have a paid content subscription for mobile phone consumption.

These different commercial policies across distribution channels should be enabled by the VMN and VMS. The VMN should enable content providers to manage content-services-fee-payment across distribution channels.

#### **11.1.1 Copy protection requirements**

R1: The design of the VMS should be capable of preventing multi-media contents distributed to the VMS from being copied from the VMS to mobile phones and/or be redistributed through the VMS hardware to external devices.

NOTE – This does not include the possibility that users record screens with other recording devices.

### **11.2 Privilege and account management**

#### **11.2.1 Use cases**

##### **11.2.1.1 Use case A**

Parental control may be enabled for children or teenager passengers to prevent access to restricted content.

An identification (ID) system (e.g., traditional ID such as mobile phone number or biometric technology ID such as face or voice recognition) and corresponding database may be necessary to carry out parental control. The passenger may be identified as either an adult or a child.

##### **11.2.1.2 Use case B**

To enable content and services rights management, identifying content classification may be necessary to replicate common practice for multi-media content on other channels (e.g., movies in theatre versus DVD). Content and services can be classified into different categories, based on age or subscription status.

### 11.2.1.3 Use case C

Depending on different business models, content and service privilege management may differ.

An original equipment manufacturer (OEM) vehicle maker may have a business agreement with a content or service provider. The OEM vehicle maker has paid for the subscription fee for its customers. The vehicle owner, upon acquiring the vehicle can receive the content subscription for personal use, but only in this very vehicle. In this situation, privilege management is based on hardware identification, as the objective of the OEM vehicle maker by paying for the subscription is to sell more vehicles by offering such services and entertainment content privilege.

### 11.2.1.4 Use case D

In the car sharing industry, several different business models leads to differing requirements for the VMS. One vehicle will welcome many different passengers per day. There are two categories of companies in the car sharing industry:

Category A,

Rental companies who provide only vehicles without drivers may pay content/service subscriptions for their customer as a strategy to enhance their market competitive strength. In that situation, the subscription may be associated to a *vehicle hardware identifier*. In addition, such rental company can also allow users to log into their own third-party content providers accounts to guarantee a similar user experience on the rental car, consistent with the one on a user's own private vehicle.

Category B,

For taxi companies, who are not only providing vehicles but also drivers, the number of customers is higher than for companies in category A. It can be very difficult to satisfy all passengers by a content/service subscription tied to the vehicle hardware as it may be impossible to predict what kind of music the next passenger may enjoy or desire to hear. For these companies, a better system may be to enable access to cloud-based content/service by each customer based on a *user identifier*.

Independently of which taxi a user is sitting in, as long as the user logs into his or her account, the user can immediately enjoy the same services and the same user-experience in different vehicles. The VMS will retrieve the user history, default recommendations, and other user-specific data from the system.

### 11.2.1.5 Use case E

Hardware and/or software suppliers may pre-load content made by themselves into vehicles (local media content). User's privilege management for local media content could differ from third party's online media content.

### 11.2.1.6 Example of mapping of different ID system

Figure 14 is an example illustrating how two ID systems (User ID and IVI/hardware ID) can be used concurrently to provide a multimedia service.

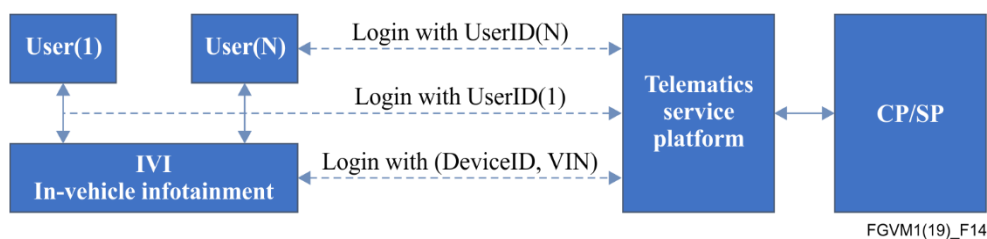


Figure 14 – ID systems

For devices, "Device ID" or "Vehicle Identification" (such as a VIN code) or other identifiers may be used to log into OEM vehicle maker management platforms (e.g., telematics service platform).

For end users, "User ID" may be used to access services and to obtain personalized content and recommendations.

NOTE – Privacy and regulatory aspects will need to be taken in account when selecting specific ID mechanisms.

## **11.2.2 Requirements**

### **11.2.2.1 Privilege management requirements**

R1: VMN should protect and manage all content copying on the platform.

