Position Paper on ETSI ITS G5 Channel Usage

CAR 2 CAR Communication Consortium

About the C2C-CC

Enhancing road safety and traffic efficiency by means of Cooperative Intelligent Transport Systems and Services (C-ITS) is the dedicated goal of the CAR 2 CAR Communication Consortium. The industrial driven, non-commercial association was founded in 2002 by vehicle manufacturers affiliated with the idea of cooperative road traffic based on Vehicle-to-Vehicle Communications (V2V) and supported by Vehicle-to-Infrastructure Communications (V2I). Today, the Consortium comprises 88 members, with 18 vehicle manufacturers, 39 equipment suppliers and 31 research organisations.

Over the years, the CAR 2 CAR Communication Consortium has evolved to be one of the key players in preparing the initial deployment of C-ITS in Europe and the subsequent innovation phases. CAR 2 CAR members focus on wireless V2V communication applications based on ITS-G5 and concentrate all efforts on creating standards to ensure the interoperability of cooperative systems, spanning all vehicle classes across borders and brands. As a key contributor, the CAR 2 CAR Communication Consortium works in close cooperation with the European and international standardisation organisations such as ETSI and CEN.

Disclaimer

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1 Introduction

In response to the ITS Standardization Mandate M/453 issued by the European Commission, several fundamental standards for cooperative systems have been / are being created in ETSI TC ITS and CEN. The set of standards defines e.g. limits for transmit power on channels, options for congestion control and message formats. The following table gives an overview on selected standards considered relevant for this document.

Title	ID / Version
Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive	EN 302 571 V1.2.1
Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band.	EN 302 663 V1.2.0
Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band.	TS 102 724 V1.1.1
Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part	TS 102 687 V1.1.1
Geo Networking	EN 302 636-4-1 V1.2.0
Basic Transport Protocols	EN 302 636-5-1 V1.2.0
Cooperative Awareness Message	EN 302 637-2 V1.3.0
Decentralized Environmental Notification Message	EN 302 637-3 V1.2.0
Common Data Dictionary	TS 102 894-2 V1.1.1
Security Header and Certificate Formats	TS 103 097 V1.1.1

Table 1 - ETSI Standards Overview

The basis of Car2Car-Communication is formed by EN 302 663, the current European Frequency Profile on ITS G5 (Figure 1), addressing the channel allocation and usage based on the EC Decision of August 5th 2008 on the harmonized use of radio spectrum in the 5875 - 5905 MHz frequency band for safety related applications of Intelligent Transport Systems (ITS).

