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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Use cases and requirements for vehicular multimedia networks

Recommendation ITU-T F.749.3

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Recommendation ITU-T F.749.3

Use cases and requirements for vehicular multimedia networks

Summary

Recommendation ITU-T F.749.3 specifies use cases and requirements for vehicular multimedia networks (VMN), including an overview, connectivity, intelligent human machine interfaces (HMI) for the vehicle multimedia system (VMS), privacy considerations, content rights protection in a converged network environment, copyright and rights management support for content delivery, security, safety, and definitions of vehicular multimedia configurations.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.749.3	2020-08-13	16	11.1002/1000/14330

Keywords

Copyright, human machine interface, network convergence transmission, privacy, safety, security, vehicular multimedia.

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FOREWORD

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Use cases and requirements for vehicular multimedia networks

1   Scope

This Recommendation describes the use-cases and requirements for vehicular multimedia networks (VMN), 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.

2   References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-R BT.2055-1]   Recommendation ITU-R BT.2055-1 (2018), *Content elements in multimedia broadcasting systems for mobile reception.*

[SAE J3016]   SAE, Standard J3016 (2018), *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.*

3   Definitions

3.1   Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1   vehicle gateway (VG) [b-ITU-T F.749.1]: A VG is a device in a vehicle that enables communications between a device in the vehicle and another device which may be physically located either inside the vehicle or outside the vehicle (e.g., roadside station, cloud-based server, etc.). A VG provides standardized interfaces and protocols, communications across heterogeneous networks, optimized network selection based on application needs and network QoS, arbitration and integration of network communications, security and switching network connections to maintain service continuity.

3.1.2   vehicle gateway platform (VGP) [b-ITU-T F.749.1]: A VGP is the collection of ICT hardware and software in a vehicle operating as an open platform to provide an integrated runtime environment for delivering the communications services of a VG. A VGP may also provide higher layer communications services such as interaction with the driver through the driver-vehicle access services and so on. Subsystems dedicated solely to vehicle operation are not considered part of the VGP. Supported applications/services include ITS and infotainment.

3.1.3   telematics [b-ISO 15638-1]: Telematics is the use of wireless media to obtain and transmit (data) from a distant source.

3.2   Terms defined in this Recommendation

This Recommendation defines the following terms:

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

3.2.2   vehicular multimedia service platform (VMSP): The VMSP is a platform in the cloud that enables the multimedia service for end-user(s) in the vehicle.

3.2.3   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).

3.2.4   VMN services (VMNS): The VMNS are the vehicular multimedia services provided by the VMSP to the end-user(s) in the vehicle.

3.2.5   VMN application: The VMN application uses the underlying vehicle multimedia system (VMS) capabilities to consume and present VMN services (VMNS) to end-user(s) in the vehicle.

3.2.6   in vehicle infotainment (IVI) service: The IVI service is a service that provides both information and/or entertainment for the end-user(s) in the vehicle.

3.2.7   network convergence transmission: Network convergence transmission is an intelligent transmission technique used by the vehicular multimedia service platform (VMSP) to efficiently and timely deliver the VMN services (VMNS) data to the vehicle multimedia system (VMS) via broadcasting and communication networks.

3.2.8   vehicle-onboard processing: Vehicle-onboard processing is the signal processing of the vehicle multimedia system (VMS), which includes the reception, consumption, and redistribution of VMN services (VMNS) data in the vehicle.

4   Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms.

ADAS	Advanced Driver Assistance System
AEC	Acoustic Echo Cancelation
AM	Amplitude Modulation
APP	Application
AR	Augmented Reality
BCM	Body Control Module
CA	Conditional Access
CDR	China Digital Radio
CW	Control Word
DAB	Digital Audio Broadcast
DRM	Digital Rights Management
DTMB	Digital Terrestrial Multimedia Broadcast
DVB	Digital Video Broadcasting
DVR	Digital Video Recorder
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
ITS	Intelligent Transport System
IVI	In Vehicle Infotainment
KWS	Keyword Spotter
LCD	Liquid Crystal Display
LEO	Low Earth Orbit (Satellite)
LIDAR	Light Detection and Ranging
MMS	Multimedia Messaging Service
OEM	Original Equipment Manufacturer
OLED	Organic Light Emitting Diode
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
SMS	Short Message Service
T-Box	Telematics System
TM-Box	Telematics Multimedia System
TS	Transport Stream
USB	Universal Serial Bus
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
VR	Virtual Reality
WLAN	Wireless Local Area Network
WG	Working Group
ZIC	Zone Interference Cancelation

5 Conventions

In this Recommendation:

– The keywords "shall" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

– The keywords "should" or "may" indicate an optional requirement which is permissible. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the vendor. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

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, broadcast and communication networks, and the vehicle multimedia system (VMS) in the vehicle.
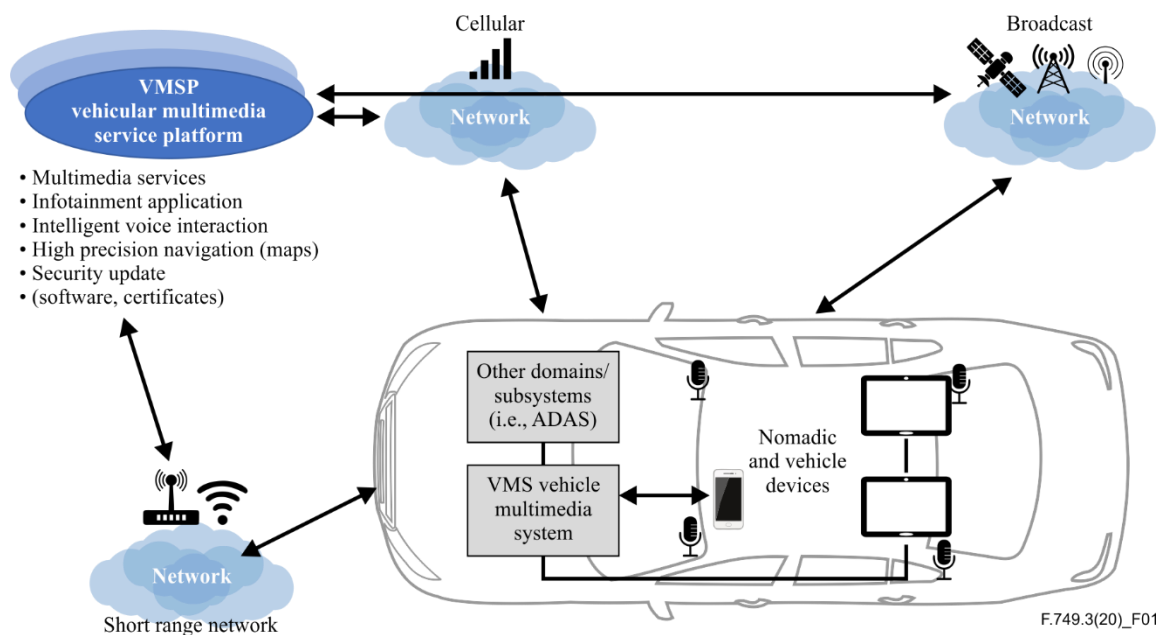