R2: User classification (e.g., based on age) and content classification is needed to carry out multi-media service privilege management.

R3: VMN should support parental control function.

R4: VMN may support an ID system and corresponding database to enable content rights and privilege management and to provide customized services.

Example of user-ID may comprise mobile phone number and/or biometric (e.g., face recognition, voice recognition, or finger-print information, etc.).

R5: VMS should be able to apply privilege management to preloaded content associated with VMS hardware. When restrictions apply, the VMS should prevent copying the preloaded content to other devices.

NOTE – As long as there is a local record of a subscription on the VMS, user can enjoy the privilege in that vehicle.

### **11.2.2.2 Account management requirements**

R1: The personalization of the multimedia portal should be enabled by the VMN account management system.

R2: The VMS should support multiple users to login concurrently in the same vehicle with different user IDs for personalization purposes.

R3: After logging in with different IDs, the displays of VMS for different users may be personalized, including greetings, interfaces and services.

R4: If one user logs into different vehicles with the same user ID, then the VMS may support retrieving and displaying the user personalized interfaces and recommended contents to ensure a consistent user experience across VMS enabled vehicles.

R5: The VMS should be capable of matching a vehicle hardware ID (such as key fobs or biometrics based ID system) with user IDs to enable access to third party services (e.g., content provider or services provider). VMS should be able to access IDs available locally and in the cloud.

## **11.3 Payment services in shared vehicle**

### **11.3.1 Use case: Time shared vehicle**

Passengers of a time-shared vehicle in exclusive use (drivers and/or passengers, no additional passengers will be picked-up during the journey) are identified (for example by facial recognition, fingerprint, iris scan, RFID in personal ID card, etc.) when entering the vehicle and then identified at each individual seat by the VMS. These passengers have deposited their payment preferences in the cloud. The payment of services and goods like parking, fuel, charging of the EV, food at a drive-in, and usage fees for a shared vehicle will be executed after confirmation through the VMS based on person identification and payment preferences.

For multi-passengers in a shared vehicle the person who has initiated the process, e.g., parking, charging, refueling, drive-in will be asked by the VMS if he wants to pay individually or if he would

like to share costs with the other passengers. In case this person wants to share costs the VMS dispatches messages to the individual VMS's of the other passengers asking confirmation of the other passengers for participation in the payment. These passengers confirm or deny the payment at their individual VMS within the vehicle using, e.g., touch screens, voice, mobile phone confirmation or other available means (like scanning RFID identification card, replying to keyword challenge they have previously established).

### **11.3.2 Proposed requirements**

R1: VMS may have access to different cloud platforms in which the different users have deposited their personal and payment data. In case user has no payment profile VMS should support payment through credit card.

R2: The VMS shall be able to dispatch VMS messages and processes to individual VMS terminals within the vehicle

R3: VMS should be able to connect to user personal mobile phone for personal information, communication, and confirmation in case vehicle would not be equipped at all seats with displays and vehicle VMS interfaces.

## **12 Security**

### **12.1 User data protection**

Use case:

As vehicles become connected and offer more interactive services, more user data and privacy-related information (such as users viewing preferences and habits) could be generated and stored in the VM system (vehicle) and in the VM service (cloud/servers). The user data and privacy-related information should not be transmitted between systems without user consent. Therefore, the protection of user data becomes an important consideration in the performance and security evaluation of vehicle multimedia systems.

The system should guarantee that the user data cannot be given to third parties without explicit authorization from the user.

Requirement:

R1: The in-vehicle multimedia platform should provide end-to-end data protection to ensure confidentiality and integrity of user data, including data protection at rest in local terminals, during transmission over different channels and when processed at the cloud platform.

### **12.2 VMN application security**

A VMN application should not bring additional risks within the vehicle and should not be tampered with or corrupted.

Requirements:

R1: A VMN application should be signed

R2: The VMS should be able to verify the signature of the VMN application prior to allowing access to APIs (e.g., communication APIs)

### **12.3 VMS security**

Use case:

Due to increasing system complexity, software error or software fault may exist in VMS, which may cause crashes.

NOTE – Also add text/use case for reset/wipe.

Requirement:

R1: The vehicular multimedia systems shall be segregated from other vehicular control systems to avoid the failure and system fault of the whole vehicle systems. The vehicular multimedia systems should also provide physical or logical access controls for the isolation of sensitive applications, application data, or systems.