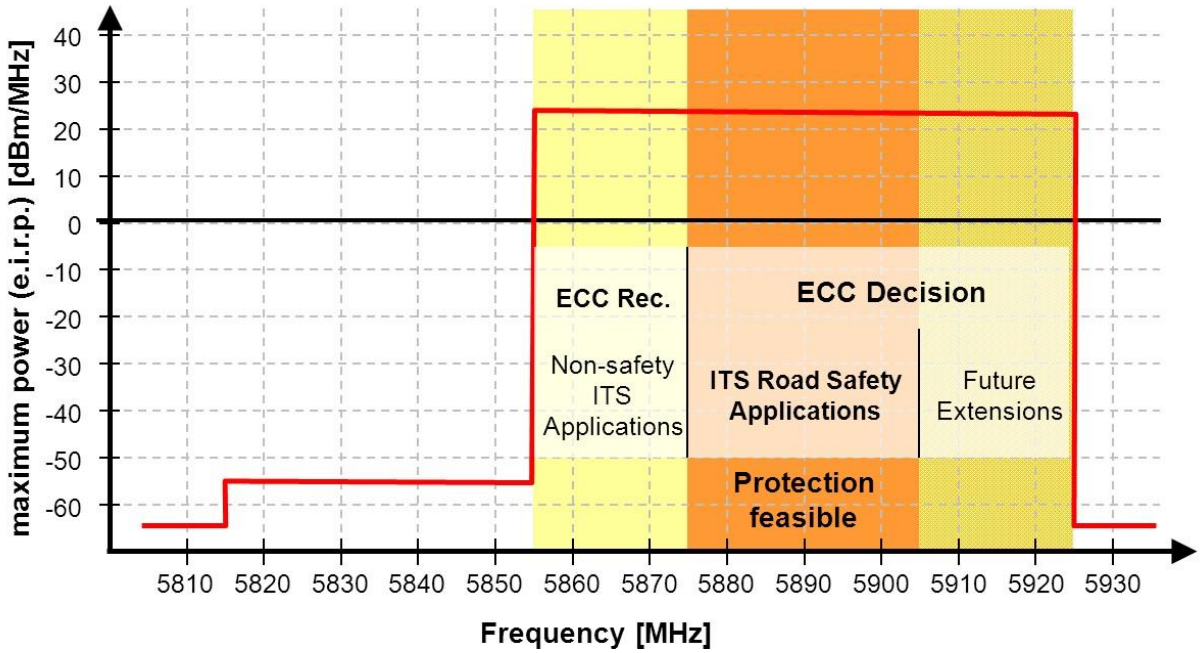

Figure 1 - Frequency Allocation in Europe

For implementation, a Relaxed Frequency Profile (Figure 2) is currently under discussion and expected to be accepted before deployment of any G5 system. At this time there is no indication this will not be accepted and even a further relaxation to -30 dBm/MHz is proposed as this is the normal value used. Release of this specification is expected beginning 2015.

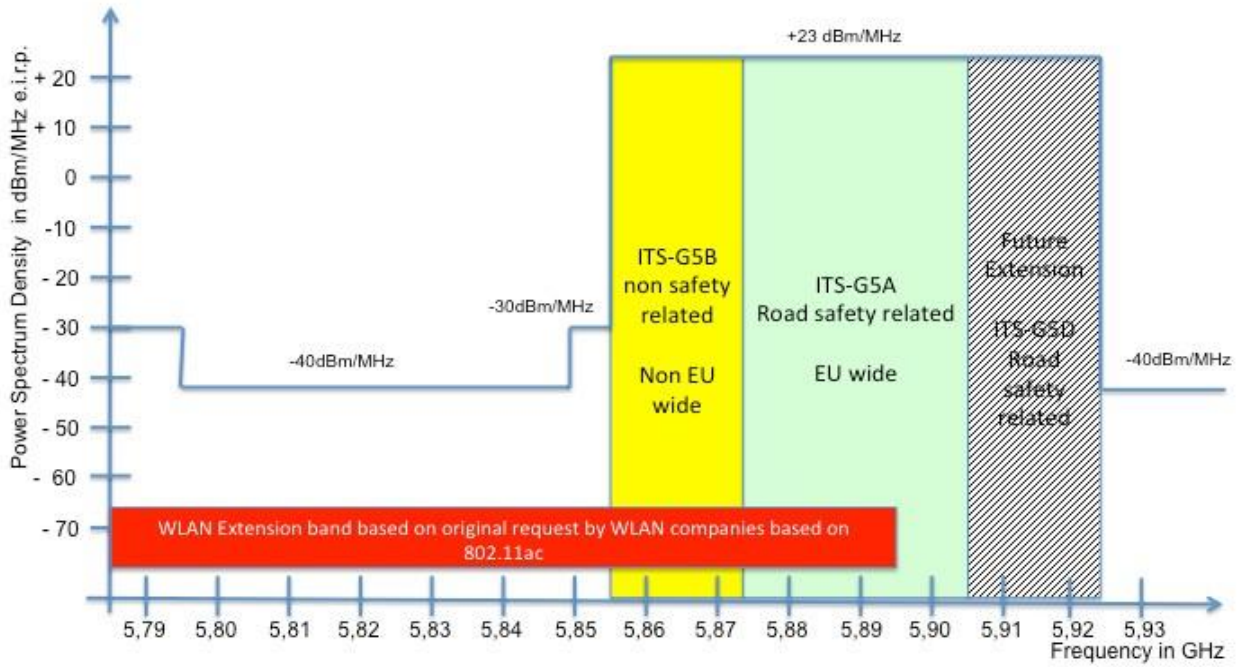

Figure 2 - Proposed Relaxed Frequency Profile in Europe

The current European Frequency Profile Standard divides the 30 MHz for Road Safety Applications into three frequency bands of 10 MHz each, where the upper channel is called "Service Channel 0 (SCH0)"[1], the lower channel "Service Channel 1 (SCH1)" and the center channel "Service Channel 2 (SCH2)" (see Figure 3).

