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D. 5.8

Standards and conformance of IoT in AD

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Abstract
This document reports the activities carried out to contribute to standardisation of IoT in the context of Mobility and automated driving as well as the project activities relating to IoT platform interoperability testing, i.e. TESTFEST.

Legal Disclaimer

Abbreviations and Acronyms

Acronym	Definition
3GPP	Third Generation Partnership Project
5GAA	5G Automotive Alliance
ADASIS	Advanced Driver Assistance System
AIOTI	Alliance for IoT Innovation
BBF	BroadBand Forum
CEN	European Committee for Standardization
CIM	Context Information Management
EC	European Commission
EN	European Standard
ERM	EMC and Radio Spectrum Matters
ETSI	European Telecom Standardisation Institute
EG	ETSI Guide
ES	ETSI Standard
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISG	Industry Specification Group
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
NGSI	Next Generation Service Interfaces
OMA	Open Mobile Alliance
OSGi	Open Service Gateway initiative
SDO	Standard Development Organization
SIG	Special Interest Group
TC	Technical Committee
TR	ETSI Technical Report
TS	ETSI Technical Specification
TTT	Transport and Traffic Telematics
WG	Working Group

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Executive Summary

The objective of this document is to provide an overview of the activity and results obtained by the AUTOPILOT activities on "Standardization". In particular, the Task has two main objectives:

- Identify relevant Standard Development Organizations (SDOs) and influence them with results obtained in the project
- Perform an interoperability TESTFEST to demonstrate the compliance to standards of the solutions implemented in the different Pilot sites.

SDOs influencing

A comprehensive list of standards and Standard Development Organizations (SDOs) was performed and summarized in Deliverable D 5.7 [1]. Based on the list and on the overall objectives of the project, a Standardization Plan has been developed.

In the standardization plan a number of key areas have been identified, with main focus on data model, use cases and requirements

- Introduce to standards (oneM2M, SmartM2M) data models on automotive domain coming from AUTOPILOT
- Create AUTOPILOT use-case based IoT data models
- Create 'need for solution': present AUTOPILOT use cases
- Create 'elements of solution': present data models for submitted use cases

During the lifecycle of the project, 25 contributions were submitted by AUTOPILOT partners to different SDOs. It is worth highlighting that a number of use cases based on AUTOPILOT activity was approved by oneM2M and included in TR-0026 "Vehicular Domain Enablement" [2] and by AIOTI and included in report "IoT relation and impact on 5G" [3].

Conformance assessment

The conformance assessment builds on top of the above activity and provide an assessment via a TESTFEST (i.e. a proof of interoperability). In particular, according to the project DOA, the objectives are:

- to create a TESTFEST event to evaluate the level of interoperability of the IoT platforms, in correlation with the suitable standards
- to organise one TESTFEST interoperability event in Year 3 to evaluate the interoperability of the AUTOPILOT solutions and compliancy against the IoT standards

The TESTFEST was organised as a remote event, i.e. pilot sites will virtually meet and test against each other to determine interoperability of the deployed AUTOPILOT infrastructures. In particular, the focus was on platform interoperability. Tests were performed in October and November 2019 and the results were presented at a workshop held at ERTICO premises in Brussels on December 16, 2019.

Both the activity of SDOs influencing and conformance assessment demonstrated the existence of gaps in standardization, in particular with respect to the focus of the activity on the data models and the oneM2M platform interoperability.

The results of the TESTFEST showed that to achieve interoperability it is necessary to follow three principles:

- adopt OneM2M interoperability platforms and Interworking Gateway
- Standardized IoT Data Models
- Standardized Ontologies

The TESTFEST also identified some points of attention:

- The oneM2M IoT platforms were deployed in the cloud. This caused an increased latency during the TESTFEST. However, the problem is expected to be solved by moving the platform to the edge in 5G networks
- Handling of security issues when interconnecting different oneM2M platforms (e.g. multiple firewalls)

Finally, as a general outcome of the project, the architecture of the use cases developed by the different Pilot sites can be an input to SDOs (e.g. oneM2M) and relevant fora (e.g. 5GAA).

1 Introduction

1.1 The AUTOPILOT project objectives and concept

Automated driving is expected to increase safety, provide more comfort and create many new business opportunities for mobility services. The market size is expected to grow gradually reaching 50% of the market in 2035.
The Internet of Things (IoT) is about enabling connections between objects or "things"; it is about connecting anything, anytime, anyplace, using any service over any network.

AUTOmated driving **P**rogressed by **I**nternet **O**f **T**hings" (AUTOPILOT) project will especially focus on utilizing the IoT potential for automated driving.

The overall objective of AUTOPILOT is to bring together relevant knowledge and technology from the automotive and the IoT value chains in order to develop IoT-architectures and platforms which will bring Automated Driving towards a new dimension. This will be realized through the following main objectives:

- Use, adapt and innovate current and advanced technologies to define and implement an IoT approach for autonomous and connected vehicles
- Deploy, test and demonstrate IoT based automated driving use cases at several permanent pilot sites, in real traffic situations with: Urban driving, Highway pilot, Automated Valet Parking, Platooning.
- Create and deploy new business products and services for fully automated driving vehicles, used at the pilot sites: by combining stakeholders' skills and solutions, from the supply and demand side
- Evaluate with the involvement of users, public services and business players at the pilot sites:
    - The suitability of the AUTOPILOT business products and services as well as the ability to create new business opportunities
    - The user acceptance related to using the Internet of Things for highly or fully automated driving
    - The impact on the citizens' quality of life
- Contribute actively to standardization activities as well as consensus building in the areas of Internet of Things and communication technologies

Automated vehicles largely rely on on-board sensors (LiDAR, radar, cameras, etc. …) to detect the environment and make reliable decisions. However, the possibility of interconnecting surrounding sensors (cameras, traffic light radars, road sensors, etc.…) exchanging reliably redundant data may lead to new ways to design automated vehicle systems potentially reducing cost and adding detection robustness.
Indeed, many types of connected objects may act as an additional source of data, which will very likely contribute to improve the efficiency of the automated driving functions, enable new automated driving scenarios as well as increase the automated driving function safety while providing driving data redundancy and reducing implementation costs. These benefits will enable pushing the SAE level of driving automation to the full automation, keeping the driver out of the loop. Furthermore, by making autonomous cars a full entity in the IoT, the AUTOPILOT project enables developers to create IoT/AD services as easy as accessing any entity in the IoT.

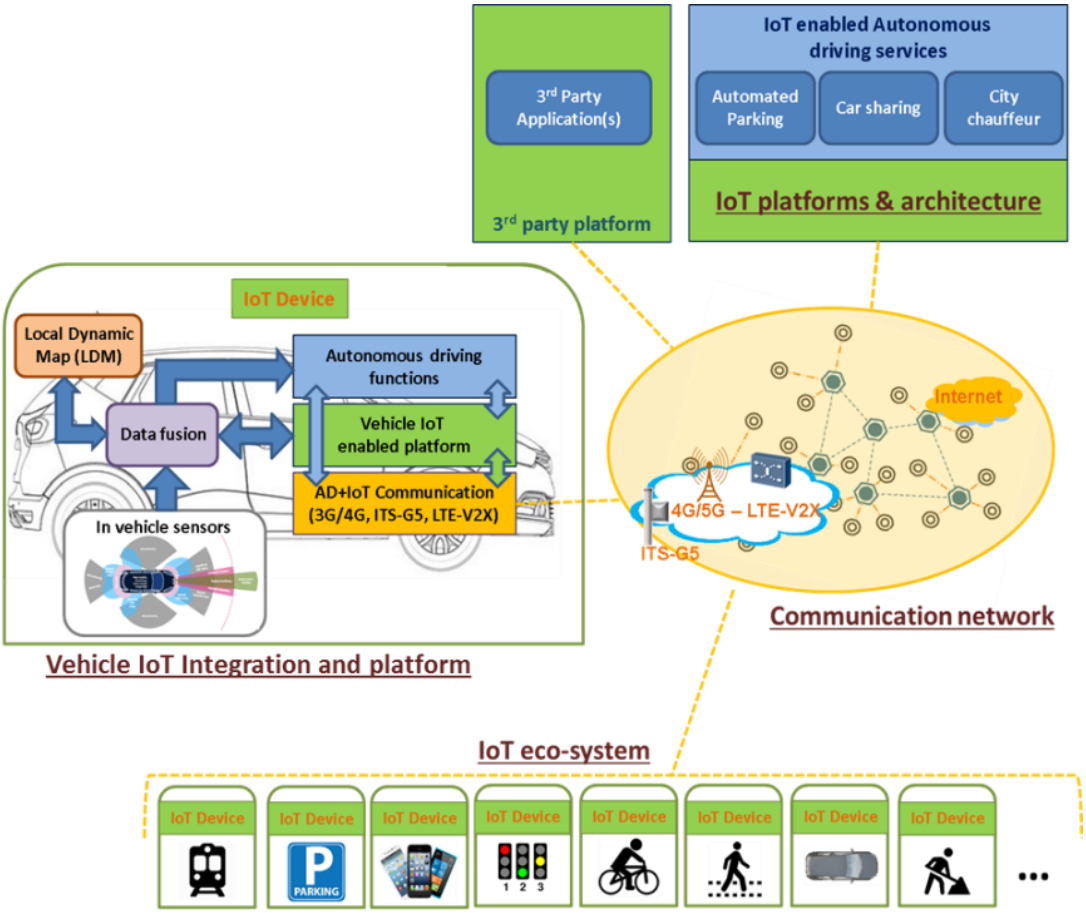

Figure 1 - The AUTOPILOT overall concept

The Figure 1 depicts the AUTOPILOT overall concept including the different ingredients to apply IoT to autonomous driving:

- The overall IoT platforms and architecture, allowing the use of the IoT capabilities for autonomous driving.
- The Vehicle IoT integration and platform to make the vehicle an IoT device, using and contributing to the IoT.
- The Automated Driving relevant sources of information (pedestrians, traffic lights …) becoming IoT devices and extending the IoT eco-systems to allow enhanced perception of the driving environment on the vehicle.
- The communication network using appropriate and advanced connectivity technology for the vehicle as well as for the other IoT devices.

1.2 Purpose of Document

The objective of this document is to provide an overview of the activity and results obtained by the AUTOPILOT activities on “Standardization”. In particular, the Task has two main objectives:

- Identify relevant Standard Development Organizations (SDOs) and influence them with results obtained in the project
- Perform an interoperability TESTFEST to demonstrate the compliance to standards of the solutions implemented in the different Pilot sites.

Standardization activity is an essential part of the project strategy. Automated driving solutions will require addressing many issues such as interoperability between systems, security aspects, the IoT ecosystem and applications.

Without standard support the solutions adopted into the project will risk being marginalized due to lack of market adoption.

Therefore, the project identified the standards relevant to automated driving. A comprehensive list of standards and Standard Development Organizations (SDOs) was performed and summarized in Deliverable D 5.7 [1].

Based on the list and on the overall objectives of the project, a Standardization Plan has been developed and contributions submitted to relevant SDOs.

Contribution to SDOs on conformance assessment is an essential part of the project strategy. Automated driving solutions will require addressing many issues such as interoperability between systems, security aspects, the IoT ecosystem and applications.

Without standardized procedures for conformance assessment the solutions adopted into the project will risk being marginalized due to lack of interoperability.

The TESTFEST represents an opportunity to demonstrate interworking capabilities and compliance to standards of the solutions developed by the Project.

1.3 Intended audience

The document is public and is addressed to professionals interested in standardization activities on automated driving and in testing activities to demonstrate interoperability of complex solutions.

1.4 Document structure

The document is organized as follows:

Chapter 2 provides the standardization plan and list of contributions to relevant SDOs.

Chapter 3 provides an overview of the standards used to develop the use cases implemented in the different Pilot sites and summarizes the results of the TESTFEST.

