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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Vehicle domain service – General information and use case definitions

Recommendation ITU-T F.749.5

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Recommendation ITU-T F.749.5

Vehicle domain service – General information and use case definitions

Summary

Recommendation ITU-T F.749.5 provides a basic definition of vehicle domain service and supplementary information on detailed concepts, as well as definitions of the typical and supplementary use cases being used to define the specification of applications. Connected vehicles are expected to expand and become even more popular in different markets worldwide. A variety of technologies is being developed and discussed for many applications. Detailed specifications of communications and applications are provided in other documents in the Recommendation ITU-T F.749 series; they are not provided in Recommendation ITU-T F.749.5.

Recommendation ITU-T F.749.5 (2021) is technically aligned with ISO 23239-1. It was developed jointly by ITU-T Study Group 16 and ISO TC22/SC31 under the Joint Project Team on Vehicular Domain Service (JVDS).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.749.5	2021-10-29	16	11.1002/1000/14792

Keywords

Connected vehicles, intelligent transport systems, use cases, vehicle domain service, vehicular multimedia systems

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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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Introduction

Connected vehicles are expected to expand and become even more popular in the markets of different countries. A variety of technologies is being developed and discussed for many applications.

Everyone who drives a car collects traffic information to determine the correct driving behaviour, and accurately recognize relevant traffic information and driving conditions without delay. Although an autonomous driving function takes over driver operation, there is the same value in a judgement of correct driving behaviour. While many independent autonomous driving cars and intelligent driver assistance functions provide information collected by various sensors, light detection and ranging (LIDAR) and radio detection and ranging (RADAR), their performance is limited and the inaccuracies increase with ambient conditions, such as weather and blind spots.

In addition, the blinkers with which all vehicles are normally equipped only provide one-way fragmentary information. If the vehicle communicates with other neighbouring vehicles or traffic participants and exchanges various pieces of information, it is able to go beyond the limits of its sensor capabilities and blind spots to provide a more accurate assessment of the traffic situation. It is also possible to negotiate planned driving manoeuvres with neighbouring vehicles and to coordinate the sequence and timing of driving manoeuvres.

This ability to share information between vehicles defined in this Recommendation is provided only on a direct communication network between the vehicle and neighbouring traffic participants. It is accomplished with on-board functionality without investing in significant communication infrastructure on the road. This enables vehicles to make more accurate and appropriate driving choices, which provides a number of benefits, such as reducing traffic accidents and congestion, with improving traffic efficiency.

An important aspect of this documentation development is the focus on implementation points throughout the vehicle. Typical use cases are collected, from which distinctive aspects of the implementation specification are derived. Beyond simple information exchange, the resulting information is reviewed, evaluated and then used to generate reliable information that can be applied to critical vehicle controls.

ITU-T F.749.5 (technically aligned with [b-ISO 23239-1]) was developed to eliminate inconsistencies and redundancies within the terminology used currently for vehicle domain service documentation. As a result of these tasks, compatibility and interoperability are confirmed, in addition to the economy and efficiency of implementation with global consistency. Furthermore, by providing a concrete path from an existing simple and partial communication interface to trusted vehicle implementation, it is expected that a smooth launch of brand-new vehicle applications can be supported and the introduction accelerated of next generation communication technologies into the future vehicle market.

Recommendation ITU-T F.749.5 (2021) is technically aligned with ISO 23239-1:2021 "Road vehicles – Vehicle domain service (VDS) – Part 1: General information and use case definitions" and it was developed jointly by ITU-T Study Group 16 and ISO TC22/SC31 under the Joint Project Team on Vehicular Domain Service (JVDS).

Recommendation ITU-T F.749.5

Vehicle domain service – General information and use case definitions

1 Scope

This Recommendation provides a basic definition of vehicle domain service (VDS) and supplementary information on detailed concepts, as well as definitions of the typical and supplementary use cases being used to define the specification of applications.

Detailed specifications of communications and applications are provided in other Recommendations in the series; they lie outside the scope of this Recommendation.

NOTE – The remote processes by the tools connected to an on-board diagnosis connector in a vehicle, such as repair and maintenance, prognostics, monitoring, configuration and reprogramming of a vehicle lie outside the scope of this Recommendation.

2 Normative 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.

None.

3 Terms and definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 domain actor (DA): Client of a master vehicle in a vehicle domain.

NOTE – They are in general traffic participants, such as vehicles, bikes and walkers around the master vehicle.

3.2.2 domain vehicle (DV): Vehicle client of a master vehicle in a vehicle domain.

3.2.3 domain participant (DP): Client of a master vehicle except for vehicle in a vehicle domain.

EXAMPLE – Walker, bike and other traffic participants with network function.

3.2.4 domain sensor (DS): Client of a master vehicle in a vehicle domain with sensing function.

NOTE 1 – It is the network entity and typically, a vehicle with network and sensing function is often both a domain vehicle and domain sensor at the same time.

NOTE 2 – The general definition of domain sensor never excludes the domain actor except vehicle.

3.2.5 master vehicle (MV): Server of vehicle domain.

NOTE – This means the vehicle in which the server function implemented.

3.2.6 primary actor (PA): Master vehicle or one of its clients in the vehicle domain.

3.2.7 secondary actor (SA): Logical or functional network entity outside the vehicle domain.

3.2.8 smart-city traffic manager (SCTM): Central management server of traffic information in a smart city.

3.2.9 smart traffic: Optimized traffic controlled by the smart city traffic manager in a smart city.

3.2.10 smart traffic architecture model proposal (STAMP): Model proposal of the multi-layer-like control structure of smart traffic.

3.2.11 traffic monitor (TM): Lower functional server of the smart-city traffic manager that monitors traffic status.

3.2.12 traffic operator (TO): Lower functional server of the smart city traffic manager that manages traffic control information.

3.2.13 vehicle domain (VD): Limited group of secure and reliable connections, provided by the master vehicle and established on an existing network service by registering the domain actor.

NOTE – Vehicle domain is only related to network connection between master vehicle and domain actor. Physical or geometrical conditions are not included.

3.2.14 vehicle domain dynamic map (VDDM): Dynamic map in the vehicle domain generated by a master vehicle.

NOTE – VDDM consists of static high definition features, dynamic actors and other characteristics.

3.2.15 vehicle domain service (VDS): Group of functions provided by the master vehicle to the domain actor in the vehicle domain.

NOTE – It includes vehicle domain dynamic map.

3.2.16 vehicle domain service account (VDSA): Unique identifier of the domain actor, certified and issued by the vehicle domain service operator.

3.2.17 vehicle domain service master time; VDS master time: Basic time steps for synchronization between the master vehicle and the domain actor generated by the master vehicle.

NOTE – It generates both past and future time steps.

3.2.18 vehicle domain service system (VDSS): Physical structure that consists of the master vehicle (server), neighbouring vehicles (client), other traffic participants (clients), and a wireless network between the server and its clients that provides vehicle domain service.

NOTE – An element in the VDSS is named as primary actor. Elements outside the VDS are named secondary actors.

3.2.19 vehicle domain service operator (VDSO): Service operator who issues the vehicle domain service account.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BUC	Business Use Case
DA	Domain Actor
DP	Domain Participant
DS	Domain Sensor
DV	Domain Vehicle
HMI	Human/Machine Interface
ID	Identifier

IP	Internet Protocol
LDM	Local Dynamic Map
LEO	Low Earth Orbit
LIDAR	Light Detection And Ranging
LRT	Light-Rail Transit
MV	Master Vehicle
NTP	Network Time Protocol
OEM	Original Equipment Manufacturer
OSI	Open Systems Interconnection
PA	Primary Actor
PTP	Precision Time Protocol
RADAR	Radio Detection And Ranging
RF	Radio Frequency
Rx	Receiver
SA	Secondary Actor
SCTM	Smart-City Traffic Manager
STAMP	Smart Traffic Architecture Model Proposal
SUC	System Use Case
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TM	Traffic Monitor
TO	Traffic Operator
Tx	Transmitter
UTC	Universal Time
VD	Vehicle Domain
VDA	Vehicle Domain Actor
VDDM	Vehicle Domain Dynamic Map
VDDMS	Vehicle Domain Dynamic Map Service
VDS	Vehicle Domain Service
VDSA	Vehicle Domain Service Account
VDSO	Vehicle Domain Service Operator
VDSS	Vehicle Domain Service System
VIN	Vehicle Identification Number
VMS	Vehicle Multimedia Service

5 Conventions

5.1 Documents overview on open systems interconnection-based services

Figure 1 shows the organization and coverage of the different ITU-T F.749.5 | ISO 23239-1 specifications on the OSI layered architecture.

As indicated by the bold-framed enclosure, this Recommendation (technically aligned with [b-ISO 23239-1] establishes general information and use case definitions. This Recommendation is the most basic document for the elaboration of other detailed and separate specific documents according to the OSI-layered architecture.

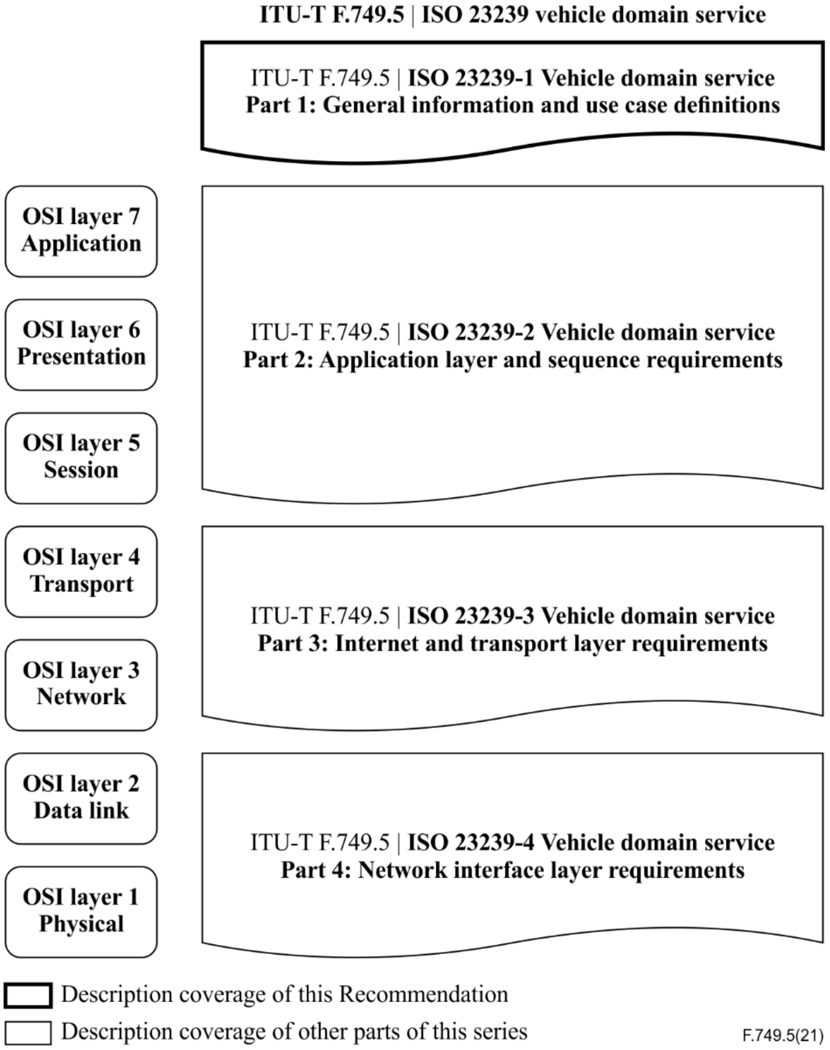


Figure 1 – Overview of documents applicable to vehicle domain service

The upper layers are not suitable for proper transmission control protocol/Internet protocol (TCP/IP) communication.

5.2 General policy structure

This Recommendation provides policies for specifications as general information. The list of policies consists of recommendations, permissions, possibilities and capabilities. Additional statements are attached in order to provide better understanding. All policies are expressed in unified format.

This Recommendation uses a policy structure, i.e., a unique number identifies each individual policy included within it, which improves readability with easier policy tracking. The following modified recommended format is applied:

'VDS''Y' – 'xxx' – policy name

{
policy text
}

where

– VDS represents the series of standards;

– Y represents the document part of the series document set;

– xxx represents the individual policy number;

– policy namerepresents the name of policy;

– policy text describes the provisions of the policy;

– { and } delimit the starting and ending points of policy.

EXAMPLE:

VDS1-000 – The form of general policy

{
This sentence should give the example form of general policy defined in this document.
}

5.4 Reference to subseries

In this Recommendation, reference to subsequent Recommendations in the series indicates other ITU-T Recommendations in the same subseries and their equivalent parts of the ISO International Standard.

6 General information for vehicle domain service

6.1 General

A vehicle domain (VD) is an area that consists of road vehicles in which the applications are implemented. The applications provide integrated information services used in the vehicle. The information provided is generated from various sources of information, acquired by communication, concerned with the area around the vehicle, such as traffic conditions. The source information is acquired directly or indirectly by communication with neighbouring vehicles and other traffic participants (bikes, bicycles, walkers, etc.) without any support from roadside infrastructure.

This clause gives basic definitions related to VDSs.

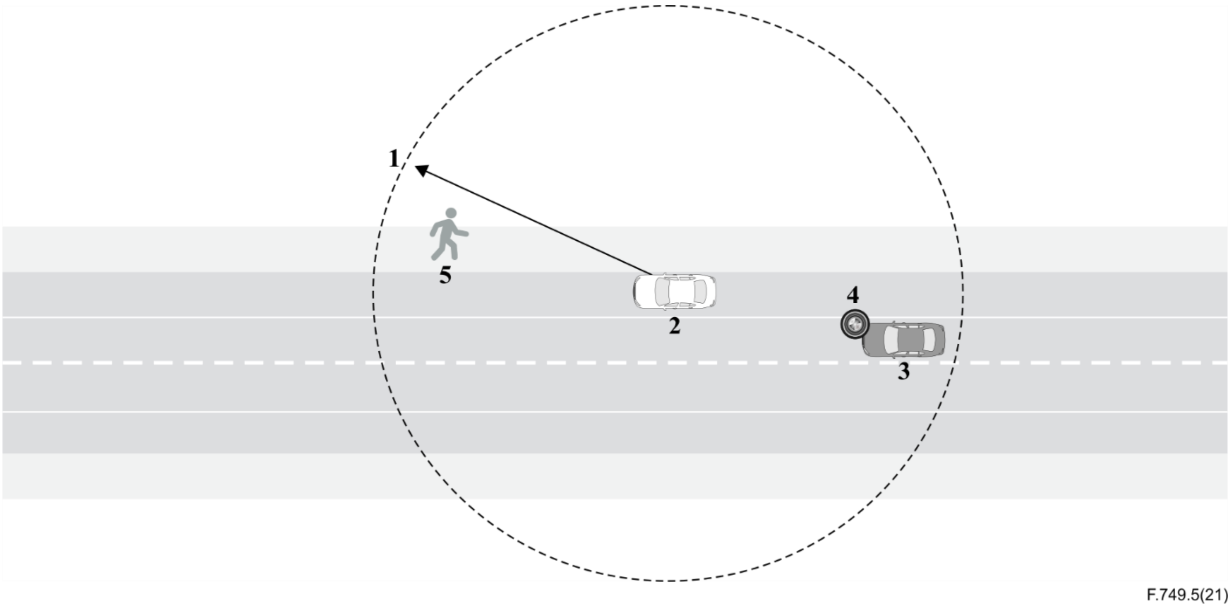
6.2 Vehicle domain service

The master vehicle (MV) generates a vehicle-domain network. Surrounding participants, such as vehicles, bikes and walkers, join that network as domain actors (DAs). Various types of sensor with which participants are equipped could also join it as additional actors. The MV may provide VDSs to the actors participating in its domain service network.

