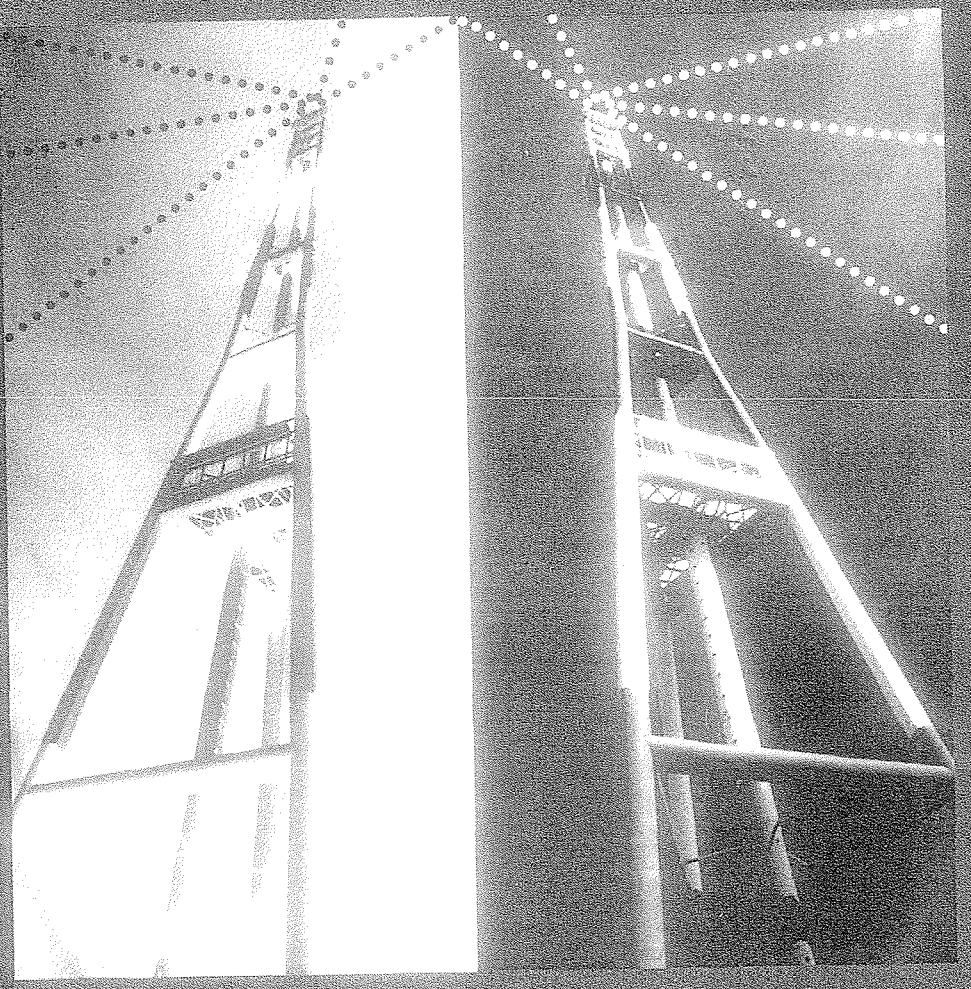
RDS: THE RADIO DATA SYSTEM

MOBILE COMMUNICATIONS SERIES



DIETMAR KOPITZ
BEV MARKS

TSOI, MINDY
Room 3215-C

RDS: THE RADIO DATA SYSTEM

KOPITZ • MARKS

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RDS: The Radio Data System

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RDS: The Radio Data System

Dietmar Kopitz
Bev Marks



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Foreword

RDS was developed as a result of the far sighted preparatory studies undertaken within EBU Technical Groups over 20 years ago. The system was designed to fulfill the requirements of all European countries and it subsequently became a European standard under the umbrella of CENELEC. In many countries RDS services were rapidly introduced with the aim of generally improving FM radio and especially mobile reception. New data services, in particular for traffic and travel information, were added and are now being introduced. RDS has been further developed to permit migration to Digital Radio which has even more powerful features built upon that experience already gained.

In recent years, the European-developed RDS has also become a global success. In the United States, RDS was first adapted to meet North American requirements, then the RDS Forum, with its worldwide viewpoint, stressed the need for converging standards. This was recently achieved by joint activity in Europe and in the United States, culminating in upgraded, harmonised standards for RDS in Europe and RBDS in the United States.

It is recognised that FM radio will still exist for many years to come. So, in the future the EBU will continue to support the maintenance of the RDS standard. But of course, one day Digital Radio will deliver much more powerful data services, a process started many years before by RDS.

The authors, Dietmar Kopitz and Bev Marks, have accompanied the development of RDS from the very earliest days. They are now highly active in the related domain of increasing importance to broadcasters—the provision of radio data services specifically for traffic and travel information.

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I wish this book a great success and I hope that it will also stimulate many new initiatives for further implementations of RDS all around the world.



Professor Albert Scharf

Acknowledgments

In the European Broadcasting Union, many working groups have contributed to the elaboration of the Radio Data System, since the early nineteen seventies. We have had the privilege and pleasure to work with these groups for many years. As a result, we both enjoy long lasting friendships with many highly gifted personalities who have contributed so much to the success story that RDS has already become, with over 50 million RDS radios in use.

Much of the content of this book is based on shared knowledge gained during the multinational development work to which many people from other countries have contributed. We cannot individually mention everyone, however, we would like to list the most significant contributors and express our appreciation to them for their contributions given to RDS. These individuals have made RDS internationally successful through standardisation in Europe. We are also pleased to acknowledge the support of their organisations or companies.

- *Josef Berger (Österreichischer Rundfunk), Austria*
- *Kari Ilmonen (Yleisradio), Finland*
- *Martti Saarelma (Yleisradio), Finland*
- *André Keller (TéléDiffusion de France), France*
- *Michel Rigal (TéléDiffusion de France), France*
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- *Hermann Eden (Institut für Rundfunktechnik), Germany*
- *Jürgen Mielke (Institut für Rundfunktechnik), Germany*

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- *Karl-Heinz Schwaiger (Institut für Rundfunktechnik), Germany*
- *Mario Cominetti (Radiotelevisione Italiana), Italy*
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- *Simon Parnall (British Broadcasting Corporation), United Kingdom*
- *Mark Saunders (British Broadcasting Corporation), United Kingdom*
- *Ian Collins (UK Independent Radio), United Kingdom*

After the European RDS standard was established within CENELEC, a new standardisation activity started in the US National Radio Systems Committee and an adaptation of RDS to the North American broadcast environment resulted in the agreement of the EIA/NAB voluntary industry standard: RBDS. Again we would like to acknowledge the significant work of additional North American contributors.

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- *John D. Casey (Denon Electronics)*
- *Almon H. Clegg (Denon Nippon Columbia)*
- *Jerry LeBow (Sage Alert Systems)*
- *Thomas D. Mock (Electronic Industry Association)*
- *Dave Wilson (National Association of Broadcasters)*
- *Scott A. Wright (Delco Electronics)*

We thank the EBU for the permission to use, for the purpose of this book, RDS material that has been elaborated over the years in our daily work. We are grateful to Philippe Juttens (EBU), for his intuitive understanding of our needs, resulting in the high quality graphical design work for RDS that we have regularly used in many EBU publications.

Our many contacts with members of the RDS Forum have given us much help and inspiration, for which we are grateful.

We also thank our publisher Artech House and, in particular, Julie Lancashire and John Walker, our editors, for their continuous encouragement to progress this project. We greatly appreciated their guidance during the development of the book concept which we conceived together for the mobile communications series.

We thank our book reviewer, Grant Klein for the excellent professional advice given to us during the writing of the manuscript. Susanna Taggart from Artech House has also given considerable and valuable help to us in this context.

Finally, we thank our families and close friends for their long patience with us. Perhaps inevitably with such a subject, we significantly underestimated the time needed to accomplish the manuscript and they were always kindly forgiving when the writing of the book made us unavailable and temporarily prevented us from enjoying life together. Now that all the hard work is done, we hope that we will find many new opportunities together which will compensate for the good times missed during the winter of 1997!

Dietmar Kopitz and Bev Marks
Geneva (Switzerland) and Battle (England)
October 1998

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1

RDS System and Applications Overview

1.1 Introduction

This chapter is conceived to give a good and detailed overview about the Radio Data System (RDS) and its origins, and does not require too much technical knowledge from the reader about mobile data communication techniques. It provides much of the necessary background that will help readers to better understand the details given about RDS and its implementation options in the remainder of this book.

1.2 Objectives to be Achieved With RDS

The Radio Data System offers broadcasters a flexible data transmission channel accompanying their very high frequency/frequency modulation (VHF/FM) sound broadcasts. Additionally, RDS offers the possibility for data service providers to introduce new data services if these are based on the concept of sending relatively few bits to many users. Thus, RDS can accommodate a wide range of possible implementation options.

Following a long period of systems development in the 1970s and early 1980s (see Figure 1.1), and field trials in several European countries, RDS is now implemented all over Western Europe, in several Central and East European countries, in some Asia Pacific region countries, in South Africa, and in the United States (using the Radio Broadcast Data System (RBDS) standard), and is also used by some broadcasters in Latin America. One important new feature for which regular services started in many European countries as of

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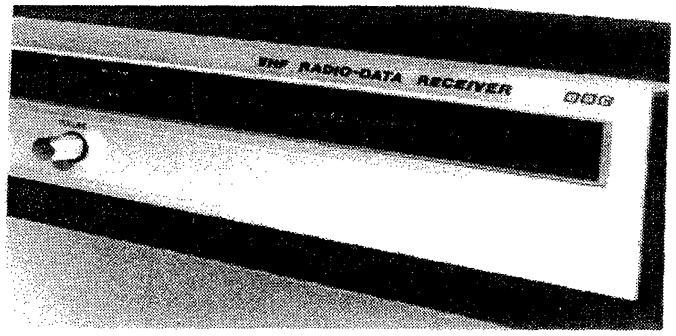


Figure 1.1 One of the first RDS demonstration receivers designed by the BBC in 1982. (*Source:* BBC.)

1997 is the Traffic Message Channel (TMC), (see Chapter 7). Another important new feature is the Open Data Application (ODA), (see Chapter 9).

1.3 Historical Development

Early in the 1970s, many public broadcasters in Europe were beginning to ask themselves what could be done with FM. It had been introduced in the 1950s and yet it was none too successful, despite continued investment in the transmission infrastructure. Many big broadcasters had, by the mid-1970s, completed their national FM networks with nominal service coverage of around 95% of the population, or more. Nevertheless, audience research and FM receiver sales continued to suggest that something was impeding the take-up of FM radio services by the public. However, in particular, the in-car entertainment sector had worked hard on improving receiver sensitivity, which helped improve reception significantly. Some other factor must have been playing a role in this slow acceptance of FM services. Various research organisations were asked to look at this situation and reported mixed but highly constructive solutions.

In 1974, we had in Europe the following situation: The largest German car radio manufacturer, Bosch/Blaupunkt had developed, in close collaboration with the research institute of the German public broadcasters (IRT), the Autofahrer Rundfunk Information (ARI) System, which means "broadcast information for motorists." The system used the 57 kHz subcarrier with a 3.5 kHz injection level as a means to identify that the so-marked programme carries from time to time announcements about road traffic. This subcarrier was then

amplitude-modulated with 125 Hz when the traffic announcement was broadcast as a means of identifying that such an announcement was on-air. In addition, one out of six possible signals (between 23.75 Hz and 53.98 Hz) was used for area identification.

Bosch/Blaupunkt was hopeful at that time that this ingenious system would be adopted by the broadcasters all over Europe, which would have been an advantage from the receiver manufacturer's point of view because of the convenience of a more uniform market for the sale of car radios. To gain the broadcasters' support, the ARI system was submitted by the German public broadcasters to the European Broadcasting Union's technical committee, with the view of obtaining a recommendation from the EBU that this system be put into general use all over Western Europe.

The EBU is a professional association of, at that time, mostly public broadcasters in Western Europe, but now also includes the broadcasters of Central and Eastern Europe. The EBU is in fact the authority to establish or harmonise operational broadcast practises in Europe. In doing so, there is full awareness in the EBU that it is not a standardisation organisation. Therefore, the EBU collaborates very closely with standardisation organisations like the International Telecommunication Union (ITU), Comité Européen de Normalisation Electrotechnique (CENELEC), and European Telecommunications Standards Institute (ETSI) to create the necessary standards, normally before any recommendation relating to an operational practice for broadcasting is issued.

Although it was rather unexpected by those who undertook the initiative in the EBU—to recommend the ARI system for general introduction in 1974—their motion launched the RDS development within the EBU. Why? In the EBU's technical committee there was a great deal of disagreement about the universal applicability of the ARI system. The broadcasting model used in Germany, and for which the ARI system was conceived, was in fact rather exceptional. Instead of regional broadcasting companies, most countries used national networks. Regionalisation, though quite useful for road traffic information, was not a common practise at that time. Also, for ARI it was assumed that in each region there would only be one programme that contained broadcast information for motorists. In reality, though, national broadcasters inserted these announcements in several of their programmes. Thus, within the technical committee of the EBU, in 1975, a number of provoking questions and statements were being put forth, such as the following:

1. Would it not be better to seek to develop a system that uses digital modulation instead of the analogue AM used in ARI?

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2. Why should we adopt a system that permits identification of only one programme, namely the one that contains the traffic announcements? It would be much better to develop a universal system that permits identification of any FM programme—for example, by Programme TYpe.
3. The hand-over mechanism for broadcast networks, by means of the area codes used within ARI, is inconvenient from the broadcasters' point of view, since it does not permit identification, unambiguously, of the possible alternative transmitters within a given network; that is, Alternative Frequency lists are required instead.

These criticisms of the ARI system immediately set the scene for the RDS development to start. There was general agreement within the EBU that this would be a very useful undertaking. The task was given to a working group that was in charge of all questions related to sound broadcasting. This group, in fact, took some time to take off the ground, since it had no experience at all with the use of digital modulation systems. Therefore, after having reflected upon the most suitable subcarrier frequency (57 kHz or 76 kHz, both integer multiples of the 19 kHz pilot tone) for the purpose of achieving a minimum of interference, the group started to work on compatibility issues. They covered such aspects as interference from the data signal to the stereophonic audio programme, the required coverage area (the same as for monophonic reception), and the ARI compatibility. Additionally, the aim was to achieve no degradation of the established protection ratios that are internationally used within the ITU for the purpose of frequency planning of broadcast networks, or even single local transmitters.

The EBU working group then created a specialised group of experts in data broadcasting. In most European countries, by the late 1970s, the public broadcasters and the telecom organisations that operated transmitter networks had already experimented with data transmissions where a subcarrier within the FM multiplex signal was phase-modulated. This kind of experience existed especially in Scandinavian counties—for example in Finland and Sweden.

The EBU technical committee had, at that time, a so-called "bureau," which was their small management committee supervising the activities of the associated working groups while also being responsible for organising the work decided on by the full committee. In that bureau there was one member from the Finish broadcasting company, Yleisradio, who had already written his doctoral thesis about the technology that was about to be developed by the EBU's specialist group.

It is interesting to note, even from the present point of view, what Mr. K. Ilmonen's thesis in 1971 was all about, and what kind of research work he had then initiated within the technical department of Yleisradio. One of his collaborators had also joined the EBU specialist group and contributed to the work then being undertaken. Ilmonen's thesis was about listener preferences for loudness in speech and music broadcasts when these occur at various sequences in the same programme. To permit a separate adjustment of the volume and some kind of automatic control function in broadcast operations and the receiver, an identification of each speech or music item was suggested. If this could be done, one could also make an identification of the Programme TYpe. He then drew up a list that closely resembles those lists now used in RDS and DAB. He suggested using a 57 kHz subcarrier, amplitude-modulated by FSK frequencies, to achieve the objective for such a universal identification system. Being in the EBU and the representative of a small country, Ilmonen insisted strongly that Europe needed a standard for a unified system, thus giving a strong impetus on the management level to conduct the work with this very important objective clearly in mind (see the historical document reproduced on page 6) [1].

How did the EBU specialists then proceed in their work? In 1976, there were already several different radio data systems proposed from Finland, the Netherlands (see the historical document reproduced on page 6), and Sweden. The specialists tried to identify what these systems had in common. They looked at a form of coding of the data stream that would permit optimal performance in the mobile reception mode at typical car-travelling speeds and subject to severe multipath interference, as would usually occur with FM in mountainous regions.