2 AUTOPILOT Standardization Plan and main results

This Chapter describes the main actions and opportunities identified so far. In particular, Figure 2 provides the timeplan for contributions, with respect to the planned meetings by SDOs.

The plan identifies a Focus Area for contribution (namely use cases and data models for use cases), where the effort has been concentrated, and opportunities, where contributions were possible on the basis of specific results obtained in the project.

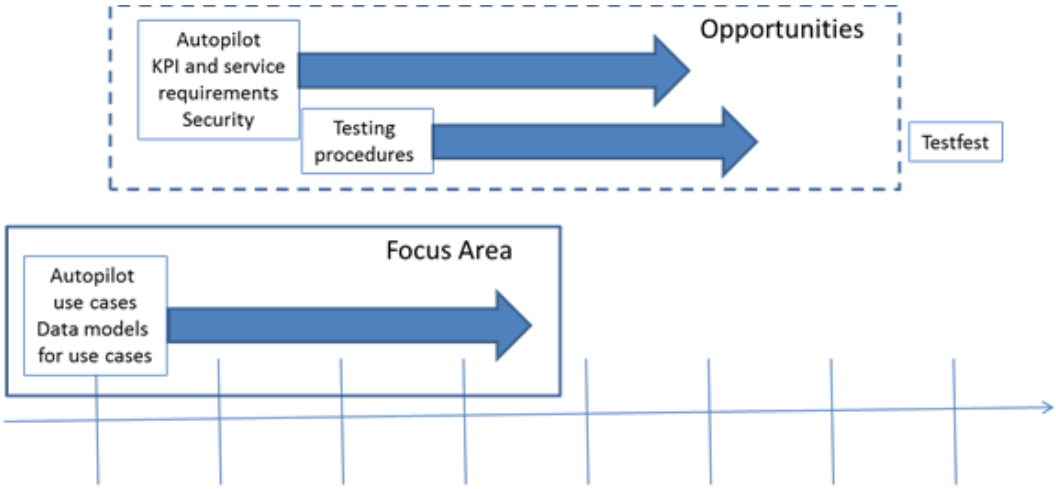

Figure 2 - The timeplan for contributions

2.1 Standardization plan

Data model, use cases and requirements

SDO	Goal	Action	Partners involved
oneM2M, ETSI SmartM2M	• Introduce to standards (oneM2M, SmartM2M) data models on automotive domain coming from AUTOPILOT • Create AUTOPILOT use-case based IoT data models • Create 'need for solution': present AUTOPILOT use cases • Create 'elements of solution': present data models for submitted use cases	Initial contributions submitted to oneM2M in March	EGM, CNIT, ISMB, Huawei, TIM, NEC
oneM2M	Architectures:	Present autopilot data	EGM, TNO, Huawei

	• Link between oneM2M and 3GPP SCEF, • Link between oneM2M and ETSI MEC	model and link it with oneM2M base ontology.	
ETSI SmartM2M	• IoT data models • Create AUTOPILOT use-case based IoT data models • Define 'need for solution': present AUTOPILOT use cases • Define 'elements of solution': present data models for submitted use cases	STF on extending SAREF waiting for approval by ETSI Present autopilot data model and link it with SAREF	EGM, ISMB, TNO, Huawei
AIOTI	• Define AUTOPILOT use-case based IoT data models • Define the requirements that are imposed by AUTOPIOLT use cases to the supporting IoT platform and underlying communication technologies	Initial contributions submitted AIOTI WP3	CNIT, Huawei, TNO
ETSI ISG CIM (Context Information Management)	• Introduce data models on automotive domain coming from AUTOPILOT	Present AUTOPILOT data model Make AUTOPILOT as CIM use case references	EGM, NEC

Conformance assessment

SDO	Goal	Action	Partners involved
oneM2M TST, ETSI SmartM2M	• Ensure AUTOPILOT test cases are part of the conformance procedures specified by oneM2M and ETSI	Analyse Task 2.5 test cases and prepare contributions	Cetecom, TIM, EGM
3GPP RAN 5, GCF	• Conformance Test Aspects and Certification of IoT and V2X solutions are planned	Monitor – no specific action planned, but check needed to assess the progress of the activity	Cetecom, TIM

Other opportunities for contributions: System requirements

SDO	Goal	Action	Partners involved
3GPP SA1	• Create AUTOPILOT use-case based IoT data models • Create 'need for solution': present AUTOPILOT use cases • Provide AUTOPILOT performance KPI	Evaluate opportunities of contribution	TIM
3GPP SA2	Architectures: • Link between oneM2M and 3GPP SCEF	Evaluate opportunities of contribution	TIM

ETSI MEC	Architectures: • Link between oneM2M and ETSI MEC • Hackaton event	Evaluate opportunities of contribution	ISMB
ETSI ISG CIM (*)	• Ensure federation of sources is feasible for sensor fusion • Ensure a very flexible information model capable of representing AUTOPILOT data and metadata	Continuous verbal contributions in weekly calls and quarterly plenary sessions	NEC, EGM

(*) Explanation of contribution method in ETSI ISG CIM
ETSI ISG CIM has the mission to define (using a RESTful interface) a simple, robust and flexible way of exchanging all kinds of data and metadata between systems. This ideally fits the AUTOPILOT goals, but there are many views how to do it. NEC has worked within weekly calls and quarterly plenary meetings of ISG CIM to ensure that the consensus in the group is aligned with requirements of AUTOPILOT, however it has not been necessary to contribute explicit AUTOPILOT use cases because others were acceptable (e.g. on correlating parking options with traffic flow in streets, routing of emergency vehicles, setting of traffic signaling to enable passage of certain vehicles, etc).
The key ("AUTOPILOT friendly") requirements which needed a lot of discussion to make part of the NGSI-LD API for exchange of context information were:

- Enable federation of sources of sensor data (and metadata) so that there is no explicit dependency on a centralized server which provides all functionality. This can be critical for some AUTOPILOT scenarios.
- Insist on a flexible information model which allows all kinds of (AUTOPILOT) data to be transported and manipulated, without restricting the model design of AUTOPILOT (which is still under discussion).

A preliminary version of the NGSI-LD API was published 17th April 2018 at:
http://www.etsi.org/deliver/etsi_gs/CIM/001_099/004/01.01.01_60/gs_CIM004v010101p.pdf

Other opportunities for contributions: IoT Reference Architecture

SDO	Goal	Action	Partners involved
AIOTI	• IoT 3D Reference Architectures and Interoperability Framework • Support of design and development • Map the AUTOPILOT case from Versailles	Refine the IoT reference architecture and propose the contribution for standardization discussions in ISO.	SINTEF, HUAWEI, SENSINOV

Other opportunities for contributions: Security

SDO	Goal	Action	Partners involved
3GPP SA3, ETSI TC Cyber, ETSI TC ITS, oneM2M, ETSI ISG CIM, …	• Identify the most relevant SDOs to focus the activity on • Create AUTOPILOT use-case • Create 'need for solution': present AUTOPILOT use cases	Evaluate opportunities of contribution	CNIT

2.2 List of AUTOPILOT contributions to SDO

During the lifecycle of the project, 25 contributions based on the activity carried out in AUTOPILOT have been submitted to SDOs.

- Six contributions submitted to oneM2M (five accepted and integrated in TR-0026) and to AIOTI WG3, adding new use cases focused on autonomous driving
- Participation to the last ETSI ITS CMS Plugtests™ with a vehicular PKI compliant to the new security standards ETSI TS 102 941 v1.3.1 e ETSI TS 103 097 v.1.3.1: compliance and interoperability tests together with 25 stakeholders and 50 observers
- The PKI by CNIT is available to the project to test secure V2X communication
- Realization the a NGSI-LD Context Broker SCORPIO following the ETSI ISG Context Information Management standard. Integration with AUTOPILOT oneM2M platform and interworking with SynchroniCity LSP. SCORPIO will be released as Open Source

The following table provide the list of contributions and obtained results

List of AUTOPILOT contributions to SDO

Standards Developing Organisation / WG	Title of Contribution	Companies Proposing the Contribution	Date	Location	Main Topics / Description of Contribution	Link to Contribution in the SDO Website	Status
oneM2M	Requirements for TS0002	TNO, NEC	02/17/17	Vancouver, Canada	Requirements on network support for time critical IoT data	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=24622&fromList=Y	Agreed
oneM2M	Autonomous Driving section for introduction	TNO	02/17/17	Vancouver, Canada	Introduction for TR-0026 on autonomous driving and levels of automation	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=20914&fromList=Y	Agreed
oneM2M	Data model for vehicular	TNO	11/13/17	Sofia Antipolis, France	Need to have data model for automotive IoT data		Ongoing
oneM2M	AUTOPILOT IoT architecture slideset	TNO	11/13/17	Sofia Antipolis, France	AUTOPILOT architecture explained	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=24622&fromList=Y	
oneM2M	Use case on Automated Valet Parking	TNO, Huawei, Telecom Italia, Sensinov, NEC	03/16/18	Dallas, USA	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26179&fromList=Y	Agreed
oneM2M	Use case: Platooning	TNO, Huawei, Telecom Italia, Sensinov,	03/16/18	Dallas, USA	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?docum	Agreed

		NEC				entId=26181&fromList=Y	
oneM2M	Use case: Highway Pilot	TNO, Huawei, Telecom Italia, Sensinov, NEC	03/16/18	Dallas, USA	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26239&fromList=Y	Agreed
oneM2M	Use case: Car Sharing	TNO, Huawei, Telecom Italia, Sensinov, NEC	03/16/18	Dallas, USA	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26144&fromList=Y	Noted
oneM2M	Use case: Car Rebalancing	TNO, Huawei, Telecom Italia, Sensinov, NEC	03/16/18	Dallas, USA	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26235&fromList=Y	Agreed
oneM2M	Use case: Urban Driving	TNO, Huawei, Telecom Italia, Sensinov, NEC	03/16/18	Dallas, USA	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26238&fromList=Y	Agreed
oneM2M	Data model for platooning - informative	TNO, NEC, Sensinov	03/16/18	Dallas, USA	Informative: data model	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=25906&fromList=Y	Noted

oneM2M	Requirements for TS0002	TNO	02/17/17		Requirements on network support for time critical IoT data	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=24622&fromList=Y	Agreed
oneM2M	Autonomous Driving section for introduction	TNO	02/17/17		Introduction for TR-0026 on autonomous driving and levels of automation	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=20914&fromList=Y	Agreed
oneM2M	MAS - AUTOPILOT	Easy Global Market	05/23/18	Sofia Antipolis, France	AUTOPILOT Data Model	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26633&fromList=Y	Noted
AIOTI	Use case on Automated Valet Parking	TNO, Huawei	01/12/18	AIOTI WG03 Teleconference	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed, to be included in AIOTI report "IoT relation and impact on 5G"
AIOTI	Use case: Platooning	TNO, Huawei	03/16/18	AIOTI WG03 Teleconference	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed, to be included in AIOTI report "IoT relation and impact on 5G"
AIOTI	Use case: Highway Pilot	TNO, Huawei	03/16/18	AIOTI WG03 Teleconference	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed, to be included in AIOTI report "IoT relation and impact on 5G"

AIOTI	Use case: Car Sharing	TNO, Huawei	03/16/18	AIOTI WG03 Teleconference	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed, to be included in AIOTI report "IoT relation and impact on 5G"
AIOTI	Use case: Car Rebalancing	TNO, Huawei	03/16/18	AIOTI WG03 Teleconference	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed, to be included in AIOTI report "IoT relation and impact on 5G"
AIOTI	Use case: Urban Driving	TNO, Huawei	03/16/18	AIOTI WG03 Teleconference	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed, to be included in AIOTI report "IoT relation and impact on 5G"
ETSI SmartM2M	Federation of IoT automotive Data Model with SAREF	Easy Global Market	06/19/18	Paris, France	AUTOPILOT Data Model	https://portal.etsi.org/ngppapp/ContributionCreation.aspx?primarykeys=152934&source=WNJKPQWRZMUL	Noted
ETSI ISG CIM	Federation of IoT automotive Data Model	Easy Global Market	06/19/18	Sofia Antipolis, France	AUTOPILOT Data Model	https://portal.etsi.org/ngppapp/ContributionCreation.aspx?primarykeys=152912&source=ZGMTZBEVXMYT	Noted
ETSI ISG CIM	Data models	NEC	06/19/18	Sofia Antipolis, France	AUTOPILOT Modelling	https://docbox.etsi.org/ISG/CIM/05-CONTRIBUTIONS/2018//CIM(18)000133_AUTOPILOTModelling.pptx	Noted

ETSI TC ITS	ITS Security - ETSI 6th CMS Plugtests™	CNIT	25/02/19	Sofia Antipolis, France	AUTOPILOT Public Key Infrastructure for trusted and secured V2X communication	https://www.etsi.org/events/1141-plugtests-2019-itscms6	Agreed
AIOTI	ETSI G5 versus LTE-V2X	SINTEF, Huawei	02/25/19	AIOTI WG03	ETSI G5 versus LTE-V2X	https://aioti.eu/aioti-report-on-iot-relation-and-impact-on-5g/	Report "IoT relation and impact on 5G" - Release 2.0

2.3 Main outcomes

A significant number of use cases based on AUTOPILOT activity was approved by oneM2M and included in TR-0026 “Vehicular Domain Enablement” [2] and by AIOTI and included in report "IoT relation and impact on 5G" [3].