VDS1-001 – Vehicle domain service

{
If a vehicle is the master vehicle of the vehicle domain, it should provide vehicle domain services to domain actors.
}

Figure 2 shows a basic VDS. The MV communicates with DAs, such as domain vehicles (DVs), sensors and participants. The MV provides VDSs and DA respond to them.



Key

1 Vehicle domain 2 Master vehicle 3 Domain vehicle 4 Domain sensor 5 Domain participant

Figure 2 – Basic vehicle domain service

The minimum structure of a VDS consists of one MV and one DA. The field in which the VD is located includes everywhere the vehicle goes, such as a road that carries traffic, public parking area and private garage.

VDS implementation depends on the decision of the original equipment manufacturer (OEM). Activation of an implemented VDS function depends on the decision of the user or owner, local regulation or other rules before driving.

6.3 Vehicle domain dynamic map service

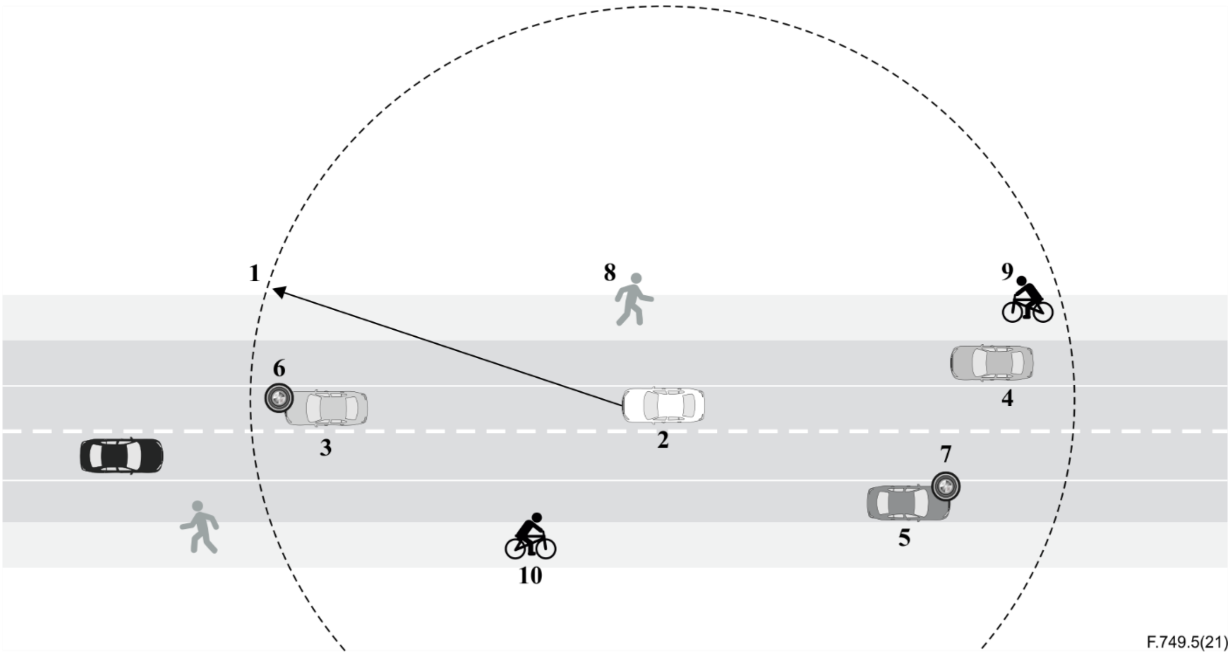
The most typical and original VDS is the vehicle domain dynamic map (VDDM) service, which is applied to vehicle driving with no restriction of location, i.e., on the road, street, freeway, public parking area and private road.

The MV collects relevant information from all DAs. Domain sensors (DSs) report acquired information about silent traffic participants and conditions instead of DAs. The MV generates dynamic map information within the VD. The MV provides VDDM-based services to DAs.

VDS1-002 – Vehicle domain dynamic map service

{
The master vehicle should provide vehicle domain dynamic map services to domain actors.
}

Figure 3 shows a typical vehicle domain dynamic map service (VDDMS). The MV communicates with the DAs, such as DVs, sensors and participants. The MV provides VDDM services and DAs respond to them.



Key

1	Vehicle domain	2	Master vehicle	3	Domain vehicle 1	4	Domain vehicle 2	5	Domain vehicle 3
6	Domain sensor 1	7	Domain sensor 2	8	Domain participant 1	9	Domain participant 2	10	Domain participant 3

Figure 3 – Typical vehicle domain dynamic map service

6.4 Variations in vehicle domain services

6.4.1 Basic vehicle domain service functions

VDS basic functions include collecting and processing traffic and driving information. Generated information services are used to improve recognition of traffic situations and driving behaviour decisions.

These kinds of generated information provided in virtual map format consist of information about dynamic actors, such as vehicles and participants, and static high-definition road features. This is defined as a VDDM.

To perform various functions, VDS has multiple services, as follows.

– Vehicle domain registration: the MV calls DAs to participate in its domain. A DA responds to the MV and exchange credentials. If mutual identification processes are successfully completed, a secure connection shared by the MV and DA is generated.

– Traffic explorer: the MV collects traffic information by communicating with the DAs. The traffic information collected is the synchronized position and other information of the DAs around the MV or information potentially related to the driving behaviour of the MV.

– Traffic reporter: the MV reports the collected local traffic information, obtained by the traffic explorer service, to the other traffic servers, such as a central dynamic map operator or another VD server. It is shared to update the latest status and can be reused in a similar use case of another MV.

– Manoeuvre coordinator: the MV generates its driving manoeuvre plan, it consists of a series of position data with synchronization times. The MV sends it to the relevant DV and request the corresponding plan of the DV. The MV and DV share their driving manoeuvre plan to get agreement or negotiate the coexistence of their plans. If it is successful, the planned driving manoeuvre is performed safely with their mutual understanding.

6.4.2 Vehicle domain registration service

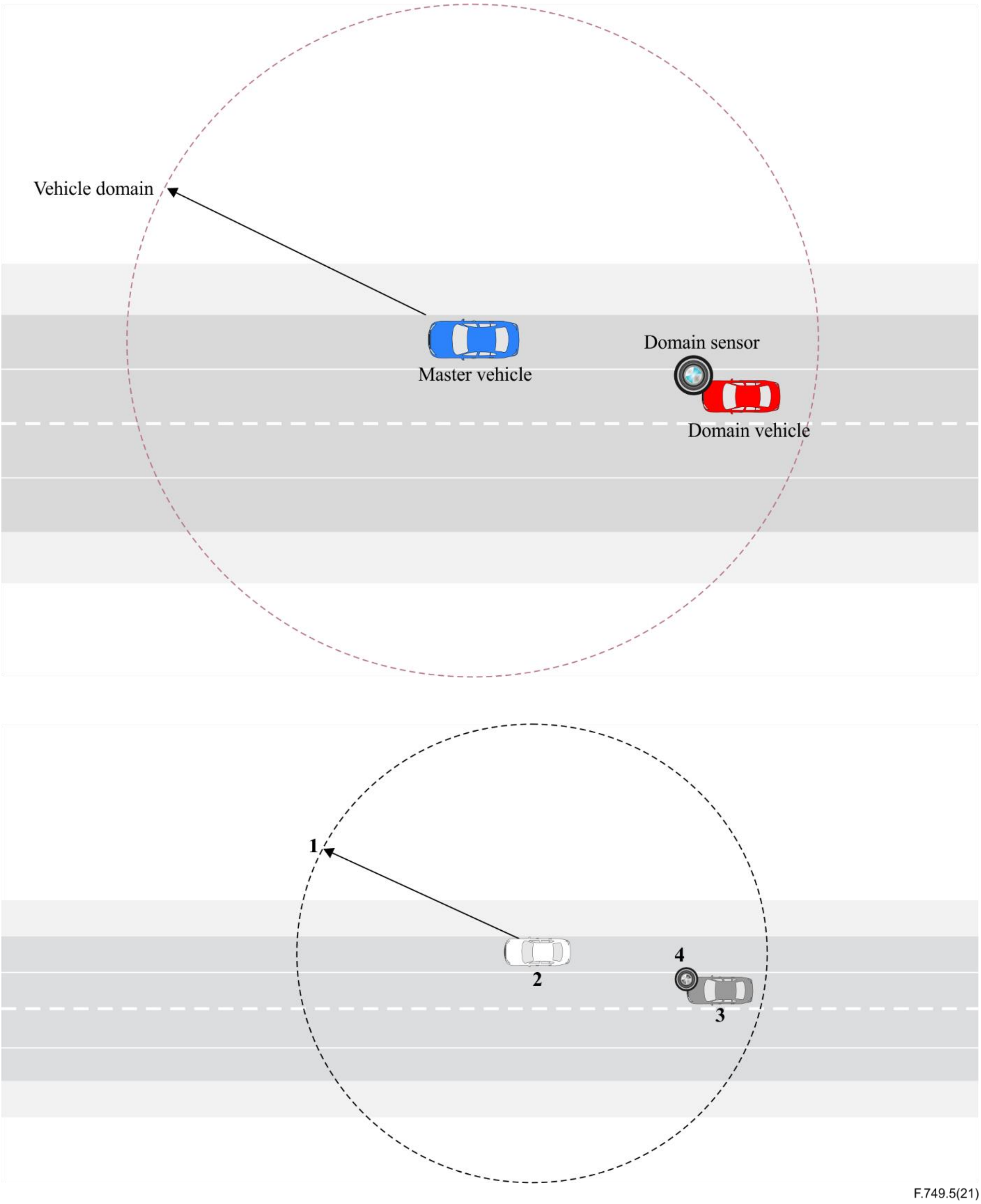
The MV provides the following VDS.

VDS1-003 – Vehicle domain registration service

{
The master vehicle should support the vehicle domain registration service.
}

Figure 4 shows a typical VD registration service. The MV calls neighbouring vehicles and traffic participants to join a VD. For example, the vehicle in the rear position is able to join the invited VD by registering. If the registration is successful, the vehicle in the rear position joins the VD as a DV. Details of procedures will be provided in the series document.

If the entity of the sensor is also registered, it joins the VD as a DS.



Key

1 Vehicle domain 2 Master vehicle 3 Domain vehicle 4 Domain sensor

Figure 4 – Typical vehicle domain registration service

The VD has the driving plan of the MV. The driving plan is a kind of driving schedule with a longer period than a driving manoeuvre, such as "turn right at the intersection 1 km away". If the driving plan of a DV differs from that of the VD, the DV exits from the VD and generate its own VD.

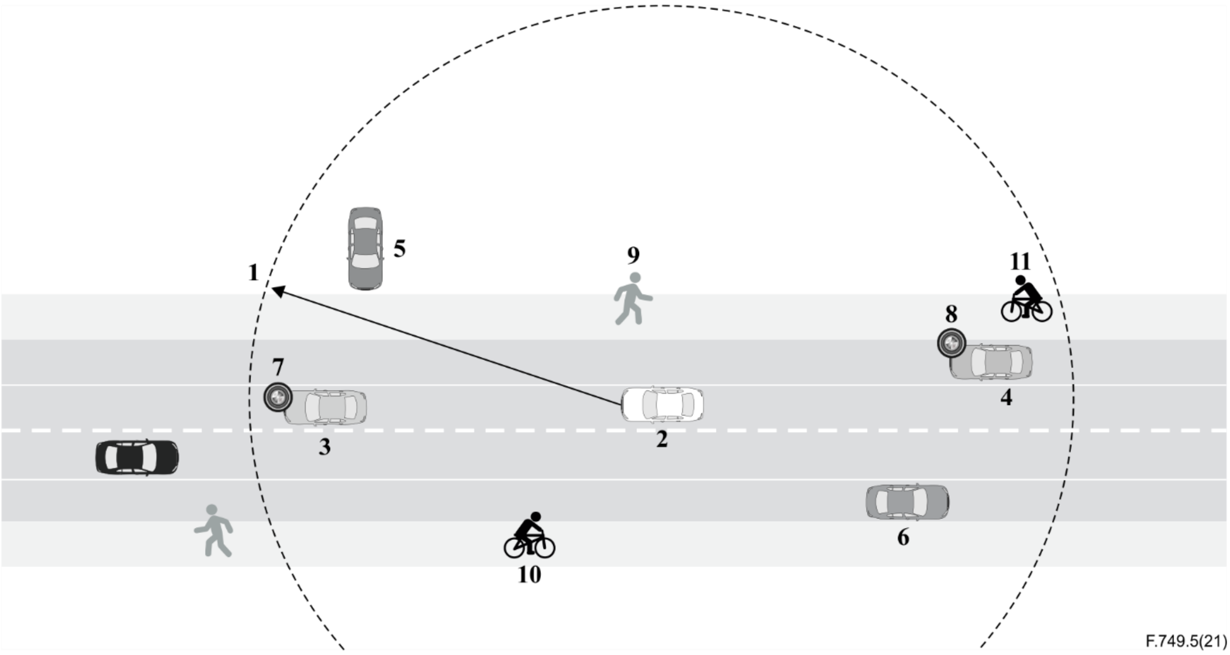
6.4.3 Traffic explorer service

The MV provides the following VDS.

VDS1-004 – Traffic explorer service

{
The master vehicle should support the traffic explorer service.
}

Figure 5 shows a typical traffic explorer service. The MV asks DAs for specific parameters (type, dimensions) and measured parameters (position, speed) calibrated with VDS master time. The DA responds to it with synchronized information. The MV creates a VD map.



Key

1	Vehicle domain	2	Master vehicle	3	Domain vehicle 1	4	Domain vehicle 2
5	Domain vehicle 3	6	Domain vehicle 4	7	Domain sensor 1	8	Domain sensor 2
9	Domain participant 1	10	Domain participant 2	11	Domain participant 3		

Figure 5 – Typical traffic explorer service

In order to generate a VDDM, the MV asks each DA to provide a list of its properties. All property tables with responses to the MV are required to be synchronized to the domain master time provided by the MV.

As one important procedure of VDDM generation, it is necessary that collected properties be mutually validated. If validation is successful, the property status changes to trustable.

VDS1-005 – Validation of vehicle domain map

{
The master vehicle should validate vehicle domain map to be trusted.
}

More detailed procedures will be provided in another document part of the series document set.