To determine these basic parameters, it was agreed to conduct a first field trial in 1980 in the area of Bern/Interlaken, Switzerland. Representatives from the European receiver manufacturing industry (EUROTECH, now the European Association of Consumer Electronics Manufacturers (EACEM)) were invited to join. A questionnaire was sent to broadcasters and industry leaders to determine the desirable features of the upcoming system. The test data broadcast in the region of Bern/Interlaken was then recorded by various research laboratories and analysed with the view of optimising the mobile reception.

In 1981, there was subsequent agreement of coordinated applications and the principles to be used in baseband coding. Test transmissions then started in several countries such as France, Finland, Germany, the Netherlands, Sweden, and the United Kingdom. Since the system parameters were not yet fully defined, each country had designed its own particular radio data system, and sometimes one country even tested several different variants. Thus, by 1982 eight different systems were already known and it became an imminent task to bring the choice straight down to one [2–6].

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Two historical EBU documents on emerging RDS

NOS Hilversum, Netherlands:
Some basic proposals for the development of a programme identification system in Band II
On the 14th of October 1975 delegates from IRT Hamburg, NV Philips Eindhoven and NOS were in Hilversum to discuss theproblems concerning the realisation of a transmitter and programme code in the FM band.

A summary of the meeting is given in this document.

....
FM transmitters can be modulated with frequencies up to 100 kHz. Within this frequency range two small bands can be pointed out for extra information. One of them is just around 57 kHz and is used by the Germany ARI system. Unfortunately no extra information can be modulated upon the carrier of 57 kHz.

The second frequency range is around 67 kHz, about 65-69 kHz and is used by the SCA system. This system is not in use in Europe.

....
The transmitter and programme code could be transmitted in a digital form. A practical type of modulation could be the frequency shift keying system, shifting from i.e. 66-68 kHz.

Due to the low modulation depth, the signal to noise ratio within this channel will be fairly low. Probably the system is not suitable for a car or a portable radio.

Information that could be transmitted:

1. Programme identification	4 characters
2. FM channel number	3 characters
3. Place name of the transmitter tower	5 characters
4. Kind of programme	2 characters

Use could be made of the ASCI code. The whole information should be given five times per second.
The type of display is still under study.

Fields tests in the near future will give information how far the system could disturb the radio programme and how far the system can be disturbed by man made noise.

H.J. v.d. Heide, NOS

****

Oy. YLEISRADIO Ab. Helsinki, January 23rd, 1976
The Finnish Broadcasting Company Ltd.

Dear Mr Kopitz,

....
With the present state of art, a radio listener meets several situations of inconvenience in connection with the listening. Firstly, almost everywhere more than one programme are receivable simultaneously on VHF, and it is not always convenient for the listener to know whether he is tuned to the right programme. Secondly, a programme is often transmitted by several VHF transmitters, a number of which are receivable at the listener's place. To find the transmitters with the strongest signal is not easy, would however be useful. Thirdly, listeners waiting for a certain programme item to start (say, the news), frequently wish to ignore the preceding programme, which results in an inconvenience: keeping a constant watch on the run of time. And, finally, research has shown that different programmes are wanted with different characteristics of reproduction, the most widely known differences being that between speech and music, or between music of different type.

By transmission of a suitable programme information signal together with the programme signal proper, all the above inconvenience could be avoided. Receivers could be developed to perform in fact any kind of changes in the listening characteristics: to find a certain programme (including the search for a traffic radio transmitter), to find a programme of a given type (including traffic programmes) to switch on at the right time, to give each programme a given level or a given setting of treble and bass, combination of loudspeakers, etc.

....
For the further development of the programme identification system, we are at present constructing a prototype transmitter and receiver, with the aim of demonstrating to our receiver industry the scope of possibilities such a system could give for the listener-consumer. We have chosen 57 kHz as sub-carrier, amplitude modulated by FSK frequencies. The code chosen allows for transmission of 1024 alternatives of programme identification. The complete data sequence consists of 12 bits.

We have heard that similar developments are going on in research laboratories of some receiver manufacturers. In order to avoid a marketing of receivers with different characteristics, we very strongly consider it of paramount importance to standardise the identification codes. This, according to our opinion, is to a great extent a task for the receiver industry. However, the system (especially if the code is large) will affect the possibility of using e.g. the band 53-75 kHz of VHF transmitters to any other purposes (SCA, tetraphony, the temporary EBU traffic-VHF systems, etc.). Thus, the EBU and CCIR should also investigate the problem.

Dr. Kari Ilmonen

The year 1982 saw the EBU specialists defining, prior to any further evaluation, the objective criteria upon which the choice should be made, and they agreed to jointly conduct a laboratory and field test in Stockholm. Figure 1.2 shows the EBU group that developed the RDS system. Out of this evaluation, the Swedish Programme Identification (PI) System emerged as the winner, and was then retained as the basis for further RDS development in the EBU. This PI system was already in use in Sweden, since 1978, for the operation of an FM data broadcasting paging system called MBS [7,8].

Subsequently, an ad hoc group was created to meet at the BBC Research Department with the task of fixing the baseband coding for all known applications to cover with the unified FM Radio Data System.

The features thus coded were tested in a second field trial in the area of Bern/Interlaken (see Figure 1.3). Once the data was evaluated by the research laboratories involved, the RDS specification was drawn up in final form by the EBU specialists meeting in 1983 in Bern, Switzerland.

The European car radio manufacturers who were consulted were still quite concerned about the EBU's RDS system meeting the requirement for ARI compatibility, because that system had, since its introduction in 1974, been very successful in Germany, Austria, Switzerland, and Luxembourg. The majority of all car radios sold in these countries were equipped for ARI functionality.

Other European countries were less interested, and did not use ARI at all. Nevertheless, since RDS was designed to be compatible with ARI, the challenge of successfully passing a field trial had to be attempted to confirm that compatibility to those manufacturers who remained doubtful. Of course, such a field trial had to be carried out in Germany, in an area where mobile reception was as difficult as the one encountered in the Bern/Interlaken area. Munich was chosen for this field trial, which took place in 1983. The RDS successfully passed this rather critical test.



Figure 1.2 The EBU working group that developed the RDS system. (*Source:* BBC.)

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Figure 1.3 Basic field trials taking place in the area of Interlaken (Switzerland) in 1982. (*Source:* EBU.)

As a consequence, the RDS specification was adopted by the EBU and EUROTECH in 1983-84, published, and also submitted to the ITU and CCIR Study Group 10. This study group extracted the essential characteristics from the EBU specification and transcribed them to a new CCIR Recommendation 643, which was then adopted in 1986 [9].

All the above shows clearly how RDS has emerged over time and between the years 1975-1984. In retrospect, during this 10-year period we saw the following occur:

1. The desire to universally identify each Frequency Modulation (FM) programme; this created the PI and Programme Service (PS) features.
2. The desire to identify broadcasts for motorists more universally than ARI; this created the Traffic Programme (TP) and Traffic Announcement (TA) features.
3. The desire to hand over a mobile receiver within a network; this created the Alternative Frequencies (AF) feature.
4. The desire to identify speech and music and programme types; this created the Music Speech (MS) and Programme Type (PTY) feature.
5. The desire to maintain radio paging within the data broadcast as it was already implemented in Sweden; this created the Radio Paging (RP) feature.

A system was now designed and available for the mobile listener, who had needed help with in-car reception of FM for the various reasons already established by audience research; namely, automatic retuning from one transmission coverage area to the next area and so on. The system also provided an emulation of the ARI system used in Austria, Germany, Luxembourg, and Switzerland that alerted drivers to traffic announcements. Many other features were proposed and built into the RDS system to be dynamically multiplexed as needed in each transmission. The key mechanisms were designed for mobile reception and a group/block data format to ensure very fast data synchronisation and decoding of certain features, while allowing some features to be conveyed at a slow rate for general information. Since the system design was developed by broadcasters working in the well-regulated environment of the 1970s, a number of features were considered but not fully developed at that time. However, their far-reaching decisions regarding future enhancements has allowed RDS to mature over the years.

In 1985, EUROTECH agreed with the EBU about the general introduction of RDS and promised, on the condition that the EBU would give their support towards the development of the RDS-Traffic Message Channel (RDS-TMC) feature (see Chapter 7), that the first RDS receivers would be presented at the international consumer electronics show, IFA'87, in Berlin. From 1988 on, these receivers would be marketed in all those countries where RDS was already introduced.

Given the fact that the RDS development was so well coordinated by the EBU, broadcasters in all European countries, through this activity, were fully aware of the benefits created for their listeners (some said they could now surf the radio waves). The introduction of RDS throughout Europe happened fast—so fast, indeed, that some then called it the "silent revolution" [10–15]. Figure 1.4 illustrates the high FM spectrum occupation which makes RDS necessary.

Broadcasters started to implement RDS transmissions with a mixture of self built RDS encoders, which led to the growth of a small, specialised professional equipment market selling RDS encoders and associated RDS monitoring equipment. The earliest implementations were undertaken by some large network broadcasters, and they selected just a few RDS features to start their trials and preservice activities. Within a couple of years, some problems had come to light as these initial transmissions began to give evidence that the original standard was somewhat lacking when real-world situations were faced.

In 1988, the BBC officially launched RDS. Johnny Beerling, chairman of the EBU Programme RDS Experts Group and cochairman of the RDS Forum, remains a strong supporter of RDS. Figure 1.5 shows Beerling at the BBC opening ceremony.

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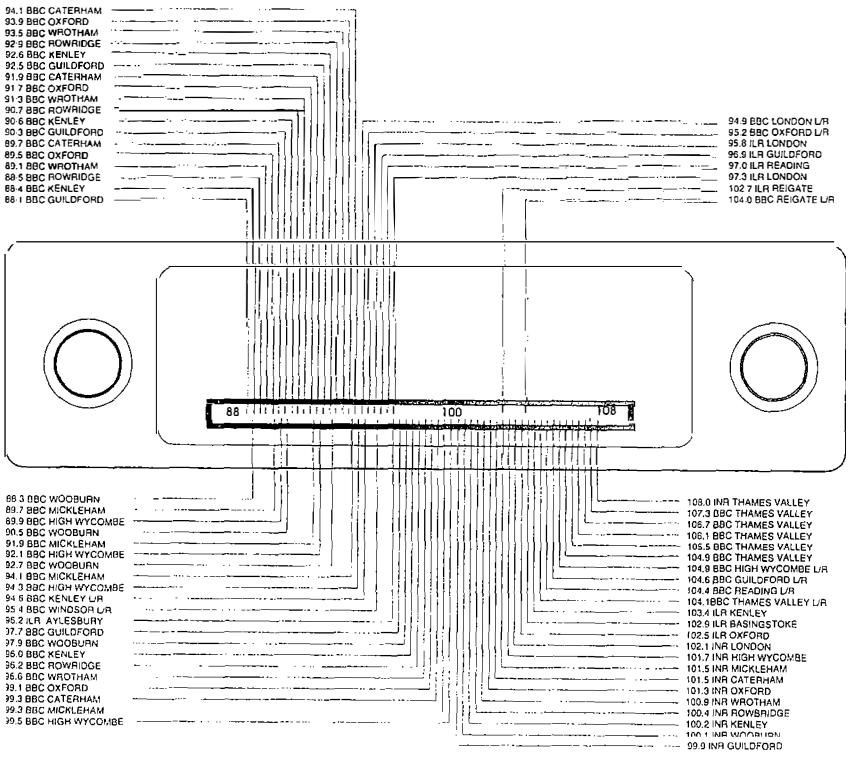


Figure 1.4 Why RDS was needed is clearly demonstrated by the high FM spectrum occupation, as this example from London shows. (*Source:* EBU.)

In 1988–89, when receivers were ready to conquer the European market, RDS was already on-air over most of Western Europe.

Table 1.1 displays the historical development of RDS.

1.4 Evolution of the RDS Standards

1.4.1 Europe

1.4.1.1 EBU

The first RDS standard was published in March 1984. It was titled "EBU Tech 3244: Specifications of the Radio Data System RDS for VHF/FM sound

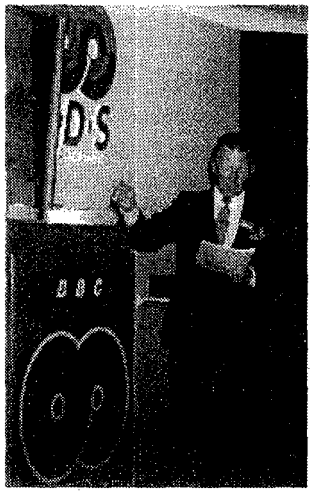


Figure 1.5 Johnny Beerling at the BBC opening ceremony in 1988. (*Source:* BBC.)

Table 1.1
History of RDS Development

1975	Pre-development start
1980	First field trial at Bern/Interlaken, Switzerland
1982	Test start in Stockholm, Sweden Evaluation of eight systems in Helsinki, Finland RDS baseband coding agreed Second field trial at Bern/Interlaken
1983	Industry/broadcasters meeting at EBU Joint industry/broadcaster field trial in Munich, Germany RDS adopted by EBU and industry—submitted to CCIR
1984	First presentation of RDS in Detroit, MI, USA Ford starts RDS car radio development in Detroit RDS specification EBU 3244 published
1985	Large scale pre-operational trial in Germany EBU recommends RDS introduction Industry/broadcasters agree first receivers target from 1987
1986	First presentation of RDS at NAB Dallas, TX, US RDS CCIR Recommendation published
1987	Ireland, France and Sweden introduce RDS First RDS receivers shown at IFA Berlin, Germany Volvo markets the world's first RDS car radio

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Table 1.1 (continued)

1988	Austria , Belgium, Denmark, Germany, Italy and the United Kingdom introduce RDS Blaupunkt, Grundig and Philips mass produce RDS car radios
1989	RDS enhancements: EON developed and tested in the UK Norway, The Netherlands, Portugal and Switzerland introduce RDS Presentation of RDS in Washington DC and NAB Las Vegas, NV, US
1990	First presentation of RDS at BroadcastAsia in Singapore and in South Africa CENELEC adopts RDS as the European standard EN 50067
1991	First RDS-EON receivers shown at IFA Berlin First presentation of RDS in China RDS presentation in New Orleans, LA to US Public Radio Hong Kong introduces RDS
1992	New version of CENELEC RDS standard published South Africa introduces RDS USA: EIA/NAB RBDS standard completed which includes RDS
1993	RDS Forum created to promote RDS implementation Grundig: presents at IFA Berlin first portable RDS receiver
1994	European Commission recommends RDS-TMC for Trans-European Road Network First European DGPS implementation in Sweden Universal encoder communication protocol enhanced
1995	RDS Paging Association created EIA activates RDS promotion in the United States First RDS Forum meeting in the United States
1996	RDS Forum enhances RDS CENELEC standard NRSC in the United States agrees with RDS Forum to harmonize RBDS and RDS
1997	New RDS CENELEC standard submitted to vote New RBDS NAB/EIA US voluntary standard submitted to vote UECP enhanced to conform with new RDS CENELEC standard Germany - first country to introduce RDS-TMC

broadcasting," and it contained some 14 different RDS features, as shown in Table 1.2 [27].

It is very illuminating to realise how the publication of a very technical and specific niche standard (notice how it was called a "specification") can affect all of us, as consumers, for evermore. It is calculated that there are now some 50 million RDS receivers worldwide in the hands of consumers by the end of 1997, and a very high proportion of those use abbreviations like AF, TA, and TP, for example, on their front panels or in their displays. Did the standards writers realise the impact their work would have? These abbreviations we

Table 1.2
List of RDS Features Defined in the Original EBU Specification in 1984

EBU Tech 3244 – Features	Abbreviation
List of Alternative Frequencies	AF
Clock Time and date	CT
Decoder Identification	DI
In-House applications	IH
Music Speech switch	MS
Information concerning Other Networks	ON
Programme Identification	PI
Programme Item Number	PIN
Programme Service Name	PS
Programme TYpe	PTY
RadioText	RT
Traffic-Announcement identification	TA
Transparent Data Channel	TDC
Traffic-Programme identification	TP

now live with do not appear to be very user friendly, and most consumers have been subjected to them not knowing their origins. This is indeed a lesson for all designers to consider very carefully for future broadcast systems: The laboratory quick-fit naming solutions need careful consideration for long-term user friendliness. However, the RDS designers were indeed very far sighted technically, as we shall see later.