R2: It shall be possible to wipe all the data (application, content and data) on the VMS to return the VMS to its factory settings.

R3: It shall be possible to wipe a subset of the data on the VMS.

R4: The wipe shall be able to be performed by the VMNS service provider, the end-user or the VMS manufacturer.

## **13 Safety**

### **13.1 Driving safety: Speed control**

Use case:

Before L4 and L5 autonomous vehicle are commercialized, consuming audio and video content in vehicles will easily be a cause for driver's distraction. In accordance with local regulation, when the vehicle speed reaches a certain threshold (it differs based on local regulation, for instance from 0 kilometer to 15 kilometers per hour), the VMS shall automatically block entertainment content on the driver-side display. Speed control is a common practice already in use in countries around the world.

Requirement:

R1: In accordance with local regulation, when the vehicle speed is above a given threshold, the VMS shall be able to automatically block entertainment content on the driver-side display.

## **14 Requirement for defining vehicular multimedia profiles**

As smart connected vehicles are more broadly available, vehicular multimedia services are becoming richer and more complex than before. Vehicular multimedia profiles for smart connected vehicle could be used to manufacture and qualify vehicles accordingly. Customers can know which multimedia capabilities his/her vehicle multimedia offers.

### **14.1 Use case**

Currently, when customers choose a vehicle to acquire, the vendor of the vehicle generally provides them with a limited configure sheet which may not have detailed information on the multimedia capability of the vehicle (e.g., FM/CD/DVD and some other storage disk such as USB disk/SD card/TF card). With the specification of VMS, and the deployment of smart connected vehicle/autonomous driving/ADAS, vehicular multimedia system (VMS) profiles should be defined and include network connectivity, media display, HMI controls, PII protection and security capabilities.

1) Networks connectivity capabilities:

VMS profiles should support one or more of the following:

- 3G/4G/5G/ cellular networks.
- Low earth orbit bi-directional communication networks (e.g., Starlink, Oneweb, HongYan, Hong Yun).
- Satellites broadcast (e.g., L Band Broadcast).
- Satellites bi-directional communications (e.g., TIAN TONG No.1 Satellite).



- Short range networks such as WLAN or Wi-Fi.
  - Terrestrial broadcast networks (e.g., FM, DAB, HD Radio, CDR, DTMB).
  - V2V and V2I networks (e.g., DSRC/LTE-V/5G PC5).
  - Brought-in, Built-in and Hybrid connectivity.
- 2) Media display and media format capabilities:  
VMS profile should support one or more of:
- Text.
  - Image.
  - Audio: Normal audio and high fidelity audio.
  - Video: Normal video, 4K/8K Video, AR and VR.
  - Holographic projection and image.
- 3) HMI control capabilities  
VMS profiles should support one or more of the following:
- Button
  - Touch screen
  - Intelligent control (speech control/gesture control/eye movement control)
- 4) Personally identifying information protection capabilities
- 5) Security capabilities.

## 14.2 Proposed profiles requirements

The above five capabilities may be considered as the main aspects to define a set of VMS profiles.

Moreover, different regions for the above aspects should be taken into consideration. The profiles should allow for geographic flexibilities to adapt to the regulatory requirements of different countries.

NOTE – Profiles may apply differently to public and private vehicle and to different levels of vehicle autonomous capabilities [SAE J3016].

