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SmartM2M;
Pilot test definition and guidelines for testing cooperation between oneM2M and Ag equipment standards

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

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Executive summary

Agricultural and Forestry accidents have a relevant social impact in the farming and forestry sector. A consistent number of accidents are involving agricultural machinery and road vehicles. In some cases, they cause heavy or fatal injuries. To increase and manage a proactive collaboration between the agriculture sector and the automotive industry, AEF, Agricultural Industry Electronics Foundation, decided to define a technical solution to mitigate the risk of collision. This solution intends to inform the drivers circulating at a higher speed on the public network that a slow-motion vehicle is entering the road or is on the road.

AEF had already started machine to machine (M2M) communication and through a collaboration with ETSI, AEF wants to extend these specifications in relation with the oneM2M and ITS environments.

The purpose and goal of oneM2M is to develop technical specifications which address the need for a common M2M Service Layer that can be readily embedded within various hardware and software and relied upon to connect the myriad of devices in the field with M2M application servers worldwide.

ITS "Intelligent Transport Systems" refers to the application of Information and Communication Technologies (ICT) to transport. These applications are being developed for different transport modes and for interaction between them.

AEF is the primary hub for ISOBUS knowledge and support, and the ITS and oneM2M environments combined with AEF Certified products were constituting the proper test environment to broadcast the warning message from agriculture and forestry equipment to the on-road vehicles via Cooperative ITS (C-ITS).

The present document has the purpose of specifying a pilot test aiming at the dissemination of a warning message to road vehicles. The coordination between the detection of this event and the sending of the notification message will be done using an oneM2M platform in the tractor as a starting point.

1 Scope

The present document provides the necessary input for a pilot Plugtests™ event to validate the possible cooperation between the oneM2M platform and AEF ISO 11783 standards implemented for communication inside and between agriculture & forestry machines. The document focuses on the description and planning of the pilot test, it is not intended to be at the level of a developer guide.

The pilot use case will consider a tractor entering a road from the fields. The collaboration of Agri IoT and the oneM2M platform will enable to trigger the transmission of an alarm to the cars on the road. ETSI TC ITS standards, such as ETSI EN 302 637-3 [i.4] (Decentralized Environmental Notification Basic Service) are also part of this cooperation between standards in the use case to be demonstrated.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 118 101: "oneM2M; Functional Architecture (oneM2M TS-0001)".

[i.2] ETSI TS 118 103: "oneM2M; Security solutions (oneM2M TS-0003)".

[i.3] ETSI EN 302 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[i.4] ETSI EN 302 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[i.5] ISO 11783-7: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 7: Implement messages application layer".

[i.6] ISO 11783-9: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 9: Tractor ECU".

[i.7] AEF web site.

NOTE: Available at https://www.aef-online.org/home.html.

[i.8] ETSI TS 102 894-2 (V1.2.2): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".

[i.9] 5th Cooperative Mobility Services Plugtests event; ETSI CTI Plugtests Guide V1.1.1 (2016-11).

NOTE: Available at https://portal.etsi.org/Portals/0/TBpages/CTI/Docs/ITS_CMS_Plugtest5_Tests_FINAL.pdf.

[i.10] ISO 11783-6: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 6: Virtual terminal".

[i.11] ISO 11783-10: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 10: Task controller and management information system data interchange".

[i.12] ETSI TS 118 104: "oneM2M; Service Layer Core Protocol (oneM2M TS-0004)".

[i.13] ETSI TS 118 109: "oneM2M; HTTP Protocol Binding (oneM2M TS-0009)".

[i.14] ISO 11783-1: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 1: General standard for mobile data communication".

[i.15] ISO 11783-2: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 2: Physical layer".

[i.16] ISO 11783-3: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 3: Data link layer".

[i.17] ISO 11783-4: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 4: Network layer".

[i.18] SAE J1939-2: "Agricultural and Forestry Off-Road Machinery and Communication Network".

[i.19] ISO 11898-2: "Road vehicles - Controller area network (CAN) -- Part 2: High-speed medium access unit".

[i.20] W3C Recommendation: "RDF 1.1 Concepts and Abstract Syntax", 25 February 2014.

[i.21] ETSI TS 118 113: "oneM2M; Interoperability Testing (oneM2M TS-0013)".

[i.22] ETSI EN 302 663: "Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.23] ETSI TS 103 264: "SmartM2M; Smart Appliances; Reference Ontology and oneM2M Mapping".

[i.24] ETSI TS 118 112: "oneM2M; Base Ontology (oneM2M TS-0012)".

[i.25] ISO 11783 (all parts): "Tractors and machinery for agriculture and forestry -- Serial control and communications data network".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

agriculture and forestry equipment: tractor, self-propelled machines (sprayer, combine harvester machine, tree harvester, forwarder, etc.)

implement: pulled equipment

3.2 Abbreviations

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

AE	Application Entity
AEF	Agricultural industry Electronics Foundation
AE-ID	Application Entity Identifier
API	Application Programming Interface
CAM	Cooperative Awareness Message
CAN	Controller Area Network
CCH	Control Channel

CF	Control Function
C-ITS	Cooperative ITS
CMS	Cooperative Mobility Services
CoAP	Constrained Application Protocol
CRUD	Create Retrieve Update Delete
CSE	Common Services Entity
CSF	Common Services Function
DA	Destination Address
DENM	Decentralized Environmental Notification Message
DEULA	Bundesverband der Deutschen Lehranstalten für Agrartechnik
DIS	Discovery
DLG	Deutsche Landwirtschafts-Gesellschaft
DMR	Data Management and Repository
ECU	Electronic Control Unit
ECU-P	Electronic Control Unit in Private/proprietary vehicle network
ETSI	European Telecommunication Standards Institute
G5-CCH	ITS-G5 (ITS 5,9 GHZ frequency band) Control Channel
GN	Geo-Networking
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HAE	Host Agriculture or forestry Equipment
HF	High Frequency
HIL	Hardware In the Loop
HMI	Human Machine Interface
HT	Header Type
HTTP	HyperText Transfer Protocol
HV	Host Vehicle
ICT	Information and Communications Technologies
ID	IDentifier
IN	Infrastructure Node
IN-CSE	CSE which resides in the Infrastructure Node
IoT	Internet of Things
IP	Internet Protocol
IPC	Inter-Process Communication
IPE	Interworking Proxy application Entity
ISO	International Organization for Standardization
ISOBUS	ISO (11783) Bus
ITS	Intelligent Transport System
ITS-S	ITS Station
KPI	Key Performance Indicator
LF	Low Frequency
M2M	Machine to Machine
Mca	Reference Point for M2M Communication with AE
Mcc	Reference Point for M2M Communication with CSE
MCG	Management Computer Gateway
MN	Middle Node
MN-CSE	CSE which resides in the Middle Node
MQTT	Message Queuing Telemetry Transport
N&T	Networking and Transport
NSE	Network Service Entity
OBU	On-Board Unit
OSI	Open Systems Interconnection (model)
OWL	Web Ontology Language
PDU	Protocol Data Unit
PGN	Parameter Group Number
PT	Project Team
RDF	Resource Description Framework
REG	REGistration
REST	Representational State Transfer
RN	Resource Name
RSU	Road Side Unit
RTK	Real-Time Kinematics

SA	Source Address
SAE	Society of Automotive Engineers
SAREF	Smart Appliances REFerence ontology
SEC	SECurity
SEM	SEMantics engine
SP	Service Provider
SUB	SUBscription and notification
TC	Technical Committee
TCP	Transmission Control Protocol
TECU	Tractor ECU
TMC	Traffic Monitoring Centre
UC	Use Case
UDP	User Datagram Protocol
URI	Uniform Resource Identifier
USB	Universal Serial Bus
UTC	Coordinated Universal Time
V2V	Vehicle to Vehicle
VT	Virtual Terminal
XML	eXtensible Markup Language

4 Global Overview

4.1 Rationale

In many cases, the definition proposed by horizontal sectors is not correlated to the needs of the end-users in vertical applications. It is thus necessary to collect the real needs from the end-users or at the level of the machine producers. In the agricultural domain, the soil definition, the certification of the pulled equipment, all these KPIs are developed at the level of the vertical sector and an alignment of the sector with the main stakeholders of the industry already exists. Without a consolidation between the vertical domain and the horizontal domain, the KPIs can hardly be considered as benefits from the sector, and silos will remain. Security and safety also needs to be addressed across sectors as trust is a vital requirement between the different sectors.

The agricultural industry is supplying a diverse market and is driven by innovations of numerous manufacturers. The objective of the Agricultural Industry Electronics Foundation (AEF [i.7]) is the interoperability of different manufacturer's equipment via common standards. This is being facilitated by joint approaches of the industry to technical challenges around electrical systems, electronics and software in agricultural technology and farming.

Initially established in order to address standardization work for ISOBUS systems (ISO 11783, e.g. [i.5] and [i.6]), the AEF's focus was expanded to a wider range of topics including electrification, camera systems, farm management information systems, Ethernet communication and wireless in-field communication. Specifically, Project Team 11 (PT 11) handles wireless in-field communication. PT 11's focus spans from technology decisions for suitable radio standards and corresponding transport layer protocols for machine-to-machine (M2M) communication to vehicle security and functional reliability.

ISO 11783 [i.25] is a family of fourteen standards that specify the communication between connected Electronic Control Units (ECU) on the vehicle network of tractors and self-propelled agricultural machines as well as on detachable, pulled farm equipment. Parts 1 to 14 of the standard cover all layers of the protocol stack ranging from a Controller Area Network (CAN) topology at the physical layer up to the specification of control functions (CF) and Virtual Terminal (VT, remote control) sessions on application layer. All communication utilizes industry-wide standardized data dictionaries.

A typical ISO 11783 scenario comprises a tractor pulling a planter connected to the tractor's main ECU (Tractor ECU, TECU) via the ISOBUS network: The planter's domain-specific functionalities are being remote controlled via the VT (display) in the tractor cabin. At the same time the planter is receiving wheel speed and positioning signals from the TECU in order to adjust the planting rate to a user-defined target rate. The planter sends sensor data on work coverage and precision to the tractor network in order to be recorded by the corresponding ISO 11783 applications. In particular, via ISO 11783-7 [i.5] (Implement Messages Application Layer) and ISO 11783-9 [i.6] (Tractor ECU), the ISO 11783 implement network provides a gateway for the exchange of information between all the platforms of the agriculture & forestry industry.

The objective of the present document is to provide the necessary input for a pilot Plugtests™ event to validate the possible cooperation between the oneM2M platform [i.1] and AEF ISO 11783 standards [i.5], [i.6], [i.10], [i.11], [i.14], [i.15], [i.16] and [i.17] implemented for communication inside and between agriculture & forestry machines. ETSI TC ITS standards, such as ETSI EN 302 637-3 [i.4] (Decentralized Environmental Notification Basic Service) are part of this cooperation in the use case to be demonstrated.

The pilot Plugtests™ will focus on the interworking between the oneM2M platform and AEF ISO 11783 standards implemented for communication inside and between agriculture & forestry machines. The demonstrated use case will also make use of Cooperative ITS messages, described in ETSI TC ITS standards, such as ETSI EN 302 637-3 [i.4] (Decentralized Environmental Notification Basic Service).

4.2 Objective

The main scenario envisioned for the pilot Plugtests™ event consists in the dissemination of a warning message to road vehicles as soon as an agriculture or forestry equipment leaves the field for road transport. The coordination between the detection of this event and the sending of the notification message will be done using an oneM2M platform in the tractor.

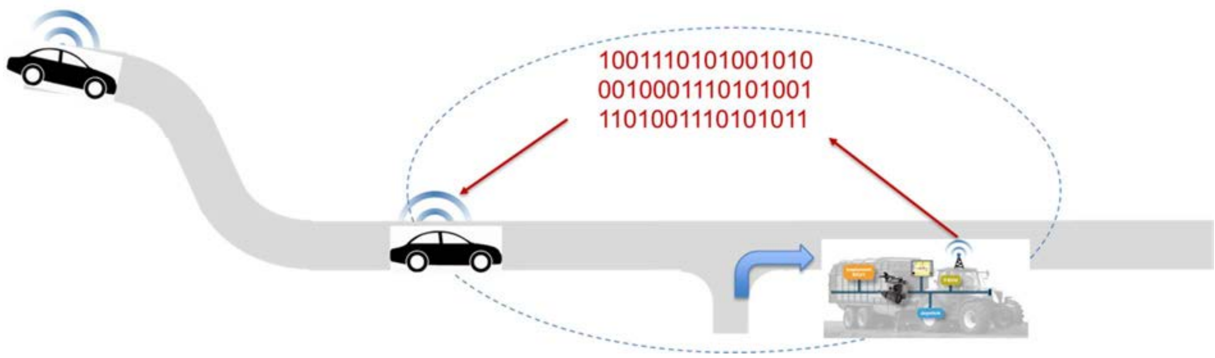

Figure 1: Schematic: Agriculture or forestry equipment leaves field and enters a road

5 Scenario definition and collection of requirements

5.1 Detection of slow agriculture or forestry equipment on the road

5.1.1 Description

The scenario addresses the case when an agriculture or forestry equipment manoeuvring in a field enters a public road where other vehicles are passing by. This scenario is an adaptation and evolution of the test "UC2: Detection of dangerous goods information and local dissemination" described in clause 6.2 of the 5th Cooperative Mobility Services (CMS) Plugtests™ event (CMS5) [i.9].

The information related to the situation of the agriculture or forestry equipment is analysed and detected by a specialized ECU on the vehicle. In addition to the ISO 11783 stack, this ECU is connected to a M2M service platform (service and application entities) that collects the relevant data from the ECU. The M2M platform is also able to trigger the dissemination of C-ITS messages as needed to passing-by vehicles. The information that the equipment is entering the road is provided to neighbouring vehicles by a "slow vehicle" event, disseminated as a CAM (Cooperative Awareness Message) [i.3] and notified as needed as a DENM (Decentralized Environmental Notification Message) [i.4]. An alternate safety scenario can be envisioned in the reverse direction, i.e. when a CAM received from a car approaching on the road is transposed to the M2M platform and triggers an alert on the Human Machine Interface (HMI) of the agriculture or forestry equipment using its internal ECU. Due to the low network coverage in rural areas, V2V (Vehicle to Vehicle) communication is envisioned but dissemination of the information to an M2M application server through a road side unit (RSU) is also considered as a third alternate scenario.

The present clause describes the normal flow and the two alternative flows. The latter are presented for the purpose of completeness, they are considered as optional implementations. Only the normal flow will be studied in clause 6 and evaluated in the pilot test.

The envisioned protocol stack in the tractor is provided in Figure 2. Figure 2 shows the M2M service platform sitting on top of three pillars: an eMobility pillar on the left (or ITS station), able to send and receive C-ITS messages; an ISO 11783 pillar on the right, which provides selected data available on the vehicle network through a specific interface; and finally, an IoT communications pillar in the middle for sensors able to interface directly with the M2M platform. The definition of the mechanism for interfacing the M2M platform with the vehicle network for the pilot test is one of the main objectives of the present document. It should be noted that the third pillar is shown here (greyed) but most of the sensors on board of the agriculture or forestry equipment are expected to be connected through the ISO 11783-9 [i.6] TECU and comply with its security rules.

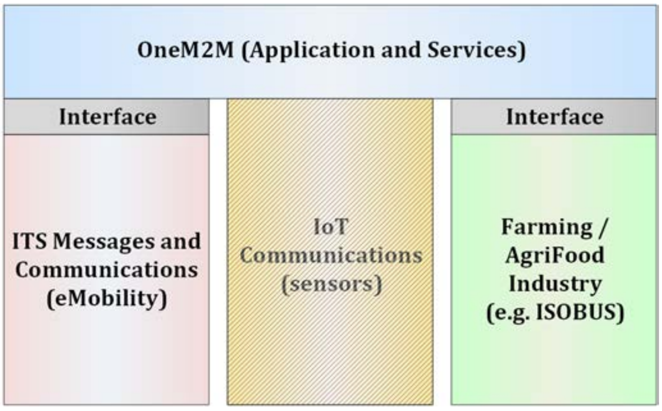

Figure 2: Envisioned protocol stack

5.1.2 Actors

- Vehicles from the agricultural domain are in the following being referred to as Host Agriculture or forestry Equipment (HAE). This includes tractors with and without pull-behind equipment as well as self-propelled equipment such as combine or forage harvesters, sprayers, potato or beet harvesters, forestry harvesters and forwarders.
- ISO 11783 certified agricultural vehicles are equipped with an ISOBUS terminal in order to read or adjust machine values and for remote control functionalities. The ISOBUS terminal in general includes a touch screen or several hardware buttons for user input. It is the central interface for machine information and safety warnings. In the following this on-board display is referred as the HAE HMI, which is considered an optional component for the below test scenario.
- One or several Host Vehicles (HV) are passing by on the road. A HV is equipped with a device capable to send, receive and process the C-ITS messages.
- The HMI of the HV is located in the on-board telematics unit. It is able to notify a warning to the driver of the vehicle through means such as a beep sound, a short text message appearing on a reduced screen, a visual sign on a larger screen or even a map showing the blinking position of the HAE.
- The RSU is an optional equipment used only for the alternative flow 2 as a communication relay between the devices in the vehicles. The RSU is able to receive and process all the received messages. It may be able to work autonomously to detect the safety issue or it may use an internet connection to the cloud, for example to connect to a traffic monitoring centre (TMC). In this case the RSU acts as a gateway between the vehicles (including the HAE) and the TMC.