Figure 1 – Vehicular multimedia networks

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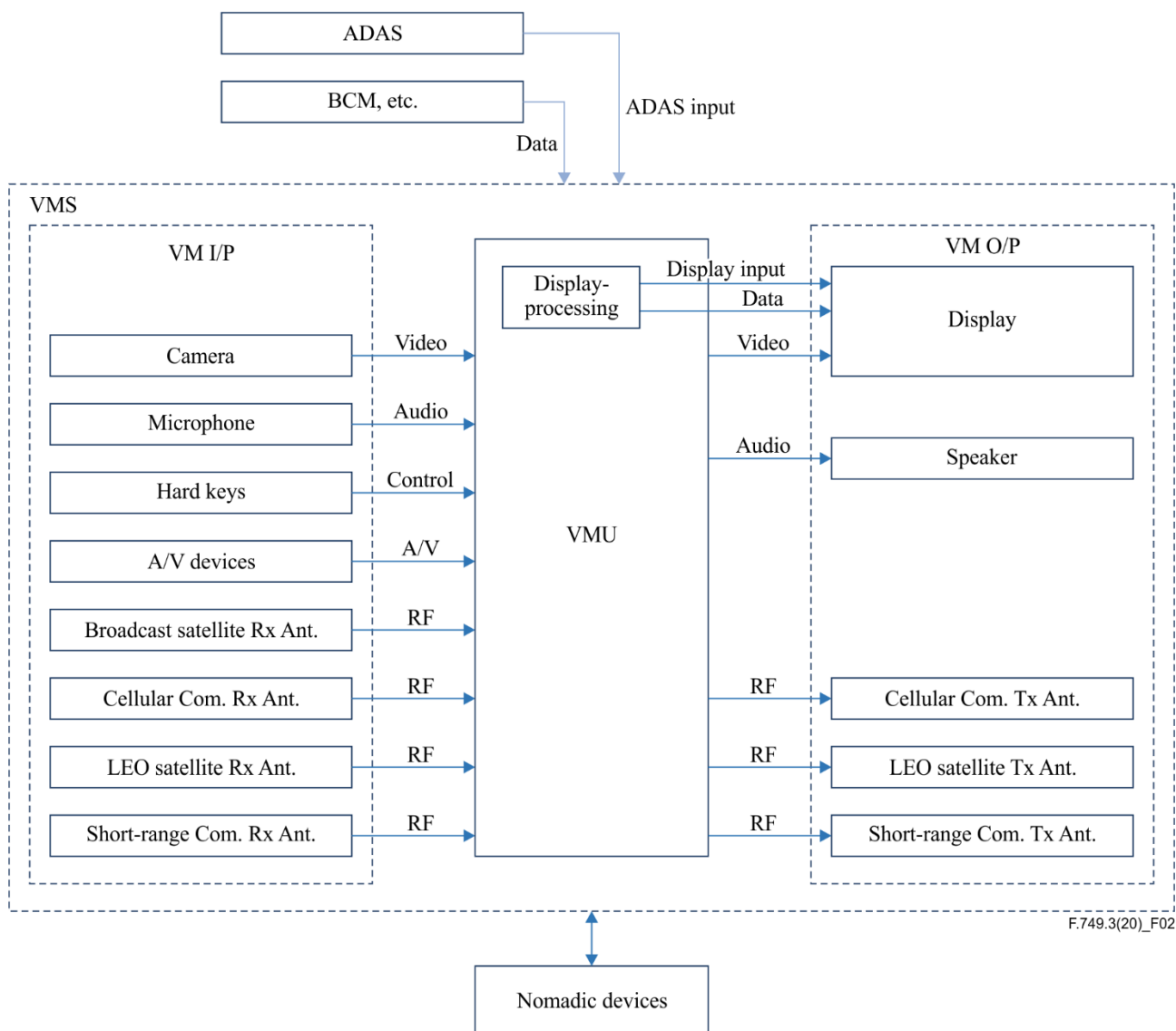
Figure 2 – A reference model for data input/output of the vehicle multimedia system

System inputs may include audio and video signals from camera, microphone and audio/video devices such as universal serial bus (USB) devices, SD-cards, CD/DVD/Blu-ray and Aux-In, control signals from hard keys, and radio frequency (RF) signals from reception antennas. Connectivity functions and the related recommendations for intelligent transport systems have been discussed in [b-ITU-T Q27/16] and may be reused for the connectivity in vehicle multimedia systems e.g., [b-ITU-T F.749.1], [b-ITU-T F.749.2], [b-ITU-T H.550] and [b-ITU-T H.560].

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), or (c) any other integrated solutions customized by automotive manufacturers such as a HUT.

Note that a T-box alone that is compatible with [b-ITU-T F.749.2] does 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.
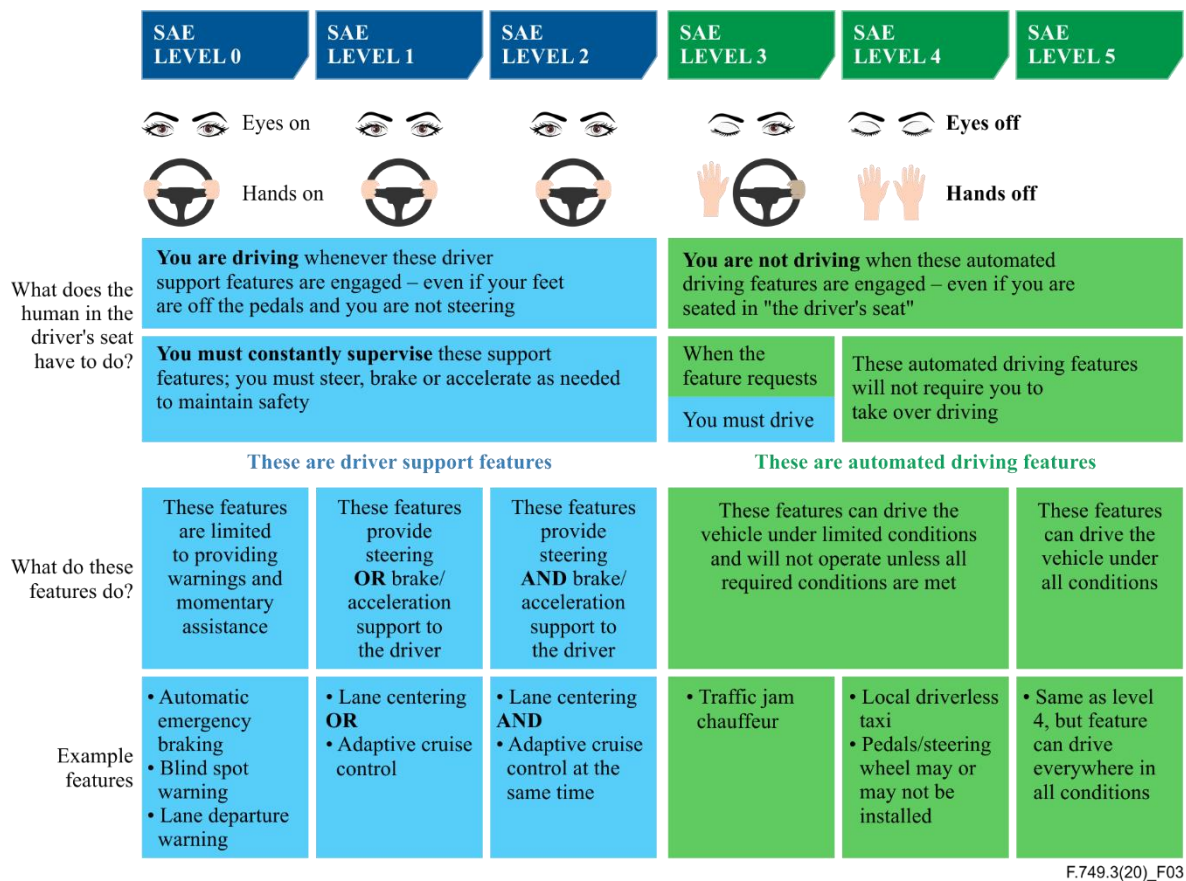
Figure 3 – SAE J3016 definition of driving levels

(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 breaking or lane keeping. However, at no time will the vehicle 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 the 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 takes 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 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

Figure 4 matches generic use cases and services 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 cases	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	X	X	X	X	X	X	X	X	X	X	X	X
Use video, TV and gaming services		X		X		X		X	X	X	X	X
Use mobile devices		X		X		X	(X)	X	X	X	X	X
Use mobile devices through VMS	X	X	X	X	X	X	X	X	X	X	X	X
Phone conferencing (handsfree)	X	X	X	X	X	X	X	X	X	X	X	X
Videoconferencing		X		X		X		X	X	X	X	X
Reading in vehicle (books, mails, news, etc.)		X		X		X		X	X	X	X	X
Getting read content (text-to-speech)	X	X	X	X	X	X	X	X	X	X	X	X
Working in vehicle (office applications)		X		X		X		X	X	X	X	X

X = Allowed
(X) = Partly allowed (in autonomous driving mode)

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

The table shown in Figure 4 follows the guidelines of current legal frameworks in place in some jurisdictions, (e.g., US and EU. Note that 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.

The vehicle can be fully autonomous, even limiting any direct user interaction (apart from emergency stop) regarding driving, choice of destination and itinerary to follow. In this case the driver and passenger roles are mostly identical.