## 15 Vehicle domain service

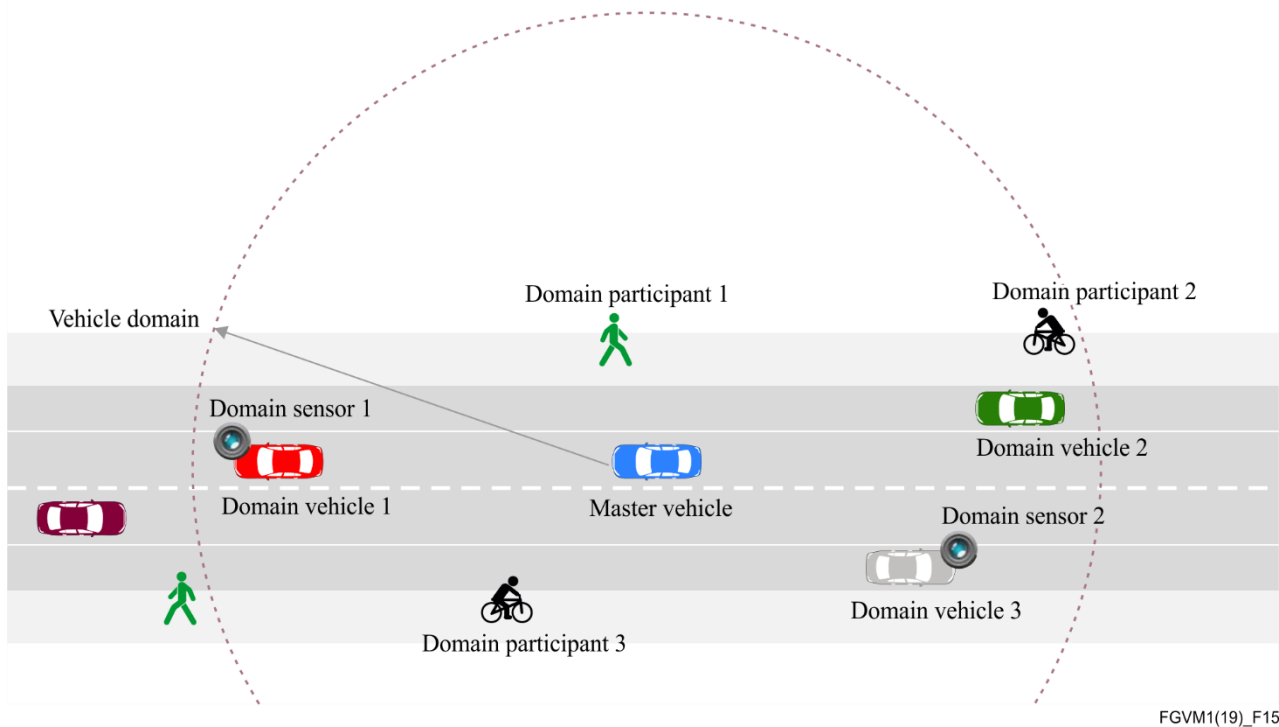
### 15.1 General

Autonomous vehicles and high intelligent driver support system will digitize whole information around the vehicle. Plenty of data from sensors or lidar, meta data provided by image recognition of motion pictures taken by cameras installed outside vehicle are integrated with communication data from neighbouring traffic participants around the vehicle in order to generate local map information surrounding the vehicle.

[ISO 23239], vehicle domain service will introduce such an information and recognition platform applied to autonomous vehicles and intelligent driver support systems. The basic definition of vehicle domain service is the service application provided vehicle server implemented in a vehicle. It will be applied in the area surrounding the vehicle named as vehicle domain, as the service connection between domain master (server) vehicle and domain actors, such as vehicles, participants represents other traffic participants and sensors, equipped with domain vehicles or participants but defined as different network nodes who report information acquired by sensors. Basic service will be exchanged by communication between master vehicle and domain actors.

The basic service of the vehicle domain system (VDS) consists of one master vehicle and one domain actor, and most simple structure with minimum elements. It is not restricted by driving speed, so stopping situation under home area will be possible. Typical and valuable service is generating high

definition map including traffic-moving bodies surrounding the master vehicle with driving speed. This is known as 'vehicle domain dynamic map service', the most important use case of VDS.