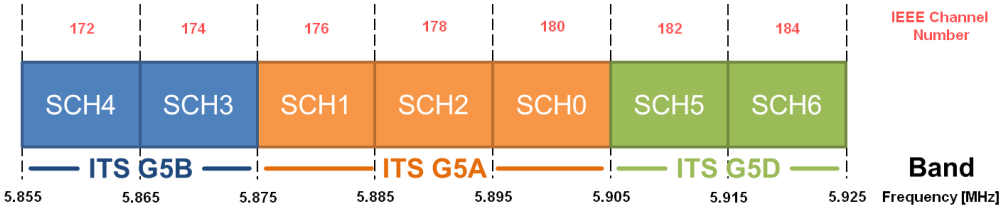

Figure 3 - Channel Naming

The ETSI standards as of today do not define a mapping of applications to channels. For interoperability, a clear mapping must be agreed so that a sender is not transmitting information on channel "A", while the intended receiver is listening on channel "B". This mapping severely impacts the hardware (and hardware costs) required for a Basic System, because multi-channel use – without a time-based switching scheme - requires multiple transceivers. **This position paper describes the C2C-CC proposal and guideline of channel usage for car-to-car- and car-to-infrastructure communication.**

[1] NOTE on channel naming: Given the current EU channel usage proposal, this document refers to Service Channel 0 (SCH0) instead of Control Channel (CCH) to avoid confusion in context of US/EU harmonization activities.

The authors of this document are aware of the ETSI Specialist Task Force (STF) 420 on MultiChannel Usage and provided an earlier version of this document for consideration in the STF activities. The proposal is basically in line with the STF420 considerations. Detailed differences can be found in these documents as far as current considerations go at this moment.

In addition to the ETSI standards above, the following C2C-CC documents are considered relevant

Title	Version
C2C-CC White Paper Decentralized Congestion Control (DCC) for Day One	V1.0
C2C-CC Basic System Standards Profile	V1.0.4

Table 2 - C2C-CC Documents

2 Scope

The C2C-CC has defined a set of Day-One Use Cases to be supported by the first deployed Basic Systems. As the C2C-CC focus is on enabling interoperability among all C2C-CC partners, this requirement addresses only the communication part of the use cases: first systems must be able to generate/forward messages for the related use cases – an HMI or implementation of vehicle behavior on top, such as automated braking, is not required.

Use Case name	Domain
Emergency Vehicle Warning	V2V
Dangerous Situation	V2V
• Emergency Brake Light	V2V
• Pre-Crash	V2V
• Automatic Emergency Breaking	V2V
Stationary Vehicle Warning, V2X Rescue Signal	V2V
Traffic Jam Ahead Warning	V2V
Collision Risk (Exchange of IRCs)	V2V
Adverse Weather Conditions	V2V
In-Vehicle Signage	I2V
Green Light Optimal Speed Advisory	I2V
Road Work Warning	I2V
Probe Traffic Data	I2V
Hazardous Location Warning	I2V

Table 3 - Day-One Use Cases

The scope of this proposal is to assign channels to the messages related to these use cases, taking into account that these messages may need to be forwarded to reach the intended destination. These messages are:

- Cooperative Awareness Message (CAM) (EN 302 637-2)
- Decentralized Environmental Notification Message (DENM) (EN 302 637-3)
- Signal Phase and Timing Message (SPaT) (ISO 19091, SAE J2735)[2]
- MAP (ISO 19091, SAE J2735)
- In-vehicle Information (IVI) (ISO 19321)

3 Channel Usage Proposal

Several channel usage concepts have been discussed within C2C-CC, but, up to this point, not been agreed upon. It seems to be consensus that SCH2 is difficult to be used due to the heavy interference by SCH0 and SCH1. Use of SCH2 can be considered later. SCH0 and SCH1 are the first channels to be used for the exchange of messages.