It is true to say that up until 1984, not too many receiver designers had considered RDS, because this standard came from the research laboratories of broadcasters and not from commercial receiver manufacturers. But that situation changed, and the commercial receiver companies soon realised the benefits that RDS had been designed to bring to the broadcasters' listeners and to their future customers. Within a year, development work was being undertaken in both Europe and elsewhere, and the first RDS receiver came from a car company, Volvo. Volvo was anxious to improve car safety through the introduction of several automatic features that an RDS receiver could provide. Figure 1.6 depicts Volvo's worldwide commercial RDS car radio in 1987. Of course, almost all well-known commercial car receiver companies now produce RDS

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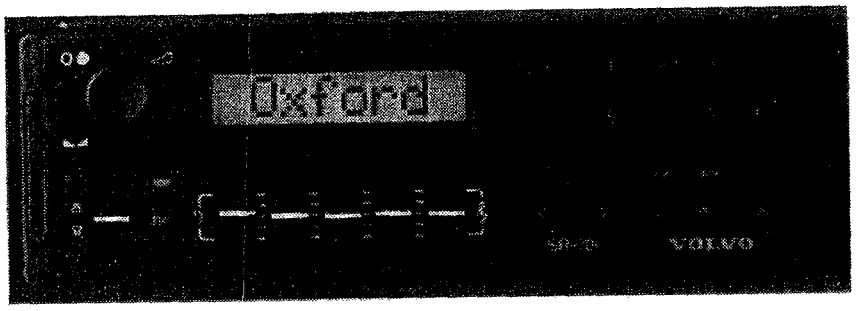


Figure 1.6 In 1987, the Volvo 701 first commercial RDS car radio in the world. (*Source:* Volvo.)

receivers, and this came about because the broadcast sector was also committed to RDS and started to introduce RDS transmissions across Europe.

Between 1984 and 1989, four supplements to the original specification were issued, covering the following areas:

- Alternative Frequencies: methods A and B;
- Radio Paging;
- Programme TYpe code definitions;
- Enhanced Other Networks.

With the perspective of that era, there is no doubt that the EON development was a major change to the standard, which had come about from the joint efforts of broadcasters and receiver designers attempting to implement a system that allowed signalling from one network belonging to a broadcaster to another network of the same broadcaster. Experience had shown that the ON mechanism of the original standard just did not work!

After much thought, at an EBU meeting held in July 1987 and a number of subsequent meetings to distill the details, several new concepts were developed, including EON, which could give a receiver a full "picture" of a broadcaster's networks over a two-minute period. Then, dynamic signalling could vector a receiver to specific services as needed; for example, a travel bulletin could be received from another transmission in the area of reception. By common consent, BBC Radio agreed to become the field test site for these techniques, and implemented EON during 1988 with signalling associated to five local radio services and referenced by the BBC Radio networks. That trial was very successful and the United Kingdom became a continuing test site for many RDS receiver designers from all over the world. These designers came to

test their software implementations of EON for second-generation RDS receivers.

Over the years, RDS has also attracted a number of different RDS encoder manufacturers. Originally, each chose a communications protocol for use between studio and transmitter site where the RDS encoders are installed to achieve dynamic control of the transmitted RDS data. Initially, this aspect of RDS escaped the standardised approach to RDS, perhaps because the manufacturers efficiently satisfied their client broadcasters and very few initially requested dynamic control. But gradually, the need for features such as TA flag control—and more recently, the PTY feature and RadioText, which have recently been more and more frequently implemented in RDS receivers—have shown that broadcasters definitely need dynamic control. What is more, because over time they have wished to purchase RDS encoders from several sources, the need for a standardised protocol became evident.

Under the auspices of the EBU, many major RDS encoder manufacturers have cooperated to develop the Universal Encoder Communications Protocol (UECP, see Chapter 11), which is now managed and maintained by the RDS Forum. During 1997, it reached version 5.1, published as SPB 490. This protocol, now briefly called the UECP, allows broadcasters to specify associated network servers and RDS control systems that will use a common data format, which will then enable easy installation with existing RDS encoders. Over time, the UECP was gradually upgraded as the transmission standard required. Normally, this has been carried out approximately yearly, with the information and the UECP specification circulated to all members of the RDS Forum, since the RDS encoder manufacturers are nearly all members and the overhead costs of a public standard would be too great for this very small niche market to sustain [16].

1.4.1.2 CENELEC

With significant development work going on in European industrial manufacturing companies, it became clear that a better recognised standard would serve well to publicise the RDS system and ensure consistent design activity in the diverse organisations working on RDS products. So, in 1988, the technical committee TC 107 (now TC 207) of the European Committee for Electrotechnical Standardisation, CENELEC, began (in close cooperation with the EBU) to transcribe EBU Tech 3244 and the four supplements mentioned above into a European standard, EN 50067. This was published in December 1990, and took over as the definitive standard for Europe.

EN 50067, published in 1990, became the "solid rock" that the RDS system needed, both from a broadcaster's standpoint to ensure reliable transmissions and also from the RDS receiver designer's point of view. Both these

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parties required the RDS standard to link them together and give each the certainty that RDS would indeed give the radio user the assistance that RDS had promised nearly 10 years before.

So, here was the first significant demonstration that the original development of the RDS specification had been given future-proofing, as the additional features in the four supplements could be added quite easily and allow continued development of both the transmission equipment and RDS receivers.

Nevertheless, standards also require stability to allow development time, and the issue of EN 50067:1990, with endorsement from both the broadcast and the manufacturing sectors, promised this time in the future. But, of course, Europe could not now keep RDS to itself. Already some broadcasters from other parts of the world had noticed what RDS could do. Notably, broadcasters in two very diverse countries—Hong Kong and South Africa—started to negotiate for RDS technology. They were prepared to invest in RDS to eventually promote the technology to both their customers (the listeners) and to the RDS receiver suppliers. In the absence of a worldwide standard for RDS they naturally opted for RDS implementations using EN 50067:1990, especially because the consumer manufacturers could only offer products manufactured for that standard. In both of these cases, the broadcasters had similar structures to those already found in Europe, so the RDS standard requirements fit their networks well and virtually no adaptation was forced upon them.

If a standard has been well designed, additions to it will offer enhancements that the industry and the consumer alike will want. However, the timing of such enhancements has to be considered carefully to ensure that the revised standard does not destabilise the marketplace. Accordingly, the EBU issued SPB 482, which proposed certain enhancements to EN 50067:1990. These enhancements were made to clarify, to a greater level of detail, certain coding issues that had become necessary. That work was ready for the next issue of the standard and completed well in advance of the marketplace actually needing the items that were standardised. This was to prove valuable in the developments that were taking place in the United States. In effect, parallel discussion proceeded over the next 24 months or so, and EN 50067:1992 was issued in April of that year. It just missed the work of another small EBU group who had developed PI codes and extended country code (ECC) proposals for the worldwide implementation of RDS, and their output was published in August 1992 by the EBU as SPB 485 (revised in 1992) covering allocation of country/area identification codes in RDS [17,18].

In the meantime, CENELEC EN 50067:1992 has been much upgraded. The new revised text, which was first published in September 1996 by CENELEC, was prepared by the RDS Forum in close collaboration with the

CENELEC technical committee 207 with full involvement of experts from the EBU. Certain elements of text were revised in accordance with experience gained from the RDS system and changes in broadcasting practise since the initial specification was published. An interesting example are the new clauses relating to the PS feature.

The Open Data Application (ODA) has been added as a new feature to permit a flexible extension of RDS to still undefined applications. Furthermore, cross-references were made to the Comité Européen de Normalisation (CEN) standards, defining the RDS-TMC feature.

Receivers produced in accordance with the new specification will, of course, be compatible with RDS broadcasts, which conform to previous editions of the RDS specification.

The resulting new European standard, EN 50067:1998, replaced from April 1998 onwards the old EN 50067:1992, and all earlier versions as well. The differences between the new and the old standard versions are summarised in Table 1.3 [19–22]. Table 1.4 lists the RDS features in upgraded RDS/RBDS standards.

Table 1.3
Comparison Between the New and the Old CENELEC RDS Standards

New: CENELEC EN 50067:1998			**Old: CENELEC EN 50067:1992**	
Section	Additions/Modifications	Page	Section	Page
0. Scope	Extended	6	0. Scope	6
1. Modulation characteristics of the data channel	Unchanged	6–11	1. Modulation characteristics of the data channel	6–11
2. Baseband coding	Unchanged	12–14	2. Baseband coding	12–14
3. Message format	PS usage explicitly restricted to programme service label	15–53	3. Message format	15–49
	ODA added			
	TMC standard references added			
	Static/Dynamic PTY flag added			
	PTYN added			
	RP transferred to Annex M			
4. Description of features	Extended	54–57	4. Glossary of terms of applications	50–53
5. Marking	Unchanged	57	5. Marking	54

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Table 1.3 (continued)

New: CENELEC EN 50067:1998			Old: CENELEC EN 50067:1992	
Section	Additions/Modifications	Page	Section	Page
Annex-A: offset words	Extended	59	Annex-A: offset words	55
Annex B: modified shortened cyclic code	Unchanged	60–65	Annex B: modified shortened cyclic code	56–61
Annex C: group and block synchronisation	Unchanged	66–68	Annex C: group and block synchronisation	62–64
Annex D: PI and ECC codes	Updated	69–72	Annex D: PI and ECC codes	65–70
Annex E: character definitions	Introduction modified Character tables unchanged	73–76	Annex E: character definitions	71–74
Annex F: PTY codes	Modification and 15 new codes added	77–80	Annex F: PTY codes	75–77
Annex G: time and date conversions	Unchanged	81–82	Annex G: time and date conversions	78–79
Annex H: ARI system	Unchanged	83	Annex H: ARI system	80
Annex J: language identification	New	84–85		
Annex K: RDS logo	RDS-EON logos added	86	Annex K: RDS logo	82
Annex L: Open Data registration	New	87–89		
Annex M: Radio Paging	Extended with enhanced paging	90–125		
Annex N: world-wide country codes	New	126–130		
Annex P: abbreviations	Updated	131	Annex J: abbreviations	81
Annex Q: bibliography		132	Annex L bibliography	83

Table 1.4
List of Possible Defined RDS Features in New Upgraded RDS/RBDS Standards

Code	Name	Function	Description
PI	Programme Identification	Tuning	16-bit code giving a unique serial number to a programme service
PS	Programme Service name	Tuning	You see what you hear An 8-character label of the programme service, e.g. "Radio 21"
AF	Alternative Frequencies	Tuning	List of other frequencies carrying the same or a related programme service
TP	Traffic Programme identification	Tuning	1-bit flag indicating of whether this programme service will carry traffic announcements
TA	Traffic Announcement identification	Switching	An on/off signal to indicate when a traffic announcement is on air
PTY	Programme TYpe identification	Radio programme related	Identifies from a list of 31 possibilities the current programme type, e.g. "News" or "Sport"
PTYN	Programme TYpe Name	Radio programme related	8-character label to indicate a more specific programme type, e.g. PTY = 4: "Sport", PTYN: "Football"
EON	Enhanced Other Network information	Tuning / switching	Provides a cross-reference to PI, PS, AF, PTY for vectorised switching to other programme services, usually operated by the same broadcaster
CT	Clock Time and date	Time reference	Universal time code with local offset and modified Julian date
RT	RadioText	Radio programme related	Text of max. 64 characters for display
PIN	Programme Item Number	Radio programme related	Scheduled start time and date for an individual programme
M/S	Music Speech code	Radio programme related	1-bit flag to indicate music or speech, e.g. for separate volume controls
DI	Decoder Identification	Radio programme related	4-bit code to indicate mono, stereo and other possibilities
TMC	Traffic Message Channel	Radio data service	Coded predetermined traffic messages for output in various languages

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Table 1.4 (continued)

Code	Name	Function	Description
ODA	Open Data Application	Radio data service	Open or encrypted service permitting to implement any possible function as given RDS capacity would permit
IH	In-House applications	Radio data service	Data which are used by the broadcaster or network operator
TDC	Transparent Data Channel	Radio data service	Unformatted text or data in 32 possible channels
RP	Basic Radio Paging and enhanced paging	Radio data service	Paging service using FM broadcasts as the transport mechanism
EWS	Emergency Warning System	Radio data service	Provides for the coding of warning messages
ECC	Extended Country Code	Tuning	Extends the 16 possible PI country codes to a unique country identifier
	Linkage	Tuning	A flag with a PI reference carried within EON of another programme service to which the tuned programme will be or is already linked

1.4.1.3 CEN

In the mid-1980s, the EBU RDS experts were prompted by European car radio manufacturers, and EUROTECH in particular, to consider an RDS feature that was quickly given the name Traffic Message Channel (TMC). Indeed, by the time EN 50067:1992 was published, TMC had the RDS group type 8A allocated. This feature was soon recognised by traffic management experts in Europe as a potentially very valuable feature since it permitted the delivery of coded traffic messages which, in-car, could be interpreted in a driver's native language regardless of the visited country. This was a simple idea but, unfortunately, many complex issues were associated with this feature and the European Commission has funded much research into the application.

In this process, many new standards were developed about messages, dictionaries for all the languages needed, and the management issues concerning these elements. The coding of RDS-TMC has been undertaken by many workers, coordinated by CEN TC 278. Field trials in the mid-1990s showed that RDS-TMC will work well, but significant infrastructure requirements will be needed to implement RDS-TMC fully across Europe, and this phase is now just beginning. Chapter 7 deals with all these issues in much more detail.

1.4.2 United States

In 1990, discussions started about standardising RDS for the United States under the auspices of the National Association of Broadcasters (NAB), and the National Radio Standards Committee (NRSC) was asked to form a subcommittee to report on the possibilities.

In the U.S. radio environment, radio networks and relay transmitters, or transposers as they are called in the United States, are more infrequently found, which is quite different from Europe. So, RDS clearly needed some adaptation. But the NRSC subcommittee, which had elected to call the American standard "Radio Broadcast Data System (RBDS)," realised that RDS would be more quickly implemented in the United States if core aspects of both systems were shared, because RDS knowledge, RDS encoders, and RDS receivers were all readily available. Indeed, the subcommittee that worked on RBDS standardisation even wished for as much harmonisation as they could achieve.

Apart from a few new features, the RBDS standard required special interpretation of two of the existing features. Firstly, the PI code structure of EN 50067:1990 was unsuited to the different regulation of radio stations in the United States, where "call letters" are the only centralised data that can be relied upon. Thus, a clever algorithm was developed to allow conversion of call letters into a unique PI code so that existing RDS encoders and RDS receivers could use this PI code without any problem. The reason for this approach was that one wanted to avoid the need for a federal organisation to be charged with administering PI codes for RBDS implementation. Secondly, the U.S.-specific programme format of radio stations needed a new list of PTY codes since PTY codes for Europe were quite inappropriate. Thus, a different set of PTY codes was developed for the United States. The other significant demonstration was that RDS could largely be compatibly upgraded as time progressed and new ideas were required.

Generally, it was thought that RDS receivers could now be used anywhere in the world, provided the ECC feature was used to uniquely designate a country. The original RDS specification had only considered countries that were members of the EBU; now, expansion to the whole world became a distinct necessity.

In the United States, the RBDS specification was adopted in January 1993 as a voluntary national standard, jointly issued by the EIA and the NAB. As explained above, this standard includes as its major component the RDS

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system, and European receivers could easily be modified for use in the United States. In the large majority of cases, they would even work well unmodified, especially with the five basic features: PI, PS, AF, TP and TA [23].

The differences between RBDS and RDS are explained in greater detail in Chapter 2. Simultaneously, as the European RDS standard was upgraded in the years 1995–97, an upgraded RBDS specification was completed by the end of 1997 within the National Radio Systems Committee (NRSC), which is jointly sponsored by the Electronics Industry Association/Consumer Electronics Manufacturers Association (EIA/CEMA) and the National Association of Broadcasters (NAB) [24].

RBDS was now drawn up with the view to harmonise, to the largest extent possible, the RBDS specification with the RDS features most recently specified in Europe in the EN 500067:1998.

In the United States since about 1995, RBDS is only the name for the American standard. When implemented in receivers, the system has been called RDS, as it is anywhere else in the world. RDS in the United States is identified with the same logo as specified in the European CENELEC standard, which is the same as was once developed for the EBU by the BBC.

1.5 System Maintenance and Promotion

While successful standards are in use by the few people who helped develop them, all is likely to be well because they know what they intended when drafting the documents! But once a wider group of users has a need for a standard, the intentions that are not specified fully or well, can be misunderstood or misinterpreted. Furthermore, field experience of implementing standards tends to throw up many new issues.

Recognising a need for more information about RDS, the EBU published the document, "Tech 3260, Guidelines for the implementation of the RDS system," which was intended to encapsulate and transfer some of that knowledge to other workers in RDS technology before it was lost [25].