**Figure 15 – Vehicle domain dynamic map service**

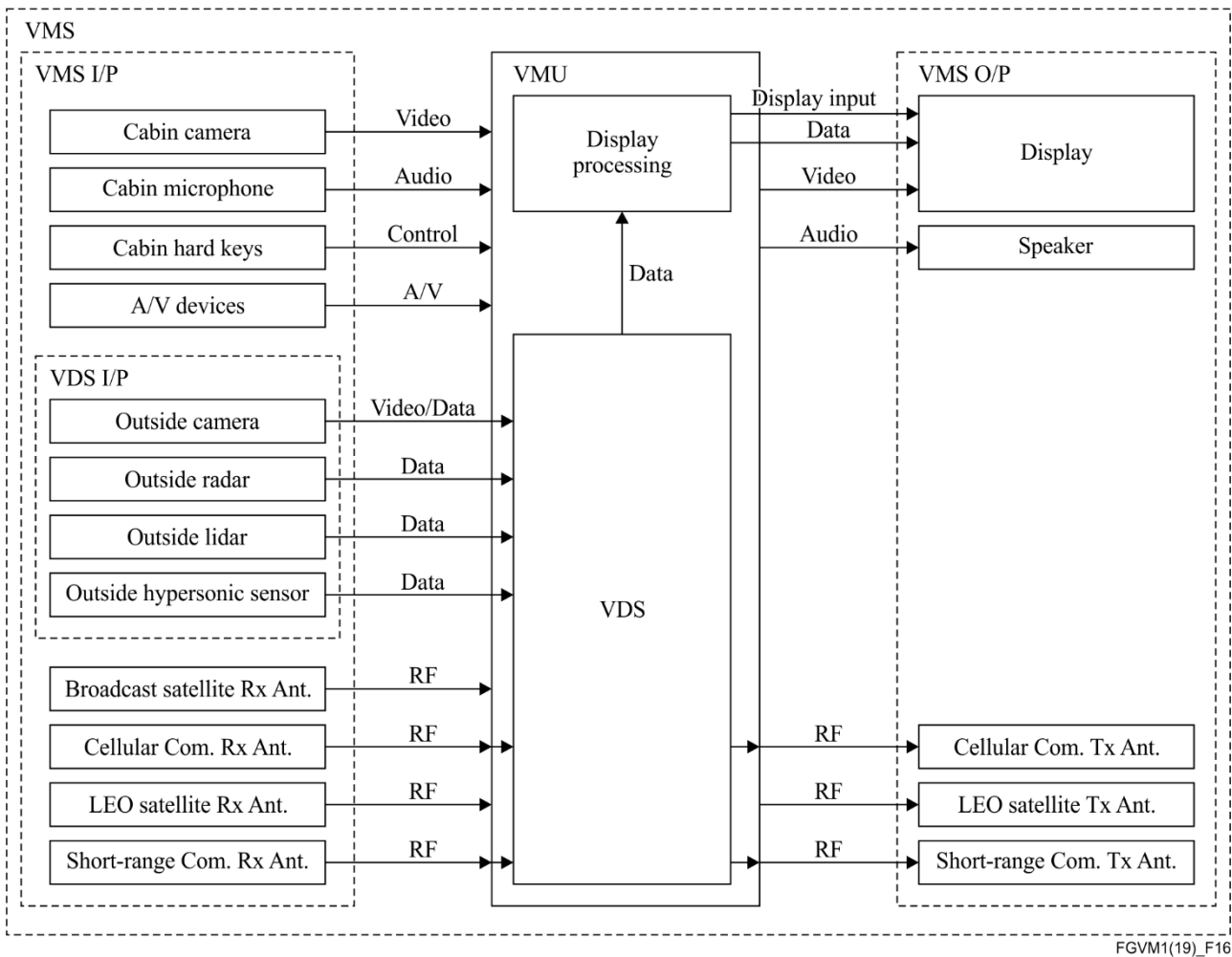
This use case is carefully distinguished from the typical use case definition of vehicle multimedia service defined in this document. Figure 15 of vehicle domain dynamic map (VDDMS) shows the different group of use case, intended to use VDS. VDDMS includes multiple inputs from outside sensors and cameras, other information provided by communication network, so it will provide another group of use case, intended to use vehicle multimedia service.

## 15.2 Use case of vehicle domain service on vehicle multimedia service

Typical vehicle domain dynamic map service collects sensor and communication data provided by sensors outside a vehicle and communication network. Information media, such as sensors and network channel could be shared between VDS and VMS, but some of dedicated information for VDS will be sent directly only to VDS. VDDMS, vehicle domain dynamic map service will generate dynamic traffic information based on high definition map around the master vehicle and send it inside vehicle human machine interactive interface. Translation should be communized by VDS and VMS as a unique interface to the driver.

Use case: VDS on VMS

Figure 16 shows the typical input/output model of the vehicle domain service integrated with that of the vehicle multimedia service. The basic reference model of VMS is defined in Figure 2 of this document.



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**Figure 16 – A reference model for data input/output of the VDS on VMS**

VDS is one of the network service provided by the master vehicle, so basic input/output of VDS are network communication channels such as cellular or short-range networks. VDDMS will generate high definition map from VDS specific signals of lidar, radar and sensors via recognized meta data objects. Motion pictures provided by vehicle outside cameras will also generate meta data of foreign objects around the master vehicle. Those meta data will be integrated as high definition map in VDS functional module.

Network communication channels connected to VDS will be shared with VMS in order to exchange other kind of communication network services. Motion pictures acquired by cameras outside the vehicle are also shared similar to the vehicle outside/surrounding monitor service of VMS.