3 Conformance assessment and TESTFEST

The activity of AUTOPILOT was mainly focused on proof of interoperability via a TESTFEST, therefore the list of standards used in the project is simply replicated below.
According to the project DOA, the objectives of conformance assessment within Task 5.5 are:

- to create a TESTFEST event to evaluate the level of interoperability of the IoT platforms, in correlation with the suitable standards
- to organise one TESTFEST interoperability event in Year 3 to evaluate the interoperability of the AUTOPILOT solutions and compliancy against the IoT standards

The TESTFEST was organised as a remote event, i.e. pilot sites will virtually meet and test against each other to determine interoperability of the deployed AUTOPILOT infrastructures. In particular, the focus was on platform interoperability. Tests were performed in October and November 2019 and the results were presented at a workshop held at ERTICO premises in Brussels on December 16, 2019. The activity and results are summarized in Section 3.2 and 3.3.

3.1 Standards used in the project

List of Standards

This section gives an overview of the Standards and technologies implemented in AUTOPILOT use cases and pilot sites.

Table 1 - Overview of standards and technologies implemented in the different use cases and pilot sites

Technology Name	**Urban Driving** *(FI, FR, IT, NL, ES)*	**Automated Valet Parking** *(FI, NL, ES)*	**Highway Pilot** *(IT, NL)*	**Platooning** *(FR, NL)*	**Car sharing** *(FR, NL)*	SUM
IoT Platform						
Fiware IoT Platform	**1** *(NL)*					1
Huawei Ocean Connect	**1** *(NL)*					1
Watson IoT Platfomr	**2** *(NL, ES)*	**2** *(NL, ES)*			**1** *(NL)*	5
oneM2M IoT platform coming from Sensinov	**4** *(NL, FR, ES, FI)*	**2** *(NL, ES)*	**1** *(NL)*	**2** *(NL, FR)*	**1** *(NL)*	10

ICON oneM2M IoT platform coming from TIM	**1** *(IT)*		**1** *(IT)*			2
oneM2M standard over MQTT/MQTTS requests	**5** *(NL, FR, IT, ES, FI)*		**2** *(NL, IT)*	**2** *(NL, FR)*	**2** *(NL, FR)*	11
Huawei Ocean Connect over HTTP/MQTT	**1** *(NL)*					1
IBM Watson over HTTP/MQTT	**1** *(NL)*	**2** *(NL, FI)*				3
Fiware over NGSI and NGSI_LD	**1** *(NL)*					1
Use of oneM2M MCA interface	**5** *(NL, IT, FR, ES, FI)*	**3** *(NL, ES, FI)*	**2** *(NL, IT)*	**2** *(NL, FR)*	**2** *(NL, FR)*	14
Use of oneM2M Interworking Proxy (on MCA interface)	**1** *(NL)*	**1** *(NL)*				2
Use of oneM2M MCC interface	**1** *(IT)*		**1** *(IT)*			2
Use of DDS	**1** *(FI)*	**1** *(FI)*				2
Use of MQTT	**4** *(NL, FR, ES, FI)*	**2** *(NL,FI)*	**1** *(NL)*	**2** *(NL, FR)*	**2** *(NL, FR)*	11
Use of MQTTS	**1** *(IT)*		**1** *(IT)*			2
Use of JSON	**1** *(IT)*		**1** *(IT)*			2
Use of HTTP	**1** *(NL)*	**1** *(NL)*		**1** *(FR)*	**1** *(FR)*	4

Use of HTTPS	**1** *(IT)*					1
Use of SOAP protocol	**1** *(IT)*					1
CEN/TS 16157 DATEX II			**1** *(IT)*			1
DIASER NF P99-071-1 G3				**1** *(FR)*		1
IoT Platfom Sum	**33**	**13 or 14?**	**11**	**10**	**9**	76
Vehicle IoT Platform						
CAN	**3** *(NL, FR, ES)*	**3** *(NL, FI, ES)*	**1** *(NL)*	**2** *(NL, FR)*	**1** *(NL)*	10
DDS	**1** *(FI)*	**1** *(FI)*				2
ROS	**1** *(NL)*	**1** *(NL)*		**1** *(NL)*	**1** *(NL)*	4
OM2M	**1** *(ES)*	**1** *(ES)*				2
IP-V4 TCP/UDP	**4** *(FI, FR, IT, NL)*	**2** *(FI, NL)*	**2** *(IT, NL)*	**2** *(FR, NL)*	**2** *(FR, NL)*	12
IP-V6 TCP/UDP	**1** *(FR)*	-	-	**1** (FR)	**1** *(FR)*	3
3GPP 4G (LTE)	**5** *(FI, FR, IT, NL, ES)*	**2** *(FI, NL)*	**2** *(IT, NL)*	**2** *(FR, NL)*	**2** *(FR, NL)*	13
3GPP 4.5G (LTE advanced)	**1** *(FR)*	-	-	**1** *(FR)*	**1** *(FR)*	3
LTE Cellular-V2X-Release14	**1** *(IT)*	-	**1** *(IT)*			2
IEEE 802.11	**4** *(FI, FR, IT, NL)*	**3** *(FI, NL, ES)*	-	**2** *(FR, NL)*	**2** *(FR, NL)*	11

IEEE 802.11-OCB	**3** *(FR, IT, ES)*	-	**1** *(IT)*	**1** *(FR)*	**1** *(FR)*	6
IEEE 802.15.4	**1** *(IT)*	-	**1** *(IT)*	-	-	2
ETSI ITS G5	**3** *(IT, NL, ES)*	**1** *(NL)*	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	7
ETSI CAM	**4** *(FR, IT, NL, ES)*	**2** *(NL, ES)*	**1** *(IT)*	**2** *(FR, NL)*	**2** *(FR, NL)*	11
ETSI DENM	**3** *(IT, NL, ES)*	**2** *(NL, ES)*	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	8
ETSI SPaT	**2** *(IT, ES)*	**1** *(ES)*	-	-	-	3
ETSI MAP	**1** *(IT)*	-	-	-	-	1
OSGi remote management tool	**1** *(IT)*		**1** *(IT)*			2
Sensoris module	**1** *(IT)*		**1** *(IT)*			2
COAP/6LoWPAN connector	**1** *(IT)*		**1** *(IT)*			2
6LowPAN CNIT vibration sensor	**1** *(IT)*		**1** *(IT)*			2
CAN CRF IMU	**1** *(IT)*		**1** *(IT)*			2
MQTT over Wifi	**1** *(IT)*		**1** *(IT)*			2
ETSI Local Dynamic Map	**1** *(IT)*		**1** *(IT)*			2
Use of MQTT connector	**4** *(NL, FR, ES, FI)*	**1** *(FI)*	**1** *(NL)*	**2** *(NL, FR)*	**2** *(NL, FR)*	11

Use of MQTTS connector	**1** *(IT)*		**1** *(IT)*			2
Huawei Ocean Connect over HTTP/MQTT	**1** *(NL)*					1
IBM Watson over HTTP/MQTT	**1** *(NL)*	**2** *(NL, FI)*				3
Fiware over NGSI and NGSI_LD	**1** *(NL)*					1
Use of oneM2M MCA interface	**5** *(NL, IT, FR, ES, FI)*	**3** *(NL, ES, FI)*	**2** *(NL, IT)*	**2** *(NL, FR)*	**2** *(NL, FR)*	14
oneM2M standard over MQTT/MQTTS requests	**5** *(NL, FR, IT, ES, FI)*		**2** *(NL, IT)*	**2** *(NL, FR)*	**2** *(NL, FR)*	11
DOMINION Interprocess Communication (IPC)		**1** *(NL)*				1
Vehicle IoT Platform Sum	**64**	**26**	**24**	**22**	**21 -22?**	157
Communication Network: Long Range Wireless Communication Networks (from D1.8)						
3GPP 4G (LTE)	**5** *(FI, FR, IT, NL, ES)*	**2** *(FI, NL)*	**2** *(IT, NL)*	**2** *(FR, NL)*	**2** *(FR, NL)*	13
3GPP 4.5G (LTE advanced)	**1** *(FR)*	-	-	**1** *(FR)*	**1** *(FR)*	3
Communication Network: IoT Wireless communication Technologies (from D1.8)						
IEEE 802.15.4	**1** *(IT)*	-	**1** *(IT)*	-	-	2
IEEE 802.11	**4** *(FI, FR, IT, NL)*	~~**2**~~ **3** *(FI, NL, ES)*	-	**2** *(FR, NL)*	**2** *(FR, NL)*	~~10~~ 11
IETF 6LoWPAN/ LP-WAN	~~**2 1**~~ *(IT, ~~NL~~)*	-	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	~~5 4~~

LoRaWAN	**1** *(FR)*	-	-	**1** *(FR)*	**1** *(FR)*	3
Bluetooth/BLE	**2** *(FR, NL)*	**1** *(NL)*	-	**2** *(FR, NL)*	**2** *(FR, NL)*	7
RFID	~~**1**~~ ~~*(FR)*~~	-	-	~~**1**~~ ~~*(FR)*~~	~~**1**~~ ~~*(FR)*~~	~~3~~
3GPP NB-IoT	-	-	**1** *(IT)*	-	-	1
Communication Network: Intelligent Transport Systems wireless technologies (from D1.8)						
ETSI ITS G5	**3** *(IT, NL, ES)*	**1** *(NL)*	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	7
IEEE 802.11-OCB	**3** *(FR, IT, ES)*	-	**1** *(IT)*	**1** *(FR)*	**1** *(FR)*	6
LTE Cellular-V2X-Release14	~~**1**~~ *(IT)*	-	**1** *(IT)*			2
Communication Network: IP Communication (from D1.8)						
IP-V4 TCP/UDP	~~**3**~~ *(FI, FR, IT)*	~~**1**~~ *(FI)*	~~**1**~~ *(IT)*	~~**1**~~ *(FR)*	~~**1**~~ *(FR)*	~~7~~
IP-V6 TCP/UDP	**1** *(FR)*	-	-	**1** (FR)	**1** **(FR)**	3
Communication Network: IoT Protocols (from D1.8)						
DDS	**1** *(FI)*	**1** *(FI)*	-	-	-	2
MQTT	**2** *(FI, FR)*	**1** *(FI)*	**1** *(NL)*	~~**1**~~ **2** *(FR, NL)*	**1** *(FR)*	~~6~~ 7
oneM2M standard	**5** *(FI, FR, IT, NL, ES)*	**3** *(FI, NL, ES)*	**2** *(IT, NL)*	**2** *(FR, NL)*	**2** *(FR, NL)*	14
Communication Network: Facilities, Transport and Application Protocols (from D1.8)						
ETSI CAM	**4** *(FR, IT, NL, ES)*	**2** *(NL, ES)*	**1** *(IT)*	**2** *(FR, NL)*	**2** *(FR, NL)*	11
ETSI DENM	**3** *(IT, NL, ES)*	**2** *(NL, ES)*	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	8