With all the developments that have taken place over recent years, it is now necessary to prepare another edition of the RDS guidelines document, and the RDS Forum proposes to undertake that work with the support of many workers in the RDS field. It will have a slightly differently focus as to implementations and the system approach needed to achieve a full set of RDS services, including non-programme-related data services multiplexed with radio programme-related data services, and the commercial and technical issues associated with managing and billing in such a system.

1.5.1 RDS Forum: a Worldwide Association of RDS Users

The RDS Forum has existed since 1993. Membership is open to all professionals involved in using RDS technology. The RDS Forum has held two plenary meetings per year, and a large proportion of the more than 100 members worldwide attend.

In 1997, the RDS Forum had four working groups concerned with maintaining the RDS standard, developing accepted guidelines for RDS system operation, upgrading the Universal Encoder Communications Protocol (UECP), and dealing with RDS/DAB cross-referencing together with the objective of implementing plans for DAB transmissions and receivers that offer a compatible user interface.

The operational expenses of the association are shared among all the membership. Members pay an annual fee for each registered representative. More detailed information about the RDS Forum is available on the Internet.

The Internet address for the RDS Forum Web site is: www.rds.org.uk.

1.5.2 The United States: NAB and EIA/CEMA

RDS is promoted in the United States through the National Association of Broadcasters (NAB) and the Consumer Electronic Manufacturers Association (CEMA), a branch of the Electronics Industry Association (EIA). Both the NAB and CEMA organise very significant annual conventions, with a major technical exhibition where RDS technology is presented at various occasions. The EBU was also invited to participate in these presentations. In addition, both the NAB and CEMA participate in the RDS Forum, which is coordinated by the EBU. Hence, there is a continuous exchange of experiences with regard to the implementation of RDS in Europe and the United States.

CEMA sponsored an RDS promotional effort in 1995–96. While there are some 5,000 FM radio stations operating in the United States, after that campaign, 750 of them had RDS implemented. The campaign concentrated on the 26 metropolitan areas with the largest population in the United States and was aimed at raising the awareness of radio broadcasters about RDS. At the same time, the NAB published a 98-page booklet explaining RDS applications to broadcasters [26].

One particular problem that existed at that time in the United States was that there were not many RDS receivers on the market, and therefore dealers and consumers were largely unaware of RDS and what benefits it could offer. In addition, many broadcast station owners were confused about RDS because the NAB was of the opinion that the United States needed a high-speed data

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system (HSDS) on a subcarrier around 76 kHz, in addition to RDS. Many broadcasters understood that this was because RDS had too many limitations (670 usable bits per second versus 10-16 kbps) with respect to the number of additional data services that it could support. They also thought that once agreement was reached about a high-speed data system, this would make RDS redundant. But this is a misperception, since the HSDS subcommittee of the National Radio Systems Committee (NRSC) is seeking a system that is complementary to RDS, in full recognition of the RBDS voluntary industry standard. Figure 1.7 depicts the RDS promotional event sponsored in 1989 by the NAB. This major U.S. convention is where the EBU helped to promote RDS in the United States.

Promotion of the RDS technology in the United States is further initiated through the RDS Advisory Group, a kind of counterpart to the European RDS Forum but without the task to coordinate the further development of the RDS technology. The RDS Advisory Group is an institution of CEMA. Membership is open to all manufacturers, broadcasters, and data service providers interested in the RDS technology. There is no membership fee to be paid and

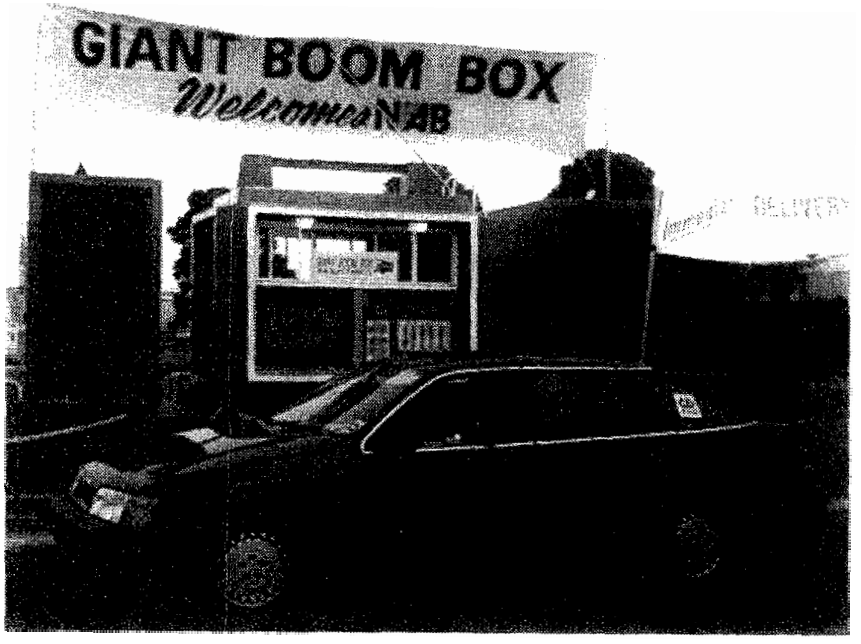


Figure 1.7 NAB'89 (*Source:* EBU.)

meetings take place during major conventions (on average, four times a year). A quarterly newsletter distributed through CEMA and NAB provides updates on new developments and products in the U.S. market. The activity is financed through voluntary contributions from interested consumer electronic manufacturers. The companies that were most active in the years 1995–97 were Delco, Denon, and Pioneer.

The following Web sites provide more information and updates about RDS in the United States:

- CEMA: www.cemacity.org/rds/
- NAB: www.nab.org./SciTech/

1.6 Usage of RDS Worldwide

1.6.1 Europe

RDS is widely implemented in Europe. Details of the features used can be found in Appendix J.

At the end of 1997, the situation was generally as follows. The basic features PI, PS, and AF (and when applicable, TP and TA) are used by almost all networks and local stations in all countries. Initially, broadcasters using networks had problems implementing radio programme-dependent RDS features, one reason being that there were generally no data links between the studios and the RDS encoders on the transmitter sites that could be used to transport the information.

Nowadays, this situation is changing. Audio links between the broadcasting house and the transmitters have become increasingly digital, and on the radio programme side, the new possibilities of digital radio and radio on the Internet require the radio programme makers to turn their interest towards the future and use the new multimedia. This creates ideal conditions for RDS to have dynamic PTY and RadioText (RT) implemented. The same is also true for MS.

RDS-TMC, a new feature in 1997, is now being more widely used. The driving force behind this is the transport sector of the European Commission and the European Conference of the Ministers of Transport (ECMT). Details about its implementation are given in Chapter 7.

Radio paging (RP) via RDS is used in a number of European countries, but the increasing success of the Global System for Mobile Communications (GSM) mobile telephone services make this less and less interesting. France is

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still the country where RDS Radio Paging (RP) is most important, but other pockets of RP can be found elsewhere and are still developing.

The Emergency Warning System (EWS) was considered in a number of European countries, but a number of alternative technologies are already in place, so this feature is generally not used. In the United States, there is a much greater interest in using this feature.

The Differential Global Positioning System (DGPS) via ODA is being considered in a number of countries, and these services are already or will soon be operational in Germany, Sweden, and the United Kingdom. However, the system specifications being used are not the same. In Germany, the service will be open, and in the other countries, it is encrypted and a subscription is required by the end user.

1.6.2 The Special Case of Central and East European Countries

The RDS standard CENELEC EN 50067:1998 is restricted to FM Band II (87.5–108 MHz), but in Central and Eastern Europe, FM Band I (65–74 MHz) is also in use. In these countries, FM broadcasting occurs now in both bands; formerly, it was in band I only. In principle, RDS would be feasible in Band I as well, but the necessary AF codes are not defined—neither for Band I nor for any cross-referencing between bands I and II.

A decision was made in the RDS Forum not to provide further support for development of RDS for Band I. This was done to encourage the transfer of radio services operating in Band I to Band II, with the view of harmonising the use of band II for Eastern Europe in the same way as it is used in Western Europe. It was also recommended by the RDS Forum that broadcasting information for motorists should only be implemented in Band II so that RDS-TMC could then become available everywhere in Europe within the same frequency band.

RDS is already used in a number of Central and Eastern European countries, but nowhere yet is it generally implemented on all band II FM stations or networks. Often, the reason for using RDS is the desire to operate an RDS paging service and/or a subscription service for DGPS; where this is the case, the basic RDS features required for tuning, such as PI, PS, and AF, are also implemented.

1.6.3 United States/Canada/Mexico

The people involved in the making of the RBDS standard for the United States generally hold the view that this standard will apply to the whole of North America, the reason being that this is one and the same market for technology.

Officially, this is not yet confirmed. The RBDS standard was made by the U.S. NRSC with this objective in mind, and it is indeed very likely that the market will, in fact, react in this way.

As already described above, only 15% of all U.S. radio stations used RDS by the end of 1997. The main reason was that up until now, there were only a few RDS receivers in the retail shops and dealers and consumers were largely unaware of benefits that RDS could offer to them. This situation is likely to change, and the RDS Advisory Group is active for just this very simple reason. Now, there is greater awareness among the car makers in America about the benefits that RDS can offer to a car radio, and many 1998/99 car models will be equipped with RDS radios for the first time.

RDS-TMC is being tested in some areas of the United States (Arizona, Minneapolis/St. Paul, and a few others), but there is no decision yet to use this technology because it is also thought that a high-speed data system (HSDS) may offer superior technical possibilities. The only drawback is that there are no system standards yet adopted, but the NRSC and also ISO TC 204 remain attentive and are prepared to do some standardisation work on this issue.

1.6.4 Other Countries

RDS is being used in a large number of countries all over the world, and usually these countries use the European CENELEC standard since a world standard for RDS does not yet exist. However, the CENELEC standard already has a large number of hooks that permit countries outside Europe to use this standard without modifying it. For example, the EN 50067:1998 contains an annex with the Extended Country Codes for all countries in the world (see Appendix G). In addition, the character tables specified in one of the annexes support many non-European languages. In certain cases, however, new character tables need to be developed. In such a case, the CENELEC standard is not entirely applicable and needs some modification. Some of the countries concerned are already considering creating a special national standard for themselves. This is the case in China, India, and South Korea.

So far, Japan is likely to remain among those countries where RDS will not be implemented. There are a number of reasons for this. The FM band has a different frequency range, so the AF section of the RDS standard cannot be applied without modification. Also, FM broadcasting doesn't generally have the same importance for radio listeners there as in other countries in the world, because a lot of radio listening still takes place on AM. In addition, there is the belief that because Japan has adopted the data radio channel (DARC) standard (which is compatible with RDS and could well be used in parallel), RDS is completely unnecessary there. This position is particularly true for the Japanese

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telecommunication authorities. However, disproving this belief is the Japanese consumer electronics industry, which makes and continues to make RDS receivers by the millions for the rest of the world. Thus, one could well imagine that these Japanese manufacturers would be quite happy for RDS to also be used in their own country. The real reason that it is not, is a kind of internal policy issue, which certainly is of no interest whatsoever to the rest of the world.

1.7 System Characteristics

1.7.1 Choice of Modulation Parameters

RDS development started with a number of functional requirements that had to be fulfilled. These are as follows:

1. The radio data signals must be compatible; they must not cause interference to the reception of sound programme signals on existing receivers or to the operation of receivers that use the ARI system.
2. The data signals must be capable of being reliably received within a coverage area as great as that of the monophonic main programme signal.
3. The usable data rate provided by the data channel should support the basic requirements of station and Programme Identification, and provide scope for future developments.
4. The message format should be flexible to allow the message content to be tailored to meet the needs of individual broadcasters at any given time.
5. The system should be capable of being reliably received on low-cost receivers.

These requirements have significantly influenced the choice of the modulation parameters and the baseband coding characteristics.

Figure 1.8 depicts the multiplex spectrum of a stereophonic FM broadcast signal with the small signal level RDS signal centred around the 57 kHz subcarrier, which is the third harmonic of the 19 kHz pilot tone of the stereophonic modulation system. This choice of subcarrier was critical for meeting the requirement to minimise data signal interference to the audio channels for existing receivers. The other parameter that is critical to achieve the same goal is

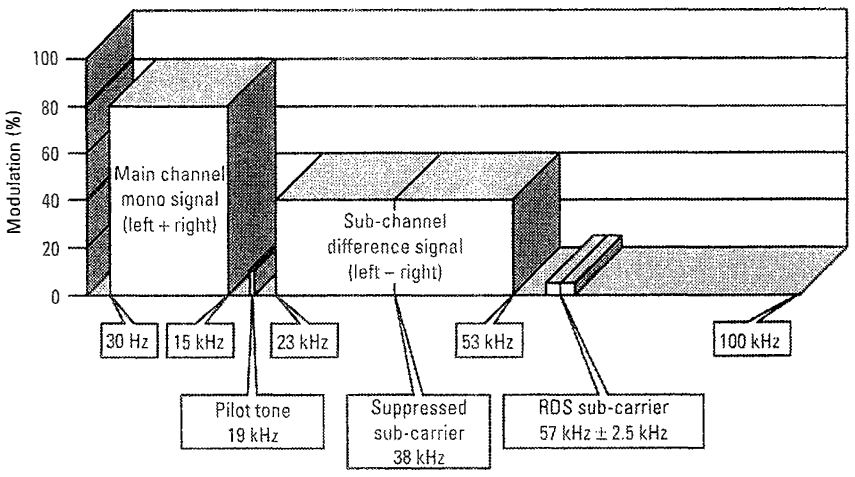


Figure 1.8 Spectrum of a pilot-tone stereo multiplex signal with RDS. (*Source:* EBU.)

the injection level of the data. The higher it is, the more rugged the data service is; however, under multipath conditions, the interference to the audio channels will also increase. It was found in field trials that a minimum was ±1 kHz, and a reasonable operational choice was ±2 kHz. At these levels, there usually is virtually no detectable interference from the data channel during radio listening.

Figure 1.9 depicts the RDS data spectrum in greater detail. As you can see, the spectrum is shaped so as not to interfere with the ARI signals. These use the 57 kHz subcarrier and some additional low frequencies close to the ARI subcarrier to provide amplitude-modulated status and area signalling. As already stated, RDS uses a modulation scheme that was initially developed for the Swedish MBS paging system and that uses a double sideband amplitude-modulated suppressed 57 kHz subcarrier and biphase (sometimes also called "Manchester") coding of the data. The effect of such coding and modulation is to produce a notched spectrum, as is shown in Figure 1.9, so that ARI remains largely unaffected by RDS. Therefore, the two systems can easily coexist.

The use of the biphase-coded data signal also helps compatibility with the audio programme signal because coherent components at around 57 kHz were found to introduce data-modulated crosstalk in receivers that used a phase-locked loop (PLL) stereo decoder, which is the demodulation technique generally used nowadays.

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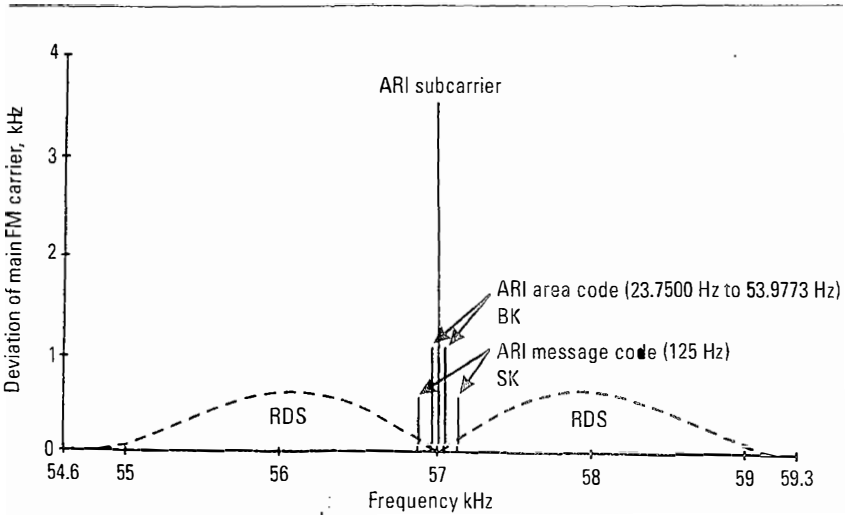


Figure 1.9 Spectra of RDS and ARI signals. (*Source:* EBU.)

The bit rate of the RDS data stream is 1187.5 bits/s (1187.5 = 57,000 / 48) which, with biphase coding and the specified 100% cosine roll-off filtering, gives an overall bandwidth for the data signal of approximately 5 kHz, centred on 57 kHz.