VDDMS will have some user interactive functions, such as traffic information monitor, warning message about closing or dangerous traffic objects and interactive messaging service between driver in the master vehicle and domain vehicles, participants of surrounding traffic participants. Driver condition monitoring by vehicle cabin camera could be optional for other kind of VDS services. These interactive human machine interface (HMI) services with the driver will be basically provided by VMS and VDS that will utilize these VMS service connecting to VMS.

As explained in clause 6, Figure 2 of the VMS input/output reference model, VDS function indicated in Figure 16 never shows a single physical unit. It is located in the VMS function in the figure, but its function is independently implemented from VMS functions. VDS shares some inputs/outputs with VMS and uses the interactive HMI service of the VMS. So it is defined in this document that VDS function will be implemented on the multimedia network platform of VMS.

### **15.3 Requirements of VDS use case in relation with VMS**

This clause will provide use case requirements about VDS, focusing VDDMS on VMS. Relevant use case definition and detailed explanation are given in clause 14.2.

Requirement: VDS on VMS

VVR1: The VMS may be designed to support VDS function.

VVR2: If the VDS is implemented with VMS, network communication channels and connection shall be accessible to both the VMS and VDS.

NOTE 1 – VMS and VDS will share with only lower layers of communication channel.

VVR3: If the VDS is implemented with VMS, raw data from external cameras of the vehicle and sensors shall be accessible by VMS and VDS independently.

NOTE 2 – Low level motion picture data input to VDS will be treated by image recognition engine to convert lighter Meta data of traffic objects.

VVR4: The VMS may provide interactive HMI with driver to the VDS, especially to VDDMS.

VVR5: If VDS is implemented with VMS, the VMS and VDS shall keep real time quality between interactive HMI and real surrounding traffic condition.

NOTE 3 – It is important for VMS and VDS to give good synchronization between their displayed contents of VDDMS and real traffic condition around the vehicle.

VVR6: If VDS is implemented with VMS, good synchronization between VDDMS graphic contents displayed by VMS and surrounding real traffic condition shall be defined as delay time between them.

NOTE 4 – The criteria of delay time depends on other requirements.

## Annex A

### VDS requirements

NOTE – The VDS requirements proposed in this section are similar to the requirement in [ISO 23239], and will be replaced by a reference once [ISO 23239] is published.

#### A.1 Background

Autonomous vehicles and high intelligent driver support system will digitize the entire information related to the vehicle. A lot of data from sensors, lidar and image recognition of motion pictures taken by cameras installed in a vehicle are integrated with communication data from neighbouring traffic participants around the vehicle to generate local map information surrounding the vehicle.

[ISO 23239], vehicle domain service will introduce such an information and recognition platform applied to autonomous vehicles and intelligent driver support systems. It will gather and integrate multimedia sensor and communication data to generate driving status of map information. It will be shared with neighbouring traffic participants and reported to central integrated vehicle dynamic map server.