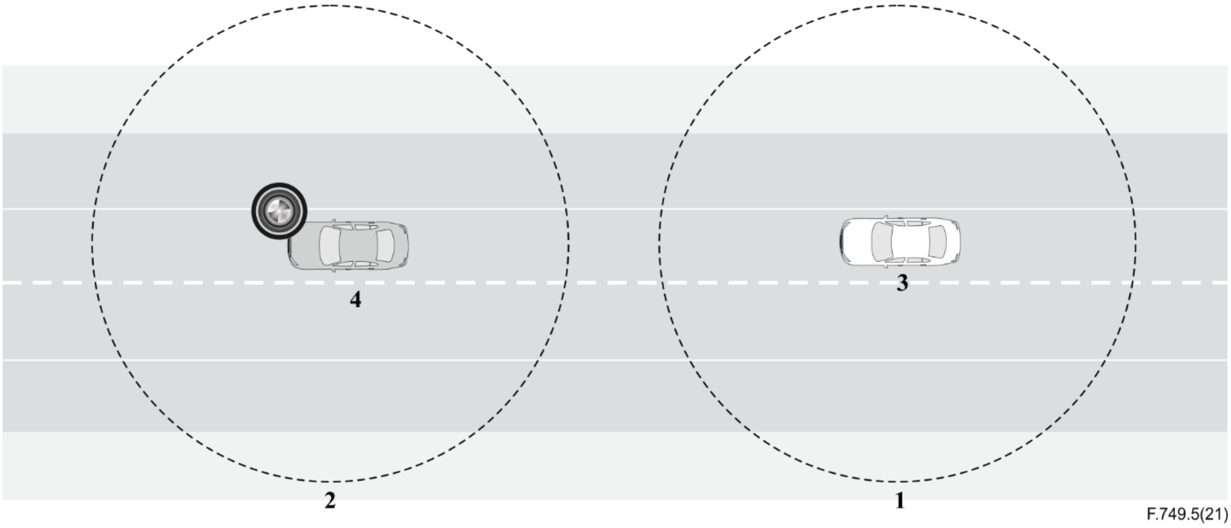
6.4.4 Traffic reporter service

The MV provides the following VDS.

VDS1-006 – Traffic reporter service

{
The master vehicle should support the traffic reporter service.
}

Figure 6 shows a typical traffic reporter service. There are multiple MVs driving on the road. MVs create their VDS map information. They report some part of VDS maps to other MVs if foresight information is included. Additionally, they also send the map report created to a central local dynamic map (LDM) server to update it.



Key
1 Vehicle domain 1 2 Vehicle domain 2 3 Master vehicle 1 4 Master vehicle 2

Figure 6 – Typical traffic reporter service

Before MV1 builds up VD1, it searches for neighbouring VDs. MV1 finds VD2 and its driving plan matches that of MV1; MV1 joins VD2. If its driving plan differs and it is better to establish VD1, MV1does so with a different driving plan from VD2. Details of sequences will be defined in subsequent Recommendations in the series.

Basically, a traffic reporter service has a valid direction and an area for the receiver of the VD. The MV and DAs within the VD are driving forward and never encounter incidents happening at the back of the VD. Also, it is inappropriate for other VDs driving in the opposite direction in the opposing lane to receive the traffic reporter service.

A vehicle domain service exchanges a lot of messages; restricting communication media access to valid information has a significant effect on efficiency of communication.

VDS1-007 – Selected media access of vehicle domain service

{
The vehicle domain service should be transmitted only to valid receivers.
}

One typical schema for selected access is filtering access control. A couple of schemas will be prepared for VDS message exchange. More detailed procedures will be provided in a subsequent Recommendation in the series.

NOTE – There exists no contradiction between an extended vehicle service and a traffic reporter of a VDS. Vehicle-to-everything solutions could exist in many ways depending on the requirements of each market.

6.4.5 Manoeuvre coordinator service

The MV provides the following VDS.

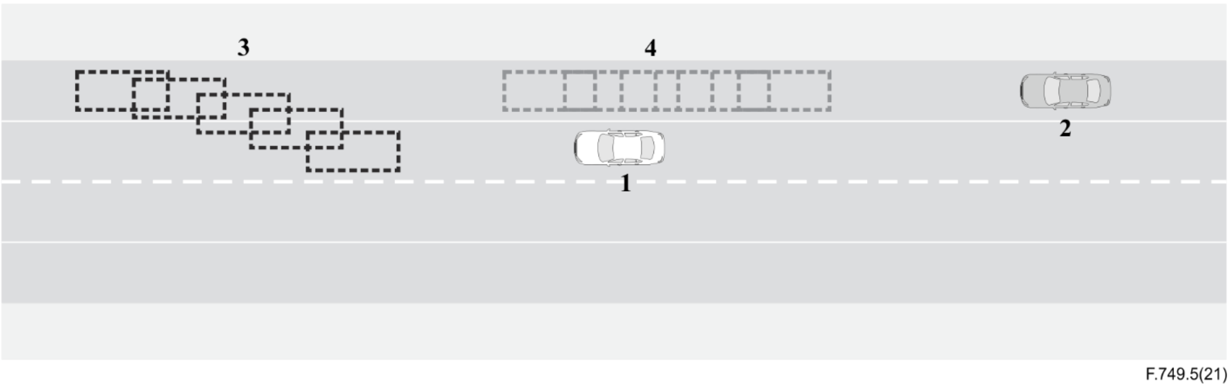
VDS1-008 – Manoeuvre coordinator service

{
The master vehicle should support the manoeuvre coordinator service.
}

Figure 7 shows a typical manoeuvre coordinator service. The MV generates its manoeuvre plan with the VDS master time. DVs respond to it with the synchronized estimated information.

In general, typical driving processes consist of the recognition, decision and operation stages. The process of recognition of the traffic situation and making the most appropriate and safest driving decisions is named as the preparation stage. For example, if the preparation stage takes 5 s and the following operation stage takes the same time, the MV generates its driving manoeuvre plan starting from its position of 5 s later, which is the end of preparation stage with following positions of 1 s durations, labelled 3 in Figure 7. The MV asks the following DV about its relevant manoeuvre plan. The DV responds with the requested driving manoeuvre plan, labelled 4 in Figure 7. The starting time of each driving manoeuvre plan or U-turn is adjusted, if necessary.

The whole driving manoeuvre negotiation process requires successful completion within the preparation stage. This indicates that the VDS includes this service and will be implemented with the next generation of communication technology with faster speed, wider traffic bands and lower latency. VDS communication is definitely different from existing broadcast message flow.



Key

1 Master vehicle 2 Domain vehicle 3 Master vehicle's driving manoeuvre plan 4 Domain vehicle's driving manoeuvre plan

Figure 7 – Typical manoeuvre coordinator service

In some cases, it is necessary for the MV and the DV to arrange their manoeuvre plan. Negotiated plans are authorized by the agent responsible for driving, such as the driver or automated driving manager. Judgement criteria for arrangement necessity, basic manoeuvre priorities, as well as negotiation strategy and authorization sequence requirements lie outside the scope of this Recommendation; they are addressed to other activities.

6.4.6 Scenario variations of vehicle domain service

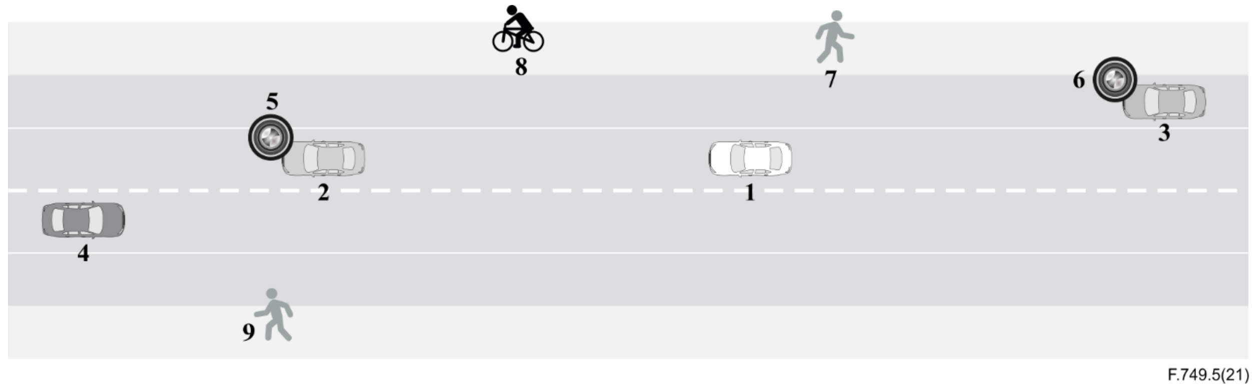
In addition to service types, traffic conditions and road geometry greatly influence a VDS scenario. The following examples show representative service scenarios. Other examples are provided in Appendix I.

All service scenarios are incorporated into each business use case (BUC), all to be covered as an element of the system use case (SUC). For BUCs and SUCs, see clauses 7 and 9, respectively.

VDS1-009 – Service scenarios and business and system use cases

{
The business use case and system use case element should cover all service scenarios.
}

Figure 8 shows a scenario example of a traffic explorer service. The MV is driving on a straight road, it collects relevant information from all nearby actors and generates a VD map.

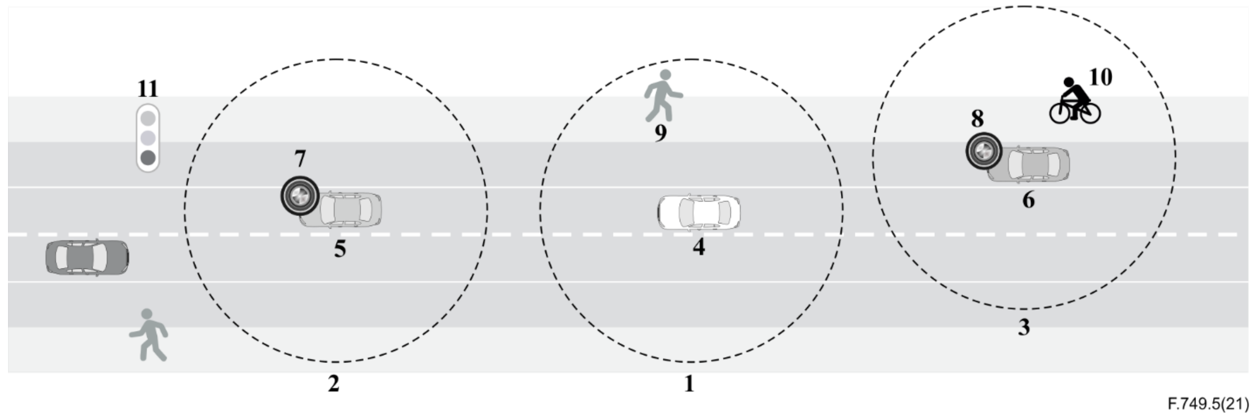


Key

1 Master vehicle 2 Domain vehicle 1 3 Domain vehicle 2 4 Domain vehicle 3 5 Domain sensor 1
6 Domain sensor 2 7 Domain participant 1 8 Domain participant 2 9 Domain participant 3

Figure 8 – Scenario of traffic explorer on straight road

Figure 9 shows a scenario example of a traffic reporter service. The MVs are driving on a straight road. MV2 generates its VD map, including a red traffic-light signal and relevant traffic status. It is issued as a traffic report to following MVs to communicate the current incoming traffic situation.

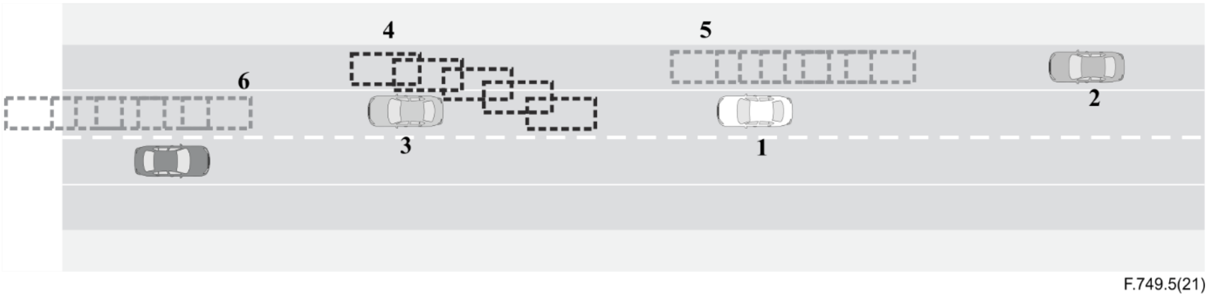


Key

1 Vehicle domain 1 2 Vehicle domain 2 3 Vehicle domain 3 4 Master vehicle 1 5 Master vehicle 2
6 Master vehicle 3 7 Domain sensor 1 (belongs to vehicle domain 2) 8 Domain sensor 2 (belongs to vehicle domain 3)
9 Domain participant 1 (belongs to vehicle domain 1) 10 Domain participant 2 (belongs to vehicle domain 3) 11 Red signal

Figure 9 – Scenario of traffic reporter of red signal

Figure 10 shows a scenario example of a manoeuvre coordinator service. The MV is driving on a straight road, it wants to make right-lane change. It generates a VD map and learns that manoeuvre coordination is necessary with DV1. The MV generates a manoeuvre plan for right-lane change with the VDS master time to coordinate it with DV1.



Key

1 Master vehicle	2 Domain vehicle 1	3 Domain vehicle 2	4 Driving manoeuvre of master vehicle
5 Driving manoeuvre of domain vehicle 1		6 Driving manoeuvre of domain vehicle 2	

Figure 10 – Scenario of manoeuvre coordinator of right lane change

These scenarios include the behaviour by actors with different responsibilities such as sending information, validating received information, following decisions and the driving actions to align to manoeuvres. All behaviours that are required by actors with different responsibilities are authorized and approved by the necessary authorities or actors with different responsibilities. Details of the different responsibilities lie outside the scope of this Recommendation.

6.5 Time synchronization in VDDMS

The VDS uses calibration of position information by synchronized time. This is applied to both the MV and DAs. The MV generates the VDS master synchronization time. The DAs respond to the MV with their calibrated information by synchronizing to it.

VDS1-010 – VDS master time generation

{
The master vehicle should generate the VDS master time as the standard time of response information by the domain actors.
}

VDS1-011 – Time synchronization in VDS

{
The domain actors should respond to the master vehicle their information calibrated by synchronizing to the VDS master time sent by the master vehicle.
}

The vehicle-domain service master time is generated on universal time (UTC) and adjusted by the network time protocol (NTP) defined in [b-IETF RFC 5905] or the precision time protocol (PTP) defined in [b-IEEE 1588].

NOTE 1 – The VDS master time is defined in detail in a subsequent Recommendation in the series.

NOTE 2 – Functional safety has no relation to time synchronization based on the VDS master time.

6.6 Other variations of vehicle domain services

6.6.1 Vehicle domain digital key service

Providing digital key service, the MV issues various types of digital key message to the customer, one per domain participant (DP). The secure protected and packaged message for the digital key is generated by the MV and sent to the customer. The message is received by the customer with their mobile device, extracted to the functional application of the digital key on the customer's mobile device. The digital key services are only applied to stopped or parked vehicles, they are never activated while the vehicle is driving.