1.7.2 Choice of Baseband Coding

Multipath in an FM system produces distortion of the demodulated signal. The distortion components resulting from the relatively large amplitude sound programme signal components can easily swamp the data signal. When a vehicle moves along a road characterised by multipath interference, the quality of the received FM signal varies rapidly. At some moments, the demodulated audio programme is distorted; at others, it is completely broken up. The very important lesson learned from the 1980 and 1982 field trials in the Bern/Interlaken area was that reliable mobile reception is only possible when the radio data message stream is broken up into small independent entities, each of which can be received, decoded, and applied independently of other parts of the data stream. This factor was crucial to the basic design of the RDS system and must be clearly understood for the design of new applications within RDS, such as those that can be carried within the ODA feature [14].

As with many other serial data transmission systems designed for mobile communications, the data stream in RDS had to be partitioned into data groups and blocks. How this is done is depicted in Figure 1.10. The groups

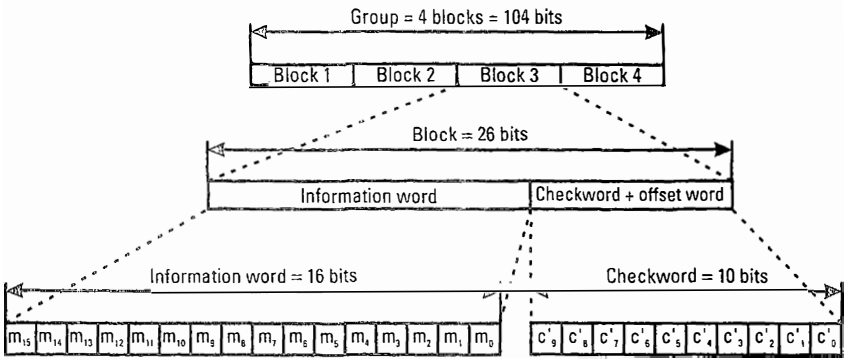


Figure 1.10 Structure of baseband coding of RDS. (*Source:* EBU.)

consist of four blocks, each being 26 bits long. The group thus consists of 104 bits. One block consists of a 16-bit long information word and a 10-bit CRC check word to which is added an offset word that creates the flywheel synchronisation mechanism that makes RDS so rugged under severe multipath receiving conditions.

1.7.3 Message Format and Addressing

Figure 1.11 clearly shows that the RDS coding is structured so that the messages repeated most frequently (and which need a short acquisition time), normally occupy the same fixed positions within a group. This allows decoding without reference to any block outside that contain the information. The first block of each group always contains a PI code, whereas the PTY code and the TP flag occupy fixed positions in block 2 of every group.

The group type code is specified by a 4-bit code that defines the group type (from 0 to 15). This code is sent in the first four bits of the second block of every group. In addition, the fifth bit of this block defines the "version" (A or B) of the group type. In version A groups, the PI code is inserted in block 1 only. In version B, the PI code is inserted in blocks 1 and 3.

Groups are, in general, reserved for a particular application or message type; for example, RT, CT, TMC, and so on.

1.8 Applications of RDS

The Radio Data System permits more than eighteen functions to be implemented. The five most important ones (also called the basic RDS features) are

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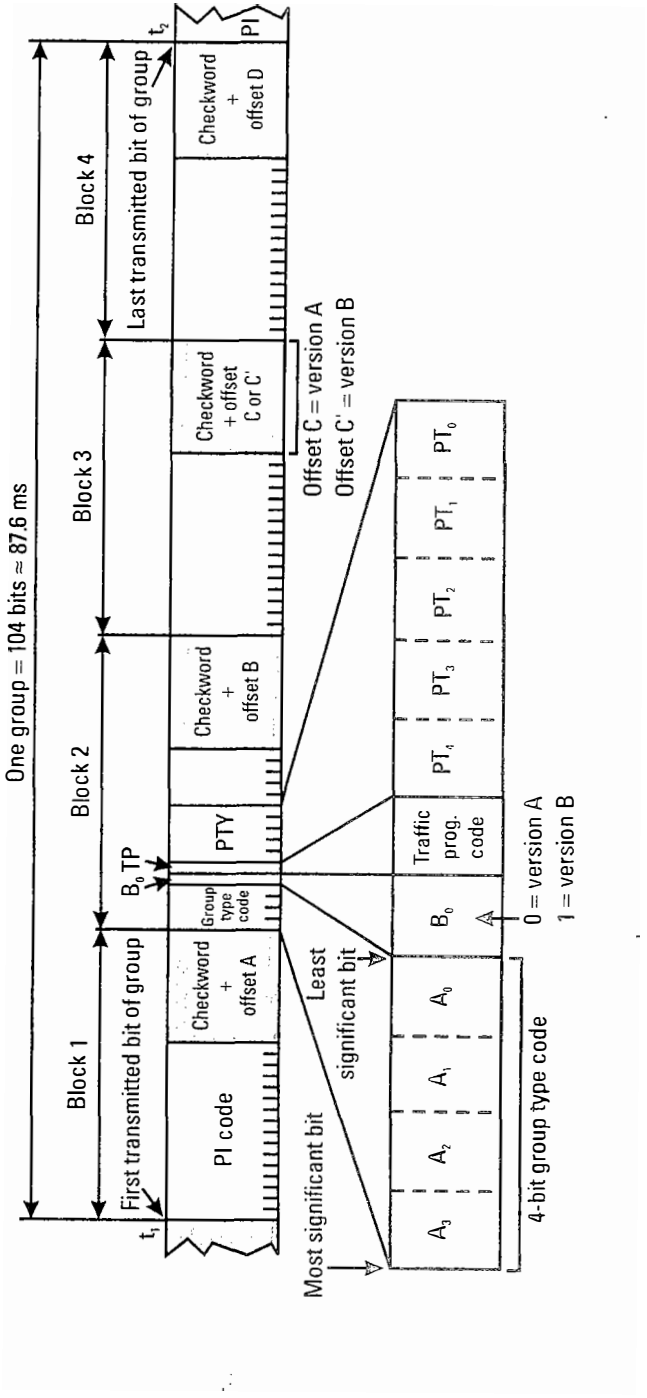


Figure 1.11 Message format and addressing. (*Source:* EBU.)

implemented everywhere and are intended primarily to be used in the mobile reception mode with car radios having automated tuning functions:

- *Programme Identification (PI):* A 16-bit code containing a country symbol, a regional code, and a number permitting the identification of the broadcaster and the particular programme.
- *Programme Service (PS) name:* Comprising eight alphanumeric characters from an uppercase and lowercase character set defined by the EBU, and serving to give the listener information about the name of the programme.
- *Alternative Frequency (AF) lists:* One or more lists can be transmitted, each containing a maximum of 25 frequencies (represented by the corresponding band II channel numbers) of transmitters or rebroadcast transmitters relaying the same programme.

If the programme will contain announcements about local and/or regional traffic situations, the following features should be used to identify this:

- *Traffic Programme (TP) code:* Serving to identify programmes that, from time to time, carry messages addressed to motorists.
- *Traffic Announcement (TA) signal:* Switches a traffic announcement to a preset volume level and, if the motorist is listening to a cassette rather than the radio, stops the cassette and switches the radio on to receive the traffic message instead.

Most of the following other features are optional:

- *Decoder Information (DI):* Indicates one of a number of operating modes for the receiver (e.g., mono, stereo).
- *Music Speech (MS):* A flag indicating whether music or speech is being broadcasted. May be used by the receiver to give independent volume settings of music or speech.
- *Programme TYpe (PTY):* An identification code to be transmitted with each programme item and which is intended to specify the current Programme Type within 31 possibilities. This code could be used for search tuning.

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- *Programme Item Number (PIN):* A code identifying a particular programme (by start time and date) to enable automatic on/off switching of receivers.
- *RadioText (RT):* Either 32 or 64 characters of text for display by receivers.
- *Enhanced Other Networks information (EON):* RDS information relating to other broadcast services. The information includes the PI and AF for quick retuning to the service referenced, TP, TA, PTY, and PIN of these services.
- *Transparent Data Channel (TDC):* Provides for a continuous data stream to receivers and associated peripherals (e.g., printer or home computer).
- *In-House (IH):* A data channel for use only by the broadcaster.
- *Clock Time and date (CT):* A code, usually originated from standard time transmissions, to enable receivers to display the current time and date. This is also used to synchronise various receivers.
- *Radio Paging (RP) and enhanced Radio Paging:* Offers the possibility of mobile pocket pagers with alphanumeric display of messages and alerting bleeps.
- *Emergency Warning System (EWS):* A feature using a very small amount of data for emergency warning services such as national disasters and hazardous chemical spills.

An additional and quite universal feature most recently being developed is:

- *Open Data Application (ODA):* which permits new applications to be designed and implemented in still available data groups with an application identification registration from the EBU or NAB. Interesting examples are differential GPS such as the Rasant system and the control of variable message signs.

1.9 Data Capacity Impact on Applications

Attention is drawn to the fact that the RDS data transmission capacity is rather limited. The system can accommodate only 11.4 data groups per second; that is, only 673 usable information bits per second. This takes into account

that each information word contains 16 bits per block and that the data group has five address bits that are used for the group type identification.

Under no circumstances can one implement all possible RDS features within the same data channel. For a better understanding of these constraints, see Appendix E.

1.10 System Performance and Reliability

Here, we briefly summarise what we consider in greater detail in Appendix C. Field tests carried out by a number of broadcasters' research laboratories all came to the same conclusions.

When signals of the ARI system are broadcast simultaneously with RDS, most first-generation RDS demodulators show some significant degradation of the data transmission reliability, which is due to interference from the ARI signals under multipath receiving conditions. This may be overcome however, by filtering out the ARI signal by means of a notch filter at the RDS demodulator input and an appropriate RDS signal injection level of at least ±2 kHz.

One of the methods used to investigate the reliability of the RDS channel for the transmission of real applications such as PI and PS, which are very important for the operation of the automated tuning function of an RDS receiver, is to measure the "waiting time" between successful acquisitions of a particular RDS message.

Relatively low RDS data injection levels, say ±1 kHz, offer a reliable data system only under receiving conditions with little or no multipath effects (typically towns with flat buildings and flat countryside). In a moving receiver, once multipath effects occur due to reflections of the transmitted signal caused by high-rise buildings or mountains, there is a sharp decrease in the reliability for a correct reception of the applications. It all depends on whether the data is repeated sufficiently often in the data stream. In ODA applications, additional CRC check words may also be considered to better protect the data transmission application that is implemented.

Studies usually confirm the ruggedness of the fixed format PI codes compared, for example, with the variable addressed format of the PS codes. Therefore, consumer receivers often store the PS name, displaying the stored name once the PI code is received. Therefore, the use of the PS name to convey, for example, some limited dynamic text information composed of scrolling text or short words of a maximum of eight characters to the radio listener, is just not admissible.

In cases where Radio Paging is implemented within the RDS data stream, the small antenna used in these special paging receivers and the reliability of

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reception required (which is often within buildings) make an RDS injection level of at least ±4 kHz necessary.

Repetition of message elements transmitted within RDS is also a general requirement. This applies to, for example, RP and TMC messages, but to a lesser degree to RT where the occasional reception of a wrong character will be perceived as less annoying to the reader.

Error detection has to be applied to all messages, and error correction can only be applied to some applications; for example, RT—that is, when an error caused by the correction system is not perceived as being critical.

References

[1] Ilmonen, K., Listener preferences for Loudness balance of broadcasts with special considerations to listening in noise, Yleisradio (Finnish Broadcasting Corporation), Research Report no. 12/1971.

[2] van der Heide, H. J., "Possibilities for the introduction and application of a programme code in sound broadcasting," Berichte der 4, NTG-Hörrundfunktagung, Düsseldorf, Germany, Nov. 1976.

[3] Sundin, L., and A. Sanfridsson, Programme Identification in FM broadcasting, Swedish Telecommunications Administration, Report RI 4022/77, 1977.

[4] MacEwan, D., "Radio in the 80's Broadcasting and the ideal sound receiver of the future," *Wireless World*, May 1977, pp. 36–40.

[5] Ely, S. R., VHF Radio Data: Experimental BBC transmissions, BBC Research Department Report No. BBC RD, 1981-1984.

[6] Ely, S. R., "The impact of radio-data on broadcast receivers," *The Radio and Electronic Engineer*, Vol. 52, No. 5, 1982, pp. 291–296.

[7] Swedish Telecommunication Administration: Paging receiver for the Radio Data System, Doc. 1301/A694 3798 (Alternative B), 1986.

[8] CCIR: Report 900-1 Radio-paging systems-standardisation of code and format (Annex II), 1986.

[9] ITU-R Recommendation B.S.643-2 (1995), System for automatic tuning and other applications in FM radio receivers for use with the pilot-tone system.

[10] Mielke, J., and K. H. Schwaiger, "Progress with the RDS system and experimental results," *EBU Review*, No. 217, June 1986.

[11] Shute, S. A., "The EBU Radio Data System," *International Broadcast Engineer*, May/June 1987.

[12] Kopitz, D., "Radio Data System-from specification to practical reality," *EBU Technical Review*, No. 233, Feb. 1989.

[13] Parnall, S. J., and J. L. Riley, "RDS developments," *International Broadcasting Convention Digest*, 1990, pp. 234–240.

[14] Ely, S. R., and D. Jeffrey, *Traffic Information Broadcasting in Mobile Information Systems*, J. Walker, Ed., Norwood, MA: Artech House, 1990, Chapter 5.

[15] Borras Amoedo, J. M., *El RDS: Una Radio Intelligente*, Biblioteca Tecnica PIONEER, Ediciones Tecnicas Rede, S. A., 1991.

[16] Universal Encoder Communications Protocol UECP-EBU doc. SPB 490, version 5.1, European Broadcasting Union, 17A Ancienne Route, CH-1218 Geneva, Aug. 1997.

[17] EBU: Proposed enhancements of the EBU on CENELEC EN 50067 (RDS), Doc. SPB 482, European Broadcasting Union, 17A Ancienne Route, CH-1218 Geneva, Switzerland, 1990.

[18] EBU SPB 485: Rev 1992-Allocation of country/area identification codes in RDS, now included in CENELEC EN 50067:1998.

[19] EN 50067:1990-Specifications of the Radio Data System RDS, European Committee for Electrical Standardisation (CENELEC), 35B rue de Stassart, B-1050 Brussels.

[20] EN 50067:1992-Specifications of the Radio Data System RDS, European Committee for Electrical Standardisation (CENELEC), 35B rue de Stassart, B-1050 Brussels.

[21] Marks, B., "The development of RDS standards," *3rd Montreux International Radio Symposium: Engineering Symposium Record*, 1996, pp. 133–142.

[22] CENELEC EN 50067:1998 - Specifications of the Radio Data System (RDS.) for VHF/FM broadcasting, European Committee for Electrical Standardisation (CENELEC), 35B rue de Stassart, B-1050 Brussels, Switzerland, April 1998.

[23] EIA/NAB, National Radio Systems Committee: United States RBDS Standard-Specification of the Radio Broadcast Data System (RBDS), Jan. 8, 1993.

[24] EIA/NAB, National Radio Systems Committee: United States RBDS Standard version 2.0, Specification of the Radio Broadcast Data System (RBDS), 1998.

[25] EBU Guidelines for the implementation of the RDS system, Doc. Tech 3260, European Broadcasting Union, 17A Ancienne Route, CH-1218 Geneva, Switzerland, Jan. 1990.

[26] NAB RDS Applications-Opportunities for Radio Broadcasters, NAB Science and Technology Department, 1771 N Street, N.W., Washington D C , 1995.

[27] EBU, Specifications of the radio data system RDS for VHF/FM sound broadcasting, Doc. Tech 3244 and Supplements 1 to 4. European Broadcasting Union, 17A Ancienne Route, CH-1218 Geneva, Switzerland, 1984.

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2

Differences Between RDS and RBDS

2.1 Introduction

In this chapter, the small but subtle differences are explained between the European RDS CENELEC standard and the North American RBDS National Association of Broadcasters/Electronic Industry Association (NAB/EIA) specification (a voluntary U.S. industry standard). Through close collaboration between the RDS Forum and the U.S. National Radio Systems Committee, both standards were harmonised to a high degree in order to facilitate the manufacturing of receivers for both markets. Since receivers can detect automatically where they are operated, they can, in principle, configure themselves automatically. Therefore, it is important that encoder/receiver designers and data service providers clearly understand the subtle differences between RDS and RBDS.

