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## Document information

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## **Executive Summary**

The aim of the EU co-funded AutoNet2030 research project is to develop and test a cooperative automated driving technology, based on a decentralized decision-making strategy and enabled by mutual information sharing among nearby vehicles. The project results are supposed to be deployed during the 2020 – 2030 time horizons, taking into account the expected preceding introduction of cooperative communication systems and sensor based lane-keeping/cruise-control technologies.

This document describes the standardisation related activities performed in AutoNet2030. The AutoNet2030 contributions to the ETSI ITS standardization work have advanced the related ITS standards from driver warning applications towards the next level *i.e.*, the transactions for automated driving facilitation.

## 1 Overview of standardisation activities

Standards for Cooperative Intelligent Transport Systems (C-ITS) are essential to achieve interoperability among communication devices from different manufacturers for vehicles and roadside infrastructure. In Europe, standards are being developed by the European Standardization Organizations (ESOs): European Telecommunications Standards Institute (ETSI) and Comité Européen de Normalisation (CEN) in their respective technical committees (TCs) ETSI TC ITS and CEN TC 278, Road Transport and Telematics, the latter in close liaison with International Organization for Standardization (ISO) TC 204. The standardization scope covers all types of transport, including rail, water, and air transport (ETSI) as well as tolling systems and road infrastructure (CEN); nevertheless, the focus is clearly on cooperative road vehicles. ESOs produce standards of different types, from which the European Norm (EN) are approved by the national standardization organizations (NSOs) of each EU member as well as associated states and the necessary legal bindings are made. In 2010 the European Commission issued a mandate to the ESOs for the development of a minimum and consistent set of standards for C-ITS. The mandate implied a common basis for national standardization in Europe and therefore prevented conflicting national standards. It was completed in 2013 with the announcement of Release 1 of the standards [1] [2], whereas some features are still under revision, such as multi-channel operation (MCO) and decentralized congestion control (DCC).

In order to promote the deployment of C-ITS in Europe, a stakeholder platform has been created that included participants from industry, academia, regulation as well as representatives from C2C-CC and Amsterdam group [4][5]. The main objective is to ensure interoperability of C-ITS across borders and along the whole value chain, as well as to identify the most likely and suitable deployment scenarios, whereas standardization has been an important aspect. As a major result and milestone of the C-ITS platform and the stakeholder involvement, a report has been published in January 2016 [3]. In parallel to these deployment-related activities, involved Standard Development Organizations (SDOs), in particular ETSI TC ITS has started to consider standardisation beyond release 1. One of the key use cases of release 2 is communication support for vehicle automation.

The AutoNet2030 project has considerably contributed to the standardization process based on the results of its research and development. The most relevant standards development organisation for the scope of AutoNet2030 work is the ETSI TC ITS committee, as this committee develops standards related to cooperative ITS communications. The AutoNet2030 consortium members are very active in the work of this committee, with the following partners being ETSI members and active contributors to the work of ETSI TC ITS: Hitachi Europe, TU Dresden, Armines and BroadBit. In fact, the WG1 (Application Requirements and Services), where the application level messages for automated driving are being standardised, was chaired by Ms. Lan Lin from Hitachi Europe. Likewise, WG3 (Networking and Transport), which develops standards for ad hoc networking protocols, is chaired by Andreas Festag from Technical University Dresden. Both of them are also actively involved in the AutoNet2030 work.

## 2 Related standardisation documents

The needed standardisation work items for automated driving support have been initiated already in the first project year of AutoNet2030. Among the stakeholders in ETSI TC ITS, it was agreed to start with study items first. These study items should give guidance to develop the corresponding specifications. Consequently, driven

by AutoNet2030 partners, two study items on ‘Platooning’ and ‘Cooperative ACC’ were initiated in the first project year and this work has continued along the second and third year with the contribution of relevant AutoNet2030 specifications. The following table maps AutoNet2030 specification topics to the relevant ETSI TC ITS work items, where the specifications were contributed. The motivation and meaning of these contributions is explained in subsequent paragraphs.