ETSI SPaT	**2** *(IT, ES)*	**1** *(ES)*	-	-	-	3
ETSI MAP	**1** *(IT)*	-	-	-	-	1
CEN/TS 16157 DATEX II	-	-	**1** *(IT)*	-	-	1
DIASER NF P 99-071-1 G3	-	-	-	**1** *(FR)*	-	1
Communication Network SUM	45	19	16	22	20 or 21?	122
IoT Eco-system						
NEC Crowd Detector	**1** *(NL)*					1
MQTT to Smart phone	**1** *(NL)*					1
HTTP to Smart phone	**1** *(NL)*					1
3GPP NB-IoT	-	-	**1** *(IT)*	-	-	1
IEEE 802.11-OCB	**3** *(FR, IT, ES)*	-	**1** *(IT)*	**1** *(FR)*	**1** *(FR)*	6
ETSI ITS G5	**3** *(IT, NL, ES)*	**1** *(NL)*	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	7
3GPP 4G (LTE)	**5** *(FI, FR, IT, NL, ES)*	**2** *(FI, NL)*	**2** *(IT, NL)*	**2** *(FR, NL)*	**2** *(FR, NL)*	13
LTE Cellular-V2X-Release14	**2** *(IT, FR)*	-	**1** *(IT)*	1 *(FR)*	1 *(FR)*	5
IETF 6LoWPAN/ LP-WAN	**1** *(IT)*	-	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	4
IEEE 802.11	**4** *(FI, FR, IT, NL)*	**2** *(FI, NL)*	-	**2** *(FR, NL)*	**2** *(FR, NL)*	10
ETSI CAM	**4** *(FR, IT, NL, ES)*	**2** *(NL, ES)*	**1** *(IT)*	**2** *(FR, NL)*	**2** *(FR, NL)*	11

ETSI DENM	**3** *(IT, NL, ES)*	**2** *(NL, ES)*	**1** *(IT)*	**1** *(NL)*	**1** *(NL)*	8
ETSI SPaT	**2** *(IT, ES)*	**1** *(ES)*	-	-	-	3
ETSI MAP	**1** *(IT)*	-	-	-	-	1
LoRaWAN	**1** *(FR)*	-	-	**1** *(FR)*	**1** *(FR)*	3
Bluetooth/BLE	**2** *(FR, NL)*	**1** *(NL)*	-	**2** *(FR, NL)*	**2** *(FR, NL)*	7
IoT Ecosystem SUM	32	11	9	13	13	49

Summary of standards and technologies implemented in use cases and pilot sites

This section provides an analysis of the Standards and technologies implemented in use cases and pilot sites.

- IoT Platform
  - Urban driving uses 19 protocols and/or platforms; Some of these protocols and/or IoT platforms are used in more than one pilot site, where the total sum of these protocols and/or IoT platforms used in more than one pilot sites (up to 5 pilot sites) is: 33 to 34. The following ones are used in common:
    - Watson IoT Platform is used in 2 pilot sites (NL and ES)
    - oneM2M IoT platform coming from Sensinov is used in 4 pilot sites (NL, FR, ES, FI)
    - oneM2M standard over MQTT/MQTTS requests, used in all 5 pilot sites
    - oneM2M MCA interface is used in all 5 pilot sites
    - MQTT used in 4 pilot sites (NL, FR, ES, FI)
  - AVP uses 8 protocols and/or platforms; Some of these protocols and/or IoT platforms are used in more than one pilot site, where the total sum of these protocols and/or platforms used in more than one pilot sites (up to 3 pilot sites) is: 13 to 14. The following ones are used in common:
    - Watson IoT Platform is used in 2 pilot sites (NL and ES)
    - oneM2M IoT platform coming from Sensinov is used in 2 pilot sites (NL, ES)
    - IBM Watson over HTTP/MQTT is used in 2 pilot sites (NL, Fi)
    - oneM2M MCA interface is used in 3 pilot sites (NL, ES, Fi)
    - MQTT used in 2 pilot sites (NL, FR, ES, FI)
  - Highway pilot uses 9 protocols and/or platforms; Some of these protocols and/or IoT platforms are used in more than one pilot site, where the total sum of these protocols and/or IoT platforms used in more than one pilot sites (up to 2 pilot sites) is: 11. The following ones are used in common:
    - IP-V4 TCP/UDP applied in the 2 pilot sites
    - 3GPP 4G (LTE) applied in the 2 pilot sites
    - Use of oneM2M MCA interface applied in 2 pilot sites
    - oneM2M standard over MQTT/MQTTS requests applied in 2 places

- Platooning uses 6 protocols and/or IoT platforms; Some of these protocols and/or IoT platforms are used in more than one pilot site, where the total sum of these protocols and technologies used in more than one pilot sites (up to 2 pilot sites) is: 10. The following ones are used in common:
    - oneM2M coming from Sensinov used in 2 pilot sites
    - oneM2M standard over MQTT/MQTTS requests applied in 2 places
    - Use of oneM2M MCA interface applied in 2 pilot sites
    - Use of MQTT connector in 2 pilot sites
- Car Sharing uses 6 protocols and/or platforms; Some of these protocols and/or IoT platforms are used in more than one pilot site, where the total sum of these protocols and/or IoT platforms used in more than one pilot sites (up to 2 pilot sites) is: 9/ The following ones are used in common:
    - oneM2M coming from Sensinov used in 2 pilot sites
    - oneM2M standard over MQTT/MQTTS requests applied in 2 places
    - Use of oneM2M MCA interface applied in 2 pilot sites
    - Use of MQTT connector in 2 pilot sites

- Vehicle IoT Platform
    - Urban driving uses 31 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 5 pilot sites) is: 64 to 65. The following ones are used in common:
        - CAN is used in 3 pilot sites (NL, FR, ES)
        - IPv4 TCP/UDP is used in 4 pilot sites (NL, FR, IT, FI)
        - 3GPP 4G (LTE), used in all 5 pilot sites
        - LTE Cellular V2X – Release 14 is used in 1 or 2 pilot sites (IT, FR?) pilot sites
        - IEEE 802.11 used in 4 pilot sites (NL, FR, IT, FI)
        - IEEE 802.11-OCB used in 3 pilot sites (FR, IT, ES)
        - ETSI ITS G5 used in 3 pilot sites (IT, NL, ES)
        - ETSI CAM used in 4 pilot sites (FR, IT, NL, ES)
        - ETSI DENM used in 3 pilot sites (IT, NL, ES)
        - ETSI SPaT used in 2 pilot sites (IT, ES)
        - Use of MQTT connector used in 4 pilot sites (NL, FR, ES, FI)
        - oneM2M standard over MQTT/MQTTS requests, used in all 5 pilot sites
        - oneM2M MCA interface is used in all 5 pilot sites
    - AVP uses 15 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 3 pilot sites) is: 26. The following ones are used in common:
        - CAN is used in 3 pilot sites (NL, FI, ES)
        - IPv4 TCP/UDP is used in 2 pilot sites (NL, FI)
        - 3GPP 4G (LTE), used in 2 pilot sites (NL, FI)
        - IEEE 802.11 used in 3 pilot sites (NL, ES, FI)
        - ETSI CAM used in 2 pilot sites (NL, ES)
        - ETSI DENM used in 2 pilot sites (NL, ES)
        - IBM Watson over HTTP/MQTT used in 2 pilot sites (NL, FI)
        - oneM2M MCA interface is used in all 3 pilot sites
    - Highway pilot uses 20 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 24. The following ones are used in common:
        - IPv4 TCP/UDP is used in 2 pilot sites (NL, IT)

    - 3GPP 4G (LTE), used in 2 pilot sites (NL, IT)
    - oneM2M standard over MQTT/MQTTS requests, used in 2 pilot sites (NL, IT)
    - oneM2M MCA interface is used in 2 pilot sites (NL, IT)
  - Platooning uses 14 or 15 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 22 or 23. The following ones are used in common:
    - CAN is used in 2 pilot sites (NL, FR)
    - IPv4 TCP/UDP is used in 2 pilot sites (NL, FR)
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, FR)
    - IEEE 802.11 used in 2 pilot sites (NL, FR)
    - ETSI CAM used in 2 pilot sites (NL, FR)
    - Use of MQTT connector used in 2 pilot sites (NL, FR)
    - oneM2M standard over MQTT/MQTTS requests, used in 2 pilot sites (NL, FR)
    - oneM2M MCA interface is used in 2 pilot sites (NL, FR)
  - Car Sharing uses 14 or 15 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 21 or 22. The following ones are used in common:
    - IPv4 TCP/UDP is used in 2 pilot sites (NL, FR)
    - IEEE 802.11 used in 2 pilot sites (NL, FR)
    - ETSI CAM used in 2 pilot sites (NL, FR)

- Communication Network
  - Urban driving uses 19 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 5 pilot sites) is: 45 to 46. The following ones are used in common:
    - 3GPP 4G (LTE), used in 5 pilot sites (FI, FR, IT, NL, ES)
    - IEEE 802.11 used in 4 pilot sites (NL, FI, IT, FR)
    - Bluetooth/BLE used in 2 pilot sites (FR, NL)
    - ETSI ITS G5 used in 3 pilot sites (IT, NL, ES)
    - IEEE 802.11-OCB used in 3 pilot sites (FR, IT, ES)
    - LTE Cellular V2X – Release 14 is used in 1 or 2 pilot sites (IT, FR?) pilot sites
    - IPv4 TCP/UDP is used in 4 pilot sites (NL, FR, IT, FI)
    - Use of MQTT connector used in 4 pilot sites (NL, FR, ES, FI)
    - oneM2M standard used in all 5 pilot sites
    - ETSI CAM used in 4 pilot sites (FR, IT, NL, ES)
    - ETSI DENM used in 3 pilot sites (IT, NL, ES)
    - ETSI SPaT used in 2 pilot sites (IT, ES)
  - AVP uses 11 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 3 pilot sites) is: 19. The following ones are used in common:
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, FI)
    - IEEE 802.11 used in 3 pilot sites (NL, ES, FI)
    - IPv4 TCP/UDP is used in 2 pilot sites (NL, FI)
    - oneM2M standard is used in all 3 pilot sites
    - ETSI CAM used in 2 pilot sites (NL, ES)
    - ETSI DENM used in 2 pilot sites (NL, ES)
  - Highway pilot uses 13 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols

and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 16. The following ones are used in common:
    - IPv4 TCP/UDP is used in 2 pilot sites (NL, IT)
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, IT)
    - oneM2M standard used in 2 pilot sites (NL, IT)
- Platooning uses 14 or 15 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 22 or 23. The following ones are used in common:
    - IPv4 TCP/UDP is used in 2 pilot sites (NL, FR)
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, FR)
    - IEEE 802.11 used in 2 pilot sites (NL, FR)
    - ETSI CAM used in 2 pilot sites (NL, FR)
    - Use of MQTT connector used in 2 pilot sites (NL, FR)
    - oneM2M standards used in 2 pilot sites (NL, FR)
- Car Sharing uses 14 or 15 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 20 or 21. The following ones are used in common:
    - IPv4 TCP/UDP is used in 2 pilot sites (NL, FR)
    - IEEE 802.11 used in 2 pilot sites (NL, FR)
    - ETSI CAM used in 2 pilot sites (NL, FR)