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. These are illustrated in Figure 5.

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 applications.

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 USB or other connections.

Content of the mobile device such as applications and mobile services will be displayed on the VMS through some tools.

All connected applications and services are accessible through the VMS.

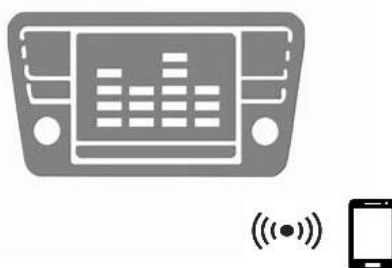### 7.1.2 Built-in connectivity

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

All applications 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 applications through its mobile devices. As for the brought-in connectivity, the mobile device connects to the vehicle through USB or other types of connection and its services and applications can be displayed on the VMS through some tools. The user accesses all vehicle connected services and applications through the VMS.

Brought-in	Build-in	Hybrid connectivity
– Vehicle has no own connectivity – User will connect through his brought-in mobile device – Mobile device will connect through short-range connections to VMS – Content will be made visible on VMS – All APPs and services are accessible through VMS	– Vehicle is fully equipped to connect to Internet and other connected services to the vehicle – All APPs and services are accessible through VMS.	– Mixed of brought-in and build-in connectivity. – Vehicle has own connectivity. – Some APPs and services are only accessible through mobile device brought into the vehicle – Mobile device connects to vehicle VMS through short-range connections. – User accesses all vehicle connected APPs and services through VMS.

Figure 5 – Vehicle connectivity

Ideally, in all the above cases, access to services, applications 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 in vehicle infotainment (IVI) systems have at least FM/AM radio functions, while digital radio and sound broadcasting receivers are becoming more common [b-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 acts as a local infotainment service provider. 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, smart phones and tablet computers using in-vehicle local area wireless connections).

The VMS seamlessly integrates the services received from various broadcasting networks and communication 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 Use case A – In-city commuting/native life service as driving purpose

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 networks 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 Use case B – Out-city driving

Traveling for long distances away from cities using family cars or SUVs during weekends or holidays is becoming a common trend. In some regions, large populations live 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.

–   Satellites (e.g., L Band Broadcast) with both broadcast and bi-directional communications.

–   Low earth orbit (LEO) bi-directional communication networks.

–   Short range networks and/or local area wireless networks.

–   Terrestrial broadcast networks.

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 and connect to a server over a cellular or short-range data connection to download metadata about the program.

– 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.

7.2.4 Requirements – VMS connectivity

Con-R1: The VMS shall be inclusive of both bi-directional communication and one-directional broadcast networks.

Con-R2: The VMS should be designed to allow access via multiple communication networks.

Con-R4: The VMS may connect via multiple communication networks simultaneously.

Con-R5: The VMS may provide seamless handoffs between communication networks.

Con-R5: The VMS shall allow the user to configure or limit types of data transmission over various communication networks when multiple networks are accessible.

7.3 Network convergence transmission and vehicle-onboard processing

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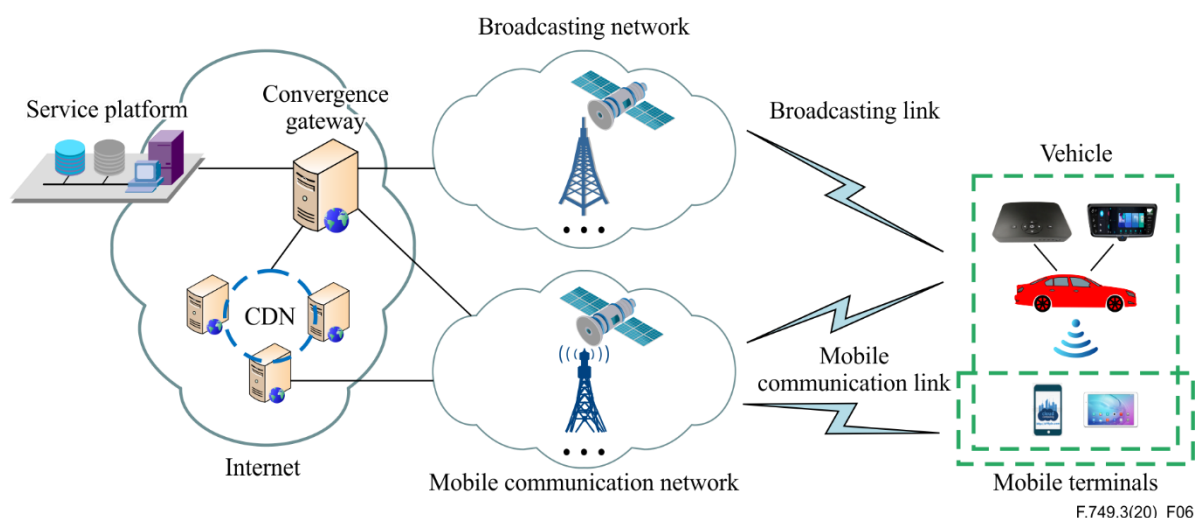
Figure 6 – The network architecture of convergence transmission

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 favourite channels from home city are played throughout the whole trip. In 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 (VMS) 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 tablet computers through local area wireless access.

Scenario 5: Users who have downloaded the application 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 local area wireless 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, should be supported by the VMSP and the 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 should be pursued. Firstly, the transmission protocols and reception methods should 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 various application layer protocols to support similar media services. Therefore, the transmission protocols and reception methods should be transparent to the upper layer protocols so that the vehicular multimedia network can be used by various service providers to run their own services. Thirdly, the transmission protocols and reception method should 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.

7.3.3 Requirements – VMS converged network

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

Con-T-R1: The VMS shall require none or minimum modifications to the existing broadcasting and mobile communication infrastructures.

Con-T-R2: Network convergence transmission and reception shall be agnostic to the underlying physical layer transmission standards and be transparent to the upper layer applications.

Con-T-R3: 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).

Con-T-R4: The increase in the end-to-end transmission delays due to the network convergence transmission and vehicle-onboard processing should be minimized.

Con-T-R5: The increase in the overall system start-up and channel switching time due to the network convergence transmission and vehicle-onboard processing shall be minimized.

7.4 Networking connection among multiple terminals within the vehicle

7.4.1 Use case A – Nomadic device connectivity

The VMS provides in-vehicle media content distribution over a local wireless network. Various types of terminal (such as various types of in-vehicle screens, mobile phones, tablet computers, etc.) can connect to the VMS and receive content adapted to the characteristics of the different terminals.

7.4.2 Use case 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.

7.4.3   Requirements – Display Screens and terminals connectivity

Net-C-R1: The VMS should be able to connect to various terminals (such as different types of in-vehicle screens, mobile phones, tablet computers, etc.) based on their capabilities.

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

Net-C-R3: The VMS should be able to selectively limit bandwidth allocated to the connected mobile devices, based on total VMS vehicle available bandwidth and user profile.

Net-C-R4: Upon detection of change of the VMS user, the VMS should wipe personal data transferred through the mobile device connected to the VMS in order to respect privacy of personal data.

7.4.4   Use case 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 and gives audible alerts, or shuts down its displays in case the driver is looking away from the road for a considerably 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 VMSP.

The information collected by the 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 VMS.

7.4.4.1   Requirements

Net-WB-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.

Net-WB-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.

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

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

Net-WB-R5: VMS shall have storage space to save each user profile data and to send them to the VMSP when network coverage becomes available.

Net-WB-R6: Upon detection of change of the VMS user, the VMS should wipe personal data in order to respect privacy of the user.

Net-WB-R7: Each individual user should have the possibility to shut down or unsubscribe the function at any time temporarily or irrevocably.

7.4.5 Use case D – On-demand functions for privately owned vehicle

Through vehicle applications available on smart devices and on the VMS, the vehicle user can demand vehicle functions that he can subscribe to at 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 application. 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-application payment could be used. VMS confirms the purchase and displays the chosen function that is ready for use.

7.4.5.1 Requirements

Net-PV-R1: In a multi-passenger vehicle, the VMS should enable a centralized or individual access to the VMNS via applications for on-demand functions and payment functions.

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

Net-PV-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.

Net-PV-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 should have enough storage space.