VDS1-012 – Vehicle domain digital key service

{
The master vehicle may provide vehicle domain digital key services to a domain participant.
}

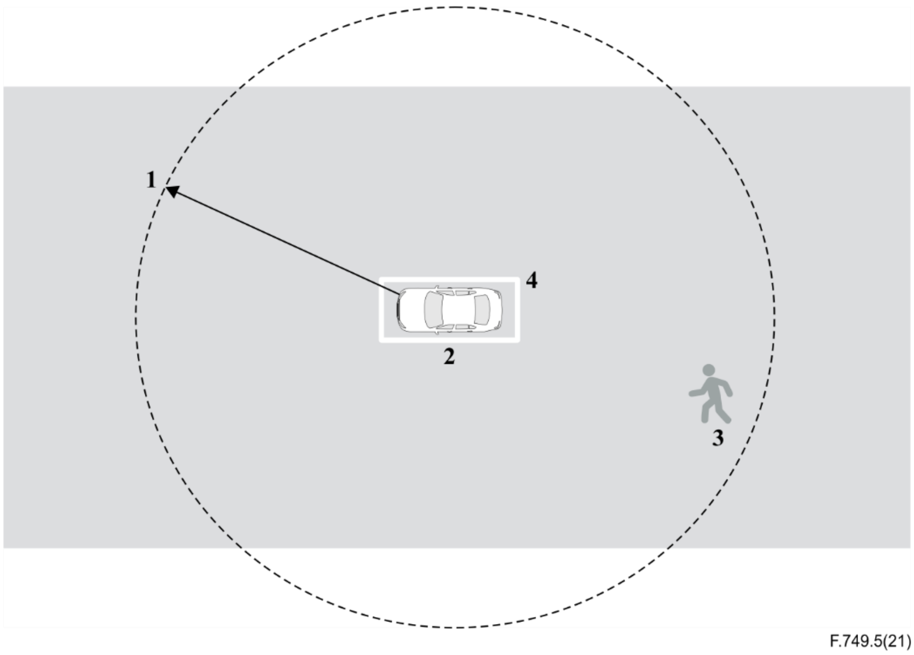
There exist some variations in digital key service according to their objects. General digital key services have different access control of vehicle functions with restricted time durations. Typical variations are as follows.

– Car-sharing key service: the MV issues the digital key service with full access control of vehicle functions with a restricted time duration linked to car rental or sharing period, such as from 3 days to 1 week. The customer receives the digital key application from the MV, and it will work as the vehicle key device within the car sharing period. It is not necessary for operators to hand over a vehicle key to their customer.

– Valet parking key service: the MV issues the digital key service with access only to the driving function, without private space access such as glove box or trunk room and with a very restricted time duration necessary for driving to a parking area, typically less than 30 min. It is not necessary for the customer to hand over a fully functional vehicle key to valet parking operators.

– Private delivery box key service: the MV issues the digital key service with access only to the vehicle trunk room, there is no driving function with specified time duration negotiated as delivery time of luggage delivery. The delivery service operator receives a private delivery-box key from the MV and is enabled access to its trunk room as a private delivery box.

Figure 11 shows a typical VD digital key service. The MV stops in a public or private, permanent or temporary parking area and communicates with the mobile device belonging to the DP.



Key

1 Vehicle domain 2 Master vehicle 3 Domain participant 4 Parking lot

Figure 11 – Typical vehicle domain digital key service

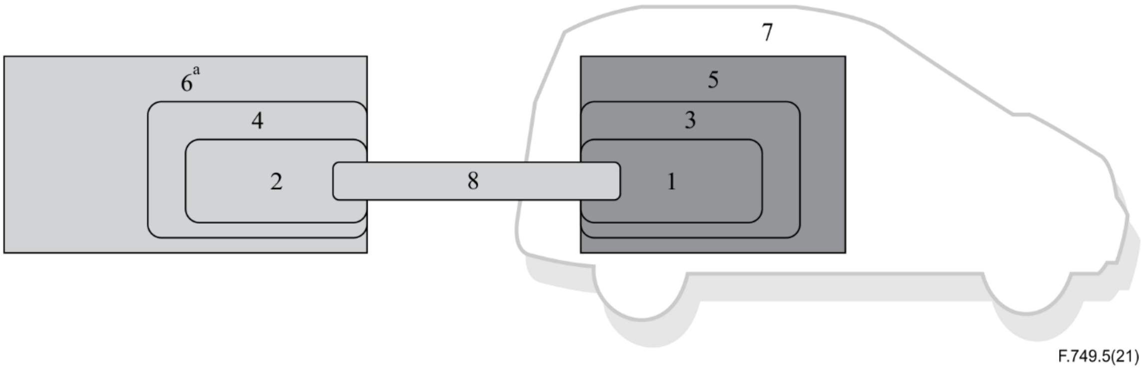
6.7 System architecture of vehicle domain services

6.7.1 General

This clause specifies the system architecture of the VDS. The main functions of the VDS are implemented in the MV; it cooperates with the DAs on the connection link between domain master and actors. The functions introduced are higher layer ones and they do not restrict physical controllers or the component structure implemented in a vehicle.

6.7.2 Basic system architecture of vehicle domain service

The VD system is one network subsystem generated by the MV. It consists of the MV, DAs and connecting service-link channel. The implemented functions of the domain master and actors are provided by the VDS and the vehicle domain actor (VDA) applications. Each application interface is connected to the service-link channel via each side of the service-link controllers. The service link-controller provides a connecting interface for all communication layers, messages, data formats and other schemas. Figure 12 shows a logical model example of the basic system architecture of the VDS.



Key

1 Domain master service link controller
2 Domain actor service link controller
3 Vehicle domain service application
4 Vehicle domain actor application
5 Vehicle domain server
6 Vehicle domain actor
7 Master vehicle
8 Service link channel

NOTE – This figure illustrates the representative domain actor group. A vehicle domain actor can consist of vehicles, sensors and participants.

Figure 12 – Basic system architecture of VDS

VDS1-013 – Basic system architecture of vehicle domain service

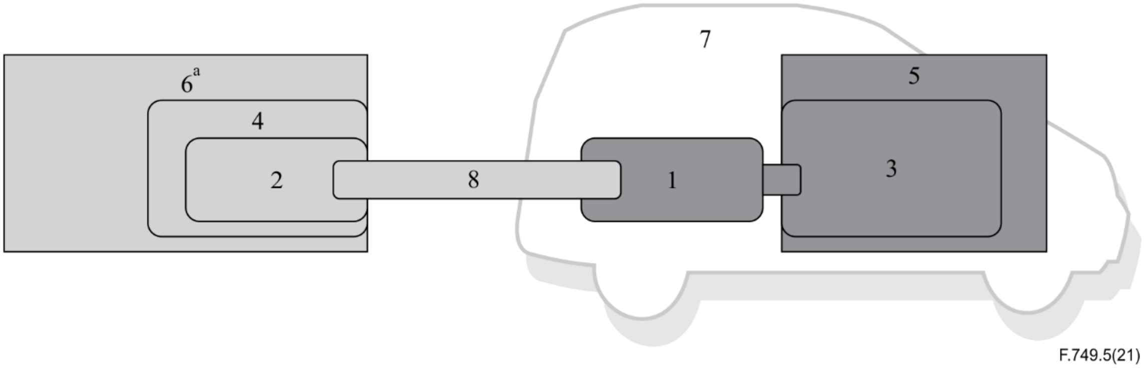
{
The master vehicle should communicate with the domain actors by service-link channel via each side of the service link controller.
}

NOTE 1 – The scope of this document is the definition of the VDS application implemented in a vehicle.

NOTE 2 – This document only focuses on that definition. The logical architecture model of the VDS does not lead to any constraint in relation to the vehicle electronic architecture design and that does not interfere with the OEM responsibility in that area.

6.7.3 Typical system architecture variation of vehicle domain service

The VDS application communicates with the service link channel via the service link controller. The life cycle of the vehicle is longer than the lifetime of communication technologies in general, so if the VDS is selected for implementation by manufacturers, the server application, functions and technologies are recommended for preparation for future updates. The server application will be changed by software updates. Some communication generation technologies will be changed by a controller replacement, which means the service-link controller of the domain master is designed to be connected to a VDS unit with a general connecting bus and to be easily replaced. Figure 13 shows a typical system architecture variation of the VDS prepared for future update.



Key

1	Domain master service link controller	2	Domain actor service link controller
3	Vehicle domain service application	4	Vehicle domain actor application
5	Vehicle domain server 6 Vehicle domain actor	7	Master vehicle 8 Service link channel

NOTE – This figure illustrates the representative domain actor group. A vehicle domain actor can consist of vehicles, sensors and participants.

Figure 13 – Typical system architecture of VDS for future update

VDS1-014 – Typical system architecture of VDS for future update

{
The service link controller of the VDS should be designed to be easily replaced for the future updates.
}

The updates in this policy will cover a variety of possible aspects, including functional, software and security.

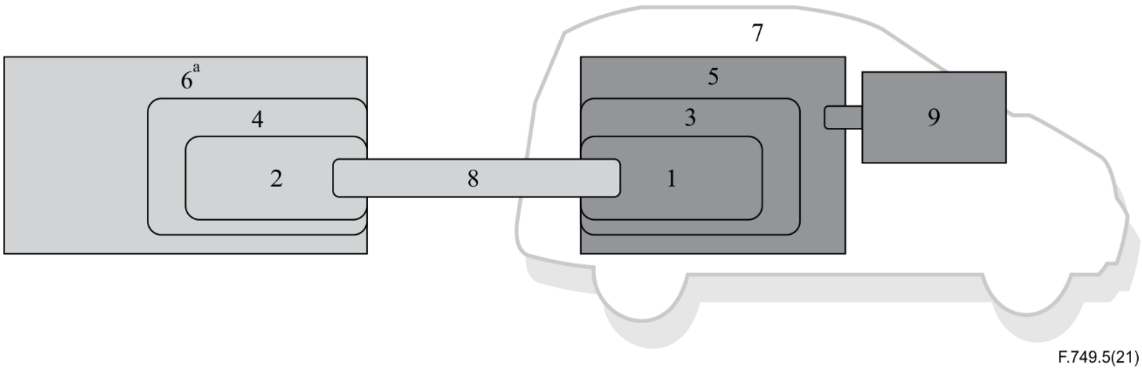
The domain master or DA service-link controller implemented in the vehicle is required to prepare for future updates. Other DA service link controllers are required to prepare for future updates, if necessary. In general, DA service link controllers for DPs have almost the same lifetime as their communication technology, so it is not required to prepare for future updates.

6.7.4 Vehicle domain service on a vehicle multimedia service

The VDS application communicates with the VDA application via the service-link channel and service-link controllers. These communications belong to the outside communication category group, and these are the main scope of the VDS.

On the other hand, the VDS outputs some information via the human/machine interface (HMI) for the vehicle driver. The contents of the information depend on the VDS provided. The information flow between the HMI and vehicle driver is implemented under OEM responsibility. If the OEM selected implementation of the VDS at level 4 [b-SAE] or a higher-level automated driving system, that information flow consists of both visual moving pictures and acoustic sound, real time and bidirectional, free from driver distraction.

The original output between VDS and a vehicle multimedia service (VMS) is based on messages on the internal communication. Those bidirectional digital messages are translated in the VMS to interact with the vehicle driver. Figure 14 shows a typical system architecture of the VDS connected to the VMS.



Key

1 Domain master service link controller
2 Domain actor service link controller
3 Vehicle domain service application
4 Vehicle domain actor application
5 Vehicle domain server
6 Vehicle domain actor
7 Master vehicle
8 Service link channel
9 Vehicle multimedia service

NOTE – This figure illustrates the representative domain actor group. A vehicle domain actor can consist of vehicles, sensors and participants.

Figure 14 – Vehicle domain service on vehicle multimedia service

The design of the HMI for drivers is clearly under the responsibility of the manufacturer. Figure 14 only provides a typical logical example model of internal connection between the VDS and VMS.

VDS1-015 – Vehicle domain service on vehicle multimedia service

{
The vehicle domain service may provide various information to the driver via the vehicle multimedia service in the vehicle.
}

NOTE – The domain sensor connection is a kind of vehicle multimedia service outside the vehicle.

A more detailed reference model between VDS and VMS is available in Appendix III.

6.8 Network operators related to VDS

The VDS requires some information support by various operators in the smart city traffic network. They gather relevant information reported by the VDS or other data collecting services, process them applying local regulation or optimizing policy and issue updated requests to the local network subsystems. These service operators outside of the VDS are classed as secondary actors. The MV and DAs inside the VDS are classed as primary actors (PAs). Typical examples of these operators are the following.

– Traffic operator: the traffic operation server generates traffic control rules in order to optimize traffic density and the length of traffic jams. Their controllable traffic rules are the setting of the priority lane and accessible area, timing of traffic signal and so on.
– Traffic monitor (TM): the TM server covers the middle range area in the network directory domain and geographical position in the city and gathers local traffic information reported by neighbouring VDSs. It issues a summary report to the central local dynamic server in order to refresh the latest situation. At the same time, it issues some attention or warning report to PAs. It gathers relevant information from the VDS or other system, validates the situation with some rules and policies to generate and issue official reports.
– User information server: the secured user accounts and relevant information database server covers the central control of the city and smart city traffic network system. General access to fully separated personal information is strictly restricted. It is allowed only to the super account of government level, used to identify user specific information by public unsigned information of the VDS.

It is possible to implement other operation servers in the smart city traffic services.

VDS1-016 – Network operators and VDS

{
The master vehicle should communicate and cooperate with various network operators in order to provide vehicle domain services.
}

The implementation of the VDS depends on an OEM decision. The customer decides on activation of the VDS function for each vehicle. The customer who wants to activate the VDS function selects whether information about the vehicle is sent to some network operators with the reception of additional benefits of services provided by them.

Whether or not the customer selects that relevant information is sent, all communications of the VDS are guaranteed to be performed via a connection that is secure enough. The details of secure schemes will be provided in subsequent Recommendations in the series.

6.9 VDS in smart traffic architecture model proposal

Information processing of the general smart traffic is implemented by a multi-layer-like infrastructure. Information is collected in a home, a street, a town, a city, a state and in a country for the geographic expanse and is bundled up. Various types of traffic classifications exist in the information group of each area, such as customer usage, commercial service, business functionality, public transport and central information manager that are mixed and act according to an individual rule of every group and form an overall traffic transport.

The infrastructure of smart traffic is implemented in a multi-layer form in order to process complicated multi-layered traffic information functionally and effectively. Therefore, the use is recommended of the figure of two-dimensional placement that constitutes an area and a function as both axes if modelling these information processes and defining use cases for further standardization by a general systematic approach. This technique is already applied to smart grid electricity transfer networks and is well known as a successful example of the systematic approach for standardization activities.

Figure 15 shows a typical example of a smart traffic architecture model proposal (STAMP) that plots a horizontal axis of area with a vertical axis of function. The classification summary of both axes is as follows.