5.1.3 Pre-conditions

- The HV is driving on the road and approaches the pilot test area.
- The HAE is in the field and not in work state: HAE vehicles are likely to exceed the maximum allowed transport width for road traffic. Therefore, in case of a tractor with pull-behind equipment, the transport ("not-in-work") state refers to the implement being folded and not ready-to-work. For a self-propelled farm vehicle, the header required to pick up the harvest is folded as well or detached from the front of the HAE.
- For the HAE to determine its location change from field to road, it is essential to receive a reliable GNSS positioning signal. Besides that, ISO 11783 defines a set of signals considered helpful for the classification of the HAE's current position. The required information is sent out by one or more ISO 11783 certified ECUs on the vehicle's CAN bus. Additional manual indicators for the HAE operator's intention to enter the road are turn signals and the activation of a beacon light.
- The HV ITS Station OBU disseminates awareness messages (e.g. C-ITS CAMs), indicating its position, speed and direction, as provided by the HV sensors.

5.1.4 Triggers

The primary trigger for the use case in the normal flow described below is defined as the HAE's position change from "in the field" to "on (or entering) the road". An important objective for the warning sign is to avoid false positive notifications in order to preserve the significance of the warning information content. For the slow vehicle warning it is therefore crucial to rely on an accurate classifier for the two states of the HAE "operating in the field" and "participating in road traffic".

5.1.5 Normal Flow

In this flow, the HAE sends a notification and an alert is visualized in the HV HMI:

1) The HAE detects the change of location based on its GNSS receiver.
2) The HAE determines that the current position interferes with road traffic via offline map information. For additional validation of the intention to enter the road, it detects the transport mode from the machine state or a relevant operator input (e.g. turn signal).
3) The HAE disseminates the information using an event notification message (e.g. DENM).
4) The HV receives the event notification message. It is processed by the C-ITS stack and transferred to the relevant application for validation and comparison with the HV's own internal data (e.g. position and speed).
5) The application in the HV determines that the received notification is relevant and a safety issue may happen. It notifies the driver through the HV HMI to inform her/him that an action may be needed, for example slowing down.

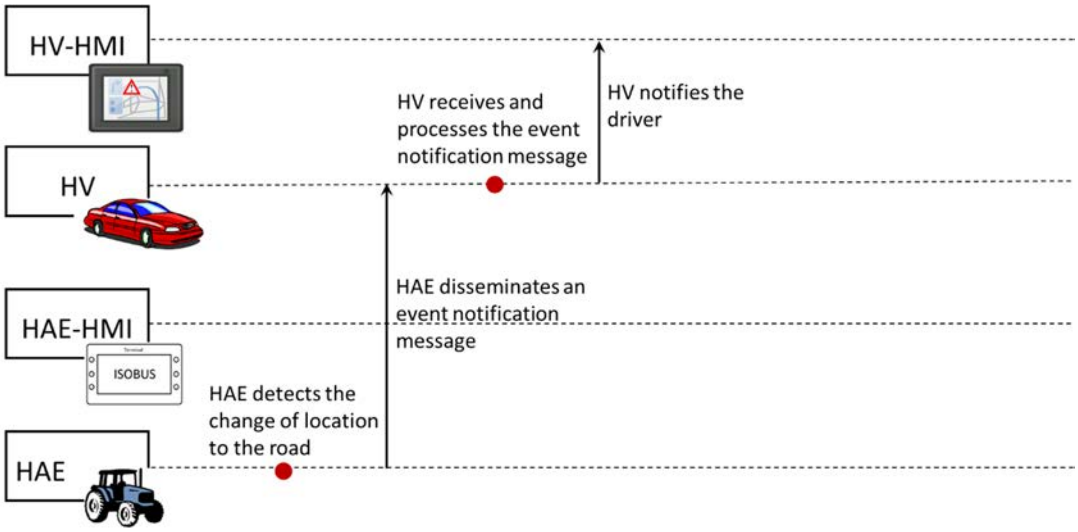

Figure 3: Main flow

5.1.6 Alternative flows

5.1.6.1 Alternative flow 1: Safety issue is detected by the agriculture or forestry equipment

In this flow, the HAE detects the safety issues and an alert is visualized in the HAE HMI:

1) The HAE detects the change of location based on its GNSS receiver.

2) The HAE receives the awareness messages (CAMs) from the HV. It forwards its content to the relevant application in the HAE.

3) The HAE uses the IoT interworking with the ISO 11783 vehicle network to retrieve additional information for further processing.

4) The HAE determines that a safety issue may happen. It transfers the information to the ISO 11783 vehicle network, which notifies the driver through its HMI.

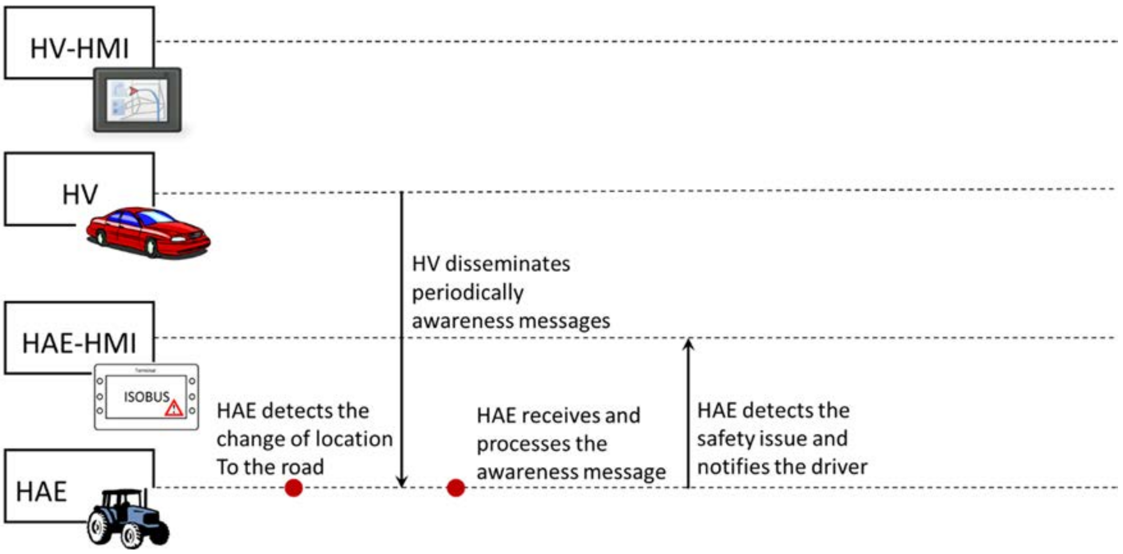

Figure 4: Alternative flow 1

5.1.6.2 Alternative flow 2: Infrastructure equipment is involved in the alert

In this flow, the HAE sends a notification which is detected and disseminated by infrastructure equipment:

1) The HAE detects the change of location based on its GNSS receiver.

2) The HAE determines that the current position interferes with road traffic via offline map information and disseminates the information using periodic CAM messages.

3) The message is received by the RSU which aggregates all the messages received and transfers the information to the TMC, using its Internet connection. The RSU may also operate autonomously to monitor its covered area and analyse the potential issues.

4) The TMC (or the RSU) determines the safety issue and disseminates (through the RSU in case of the TMC) an event notification message (e.g. DENM) in the relevant area.

5) The HV receives the event notification message. It is processed by the C-ITS stack and transferred to the relevant application for validation and comparison with the HV's own internal data (e.g. position and speed).

6) The application in the HV determines that the received notification is relevant and a safety issue may happen. It notifies the driver through the HV HMI to inform her/him that an action may be needed, for example slowing down.

7) The HAE determines that a safety issue may happen. It transfers the information to the ISO 11783 vehicle network, which notifies the driver through its HMI.

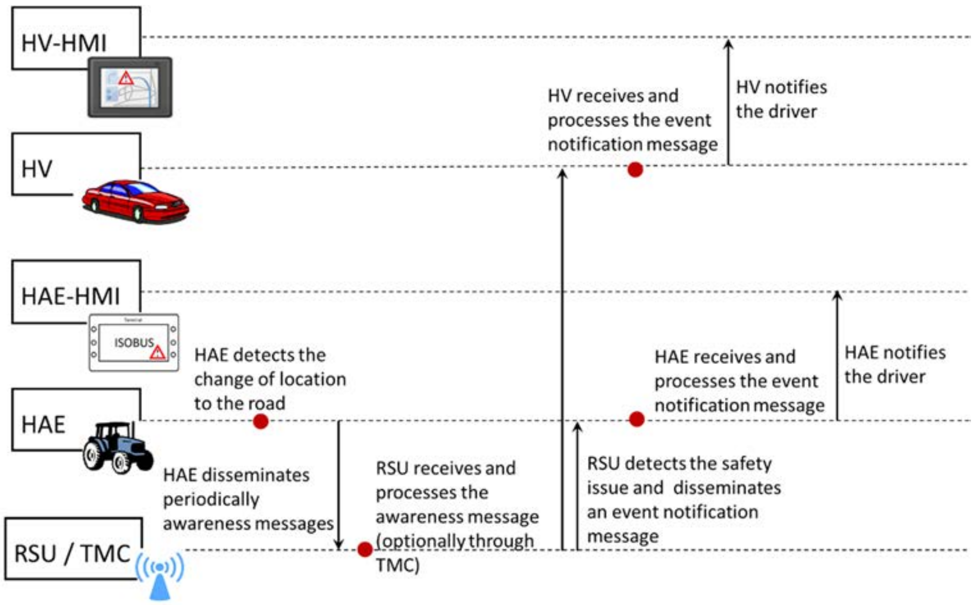

Figure 5: Alternative flow 2

5.1.7 Post-conditions

- In all cases, the HAE disseminates an awareness message (CAM) to signal its presence.
- Main flow and alternative flow 2: the HV driver slows down to avoid potential collision.
- Alternative flow 1: the HAE driver waits until the HV has passed before entering the road.

5.1.8 High Level Illustration

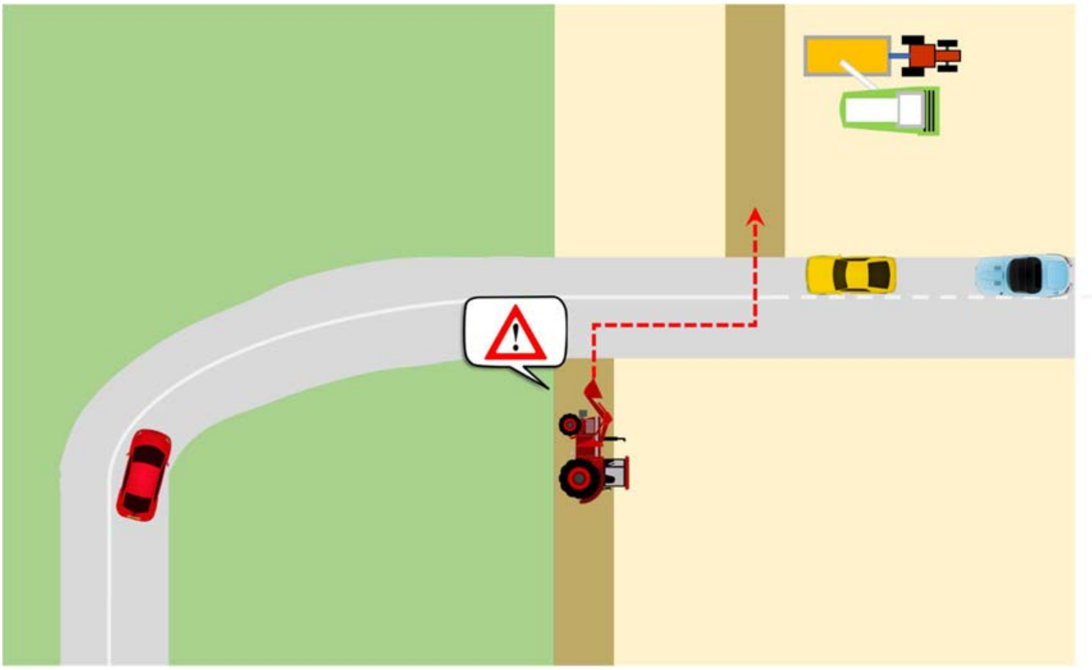

Figure 6: High level illustration for main flow

5.2 Potential requirements

5.2.1 ITS messages main parameters

The present clause gives a preliminary list of the parameters that should be present in the CAM and DENM messages [i.8]. For each parameter, the table indicates whether it can be obtained from the ITS or ISO 11783 family of standards and whether this is a mandatory (M) or optional (O) field in the ITS message.

Table 1: CAM message parameters

Container	Parameter	M/O	Available on HAE via
N/A	Generation Time	M	ISO 11783-7 [i.5], B.1
Basic Container	type of the originating ITS-S	M	ETSI EN 302 637-2 [i.3]
	latest geographic position of the originating ITS-S	M	ISO 11783-7 [i.5], B.5
HF Container	heading (N, E, S, W)	M	ISO 11783-7 [i.5], B.5
	speed	M	ISO 11783-7 [i.5], B.3
	drive direction (forward, backward)	M	ISO 11783-7 [i.5], B.3
	vehicle size	M	ISO 11783-10 [i.11]
	longitudinal acceleration	M	ISO 11783-7 [i.5], B.3
	curvature	M	ISO 11783-7 [i.5], B.26.2
	yaw rate	M	ISO 11783-7 [i.5], B.5
	steering wheel angle	O	ISO 11783-9 [i.6]
	lateral and vertical acceleration	O	ISO 11783-7 [i.5], B.5
LF container (Optional)	vehicle role (e.g. default(0), publicTransport(1), emergency(6), agriculture(8))	M	ETSI EN 302 637-2 [i.3]
	exterior lights	M	ISO 11783-7 [i.5], B.19
	path history	M	ETSI EN 302 637-2 [i.3] (internal to ITS stack)

Table 2: DENM message parameters

Container	Parameter	M/O	Available on HAE via
Management Container	action ID (originating Station ID, sequence number)	M	ETSI EN 302 637-3 [i.4]
	detection time	M	ISO 11783-7 [i.5], B.1
	reference time	M	ISO 11783-7 [i.5], B.1
	event position	M	ISO 11783-7 [i.5], B.5
	relevance distance	O	ETSI EN 302 637-3 [i.4] (internal to ITS stack)
	relevance traffic direction	O	ETSI EN 302 637-3 [i.4]
	originating station type	M	ETSI EN 302 637-3 [i.4]
Situation Container (Optional)	information Quality	M	ETSI EN 302 637-3 [i.4]
	event Type (e.g. slowVehicle (26))	M	ETSI EN 302 637-3 [i.4]
Location Container (Optional)	event speed	O	ISO 11783-7 [i.5], B.3
	event position heading	O	ISO 11783-7 [i.5], B.5
	traces (location referencing)	M	ISO 11783-7 [i.5], B.5
	road type	O	ETSI EN 302 637-3 [i.4]

5.2.2 Scenario requirements for the pilot test

- In the given scenario, the warning transmitted to the HV (or the HAE in the alternative flow) shall result in a notification to the driver of the vehicle via a visual or an acoustic alarm on the HMI. **HV and HAE therefore need to be equipped with an HMI**. Infotainment or dashboard displays in the instrument clusters are becoming popular for any kinds of HVs. Similarly, an ISO 11783 certified HAE is required to be equipped with an ISOBUS terminal, which can display warning screens or play alert sounds sent by an ISOBUS implement. The display supports a minimum set of resolutions defined in ISO 11783-6 [i.10].

- For the wireless vehicle-to-vehicle communication, **an ITS station shall be installed on both HV and HAE**. In order to populate basic ITS message containers, **the vehicles' GNSS position is required to be known in sufficient spatial and temporal resolution**. GNSS sensors are parts of nearly any recent HV as they support navigation services and on a HAE high-precision Real-Time Kinematics (RTK) systems are being mounted for row guidance and automatic steering systems.

- The interconnection of ISO 11783 services and the ITS station on board of the HAE requires **an M2M platform for a successful translation in both directions of communication**. This pilot test will be based on the SmartM2M suite of standards and their specific components for publishing their domain-specific information and services.

- As far as possible, the **trigger for the alarm** is **generated automatically** by the M2M application. Hence the need to avoid false positives by validating the trigger with additional conditions.