- IoT Ecosystem
  - Urban driving uses 15 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 5 pilot sites) is: 32 to 33. The following ones are used in common:
    - IEEE 802.11-OCB used in 3 pilot sites (FR, IT, ES)
    - ETSI ITS G5 used in 3 pilot sites (IT, NL, ES)
    - 3GPP 4G (LTE), used in 5 pilot sites (FI, FR, IT, NL, ES)
    - LTE Cellular V2X – Release 14 is used in 1 or 2 pilot sites (IT, FR?) pilot sites
    - IEEE 802.11 used in 4 pilot sites (NL, FI, IT, FR)
    - ETSI CAM used in 4 pilot sites (FR, IT, NL, ES)
    - ETSI DENM used in 3 pilot sites (IT, NL, ES)
    - ETSI SPaT used in 2 pilot sites (IT, ES)
    - Bluetooth/BLE used in 2 pilots (FR, NL)
  - AVP uses 7 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 3 pilot sites) is: 11. The following ones are used in common:
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, FI)
    - IEEE 802.11 used in 3 pilot sites (NL, ES, FI)
    - ETSI CAM used in 2 pilot sites (NL, ES)
    - ETSI DENM used in 2 pilot sites (NL, ES)
  - Highway pilot uses 8 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 9. The following ones are used in common:
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, IT)
  - Platooning uses 9 or 10 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols

and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 13 or 14. The following ones are used in common:
    - 3GPP 4G (LTE), used in 2 pilot sites (NL, FR)
    - IEEE 802.11 used in 2 pilot sites (NL, FR)
    - ETSI CAM used in 2 pilot sites (NL, FR)
    - Bluetooth/BLE used in 2 pilot sites (FR, NL)
- Car Sharing uses 9 or 10 protocols and/or specifications; Some of these protocols and/or specifications are used in more than one pilot site, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 13 or 14. The following ones are used in common:
    - IEEE 802.11 used in 2 pilot sites (NL, FR)
    - ETSI CAM used in 2 pilot sites (NL, FR)
    - Bluetooth/BLE used in 2 pilot sites (FR, NL)

Aggregated results on standards

Based on the information provided in the previous sections, in the context of IoT Platform, Vehicle IoT Platform, Communication Network and IoT Ecosystem, respectively, the following aggregated results are derived.

IoT Platform

- Urban driving uses 19 protocols and/or platforms, where the total sum of these protocols and/or platforms used in more than one pilot sites (up to 5 pilot sites) is: 33 to 34.
    - There are 5 common protocols and/or IoT platforms that are used, for this use case, in more than one pilot sites. Moreover, the oneM2M standard is used in all 5 pilot sites and the oneM2M IoT platform coming from Sensinov is used in 4 pilot sites (NL, FR, ES, FI), while the oneM2M platform coming from TIM is used in the IT pilot site. Note that the interoperability between these two oneM2M IoT platforms can be realized based on the oneM2M MCC interface.
- AVP uses 8 protocols and/or platforms, where the total sum of these protocols and/or platforms used in more than one pilot sites (up to 3 pilot sites) is: 13 to 14.
    - There are 5 common protocols and/or specifications that are used, for this use case, in more than one pilot sites. Moreover, the oneM2M standard is used in 2 pilot sites (NL, ES).and the oneM2M IoT platform coming from Sensinov is used as well in these 2 pilot sites (NL, ES).
- Highway pilot uses 9 protocols and/or platforms, where the total sum of these protocols and/or platforms used in more than one pilot sites (up to 2 pilot sites) is: 11.
    - There are 4 common protocols and/or specifications that are used, for this use case, in two pilot sites (IT, NL). Moreover, the oneM2M IoT platform coming from Sensinov is used in 1 pilot site (NL), while the oneM2M platform coming from TIM is used in the IT pilot site. Note that the interoperability between these two oneM2M IoT platforms is realized based on the oneM2M MCC interface.
- Platooning uses 6 protocols and/or platforms, where the total sum of these protocols and technologies used in more than one pilot sites (up to 2 pilot sites) is: 10.
    - There are 4 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR). Moreover, the oneM2M standard is used in the 2 pilot sites (NL, FR) and the oneM2M IoT platform coming from Sensinov is as well used in 2 pilot sites (NL, FR).
- Car Sharing uses 6 protocols and/or platforms, where the total sum of these protocols and/or platforms used in more than one pilot sites (up to 2 pilot sites) is: 9.
    - There are 4 common protocols and/or specifications that are used, for this use case, in two pilot sites. Moreover, the oneM2M standard is used in the 2 pilot sites (NL,

FR) and the oneM2M IoT platform coming from Sensinov is as well used in 2 pilot sites (NL, FR).

Vehicle IoT Platform

- Urban driving uses 31 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 5 pilot sites) is: 64 to 65.
    - There are 11 common protocols and/or specifications that are used, for this use case, in at least three pilot sites. (NL, FR, IT) or (NL, FR, ES);
- AVP uses 15 protocols and/or specifications, where the total sum of these protocols and technologies used in more than one pilot sites (up to 3 pilot sites) is: 26.
    - There are 8 common protocols and/or specifications that are used, for this use case, in at least two pilot sites (NL, FI) or (NL, ES);
- Highway pilot uses 20 protocols and/or specifications, where the total sum of these protocols and technologies used in more than one pilot sites (up to 2 pilot sites) is: 24.
    - There are lists 4 common protocols and/or specifications that are used, for this use case, in two pilot sites (IT, NL));
- Platooning uses 14 or 15 protocols and/or specification, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 22 or 23.
    - There are 8 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR);
- Car Sharing uses 14 or 15 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 21 or 22.
    - There are 3 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR);

Communication Network

- Urban driving uses 19 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 5 pilot sites) is: 45 to 46.
    - There are 9 common protocols and/or specifications that are used, for this use case, in at least three pilot sites. (NL, FR, IT) or (NL, FR, ES);
- AVP uses 11 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 3 pilot sites) is: 19.
    - There are 6 common protocols and/or specifications that are used, for this use case, in at least two pilot sites (NL, FI) or (NL, ES);
- Highway pilot uses 13 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 16.
    - There are 3 common protocols and/or specifications that are used, for this use case, in two pilot sites (IT, NL));
- Platooning uses 14 or 15 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 22 or 23.
    - There are 6 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR));
- Car Sharing uses 14 or 15 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 20 or 21.
    - There are 3 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR));

IoT Ecosystem

- Urban driving uses 15 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 5 pilot sites) is: 32 to 33.

    - There are 7 common protocols and/or specifications that are used, for this use case, in at least three pilot sites. (NL, FR, IT) or (NL, FR, ES);
- AVP uses 7 protocols and/or specification, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 3 pilot sites) is: 11.
    - There are 4 common protocols and/or specifications that are used, for this use case, in at least two pilot sites (NL, FI) or (NL, ES);
- Highway pilot uses 8 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 9.
    - There is 1 common protocol and/or specification that is used, for this use case, in two pilot sites (IT, NL));
- Platooning uses 9 or 10 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 13 or 14.
    - There are 4 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR));
- Car Sharing uses 9 or 10 protocols and/or specifications, where the total sum of these protocols and/or specifications used in more than one pilot sites (up to 2 pilot sites) is: 13 or 14.
    - There are 3 common protocols and/or specifications that are used, for this use case, in two pilot sites (NL, FR);

3.2 TESTFEST organization

3.2.1 TESTFEST objective

The objective of the TESTFEST exercise was to prove the interoperability of the IoT platforms deployed in the pilot sites including interoperability of services, data and applications.
The TESTFEST was also an obligation described in the AUTOPILOT Grant Agreement as expected impact in clause 2.1.1

"… to create a TESTFEST event to evaluate the level of interoperability of the IoT platforms, in correlation with the suitable standards"

and in the description of task T5.5 (Standardisation & conformance assessment)

"… organisation of one TESTFEST interoperability event in Year 3 to evaluate the interoperability of the AUTOPILOT solutions and compliancy against the IoT standards".

3.2.2 TESTFEST preparation process

The process of preparing the TESTFEST started with a kick-off meeting, held in Brussels on March 12, 2019. The following discussion points were considered at that meeting by the participants.

- What/how to test?
  Move "items" (cars, other equipment, etc.) from one pilot site to another one and test there
  However, restrictions to move cars across national borders were identified for a number of pilot sites.
- Test interoperability of data (Publish/Consume) in basic scenarios taken from AUTOPILOT project deliverables D2.5 (Readiness verification approach) and D2.6 (Readiness verification report per pilot site / use case) such as
    - One hop communication between proprietary IoT platform and oneM2M platform
    - One hop communication between oneM2M platforms
    - Two hop (E2E) communication between IoT platforms
    - Vehicle hand over between all IoT platforms

and extent the scope with new scenarios covering
  - Transformation/Policy enforcement
  - Privacy aspects
  - Data integrity
  - Geo queries
  - Third party access
- Co-location of AUTOPILOT TESTFEST with OneM2M PlugTest
  It was decided to contact the responsible CTI officer at ETSI to discuss to organize a joint event with ETSI.
- Liaise with SYNCHRONICITY
  It was considered beneficial to prove also interoperability beyond the AUTOPILOT framework with other LSPs to avoid the impression that the project is developing silo solutions.
- Organisation of bi-weekly conference calls (1st call on March 26)
  Purpose of the calls was to inform/liaise with pilot sites and to proceed the TESTEFST activity.

After this kick-off meeting a sequence of 11 conference calls took place, starting on March 26 with the last call held on December 12. Main decisions taken were:

- On April 9 (Call #2) - Abandon the idea of having a joint event with the oneM2M PlugTest
  Discussions with ETSI showed that an one M2M interoperability event would most likely not be feasible within the lifetime of AUTOPILOT, i.e. in 2019. Additionally, the preferred location of an oneM2M PlugTest event would lie in Asia, were very active (e.g. in Korea) IoT communities reside. Furthermore, an oneM2M PlugTest may easily draw 100+ participants and none of the AUTOPILOT pilot sites was prepared to host an event with such a high number of participants.
  Main technical aspect for not proceeding the idea of a joint event was the restricted overlap in test objectives as the oneM2M PlugTests focus on table-top testing of devices in a lab-like environment whereas AUTOPILOT was aiming at a much wider scale with testing the overall interoperability of pilot site deployments.
- On July 31 (Call #6) - Organise the TESTFEST as remote event
  The discussions during and between the conference calls showed that the test scopes for evaluating interoperability between the different pilot sites presented as quite complex variation of testing opportunities. Also, which project, if not a project dealing with the internet of things, would be a better candidate for a remote testing exercise?
  At a physical TESTFEST event experts from all the pilot sites would meet in one spot where they would connect remotely to their home environments to test against the peer home equipment remotely connected to their colleagues physically sitting beside them. In the remote TESTFEST, everybody stays at their workplace, connects to peer pilot sites and tests. Besides avoiding the difficulty of finding a commonly available date and a venue for a physical TESTFEST event, the remote organisation also helped to give the TESTFEST activity a much smaller ecological footprint.

3.2.3 Remote TESTFEST

Due to the decision taken at call #6, the TESTFEST was organised as a remote event, i.e. pilot sites did virtually meet and test against each other to determine interoperability of the deployed AUTOPILOT infrastructure.
Interoperability was shown at different levels:

- Platform interoperability
- Device interoperability
- Other, defined dependent on the test pairings

The test architectures and test cases derived from AUTOPILOT deliverables D2.5 and D2.6 were used

in this testing exercise. The tests selected were:

- One hop communication between proprietary IoT platforms and e.g. cars
  - **IoT_platform_3** (To verify IoT-platform is capable of receiving events/messages from the devices connected.)
  - **IoT_platform_4** (To verify IoT-platform is capable of sending events/messages to the devices connected.)
  - **Functionality_1** (To verify that the IoT platform is able to process a new message from an IoT message.)
  - **Interoperability_1** (OPTIONAL - To verify that an application can transmit a message to another application within one IOT platform)
- One hop communication between oneM2M platforms and e.g. cars
  - **IoT_platform_3** (To verify IoT-platform is capable of receiving events/messages from the devices connected.)
  - **IoT_platform_4** (To verify IoT-platform is capable of sending events/messages to the devices connected.)
  - **Functionality_1** (To verify that the IoT platform is able to process a new message from an IoT message.)
  - **Interoperability_1** (OPTIONAL - To verify that an application can transmit a message to another application within one IOT platform)
- Two hop (E2E) communication between IoT platforms and e.g. cars
  - **IoT_platform_6** (To verify that central IoT-platform is capable of receiving events/messages from other IoT-platforms used in AUTOPILOT)
  - **IoT_platform_7** (To verify that central IoT-platform is capable of sending events/messages to other IoT-platforms used in AUTOPILOT)
  - **Interoperability_2** (To verify that an application can consume a message from another IoT platform.)