2.2 The RDS Component Within RBDS

The RDS for FM broadcasting in the frequency range 87.5–108.0 MHz was developed within the European Broadcasting Union (EBU), as explained in Chapter 1. This system was specified by the EBU in 1984, and has now been introduced in the large majority of European countries as well as a number of other countries all over the world. It is also now being used by a significant portion of the FM broadcast stations in the United States. Later, the system was enhanced through several modifications as more experience was gained during different implementations—in 1987, on large broadcast networks that were

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then just starting and in 1990, when RDS was adopted as a European standard of CENELEC (EN 50067:1990) [1]. Today, most FM radio stations in Western Europe and several FM radio stations in Central and Eastern Europe use RDS. Receivers—mostly car radios with RDS functionality—are available in Europe from some 75 different manufacturers at prices that are only slightly higher than those of conventional radios.

Although the RDS system offers a wide range of implementation options (some, like the TMC feature, just started implementation in 1997/98), most of the existing RDS car radios have only the five basic features: PI, PS name, AF list, TP identification, and TA signal. PTY code (see Chapter 4) will definitely be one of the popular features in the future, apart from the EON function (see Chapter 6), which is increasingly used now by the European broadcasting networks, and which has led to a second-generation of RDS receivers.

In the United States, a subcommittee on Radio Broadcast Data Systems of the National Radio Systems Committee (NRSC), sponsored by the Electronics Industry Association (EIA) and the National Association of Broadcasters (NAB), began its work in February 1990, after the EBU had demonstrated RDS at various NAB and SAE conventions. The NRSC based its work on RDS as specified within the EBU, and every attempt was made to keep the U.S. standard compatible with it. However, it soon became evident that the completely different broadcasting structure of the United States required that a number of modifications be made. Finally, the U.S. standard had to cover FM broadcasting, as is the case in Europe, but it also had to have certain AM broadcasting-related extensions.

In January 1993, the EIA and the NAB jointly published the U.S. Standard RBDS as a voluntary industry standard that was adopted through a voting procedure that involved both organisations [2].

Since the introduction of the RBDS standard in North America in 1993, much activity has surrounded the introduction of the system by both broadcasters and receiver manufacturers. The EIA created an advisory group to promote the technology to broadcasters and manufacturers, and the RBDS subcommittee remains active for the purpose of upgrading the standard as implementation experience brings about necessary changes. This is completely in line with what was done in Europe only six years earlier. Figure 2.1 shows the EIA booth at the 1993 Chicago Consumer Electronics Show.

Large coordination activities that surrounded the upgrade of the standard took place with the RDS Forum in Europe during the years 1994–1998, with the goal of achieving even more harmonisation between RDS and RBDS. The first result of this harmonisation was that the advisory group proposed the use, at the consumer level, of only one name for the system—namely, only RDS. RBDS is kept as the name for the North American standard to keep it distinct



Figure 2.1 RBDS promotion during the 1993 Chicago Consumer Electronics Show. From left to right: Casey (Denon), Haber (Radio World), Lebow (Sage Alert Systems), and Kopitz. (*Source:* EBU.)

from the European RDS CENELEC standard, since there is no single world standard combining the elements of both standards.

Recent changes to both standards, which were officially adopted in early 1998, have resulted in a significant harmonisation of features, allowing the development of global broadcast equipment, consumer receivers, and data services. The newly revised RDS and RBDS standards both move forward into a new era for FM data services. All changes have been devised to be fully backward compatible with the prior standards while offering a tremendous amount for future growth and extension. The new ODA feature (see Chapter 9) will even permit the definition of additional functionality without the need to revise the RDS/RBDS standards yet again.

Figure 2.2 depicts the actual construction of the RBDS standard. As is shown in this functional diagram of the RBDS standard, the RDS standard is entirely contained within the RBDS standard, and this is true word by word; that is, the corresponding text is identical with the copyright being agreed to by all the organisations concerned. In the RBDS standard, the few remaining functional differences are added within the appropriate sections of the text or within entirely new annexes. This reflects the fact that the functional core of RBDS is completely identical with RDS. This can also be seen by examining the RDS/RBDS group allocations shown in Table 2.1 [3,4].

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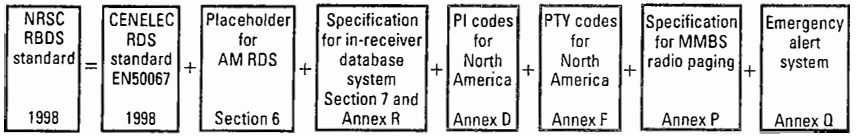


Figure 2.2 Functional diagram of the RBDS standard. (*Source:* NAB/EIA.)

Table 2.1
RDS/RBDS Data Groups

Group Type	Description of Usage
0A	Basic tuning and switching information only
0B	Basic tuning and switching information only
1A	Programme Item Number and slow labelling codes
1B	Programme Item Number
2A	RadioText only
2B	RadioText only
3A	Applications IDentification for ODA only
3B	Open Data Applications—ODA
4A	Clock Time and date only
4B	Open Data Application—sODA
5A	Transparent Data Channels (32 channels) or ODA
5B	Transparent Data Channels (32 channels) or ODA
6A	In-House applications or ODA
6B	In-House applications or ODA
7A	Radio Paging or ODA
7B	Open Data Application—sODA
8A	Traffic Message Channel or ODA
8B	Open Data Application—sODA
9A	Emergency Warning System or ODA
9B	Open Data Application—sODA
10A	Programme TYpe Name
10B	Open Data Application—sODA
11A	Open Data Application—sODA
11B	Open Data Application—sODA
12A	Open Data Application—sODA
12B	Open Data Application—sODA

Table 2.1 (continued)

Group Type	Description of Usage
13A	Enhanced Radio Paging or ODA
13B	Open Data Applications—ODA
14A	Enhanced Other Networks information only
14B	Enhanced Other Networks information only
15A	Undefined (fast PS of RBDS being phased out)
15B	Fast switching information only

2.3 Details About the Differences

2.3.1 Programme TYpe (PTY) Definitions

PTY information allows a user to seek for his or her favourite programme format, such as a particular type of music. Since broadcasting in the United States differs in content, RBDS uses a different Programme TYpe list, as compared to CENELEC RDS. RBDS defines 26 different PTY codes, leaving five codes still unassigned for future extensions, while CENELEC RDS now defines all 32 codes (see Table 2.2).

Table 2.2
European (CENELEC) and North American (US NRSC) PTY Codes

PTY Decimal No.	RDS PTY (CENELEC)		RBDS PTY (US NRSC)	
Number	Description	8-character	Description	8-character
0	No programme type or undefined	None	No program type	None
1	News	News	News	News
2	Current affairs	Affairs	Information	Inform
3	Information	Info	Sports	Sports
4	Sport	Sport	Talk	Talk
5	Education	Educate	Rock	Rock
6	Drama	Drama	Classic rock	Cls_Rock
7	Culture	Culture	Adult hits	Adlt_Hit

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Table 2.2 (continued)

PTY Decimal No.	RDS PTY (CENELEC)		RBDS PTY (US NRSC)	
Number	Description	8-character	Description	8-character
8	Science	Science	Soft Rock	Soft_Rck
9	Varied	Varied	Top 40	Top_40
10	Pop music	Pop_M	Country	Country
11	Rock music	Rock_M	Oldies	Oldies
12	Easy listening music	Easy_M	Soft	Soft
13	Light classical	Light_M	Nostalgia	Nostalga
14	Serious classical	Classics	Jazz	Jazz
15	Other music	Other_M	Classical	Classicl
16	Weather	Weather	Rhythm and blues	R_&_B
17	Finance	Finance	Soft rhythm and blues	Soft_R&B
18	Children's programmes	Children	Foreign language	Language
19	Social Affairs	Social	Religious music	Rel_Musc
20	Religion	Religion	Religious talk	REL_TALK
21	Phone In	Phone_In	Personality	Persnlty
22	Travel	Travel	Public	Public
23	Leisure	Leisure	College	College
24	Jazz music	Jazz	Unassigned	
25	Country music	Country	Unassigned	
26	National music	National	Unassigned	
27	Oldies music	Oldies	Unassigned	
28	Folk music	Folk_M	Unassigned	
29	Documentary	Document	Wheather	Wheather
30	Alarm test	TEST	Emergency test	Test
31	Alarm	Alarm_!	Emergency	ALERT_!

Note: "_" indicates a space.

Broadcasters in the United States are very sensitive to the Programme TYpe Name shown on the receiver, because their whole market offering is based on the careful definition of the material they offer. Therefore, Programme TYpe Name (PTYN) Group Type 10A, was already defined in the 1993 version of the

RBDS standard, but it is now included in both the new RDS and RBDS standards. The default PTY eight-character name should be shown during the scanning process. Once the receiver stops on a station with the default PTY category, a more specific PTY category may be given with PTYN; for example, "SPORTS" is coded by PTY and then the sport is detailed as "BASEBALL" by PTYN. The PTYN is not intended to change the default eight characters that will be used during the search, but only to more clearly define the Programme TYpe once tuned to a programme. However, if the broadcaster is satisfied with the default PTY name, he or she will not *need* to use data transmission capacity to add PTYN detail to the default name.

Receivers that implement the PTY feature should allow the user to select one entry from the two different PTY tables (European CENELEC version and North American RBDS version). The table may also be automatically switched using the Extended Country Code (ECC).

2.3.2 Programme Identification (PI) Coding

In North America (United States, Canada and Mexico), PI codes are based on call letters rather than being assigned by a regulatory organisation—as carried out throughout the rest of the world. A portion of the PI codes are reserved for network usage and also for assignment to stations in Canada and Mexico. During the upgrade to the RBDS standard, several mistakes were discovered in the noncall-based PI codes, which had to be corrected. For further details, see Appendix F.

The ECC table was modified for these changes as well. The new PI assignments allow 3,584 possible nonregional PI codes for Canada and Mexico, as well as 765 national network PI codes for all three countries: the United States, Canada, and Mexico.

The ECC codes allow receivers to identify the country that the broadcast is coming from. Since PI Country Identifier codes are limited in number (i.e., there are only 15 codes available), they must be repeated throughout the world. When the PI country identifier code is received in conjunction with the ECC, the exact country of origin can be identified. The updated ECC code table has been expanded to be international in scope, and reflects recent changes in the political landscape. It is contained in Annexes D and N of the RDS and RBDS standards (for details about these codes, see Appendix G in this book). The ECC should be transmitted by all broadcasters, and it is recommended that it be a default automatic transmission in encoders.

The ECC supports the development of global receivers that can automatically compensate for things such as the following:

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1. E blocks (MMBS);
2. PI codes;
3. PTY tables;
4. Tuning range and step;
5. FM de-emphasis (North America uses a 75 μs pre-emphasis in the transmitted AF response, while Europe uses 50 μs).

2.3.3 Programme Service (PS) Name

During the update to the CENELEC RDS standard, a movement was made in the RDS Forum to specifically prohibit stations from dynamically changing the PS name [5]. In some countries, broadcasters have used the PS display as a text-messaging feature similar to RT, but only eight characters at a time.

The design intent of PS is to provide a label for the receiver preset that is invariant, since receivers incorporating the AF will switch from one frequency to another in following the selected programme. To combat unintended dynamic use of the PS, the RDS standard adopted strict wording on the use of the PS feature.

During adoption of the RBDS draft, considerable debate about "dynamic" PS resulted in less stringent requirements for PS usage. Set makers should realise this difference—although in actual practical system design they should not prepare for dynamic PS, but just cope with occasional changes of PS as required by the broadcaster to signal a different broadcast network configuration caused by linking or regionalisation.

Excerpts from the text of both standards follows:

- *RDS standard:* The Programme Service name comprises eight characters, intended for static display on a receiver. It is the primary aid to listeners in programme service identification and selection. The use of PS to transmit text other than a single eight-character name is not permitted. Transmission of a PS name usually takes four type 0A groups, but to allow an instant display of the PS when a receiver pre-set is selected, the PS name is often stored for subsequent recall from memory when a programme service is selected. For this reason, PS should generally be invariant. If a broadcaster wishes to transmit longer Programme Service names, programme-related information or any other text, then RT provides this feature.

A similar effect could be experienced with a dynamic text transmission of PTYN. As a result, dynamic PS and PTYN transmissions are expressly forbidden.

- *RBDS standard:* The Programme Service name comprises eight characters. It is the primary aid to listeners in programme service identification and selection. The Programme Service name is to be used only to identify the station or station programme. This text may be changed as required by the station, but shall not be scrolled or flashed or altered in a manner that would be disturbing or distracting to the viewer (i.e., not more frequently than once per minute).

2.3.4 Fast PS Acquisition: Phased Out

The prior version of the RBDS standard included a fast PS feature contained in type 15A groups. This use will now be phased out; however, existing transmissions may still occur for several years. Newly designed equipment should not contain this feature. The type 15A group will remain undefined until at least the next upgrade of the RDS/RBDS standards, which is unlikely to occur before the year 2003.

2.3.5 Optional Multiplexing of RDS and MMBS: Offset Word E

Since 1993, RBDS has included an option for the multiplexing of RDS with the slightly modified MBS (MMBS) system, used exclusively by the company called Cue Paging. MBS is a kind of predecessor to RDS, and MMBS still thrives throughout North America. MBS/MMBS is mainly used as a paging system through a network of approximately 500 stations within the United States. The MBS/MMBS system utilises the same modulation and data structure as RDS but employs a different data protocol. An MMBS broadcast is identified through the offset word E. Since there are similarities between the two systems, it is possible to time division multiplex MMBS and RDS data. Receivers should be able to differentiate between RDS and MMBS broadcasts, but usually disregard the MMBS data, which is only used by specific receivers licensed by the Cue Paging company.

The RDS and MMBS multiplexing will unavoidably degrade the performance for stations that desire to make use of the AF feature due to the loss of repetition of the fast, pertinent tuning information needed by the receiver. A typical time division multiplex of RDS and MMBS data is shown in Figure 2.3. Currently, Cue Paging utilises the MBS (Mobile Search) paging protocol [6] in about 500 stations out of the approximately 5,000 existing FM stations—usually one per area, covering 90% of the population of the United States.

The option of multiplexing between RDS and MMBS will thus permit these stations to implement RDS while maintaining compatibility with the existing MBS paging receivers.

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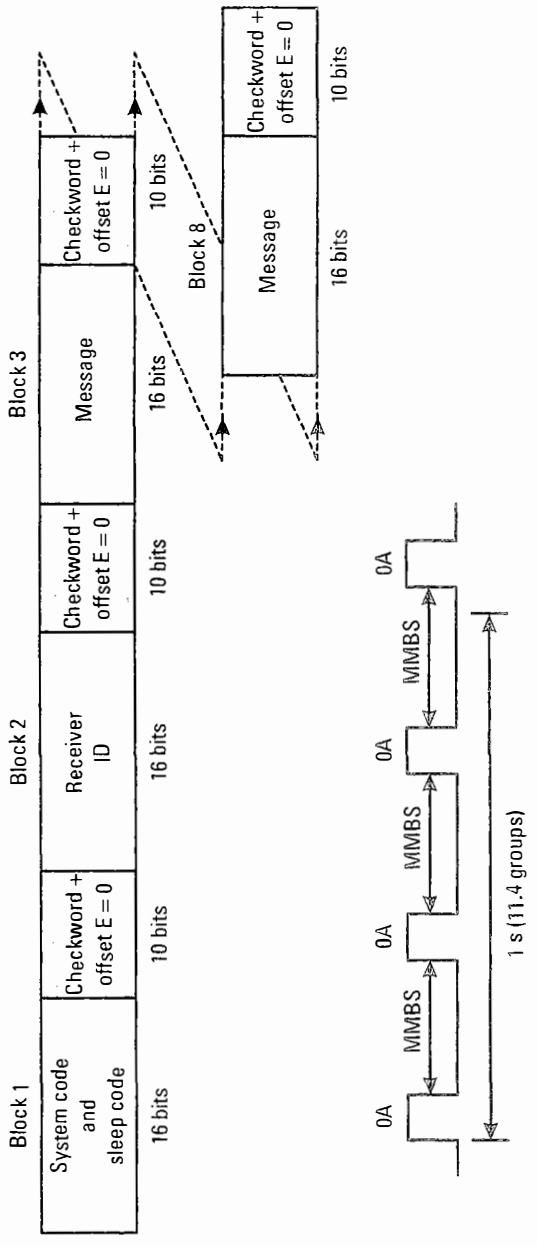


Figure 2.3 RDS/MMBS multiplexing. (*Source*: EBU.)