- For the successful communication of the slow vehicle warning in an actual case of agricultural equipment participating in road traffic, **a reliable decision shall be made on whether the HAE is located in the field or on the road**. An automatic classification based on the GNSS position is possible as long as reliable, high-resolution position information is available as well as sufficient map data on board of the HAE. In particular, a headland turn manoeuvre (which is a frequent operation in order to enter the next row in the field) shall be differentiated from the intention to enter the road. High-resolution GPS positions are being retrieved from the HAE's RTK receiver with an accuracy of few centimetres in case such a system is installed on the HAE.

- Based on ISO 11783-7 [i.5] the HAE is as well able **to differentiate between "in-work" or "transport" state of its header**, front or rear hitch or the attached implement. The corresponding CAN information, however, is optional in ISO 11783.

- In the absence of the automatic classifiers, it is possible to trigger the slow vehicle warning based on an operator input. This includes switching the turn signal in order to indicate the direction of the HAE entering the road as well as activating the optional beacon light on the HAE's roof.

- The full system shall remain **reliable and secured** and enable trust in the different equipment involved. Both the C-ITS and the ISO 11783 stack already include security features, which requires also compatibility with the security solutions of the oneM2M platform [i.2].

- Regarding the assumption that **infrastructure would be available in all rural areas** to support the use case involving infrastructure, it may happen that infrastructure is deployed in some locations with high safety risk. However, the main scenario addressed by the pilot test is the one described in clause 5.1.5 (no infrastructure), the second, alternative one described in clause 5.1.6.2 has been introduced for the comprehensiveness of the scenario study.

5.2.3 Potential requirements for a M2M system

The potential requirements defined above can be transposed into the following text:

- "The M2M system shall be able to enable the broadcast of an alert to other entities within the M2M system (e.g. passing-by vehicles).

- The M2M system shall be able to support the exchange of data and services between the ISO 11783 entities and vehicular entities.

- The M2M system shall support the automatic generation of an event under specific conditions.

- The M2M system shall be able to handle location information from related sensors.

- The M2M system shall be able to handle the status of available devices on board the HAE.

- The M2M system shall be able to support a reliable decision making when the HAE is located in the field or on the road, based on the input of suitable sensors.

- The M2M system shall be able to support the identification of vehicle status (e.g. "in-work" or "transport" state).

- The M2M system shall ensure compatibility of reliable and secured operation with ISO 11783 and C-ITS [i.2].

- The M2M system shall support continued operation when infrastructure is not available."

6 Test definition and guidelines

6.1 Overview

The content of the present clause leverages the scenario description and requirements identified in clause 5 and performs a close analysis of the ISO 11783 standards. It starts with the definition of the interworking framework necessary to enable the exchange of information, and potentially services, between the ISO 11783 and the oneM2M standards. The work focusses essentially on those functions necessary to achieve the pilot test scenario. The agriculture equipment is seen as an IoT device able to provide data to the oneM2M service platform. In particular, clause 6.2 introduces a common data model, referencing the oneM2M base ontology and SAREF (Smart Appliances REFerence ontology) for semantic interoperability.

In a second step, the next clauses refine the test definition, including a description of the "things" involved and of their interactions. In more details, it contains the identification of the required equipment and nodes involved in the scenario. The test specification and guidelines describe the different test cases, the phasing of each test and their triggering conditions. The functional entities and the protocols involved are listed, together with their configuration and parametrisation, the description of the messages used in the test and the parameters to be exchanged at the different interfaces. Finally, clause 6.6 includes a set of recommendations for the logistics of the Plugtest implementation.

The next clauses provide recommendations for:

- the data model to be used in the test;

- the protocols to be used and their interfaces;

- the data management for the exchange of information;
- the data security and safety;
- guidelines for the pilot test implementation and protocol parametrization.

6.2 Data model

6.2.1 Parameters for the data model

The present clause provides the semantics of the data to be exchanged through the M2M platform. These data include the parameters of the ITS messages and those required to assess the triggering condition. Each of the parameters is associated to a set of meta-data: parameter name, type, size and valid range for values. The parameters have been split into four tables depending on whether they are originating from the ISO 11783 (used/not used for triggering the event) or from the ITS side. An additional table contains purely internal parameters.

Table 3 contains the parameters which are read from the ISO 11783 network and are involved in the triggering of the event.

Table 3: Parameters read from ISO 11783 and involved in the triggering

Parameter	ISO 11783 /SAE J1939 Message	PGN	Unit	Resolution	Range	Data Type
Latitude Geographic Position	Vehicle Position - Latitude	0xFEF3	deg	10^{-7} deg	-90..90 deg	float (reference: Equator)
Longitude Geographic Position	Vehicle Position - Longitude	0xFEF3	deg	10^{-7} deg	-180..180 deg	float (reference: Prime Meridian)
Altitude	Vehicle Direction/Speed	0xFEE8	m	0,125 m	-2 500..5 531,875 m	float (reference: sea level)
beaconLightOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
leftTurnSignalOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
rightTurnSignalOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
Implement in work state	Implement Operating State	0xFD03	N/A	N/A	N/A	enumerated (set implement to field working state, set implement to transport state, set implement to park state, take no action)
Implement start/stop operations	Wheel-based speed and distance	0xFE48	N/A	N/A	N/A	enumerated (stop or disable implement operations, start or enable implement operations, error, not available/installed)

Table 4 contains the parameters which are read from the ISO 11783 network.

Table 4: Parameters read from ISO 11783 and not involved in the triggering

Parameter	ISO 11783 /SAE J1939 Message	PGN	Unit	Resolution	Range	Data Type
Heading	Vehicle Direction/Speed	0xFEE8	deg	1/128 deg	0..360 deg	float (reference: north)
Speed	Wheel-based speed and distance	0xFE48	m/s	0,001 m/s	0..64,255 m/s	float
Drive Direction	Wheel-based speed and distance	0xFE48	N/A	N/A	N/A	enumerated (reverse, forward, not available)
Longitudinal Acceleration	Vehicle Dynamic Stability Control	0xF009	m/s^2	0,1 m/s^2	0..25,0 m/s^2	float
Curvature	Guidance Machine Status	0xAC00	km^{-1}	0,25 km^{-1}	-8 032..8,031,75 km^{-1}	float (0 = straight)
Yaw Rate	Vehicle Dynamic Stability Control	0xF009	rad/sec	1/8 192 rad/sec	-3,92..3,9236279 rad/sec	float
Steering Wheel Angle	Vehicle Dynamic Stability Control	0xF009	rad	1/1 024 rad	-31,374..31,375023 rad	float (0 = straight)
Lateral Acceleration	Vehicle Dynamic Stability Control	0xF009	m/s^2	1/2048 m/s^2	-15,687..15,687 m/s^2	float
LowBeamHeadlightsOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
highBeamHeadlightsOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
daytimeRunningLightsOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
reverseLightOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
fogLightOn (Rear)	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
parkingLightsOn	Lighting Command	0xFE41	N/A	N/A	N/A	Boolean
Timestamp	Time/Date	0xFEE6	s	0,25 s	N/A	float (reference: UTC, source TECU)

Table 5 contains the ITS specific parameters which are needed to build the ITS messages.

Table 5: ITS specific parameters

Parameter	Unit	Resolution	Range	Data Type
vehicleLength	m	0,1 m	1..102,2 m	Float
vehicleWidth	m	0,1 m	1..6,1 m	Float
vehicleRole	N/A	N/A	N/A	enumerated (agriculture = 8)
pathHistory	N/A	N/A	N/A	sequence of path points (internal to its)
actionID	N/A	N/A	N/A	sequence counter (internal to its)
stationType	N/A	N/A	0..255	Enumerated (specialVehicle = 10)
informationQuality	N/A	N/A	0..7	integer (unavailable(0), lowest(1), highest(7))
relevanceTrafficDirection	N/A	N/A	N/A	enumerated (alltrafficdirections(0), upstreamtraffic(1), downstreamtraffic(2), oppositetraffic(3))
relevanceDistance	N/A	N/A	0..7	enumerated (lessthan50m(0), lessthan100m(1), lessthan200m(2), lessthan500m(3), lessthan1000m(4), lessthan5km(5), lessthan10km(6), over10km(7))
eventType	N/A	N/A	0..255	enumerated (slow vehicle = 26, subCauseCode for agriculture to be defined by ITS standards)
roadType	N/A	N/A	0..3	enumerated (urban-NoStructuralSeparationToOppositeLanes, urban-WithStructuralSeparationToOppositeLanes, enumerated (urban-NoStructuralSeparationToOppositeLanes, urban-WithStructuralSeparationToOppositeLanes, nonUrban-NoStructuralSeparationToOppositeLanes, nonUrban-WithStructuralSeparationToOppositeLanes) - obtained from map information if available

Table 6 contains other parameters used internally.

Table 6: Parameters used internally

Parameter	Unit	Resolution	Range	Data Type
triggerActivated	N/A	N/A	N/A	Boolean

6.2.2 Functional Architecture

Figure 7 illustrates the functional architecture built upon the different protocol stacks that were presented in clause 5, Figure 2. This is compliant with the oneM2M architecture specified in ETSI TS 118 101 [i.1], specifically its Annex F.

For the pilot test, the agriculture equipment hosts a oneM2M platform, which is able to operate as a standalone device, even though it is possible to add an interface to a MN-CSE or IN-CSE from the Base CSE if needed.

This interworking model involves three application level entities, hereafter named the Safety AE, the AGRI-IPE and the ITS-IPE, which operate on top of a common CSE entity, the HAE-CSE.

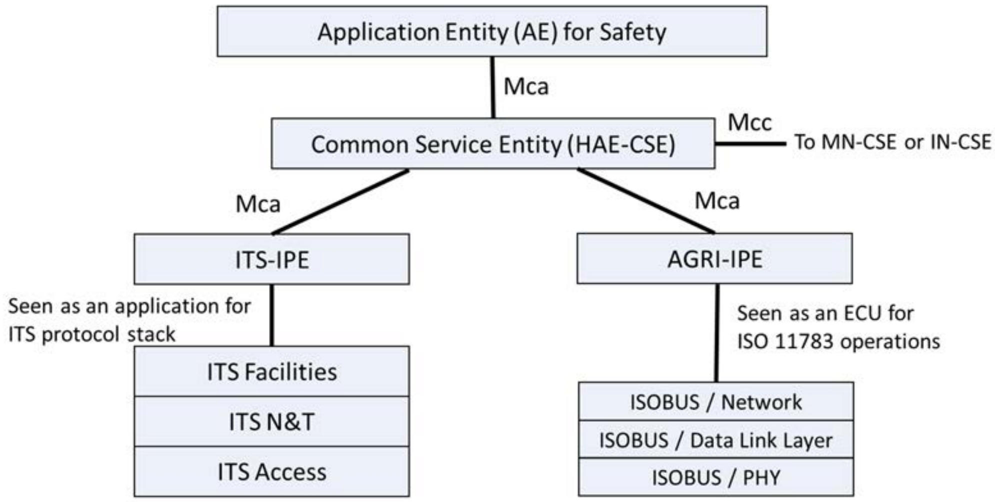

Figure 7: Interworking Reference Model in the HAE

Roles of the functional entities

The oneM2M service platform is modelled as a Base CSE (**HAE-CSE**), a oneM2M Common Services Entity (CSE). It serves as a registrar CSE for the Safety application and the two Interworking Proxy Application Entities (IPE).

The **AGRI-IPE** is seen as a specialized ECU on the ISO 11783 network. It is hosted by the Management Computer Gateway (MCG) and performs the inter-working between the ISO 11783 and the oneM2M Mca interface. The MCG is a gateway able to route information between the vehicle's implement network and any external network, i.e. the oneM2M environment via Internet Protocol in the given setup. It retrieves the ISO 11783 messages and creates new instances of the related resources in the HAE-CSE. In order to avoid creating new instances when the value of a parameter has not changed, it keeps an updated state of the ISO 11783 data and creates a new instance only when a value has changed. For example, this applies to the lighting information, which is broadcasted every second on the ISO 11783 network, even if no change of the HAE lights has occurred.

The test is controlled by an application identified as **Application Entity (AE) for Safety**. This application hosts an algorithm that triggers an actuator when a safety condition is met and an alert should be sent to the neighbouring vehicles. The Safety AE subscribes to the TriggerSensors resource in order to receive a notification when a new contentInstance has been created. When this happens, it retrieves the latest instance of the child resources and runs its internal algorithm. On a positive result, it changes the value of the EventTrigger to ON, for notification of the ITS-IPE.

The **ITS-IPE** is seen as an application by the ITS protocol stack. It subscribes to the EventTrigger resource of the Safety AE. When receiving a notification on the EventTrigger resource (change to ON), it retrieves the latest instance of all resources associated to the AGRI-IPE and triggers the ITS protocol stack to send an alert as a DENM first, followed by CAMs informing the neighbouring vehicles that an agriculture equipment is present on the road.

The main Common Service Functions (CSF) listed in ETSI TS 118 101 [i.1] and expected to be implemented in the HAE-CSE are the Discovery (DIS), Registration (REG), Subscription and Notification (SUB), Data Management and Repository (DMR), Semantics (SEM), and Security (SEC) functions, as illustrated in Figure 8.

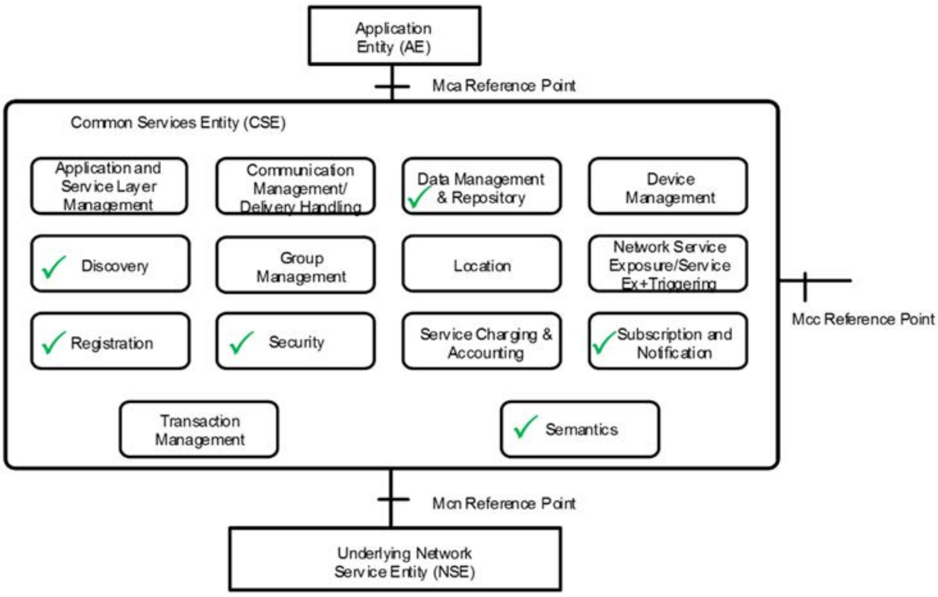

Figure 8: Common Services Functions (CSF) implemented in the CSE in the HAE (from [i.12])

6.2.3 Data model files

The tables defined in clause 6.2.1 have been used to define the resource tree at the HAE-CSE. This resource tree is illustrated in Figure 9.

The root HAE-CSE has four direct child resources:

- HAE-CSE_acp for the access control policies (see clause 6.5).
- Safety-AE represents the safety AE and has one child resource as the EventTrigger container. This Container has child resources for holding the subscription to the trigger and the content instances of the trigger.
- AGRI-IPE represents the ISO 11783 IPE and has two child Container resources. They are both respectively related to Table 3 and Table 4 described in clause 6.2.1.
- ITS-IPE represents the IPE running the interworking with the ITS protocol stack and has one child Container resource, which is related to Table 5 described in clause 6.2.1.