– VMS should have enough computing 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 environments (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 application on a tablet computer through the local area wireless 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:

HET-SC-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, tablet computers, etc.

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

> HET-SC-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.

> HET-SC-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.

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

> HET-SC-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.

HET-SC-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 Requirements

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

HET-CL-R2: VMS should identify driver/passenger(s) through its mobile phone (NFC, and other) or cameras or sensors (scan of fingerprint, iris, face, other).

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

HET-CL-R4: VMS should access cloud content of passenger or the user provided profile of the mobile phone, display it at the place user is occupying in the vehicle and adapt 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. should 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 should be secured against intrusion and cyber-attacks.

– VMS should have storage space to save profile data and to send them to the cloud when network coverage becomes available.

HET-CL-R5: Upon detection of change of the VMS user, the VMS should wipe personal data in order to respect privacy of the user.

8 Intelligent human machine interfaces (HMI) 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. This is illustrated in Figure 7.

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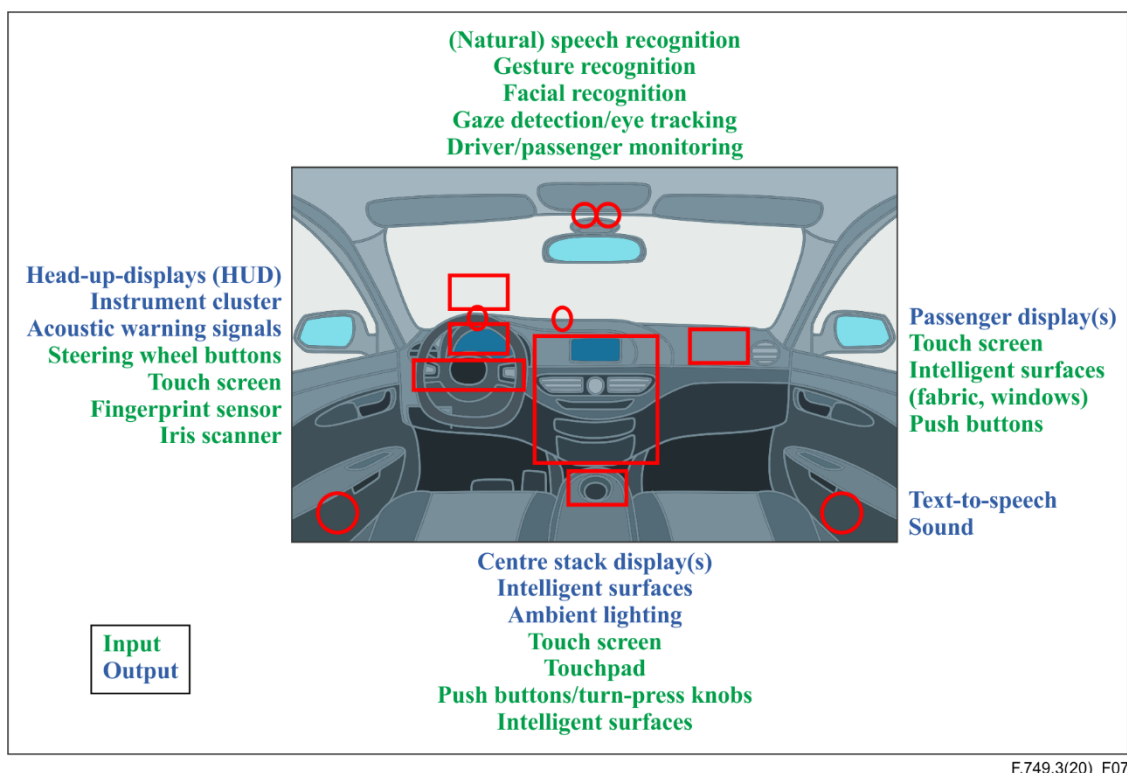
Figure 7 – VMS input and output devices, cockpit view

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:

– Centre 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)
– Centre 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.)

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 Use case A – Initiating a voice recognition session

A person in a vehicle containing multiple occupants wishes to initiate a voice recognition session by uttering a keyword. 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 behaviour 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-2A   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.
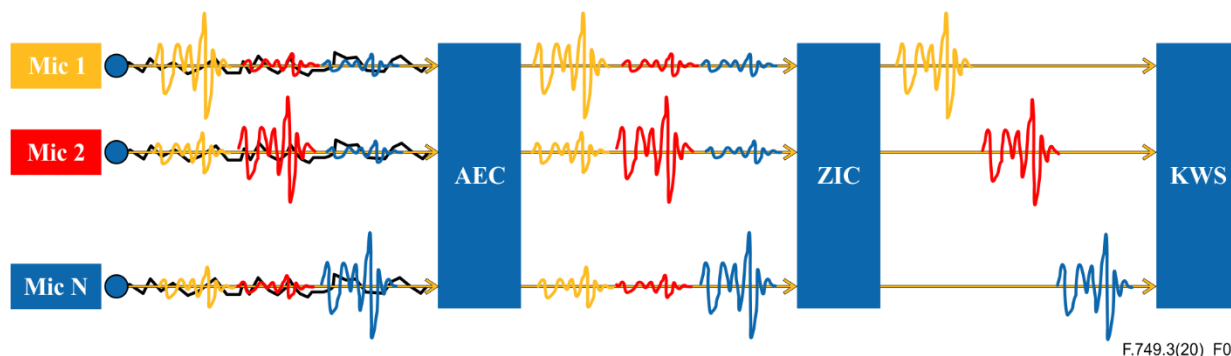

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Figure 8 – Acoustic processing (AEC and ZIC) on each zone dedicated microphone

Figure 8 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   Use case B – Interference during a voice recognition session

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.
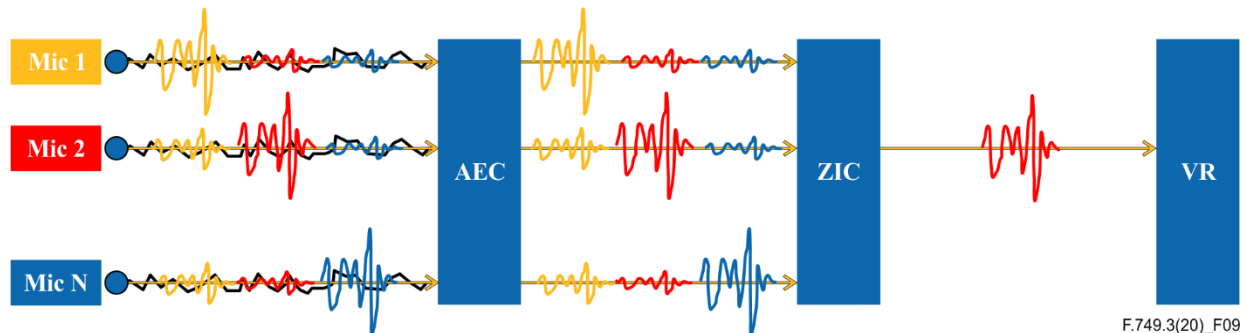

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Figure 9 – Illustration of use case B, where zone 2 has been identified as the target zone

8.1.3   Gap analysis

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

–   [b-ITU-T P.1150] In- car communication 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, the quality of voice is ensured 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 [b-ITU-T P.1150] addresses the requirements associated with the use of voice recognition in a vehicular multimedia context.

–   [b-ITU-T P.11.x] 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 [b-ITU-T P.11.x] can address the use cases and requirements for multiple talkers, KWS, voice commands and voice recognition sessions.

8.1.4   Requirements – Acoustic

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:

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

AUD-R1.1: 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.

AUD-R2: It shall be possible to process each channel/zone independently.

AUD-R3: It shall be possible to identify a target zone/target speech (e.g., scenario A-1).

AUD-R4: 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).

AUD-R5: 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).

AUD-R6: The VMS or vehicle should provide at least one voice/speech/audio channel per zone (e.g., one microphone per zone).

AUD-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 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 VMS

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, such as the one illustrated in Figure 10.

Figure 10 – Example of interactive eye-gaze-controlled HUD

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.

– 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 alert passengers if the passenger in the 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 – Gaze tracking

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.

8.3.2.1 Requirements

GC-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 the automotive environment on the HMI.