Note 1: For all above tests publishing and subscribing in both directions was tested and data integrity was verified, i.e. check that data formats compliant with AUTOPILOT data model after transfer.

Note 2: IoT_platform_1 und IoT_platform_2 could be used as pre-Conditions for the test cases IoT_platform_3 and IoT_platform_4.

This selection has been extended with tests covering geo queries and data integrity. Those tests have been developed especially for the TESTFEST exercise and are listed below.

Test Identifier:	Advanced_IoT_platform_1
Test Objective:	To verify that an IoT platform (here Watson IoT Platform) supports the case where a specific event is extracted from a message and then shared with the relevant actors through the oneM2M interoperability platform and other IoT platforms, without sharing the original message, which may be private.
References:	N.A.
Applicability:	This test case is applicable to all use cases, more specifically for every vehicle that detects events that are relevant to other vehicles.
Pre-conditions:	• A filter (authorised "virtual device") listens to vehicle data (Sensoris), and extracts events that are relevant to other vehicles, to publish them again on the same IoT platform it is listening to. • A oneM2M interworking gateway

Expected Test Sequence:	Step	Type	Description
	1	stimulus	A vehicle Sensoris message is sent to Watson IoT Platform, containing a detected hazard.
	2	stimulus	The filter extracts the hazard event from the Sensoris message, generates an event complying with the common IoT data model, and publishes it to Watson IoT Platform.
	3	verify	The generated event is received by an authorised listener to Watson IoT Platform.
	4	verify	The generated event is received by an authorised listener to the oneM2M interoperability platform.
	5	verify	An unauthorised listener on Watson IoT Platform does not receive the original Sensoris message.
	6	verify	An unauthorised listener on the oneM2M interoperability Platform does not receive the original Sensoris message.

Table 2 - Advanced_IoT_platform_1

Test Identifier:	Advanced_IoT_platform_2		
Test Objective:	To verify that a *central* IoT-platform is capable of executing a geographic query and return the information for the specified geographic scope.		
References:	-		
Applicability:	IoT platform capable of executing geographic queries.		
Pre-conditions:	• IoT platform infrastructure is up and ready		
Expected Test Sequence:	Step	Type	Description
	1	stimulus	Initiate a query for information of a given type related to a geographic area specified as a geographic scope based on geographic coordinates.
	2	verify	That the information returned is of the given type.
	3	verify	That the information returned is from within the specified geographic scope.

Table 3 - Advanced_IoT_platform_2

Test Identifier:	Advanced_IoT_platform_3		
Test Objective:	To verify that a *federated* IoT-platform is capable of executing a geographic query, choosing the pilot site(s) overlapping with the geographic scope.		
References:	-		
Applicability:	Federated IoT platform capable of executing geographic queries.		
Pre-conditions:	• Federated IoT platform infrastructure is up and ready		
Expected Test Sequence:	Step	Type	Description
	1	stimulus	Initiate a query for information of a given type related to a geographic area specified as a geographic scope based on geographic coordinates.
	2	verify	That the information returned is of the given type.
	3	verify	That the information returned is from within the specified geographic scope.
	4	verify	That information from the IoT platforms whose geographic area overlaps with the specified geographic scope has been integrated.

Table 4 - Advanced_IoT_platform_3

Test Identifier:	Advanced_IoT_platform_4		
Test Objective:	To verify that an application can request information from the federated IoT platform, which requests it from a single pilot site / third party platform and provides the result to the application.		
References:	-		
Applicability:	Federated IoT platform		
Pre-conditions:	• Federated IoT platform infrastructure is up and ready		
Expected Test Sequence:	Step	Type	Description
	1	stimulus	Initiate a query for information to the federated platform that is related to information coming from a single pilot site.
	2	verify	That the information returned is of the given type.
	3	verify	That the information is the information from the expected pilot site (e.g. by comparing to the results of a direct query to the pilot site).

Table 5 - Advanced_IoT_platform_4

Test Identifier:	Advanced_IoT_platform_5		
Test Objective:	To verify that an application can request information from a federated IoT platform that includes information from multiple sites. The federated platform requests and aggregates the information from the different sites and provides the result to the application.		
References:	-		
Applicability:	Federated IoT platform		
Pre-conditions:	• Federated IoT platform infrastructure is up and ready		
Expected Test Sequence:	Step	Type	Description
	1	stimulus	Initiate a query for information to the federated platform that is related to information coming from multiple pilot sites.
	2	verify	That the information returned is of the given type.
	3	verify	That the information is the aggregated information from the expected pilot sites (e.g. by comparing to the aggregated result of direct queries to the respective pilot sites).

Table 6 - Advanced_IoT_platform_5

The pilot sites did chose from the listed test cases as they were applicable for testing against a particular peer pilot site. However, the TESTFEST scope was not restricted to the tests listed in

paragraphs above and pilot sites were free to test different scenarios against their peers as they saw fit.
Optimally, all pilot sites would have tested against each other, leading to a maximum of ten test pairings as shown in the matrix below. Any pilot site had the possibility to perform a maximum of four test sessions.

	Brainport	Livorno	Tampere	Versailles
Livorno				
Tampere				
Versailles				
Vigo				

Table 7 – Test pairing matrix

3.2.4 Plan of action

3.2.4.1 TESTFEST responsible per pilot site

Per pilot site a responsible was named. Those individuals were acting as

- contact point for all TESTFEST related matters
- coordinator for test efforts with peer pilot sites
- reporter on test results

The contacts names below have been discussed during the conference call on August 28.

Pilot site	Name	E-Mail
Helmond	Daan Ravesteijn	daan.ravesteijn@tno.nl
Livorno	Mariano Falcitelli	mariano.falcitelli@cnit.it
Tampere	Johan Scholliers	Johan.Scholliers@vtt.fi
Versailles	Floriane Schreiner Mahdi Ben Alaya	floriane.schreiner@vedecom.fr benalaya@sensinov.com
Vigo	Main contact: Diego Bernárdez Secondary contacts: Carlos Rosales Pablo García	 diego.bernardez@ctag.com carlos.rosales@ctag.com pablo.garcía@ctag.com
NEC and SYNCHRONICITY	Martin Bauer	martin.bauer@neclab.eu

Table 8 – TESTFEST responsible per pilot site

Co-ordinator of the TESTFEST activity was:
Peter Schmitting, ERTICO (p.schmitting@mail.ertico.com

3.2.4.2 TESTFEST timeline

The TESTFEST activity was split into three phases as described below.

Phase 1: Match making
Starts 15/08/19
Ends 27/09/19
Activity
The pilot site TESTFEST responsible gets in contact with their peers and agree per test pairing

- Test scope, i.e. selection of test cases from list and/or definition of alternative applicable test procedures for the test pairing;
- Connection details and any other technical details enabling meaningful testing between peer pilot sites;

- Testing slot(s), i.e. the date(s) and time(s) when the testing will be performed within the testing phase (01/10 – 15/11/2019).

Phase 2: Testing and reporting
Starts 01/10/19
Ends 13/12/19
Activity
The pilot sites remotely meet to perform the tests as per the agreed-upon test scope. Test results are gathered and preparaed for phase 3.

Phase 3: Presentation
Starts 18/11/19
Ends 16/12/19
Activity
Organise a workshop to report and discuss about the remote TESTFEST.
Topic of the workshop

- Presentation of TESTFEST results
- Results and conclusions
- Interoperability with other LSPs, e.g. SYNCHRONICITY

The workshop was scheduled for December 16 11:00 – 16:00 at the ERTICO offices in Brussels.

3.3 TESTFEST results

3.3.1 Introduction

The results from the TESTFEST activity have been presented at the workshop of December 16, 2019. Each of the pilot sites reported on their test efforts and the achieved results. In addition, a presentation was made showing the visualization of federated data objects from pilot sites on a geographical map of Europe. Another presentation described the possibilities for interworking and interoperability of AUTOPILOT data with the concepts developed in the large scale pilot European project SYNCHRONICITY.

3.3.2 Test results reported from Brainport pilot site

The Brainport pilot site concentrated its testing activities towards the Versailles platform and tested level 1 of the test architecture shown in the figure below. The tests were performed in both directions

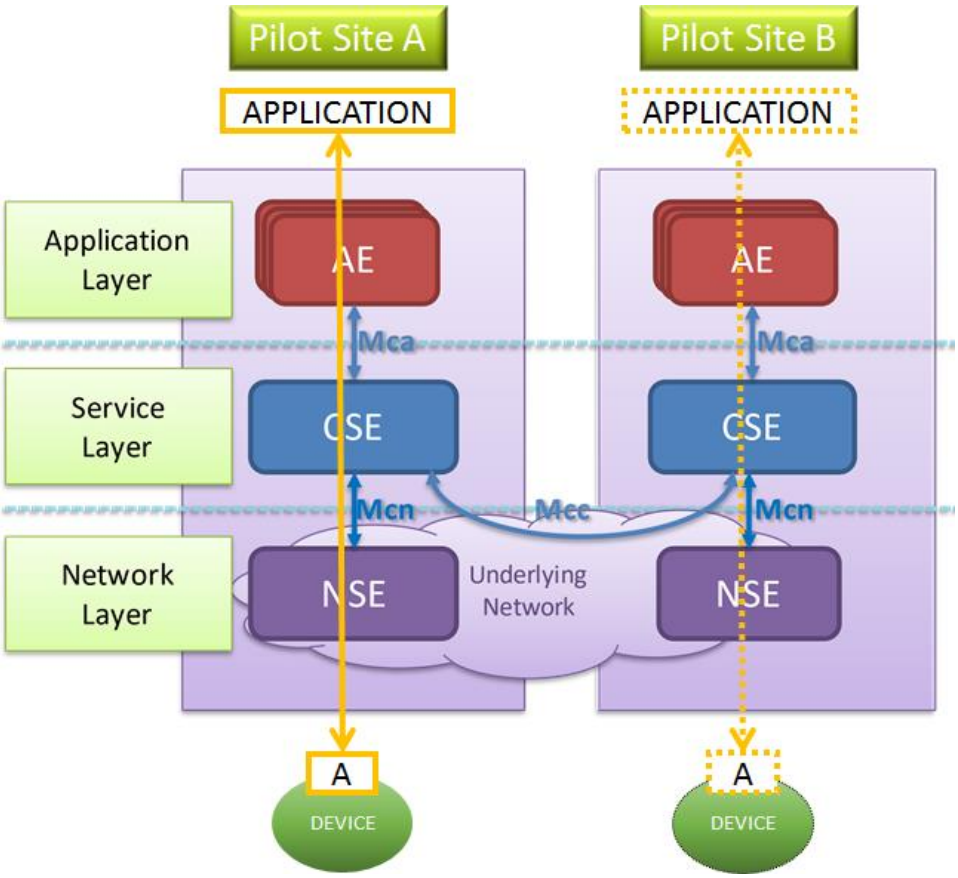

Figure 2 - Test architecture

The test results achieved are summarized in the table below and show successful execution of 11 test scenarios. The N/A (Not Applicable) entries stand for scenarios where the testing on level 1 was not achievable.