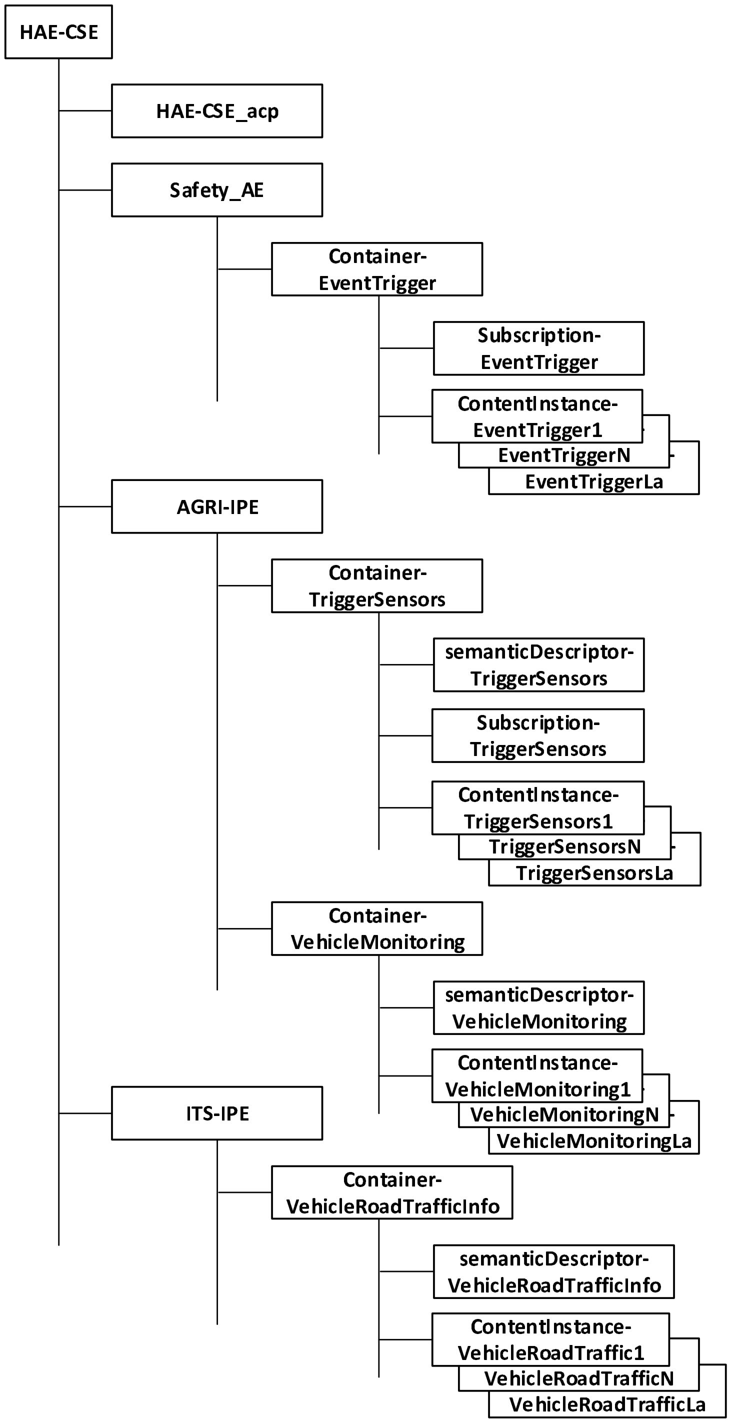

Figure 9: HAE-CSE resource structure

6.2.4 Semantic model

The present clause provides a semantic model for the pilot test data, with the objective to remain close to the oneM2M base ontology and SAREF. It is built around the HAE and addresses mainly the parameters common to both ISO 11783 and C-ITS standards (e.g. Location-time information and Vehicle State information) for the cooperation between both IPEs through the M2M platform. Information which is more specific to the C-ITS side, i.e. Vehicle Type information or Road and Traffic information has been left out of the common model.

The main model is presented in Figure 10. This model is based on the following main concepts, principally reused from SAREF (see ETSI TS 103 264 [i.23]):

- AgriEquipmentDevice, as sub-class of Device (e.g. ECU or MCG, as defined in clause 6.2.2).

- Service (e.g. Alert of Slow Vehicle).
- Function (i.e. Actuating Function, Event Function, Metering Function, Sensing Function).
- Command (e.g. Trigger Alert at C-ITS).
- Profile (e.g. triggering conditions).
- State (e.g. TriggerActivated, TriggerOff).
- Measurement (e.g. sensing and measuring in ISO 11783 [i.25]).
- Property (e.g. Exterior lights, Motion, Implement states, as defined in Table 3 and Table 4).
- UnitOfMeasure (e.g. SpeedUnit, AccelerationUnit, AngleUnit).

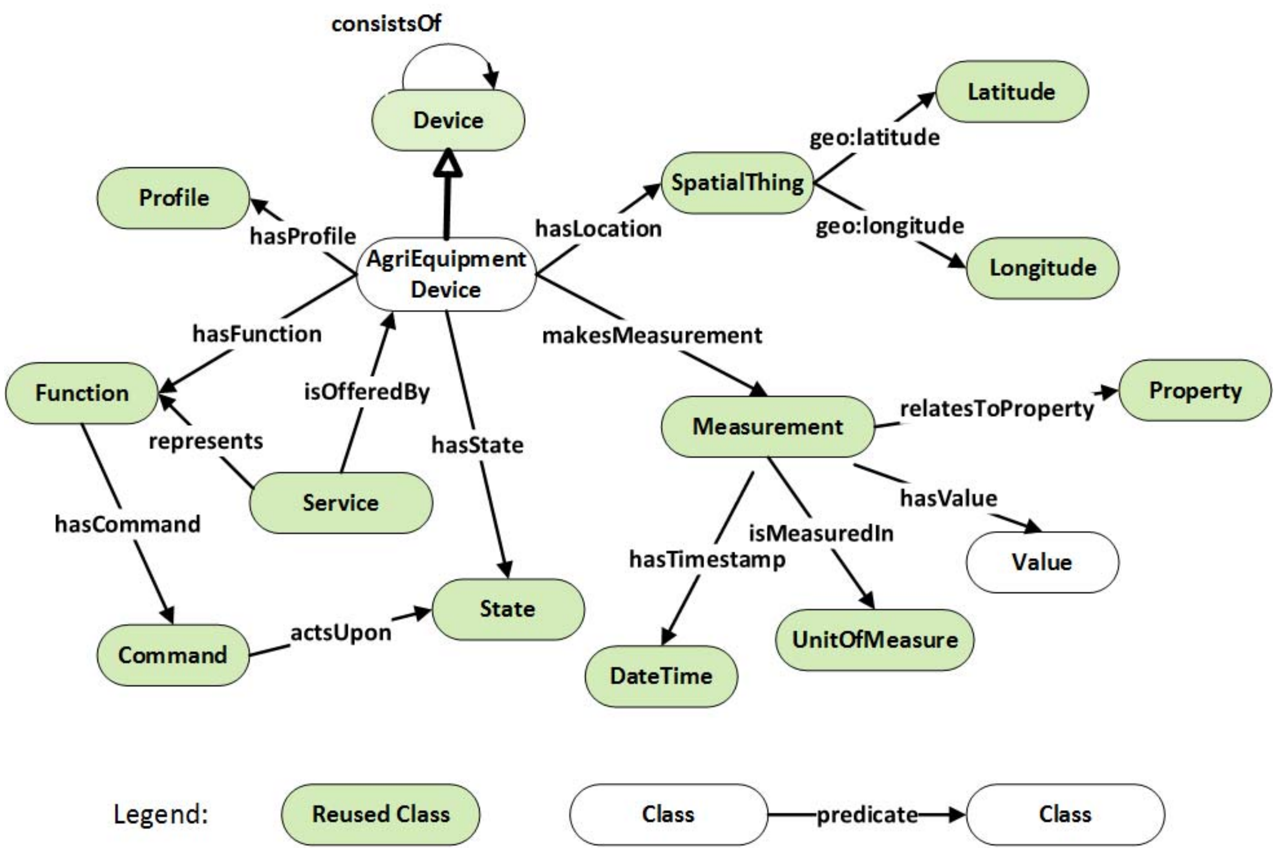

Figure 10: HAE semantic model (main classes)

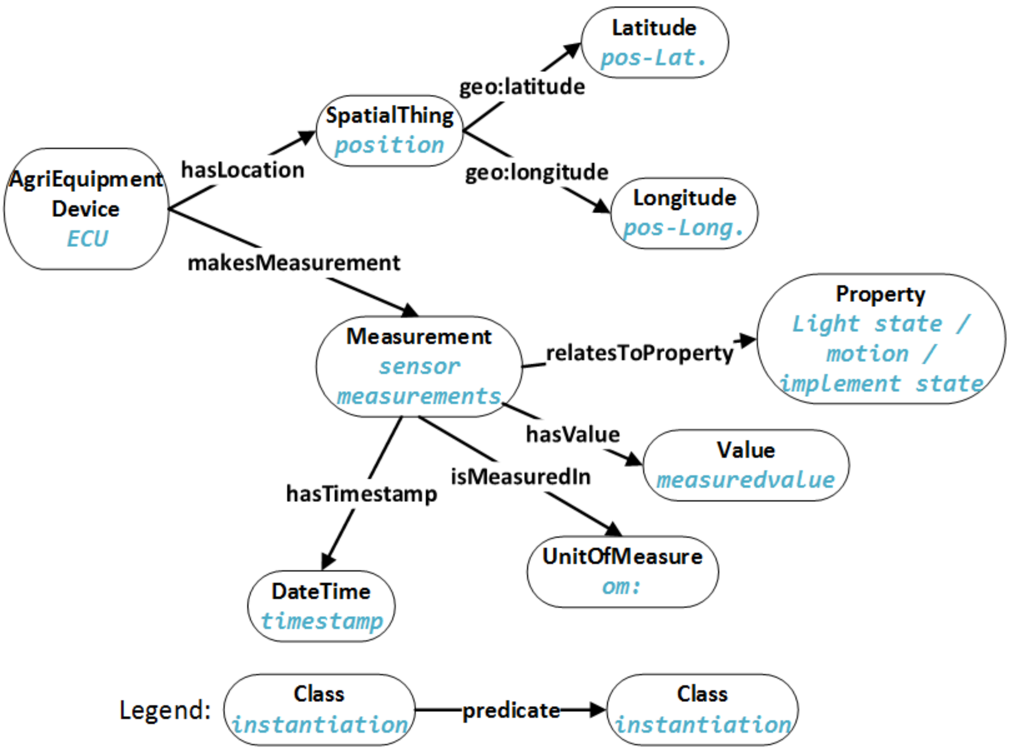

Figure 11: HAE semantic model (instantiation of the sensing/measuring)

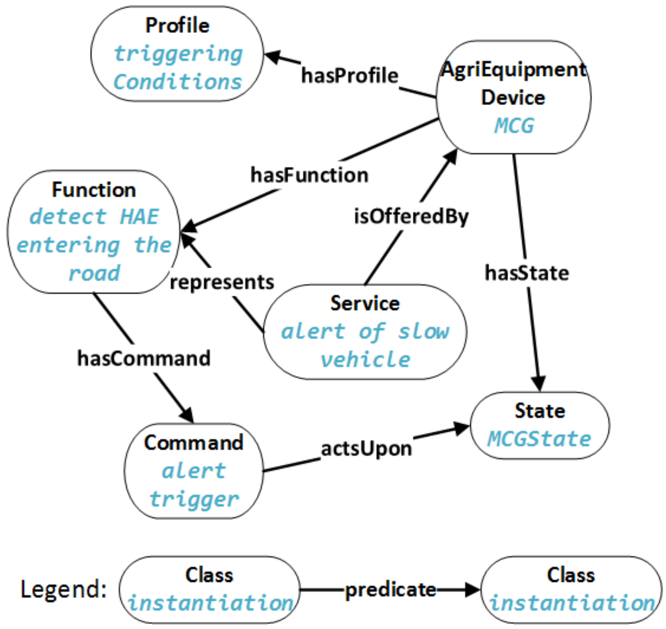

Figure 12: HAE semantic model (instantiation of the actuation)

A very simplified associated ontology has been defined based on the semantic model above and the parameters defined in the tables of clause 6.2.1. The output is an xml file referring to the SAREF ontology and can be found in Annex C.

6.3 Protocols and interfaces

The following protocols are used at the different interfaces illustrated in Figure 7:

- Mca Reference Points: The primitives for Application Registration, Resource creation, Discovery of container resource, Security Management, Retrieval of resources and creation of new content instances are used.

- From AGRI-IPE to ISO 11783 stack: The interface is used for reading and filtering of CAN messages, as described in clause 6.4.
- From ITS-IPE to ITS protocol stack: The ITS-IPE is seen as an ITS application and uses the internal ITS API provided by the ITS stack used. This API has been specified to be implementation-dependent, as it is internal to each manufacturer system.

6.4 Data management for the exchange of information

The exchange of information and main scenario can be divided into three different phases, as described below. For the main phases and steps, the content of the primitives exchanged is presented. The following assumptions apply.

The HAE-CSE entity is addressable with the following identifiers: CSE-ID: *hae-cse*; resource name of CSEBase resource: *hae_gateway*. The CSE is hosted in the HAE-GW-Node, with short name *hgn*. All Aes are hosted in that same node. If any AE is hosted in other nodes, then the tables below need to be adjusted to include the Point of Attachment information.

Table 7: Resource identifiers convention

Resource and Identifiers	Resource Name	Resource Id
AE Safety_AE (AE-ID: Safety-AE)	safety-ae	ae-SFAEnn
Container EventTrigger	event-trigger	cnt-CETnn
AE AGRI-IPE (AE-ID: Agri-IPE)	agri-ipe	ae-AIPEnn
Container TriggerSensors	trigger-sensors	cnt-CTSnn
Container VehicleMonitoring	vehicle-monitor	cnt-CVMnn
AE ITS-IPE (AE-ID: ITS-IPE)	its-ipe	ae-IIPEnn
Container VehicleRoadTrafficInfo	vehicle-info	cnt-CRSInn

Phase 1: System initialization: applications registration, access control policy creation, initial resource creation, discovery and subscriptions. The discovery function is not needed in the AGRI-IPE because it operates mainly as a data provider, not as a data consumer.

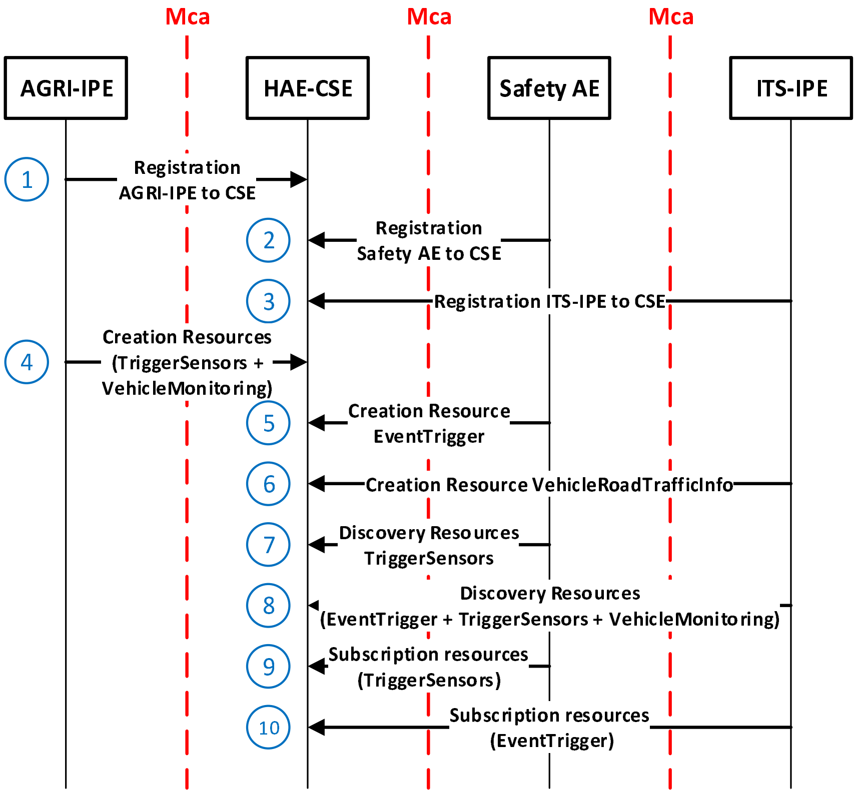

Figure 13: Phase 1 - System initialization

Step 1

The AGRI-IPE registers with the oneM2M service platform (HAE-CSE). The registration of an AE includes the creation of an <AE> resource (Resource type = AE (2)) under the <CSEBase> of its registrar CSE (here, the HAE-CSE).

Table 8: Primitive content - AGRI-IPE registration

```
HTTP Request:

POST /hae_gateway HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: agri-ipe
Content-Type: application/xml;ty=2
X-M2M-RI: haecse-xxxxx

<?xml version="1.0" encoding="UTF-8"?>
<m2m:ae xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="agri-ipe">
<api>haeNode.Agri-IPE</api>
<rr>false</rr>
</m2m:ae>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/ae-AIPEnn
```

Step 2

The safety AE registers with the oneM2M service platform (HAE-CSE).

Table 9: Primitive content - Safety AE registration

```
HTTP Request:

POST /hae_gateway HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: safety-ae
Content-Type: application/xml;ty=2
X-M2M-RI: haecse-xxxxx

<?xml version="1.0" encoding="UTF-8"?>
<m2m:ae xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="safety-ae">
<api>haeNode.Safety-AE</api>
<rr>false</rr>
</m2m:ae>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/ae-SFAEnn
```

Step 3

The ITS-IPE registers with the oneM2M service platform (HAE-CSE).

Table 10: Primitive content - ITS-IPE registration

HTTP Request: POST /hae_gateway HTTP/1.1 Host: hgn.provider.com:8080 X-M2M-Origin: safety-ae Content-Type: application/xml;ty=2 X-M2M-RI: haecse-xxxxx <?xml version="1.0" encoding="UTF-8"?> <m2m:ae xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="its-ipe"> <api>haeNode.ITS-IPE</api> <rr>false</rr> </m2m:ae>
HTTP Response: 201 Created X-M2M-RSC: 2001 X-M2M-RI: haecse-xxxxx Content-Location: /hae-cse/ae-IIPEnn

Step 4

The AGRI-IPE creates resources in the HAE-CSE (TriggerSensors and VehicleMonitoring containers). In this step, it also creates the first contentInstance of these two containers.