8.3.3 Use case – Controllable camera through eyes

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

NOTE – This is not a digital video recorder (DVR) camera which is mandated in certain countries to record. DVR cameras 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 electronic control unit (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 devices 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 light detection and ranging (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.

8.4.1.1 Requirements – Data format

DFS-R1: For multimedia broadcasting services provided by a VMNS provider, the media types, content navigation methods and interactivity methods recommended in [ITU-R BT.2055-1] shall be supported by the VMS and the VMNP.

DFS-R2: Additional media types may be supported by the VMS and the VMNP to address some regional requirements.

DFS-R3: A VMN application may support additional software video and/or audio codecs to address the need of a VMNS provider.

DFS-R4: For interactive, and non-broadcasted VMNS, the VMNP and VMS should support the same multimedia broadcast media types.

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 personalisable, 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). [b-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 [b-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 VMS may be shared by different individuals in the vehicle (driver and passengers) with no relation between them, for instance in a public transportation shuttle.

– 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 [b-IETF e-mail] and [b-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 [b-ITU-R BT.2052].

From the above it becomes apparent that VMNS need 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

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

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

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

PrivGen-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.

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

PrivGen-R6: The VMS should have the capability to wipe personal data transferred through the mobile device connected to the VMS in order to respect privacy of personal data.

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

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

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

PrivPV-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 – 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

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

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

Priv-SVS-R3: VMS should 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).

Priv-SVS-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.

Priv-SVS-R5: User should be able to change itinerary, overwriting agenda information and previous instructions in the VMS at any time.

Priv-SVS-R6: Upon detection of change of the VMS user, the VMS should wipe personal data transferred through the mobile device connected to the VMS in order to respect privacy of personal data.

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

Priv-SVM-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.

Priv-SVM-R2: Connectivity from mobile devices to VMS should be allowed.

Priv-SVM-R3: VMS should be able to receive agenda and personal information from user mobile devices.

Priv-SVM-R4: VMS should be able to 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).

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

Priv-SVM-R6: User should be able to change itinerary, overwriting agenda information and previous instructions via VMS or via their mobile phone at any time.

Priv-SVM-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.

Priv-SVM-R8: Upon detection of change of the VMS user, the VMS should wipe personal data transferred through the mobile device connected to the VMS in order to respect privacy of personal data.

10 Content rights protection in a converged network environment

10.1 Background

The convergence of different networks combines features of unidirectional 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 11.
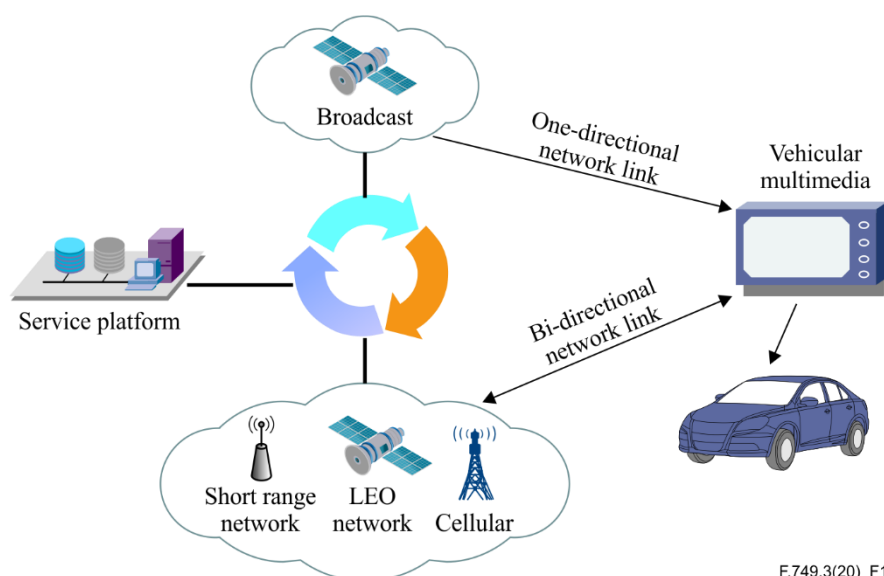
Figure 11 – Convergence of different networks for vehicular multimedia content

Consider live television service as an example. Currently, live television service is delivered solely by satellite broadcast networks. To protect the television video content from being received at unauthorized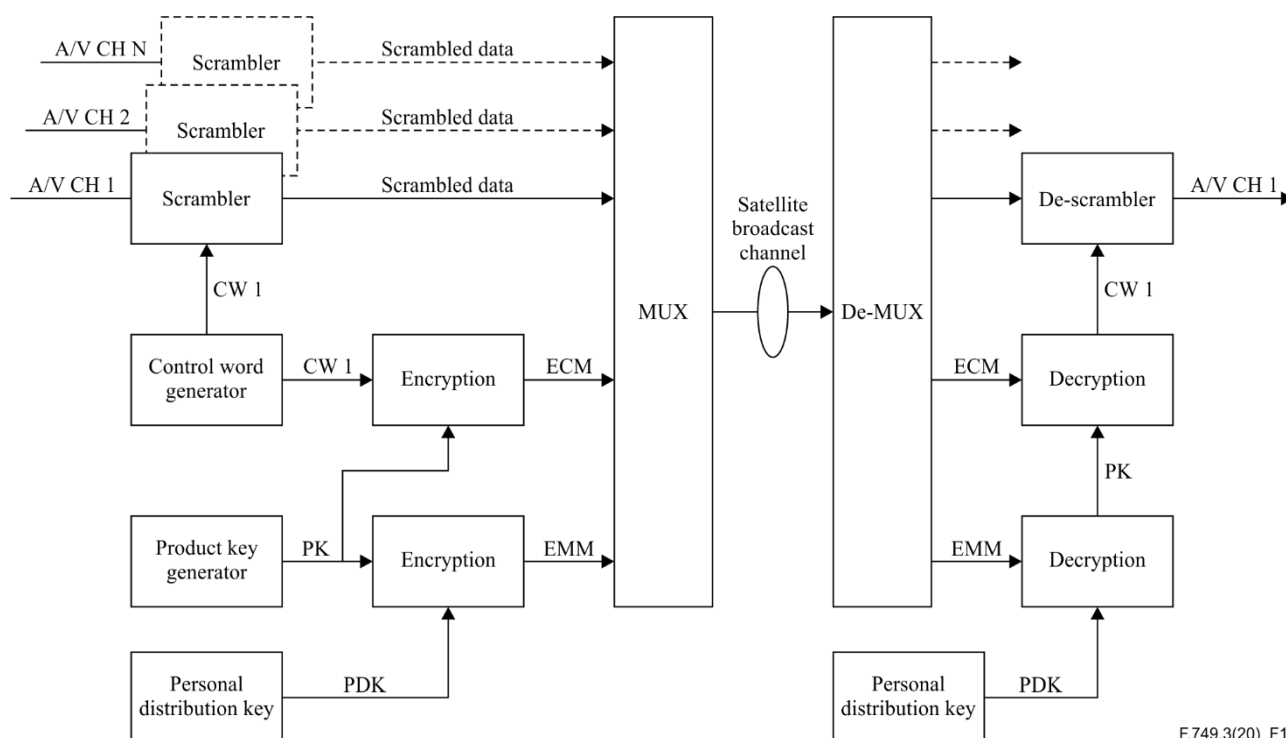 terminals, the following conditional access (CA) technique is applied. The architecture of the satellite broadcast system with CA support is illustrated in Figure 12.