AutoNet2030 specifications	ETSI TC ITS Work Items
AutoNet2030 use cases	TR 102 638: use case definition [6]
CAM extension for cooperative automated driving applications	EN 302 637 – 3: CAM basic service [7]
Cooperative lane change service	Potential new WI proposal
Convoy control service	TR 103 298: Platooning pre-standardization [8] TR 103 299: Cooperative ACC pre-standardization [9]
Cooperative Intersection Control Service	TS 101 539-2: Intersection collision risk warning [11]
Cooperative sensing service	TS 103 324: Collective Perception Service [10]
Cooperative RTK Positioning	TS 102 890 – 3: Position and Time [12]
All message format specifications	TS 102 894- 2: Common Data Dictionary [13]
Reliable Basic Transport Protocol	ETSI EN 302 636-5-1: BTP [14]
Extended GeoNetworking	ETSI EN 302 636-4-1: GeoNetworking [15]

Table 1 List of standardisation work items in ETSI TC ITS where AutoNet2030 has contributed

Truck ‘Platooning’ is expected to be the pioneering application for cooperative automated driving. Interoperable communication among ‘platooned trucks’ is essential for synchronized braking actions, which allows tight and non-oscillating platoon formations. Therefore, the ‘Platooning’ work item (TR 103 298) has been initiated in the first project year under the editorship of Katrin Sjöberg from Volvo Technology, who has been contributing to the project during that year<sup>1</sup>. Furthermore, the ‘Cooperative ACC’ work item (TR 103 299)

<sup>1</sup> Volvo Technology announced their withdrawal from the AutoNet2030 project on the 31<sup>st</sup> of October 2014 due to internal management reasons.

has been initiated in order to standardize the analogous longitudinal speed control interactions among passenger vehicles. The editing of the ‘Cooperative ACC’ work item has been taken up by Lan Lin from Hitachi Europe.

Because of critical safety implications, vehicle automation use cases require low-latency communication and frequent broadcasting of vehicle data. AutoNet2030 overcomes CAM frequency limitation (as set by congestion control on the CCH channel) by sending additional CAM messages on the SCH1 Service Channel. This same policy is being considered also by the Adaptive project (<https://www.adaptive-ip.eu/>). For future ITS deployment, the ETSI SCH6 could be the candidate for the broadcasting of these high-frequency messages. However, as shown in Figure 1, the current standard ETSI EN 302 663 [17] sets too low power limit, which we have proposed to be raised.

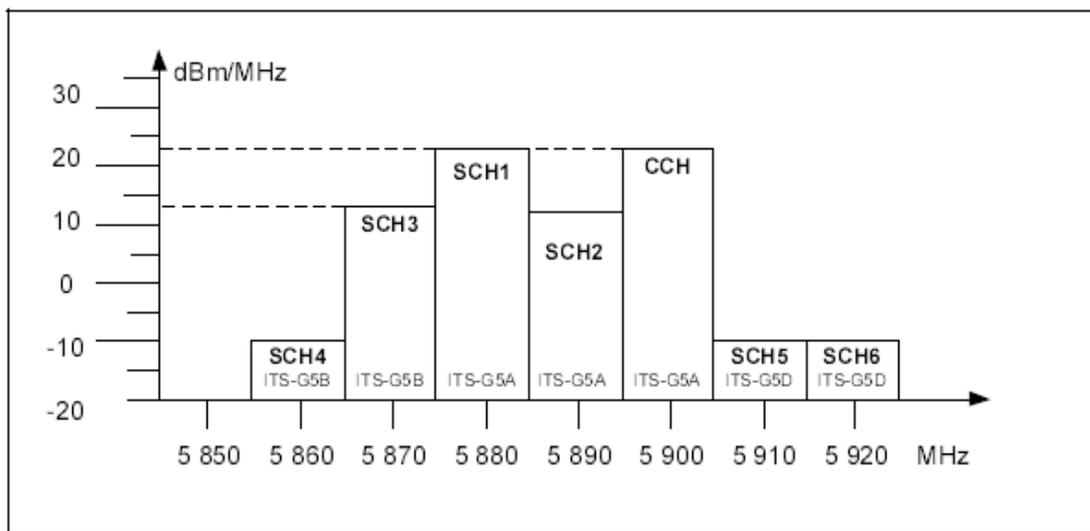


Figure 1 Maximum limit of mean spectral power density for each channel type as standardized in EN 302 663 [17]

