Dedicated Short Range Communication

DSRC

A Tutorial

Acknowledgement

This document is the result of eleven years of work in the area of standardization of Dedicated Short Range Communication within

- *DIN/DKE GK717 AK9*
- *CEN TC278 WG9*
- *CEN M018 PT06*
- *ETSI RES08 WG4*
- *ETSI ERM TG29*
- *ISO TC204 WG15,*

and is based on practical experience from several projects.

Fruitful discussions with a lot of excellent engineers and scientists all around the world allowed me to gather the best information and knowledge on Dedicated Short Range Communication for Road Transport and Traffic Telematics as it is used in Europe today and as it is best for usage all around the world.

The list of all my friends and colleagues, who contributed to this work, is that big, that it can not be printed here totally. However my special thank is to representatives of the following organizations (in alphabetic order):

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- *Automobile Manufacturer Volkswagen, Germany*
- *Semiconductor Manufacturer ST Microelectronics, Italy*
- *Several DSRC Manufacturers*
- *Toll-road Operator ASFINAG, Austria*
- *Toll-road Operator Autostrade, Italy*
- *Toll-road Operator Brisa, Portugal*
- *Toll-road Operator Cofiroute, France*
- *Toll-road Operator Iceland*
- *Toll-road Operator EZV-LSVA, Switzerland*
- *Toll-road Operator NPRA, Norway*
- *Toll-road Operator Toll-Collect, Germany*

Dr. Hans-Joachim Fischer, July 2003

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1 Introduction

The intention of this book is to provide a detailed technical description of DSRC in textbook-style. This book is mainly intended for technically interested operators and technical newcomers that have to design, develop and implement DSRC systems.

1.1 History

Road Traffic Transport Telematics (RTTT) is a major issue of the mobile information society. The European Commission with its Directorate General DG XIII prepared this approach within the research programs DRIVE I and DRIVE II. The Technical Expert Group, that defined and catalogued RTTT applications already more than one decade ago, played a major role.

Candidates for the communication tasks related to RTTT are

- the **cellular phone GSM** and its successor **UMTS** for the wide area communication, and
- **Dedicated Short Range Communication** (**DSRC**) for localized communication within limited communication zones along the road network.

A new approach at the international standards organization ISO TC204 WG16 investigates in

- **CALM (Communication Air interfaces for Long and Medium range)**

that combines several communication technologies in a smart system for Intelligent Transport System (ITS) [1] applications.

The standardization of DSRC protocols is being done within the national standardization institutes of the European countries, within WG9 of the RTTT Technical Committee of the Commission Européen de Normalisation CEN TC278, and within ISO TC204 WG15. WG9 of CEN has the lead. What concerns radio parameters, ETSI is responsible in Europe. Currently ETSI ERM TG29 is working on a new version of the standard EN 300 674 in order to consider the R&TTE directive. At the level of ISO, there has been a decision in 1998 to consider the divergent needs and approaches in the regions "Europe", "North America", "Asia", and to standardize only the DSRC application layer at ISO.

In what follows, only the approach in Europe is considered.

New radio frequencies to be used for RTTT communication are in the bands around 5.8 GHz and around 63.5 GHz as recommended already in 1992 by ERC [1] and as already adopted by the European Union. The upper band provides 1 GHz bandwidth and was proposed for standardization at CEN TC278 by the author of this book, at this time still employed at Daimler-Benz Aerospace AG in Ulm / Germany. This work item was closed during the work of CEN TC278 WG9 because the technology of monolithic millimeter wave integrated circuits (MMMICs) had not been developed sufficiently so far to support the requested very low price of the mass market. However in principle this technology is mature as well and has been demonstrated successfully already within DRIVE II – COMIS [12].

Further on the use of infrared (IR) light was proposed for standardization at CEN TC278 by Siemens AG München / Germany, who had the lead in standardization at the German level at DIN/DKE GK717 AK9, the European level at CEN TC278 WG9 and the International level at ISO TC204 WG15. Siemens has withdrawn this proposal and left the chairs at DIN/DKE, CEN and ISO. These chairs have been taken by the University of Aachen / Germany. Although the work item was closed at CEN the Austrian company EFKON AG / Graz continued to develop IR technology, which now is selected for enforcement purposes in the German GNSS/CN truck tolling system.

There are currently two frequency bands allocated at 5.8 GHz each with width of 10 MHz. The first one is allocated on a Pan-European basis at the center frequency of 5.8 GHz. The other one is allocated in some European countries at the center frequency of 5.81 GHz. It has to be noted that these bands are within an ISM band and are allocated for RTTT applications without exclusive rights. As these bands have to be shared with other applications, e.g. radio amateurs, some unintended interference might be possible. The process to request exclusive use of these bands for RTTT applications, at least for the Pan-European band, has been started already.

[1] Practically, ITS is nothing else than the US-American equivalent of RTTT.

Beyond other smaller systems, currently three different systems are using the frequency bands at 5.8 GHz for RTTT applications, mainly for road tolling. These systems are referred to as DSRC-LDR (Low Data Rate), DSRC-MDR (Medium Data Rate) and DSRC-HDR (High Data Rate) [10]. The three largest installations of DSRC in Europe are among others e.g.:

- The DSRC-LDR road tolling system in Portugal operated by BRISA and manufactured by Micro Design ASA / Norway (today this is Q-Free ASA).
- The DSRC-MDR national road tolling system in Norway, manufactured by Q-Free ASA.
- The DSRC-HDR road tolling system in Italy designed and operated by AUTOSTRADE. Different manufacturers provide the equipment.