Figure 12 – Diagram of the satellite broadcast system with CA support

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).
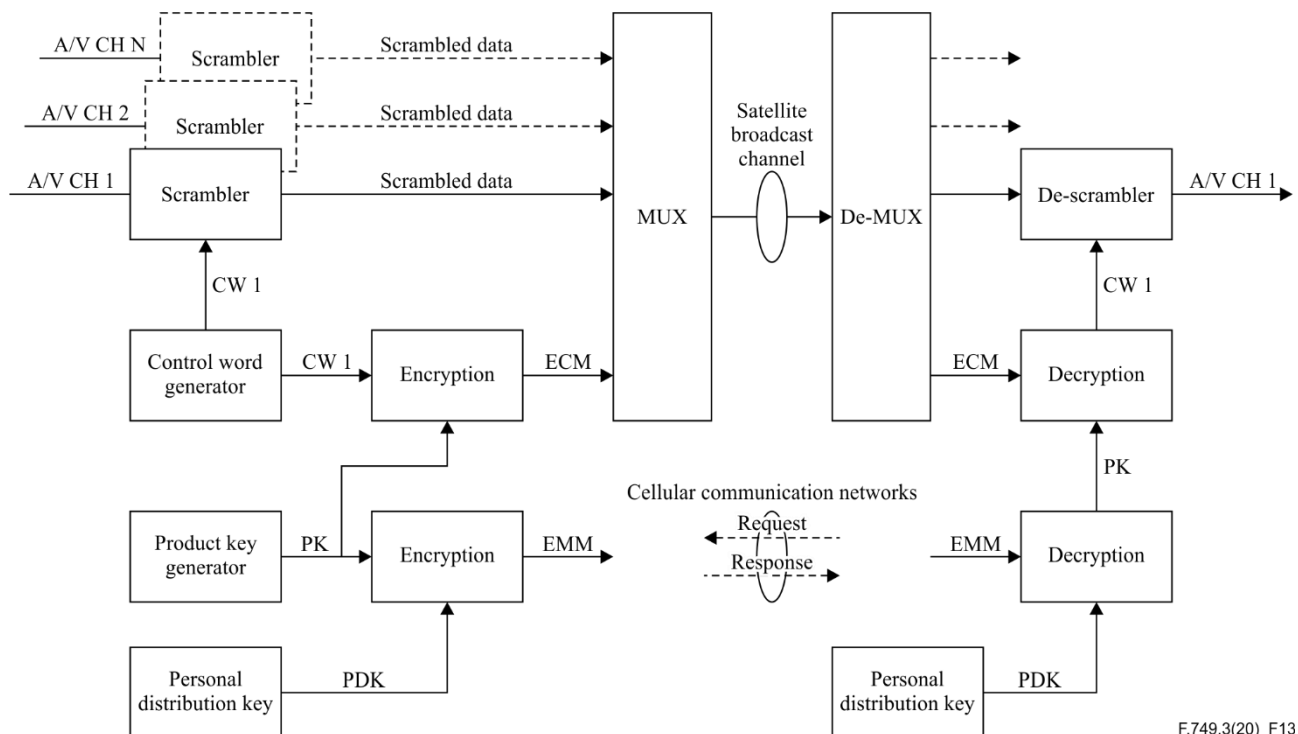
10.2 Use cases

The conditional access system shown in Figure 12 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 – VMS with flexible EMM

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 13, where the scrambled data and ECMs are transmitted over satellite broadcast channel and the EMMs are transmitted over cellular communication networks.

Figure 13 – Diagram of the multimedia system with flexible EMM transmission

10.2.2 Use case B – VMS with extended EMM

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 operators, 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 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 14, 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.
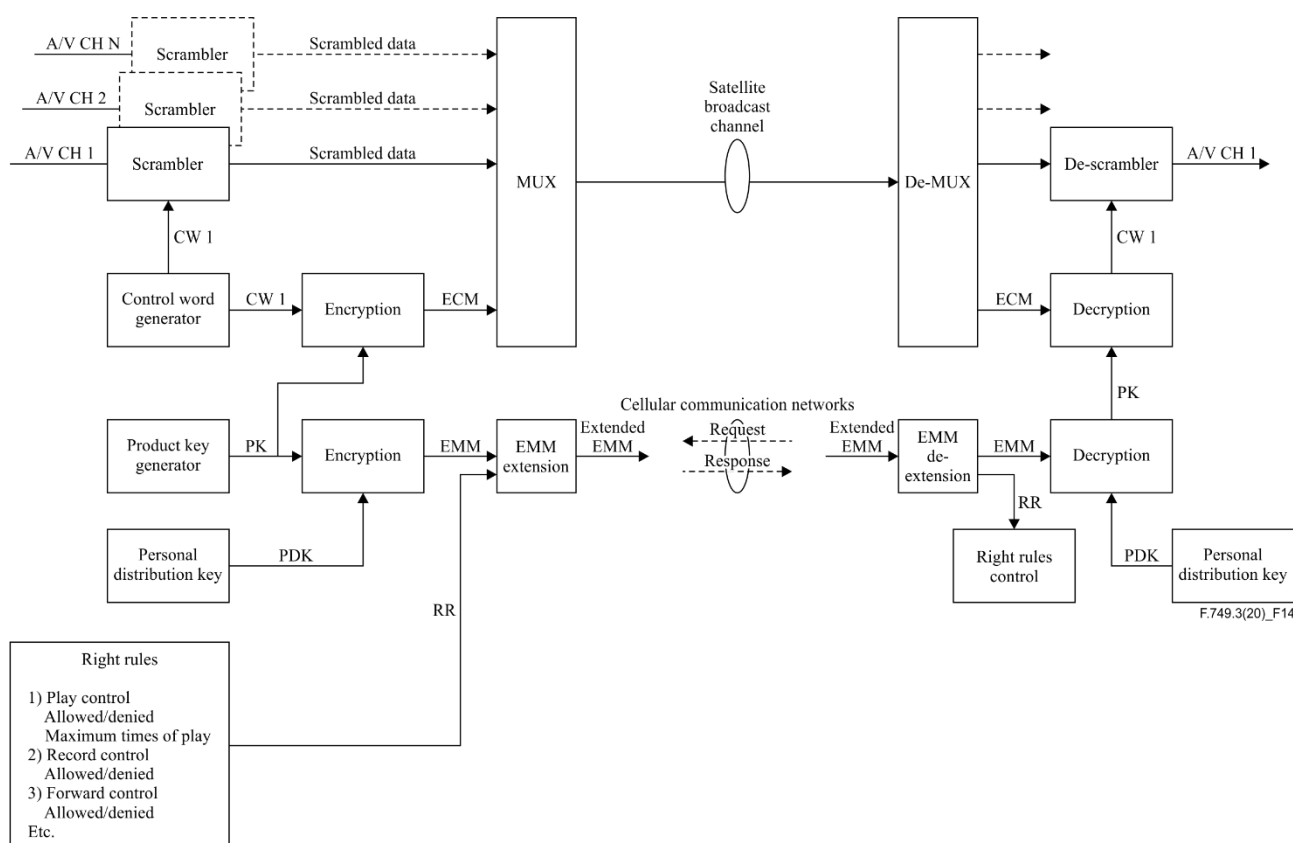
Figure 14 – Diagram of the multimedia system with extended EMM to support more rights control options

10.3   Gap analysis

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

For multimedia information systems 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) [b-ETSI ETR 289]

2) ATSC Standard: Conditional access system for terrestrial broadcast (A/70 Part 1:2010) [b-ATSC]

3) China's radio and television industry standard: Specification of conditional access system for digital television broadcasting GY/Z 175-2001 [b-CN-CAS]

For multimedia information systems 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) [b-OMA DRM]

2) ChinaDRM: Technical specification of digital rights management for internet television, GY/Z 277-2014 [b-ChinaDRM]

10.4 Requirements – Content rights protection requirements for CA

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

RP-R1: The integrity of rights rules for a terminal shall be guaranteed during its transmission from the head-end to the terminal.

RP-R2: The rights control options shall be extensible for additional rules to be added in the future.

RP-R3: Conventional conditional access schemes for unidirectional networks may be supported.

RP-R4: Entitlement management messages in conventional CA schemes may be delivered over bidirectional networks. Further:

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.

RP-R5: Rights rules for a terminal may be transmitted along with the EMM to the terminal.

RP-R6: Rights rules for a terminal may be transmitted in an independent message to the terminal.

11 Copyright and rights management support for content delivery

11.1 Use case – Content payment and copyright protection

For some content providers the in-vehicle screen and mobile phones are two different distribution channels with different service costs and price offerings. 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 Requirements – Copy protection

RM-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

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 – Content classification

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 – Privilege management in single use vehicle

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 – Privilege management in shared vehicle

In the car sharing industry, several different business models lead 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 with 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 – Privilege management for local media content

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 15 is an example illustrating how two ID systems (User ID and IVI system/hardware ID) can be used concurrently to provide a multimedia service.
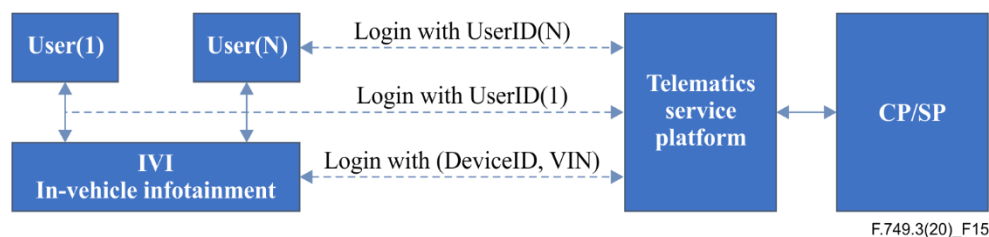
Figure 15 – ID systems

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

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

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

PM-R3: VMN should support parental control function.