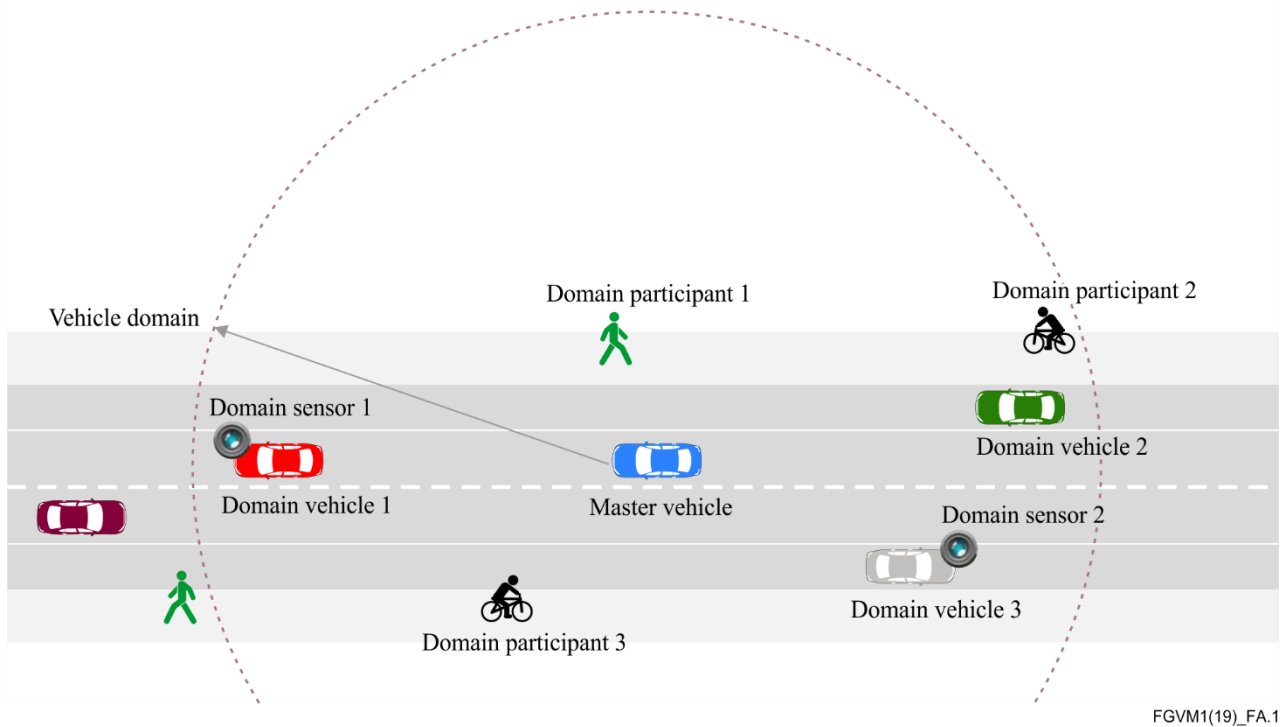
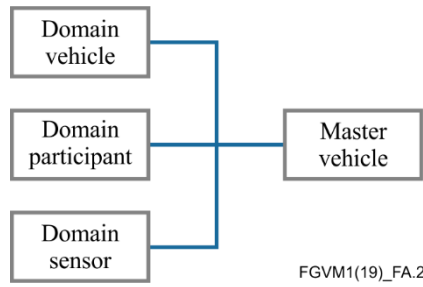


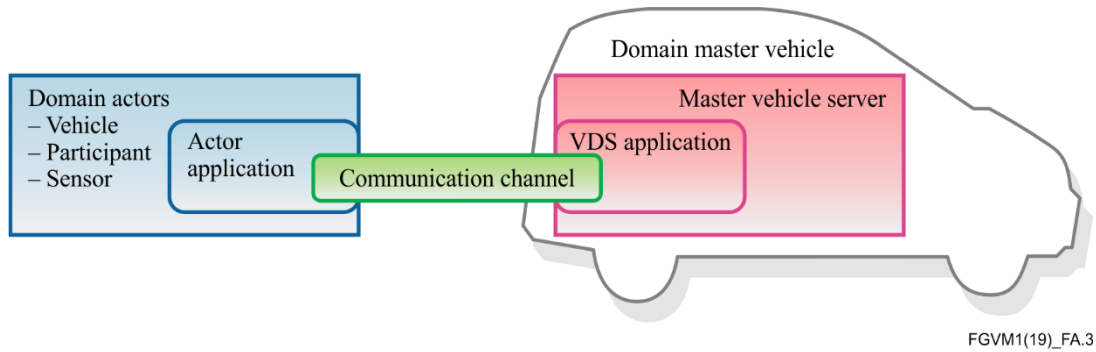
Figure A.1 – Vehicle domain dynamic map

In order to collect the necessary information, the vehicle with VDS will use communication with domain actors. There are various types of domain actors, but their communication interfaces are unified.



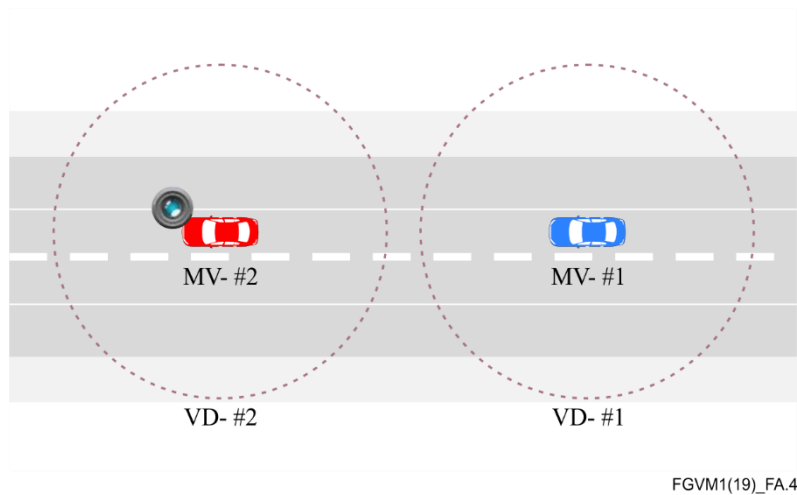
**Figure A.2 – Unified communication interface of VDS**

In order to provide secure and safe communication, necessary schema will be applied.