Vertical axis:

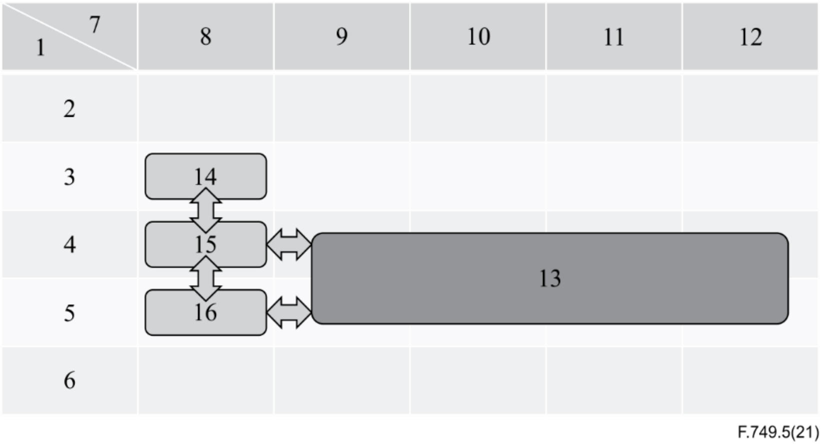
– home: processing of information about traffic to the home or the area around the home;
– town/street: processing of information about traffic in the town or street area;
– city: processing of information about traffic in a city area;
– state: processing of information about traffic in a state or area containing multiple cities;
– country: processing of information about traffic in a country area.

Horizontal axis:

– customer travel: processing of information about traffic involving customer usage of vehicles such as personal driving;
– commercial/consumer travel: processing of information about traffic involving commercial services such as taxi or car sharing;
– business transportation: processing of information about traffic for commercial objectives such as logistics, transport or delivery to home;
– public transportation: processing of information about traffic for public transport such as bus or train;

– traffic management: processing of information about traffic control such as traffic monitoring.

The conventional infrastructure information model focuses only on the contents and not the structure of information, so that it only provides a simple and individual one-dimensional model. In a systematic approach, a hierarchical function of the smart traffic information processing is generalized by modelling the infrastructure implementation to define functions and processes of traffic information for further standardization.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

Smart traffic entities

13	Vehicle domain service	14	Smart city traffic manager
15	Traffic control operator	16	Traffic monitor operator

Figure 15 – Smart traffic architecture model proposal

Additional examples of a STAMP are provided in Appendix II.

The development of such a logical traffic information model lies outside the scope of this document. It is introduced in order to derive recommended implementation policy for the VDS.

The VDS is allocated in STAMP as a low-end model of smart traffic information process. It indicates that the VDS implemented in vehicles belonging to different business domains such as consumer car, taxi, logistic truck and public transporter, will have unique communication interfaces.

VDS1-017 – VDS in STAMP

{
The VDS should be defined to have unique communication interface for the relevant parts in STAMP.
}

Detailed specifications of the VDS unified communication interface will be provided in subsequent Recommendations in the series.

6.10 Information security in VDS

The VDS is specified with a couple of security schemata in order to ensure security and the safety of the information handled. The basic policy of VDS security is the following.

– VDS identification: before setting up a secure connection between the MV and the DA, the vehicle domain service account (VDSA) of the DA is evaluated and correctly accepted.
– Communication with ensured secure connection: the communication link applied to the VDS uses a secure schema with encryption of sufficient strength such as transport layer security (TLS), data encryption and other security methods.
– Fully separate public unsigned data from personal information: private specific data that directly enables identification of customer personal information is never included in VDS communication. Only the unsigned public property of the MV and actors is exchanged and gathered. Personal information is stored in a specific customer data base server, which can only be accessed by some restricted accounts.

A detailed security schema for VDS communication will be provided in subsequent Recommendations in the series.

VDS1-018 – VDS security

{
The communication channel of the VDS communication should be performed with a secure connection of enough strength.
}

VDS1-019 – Unsigned data policy of VDS

{
All the data contents exchanged by the VDS communication should only include unsigned public information.
}

NOTE 1 – Some vehicle identifiers (IDs) or actor IDs included in VDS that indirectly link to personal information are transformed to public unsigned information, which hides its indirect link from each actor.

NOTE 2 – The vehicle identification number (VIN), is the most used vehicle ID and it is applied to many existing vehicles and applications, A VIN is considered as a direct link to personal information, so is never included in VDS messages.

7 Business use cases for VDS

7.1 General

This clause gives the basic definitions of BUC s for VDSs.

In clause 6.4, some domain services provided by the MV are defined.

7.2 Business use case of vehicle domain registration

The MV establishes its VD and invites DAs. DAs join the VD with an authentication provided by the MV. The MV and DA establish a secure connection before starting other services.

VDS1-020 – BUC of vehicle domain registration

{
The master vehicle should provide the vehicle domain registration function of the VDS as defined in Table 1.
}

Table 1 – Business use case of vehicle domain registration

No.	Type	Description
1	Type of use case	Business UC
2	Use case ID – name	VDS-BUC-001 – Vehicle domain registration
3	Objectives	The master vehicle will accept the participation of domain actor in its VD.
4	Description	1) The master vehicle calls the domain actor to join its domain network service. 2) The domain actor will respond to the master vehicle and they will exchange credentials to validate each VDSA. 3) If authentication is successfully completed, the master vehicle and domain actor will establish secure connection.
5	Prerequisites	– The master vehicle is equipped with a VDS server. – The domain actors are equipped with VDS clients. – The master and actors communicate with each other through the VDS.
6	Operations	– The master vehicle sets up the vehicle domain service system (VDSS). – The master vehicle provides the VDS.
7	End conditions	– The master vehicle successfully initiates the VDS.

7.3 Business use case of traffic explorer

The MV gathers information from surrounding actors in order to acquire a traffic map and check its driving plan and manoeuvres. The MV sets up a VD as the MV, establishes communication links with participating DAs and exchanges relevant messages.

VDS1-021 – BUC of traffic explorer

{
The master vehicle should provide the traffic explorer function of the VDS as defined in Table 2.
}

Table 2 – Business use case of traffic explorer

No.	Type	Description
1	Type of use case	Business UC
2	Use case ID – name	VDS-BUC-002 – Traffic explorer
3	Objectives	The master vehicle acquires a complete map about the vehicle domain actors.
4	Description	1) The master vehicle establishes a VD. 2) The master vehicle requests map information from domain actors. 3) The domain actors respond to the master vehicle with the requested information. 4) The master vehicle validates the received responses to generate map information. 5) The master vehicle closes the VDS service and communication link.
5	Prerequisites	– The master vehicle is equipped with a VDS server. – The domain actors are equipped with VDS clients. – The master and actors communicate with each other through the VDS.

Table 2 – Business use case of traffic explorer

No.	Type	Description
6	Operations	– The master vehicle sets up the VDSS. – The master vehicle provides the VDS. – The master vehicle generates the VDDM.
7	End conditions	– The master vehicle successfully completes the VDDM.

7.4 Business use case of traffic reporter

The MV reports the acquired VD map to the other operators. One destination is the smart-city traffic manager (SCTM) in order to update the central LDM database. The other destinations surround other VDS MVs in order to reuse the original VDS map information as the shared map or the basis of an updated map.

VDS1-022 – BUC of traffic reporter

{
The master vehicle should provide the traffic explorer function of the VDS as defined in Table 3.
}

Table 3 – Business use case of traffic reporter

No.	Type	Description
1	Type of use case	Business UC
2	Use case ID – name	VDS-BUC-003 – Traffic reporter
3	Objectives	The master vehicle issues the traffic report.
4	Description	1) The master vehicle establishes a VD. 2) The master vehicle requests map information from domain actors. 3) The domain actors respond to the master vehicle with the requested information. 4) The master vehicle validates the received responses to generate map information. 5) The master vehicle issues the generated traffic status report. 6) The master vehicle closes the VDS service and communication link.
5	Prerequisites	– The master vehicle is equipped with a VDS server. – The domain actors are equipped with VDS clients. – The master and actors communicate with each other through the VDS.
6	Operations	– The master vehicle sets up the VDSS. – The master vehicle provides the VDS. – The master vehicle generates the VDDM. – The master vehicle issues the traffic status report.
7	End conditions	– The master vehicle successfully issues the traffic report.

7.5 Business use case of manoeuvre coordinator

The MV plans to perform some driving manoeuvres, such as start, acceleration, deceleration, stop, right/left turn or right/left lane change.

According to the result of analysis based on acquired traffic status, the next driving manoeuvre plan will be made. Sometimes it is necessary for other relevant DAs to agree or to negotiate with their driving plans. So, the MV asks the other DAs for a driving plan to reach an agreement or negotiation.

VDS1-023 – BUC of manoeuvre coordinator

{
The master vehicle should provide the manoeuvre coordinator function of the VDS as defined in Table 4.
}

Table 4 – Business use case of manoeuvre coordinator

No.	Type	Description
1	Type of use case	Business UC
2	Use case ID – name	VDS-BUC-004 – Manoeuvre coordinator
3	Objectives	The master vehicle makes agreement about its driving manoeuvre with other VDS entities.
4	Description	1) The master vehicle establishes a VD. 2) The master vehicle generates its driving manoeuvre plan. 3) The master vehicle asks to other VDS entities with the generated driving plan. 4) The domain actors respond to the master vehicle with their response to the proposed manoeuvre plan. 5) The master vehicle validates the received responses to negotiate with the manoeuvre plan. 6) The master vehicle closes the VDS service and communication link.
5	Prerequisites	– The master vehicle is equipped with a VDS server. – The domain actors are equipped with VDS clients. – The master and actors communicate with each other through the VDS.
6	Operations	– The master vehicle sets up the VDSS. – The master vehicle provides the VDS. – The master vehicle generates the VDDM. – The master vehicle agrees with domain vehicles about driving manoeuvre.
7	End conditions	– The master vehicle successfully completes the driving manoeuvre plan.

8 System sequences for VDS

8.1 General

This clause gives the SUC sequence by the method of detailing, dividing and classifying the process of BUCs. General texts divided and classified as the communication steps of a BUC are defined as SUCs, and are defined in clause 8.2.

Implementations of each SUC are specified in subsequent Recommendations in the series.

8.2 Basic elements of a general BUC

A typical BUC consists of following communication steps:

– VDS start: user or vehicle driving manager initiates VDS service with some triggers that consist of additional conditions;

– communication set up: the MV establishes a communication link with DAs;

– security set up: the MV establishes a secure communication link with DAs;

– VDS selection: the MV informs of the selected VD service to the DAs;

– VD data collection: the MV requests the relevant information of the DAs;

– VD status report: the MV issues the generated VDS information report to other VDS entities;
– driving manoeuvre query: the MV asks other DAs whether they accept the planned driving manoeuvre proposed by the MV;
– VDS stop: the MV terminates the VD service and informs the DAs of it.

The first four and the last elements are common and mandatory for all VDS implementations. Alternative selection from the fifth to seventh elements gives variations in the VDS.

Table 5 shows the basic elements of VDS BUCs.

Table 5 – Basic elements of the VDS business use cases

vehicle domain service start
communication set up
security set up
vehicle domain service selection
vehicle domain data collection
vehicle domain status report
driving manoeuvre query
vehicle domain service stop

VDS1-024 – Basic elements of VDS business use cases

{
The master vehicle should build up the VD service by integrating the basic elements of business use cases as defined in clause 8.2.
}

More details of these use case elements are described in Clause 9.

9 System use cases for VDS

9.1 General

This clause provides the basic definitions of SUCs for each BUC.

Fully detailed message form, data content definitions and application sequences are defined in subsequent Recommendations in the series.

9.2 System use case of VDS start

The user or a driving management controller uses the VDS to collect traffic information around the MV. A switch or other alternative trigger condition starts VD services.

VDS1-025 – SUC of VDS start

{
The master vehicle should perform the VDS start of SUC for VDS as defined in Table 6.
}

Table 6 – System use case of VDS start

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-001 – VDS start
3	Objectives	The user or driving management system in the master vehicle initiates VD services.
4	Description	1) The user operates some driving interface to initiate VD services. 2) The alternative driving management system in the master vehicle initiates VD services.
5	Prerequisites	– The master vehicle drives with no malfunctions. – Some of the domain actors exist around the master vehicle.
6	Operations	– The user will initiate VD services by user operation. – The driving management system will initiate VD services by some trigger conditions.
7	End conditions	– The master vehicle successfully initiated the VD services.

9.3 System use case of communication set up

The MV generates a VD network. Relevant traffic participants, such as vehicles, bikes and walkers join that network as DAs. The MV provides VDSs to the actors participating in the domain service network.

VDS1-026 – SUC of communication set up

{
The master vehicle should perform the communication set up of SUC for the VDS as defined in Table 7.
}

Table 7 – System use case of communication set up

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-002 – Communication set up
3	Objectives	The master vehicle establishes a communication link with other VDS entities.
4	Description	1) The master vehicle sends a connection request to other VDS entities. 2) The domain actors respond to the master vehicle. 3) The communication links between the master vehicle and domain actors are established.
5	Prerequisites	– VDS start process was successfully finished. – The master vehicle is ready to perform the communication set up process. – The domain actors are also ready to perform the communication set up process.
6	Operations	– The master vehicle is equipped with a communication set up function. – The domain actors are equipped with a communication set up function.
7	End conditions	– The master vehicle successfully established the communication link with domain actors.

9.4 System use case of security set up

The MV establishes a secure communication link on the established communication link. It is a mutual encryption schema using a certificate. Details of the security schema are defined in subsequent Recommendations in the series.

VDS1-027 – SUC of security set up

{
The master vehicle should perform the security set up of SUC for VDS as defined in Table 8.
}

Table 8 – System use case of security set up

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-003 – Security set up
3	Objectives	The master vehicle establishes secure communication link with other VDS entities.
4	Description	1) The master vehicle sends secure connection request to other VDS entities. 2) The domain actors respond to the master vehicle. 3) The secure communication links between the master vehicle and domain actors are established.
5	Prerequisites	– VDS communication link was successfully established. – The master vehicle is ready to perform security set up process. – The domain actors are also ready to perform security set up process.
6	Operations	– The master vehicle is equipped with security set up function. – The domain actors are equipped with security set up function.
7	End conditions	– The master vehicle successfully established the secure communication link with domain actors.

9.5 System use case of VDS selection

The MV selects the applied VD service. Other DAs are informed and it is agreed with them as the selected VDS function.

VDS1-028 – SUC of VDS selection

{
The master vehicle should perform a VDS selection of SUC for the VDS as defined in Table 9.
}

Table 9 – System use case of VDS selection

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-004 – VDS selection
3	Objectives	The master vehicle selects the applied VD service.
4	Description	1) The master vehicle sends the VDS selection request to other VDS entities. 2) The domain actors respond to the master vehicle. 3) The VDS selection is agreed.