PM-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 a mobile phone number and/or biometric (e.g., face recognition, voice recognition, or finger-print information, etc.).

PM-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, a user can enjoy the privilege in that vehicle.

11.2.2.2   Account management requirements

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

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

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

AM-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.

AM-R5: The VMS should be capable of matching a vehicle hardware ID (such as key fobs or biometric 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, refuelling, 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).

11.3.1.1 Requirements

PTS-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.

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

PTS-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.

PTS-R4: Upon detection of change of the VMS user, the VMS should wipe personal data transferred through the mobile device connected to the VMS in order to respect privacy of personal data.

12 Security

12.1 Use case – User data protection

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. Similarly, these data should not be accessed by another system without user consent. When the user data and privacy-related information are transmitted between systems, the protection of user data shall be ensured and 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.

12.1.1 Requirements

UsrDP-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 Use case – VMN application security

A VMN application should be securely developed according to best practices and applicable local regulations and not bring additional risks within the vehicle and should not be tampered with or corrupted.

12.2.1 Requirements

AppSec-R1: In order to verify the application and to ensure its origin authorization, a VMN application should be signed with a digital signature.

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

AppSec-R3: It shall be possible to wipe all the data (application, content and data) on the VMS to return the VMS to its factory settings.

AppSec-R4: It shall be possible to wipe a subset of the data on the VMS.

AppSec-R5: The wipe shall be able to be performed by different authorised entities such as the VMNS provider, the end-user or the VMS manufacturer.

12.3 Use Case – VMS software security

Due to increasing system complexity, software error or software fault may exist in VMS, which may cause crashes. The system should guarantee that such fault would not cause operation errors or abnormal stop that would threaten security, and would cause the entire vehicle system may not work properly.

12.3.1 Requirements

SwSec-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.

13 Safety

13.1 Use case – Driving safety: Speed control

Before L4 and L5 autonomous vehicles are commercialized, consuming audio and video content in vehicles could easily be a cause for driver distraction. In accordance with the local regulation, when the vehicle speed reaches a certain threshold (it differs based on local regulations, for instance from 0 km/s to 15 km/s 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.

13.1.1 Requirement

Saf-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 Definition of vehicular multimedia configurations

As smart connected vehicles are more widely available, vehicular multimedia services are becoming richer and more complex than before. Vehicular multimedia configurations for smart connected vehicles could be used to manufacture and qualify vehicles accordingly. Customers can know which multimedia capabilities his/her vehicle multimedia offers. Examples of VMS reference configurations can be found in Appendix I.

14.1 Use case – Vehicular multimedia configurations

Currently, when customers choose a vehicle to acquire, the vendor of the vehicle generally provides them with a limited configuration sheet which may not have detailed information on the multimedia capability of the vehicle (e.g., FM/CD/DVD and some other storage disks 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) configurations should be defined and include network connectivity, media display, HMI controls, PII protection and security capabilities.

1)   Networks connectivity capabilities:

VMS configurations should support one or more of the following:

– 3G/4G/5G cellular networks.

– Satellites bi-directional communication networks, including low earth orbit bi-directional communication networks.

– Satellites broadcast networks.

– Terrestrial broadcast networks.

– Short range networks and/or local area wireless networks.

– V2V and V2I networks.

– Brought-in, built-in and hybrid connectivity.

2)   Media display and media format capabilities:

VMS configurations 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 configurations 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.

14.1.1 Requirements – Vehicular multimedia configurations

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

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

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

15 Matching of described use cases with driving levels

The table in Figure 16 matches use cases and services that have been defined within the focus group with the SAE 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 cases	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
7.3.1 Multimedia content		X		X		X	(X)	X	X	X	X	X
7.4.1/2 Nomadic device connectivity	X	X	X	X	X	X	X	X	X	X	X	X
7.4.4 Comfort and well-being on board	X	X	X	X	X	X	X	X	X	X	X	X
7.4.5 On-demand functions private vehicle	X	X	X	X	X	X	X	X	X	X	X	X
7.5.1 Continuity of service – Video streaming		X		X		X	(X)	X	X	X	X	X
7.5.2 Cloud based services		X		X		X	(X)	X	X	X	X	X
8.1.2.1/2, Voice recognition session	X	X	X	X	X	X	X	X	X	X	X	X
8.3 Gaze tracking	X	X	X	X	X	X	X	X	X	X	X	X
9.3 Private vehicle-single user		X		X		X	(X)	X	X	X	X	X
9.4 Long distance shared vehicle		X		X		X	(X)	X	X	X	X	X
9.5 Public transport shared vehicle multi users		X		X		X		X		X		X
10.2.1 VMS with flexible EMM		X		X		X	(X)	X	X	X	X	X
10.2.2 VMS with extended EMM		X		X		X	(X)	X	X	X	X	X
11.2 Privilege and account management	(X)	X	(X)	X	(X)	X	(X)	X	X	X	X	X
11.3 Payment services shared vehicles	(X)	X	(X)	X	(X)	X	(X)	X	X	X	X	X

X = Allowed

(X) = Partly allowed (in autonomous driving mode or when it is an audio application only, or according to details that are defined in the respective use-cases). Local or global regulations apply.

Figure 16 – Matching of specific multimedia use cases with SAE driving levels

Appendix I

Examples of VMS reference configurations

(This appendix does not form an integral part of this Recommendation.)

M0-M5 configurations are example capabilities and use cases.

M0 and M1 are for after-market solutions while M2 to M5 are embedded solutions with increasing capabilities.

I.1   M0 configuration

–   Aftermarket VMS. Fitted after buying the car.

–   Not connected to vehicle network.

–   Brought-in connectivity. Mobile device connected to car through USB.

–   Connected to vehicle only for the operating power requirements.

Table I.1 shows M0 configuration.

Table I.1 – M0 configuration

Entertainment capability	Social usage capability	Office use capability	Game play capability
1. Music playback: Local music/CD-AUX-SD-USB 2. Radio: FM-AM	1. Text social: Support for SMS. Received SMS displayed in VMS display using short-range connections protocol feature, brought-in connectivity 2. Communication social: Only a short-range connection phone is supported, and only one person can be connected to at a time. Restricted by design	Hands-free-phone through the brought-in connectivity	No. Restricted by design

I.2   M1 configuration

Provides the following capabilities above M0:

–   Provides advance mobile connectivity solutions such as screen mirroring.

–   Interactive applications and control sharing between VMS and brought-in connectivity.

–   Connected to vehicle for power requirements and game control requirements.

Table I.2 shows M1 configuration.

Table I.2 – M1 configuration

Entertainment capability	Social usage capability	Office use capability	Game play capability
1. Music playback: Local music/CD-AUX-SD-USB 2. Radio: FM-AM 3. Video playback: Local video 4. Support mobile connectivity solutions 5. Screen casting.	1. Text and pictures social: Support for SMS and MMS. Received SMS and MMS displayed in VMS display using short-range connections protocol feature 2. Communication social: Support for multi-way short-range connections and single-way telephone access dial-out, car can be connected at the same time, no need to reconnect	1. Hands-free-phone through the brought-in connectivity 2. Calendar events sync from mobile phone to VMS (viewable from car)	Interactive gaming

I.3 M2 configuration

– Connected to vehicle network.

– Hybrid connectivity. Vehicle has its own built-in connectivity to access applications and other services also possible to connect mobile phone connectivity through USB or other solutions.

– Connectivity through 2G/3G/4G/5G.

– Service continuity between different use places.

– Voice interaction controls.

Table I.3 shows M2 configuration.