Main parameters values: Resource type = container (3)

Table 11: Primitive content - Creation of triggerSensors container Resource

HTTP Request: POST /hae_gateway/agri-ipe HTTP/1.1 Host: hgn.provider.com:8080 X-M2M-Origin: agri-ipe Content-Type: application/xml;ty=3 X-M2M-RI: haecse-xxxxx <m2m:cnt xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="trigger-sensors"> </m2m:cnt>
HTTP Response: 201 Created X-M2M-RSC: 2001 X-M2M-RI: haecse-xxxxx Content-Location: /hae-cse/cnt-CTSnn

For the creation of the VehicleMonitoring container, the request is similar, but for parameter `rn="vehicle-monitor"` in the request and `Content-Location /hae-cse/cnt-CVMnn`

Main parameters values for the creation of the contentInstance: Resource type = contentInstance (4)

Table 12: Primitive content - Creation of triggerSensors contentInstance

```
HTTP Request:

POST /hae_gateway/agri-ipe/trigger-sensors HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: agri-ipe
Content-Type: application/xml;ty=4
X-M2M-RI: haecse-xxxxx

<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cin-CITSnn
Content-Type: application/xml
```

For the creation of the first contentInstance of VehicleMonitoring container, the request is similar, but for parameter to which is equal to `/hae_gateway/agri-ipe/vehicle-monitor` in the request and `Content-Location /hae-cse/cin-CIVMnn`

Step 5

The safety AE creates resources in the HAE-CSE (EventTrigger container). In this step, it also creates the first contentInstance of this container.

Table 13: Primitive content - Creation of EventTrigger container Resource

```
HTTP Request:

POST /hae_gateway/safety-ae HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: safety-ae
Content-Type: application/xml;ty=3
X-M2M-RI: haecse-xxxxx

<m2m:cnt xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="event-trigger">
</m2m:cnt>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cnt-CETnn
```

Table 14: Primitive content - Creation of EventTrigger contentInstance

```
HTTP Request:

POST /hae_gateway/safety-ae/event-trigger HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: safety-ae
Content-Type: application/xml;ty=4
X-M2M-RI: haecse-xxxxx

<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cin-CIETnn/
Content-Type: application/xml
```

Step 6

The ITS-IPE creates resources in the HAE-CSE (VehicleRoadTrafficInfo container). In this step, it also creates the first contentInstance of this container.

Table 15: Primitive content - Creation of VehicleRoadTrafficInfo container Resource

```
HTTP Request:

POST /hae_gateway/ its-ipe HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: its-ipe
Content-Type: application/xml;ty=3
X-M2M-RI: haecse-xxxxx

<m2m:cnt xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="vehicle-info">
</m2m:cnt>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cnt-CRSInn
```

Table 16: Primitive content - Creation of VehicleRoadTrafficInfo contentInstance

```
HTTP Request:

POST /hae_gateway/its-ipe/vehicle-info HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: its-ipe
Content-Type: application/xml;ty=4
X-M2M-RI: haecse-xxxxx

<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cin-CIRSInn
Content-Type: application/xml
```

Step 7

The safety AE discovers the resource associated with the AGRI-IPE, filtering on the TriggerSensors.

Table 17: Primitive content - Resource Discovery of TriggerSensors

```
HTTP Request:

GET /~/hae-cse/hae_gateway?fu=1&rty=3&drt=2&ri="trigger-sensors" HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: /hae-cse/safety-ae
X-M2M-RI: haecse-xxxxx
Accept: application/xml
```

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
X-M2M-CNST: 2
Content-Type: application/xml

<?xml version="1.0" encoding="UTF-8"?>
<m2m:uril xmlns:m2m="http://www.onem2m.org/xml/protocols">
      /hae-cse/agri-ipe/cnt-CTSnn
</m2m:uril>
```

Step 8

The ITS-IPE discovers the resource associated with the AGRI-IPE, with no filtering, as it is interested in all resources. It also discovers the resources associated with the safety AE.

Table 18: Primitive content - Resource Discovery of AGRI-IPE resources

```
HTTP Request:

GET /~/hae-cse/hae_gateway?fu=1&rty=3&drt=2&pi="agri-ipe" HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: /hae-cse/its-ipe
X-M2M-RI: haecse-xxxxx
Accept: application/xml
```

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
X-M2M-CNST: 2
Content-Type: application/xml

<?xml version="1.0" encoding="UTF-8"?>
<m2m:uril xmlns:m2m="http://www.onem2m.org/xml/protocols">
      /hae-cse/agri-ipe/cnt-CTSnn /hae-cse/agri-ipe/cnt-CVMnn
</m2m:uril>
```

Step 9

The safety AE subscribes to the child resource TriggerSensors of the AGRI-IPE resource.

Main parameters values: Resource Type = subscription (23) ; eventNotificationCriteria = Create_of_Direct_Child_Resource (3); notificationURI = safety-ae; notificationContentType = All Attributes (1)

Table 19: Primitive content - Resource Subscription to TriggerSensors resource

HTTP Request: POST /hae_gateway/agri-ipe/trigger-sensors HTTP/1.1 Host: hgn.provider.com:8080 X-M2M-Origin: safety-ae Content-Type: application/xml;ty=23 X-M2M-RI: haecse-xxxxx <?xml version="1.0" encoding="UTF-8"?> <m2m:sub xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="trigger-sensors">   <enc> <net>3</net>   </enc>   <nu>safety-ae</nu> <nct>1</nct> </m2m:sub>
HTTP Response: 201 Created X-M2M-RSC: 2001 X-M2M-RI: haecse-xxxxx Content-Location: /hae-cse/sub-CTSnn

Step 10

The ITS-IPE subscribes to the child resource EventTrigger of the safety AE resource.

Main parameters values: Resource Type = subscription (23); eventNotificationCriteria = Create_of_Direct_Child_Resource (3); notificationURI = its-ipe; notificationContentType = All Attributes (1)

Table 20: Primitive content - Resource Subscription to TriggerSensors resource

HTTP Request: POST /hae_gateway/safety-ae/event-trigger HTTP/1.1 Host: hgn.provider.com:8080 X-M2M-Origin: its-ipe Content-Type: application/xml;ty=23 X-M2M-RI: haecse-xxxxx <?xml version="1.0" encoding="UTF-8"?> <m2m:sub xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="event-trigger">   <enc> <net>3</net>   </enc>   <nu>its-ipe</nu> <nct>1</nct> </m2m:sub>
HTTP Response: 201 Created X-M2M-RSC: 2001 X-M2M-RI: haecse-xxxxx Content-Location: /hae-cse/sub-CETnn

Phase 2: System normal operation when the HAE is in the field (update from ISO 11783 and creation of new resource instances accordingly in the CSE).

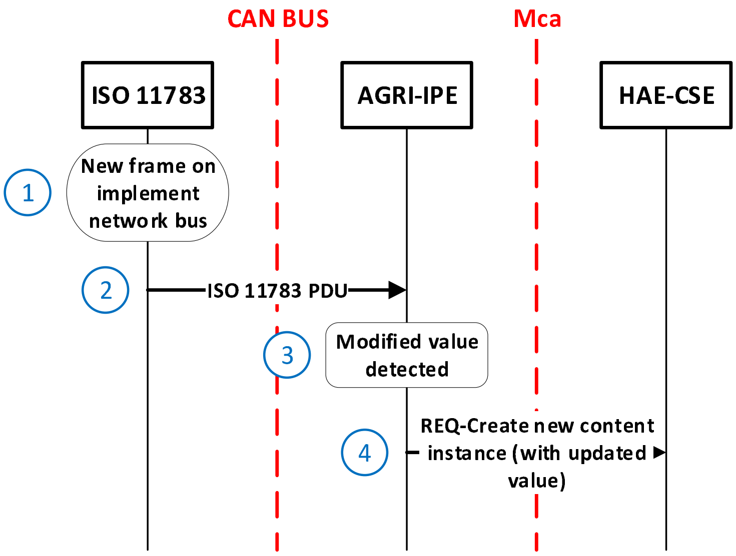

Figure 14: Phase 2 - System normal operation when HAE is in the field

Step 1

ISO 11783 CAN messages are subject to specific (suggested) repetition rates. In particular, most of the messages relevant for the present document are not destination-specific and via broadcast visible to any ECU on the CAN bus. For the relevant message types, the standard suggests the following periods:

- Wheel-Based Speed and Distance: 100 ms
- Vehicle Dynamic Stability Control: 100 ms
- Guidance Machine Status: 100 ms
- Lighting Command: every 1s and on change of state but not less than 100 ms
- Time/Date: on request
- Vehicle Direction/Speed: on request
- Vehicle Position: 200 ms
- Implement Operating State Command: every 1s and on change of state but not less than 100 ms

Step 2

The AGRI-IPE retrieves the above message types from the CAN bus in a loop and maintains an internal state monitoring the latest values for the data model. Requests for Vehicle Direction/Speed are being sent out by the IPE with a period of 100 ms in order to obtain heading information with the same sampling rate as the remaining speed and location related values. Time/Date may be interpolated by the IPE's system clock over longer periods such that Time/Date is being requested infrequently for clock synchronization (i.e. once per hour).

Step 3

As soon as the AGRI-IPE observes a state change for one of the above messages, it prepares the information retrieved from the periodic CAN messages or via the specific requests for communication to the CSE.

Step 4

The AGRI-IPE sends a request for creation of a new content instance to the CSE with the updated value.

Table 21: Primitive content - Request for new contentInstance of updated resource

```
HTTP Request:

POST /hae_gateway/agri-ipe/trigger-sensors HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: agri-ipe
Content-Type: application/xml;ty=4
X-M2M-RI: haecse-xxxxx

<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cin-CITSnn
Content-Type: application/xml
```

Phase 3: Pilot scenario when the HAE enters the road

The following sequence chart walks through the flow of sending a DENM message based on the manual trigger of switching the HAE's beacon light. This is an exemplary flow for all trigger conditions considered within this pilot setup.

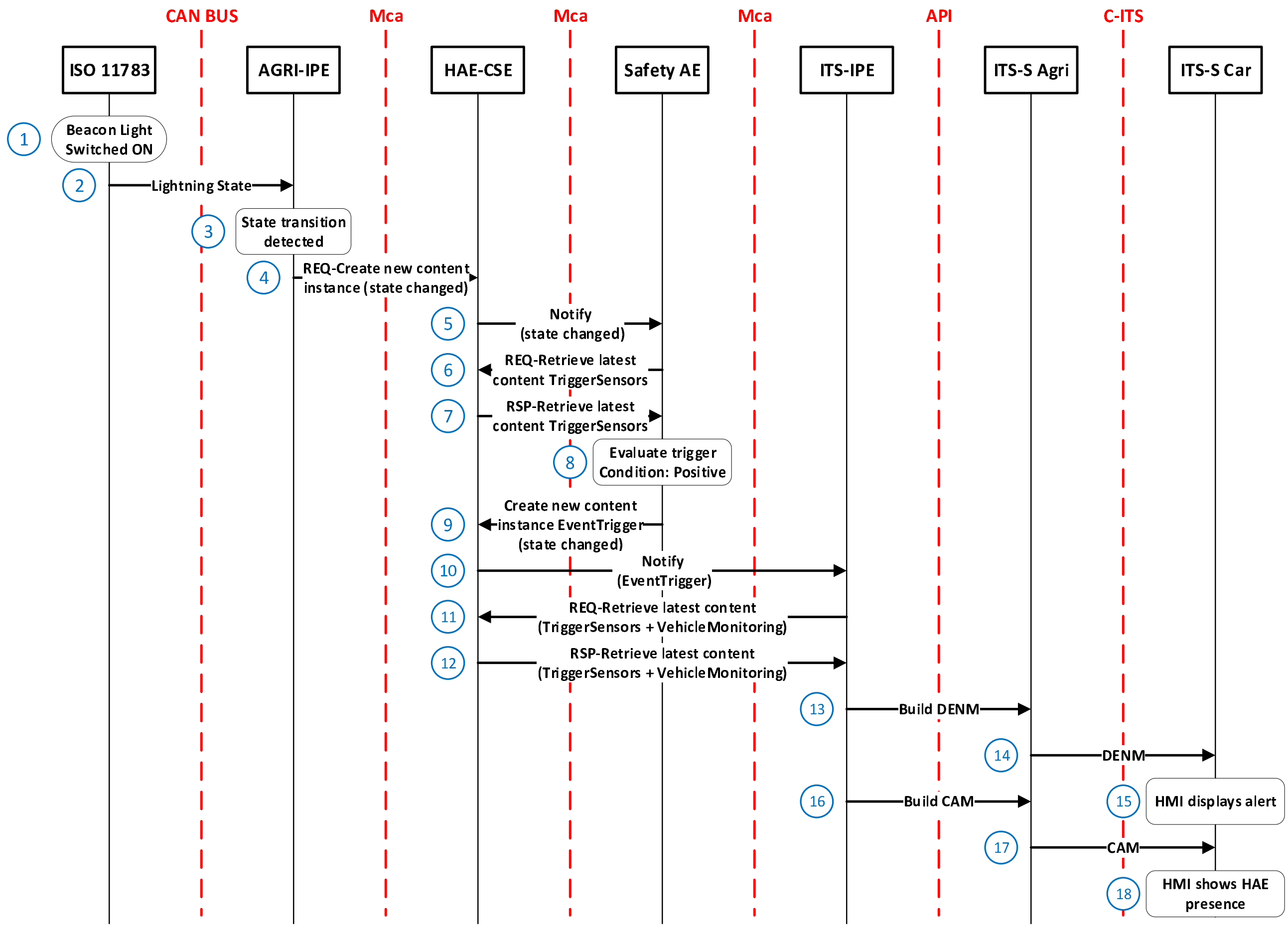

Figure 15: Phase 3 - HAE enters the road

By subscription to the TriggerSensors resource, the AE receives notifications about updates to the following fields of the data model:

- Geographic position
- beaconLightOn
- leftTurnSignalOn
- rightTurnSignalOn
- Implement in work state
- Implement start/stop operations

Step 1

The operator engages the beacon light as he intends to enter road traffic after finalizing the field operation.

Step 2

The HAE's Tractor ECU (TECU) sends a new lighting command with "beacon light enabled".

Step 3

The AGRI-IPE receives the CAN message and observes the updated lighting state with the relevant information of the activated beacon light.

Step 4

For all values relevant for the trigger condition, the AGRI-IPE requests new content instances with their most recent values at the CSE.

Table 22: Primitive content - Request for new contentInstance of trigger condition

```
HTTP Request:

POST /hae_gateway/agri-ipe/trigger-sensors HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: agri-ipe
Content-Type: application/xml;ty=4
X-M2M-RI: haecse-xxxxx

<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cin-CITSnn
Content-Type: application/xml
```

Step 5

Being subscribed to modifications of beaconLightOn, the AE is being notified about the state change by the CSE.

Table 23: Primitive content - Notification about state change

```
HTTP Request:

POST / HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: hae-cse
Content-Type: application/xml
X-M2M-RI: haecse-xxxxx

<?xml version="1.0" encoding="UTF-8"?>
<m2m:sgn xmlns:m2m="http://www.onem2m.org/xml/protocols">
  <nev>
    <rep>
      <m2m:cin>
        <cnf>ENCODING</cnf>
        <con>VALUES</con>
      </m2m:cin>
    </rep>
    <net>3</net>
  </nev>
  <sur>
    /hae-cse/sub-CTSnn
  </sur>
</m2m:sgn>
```

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
```

Step 6

On update of beaconLightOn the AE retrieves the latest instance of all values relevant for the trigger (content of TriggerSensors resource).

Table 24: Primitive content - Retrieval of resource TriggerSensors

```
HTTP Request:

GET /hae_gateway/hae-cse/cin-CIETnn/la HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: safety-ae
Accept: application/xml
X-M2M-RI: haecse-xxxxx
```

Step 7

The CSE responds with the most recent content instance for TriggerSensors resource.

Table 25: Primitive content - Response containing contentInstance of TriggerSensors

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
Content-Type: application/xml

<?xml version="1.0" encoding="UTF-8"?>
<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="trigger-sensors">
<ty>4</ty>
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

Step 8

Upon receiving the TriggerSensors latest contentInstance, the AE validates the trigger conditions based on the decision logic outlined in clause 6.6.2. As long as none of the trigger conditions are met, *EventTrigger=FALSE* remains in the CSE's data model.

Step 9

In case the decision logic concludes the activation of the trigger (i.e. a necessary subset of pre-conditions is met), an update with *EventTrigger=TRUE* is being sent to the CSE.

Table 26: Primitive content - Request for new contentInstance of EventTrigger

```
HTTP Request:

POST /hae_gateway/agri-ipe/event-trigger HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: safety-ae
Content-Type: application/xml;ty=4
X-M2M-RI: haecse-xxxxx

<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

201 Created
X-M2M-RSC: 2001
X-M2M-RI: haecse-xxxxx
Content-Location: /hae-cse/cin-CIETnn/
Content-Type: application/xml
```

Step 10

The ITS-IPE subscribed to *EventTrigger* and receives a corresponding notification.

Table 27: Primitive content - Notification on modified EventTrigger

```
HTTP Request:

POST / HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: hae-cse
Content-Type: application/xml
X-M2M-RI: haecse-xxxxx

<?xml version="1.0" encoding="UTF-8"?>
<m2m:sgn xmlns:m2m="http://www.onem2m.org/xml/protocols">
  <nev>
    <rep>
      <m2m:cin>
        <cnf>ENCODING</cnf>
        <con>VALUES</con>
      </m2m:cin>
    </rep>
    <net>3</net>
  </nev>
  <sur>
    /hae-cse/sub-CETnn
  </sur>
</m2m:sgn>
```

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
```

Step 11

The ITS-IPE retrieves the latest content instance for TriggerSensors and VehicleMonitoring resources from the CSE.