One of the most important ETSI ITS standardization proposal is the extension of the periodic Cooperative Awareness Messaging (EN 302 637 – 2 [7]) for automated driving support. The AutoNet2030-Adaptive-iGame projects have prepared a joint CAM extension proposal. The proposed additional fields are shown in Figure 2. These additional fields cover data, which automated vehicles need to periodically share with their neighbours. In AutoNet2030, we consider traffic situations in which the awareness is paramount and we require that CAMs are transmitted with 10 Hz in several situations *e.g.*, when driving in a platoon or convoy. For this reason, we have proposed additional generation rules that transmit CAMs at a high frequency in such situations, also exploiting more than one transmission channel to divide up the load. These proposals are being considered in the current revision of TS 102 894-2 CDD [13] and EN 302 637-2 CAM [7].

Parameter	Data Requirement	Optionality
<b>Operating Mode</b>	The operating mode of the CABS. Shall be set to either <i>Normal Mode</i> or <i>High Awareness Mode</i> .	Mandatory
<b>Driving Mode</b>	The level of automation of the ego-vehicle: semi- or fully automated	Mandatory
<b>Automated Control</b>	The automated driving functions engaged by the ego-vehicle	Mandatory
<b>Target Speed</b>	The target speed of the ego-vehicle.	Mandatory
<b>Target Longitudinal Acceleration</b>	The target acceleration in the longitudinal direction of the ego-vehicle	Mandatory
<b>Braking Capacity</b>	The maximum brake capacity of the ego-vehicle. This value may be calculated on-line taking into account e.g. the vehicle's weight, weather conditions, tire conditions, etc.	Mandatory
<b>Target Distance to Preceding Vehicle</b>	The target distance between the ego-vehicle's front bumper and the rear bumper of the immediate preceding vehicle in the same lane.	Optional; Provided when available
<b>Target Distance to Following Vehicle</b>	The target distance between the ego-vehicle's rear bumper and the front bumper of the immediate following vehicle in the same lane.	Optional; Provided when available
<b>Path Prediction</b>	Trajectory prediction of the ego-vehicle	Optional; Provided when available
<b>Group Identifier</b>	Identifier of the platoon or convoy in which the ego-vehicle is driving	Optional; Provided when driving in a platoon or convoy
<b>Group Speed</b>	Target speed of the convoy or platoon	Optional

Figure 2 Additional fields of the CAM as standardized in EN 302 637-2 [7] for automated driving support

Knowing precisely the vehicle position -including high speed driving scenarios- is essential for the safe execution of automated manoeuvres. The AutoNet2030 project has developed and demonstrated a very precise cooperative RTK positioning technology for this purpose. The related specifications describing the transmission of the required RTK over 5.9 GHz media have been contributed by BroadBit to the Position and Time (TS 102 890 – 3) work item, thereby establishing the possibility of interoperable positioning augmentation between any roadside unit vendor and any vehicle manufacturer. In order to ensure a completion of the work item, the standardization efforts will be carried out in collaboration with the EU project HIGHTS (<http://hights.eu>).

Further contributions have been made to the networking & transport layer standards developed in ETSI TC ITS, namely the Basic Transport Protocol (BTP) and GeoNetworking, as standardized in ETSI EN 302 636-5-1 [14] and EN 302 636-4-1 [15], respectively. However, although these standards are under revision, the corresponding

work items are for the release 1 of standards. Therefore, the AutoNet2030 project rather contributed to the consolidation of the specifications instead of introducing new features related to vehicle automation.