A common understanding within C2C-CC is that initial safety-related information exchange between ITS-Ss is assigned to SCH0, with additional safety, traffic-safety and automation-safety information could be assigned to SCH1 and in future to additional channels. The option of using

[2] NOTE: these messages (SPaT, MAP, IVI) support efficiency as well as safety applications, e.g. signal violation warning as described in the table above.

SCH1 for forwarding of DENMs after the first hop to keep additional load from SCH0 is considered. Given that the CAMs sent periodically by each vehicle with a rate of 1 Hz … 10 Hz and DENMs are generated event-based, even with first and multi-hop DENMs on SCH0, the vast majority of communication data exchange on the SCH0 can be attributed to CAMs – which makes DENM load on SCH0 practically negligible. Continuing in this direction, SPaT, MAP and IVI messages, even though SPaT and MAP being potentially larger than CAMs – when sent on SCH0 likewise only comprise a marginal part of the overall channel load. Thus, SCH0 load can be expected to be as in the image below.

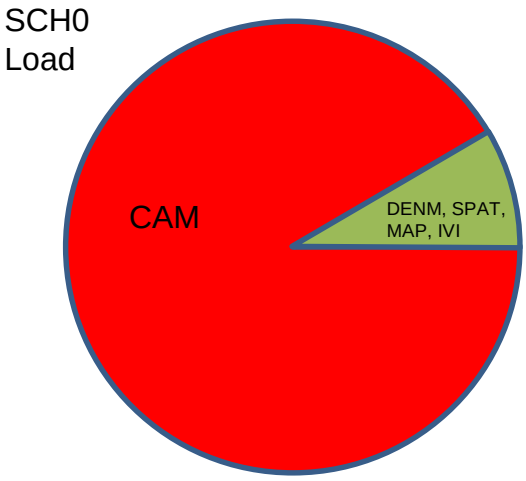

Figure 4 - Expected SCH0 Load

With these observations, the following initial pragmatic mapping is proposed:

Message Type (PDU Header)	**First Hop Mapping**	**Further Hops Mapping** ***Low channel load***	**Further Hops Mapping** ***High channel load***
CAM (2)	SCH0	-	-
DENM (1)	SCH0	SCH0	SCH1[3]
SPAT (4)	SCH0	-	-
MAP (5)	SCH0	-	-
IVI (6)	SCH0	-	-

Table 4 - Channel Usage Proposal

The mapping distinguishes between “Low channel load” and “High channel load” conditions and the following assertion hold for the start of deployment

The channel load is always low as long as all of the following conditions are fulfilled

[3] NOTE: Multi-channel/Multi-radio support is optional for C2C-CC day1 systems. Consequently, other channels (e.g. SCH1) are only used if available.

- CAM rate up to 10Hz with DCC
- Received packet rate £ 400 packets/second[4]

This **stringent assignment of all messages to Service Channel 0 (SCH0)** at the start enables single-transmitter-single-receiver solutions for the Basic System, representing the most simple, easiest-to-implement, and most cost-effective option.

Any station transmitting on SCH0 must comply with the DCC control mechanism specified according to ETSI TS102 687 or the C2C-CC White Paper Decentralized Congestion Control (DCC) for Day One.

Regarding infrastructure originating messages, the following applies

- Messages from infrastructure are subject to same restrictions as messages send by other ITS-Ss: All message rate settings in the document (rate R) rely on an average message air time of Tavg = 0.5 ms corresponding to 375 bytes @ 6Mbps. Longer messages (air time T) shall only be sent at a reduced rate R*Tavg/T.
- Infrastructure messages sent by road side ITS-Ss (RSUs) not implementing DCC are allowed to send at a maximum of 1 Hz
- Road side ITS-Ss shall implement DCC if they send with frequency >1Hz

Channel usage shall be monitored after deployment of Car-to-Car Communication and – at least – annually the necessity of a deviation from the proposed channel usage shall be discussed, ideally supported by simulation. Especially for the case of vast and dense infrastructure deployment, and heavy service-oriented traffic of unicast nature, Service Channel use can be expected.

[4] This is a workaround in case that chipsets do not support measuring the channel load as fraction of time that a signal is above the given carrier sense threshold.