Table 28: Primitive content - Retrieval request for TriggerSensors and VehicleMonitoring latest contentInstance

```
HTTP Request:

GET /hae_gateway/hae-cse/cin-CITSnn/la HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: its-ipe
Accept: application/xml
X-M2M-RI: haecse-xxxxx
```

```
HTTP Request:

GET /hae_gateway/hae-cse/cin-CIVMnn/la HTTP/1.1
Host: hgn.provider.com:8080
X-M2M-Origin: its-ipe
Accept: application/xml
X-M2M-RI: haecse-xxxxx
```

Step 12

The CSE responds with TriggerSensors and VehicleMonitoring resources.

Table 29: Primitive content - Response containing latest contentInstance

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
Content-Type: application/xml


<?xml version="1.0" encoding="UTF-8"?>
<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="trigger-sensors">
<ty>4</ty>
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

```
HTTP Response:

200 OK
X-M2M-RSC: 2000
X-M2M-RI: haecse-xxxxx
Content-Type: application/xml


<?xml version="1.0" encoding="UTF-8"?>
<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols" rn="vehicle-
monitoring">
<ty>4</ty>
<cnf>ENCODING</cnf>
<con>VALUES</con>
</m2m:cin>
```

Step 13

This provides the ITS-IPE with all required information to build a DENM message for a "slow vehicle warning".

Step 14

The DENM message is being broadcasted by the ITS-S of the HAE and is being received by the ITS-S of a HV located within the signal range and in the relevance area.

Step 15

The HV's HMI displays the "slow vehicle warning".

Step 16

Based on the information from TriggerSensors and VehicleMonitoring resources, the ITS-S of the HAE is instructed to build a CAM message.

Step 17

The CAM message is broadcasted by the ITS-S of the HAE and is received by the ITS-S of an HV located within the signal range.

Step 18

The HV's HMI notifies about the presence of the HAE within its communication range.

6.5 Security of connectivity and data

The Security model relies on the following assumptions, illustrated in Figure 16:

- Each sub-system keeps its own security mechanisms (e.g. ISO 11783; oneM2M; ITS) and is isolated by design in the two IPEs.
- Data integrity needs to be ensured across the Mca interfaces.
- The ISO 11783 bus is accessed only for reading and requesting updates. No Write operation with the capability to update values or operate actuators is enabled.
- The oneM2M security framework is active, mainly for the authentication of entities (registration of AE/IPEs to the CSE) and the validation of data access authorization through the creation of Access Control Policies.
- The ITS protocol stack will apply the required ITS security measures, such as certificates or anonymisation of ITS stations.

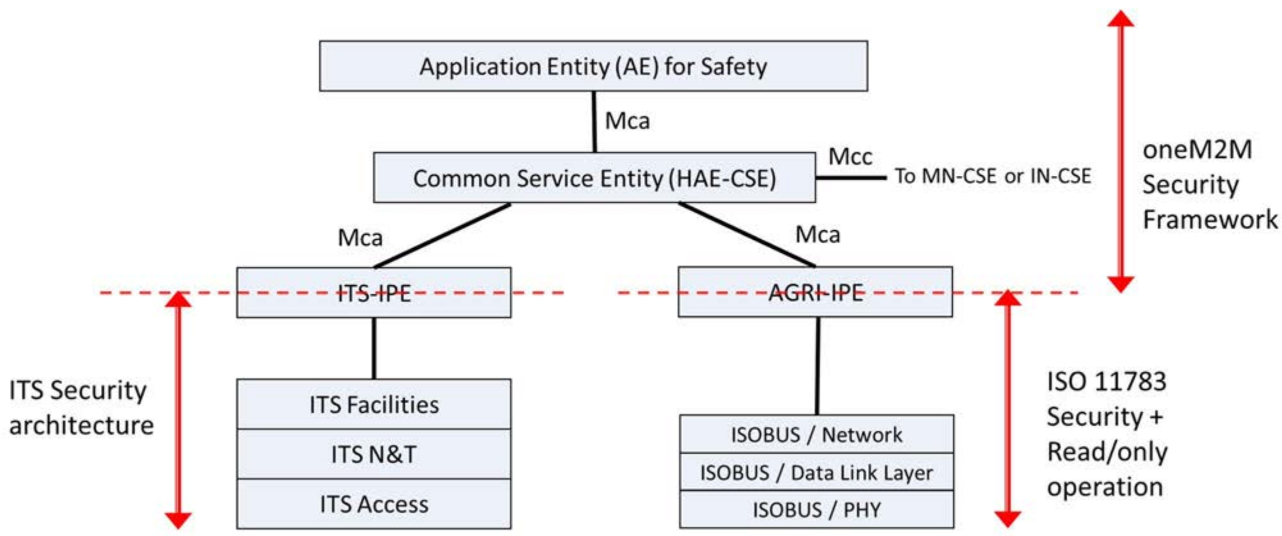

Figure 16: Security Model

6.6 Guidelines for the implementation of the pilot test and parametrization

6.6.1 Test Setup

The system under test is a tractor where the reference model for the HAE has been implemented. Depending on the availability of space and resources, two options are proposed for the demonstration of the pilot test, as described below.

1 - Real machines (tractors and cars)

A test with real machines requires a dedicated test site that is isolated from public road traffic. This could be a manufacturer's facility, the farm of a test contractor or agricultural training facilities (e.g. DEULA, DLG). A small road segment needs to be part of the test site in order to simulate the road traffic via a car equipped with an ITS on-board unit.

2 - Table setup

In case a test with real vehicles can not be facilitated, a hardware in the loop (HIL) setup with a basic ISO 11783 vehicle network will be applied. The HIL setup includes the essential components of an ISO 11783 vehicle network:

- Tractor ECU.
- Implement bus.
- Virtual Terminal.
- Management Computer Gateway.

The setup is completed by an ITS evaluation kit.

The MCG runs the software of the AGRI-IPE, the CSE, the AE and the ITS-IPE. The ITS-IPE feeds CAM and DENM information into the ITS evaluation kit via its specific interfaces for setting the required fields of both message types.

In case of the table setup, the MCG can be facilitated with a laptop computer equipped with a CAN interface (e.g. via USB). Ideally, the MCG is being set up on some embedded or prototyping platform so as to apply it in the real test environment as well.

The receiving side of the table setup is either implemented on a second computer with an ITS radio interface / coaxial cable replacing the antenna or replaced by an ITS monitoring tool.

The criteria for choosing the option for the pilot test can be listed as:

- availability of machines (agricultural equipment, cars, embedded hardware for MCG and evaluation hardware for ITS radio and protocol stack);
- cost of event organization and potentially higher development effort for real machines;
- logistics (full event or engineers test);
- visibility and demo impact (press release, visitors).

The rest of the present document considers the first option (real machines), with a back-up solution via the second option (table setup) which is easier to implement. The choice will be made when organizing the actual pilot test.

Estimation of the development needs for implementing the reference model:

- The reference model will be implemented using an open source oneM2M platform. Based on this framework, the CSE can be derived and customized from a generic CSE implementation.
- The AGRI-IPE will set up on a publicly available ISO 11783 library. In particular, the session establishment with the implement bus (CAN address claim) as well as the filtering and request of the relevant CAN messages (clause 6.4) shall be implemented inside the AGRI-IPE.

- The ITS communication will be provided by an ITS stack development or evaluation kit. The ITS-IPE populates CAM and DENM messages with the corresponding fields from the data model. Ideally, it provides dedicated interface calls to set the single message parameters.
- The AE for road safety is the core of the pilot implementation. With the data model maintained at the CSE, the AE coordinates and controls the actual safety application. In particular it hosts the decision logic responsible for a reliable detection of trigger events for the DENM message notifying the road traffic about slow agricultural equipment.

The communication between the two IPE nodes, the CSE and the AE is based on Representational State Transfer (REST) and is mapped onto HTTP bindings over IP (sockets) with XML serialization of oneM2M primitives, as described in ETSI TS 118 104 [i.12] and ETSI TS 118 109 [i.13]. If all nodes are located on the same hardware component, this communication is based on local network sockets, which results in fast and reliable Inter-Process Communication (IPC). The HTTP-based communication allows for transparent transition of the road safety application to a distributed system (e.g. Ethernet) with single nodes located on separate hardware components.

6.6.2 Triggering conditions

Trigger signals, as introduced in clause 5.1, as well as the related parameters listed in Table 3 of clause 6.2.1, are separated into three categories:

- **Based on geo location:** This trigger is considered to differentiate the vehicle's position into the states "in the field" vs. "on the road" with maximum confidence. The confidence level depends on the availability of high-resolution GNSS signals as well as map information on the HAE. Map information can be obtained dynamically in case connectivity to an online map service provider is available (e.g. via mobile Internet) or map information for the operating range of the HAE (e.g. 50 km range around the farm) can be downloaded beforehand and stored on the HAE's HMI for offline usage.
- **Manual trigger (beacon light, turn signals):** Manual triggers rely on the operator's obligation to indicate the intention of entering the road traffic via turn signals. For oversized vehicles, a beacon light is mandatory by legal requirements. The confidence level of manual triggers depends entirely on the operator's execution of legal obligations in the road traffic.
- **Based on machine or implement state:** In case the corresponding CAN messages are implemented, they provide a semi-automatic classification of the HAE being in field work or transport mode. For this information in general a manual input (e.g. machine/implement master switch on/off) is necessary to modify the state indicated by the CAN message. However, this operator input is subject to legal regulations or physical and mechanical constraints in order to prepare the agricultural equipment for road transport (e.g. fold it to the maximum permitted transport width or disengage the master switch for all valves or outlets for product application).

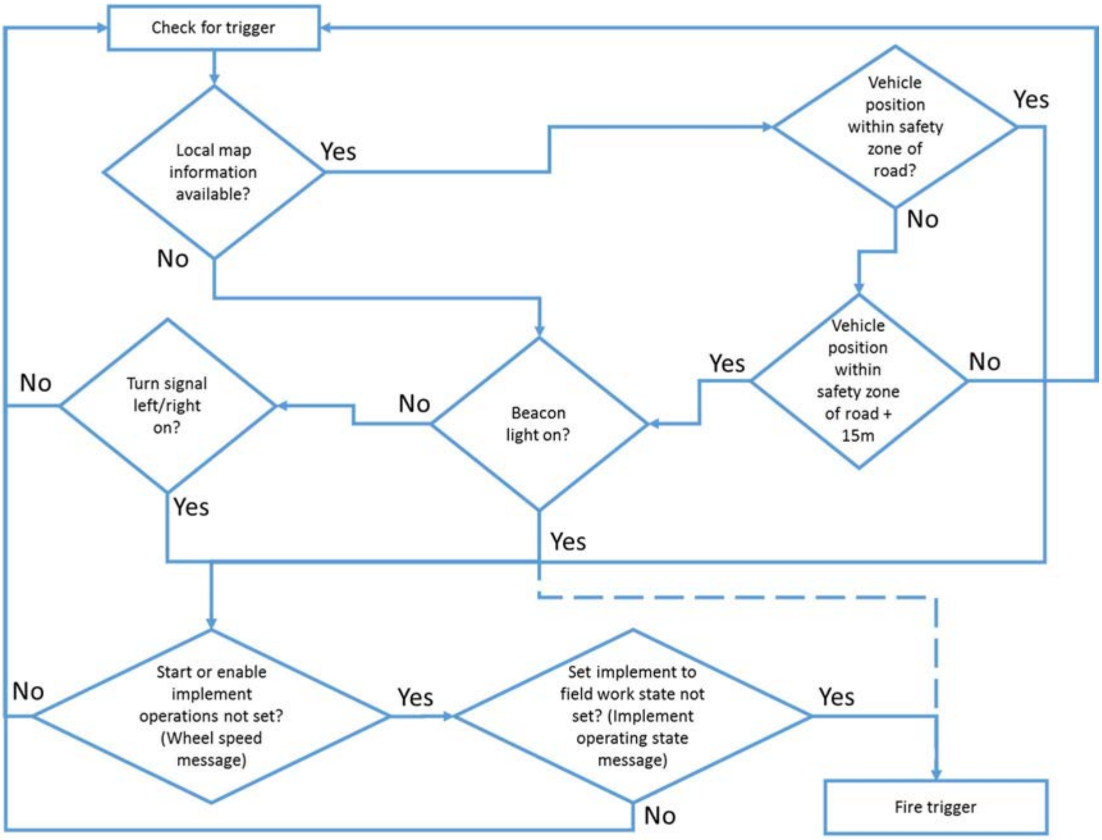

Figure 17: Decision algorithm for the trigger

Figure 17 outlines the decision flow for the trigger. The most reliable trigger conditions are met when a decision can be made based on the HAE's geographic position and map data. If map data are unavailable, the decision logic relies on the state of the beacon light or the turn signals as a condition manually set by the operator. Manual triggers are considered as well if the location-based decision considers the HAE close to the road's safety zone (e.g. within a range of 15 m of the same plane level). This branch of the decision logic covers situations in which the manual trigger conditions are met and should outweigh the location-based trigger (e.g. operator proactively enables beacon light/turn signal well before entering the road) and ensures a trigger being fired based on the manual conditions as well in case of a noisy GNSS signal. The machine and implement state information obtained via the Wheel Speed and Implement Operating State messages provides a plausibility gate for the trigger conditions. This branch filters out false positives in case the relevant CAN messages are implemented on the HAE with high reliability. Based on the flow chart the confidence level of the trigger decision (e.g. Information Quality) can be derived as follows:

- **Low confidence [informationQuality = 3]** in case only manual conditions are available on the HAE via the states of turn signal or beacon light.
- **Medium confidence [informationQuality = 5]** in case a location-based decision can be made but the operator's manual input is unreliable (e.g. turn signals or beacon light disengaged).
- **High confidence [informationQuality = 6]** in case a location-based decision can be made and is aligned with the operator's manual input (e.g. vehicle position close to road AND turn signals or beacon lights engaged).
- **Highest confidence [informationQuality = 7]** in case location-based and/or manual decision criteria are met and validated via a reliable indicator of the machine/implement state (e.g. vehicle position close to road AND turn signals or beacon lights engaged AND machine/implement not in work/start state).

6.6.3 Configuration and common parameters

6.6.3.1 OneM2M system configuration

The oneM2M is configured as designed in ETSI TS 118 113 [i.21].

6.6.3.2 C-ITS sub-system configuration

The ITS sub-system uses configuration parameters similar to what was adopted during the ETSI CMS5 event [i.9].

Configuration of the Access

All C-ITS messages defined in the present document are sent on the channel type G5-CCH with the channel number 180, see ETSI EN 302 663 [i.22].

Configuration of the GeoNetworking layer

The GN layer is configured with the following common characteristics:

- Maximum repetition time: until the end of the test scenario
- Repetition interval: 1 000 ms
- Header Type (HT): GEOBROADCAST
- HopLimit: 1
- GeoArea: Circular, with Lat/Long = ITS-S position and diameter: 2 000 m
- Azimuth: 0

Configuration of the DEN message

The DEN message uses the following parameters:

- detectionTime and validityDuration: at reception of the DENMs the event shall be valid, i.e. the detectionTime is in the past and the validityDuration is sufficiently long (validityDuration of 1,5 hours is recommended)
- termination: Negation is forbidden. Only cancelation of the own actionID is allowed
- eventPosition: the positionConfidenceEllipse is set as follows:

```
positionConfidenceEllipse ::= {
  semiMajorConfidence 100,
  semiMinorConfidence 100,
  semiMajorOrientation 0
}
```

- altitude is set to `0`
- relevanceDistance: `lessThan200m(2)`
- relevanceTrafficDirection: `allTrafficDirections(0`

6.6.3.3 ISO 11783 sub-system configuration

The relevant ISO 11783 signals retrieved from the vehicle network are present and standardized across any agricultural vehicle certified via the AEF's conformance test. Moreover, write access to the vehicle network is excluded by security rules. As a result, the test environment does not depend on the configuration of any ISO 11783 related parameters.