Table 9 – System use case of VDS selection

No.	Type	Description
5	Prerequisites	– Security set up process was successfully finished. – The master vehicle is ready to perform the VDS selection process. – The domain actors are also ready to perform the VDS selection process.
6	Operations	– The master vehicle is equipped with a VDS selection function. – The domain actors are equipped with a VDS selection function.
7	End conditions	– The master vehicle successfully performs the VDS selection process.

9.6 System use case of VD data collection

The MV gathers relevant information about the DAs participating in its service domain. The MV requests some information synchronized to pointed standard timing.

VDS1-029 – SUC of VD data collection

{
The master vehicle should perform the VD data collection SUC for the VDS as defined in Table 10.
}

Table 10 – System use case of VD data collection

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-005 – VD data collection
3	Objectives	The master vehicle gathers the VD data from other VDS entities.
4	Description	1) The master vehicle sends a VD data collection request to other VDS entities. 2) The domain actors respond to the master vehicle. 3) The VD data collection is completed by receiving all the responses from the domain actors.
5	Prerequisites	– VD selection process was successfully finished. – The master vehicle is ready to perform the VD data collection process. – The domain actors are also ready to perform the VD data collection process.
6	Operations	– The master vehicle is equipped with a VD data collection function. – The domain actors are equipped with a VD data collection function.
7	End conditions	– The master vehicle successfully completed the VD data collection from the domain actors.

9.7 System use case of VD status report

The MV generates a VD status report. This report is sent to the SCTM in order to refresh the central LDM, and it will also be sent to surrounding VDS entities in order to reuse the basis of VD map information.

VDS1-030 – SUC of VD status report

{
The master vehicle should generate a VD status report of SUC for the VDS as defined in Table 11.
}

Table 11 – System use case of VD status report

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-006 – VD status report
3	Objectives	The master vehicle issues the traffic status report to other VDS entities.
4	Description	1) The master vehicle generates the traffic report based on the collected VDS information. 2) The master vehicle issues the traffic status report to other VDS entities. 3) Another master vehicle reuses this report as the basis of another VDS data collection.
5	Prerequisites	– VD selection process was successfully finished. – The master vehicle is ready to perform the VD status report process. – The domain actors are also ready to perform the VD status report process.
6	Operations	– The master vehicle is equipped with a VD status report function. – The domain actors are equipped with a VD status report function.
7	End conditions	– The master vehicle successfully issued the VD status report to other VDS entities.

9.8 System use case of driving manoeuvre query

The MV generates a driving manoeuvre plan. This plan should be accepted and negotiated with other DAs. The agreed manoeuvre plan is then sent to other VDS entities.

VDS1-031 – SUC of driving manoeuvre query

{
The master vehicle should send a driving manoeuvre query of SUC for the VDS as defined in Table 12.
}

Table 12 – System use case of driving manoeuvre query

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-007 – driving manoeuvre query
3	Objectives	The master vehicle establishes a communication link with the other VDS entities.
4	Description	1) The master vehicle sends the planned driving manoeuvre to the other VDS entities. 2) The domain actors respond to the master vehicle. 3) The planned driving manoeuvre of the master vehicle is agreed or negotiated with the other VDS entities.
5	Prerequisites	– VD selection process was successfully finished. – The master vehicle is ready to perform the driving manoeuvre query process. – The domain actors are also ready to perform the driving manoeuvre query process.
6	Operations	– The master vehicle is equipped with a driving manoeuvre query function. – The domain actors are equipped with a driving manoeuvre query function.

Table 12 – System use case of driving manoeuvre query

No.	Type	Description
7	End conditions	– The master vehicle successfully negotiated its driving manoeuvre plan with the other VDS entities.

9.9 System use case of VDS stop

The MV terminates the VD services. The other VDS entities are informed before the MV stops the VD services. The service is stopped, and security and communication links are terminated.

VDS1-032 – SUC of VDS stop

{
The master vehicle should perform the VDS stop of SUC for the VDS as defined in Table 13.
}

Table 13 – System use case of VDS stop

No.	Type	Description
1	Type of use case	System UC
2	Use case ID – name	VDS-SUC-008 – VDS stop
3	Objectives	The master vehicle terminates the VD services.
4	Description	1) The master vehicle terminates the VD services. 2) The master vehicle terminates the security links. 3) The master vehicle terminates the communication links.
5	Prerequisites	– Applied VDS services are successfully finished. – The master vehicle is ready to perform the VDS stop process. – The domain actors are also ready to perform the VDS stop process.
6	Operations	– The master vehicle is equipped with a VDS stop function. – The domain actors are equipped with a VDS stop function.
7	End conditions	– The master vehicle successfully terminated the VD services and communication links.

Appendix I

Scenario variations of vehicle domain dynamic map service

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

I.1 General

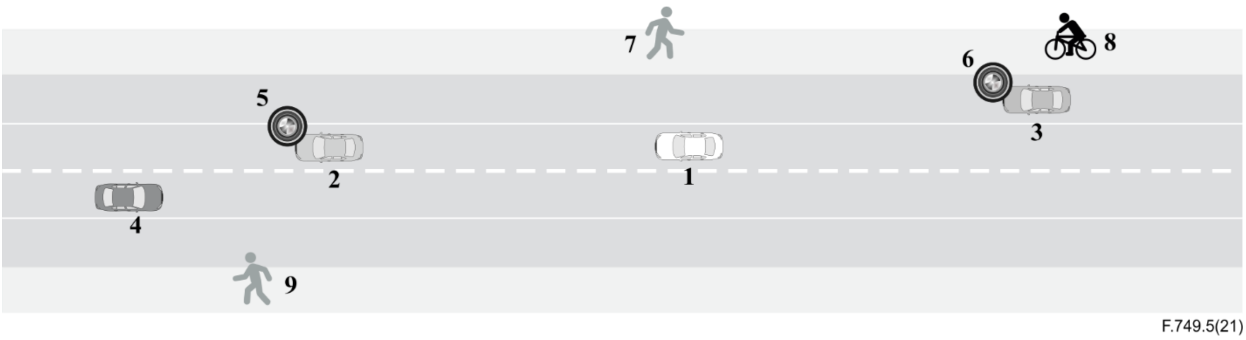
As described in clause 6.4.6, it is necessary to consider many service scenarios to pick up all BUCs and determine the system use elements.

Some of these scenarios include specific features for the VDS and others are very general, but expressed by PAs of VDS. All scenarios will be considered to derive detailed requirements for specification of implementation provided in subsequent Recommendations in the series.

I.2 Scenario examples of traffic explorer service

I.2.1 Scenario TE1: Traffic explorer on a straight road

Figure I.1 shows a typical scenario of a traffic explorer service on a straight road. The MV collects the response information from the DAs and generates a VDDM.



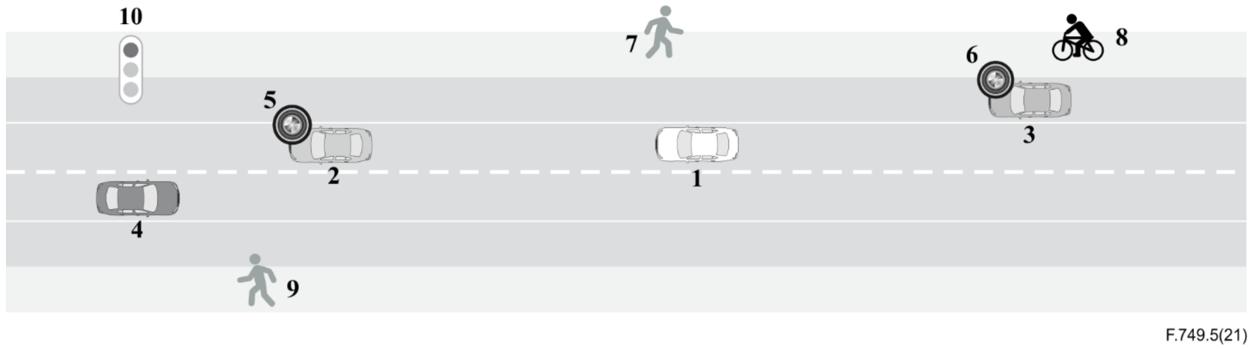
Key

1	Master vehicle	2	Domain vehicle 1	3	Domain vehicle 2	4	Domain vehicle 3	5	Domain sensor 1
6	Domain sensor 2	7	Domain participant 1	8	Domain participant 2	9	Domain participant 3		

Figure I.1 – Scenario TE1: Traffic explorer on a straight road

I.2.2 Scenario TE2: Traffic explorer on a straight road with a green signal

Figure I.2 shows a typical scenario of a traffic explorer service with a green signal on a straight road. DV1 responds with the driving status and domain sensor 1 responds with a green signal. The MV collects the response information from the DAs and generates a VDDM.



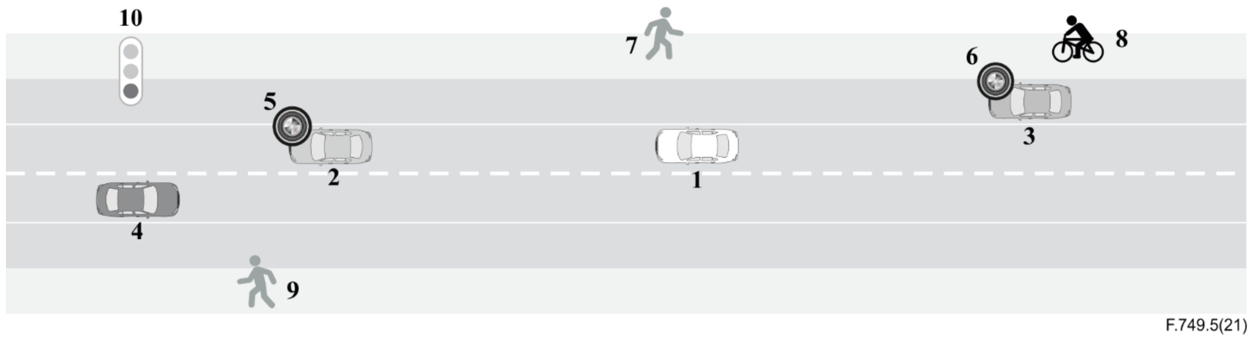
Key

1	Master vehicle	2	Domain vehicle 1	3	Domain vehicle 2	4	Domain vehicle 3	5	Domain sensor 1
6	Domain sensor 2	7	Domain participant 1	8	Domain participant 2	9	Domain participant 3	10	Green signal

Figure I.2 – Scenario TE2: Traffic explorer on a straight road with a green signal

I.2.3 Scenario TE3: Traffic explorer on a straight road with a red signal

Figure I.3 shows a typical scenario of a traffic explorer service with a red signal on a straight road. DV1 responds with a stopped status and the DS1 responds with a red signal. The MV collects the response information from the DAs and generates a VDDM.



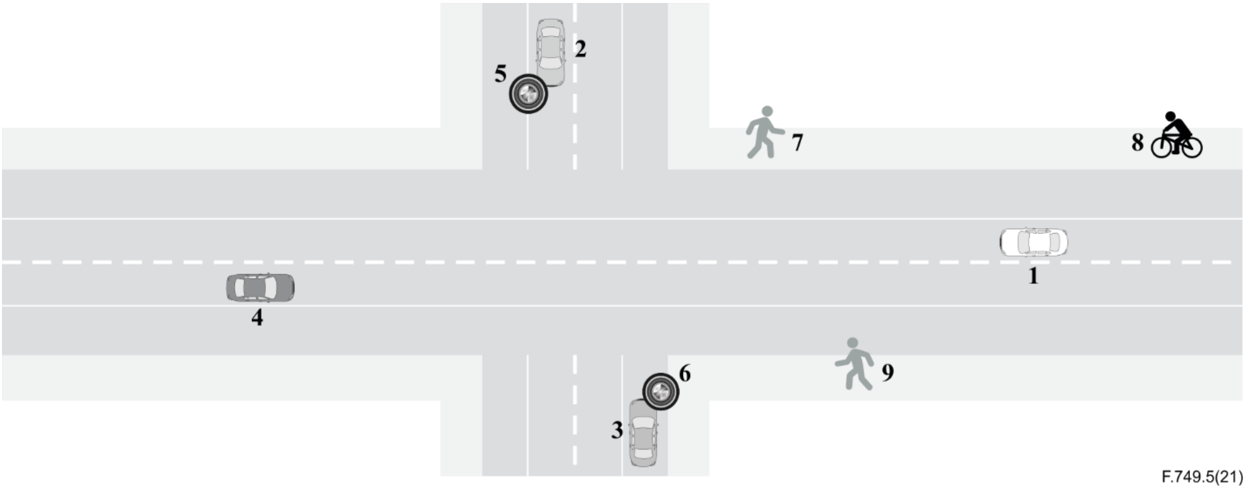
Key

1	Master vehicle	2	Domain vehicle 1	3	Domain vehicle 2	4	Domain vehicle 3	5	Domain sensor 1
6	Domain sensor 2	7	Domain participant 1	8	Domain participant 2	9	Domain participant 3	10	Red signal

Figure I.3 – Scenario TE3: Traffic explorer on straight road with a red signal

I.2.4 Scenario TE4: Traffic explorer crossing an intersection

Figure I.4 shows a typical scenario of the traffic explorer service for crossing an intersection without a signal. DV1, DV2, DS1 and DS2 respond with a crossing or waiting status. The MV collects the response information from the DAs and generates a VDDM.



Key

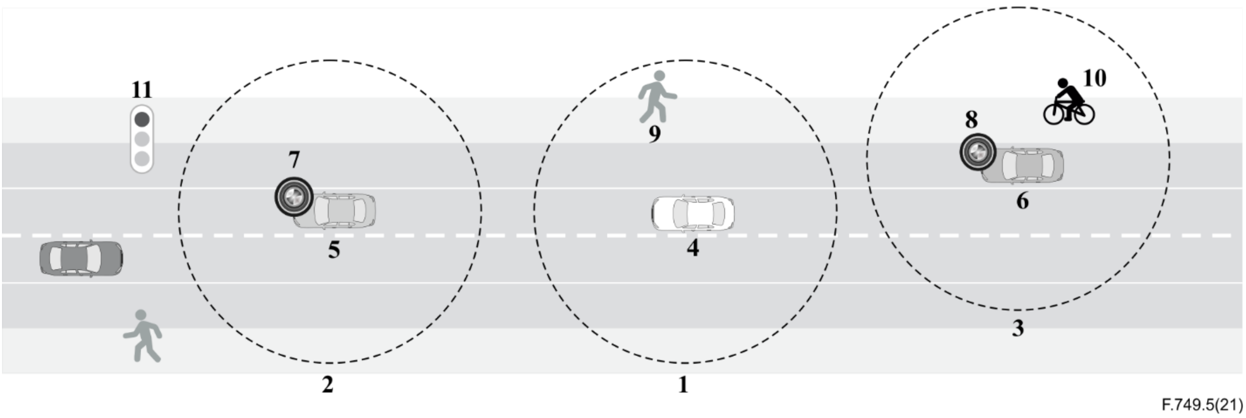
1 Master vehicle 2 Domain vehicle 1 3 Domain vehicle 2 4 Domain vehicle 3 5 Domain sensor 1
6 Domain sensor 2 7 Domain participant 1 8 Domain participant 2 9 Domain participant 3

Figure I.4 – Scenario TE4: Traffic explorer crossing an intersection

I.3 Scenario examples of traffic reporter service

I.3.1 Scenario TR1: Traffic signal reporting on a straight road

Figure I.5 shows a typical scenario of a traffic reporter service for signal status on a straight road. MV2 collects the response information from the DAs and generates a VD map. If a valid signal status is detected from the VD map, MV2 issues the traffic report to share with the neighbouring MVs. The MV1 and MV3 receive it.