Test Identifier	Objective	Versailles vs Brainport	Brainport vs Versailles
IoT_platform_1	To verify that the IoT-platform is capable of registering a new device	Success	Success
IoT_platform_2	To verify IoT-platform is capable of managing devices	Success	Success
IoT_platform_3	To verify IoT-platform is capable of receiving events/messages from the devices connected.	Success	Success
IoT_platform_4	To verify IoT-platform is capable of receiving events/messages from the devices connected.	Success	Success
IoT_platform_6	To verify that central IoT-platform is capable of receiving events/messages from other IoT-platforms used in AUTOPILOT; This is realized in order to test interoperability between IoT-platforms	Success	N/A
IoT_platform_7	To verify that central IoT-platform is capable of sending events/messages to other IoT-platforms used in AUTOPILOT; This is realized in order to test interoperability between IoT-platforms	Success	N/A

Functionality_1	To verify that the IoT platform is able to process a new message from an IoT message.	Success	N/A
Interoperability_1	To verify that an application can transmit a message to another application.	Success	Success
Interoperability_2	To verify that an application developed in one Pilot Site can consume the message sent by a device to the IoT platform, even if the IoT platform is deployed in another Pilot Site	Success	Success
Interoperability_3	To verify that an IoT OneM2M platform deployed in one Pilot Site can interwork with another IoT OneM2M platform deployed in another Pilot Site via MCC interface	Success	N/A

Table 9 – TESTFEST results for Brainport pilot site

3.3.3 Test results reported from Livorno pilot site

The testing activity of the Livorno pilot sites included testing against all other pilot sites with a concentration on the two test cases Interoperability_2 and Interoperability_3 based on the reference architecture deployed in Livorno. A high level picture of that architecture is in the figure below.

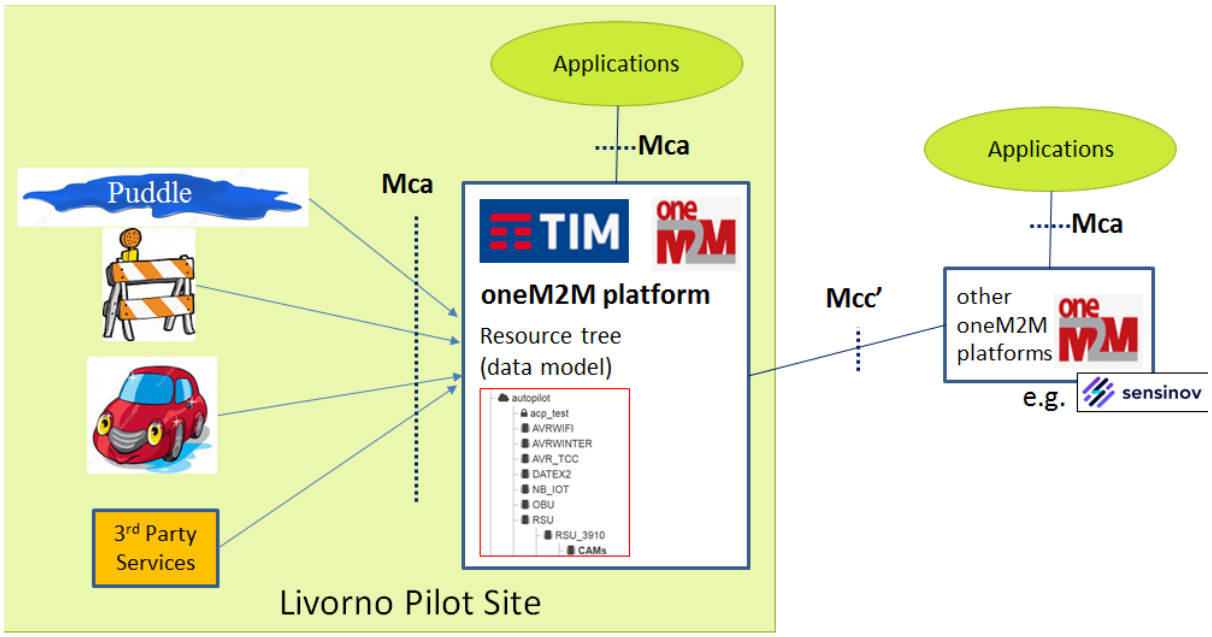

Figure 3 – Livorno high level reference architecture

The test results are summarized in the tables below and show successful test results for the deployed highway and urban uses cases via the MCA and MCC interfaces, respectively.

Test: Interoperability_2 (via MCA)												
Test #	CONTEXT		DEVICE			APPLICATION			TEST RESULTS			
	UC	Datamodel: DMAG subtype	Type	Protocol	PS	Type	Protocol	PS	LIVORNO PS (TIM ICON oneM2M)	BRAINPORT PS (Sensinov oneM2M)	VERSAILLES PS (Sensinov oneM2M)	TAMPERE PS (Eclipse oneM2M)
1	HIGHWAY	ETSI ITS G5	RSU (CNIT)	HTTPs	LIVORNO	TCC (AVR)	MQTTs	LIVORNO	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **YES** MSG consumed from: **NO**	MSG received from: **YES** MSG consumed from: **NO**	MSG received from: **YES** MSG consumed from: **NO**
								COMMENTS		*CAM simplified*	*CAM simplified*	
2	URBAN	ETSI ITS G5	RSU (CNIT)	HTTPs	LIVORNO	MONICA 3D (CNIT)	HTTPs	LIVORNO	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **YES** MSG consumed from: **YES**
								COMMENTS		*CAM simplified*	*CAM simplified*	
3	URBAN	ETSI ITS G5	RSU (LINKS)	MQTTs	LIVORNO	MONICA 3D (CNIT)	HTTPs	LIVORNO	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **NO** MSG consumed from: **NO**	MSG received from: **YES** MSG consumed from: **YES**
								COMMENTS				
4	URBAN	ETSI ITS G5	OBU (CTAG)	HTTPs	VIGO	MONICA 3D (CNIT)	HTTPs	LIVORNO	MSG received from: **YES** MSG consumed from: **YES**	MSG received from: **YES** MSG consumed from: **YES**	- -	- -
								COMMENTS				
5	URBAN	SENSORIS	OBU (LINKS)	MQTTs	LIVORNO	-	-	-	MSG received from: **YES** -	MSG received from: **YES** -	MSG received from: **NO** -	MSG received from: **YES** -
								COMMENTS				
6	URBAN	SENSORIS	OBU (VTT)	HTTPs	TAMPERE	AVP / PMS (VTT)	HTTPs	TAMPERE	MSG received from: **YES** MSG consumed from: **YES** (1)	MSG received from: **YES** MSG consumed from: **YES** (1)	- -	MSG received from: **YES** MSG consumed from: **YES** (1)
								COMMENTS	*(1) Using Discovery*	*(1) Using Discovery*		*(1) Using Discovery*

Table 10 – TESTFEST results for Livorno pilot site – Interoperability_2

Test: Interoperability_3 (via MCC)											
Test #	**CONTEXT**		**DEVICE**			**APPLICATION**			**TEST RESULTS**		
	UC	**Datamodel: DMAG subtype**	**Type**	**Protocol**	**PS**	**Type**	**Protocol**	**PS**	**Device --> BRAINPORT PS (Sensinov oneM2M) App --> Livorno PS (TIM ICON oneM2M)**	**Device --> VERSAILLES PS (Sensinov oneM2M) App --> Livorno PS (TIM ICON oneM2M)**	**Device --> TAMPERE PS (Eclipse oneM2M) App --> Livorno PS (TIM ICON oneM2M)**
1	HIGHWAY	ETSI ITS G5	RSU (CNIT)	HTTPs	LIVORNO	TCC (AVR)	MQTTs	LIVORNO	MSG received from: **YES** MSG consumed from: **NO**	MSG received from: **YES** MSG consumed from: **NO**	MSG received from: **YES** MSG consumed from: **NO**
								COMMENTS			
2	URBAN	ETSI ITS G5	RSU (CNIT)	HTTPs	LIVORNO	MONICA 3D (CNIT)	HTTPs	LIVORNO	MSG received from: **YES** MSG consumed from: **~YES** (1)	MSG received from: **YES** MSG consumed from: **~YES** (1)	MSG received from: **YES** MSG consumed from: **YES**
								COMMENTS	*(1) only retrieve, no subscription*	*(1) only retrieve, no subscription*	*ALL RIGHT ! (subscription, ok)*
3	URBAN	ETSI ITS G5	RSU (LINKS)	MQTTs	LIVORNO	MONICA 3D (CNIT)	HTTPs	LIVORNO	MSG received from: **YES** MSG consumed from: **~YES** (1)	MSG received from: **NO** MSG consumed from: **NO**	MSG received from: **YES** MSG consumed from: **YES**
								COMMENTS	*(1) only retrieve, no subscription*		*ALL RIGHT ! (subscription, ok)*
4	URBAN	ETSI ITS G5	OBU (CTAG)	HTTPs	VIGO	MONICA 3D (CNIT)	HTTPs	LIVORNO	MSG received from: **YES** MSG consumed from: **~YES** (1)	- -	- -
								COMMENTS	*(1) only retrieve, no subscription*		

Table 11 – TESTFEST results for Livorno pilot site – Interoperability_3

3.3.4 Test results reported from Tampere pilot site

The Tampere pilot site used the deployed Eclipse OM2M server for dashboard (management) as openMTC does not have functionalities for visualization see figure below.

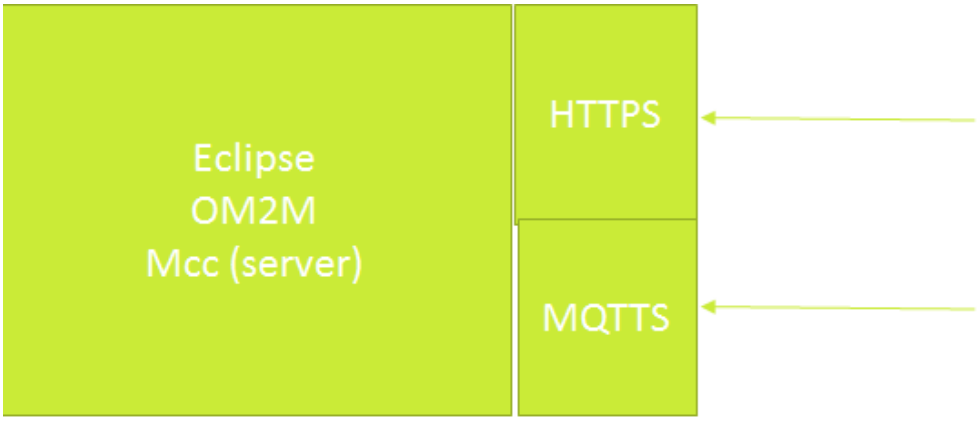

Figure 4 – Tampere setup for interoperability testing

Successful tests with SENSORYS data were performed towards the Brainport, Livorno and Versailles pilot sites with the Mcc' interface realized over HTTPS showing correct publication of oneM2M message with SENSORIS payload. The detailed testing setup is shown in the figure below.