6.6.4 Test Procedure

In order to simplify its description and operation, the test flow showing the result of a trigger (illustrated in Figure 15) has been divided into two parts**.** Each part can be run independently, the full pilot demonstration will be able to run both of them in sequence. The first part checks that changing the status of a triggering parameter from Table 3 generates a trigger condition. The second part checks that when the trigger condition is met, DENM and CAM messages are visualised on the HV.

The pilot is divided into nine tests, as described below and detailed in Table 30 to Table 38:

- Four tests associated to part 1. There is one test for each trigger from {geo-location; beaconLightOn; leftTurnSignalOn; rightTurnSignalOn}.
- One test associated to part 2.
- Four tests associated to the full pilot test flow. One test is executed for each parameter in the list above.

NOTE: The tables below show only the points in the flow that will be exposed during the test, and not the internal parts of the test. Some of these points may be demonstrated using debugging tools. These debugging tools are expected to be available together with the open source oneM2M platform. They allow to check that resources have been created successfully and primitives received (verify parts of the test sequence). Similarly, they support the capability to create a new content instance (stimulus) from a specific application or script.

Table 30: T01 - Sub-test: trigger from geo-location

Sub-test: trigger from geo-location				
Identifier:	T01			
Objective:	Test triggering condition: geo-location			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • HAE receives a reliable GNSS positioning signal • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	Geo-Position changes as HAE reaches the road	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	Trigger condition is fired at the HAE-CSE	Debugging tool at HAE shows trigger of alert
NOTES:				

Table 31: T02 - Sub-test: trigger from beaconLightOn

Sub-test: trigger from beaconLightOn				
Identifier:	T02			
Objective:	Test triggering condition: beaconLightOn			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	beaconLightOn is activated manually	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	Trigger condition is fired at the HAE-CSE	Debugging tool at HAE shows trigger of alert
NOTES:				

Table 32: T03 - Sub-test: trigger from leftTurnSignalOn

Sub-test: trigger from leftTurnSignalOn				
Identifier:	T03			
Objective:	Test triggering condition: leftTurnSignalOn			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	leftTurnSignalOn is activated manually	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	Trigger condition is fired at the HAE-CSE	Debugging tool at HAE shows trigger of alert
NOTES:				

Table 33: T04 - Sub-test: trigger from rightTurnSignalOn

Sub-test: trigger from rightTurnSignalOn				
Identifier:	T04			
Objective:	Test triggering condition: rightTurnSignalOn			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	rightTurnSignalOn is activated manually	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	Trigger condition is fired at the HAE-CSE	Debugging tool at HAE shows trigger of alert
NOTES:				

Table 34: T05 - Sub-test: trigger generates ITS messages

Sub-test: trigger generates ITS messages				
Identifier:	T05			
Objective:	Verify that the fire of triggering condition leads to sending DENM and CAM messages			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	Safety application creates a new contentInstance of EventTrigger resource (using a debugging tool)	
	2	verify	HAE-CSE sends a notification on the EventTrigger	
	3	verify	ITS-IPE retrieves the latest content from the HAE-CSE	
	4	verify	HV receives a DENM	HV HMI shows an alert
	5	verify	HV receive CAMs	HV HMI displays the HAE
NOTES:				

Table 35: T06 - Full test: trigger from geo-location

Full test: trigger from geo-location				
Identifier:	T06			
Objective:	Test triggering condition: geo-location leads to sending DENM and CAM messages			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • HAE receives a reliable GNSS positioning signal • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	Geo-Position changes as HAE reaches the road	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	HAE-CSE sends a notification on the EventTrigger	
	7	verify	ITS-IPE retrieves the latest content from the HAE-CSE	
	8	verify	HV receives a DENM	HV HMI shows an alert
	9	verify	HV receive CAMs	HV HMI displays the HAE
NOTES:				

Table 36: T07 - Full test: trigger from beaconLightOn

Full test: trigger from beaconLightOn				
Identifier:	T07			
Objective:	Test triggering condition: beaconLightOn leads to sending DENM and CAM messages			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	beaconLightOn is activated manually	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	HAE-CSE sends a notification on the EventTrigger	
	7	verify	ITS-IPE retrieves the latest content from the HAE-CSE	
	8	verify	HV receives a DENM	HV HMI shows an alert
	9	verify	HV receive CAMs	HV HMI displays the HAE
NOTES:				

Table 37: T08 - Full test: trigger from leftTurnSignalOn

Full test: trigger from leftTurnSignalOn				
Identifier:	T08			
Objective:	Test triggering condition: leftTurnSignalOn leads to sending DENM and CAM messages			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	leftTurnSignalOn is activated manually	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	HAE-CSE sends a notification on the EventTrigger	
	7	verify	ITS-IPE retrieves the latest content from the HAE-CSE	
	8	verify	HV receives a DENM	HV HMI shows an alert
	9	verify	HV receive CAMs	HV HMI displays the HAE
NOTES:				

Table 38: T09 - Full test: trigger from rightTurnSignalOn

Full test: trigger from rightTurnSignalOn				
Identifier:	T09			
Objective:	Test triggering condition: rightTurnSignalOn leads to sending DENM and CAM messages			
Configuration:	See Figure 6 and clause 6.6.3			
Pre-test conditions:	• HAE is close to entering the road and not in work state • All entities are properly registered to the HAE-CSE. Resource subscription is active			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	rightTurnSignalOn is activated manually	
	2	verify	AGRI-IPE creates a new content instance at the HAE-CSE	
	3	verify	HAE-CSE sends a notification on the TriggerSensors	
	4	verify	Safety AE retrieves the latest content from the HAE-CSE	
	5	verify	Safety AE creates a new content instance at the HAE-CSE	
	6	verify	HAE-CSE sends a notification on the EventTrigger	
	7	verify	ITS-IPE retrieves the latest content from the HAE-CSE	
	8	verify	HV receives a DENM	HV HMI shows an alert
	9	verify	HV receive CAMs	HV HMI displays the HAE
NOTES:				

7 Conclusion

The present document has specified the concept and guidelines of a pilot use case for testing the cooperation between oneM2M and Agriculture Equipment standards, involving Cooperative ITS. The future validation of this use case built on the present document is only the first brick of this agriculture eco-system, which will give access to the data carried through the ISOBUS architecture. The validation of the concept of interoperability between two silos from different sectors as the automotive and the agriculture industries, relying on the oneM2M backbone, will enable various collaborations in the value chain of the agri-food industry. Many other use cases could enrich this eco-system providing into the future compliance to harmonized standards, which could be referenced in the European legislation for the Digital Single Market. The agriculture industry is already aligned behind the AEF certification, which demonstrated that collaboration adds more value for all stakeholders. Duplicating this model through the ETSI support by bringing its expertise with the oneM2M framework, could clearly speed up the adoption of Smart Farming, not only for Europe but also for other parts of the world.

Annex A:
Summary of ISO 11783 protocol stack

A.1 High level description

The ISO 11783 communications system [i.14] is based on the ISO 11898-2 protocol [i.19] and the SAE J1939 standard (CAN bus) [i.18], which has been jointly developed for applications in trucks, busses, construction vehicles and agricultural equipment. ISO 11783's objective is the specification of an open, interconnected communications system for electronic control units (ECUs).

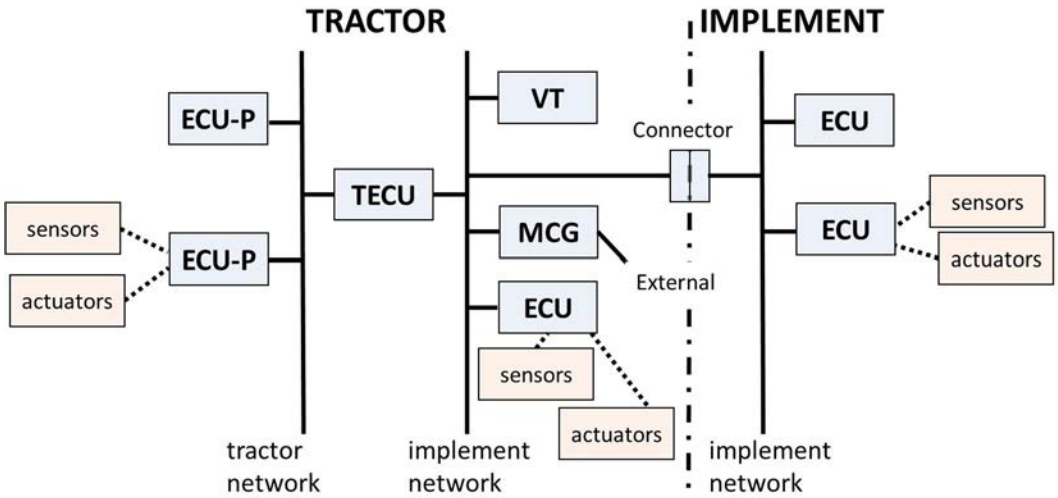

Figure A.1: Typical tractor/implement network connection structure in ISO 11783

The Tractor architecture contains two networks:

- A generally proprietary vehicle network (vehicle bus) that connects essential functions of a tractor e.g. engine, transmission, brakes (marked as ECU-P). The ISO 11783 standard does not require a standardized dictionary for the vehicle network.
- An implement network (implement bus), that complies with the ISO 11783 standard. The implement bus connects generally optional or detachable components and functions of specific ISO 11783 layers. This bus is extensible via standardized connectors (implement connector, extension port) in order to integrate ISO 11783 certified implements, displays and input devices into the implement network.

An Electronic Control Unit (ECU) is a node hosting one or more (up to 30) Control Functions (CF). A CF performs operations to complete a specific function on or within devices. It has one unique address on the network. The CFs are served by a loop scheduler that reads/writes information on the CAN bus interface.

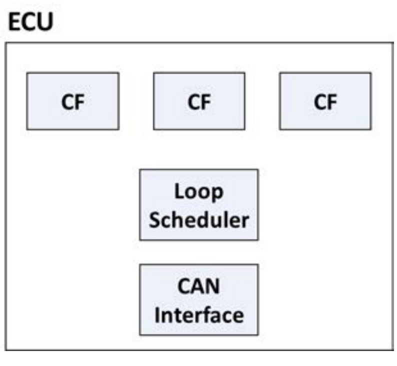

Figure A.2: Example ECU structure

The Tractor ECU (TECU) is an ECU with gateway functionalities, collecting selected information from the potentially proprietary vehicle network as well as directly connected sensors and feeds this information into the implement network. The forwarding of specific information is being initiated on demand.

The Virtual Terminal (VT) is a graphical display combined with input controls capable of displaying information to and retrieving input from the operator. The VT provides a graphical representation of a working set, which might be uploaded from a detachable implement in form of an ISO 11783-6 object pool [i.10].

The Management Computer Gateway (MCG) is a gateway forwarding specific data received from the implement network to any outside entity (interface to the external world). In the present document, the MCG serves as the AGRI-IPE, which connects the standardized implement network to the oneM2M architecture.

A.2 Protocol stack

The ISO 11783 network does not implement all the OSI layers since most applications in this communications system are specific to the agricultural industry and therefore use a flat protocol stack. For each layer required for the anticipated use, a separate part of ISO 11783 has been published. The mapping between ISO 11783 parts and the corresponding OSI layers is specified as follows:

- Physical layer - ISO 11783-2 [i.15]
- Data link layer - ISO 11783-3 [i.16] and ISO 11898-2 [i.19]
- Network layer - ISO 11783-4 [i.17]
- Application layer - specific to each CF

Figure A.3 shows the protocol stack implemented in the ISO 11783 network.

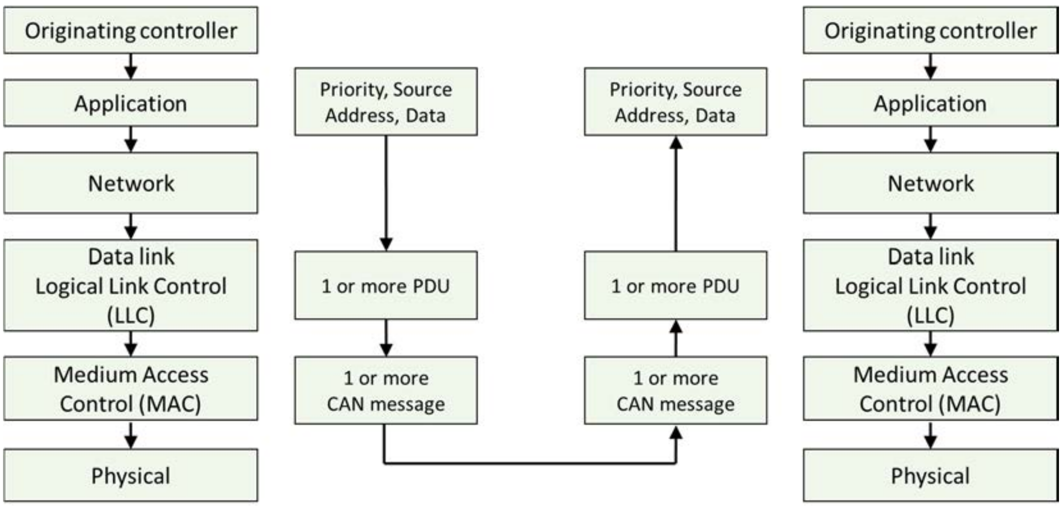

Figure A.3: Protocol stack implemented in the ISO 11783 network

A.3 High-level CAN mechanism

The CAN standard defines a specific bus access. When the bus is free, any controller can start transmitting a frame. If two or more controllers start to transmit frames at the same time, the bus access conflict is resolved by contention-based arbitration using the CAN data frame identifier. The mechanism of arbitration ensures that neither information nor time is lost. The originating controller with the frame of the highest priority gains bus access.

Fundamental ingredients of an ISO 11783 CAN frame [i.16] are the following:

- A **CAN packet** consists of a single data frame. A protocol message might be represented by a single CAN packet or might span several packets in case it exceeds the maximum payload size of 8 Bytes.

- The **Protocol Data Unit (PDU)** in an ISO 11783 CAN packet specifies the transmitted information.
- The **Parameter Group Number (PGN)** identifies a particular parameter group with specific rules for parsing the CAN payload.
- The **Source Address (SA)** provides unique identification of the message source.
- The **Destination Address (DA)** determines the SA of the intended recipient of the CAN message.

The header of a PDU is presented in Figure A.4. The PGN field determines the semantics and instructions for parsing the CAN data field depicted in Figure A.5. "FLAGS" are not detailed further in the present document as their settings are not of major effect for the pilot test. Details on PDU formats are provided in ISO 11783-3 [i.16].

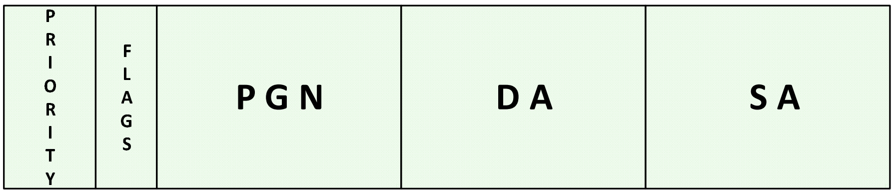

Figure A.4: Example PDU format

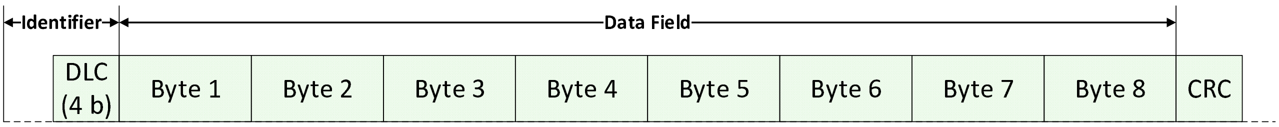

Figure A.5: CAN data field

Annex B: Summary of oneM2M architecture

B.1 oneM2M functional architecture (from [i.1])

Figure B.1 (from [i.1], clause 5.2.2) illustrates the oneM2M functional architecture.