The DSRC-LDR system was developed simultaneously to the work in the project team CEN M018 PT06 (the author of this book was chairman of PT06) and was proposed to CEN to be included in the DSRC standards. Due to the majority situation within CEN TC278 WG9 the proposal was rejected in the phase of preparing and voting on the pre-standards (ENV) in order to hinder a successful competitor. Basic important parameters of the DSRC-LDR system were lost in prENV 12253 by TC278, as confirmed recently [23]. Thus, by accident, ENV 12253 [2] does not cover the DSRC-LDR system. However DSRC-LDR is described in this book. There exists the ETSI standard ES 200 674-2 for DSRC-LDR [28].

The DSRC-HDR system is according to an Italian standard [14] and had not been considered for the work in CEN although it had been existent already in advance. The reason was that the Italian system needs more transmission bandwidth than is available at 5.8 GHz on a pan-European basis. DSRC-HDR is not described in this book, as it was not developed at CEN. There exists the ETSI standard ES 200 674-1 for DSRC-HDR [29].

The DSRC-MDR system finally is the one standardized by CEN TC278 WG9 in the standards documents

- ENV/prEN 12253 for the physical layer [2, 26]
- ENV/EN 12795 for the data link layer [3, 24]
- ENV/EN 12834 for the application layer [4, 25] and
- ENV/prEN 13372 for the DSRC profiles [5, 27].

As the CEN pre-standard documents [3, 4] neither are consistent nor are complete, partly are wrong, and thus are enabling in a way that compatibility of equipment can not be guaranteed, the Norwegian Public Roads Administration (NPRA) set up an expert team in 1998 to evaluate the CEN ENVs, to write a precise DSRC and EFC specification, and to harmonize this specification with the major DSRC manufacturers in Europe such that compatibility of equipment provided by different manufacturers and interoperability of RTTT applications offered by different operators is enabled. The result of this action was the autoPASS specification [15] owned by NPRA and made available publicly. ESF GmbH was in charge of the DSRC part of this specification.

Within several real projects in Europe and world-wide, the competing companies in the DSRC arena have proven successfully both,

- **compatibility of DSRC equipment provided by different manufacturers**

and

- **interoperability of EFC operated by different organizations.**

During the process of conversion of ENV 12795 [3] and ENV 12834 [4] into ENs [24, 25] (full standards) large parts of the autoPASS specification were used, which is a clear proof for the excellent work done by this expert group.

In January 2003, CEN TC278 succeeded to agree on a compromise proposal for prEN 12253/13372 [26, 27], after the GSS group gave up to insist on their very strong position, which was not accepted by CEN BT and which was not in line with resolutions of CEN TC278. The solution found is illustrated in this book. The basic idea is to allow for two co-existent physical layer parameter profiles, referred to as Set A and Set B, where both sets are referenced by the same pair of DSRC profiles, i.e. 0 and 1.

Note: Although the parameters related to the difference in Set A and Set B are parameters of the OBU, these sets characterize complete systems, as the parameters have impact on requirements for the roadside installation.

- Set A is identical to ENV 12253.
- Set B is a further simplification requested by the GSS group.

The author of this book urgently recommends **not to use Set B**, as this set seems to be introduced just for commercial reasons in a fight for market shares, and as this Set B is not at all technically verified.

- Set B but implies severe restrictions of performance and applicability of DSRC.

Nevertheless,

- Set A and Set B are technically compatible

and even

- interoperable in system configurations, where Set B is sufficiently powerful.

There are several indications on the market, e.g. by semiconductor manufacturers and operators, that there will be a **migration from Set B towards Set A**.

This book focuses on **MDR-DSRC Set A Class C**, as it is used in the largest and most powerful EFC system in Europe.

Although the whole book has passed a quality control process, there might be small errors and/or inconsistencies. Please report to the author of the book about any deficiencies detected.

1.2 This document

The goal of this document is to describe as precisely as possible the current interpretation of the DSRC protocol as based on the CEN (pr)ENs [24-27], the ETSI EN [9], and as implemented by known manufacturers. As Electronic Fee Collection (EFC) is the most important application so far, and as EFC mainly is implemented in a very simple and efficient way based on a central account, this document reflects the special needs of simple but efficient EFC. However it covers as well the usage of DSRC for other applications, e.g. Tolling with Smart Cards, Ecopoint Collection (Austria, provided by Q-Free), LSVA tax declaration (Switzerland, provided by Q-Free), Access Control, Freight and Fleet Management, Interrogation of Digital Tachographs [13] and others.

The specification of the Application Layer Broadcast Kernel (B-KE) as presented in EN 12834 [25] is not included. The B-KE is important for broadcast information services. A solution without B-KE as currently being discussed by manufacturers is shown.

The structure of this document is as follows:

- Chapter 2 provides basic information on localized dedicated short range communication.
- Chapter 3 is dedicated to the physical layer parameters. These parameters mainly are controlled by ETSI.
- Chapter 4 is dedicated to the data link layer (DLL). The presentation follows the subdivision of the DLL into the MAC sub-layer and the LLC sub-layer. However the interface between both sub-layers is not presented as it does not exist in reality.
- Chapter 5 is dedicated to the application layer.
- Chapter 6 is a reference to the related ETSI standard for type approval / conformance testing of radio equipment.
- Chapter 7 provides a real example for electronic fee collection, i.e. a coarse description of the Norwegian autoPASS specification.
- Additional important information is provided in the annex.