Table I.3 – M2 configuration

Entertainment capability	Social usage capability	Office use capability	Game play capability
1. Music playback: Local music/CD-AUX-SD-USB 2. Radio: FM-AM/Online Internet radio 3. Video playback: Local video 4. Support for mobile connectivity solutions 5. Screen casting	1. Text, pictures and voice social: Support for SMS, MMS and social media connectivity 2. Support for multi-channel short-range connections and headphone bone conduction calls (single person support)	1. Support multi-person car conference call 2. Calendar events sync from phone to car (viewable from car) 3. Nomadic devices connectivity. 4. Continuity in service between different use places viz home/office/car using local area wireless	Interactive gaming

Table I.3 – M2 configuration

Entertainment capability	Social usage capability	Office use capability	Game play capability
6. Voice interaction: Specific instruction voice interaction	3. Support for simple team travel: location real-time sharing 4. Continuity in service between different use places viz home/office/car using local area wireless connections, APP connectivity	connections, APP connectivity	

I.4 M3 configuration

– Connected to vehicle network.

– Hybrid connectivity. Vehicle has its own built-in connectivity to access applications and other services possible to connect mobile phone connectivity through short-range connections or other solutions.

– Single display.

– Continuity in service between different use places viz home/office/car using local area wireless networks, application connectivity.

– Advance voice control.

– Shared mobility applications capabilities.

– Build-in game applications capabilities.

– Basic security capabilities.

Table I.4 shows M3 configuration.

Table I.4 – M3 configuration

Entertainment capability	Social usage capability	Office use capability	Game play capability
1. Music playback: Local music/CD-AUX-SD-USB 2. Radio: FM-AM/DAB/Online Internet radio 3. Video playback: Local video 4. Support mobile connectivity solutions 5. Voice interaction: Smart voice interaction through Internet services	1. In-car social support is in the following formats: Text, pictures, voices, and small video social 2. Communication social: Support for short-range connections phones and seat bone conduction calls (headphone-free, single-way calls) / headphone bone conduction calls	1. Support for on-board video conference calls (support for live screen; no support for file picture sharing), support for voice memos, voice memos to text and memos to share to mail 2. Two-way synchronization of mobile phones and car for calendar events (not only can	1. Mini-games (question-and-answer games based on voice interaction) 2. The on-board version of the online competitive game is supported when parking; 3. Support for action adventure game machine version when parking

Table I.4 – M3 configuration

Entertainment capability	Social usage capability	Office use capability	Game play capability
6. AR enhanced display APP on Centre Screen 7. Simple multi-screen interaction: Display entertainment function information on the instrument screen/HUD/air conditioning control screen, which can be easily interacted by protocol 8. Anthropomorphic interactions: Emotional interaction robots (e.g. NOMI, Small-scale car robots)	(supporting single person) 3. Support complex group travel: positioning and navigation route sharing	be seen on board, but can also be edited) 3. Support event trigger navigation 4. The computer can use the computer local area wireless networks, the computer edited mail can be sent through the car network	

I.5 M4 configuration

– Connected to vehicle network.

– Hybrid connectivity. Vehicle has its own built-in connectivity to access applications and other services possible to connect mobile phone connectivity through short-range connections or other solutions.

– Higher display capability.

– Multi-screen interaction capability.

– Continuity in service between different use places viz home/office/car using local area wireless networks, application connectivity.

– Occupant health and comfort monitoring capability.

– Advance HMI capability.

– Advanced integrated control capability for game play.

– Shared mobility and connected cars applications capabilities.

– PII protection and security capability.

Table I.5 shows M4 configuration.

Table I.5 – M4 configuration

Entertainment functions	Social use functions	Office use functions	Game play functions
1. Music playback: Local music/CD-AUX-SD-USB	1. Pre-install edgy social software for the car, and the in-	1. Support for on-board video conference calls (support for live	1. Co-driver or main driver parking can support small games

Table I.5 – M4 configuration

Entertainment functions	Social use functions	Office use functions	Game play functions
2. Radio: FM-AM/DAB/SDARS/Online Internet radio 3. Video playback: Local video 4. Support mobile connectivity solutions 5. Voice interaction: Smart voice interaction to Get Through the Internet Service Ecology 6. Simple multi-screen interaction: Display entertainment function information on the instrument screen/HUD/air conditioning control screen, which can be easily interacted by protocol 7. Multimedia entertainment information system platform and rich content resources with the fusion of multi-satellite broadcasting network and terrestrial cellular networks 8. AR Enhanced display APP on HUD and Centre Screen 9. Holographic projection display in specific areas of the vehicle, but only for display and not for interaction	car social support is in the following formats: Text, pictures, voice, small video social 2. Communication social: Support for short-range connections phones and seat bone conduction calls (headphone-free, dual-way calls supported) and headphone bone conduction calls (single-supporting) 3. Support complex team travel: positioning, navigation route sharing, support mobile bus route planning sharing	screen, no support for file picture sharing), support for voice memos, voice memos to text and memos shared to mail/social software Back support for hand-written board recording MEMO 2. Calendar event mobile phone, car two-way synchronization (the car can not only be seen, but also edited) 3. The rear screen of the car system supports checking and editing mail; 4. Support handwriting/ review/forward mail when parking	based on gesture recognition, such as cutting fruit 2. Racing games based on the steering wheel when parking 3. Mini games (question and answer games based on voice interaction) 4. Parking support: on-board version of online competitive games

I.6   M5 configuration

–   Connected to vehicle network.

–   Hybrid connectivity. Vehicle has its own built-in connectivity to access applications and other services also possible to connect mobile phone connectivity through short-range connections or other solutions.

–   Satellite media reception capability.

–   LCD screen support for hetero-shaped screen/OLED flexible screen/all-in-one screen.

–   Advanced multi display interaction and HMI capabilities such as gesture recognition, voice capability.

–   Continuity in service between different use places viz home/office/car using local area wireless networks, application connectivity.

–   Advanced Audio, video formats playing capabilities.

–   Advanced connected car, shared mobility features.

–   PII protection and security capability (such as driver monitoring cameras).

Table I.6 shows M5 configuration.

Table I.6 – M5 configuration

Entertainment functions	Social use functions	Office use functions	Game play functions
1. Music playback: Local music/CD-AUX-SD-USB 2. Radio: FM-AM/Online Internet radio 3. Video playback: Local video 4. Support mobile connectivity solutions 5. Voice interaction: Smart voice interaction to Get Through the Internet Service Ecology 6. Simple multi-screen interaction: Display entertainment function information on the instrument screen/HUD/air conditioning control screen, which can be easily interacted by protocol 7. Multimedia entertainment information system platform and rich content resources with the fusion of satellite broadcasting networks multi-satellite and terrestrial cellular networks 8. AR enhanced display can be applied on any screen, including HUD	1. Pre-installed customized social software for the car and in-car social support is in the following formats: text, pictures, voices, small video social and Live social, interactive games social 2. Communication social: Support for short-range connections phones (headphone-free, multiple-way calls, unheard-of content between different passengers) and headphone conduction calls (single support) 3. Support complex team travel: positioning, navigation screen sharing, support mobile bus route planning sharing, route 3D visualization	1. Support for on-board video conferencing (supports real-time screens, does not support file picture sharing), voice memos, voice memos, text and voice memos, and memos shared to mail/social software, Support for tablet recording memo 2. Calendar event phone, two-way synchronization (car cannot only see, but also can be edited) 3. The rear windshield supports the inspection and editing of mail 4. Support for handwriting/review/forwarding messages when parking 5. Front row supports on-board custom office software operations based on holographic projection/gesture recognition/eye	1. Co-driver or main driver parking can support small games based on gesture recognition, such as cutting fruit 2. Racing games based on the steering wheel when parking 3. Mini games (question and answer games based on voice interaction) 4. Parking support: on-board version of online competitive games; 5. Games that support holographic projection and holographic interaction

Table I.6 – M5 configuration

Entertainment functions	Social use functions	Office use functions	Game play functions
and Centre Screen 9. Customized holographic projection, users can display the contents of the screen in multiple areas of the car, not only to support display, but also to support interaction, similar to virtual assistant 10.Driver video recording, Driver Monitoring System, Around view Monitoring Cameras 11.Gesture Recognition capability 12.Voice Biometric identity		control (in conjunction with hardware)	

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