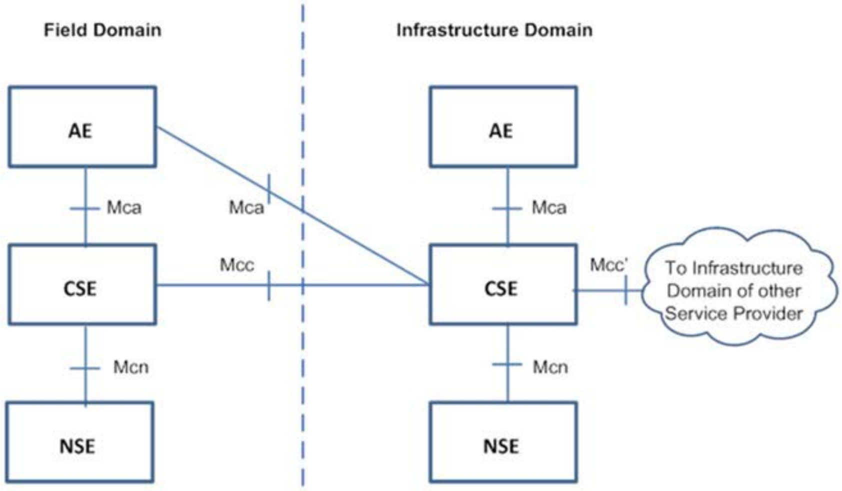

Figure B.1: oneM2M Functional Architecture (from [i.1])

Entities and reference points are defined as below:

- An **Application Entity (AE)** is an entity in the application layer that implements an M2M application service logic. Each execution instance of an application service logic is termed an "Application Entity" (AE) and is identified with a unique AE-ID.
- A **Common Services Entity (CSE)** represents an instantiation of a set of "common service functions" of the M2M environments. Each CSE is identified with a unique CSE-ID.
- A **Network Services Entity (NSE)** provides services from the underlying network to the CSEs. No particular organization of the NSEs is assumed.
- Communication flows between an Application Entity (AE) and a Common Services Entity (CSE) cross the **Mca** reference point. These flows enable the AE to use the services supported by the CSE, and for the CSE to communicate with the AE.
- Communication flows between two Common Services Entities (CSEs) cross the **Mcc** reference point. These flows enable a CSE to use the services supported by another CSE.
- Communication flows between a Common Services Entity (CSE) and the Network Services Entity (NSE) cross the **Mcn** reference point. These flows enable a CSE to use the supported services (other than transport and connectivity services) provided by the NSE.
- Communication flows between two Common Services Entities (CSEs) in Infrastructure Nodes (IN) that are oneM2M compliant and that resides in different M2M SP domains cross the **Mcc'** reference point. These flows enable a CSE of an IN residing in the Infrastructure Domain of an M2M Service Provider to communicate with a CSE of another IN residing in the Infrastructure Domain of another M2M Service Provider to use its supported services, and vice versa.

B.2 Interworking with non-oneM2M entities

The solution to enable interworking with non-oneM2M entities is based on the use of specialized interworking Application Entities, called Inter-working Proxy (IPE), that are interfaced to the CSE via standard Mca reference points. This is described in [i.1], Annex F and is illustrated in Figure B.2.

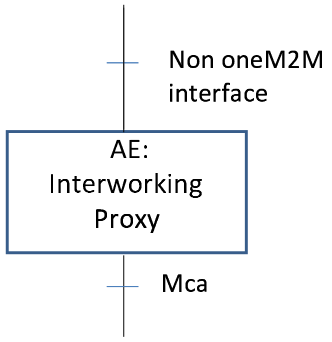

Figure B.2: Inter-working Proxy (from [i.1])

B.3 Resources

All entities in the oneM2M System, such as Aes, CSEs, data, etc. are represented as resources. A resource structure is specified as a representation of such resources. A Resource is a uniquely addressable entity in the oneM2M architecture. A resource is transferred and manipulated using Create Retrieve Update Delete (CRUD) operations. A resource can contain child resource(s) and attribute(s).

Resources for sharing data can be:

- Containers: They share data instances among entities. They are used as a mediator that buffers data exchanged between Aes and/or CSEs.
- contentInstances: They represent a data instance in the <container> resource.

Note that [i.1], clause 9.6, also specifies other types of resources beyond those described above, for example latest, oldest, pollingChannel, statsConfig or subscription.

The resource specification provides the graphical representation for the resource as in Figure B.3 (from [i.1], clause 9.5). The graphical representation of a resource shows the multiplicity of the attributes and child resources. The set of attributes, which are common to all resources are not detailed in the graphical representation of a resource.

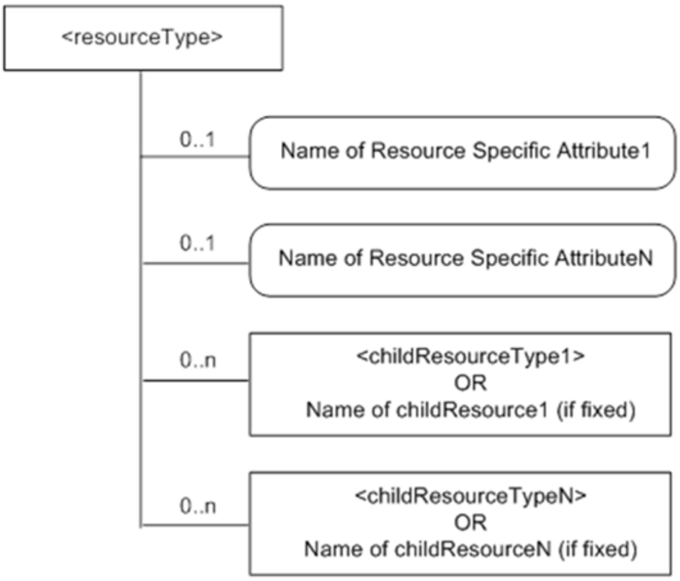

Figure B.3: <resourceType> representation convention (from [i.1])

B.4 Primitives (from ETSI TS 118 104)

Primitives are common service layer messages exchanged over the Mca, Mcc and Mcc' reference points.

In case of using an IP-based underlying network as illustrated in Figure B.4, the primitives are mapped to application layer communication protocols such as HTTP, CoAP, MQTT or WebSocket which use TCP or UDP on the transport layer. The specification of primitives, however, is independent of underlying communication protocols and allows introduction of bindings to other communication protocols.

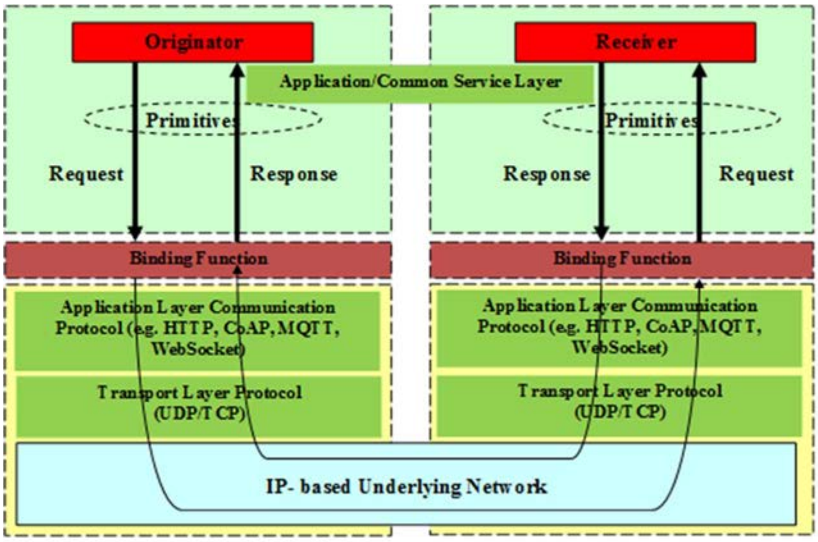

Figure B.4: Communication model using Request and Response primitives over an IP-based Underlying Network

The Originators send requests to Receivers through primitives. The Originator and Receiver may be represented by either an AE or a CSE. The CRUD request primitive addresses a resource residing in a CSE. The Notify request primitive may address an AE or CSE.

B.5 Semantic description

The Resource Description Framework (RDF) is a framework for representing information in the Web. The core structure of the abstract syntax is a set of triples, each consisting of a subject, a predicate and an object. A set of such triples is called an RDF graph. An RDF graph can be visualized as a node and directed-arc diagram, in which each triple is represented as a node-arc-node link.

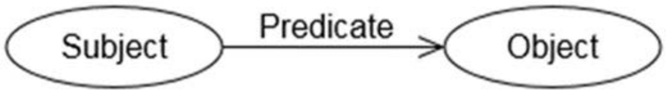

Figure B.5: An RDF graph with two nodes (Subject and Object) and a triple connecting them (Predicate) (from [i.20])

A semantic description is an abstraction of a data model. Ontologies and their OWL (Web Ontology Language) representations are used in oneM2M to provide syntactic and semantic interoperability of the oneM2M System with external systems. These external systems are expected to be described by ontologies.

The ontology or semantic model describes a system and its components. It provides a formal specification of a system, including its main concepts, the relationship between its main components and their attributes. It indicates the meaning of the data shared by a device, which can be understood by machines from different origins. Semantic interoperability is the next step of interoperability, it enables interoperability at data level between platforms and IoT systems, but also between verticals domains. When an ontology is defined for one machine (e.g. an agriculture equipment), it provides a generic interworking, i.e. the semantics will be understood by machines and devices operating in other domains, for example smart mobility or smart city. It enables the IoT applications to make smarter decisions because they can obtain and understand the meaning of data from all sorts of devices. There is no need any more to develop one-to-one interfaces.

The semantic description of a device is defined in the oneM2M standards as yet another type of resource called <semanticDescriptor>. It can be registered in the resource tree, and also discovered and retrieved by applications and other entities in the registrar CSE.

OneM2M aims at providing tools to provide full semantic support. The standards specify the oneM2M Base Ontology, a minimal ontology (i.e. mandating the least number of conventions) that is required such that other ontologies can be mapped into oneM2M and provide extensions if needed for domain specifics. This ontology is described in ETSI TS 118 112 [i.24].

Figure B.6 shows the essential Classes and Properties of the oneM2M Base Ontology. The nodes (bubbles) denote Classes whereas edges (arrows) denote Object Properties. A formal OWL representation of the base ontology can be found at http://www.onem2m.org/ontology/Base_Ontology.

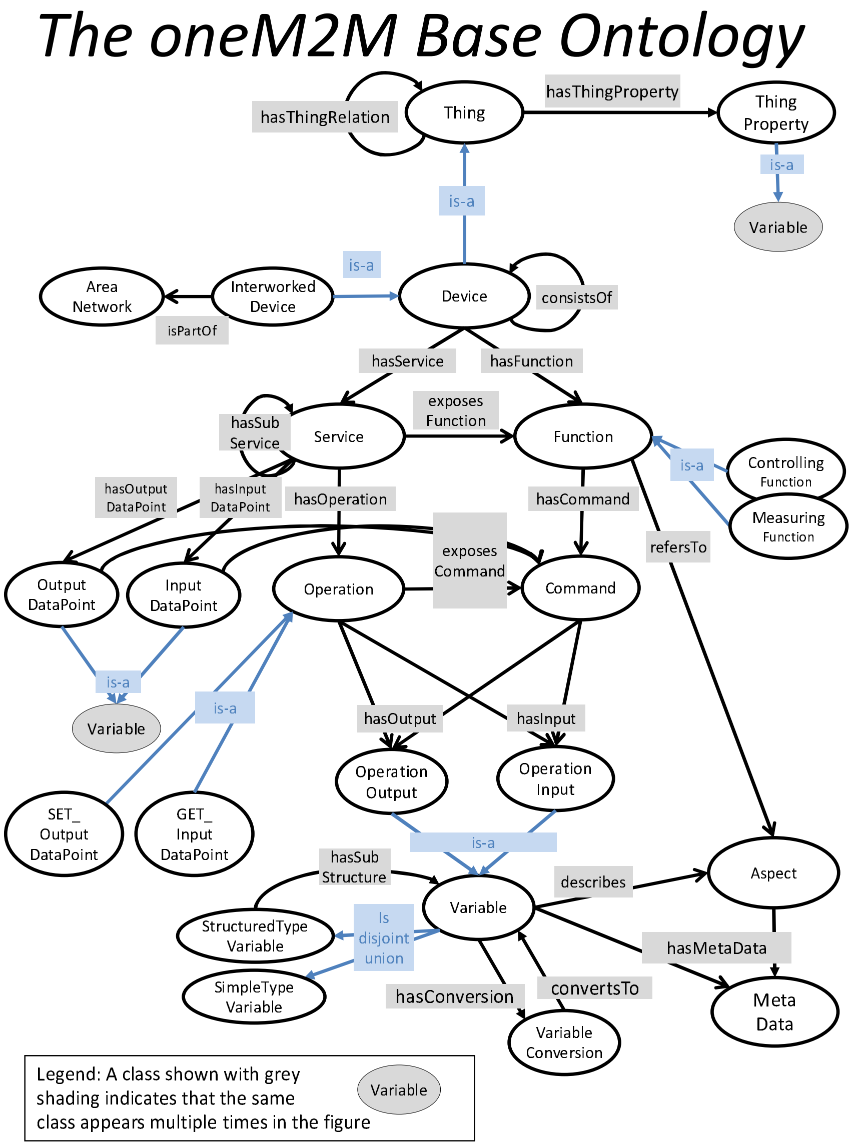

Figure B.6: The oneM2M Base Ontology (from ETSI TS 118 112 [i.24])

Annex C: Preliminary simplified ontology for the pilot prototype


```
<?xml version="1.0"?>
<rdf:RDF xmlns="https://w3id.org/def/pilot4agri#"
     xml:base="https://w3id.org/def/pilot4agri"
     xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
     xmlns:terms="http://purl.org/dc/terms/"
     xmlns:owl="http://www.w3.org/2002/07/owl#"
     xmlns:xml="http://www.w3.org/XML/1998/namespace"
     xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
     xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    <owl:Ontology rdf:about="https://w3id.org/def/pilot4agri">
        <owl:versionIRI rdf:resource="https://w3id.org/def/v1/pilot4agri"/>
        <dc:description xml:lang="en">This ontology extends the SAREF ontology for the pilot test
testing cooperation between oneM2M and Ag equipment standards. Note: properties as sub-classes of
the Property class for the HAE Device to be described in further details after implementation. The
same applies for the sub-classes of UnitOfMeasure class</dc:description>
        <dc:title xml:lang="en">SAREF extension for agriculture pilot test</dc:title>
        <owl:versionInfo
rdf:datatype="http://www.w3.org/2001/XMLSchema#string">1.0</owl:versionInfo>
    </owl:Ontology>

    <!–
    Object Properties
    →

    <owl:DatatypeProperty rdf:about="https://w3id.org/saref#hasValue">
        <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#FunctionalProperty"/>
        <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#dateTime"/>
        <rdfs:comment xml:lang="en">A relationship stating the Value obtained by a
Measurement.</rdfs:comment>
        <rdfs:isDefinedBy
rdf:datatype="http://www.w3.org/2001/XMLSchema#string">https://w3id.org/saref#</rdfs:isDefinedBy>
        <rdfs:label xml:lang="en">has value</rdfs:label>
    </owl:DatatypeProperty>

    <!–
    Classes
    →

    <owl:Class rdf:about="https://w3id.org/def/pilot4agri#AgriEquptDevice">
        <rdfs:subClassOf rdf:resource="https://w3id.org/saref#Device"/>
        <rdfs:comment xml:lang="en">A tangible object designed to accomplish a particular task as an
agriculture equipment.</rdfs:comment>
        <rdfs:label xml:lang="en">Agriculture equipment device</rdfs:label>
    </owl:Class>

    <owl:Class rdf:about="http://www.w3.org/2003/01/geo/wgs84_pos#SpatialThing">
        <owl:disjointWith rdf:resource="https://w3id.org/saref#Measurement"/>
        <owl:disjointWith rdf:resource="https://w3id.org/saref#Property"/>
        <owl:disjointWith rdf:resource="https://w3id.org/saref#UnitOfMeasure"/>
        <rdfs:comment xml:lang="en">Anything with spatial extent, i.e. size, shape, or position.
E.g. people, places, bowling balls, as well as abstract areas like cubes.</rdfs:comment>
        <rdfs:isDefinedBy rdf:resource="http://www.w3.org/2003/01/geo/wgs84_pos#"/>
        <rdfs:label xml:lang="en">Spatial thing</rdfs:label>
    </owl:Class>

    <owl:Class rdf:about="https://w3id.org/pilot4agri#Value">
        <rdfs:subClassOf rdf:resource="https://w3id.org/pilot4agri#Value"/>
        <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#float">The Value obtained by a
measurement. This is shown here as float, but it can also be a 58oolean or a specific enumerated
data type</rdfs:comment>
        <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Temperature
unit</rdfs:label>
</owl:Class>
```

Annex D: Change History

Date	Version	Information about changes
December 2017	0.0.1	Preliminary draft with table of content and scope uploaded to SmartM2M
February 2018	0.0.2	Initial Draft, with content of clause 5, as result of Task 2
April 2018	0.0.3	Stable draft with first version for clause 6
June 2018	0.0.4	Pre-final draft for SmartM2M #46
June 2018	0.0.5	Final draft for SmartM2M approval
July 2018	0.0.6	ETSI Secretariat Technical Officer checks, EditHelp clean-up of final draft before Final Draft TB approval
July 2018	0.0.7	Final Draft after Comment Resolution, Remote Consensus for TB Approval ratified on 27 July 2018

History

Document history		
V1.1.1	August 2018	Publication