**Figure A.3 – Communication channel of VDS**

In order to utilize the generated map efficiently, it is necessary that it is reported to neighbouring vehicles and data collecting server of vehicle dynamic map and shared with other domain actors.



**Figure A.4 – Reporting & sharing of VDDM**

## A.2 Proposed requirements

If the vehicle is implemented with vehicle domain dynamic map (VDDM), the following requirements shall be applied.

VDDM-1: If the vehicle uses VDDM, it shall consist of dynamic traffic information and static road situation surrounding the vehicle.

VDDM-2: The static road situation part of VDDM shall consist of the temporary situation part and the permanent status part.

NOTE 1 – The permanent status part of VDDM consists of detailed features and figures of road, similar structure and properties to those of high definition map.

VDDM-3: The dynamic traffic information part of VDDM shall consist of traffic participants part and traffic control status part.

NOTE 2 – Traffic participants includes vehicles, bikes, walkers and all other traffic movable bodies.

NOTE 3 – Traffic control status includes signals, priority lane, access control and all other controlled traffic status on the road.

VDDM-4: If the vehicle generates VDDM, the vehicle shall collect the necessary information by communicating with surrounding domain actors and scanning result of equipped sensors.

NOTE 4 – Domain actors are traffic participants, such as vehicles, bikes, walkers and other movable bodies on the road.

VDDM-5: If the vehicle generates VDDM, the vehicle shall collect the necessary information by communication from both domain actors and scanning results from domain sensors.

NOTE 5 – Domain sensor is one of the domain actors such as the vehicle equipped with sensors scanning surrounding traffic situation, which reports sensor output.

VDDM-6: If the vehicle generates VDDM, the static road situation part shall be generated from sensor output or a combination of sensor output and downloaded high definition map.

NOTE 6 – High definition map only defines the permanent status of the road.

NOTE 7 – The temporary situation part of static road situation is given by sensor output.

VDDM-7: If the vehicle is applied with VDDM, the master vehicle shall report the generated VDDM to other domain actors and VDDM collecting servers.

NOTE 8 – The format of the report and its communication interfaces are unified between domain actors and data collecting servers.

NOTE 9 – Sending and receiving of the VDDM report is performed in aligning to VDS communication requirements.

NOTE 10 – The format of the report may contain multiple sensor data which can be sent in a compressed format to reduce bandwidth consumption. ISO/IEC 23090-9 compresses point cloud scene/maps.

VDDM-8: If the vehicle is applied with VDDM, the master vehicle shall share the received VDDM report and utilize it as the basis of the next generation of VDDM.

NOTE 11 – Details of sharing method are addressed to ISO 23239 series documents.

[ISO 23239] is drafted in ISO TC 22/SC 31/WG 8. It will be harmonized with ITU-T SG16.

If the vehicle communicates with domain actors for applying vehicle domain service (VDS), the following requirements shall be applied.

VDS-1: If the vehicle uses VDS, it shall communicate with surrounding domain actors of various types in order to collect information.

NOTE 12 – Basic types of domain actors are domain vehicle, domain participant and domain sensor.

NOTE 13 – Domain vehicle includes various types of road vehicles such as consumer (driving) vehicle, taxi, sharing car, logistics trucks, public bus and tram.

VDS-2: The communication interface such as messages, protocols, data link layer and physical layer shall be unified for the various types of domain actors.

For the minimum treatment to integrate a lot of responses from various actors, unified message format definition and sequences are important features.

NOTE 14 – Different data container is required for each type of actor in order to treat various responses with the same message format.

VDS-3: If the vehicle uses VDS, the appropriate security at the right level shall be applied on the communication channel among VDS.

NOTE 15 – Part of the latest security specifications used in Internet communication will be enough for VDS communication.

VDS-4: Privacy relevant and personal traceable information shall be contained in VDS messages.

NOTE 16 – Personal private information might be managed in totally separate methods and location from VDS in order to respond to supervised requests such as government or police level.

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