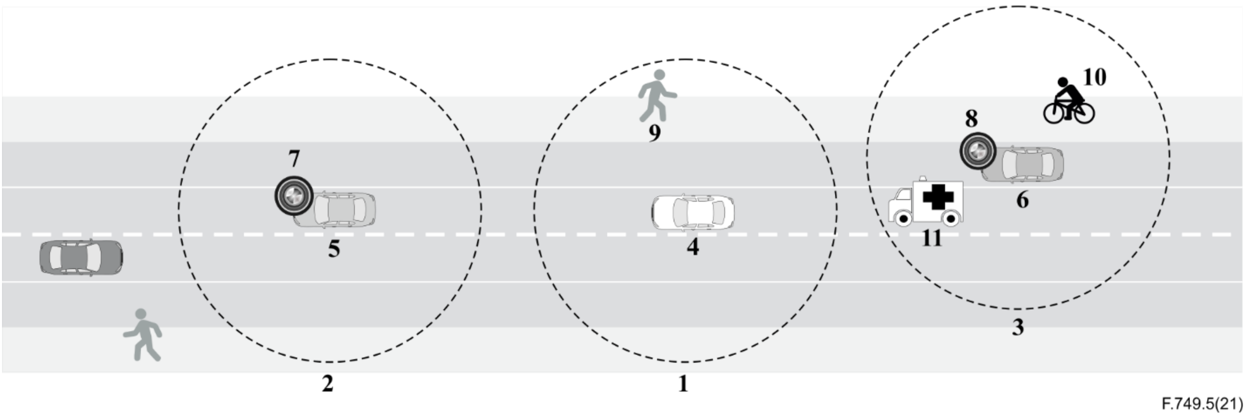
Key

1 Vehicle domain 1 2 Vehicle domain 2 3 Vehicle domain 3 4 Master vehicle 1 5 Master vehicle 2
6 Master vehicle 3 7 Domain sensor 1 (belongs to vehicle domain 2)
8 Domain sensor 2 (belongs to vehicle domain 3) 9 Domain participant 1 (belongs to vehicle domain 1)
10 Domain participant 2 (belongs to vehicle domain 3) 11 Green signal

Figure I.5 – Scenario TR1: Traffic signal reporting on a straight road

I.3.2 Scenario TR2: Emergency vehicle traffic reporter on a straight road

Figure I.6 shows a typical scenario of a traffic reporter service for an approaching emergency vehicle on a straight road. MV3 collects response information from the DAs and generates a VD map. If a valid emergency vehicle is detected from the VD map, MV3 will share a traffic report with the neighbouring MVs. MV1 and MV2 receive it.



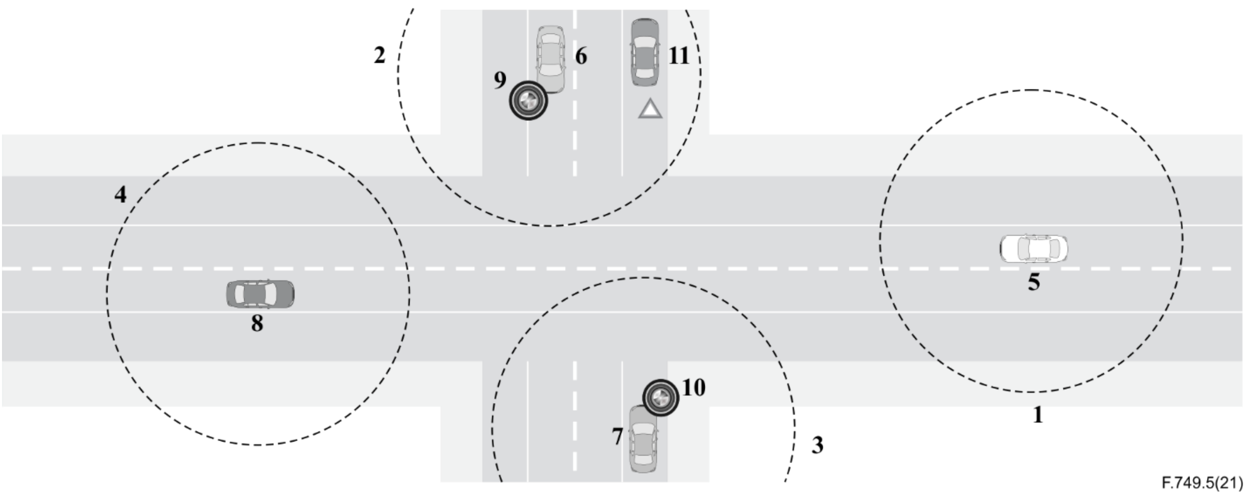
Key

1	Vehicle domain 1	2	Vehicle domain 2	3	Vehicle domain 3	4	Master vehicle 1	5	Master vehicle 2
6	Master vehicle 3	7	Domain sensor 1 (belongs to vehicle domain 2)						
8	Domain sensor 2 (belongs to vehicle domain 3)	9	Domain participant 1 (belongs to vehicle domain 1)						
10	Domain participant 2 (belongs to vehicle domain 3)	11	Domain vehicle 1 (emergency vehicle belongs to vehicle domain 3)						

Figure I.6 – Scenario TR2: Approaching emergency vehicle traffic reporting on a straight road

I.3.3 Scenario TR3: Traffic reporter for a temporary road block around an intersection

Figure I.7 shows a typical scenario of a traffic reporter service for a temporary road block around an intersection. MV2 collects the response information from the DAs and generates a VDDM. If a valid temporary road block such as a stationary vehicle that has broken down is detected in the VDDM, MV2 shares a traffic report with other neighbouring MVs. MV1, MV3 and MV4 receive and utilize it.



Key

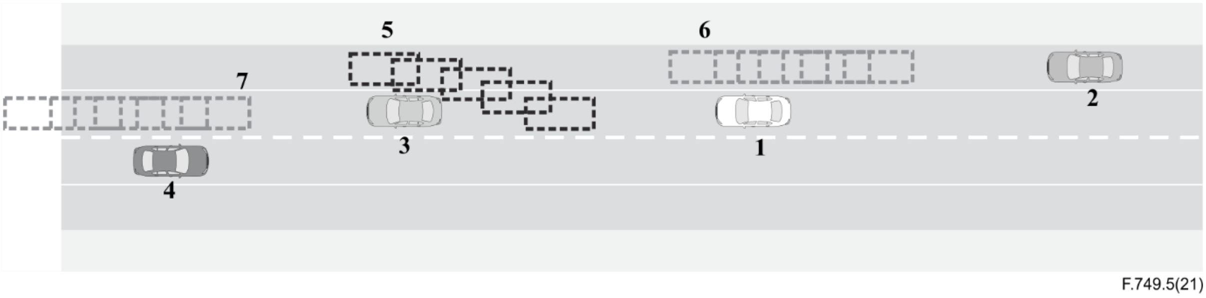
1	Domain vehicle 1	2	Domain vehicle 2	3	Domain vehicle 3	4	Domain vehicle 4	5	Master vehicle 1
6	Master vehicle 2	7	Master vehicle 3	8	Master vehicle 4				
9	Domain sensor 1 (belongs to vehicle domain 2)			10	Domain sensor 2 (belongs to vehicle domain 3)				
11	Domain vehicle 1 (temporarily stops for trouble, belongs to vehicle domain 2)								

Figure I.7 – Scenario TR3: Temporary road block around an intersection

I.4 Scenario examples of manoeuvre coordinator service

I.4.1 Scenario MC1: Manoeuvre coordinator for a right lane change

Figure I.8 shows a typical scenario of a manoeuvre coordinator service for a right-lane change on a straight road. MV collects response information from the DAs and generates a VDDM. If the MV wants to make a right-lane change, it generates an appropriate driving manoeuvre plan with VDS master time. The MV requests their planned or predicted position from the relevant DVs. They respond to the MV with the generated position information.



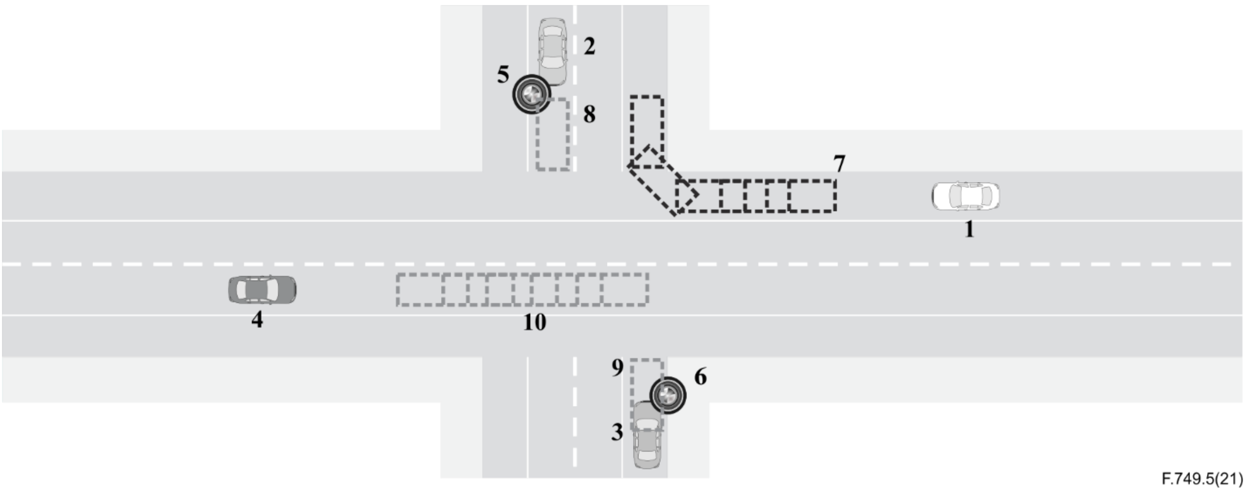
Key

1 Master vehicle 2 Domain vehicle 1 3 Domain vehicle 2 4 Domain vehicle 3
5 Driving manoeuvre of master vehicle 6 Driving manoeuvre of domain vehicle 1
7 Driving manoeuvre of domain vehicle 2

Figure I.8 – Scenario MC1: Manoeuvre coordinator for right lane change

I.4.2 Scenario MC2: Manoeuvre coordinator for a right turn at an intersection

Figure I.9 shows a typical scenario of a manoeuvre coordinator service for a right turn at an intersection. The MV collects response information from DAs and generates a VDDM. If the MV wants to turn right at the closing intersection, it generates a driving manoeuvre plan for a right turn with VDS master time. The MV requests the planned or predicted position from relevant DVs. They respond to the MV with generated position information.



Key

1 Master vehicle 2 Domain vehicle 1 3 Domain vehicle 2 4 Domain vehicle 3 5 Domain sensor 1
6 Domain sensor 2 7 Driving manoeuvre of master vehicle 8 Driving manoeuvre of domain vehicle 1
9 Driving manoeuvre of domain vehicle 2 10 Driving manoeuvre of domain vehicle 3

Figure I.9 – Scenario MC2: Manoeuvre coordinator for a right turn at an intersection

Appendix II

Typical examples of the smart traffic architecture model

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

II.1 General

The smart traffic and transport information exchange architecture model is generated by a systematic approach to standardization. The basic policy of the systematic approach is generalization and modelling of functions that already exist explicitly or implicitly within traffic and city. Listed whole functions of traffic, transport and city are imported from a generalized information model and are allocated in a STAMP.

Figure II.1 shows typical template for a STAMP. It is characterized by plotting functions on the horizontal axis against areas on the vertical axis.

1 \ 7	8	9	10	11	12
2					
3					
4					
5					
6					

F.749.5(21)

Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

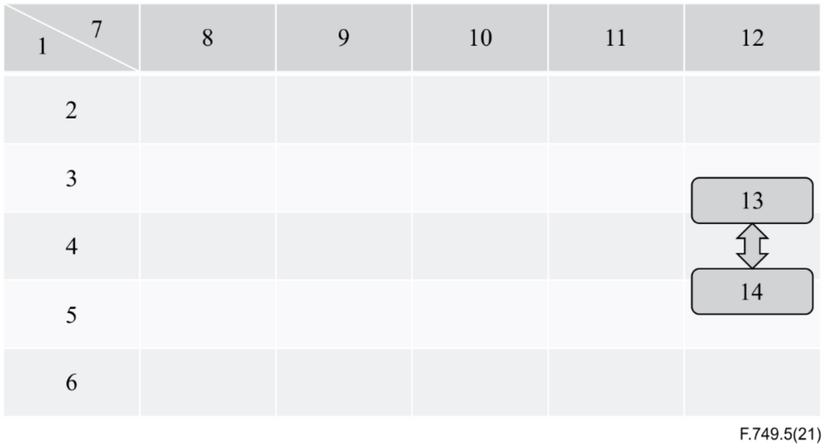
7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

Figure II.1 – Basic template for a smart traffic architecture model

II.2 Typical examples of the function domain service model

II.2.1 Typical services in a customer domain

Figure II.2 shows typical examples of a customer function domain. A customer domain is a functional service group consisting of general users or customer-driven vehicles and other actors. Typical services are those for intelligent transport system information or OEM telematics.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

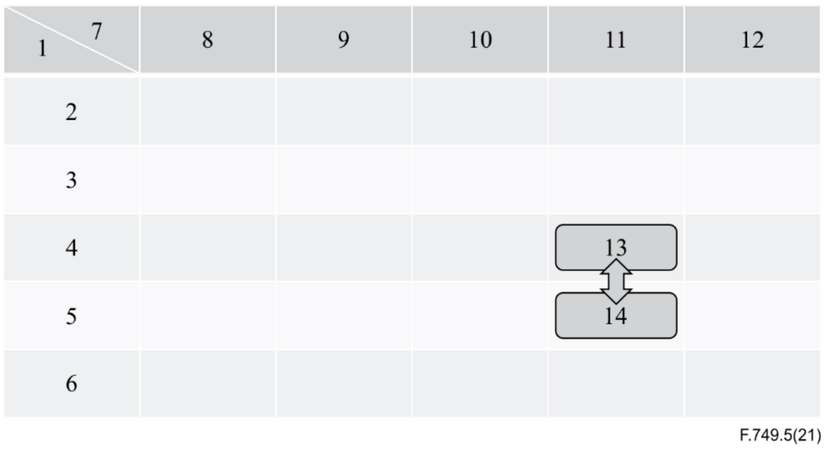
Smart traffic entities

13	ITS information service	14	OEM telematics service

Figure II.2 – Typical customer function services

II.2.2 Typical services in a commercial and consumer domain

Figure II.3 shows typical examples of a commercial and consumer function domain. A commercial and consumer domain is a functional service group provided by a consumer-based transport service, sometimes used as an alternative to public transport by customers. Typical services are those for taxi management or car sharing.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