2.3.6 Optional ID Logic Feature

The ID Logic feature is a licensed technology (PRS Corporation) that allows the incorporation of an in-receiver database that contains the programme format type and call letters for all AM and FM stations. When combined with RDS, ID Logic can provide similar data and features for non-RDS FM and all AM stations. The I-RDS feature allows the database to be updated through an RDS open data application (ODA) so that station information can be updated and maintained automatically. The specification of ID Logic is contained within a separate section of the RBDS standard, while the I-RDS ODA is described in detail within an annex.

According to our knowledge, the ID-Logic feature was not used anywhere in 1997, which is probably due to the difficulty of creating the necessary agreements for a reliable and future-proof broadcast infrastructure to be operated using this technology.

2.3.7 Optional ODA Emergency Alert System

Within the RBDS standard, the emergency alert system ODA protocol is defined for use in the United States. This optional feature set is constructed around the Federal Communication Commission's (FCC) newly developed EAS system and is open for public use. RDS and RBDS allow the silent transmission of emergency information. This has been combined with existing consumer-oriented emergency features to allow additional feature functionality to consumer receivers, as well. The EAS ODA can well accommodate private emergency systems, but it should also be noted that Annex Q of the new RBDS standard has no corresponding section in the RDS standard.

In Europe, there is not yet much interest in this kind of application, and it is thought that it has little or no relevance for consumer receivers. The implementation will most likely remain restricted to special alert radios to be used under specific well-defined conditions applying to closed user groups only.

2.3.8 Option for Adding an AM Radio Data System

Section 5 of the new RBDS standard serves as a "placeholder" for a future AM data system (AMDS). The development of an AM data system is still supported by the NRSC and has been studied for more than five years by the RBDS subcommittee without an agreement being found as to the modulation system to be used. The requirement, difficult to meet, is that any such system must be compatible with the C-Quam AM stereo system.

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In Europe, tests in the 1980s showed that low rate data could be carried by low frequency (LF) and medium frequency (MF) transmissions. For many years, the BBC 198 kHz transmitter has used phase modulation of the carrier to achieve 50 bps, but tests on "Hochschule für Verkehrswesen Dresden" showed that it was possible to add a data stream of 200 bps using a phase modulation of ±15 degrees to an AM transmitter, with minimal degradation of received audio quality.

Since 1986, extensive field trials have been conducted to find an appropriate baseband coding to match the bit error conditions of AM channels in LF, MF, and high frequency (HF).

AMDS [7], as it has become known, owes its origin to these trials. During 1994, the EBU ad hoc group R1/AMDS prepared a comprehensive proposal for the standardisation of the baseband coding for AMDS, leaving the modulation system still undecided since the phase modulation that was used in the tests is incompatible with the C-Quam AM stereo system still used in the United States.

2.3.9 Location/Navigation Information Deleted

The 1993 version of the RBDS standard had defined type 3A groups for location/navigation information. However, since this specification left a large number of options open, in which studies were continued within the RBDS subcommittee, nobody had implemented this feature, which was of no interest in Europe.

The new RBDS standard deleted that kind of specification and redefined the type 3A group to the Open Data Application's IDentification (AID) as required in the new RDS standard. As a result, the type 3A group is completely identical in both RDS and RBDS.

2.4 Use of the RDS Logos

In the United States, the RDS logos (shown in Figure 2.4) are now a registered trademark of the National Association of Broadcasters (NAB). The reason for this registration is solely to protect the logos against other registrations by individuals seeking to exploit them for commercial advantage. The copyright of the logos is jointly owned by the BBC and the EBU. Initially, these logos were developed by the BBC, and in August 1988, they were first published by the EBU in their RDS newsletters.

Before the logo can be used in the United States on any product, manufacturers will need to perform a self-certification test on their equipment, and submit a self-certification application to the Consumer Electronic

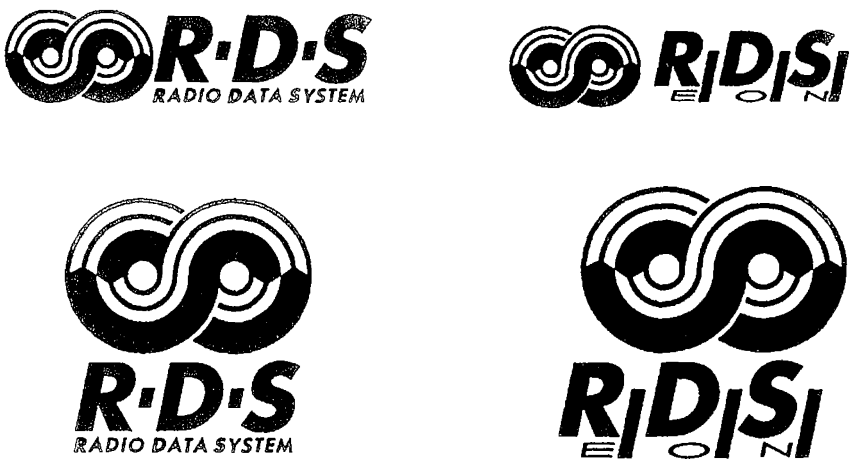


Figure 2.4 The RDS logos. (*Source:* EBU.)

Manufacturers Association (CEMA). The cost is $100.00 per year, per manufacturer. Only equipment displaying the logo will require registration. Figure 2.5 illustrates an RDS product demonstration.

Note that consumer receivers must use the term "RDS" rather than "RBDS." The use of the RBDS term is only permitted when referring to the North American standard.

In Europe, there is no self-certification test required, and the RDS logos can be used freely on equipment that implements *any* of the RDS features.

2.5 Conclusions

RDS and RBDS both allow broadcasters and receiver manufacturers to decide which of the possible standardised features they wish to implement. It is in that context that the question arises as to whether RDS manufacturers can adapt their software to modify existing products that were designed for Europe to create products for sale in the United States.

The answer to this question is not very obvious because of the large range of implementation options that are theoretically permitted in the two standards. However, in reality, the problem is not too difficult to be solved simply because most existing RDS car radios have implemented only the five basic features already mentioned above, and these also appear to be quite sufficient during the initial phase of the RBDS implementation in the United States.

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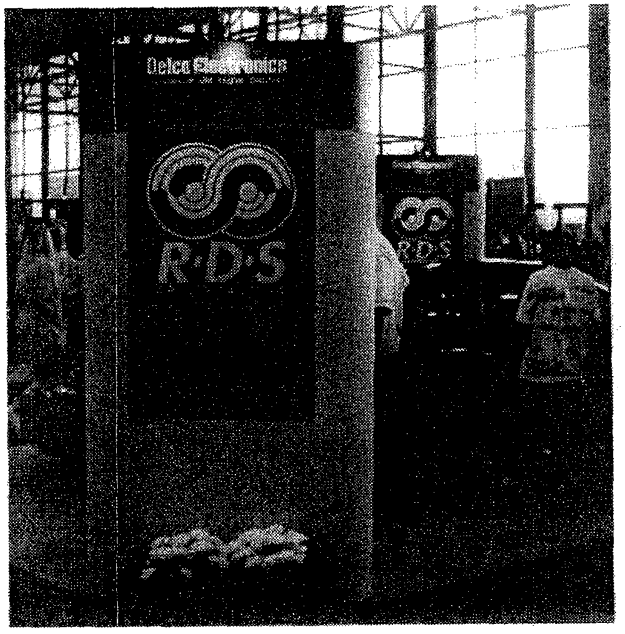


Figure 2.5 RDS product demonstration in the United States. Note: RBDS is the name of the standard, but products shall be marked with the RDS logo. (*Source:* EBU.)

RDS and RBDS have in common exactly the same data broadcast signal modulation characteristics. This is the suppressed 57 kHz subcarrier that is PSK modulated with a data stream of 1187.5 bps and has identical baseband coding—the data synchronisation being optimised for mobile reception. Consequently, the same hardware for data demodulation and display can be used, and suitable radio data decoder ICs are currently available from Philips Semiconductors, SGS-Thomson, and others. Prices for these ICs are very competitive because several millions of these chips are now being made each year. Consequently, the question of adaptation becomes entirely a matter of software.

Depending on the feature set of a particular receiver, some differences may be discounted. However, "Caution should be exercised when making such decisions," said the chairman of the RBDS subcommittee, Scott Wright (Delco Electronics Corp.), when he analysed the differences of the new RDS/RBDS standards [8,9].

The essential differences between RDS and RBDS that have an impact on the design of consumer receivers are listed below. Recognition of these

differences is essential to all manufacturers interested in a global market for RDS equipment and consumer receivers. The main differences are as follows:

- *Programme TYpe definitions (PTY):* The RBDS standard calls out a different set of programme type terms.
- *Programme Identification coding (PI):* North American PI codes differ in functionality: This affects alternate frequency switching and regionalisation.
- *Dynamic Programme Service (PS) name:* The RBDS standard differs in its allowance of "nondistracting" changes to the PS.
- *Phase out of fast Programme Service (PS) feature:* Type 15A group of RBDS was previously defined for use as a fast PS feature. This usage is being discontinued.
- *Multiplexed MMBS:* This is used as a commercial nationwide paging system in the United States. Since it shares the same modulation format and data protocol as RDS, it may be time division multiplexed with RDS. MMBS uses the offset word E (see also Appendix B), which is defined in both the RDS and RBDS standards to permit this multiplexing to take place without disturbing synchronisation of the received RDS/RBDS data stream.

If a receiver designer aimed at adapting existing RDS receiver designs for use in North America and made a receiver comply with the RBDS standard, all the above, as we have seen, indicates that the software changes that are needed are relatively small. Recognition of the offset word E (all zeros) would definitely be the most important change to be made, and when PTY is implemented in the receiver, the RBDS code table has to be used, of course. Finally, the PI codes have to be interpreted differently as far as AF switching and regionalisation are concerned (see Appendix F). That is practically all that is needed to make RDS receivers work correctly in North America (i.e., United States, Canada and Mexico).

References

[1] CENELEC, Specifications of the radio data system; EN 50067:1992, European Committee for Electrotechnical Standardisation, Brussels, Belgium, 1992.

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[2] EIA/NAB National Radio Systems Committee, United States RBDS Standard, Specification of the Radio Broadcast Data System (RBDS), Washington, D.C., Jan. 8, 1993.

[3] CENELEC, Specification of the radio data system (RDS) for VHF/FM sound broadcasting, EN50067:1998, European Committee for Electrotechnical Standardisation, Brussels, Belgium.

[4] EIA/NAB National Radio Systems Committee RBDS Subcommittee-United States RBDS Standard, Draft 2.0, Specification of the Radio Broadcast Data System (RBDS), Washington, D.C., Aug. 1997.

[5] RDS Forum, Document 96/007: Comments on Programme Service name (PS)-Non-standard transmission of type 0 group. European Broadcasting Union/RDS Forum, 17A, Ancienne Route, CH-1218 Geneva, Switzerland, 1996.

[6] Swedish Telecommunication Administration (Televerket)-Paging Receiver for the Swedish Public Radio Paging System, 76-1650-ZE, 1976.

[7] EBU, Proposal for a Data System for AM transmitters, EBU Document GT R1/AMDS 009, GT R1 910, European Broadcasting Union, 17A, Ancienne Route, CH-1218, Geneva, Switzerland, Sept. 9, 1994.

[8] Wright, S., *The Broadcaster's Guide to RDS*, Focal Press, 1997.

[9] EIA/NAB, Wright, S., "RBDS versus RDS: What are the differences and how can receivers cope with both systems?" 1997.

[10] Beale, T., D. Kopitz, "RDS in Europe, RBDS in the USA - What are the differences and how can receivers cope with both systems?" *EBU Technical Review*, No. 255, 1993.

3

RDS Features Serving as Tuning Aids

3.1 Introduction

In this chapter, RDS features that help the tuning functionality of FM receivers are introduced. In this connotation, a feature in RDS is considered to be something that gives a distinctive functionality. Originally in the earliest versions of the specification, these tended to be defined into a single RDS group such as RadioText, which is described in Chapter 4 (although there are notable exceptions such as PI, which is described in this chapter). But, as the specification was enhanced, some features were defined that make use of more than one group to be transmitted (e.g. Radio Paging, which is described in Chapter 8) to obtain full functionality.

Many of these features are considered to be included in the minimum set of RDS features that would be implemented initially by a transmission operator.

3.2 Basic RDS Features

The RDS specification, EN 50067:1998, defines a number of RDS group types that are generally reserved for a particular application. The type 0A group—basic tuning and switching information—is a special case, designed to carry the fundamental components of RDS all together in a single group that will be transmitted frequently to convey many pieces of information to an RDS receiver to enable it to perform a considerable number of tuning functions. These fundamental components, known as features, allow a degree of

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automatic tuning in an RDS receiver and allow it to present tuning-related information to the user. The type 0A group contains all of the following RDS features: Alternative Frequency (AF), Decoder Information (DI), Music Speech (MS), PI, Programme Type (PTY), Traffic Announcement (TA), and Traffic programme (TP). The type 0B group contains the same features except the AF feature [1].

The implementation of the type 0 groups in any RDS transmission is essential, and not optional—unlike many of the other possible groups in RDS—because it carries vital information required for automated tuning of an RDS receiver.

From these basic RDS features serving as tuning aids, it is useful to initially consider AF, PI, PS, and TP. They can be seen in various locations within the type 0A group, as shown in Figure 3.1. Furthermore, PI and TP can be found in *all* other groups to provide immediate information to an RDS receiver from every single group decoded.

The type 0B group has a very similar structure, but there is a simple difference in block 3, as shown in Figure 3.2. In block 3, the AF feature is not used, so it is replaced by a second PI code. This group is normally used by single-service RDS transmissions, where there is no need for an AF list because there are, indeed, no alternates.

3.3 Programme Identification—PI

The PI code is transmitted in block 1 of *every* single RDS group. PI is a machine-readable code that is not intended for direct display. It is uniquely allocated to each individual programme service within a geographical area to enable it to be distinguished from all other programme services. (For more detail about PI coding, see Appendix F.) Irrespective of frequencies used, transmissions with identical PI codes in any given area must have the *identical* audio programme. A receiver may therefore freely switch between two different transmissions with the same PI code in order to track optimum reception, assured that programme audio will be identical on both transmitters.

One important application of the information contained in the PI code is to enable an RDS receiver to automatically search for an alternative frequency in case of bad reception of the programme to which the receiver is tuned; the criteria for the changeover to the new frequency would be the presence of a better signal having the *same* PI code.

The PI code consists of 16 bits and is usually referred to by four hexadecimal characters, or nibbles, as shown in Figure 3.3.

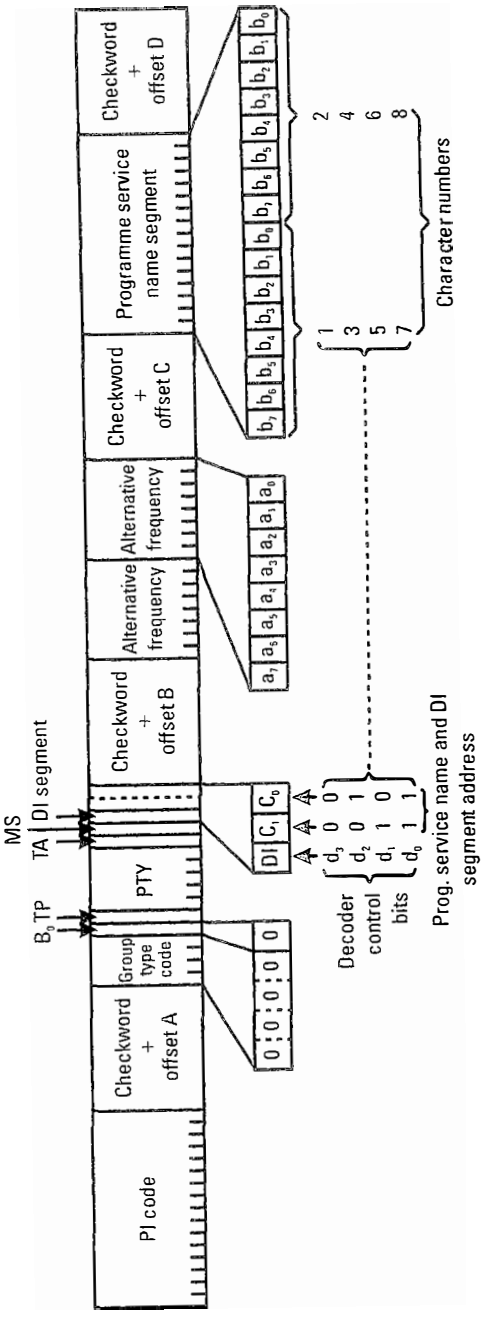


Figure 3.1 Type 0A group, showing the disposition of features carried. (*Source:* EBU.)