### 3 AutoNet2030 contributions to standardization-related events and publications

In order to facilitate active feedback between AutoNet2030 and ETSI ITS delegates, a number of technical presentations have been made at ETSI about the interim AutoNet2030 results. They are reported in Table 2.

ETSI ITS standardisation meeting details	AutoNet2030 presentation title
Annual ETSI ITS workshop - 2015 March 26-27, Helmond	Andras Kovacs (BroadBit): "AutoNet2030 Project: Automated Driving Supported by Cooperative ITS"
ETSI ITS WG1 meeting #31 - 2015 April 14, Sophia Antipolis	Laurens Hobert (Hitachi Europe): "Cooperative ITS facilities for automated driving"
ETSI ITS WG1 meeting #32 - 2015 June 10, Sophia Antipolis	Andras Kovacs (BroadBit): "Communication interfaces for RTK-based position augmentation"

Table 2 - List of AutoNet2030 interim results presentations at ETSI TC ITS

These presentations have also been published on the AutoNet2030 website.

In addition, Prof. Arnaud de La Fortelle (Armines) has represented AutoNet2030 at the "Standardization meeting within the EU FP7 Call 10 Projects" event, which has been held on June 30<sup>th</sup> 2015 in Brussels. The objective of the meeting was to coordinate the forthcoming standardisation and homologation related actions and results among the attending projects. This activity has been followed up by the AutoNet2030 participation in the 2016 AdaptIVe Technical Workshop, where Laurens Hobert (Hitachi Europe) gave the presentation "AutoNet2030: Towards the improvement of V2X standards for automated driving", and led a constructive discussion among representatives from other EU FP7 Call 10 projects about harmonized contribution to the ETSI ITS standardization work.

Some of the publications from AutoNet2030 partners addressed the on-going standardisation work. Andreas Festag from Technical University Dresden published an overview of the standardization status in the article "Cooperative Intelligent Transport Systems standards in Europe" [18]. Laurens Hobert (Hitachi Europe) *et al.*, summarized the AutoNet2030 protocol extensions compared with the current set of communication standards in "Enhancements of V2X Communication in Support of Cooperative Autonomous Driving" [19]. Both articles were published in the IEEE Communication magazine, a renowned magazine with a wide-spread

audience. Finally, other articles published results from simulation-based performance evaluations, where the standardized system was taken as a baseline [20] or the proposed solution extended the standardized system [21][22].

## **4 Summary and Outlook**

The AutoNet2030 project has significantly contributed to the on-going activities in ETSI Technical Committee ITS. The focus of these activities was on extending the existing set of standards (release 1); this was obtained by sharing specifications of communication support for automated driving. Specifically, the AutoNet2030 has been the main contributor to the study item on Cooperative ACC and for extensions of CDD and CAM for automated driving. As a result of these activities, the scope of ETSI ITS standards are clearly expanding from just driver warning applications towards the active facilitation of automated driving.

The work of the AutoNet2030 has laid the basis for the next steps of standardization. Though the corresponding study items are not finalized yet, the reports give clear guidelines to turn the reports in technical specifications. The required standardization efforts can be continued by the C-ITS stakeholders, also further promoted by other EU projects in the field of C-ITS and in collaboration with other SDOs, such as SAE.

## Abbreviations

ACC	Advanced Cruise Control
BTP	Basic Transport Protocol
CAM	Cooperative Awareness Message
CDD	Common Data Dictionary
CEN	Comité Européen de Normalisation / European Committee for Standardisation
DCC	Decentralized Congestion Control
EN	European Norm
ESO	European Standardisation Organisation
ETSI	European Telecommunications Standards Institute
MCO	Multi-Channel Operation
NSO	National Standardization Organizations
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
SAE	Society of Automotive Engineers
SDO	Standard Development Organization
WG	Working Group

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