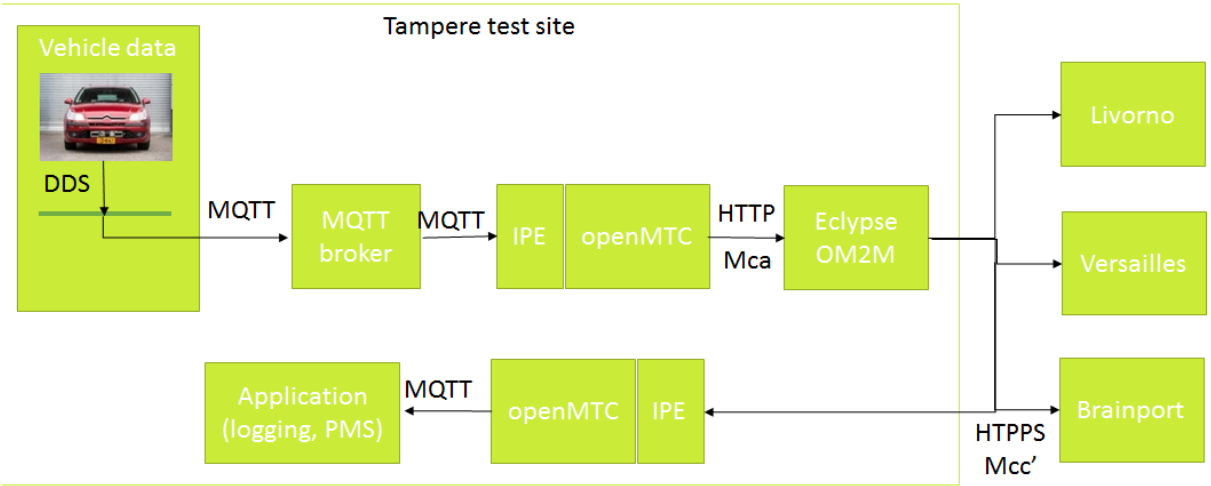

Figure 5 – Tampere test setup – oneM2M over HTPPS

Further tests with SENSORYS data were performed towards the Livorno pilot site with the Mcc' interface realized over MQTTS showing again the correct publication of oneM2M message with SENSORIS payload. The testing setup for this case is shown in the figure below.

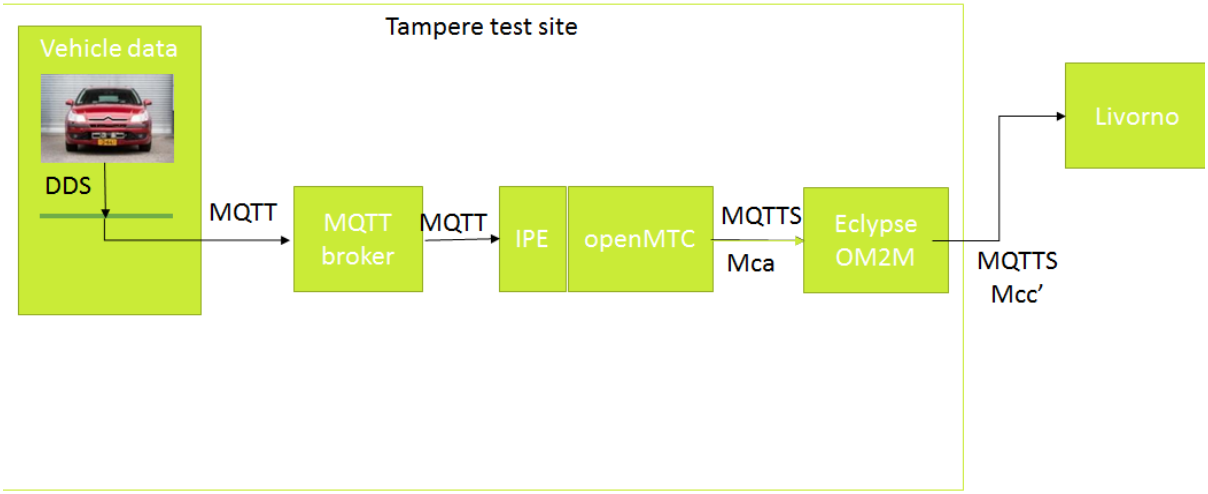

Figure 6 – Tampere test setup – oneM2M over MQTTS

The lessons learnt from this testing exercise are summarized below:

- Handling of security issues requires much time
  - High number of firewalls to be crossed, e.g. VTT organisation public network, VTT ERVE network, server for openMTC
- MQTT client library can show incompatibilities when using TLS
- Certificates require public domain names for secure communication
- Different user authentication methods are in use between oneM2M implementations and need to be taken in to account

3.3.5 Test results reported from Versailles pilot site

The test results from the Versailles pilot site are found in clause 3.3.2. Brainport and Versailles performed the tests bi-directionally; the results are therefore already completely described in Table 9.

3.3.6 Test results reported from Vigo pilot site

The Vigo pilot site does not have a central IoT platform (like other pilot sites) but it has an In-vehicle oneM2M platform where all the car's information is set. Nevertheless, this platform fully complies with the interoperability standards defined in the AUTOPILOT project and enables the possibility to connect and duplicate its structure and information in any other platform.

CTAG's implementation could, technically, publish the car information to any IoT platform but it was preferred to find one application that showed the capabilities of both sides. In this sense, the Livorno pilot site was contacted and it was agreed that Vigo data could be published into the Livorno "ICON IoT platform" in a way that could let any connected application to consume it, as is the case of Monica3D, a 3D map representation of the port of Livorno with capabilities to represent "live" cars moving around such place.

This setup allowed to perform the test procedure as described in test case Interoperability_2. Other pilot sites have also been contacted, like Versailles or Tampere, but either they did not have a client to consume our car data, or the connection could not be done for security related reasons such as requesting direct access to our in-vehicle platform. The scope of the test was to publish the car position and heading into the Icon IoT platform with the aim to be consumed at the very moment by the 3D map application and show it in a graphical interface representing the map and the vehicle.

The equipment required for this test, involved a HMCU (OBU) from CTAG's vehicle, injected with a car GPS log containing a route inside the port of Livorno. This information was consumed and published in Vigo's in-vehicle platform.

To publish this data in the ICON platform, the Vigo pilot site needed to deploy a gateway across the two platforms that permitted to replicate all containers' structure and data published in Vigo platform to the ICON platform. This way,the ICON platform has a container with the same structure and data as Vigo, replicated in its platform, and the 3D map application can show in its graphical interface the car's location, and then broadcast it live to Vigo by other means.
The test was satisfactory because the application could represent a car moving in the road in the port of Livorno. No misunderstanding or lag in the data was produced.

The main results of this successful testing exercise can be summarized as follows:

- Vigo PS is able to publish data in ICON IoT platform
- MONICA application from Livorno PS accessed the data published and processed it to represent a car on its 3D map
- CTAG is interoperable with other IoT infrastructures and the data can be consumed with third applications

3.3.7 Interoperability with SYNCHRONOCITY

The SYNCHRONOCITY was present at the TESTFEST workshop and demonstrated interoperability of AUTOPILOT data with the architectures deployed in SYNCHRONOCITY. As an example the visualisation of data related to parking spaces published by the AUTOPILOT pilot sites could be use by the SYNCHRONOCITY deployment, see figure below.

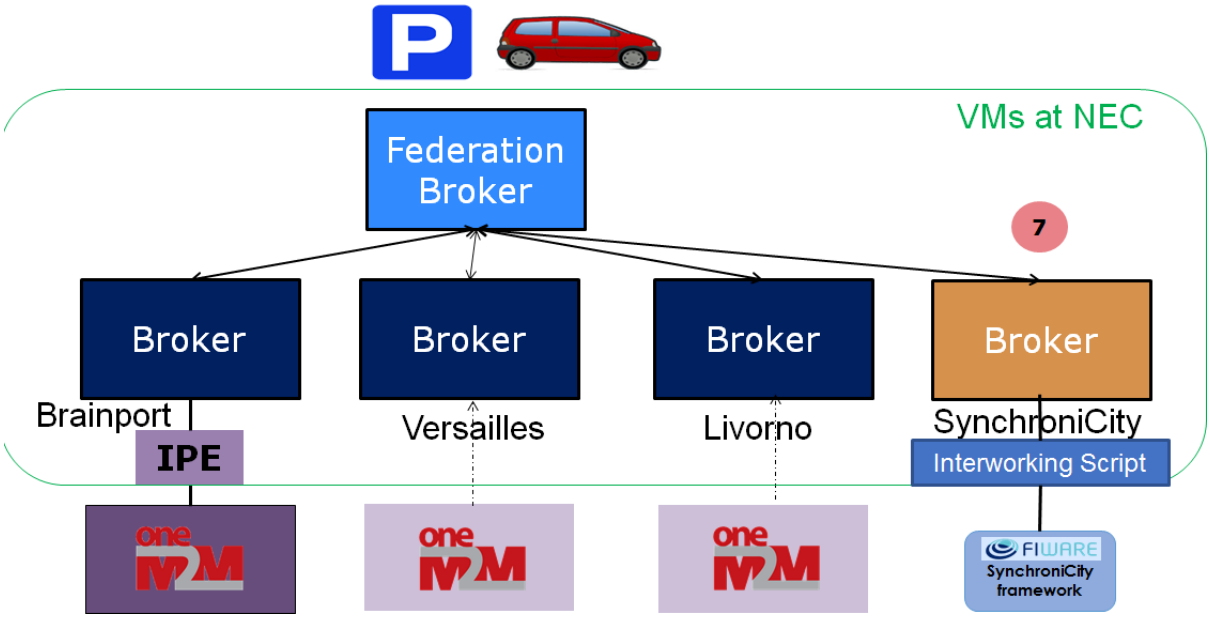

Figure 7 – Visualisation of AUTOPILOT parking information in SYNCHRONOCITY

Conclusion

This document provides an overview of the activity and results obtained by AUTOPILOT Task 5.5 “Standardization”. In particular, the Task has two main objectives:

- Identify relevant Standard Development Organizations (SDOs) and influence them with results obtained in the project
- Perform an interoperability TESTFEST to demonstrate the compliance to standards of the solutions implemented in the different Pilot sites.

A comprehensive list of standards and Standard Development Organizations (SDOs) was performed and summarized in Deliverable D 5.7 [1]. Based on the list and on the overall objectives of the project, a Standardization Plan has been developed, focusing mainly on data model, use cases and requirements with main contributions to oneM2M and AIOTI. During the lifecycle of the project, 25 contributions were submitted by AUTOPILOT partners to different SDOs and a number of use cases based on AUTOPILOT activity was approved by oneM2M and included in TR-0026 “Vehicular Domain Enablement” [2] and by AIOTI and included in report "IoT relation and impact on 5G" [3].

The conformance assessment activity was mainly focused on proof of interoperability via a TESTFEST, with objectives:

- to create a TESTFEST event to evaluate the level of interoperability of the IoT platforms, in correlation with the suitable standards
- to organize one TESTFEST interoperability event in Year 3 to evaluate the interoperability of the AUTOPILOT solutions and compliancy against the IoT standards

The TESTFEST was organized as a remote event, i.e. pilot sites will virtually meet and test against each other to determine interoperability of the deployed AUTOPILOT infrastructures.

Both the activity of SDOs influencing and conformance assessment demonstrated the existence of gaps in standardization, in particular with respect to the focus of the Task activity on the data models and the oneM2M platform interoperability.
In general, the results of the TESTFEST showed that to achieve interoperability it is necessary to follow three principles:

- adopt OneM2M interoperability platforms and Interworking Gateway
- Standardized IoT Data Models
- Standardized Ontologies

Moreover, the TESTFEST identified the following points of attention:

- In most of the cases the communication platform was based on ITS G5, due to lack of LTE C-V2X equipment during the set up of the pilot sites. Since the project was focused on the use of IoT for vehicular applications, this is not an issue, and in any case it is not expected to influence the overall performance
- The oneM2M IoT platforms were deployed in the cloud. This caused an increased latency during the TESTFEST. However, the problem is expected to be solved by moving the platform to the edge in 5G networks
- The level of data to be exchanged seems to be very large but again the issue is expected to be solved by moving the platform to the edge in 5G networks
- Handling of security issues when interconnecting different oneM2M platforms (e.g. multiple firewalls)

Finally, as a general outcome of the project, the architecture of the use cases developed by the different Pilot sites can be an input to SDOs (e.g. oneM2M) and relevant fora (e.g. 5GAA).

References

[1] AUTOPILOT D5.7 “Standardization Plan” https://autopilot-project.eu/wp-content/uploads/sites/16/2018/10/AUTOPILOT-Project-Management-D5.7-v1.0.pdf

[2] oneM2M TR-0026 “Vehicular Domain Enablement” http://onem2m.org/technical/published-drafts/release-4

[3] AIOTI report "IoT relation and impact on 5G", https://aioti.eu/aioti-report-on-iot-relation-and-impact-on-5g/