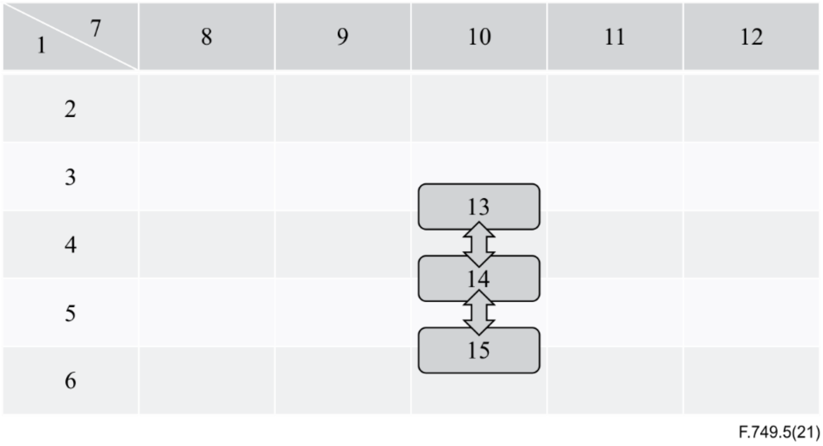
Smart traffic entities

13	Taxi management service	14	Car-sharing service

Figure II.3 – Typical commercial and consumer function services

II.2.3 Typical services in a business domain

Figure II.4 shows typical examples of a business function domain. A business domain is a functional service group consisting of transport or logistics vehicles and trucks, ranging from intercity transport to delivery service for baggage or food to homes. Typical services are those for logistics and transport management, baggage or food delivery.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

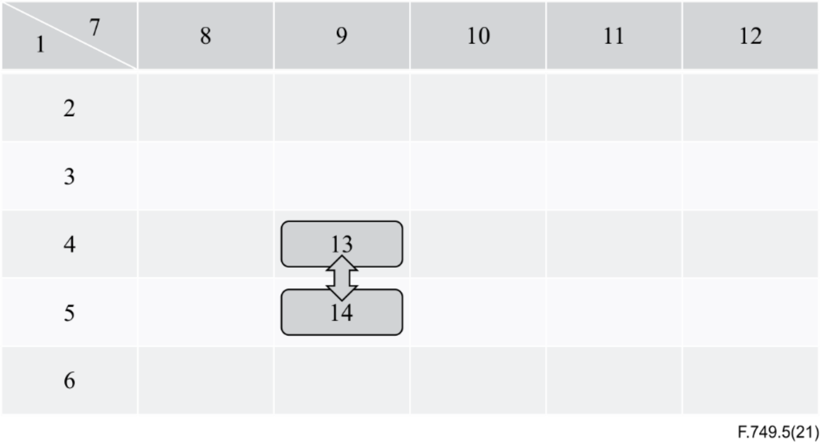
Smart traffic entities

13	Logistic transport management service	14	Baggage delivery service	15	Food delivery service

Figure II.4 – Typical business function services

II.2.4 Typical services in the public domain

Figure II.5 shows typical examples of the public function domain. The public domain is the functional service group consisting of public transport. Typical services are those for buses, light-rail transit (LRT) or traffic and road use management monitoring and management.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

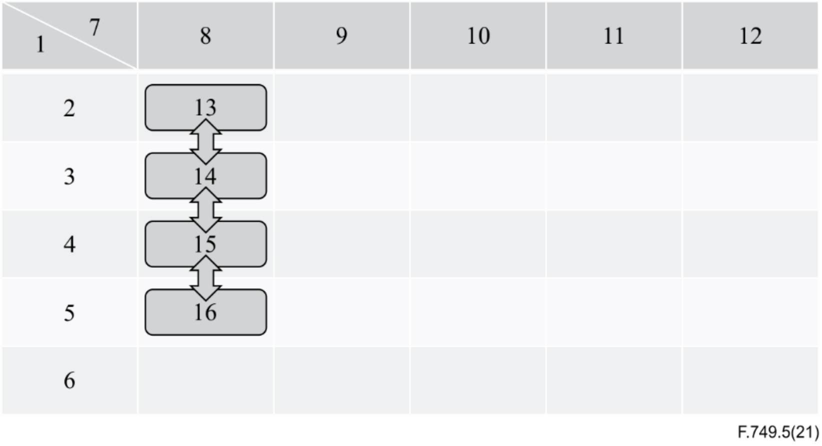
Smart traffic entities

13	Bus monitor management service	14	LRT monitor management service

Figure II.5 – Typical public function services

II.2.5 Typical services in the traffic manager domain

Figure II.6 shows typical examples of the traffic manager function domain. The traffic manager domain is the functional service group provided for public traffic monitoring, local traffic control and overall optimization controls by public or governmental organizations. Typical services are those for local traffic monitoring, traffic control, smart city traffic control management or central local dynamic server provision.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

Smart traffic entities

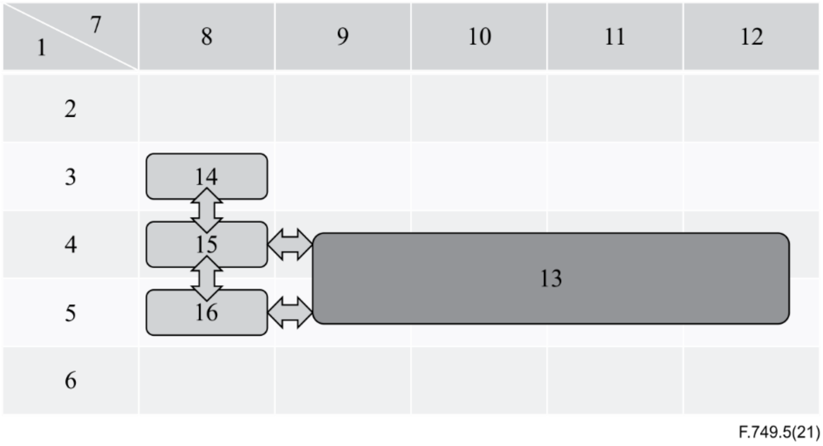
13	Local dynamic map service	14	Smart city traffic manager
15	Traffic control operator	16	Traffic monitor operator

Figure II.6 – Typical transport manager function services

II.3 Typical functional service in cooperation with VDS

II.3.1 Smart city control manager with vehicle domain service

Figure II.7 shows typical examples of harmonized implementation of the smart city control manager and VDS. Traffic information collected by VDS is sent to a local TM or smart city traffic manager and is validated. The result from a SCTM or local traffic control is sent back to VDS as value-added information.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

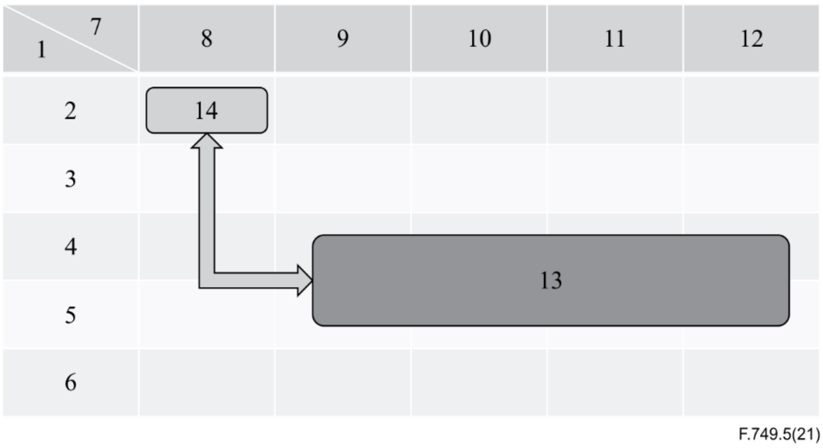
Smart traffic entities

13	Vehicle domain service	14	Smart city traffic manager
15	Traffic control operator	16	Traffic monitor operator

Figure II.7 – Typical harmonization between a SCTM and VDS

II.3.2 Local dynamic map with vehicle domain service

Figure II.8 shows typical examples of harmonized implementation of the LDM and VDS. Traffic information collected by VDS is sent to the local dynamic server as the latest refresh report to the LDM.



Key

Vertical axis

1	Area	2	Country	3	State/intercity
4	City	5	Town/street	6	Home

Horizontal axis

7	Function	8	Traffic management	9	Public transport
10	Business transport	11	Commercial/consumer travel	12	Customer travel

Smart traffic entities

13	Vehicle domain service	14	Local dynamic map service

Figure II.8 – Typical harmonization between a LDM and VDS

Appendix III

Reference model of vehicle domain service on vehicle multimedia system

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

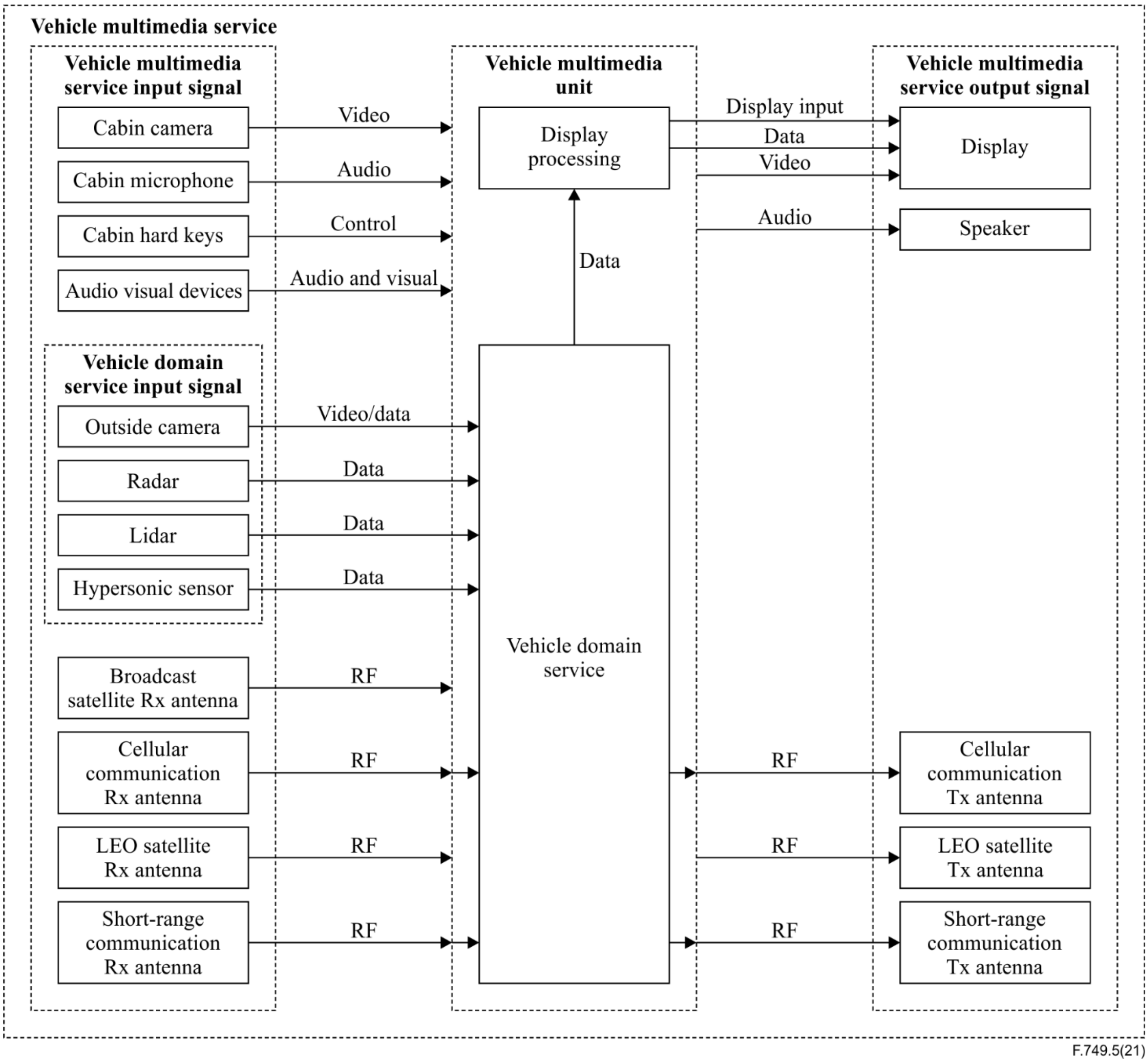
III.1 General

As described in clause 6.7.4, some input and output signals of the VDS implementation are generally shared with those of the VMS. The relationship between the VDS and the VMS in the functional overview is represented in Figure 14, but because it is an overview diagram, it does not represent the actual situation of sharing input and output signals or the detailed relations of the outputs generated by the VDS. In order to express these details, a reference model describing detailed information about input and output signals and internal information flow is more appropriate, rather than an overview diagram.

III.2 Typical example of a reference model of VDS on VMS

A typical VDDM service collects sensor and communication data provided by sensors outside a vehicle and communication network. Information media, such as sensors and network channels, could be shared between the VDS and VMS, but some dedicated information is directly sent only to VDS. A VDDMS generates dynamic traffic information based on a high definition map around the MV and sends it to the vehicle interactive HMI. A translation is required to be communicated by a VDS and VMS as a unique interface to the driver.

Figure III.1 shows the typical input/output model of the VDS integrated with that of the VMS. The basic reference model of a VMS is provided in [b-ITU-T F.749.3].



LEO: low earth orbit; RF: radio frequency: Rx: receiver; Tx: transmitter

Figure III.1 – Reference model for data input/output of the VDS on VMS

VDS is one of the network services provided by the MV, so the basic input and output of the VDS are network communication channels such as cellular or short-range networks. A VDDMS generates a high-definition map from the VDS specific signals of light detection and ranging (LIDAR), radio detection and ranging (RADAR) and sensors via recognized metadata objects. Motion pictures provided by the outside cameras of a vehicle also generate metadata of foreign objects around the MV. Those metadata are integrated as a high-definition map in the VDS functional module.

Network communication channels connected to the VDS are shared with the VMS in order to exchange other kinds of communication network services. Motion pictures acquired by cameras outside the vehicle are also shared in a similar fashion to the vehicle outside or surrounding monitor service of the VMS.

A VDDMS has some user interactive functions, such as a traffic information monitor, warning message about closing in or dangerous traffic objects and an interactive messaging service between the driver in the MV and both the DVs and the participants in surrounding traffic. Driver condition monitoring by the vehicle cabin camera could be optional for other kinds of VDS service. These interactive HMI services with the driver are provided by the VMS and VDS that utilize VMS services.

As explained in clause 6.7.2, the VDS function indicated in Figure III.1 expresses a logical function model and never shows a single physical unit. It is located in the VMS function in Figure III.1, but its function is independently implemented from VMS functions. The VDS shares some inputs or outputs with the VMS and uses its interactive HMI service. This Recommendation determines which VDS function is implemented on the multimedia network platform of the VMS.

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