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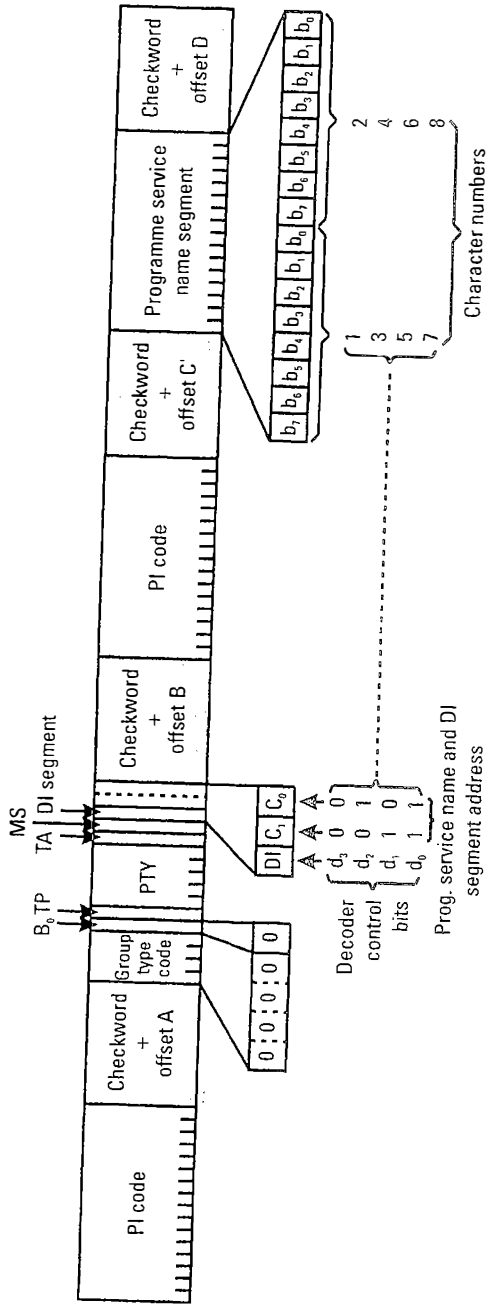


Figure 3.2 Type 0B group, showing the second PI code in place of the AF feature. (*Source:* EBU.)

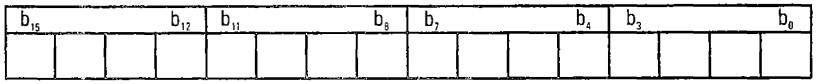


Figure 3.3 PI code structure. (*Source:* EBU.)

PI codes assigned to programme services are invariant, and other than changing the second nibble (regional element) in accordance with the specific rules, it must not be changed as part of regular radio programming. Furthermore, when cross-referring to other services, the PI code of referenced services is transmitted in block 4 of type 14 groups (see Chapter 5).

3.3.1 Broadcasting Conventions

PI codes must be allocated so that two different services do *not* transmit the same PI code in the same area. As part of this allocation process, the first nibble (hexadecimal character) is a Country Identifier, signifying the country of origin of the broadcast (not necessarily the country in which a transmitter is located), as shown in Figure 3.4. The country/area code allocations are given in the RDS specification EN 50067:1998, Annexes D and N [1], and in Appendix G of this book. The PI code allocations for Europe are shown in Figure 3.5.

In Europe, most broadcast networks are in fact services comprised of more than one transmitter which, at times, separate or split in order to offer regional information or programmes. Each of these regions must be provided

Ar eacoverage code	L	I	N	S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

I = International	The same programme is also transmitted in other countries
N = National	The same programme is transmitted throughout the country
S = Supra-regional	The same programme is transmitted throughout a large part of the country
R1 to R12 = Regional	The programme is available only in one location or region over one or more frequencies, and there exists no definition of its frontiers
L = Local	Local programme transmitted via a single transmitter (only) during the whole transmission time

Figure 3.4 Coverage area: hex codes used in the second nibble of the PI code. (*Source:* EBU.)

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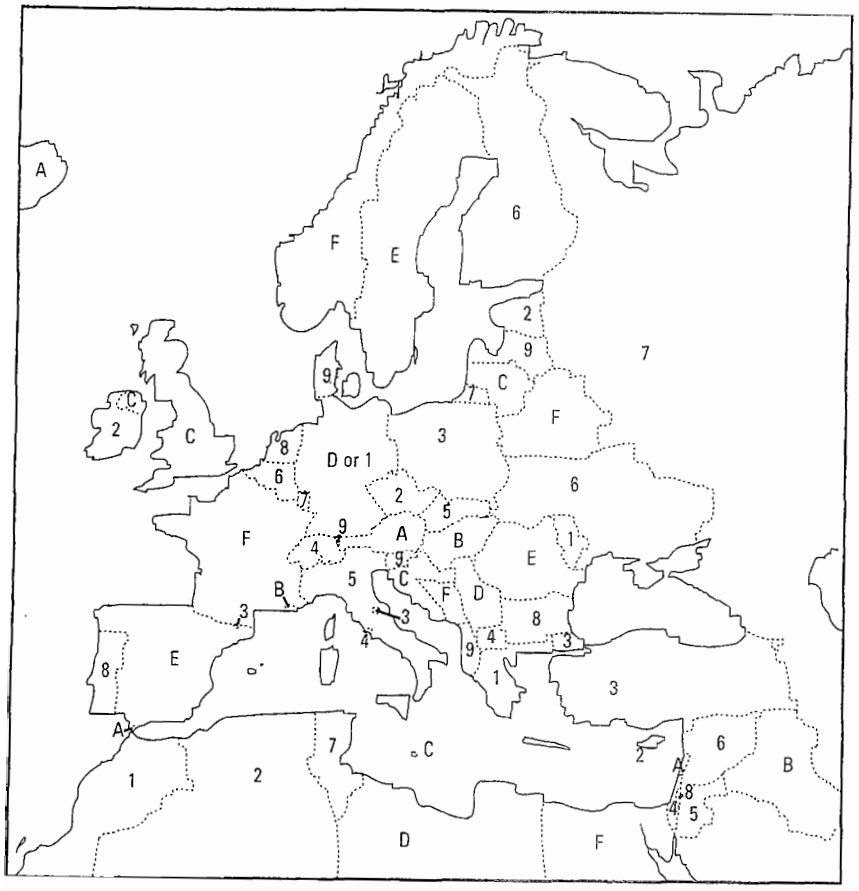


Figure 3.5 PI country code allocations for Europe. (*Source:* EBU.)

with a unique PI code by allocation of a different regional code in the second element. The regional element must be in the range 4-F hex. Services having identical first, third, and fourth elements, and a regional element in the range 4-F hex are said to be generically related or regional equivalent services. Up to 12 services, each using one of the regional codes (4-F hex) may be associated in this way. During the times when *all* regions are carrying common programmes, it is permitted for the services to change the regional element of the PI code to either 2 or 3 hex on each regional service. If the code is changed in this manner, all regions should ideally join/split at the *same* time. Partial splits/joins will cause undesirable effects for some listeners. This is the only change of PI code

normally permitted. Changing PI codes is *not* permitted on programme services used as part of an Enhanced Other Network (EON).

Although within a country code area, PI codes *may* be reused at geographically separated areas, it is preferable that each service be allocated a unique code. RDS receivers use the PI code as addresses against which to store programme attributes (Programme Service name, list of alternative frequencies, etc.). Use of the same PI code by more than one programme service would probably cause data about one service to be misassociated with another having the same PI code.

To prevent having to reuse PI codes and yet still be able to associate together more than 12 regional equivalent services, the Extended Generic (EG) feature should be used. The word generic has a somewhat special meaning in RDS and involves some very complex ideas, which require a very full appreciation of how broadcasters view their services. Furthermore, sometimes they transmit common programmes in a network and this must be signalled to an RDS receiver. A more detailed explanation can be found in the EBU/RDS Forum document BPN 009: RDS Guidelines [2].

In this case, PI codes that have the extended generic indicator (EG) flag set, and are identical in the first and third elements only, and regional elements in the range 4-F hex, are also regional equivalent services to each other. Up to 192 (12 × 16) such services may be grouped in this way.

3.3.2 Reception

The PI code is arguably the single most important feature of RDS. It uniquely identifies a programme service, within any geographical area, where broadcasts sharing the same PI code are guaranteed to be carrying identical programme audio. Although there are many designs possible for an RDS receiver, evaluation of the PI code is fundamental to operation.

In any receiver with preset memories, it is essential for the PI code of the broadcast to be stored in nonvolatile memory when a service is assigned to a memory location. If no signal with the correct PI code is available, on the last tuned frequency or AFs, when a preset is chosen, the receiver should scan the FM band, stopping on each receivable RDS service and evaluating the PI code.

The correct transmission to select is that which gives the best signal with a PI code matching that recalled from memory. If no service with a matching PI code can be found, a receiver should select a transmission with (in order of priority) a PI code identical in the first, third, and fourth elements or a PI code identical in the first and third elements only. Although accepting these transmissions as regional variations of the wanted service, under no circumstances

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should the PI code stored in preset memory be overwritten by any other PI code.

An RDS receiver must always evaluate the PI code and confirm it is correct before it remains tuned to a different transmission. Usually, switching between two different transmissions should occur only when PI codes are identical in all four nibbles. Optionally, a receiver may provide a mode that enables receivers to switch automatically to other regional variants of the same service.

3.4 Programme Service (PS) Name

The PS name is an eight-character alphanumeric label transmitted by the broadcaster to identify to the listener the name of the tuned service. It is not intended for automatic tuning purposes. The PS name is transmitted two characters at a time in either the type 0A or type 0B groups. (See Figures 3.1 and 3.2 above.) A complete PS name requires a minimum of four groups, which at the recommended rate takes just one second to be transmitted. As the reception of a PS name takes a minimum of one second, and even longer in adverse reception conditions, receivers may store the PS name to allow instant recall upon the user accessing a preset memory. Since broadcasters may choose to transmit PS names in either type 0A or 0B groups, receivers must be capable of using both transmission methods.

PS names can also be carried as part of the EON data and then provide the PS name of the cross-referenced programme services.

The PS name should only be used as a static feature, but it may occasionally change. For example, regional services may carry their own PS name during the day when they originate their own programmes. However, the PS name is changed when they are transmitting a common programme originated by one of these broadcast services during the evenings and nights.

Due to these design parameters for PS, the use of the PS feature to transmit text other than a single eight-character representation of the Programme Service name is not permitted. If a broadcaster wishes to transmit more programme service information, programme-related information, or any other text, then the RadioText feature provides the capability to achieve dynamic text possibilities. The RDS Forum has been instrumental in keeping media regulators informed about the correct use of PS, which has, unfortunately, been incorrectly implemented by several broadcasters who have not realised the importance of these design parameters for PS [3].

Appropriate use of spaces, punctuation, and combinations of uppercase/lowercase characters and accented characters should all be used to improve

readability of the PS name. For example, in the Untied Kingdom, the BBC uses >_BBC_ R4_< for the BBC Radio 4 network PS and classic FM uses >Classic_< for its PS. The characters to be used for PS are shown in the RDS specification EN 50067:1998 Annex E, which indicates a "limited character set" that may only be available to a low-cost receiver, using only uppercase characters together with numbers and a few punctuation marks. The limited character set for display is indicated in a footnote to Figure E1 in Annex E of the RDS specification (see Appendix I, Figure I.1). Receivers capable of only displaying the limited character set must convert the lowercase characters in columns/rows 6/1–7/10 to their column 4 and 5 uppercase character equivalents and convert accented characters in columns 8-15 to their non accented equivalent. For example, a low-cost receiver would need to convert the received character "a" to "A" for display; it would also have to convert "å" to "A" and convert other characters such as "é" to "E." A midrange receiver displaying lowercase characters in columns 6 and 7 may still be required to convert received accented characters such as "ñ" to "n" for display. Clearly, receivers capable of displaying the full character set will provide a superior presentation.

Broadcasters have to be aware that not all receivers' displays will support the full code table, and may only support the limited character set.

Even though PS has constrained design parameters, to achieve very reliable PS reception and to provide a safe invariant display, it can be employed in a receiver to offer exceptionally user-friendly performance. For example, a dual front-end tuner car radio from Becker (see Figure 3.6) uses incoming PS information to derive and generate a three-character soft label for a number of preset buttons. This allows the user to see a description of other radio stations with some identification, which is better than seeing a preset number label such as "1," "2," "3," and so on.

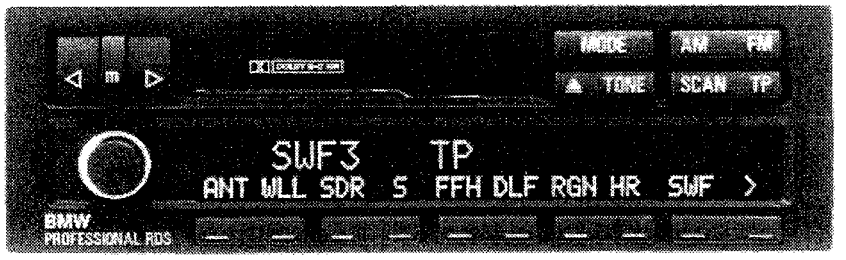


Figure 3.6 Becker car radio using PS-derived soft labels for programme selection buttons. (*Source:* Becker.)

3.5 Alternative Frequency List—AF

The purpose of the AF list is to facilitate the automatic tuning of an RDS receiver. The AF list indicates carrier frequencies on which the specified service is broadcast. AF lists may be broadcast for the tuned service and also for other services using the EON feature. Generally, at any one location, only a few (or even none) of the frequencies indicated will carry the intended service at good signal strength. Receivers must ascertain the suitability of each frequency in the list by evaluating the signal quality and then decoding the PI code to check that there is an exact match before switching frequencies automatically.

AFs for the tuned network are broadcast two codes at a time, in block 3 of type 0A groups, according to codes given in Tables 3.1 and 3.2.

AF lists for cross-referenced services are carried in variants 4, 5, 6, 7, 8, and 9 of type 14A groups.

Ideally, AF lists should be as short as possible and contain *only* the frequencies of immediately adjacent transmitters. Broadcasters may achieve this by installing RDS encoders at each transmitter site, with an individual appropriate list of frequencies. This coding method, known as *Method-A*, is the most widely used and suitable for lists not exceeding 25 frequencies. At the recommended repetition rate for the transmission of type 0A groups (i.e., four groups per second), a list with the maximum of 25 frequencies will take less than four seconds to transmit in its entirety. Figure 3.7 shows an example Method-A list and explains the format when an even number of frequencies are in the list, necessitating the use of the filler code (which can be ignored by the receiver).

A second way to transmit AFs is provided where it is not possible to restrict the list to fewer than 25 frequencies, or where it is required to indicate frequencies that belong to different regions that at times carry different programmes. In this coding of alternative frequencies, known as *Method-B*, all

Table 3.1
VHF Code Table

Number	Binary Code	Carrier Frequency
0	0000 0000	Not to be used
1	0000 0001	87.6 MHz
2	0000 0010	87.7 MHz
:	:	:
:	:	:
204	1100 1100	107.9 MHz

Table 3.2
Special Meanings Code Table

Number	Binary Code	Special Meaning
0	0000 0000	Not to be used
205	1100 1101	Filler code
206	1100 1110	Not assigned
:	:	:
223	1101 1111	Not assigned
224	1110 0000	No AF exists
225	1110 0001	1 AF follows
:	:	:
249	1111 1001	25 AFs follow
250	1111 1010	An LF/MF frequency follows
251	1111 1011	Not assigned
:	:	:
255	1111 1111	Not assigned

transmitters broadcast in sequence, a series of transmitter-related lists that are organised in frequency pairs, with the particular transmitter frequency always repeated in each pair as a reference together with one of the respective alternative frequencies of that transmitter.

The particular way in which the data is organised within block 3 of type 0A groups enables a receiver to deduce whether Method-A or Method-B coding is being used and, in the case of Method-B, to derive the shorter lists

F_1	F_2	Explanations
# 6	89.3	Total number (6) of frequencies in this list (excluding the Filler code) 89.3 MHz is the frequency of a "main transmitter"
88.8	89.0	88.8 MHz and 89.0 MHz are AFs of tuned frequency (possibly re-broadcast transmitters)
99.5	101.7	99.5 MHz and 101.7 MHz are AFs of tuned frequency (possibly re-broadcast transmitters)
102.6	"F"	102.6 MHz is an AF of the tuned frequency (possibly re-broadcast transmitter) and Filler code

Figure 3.7 Example of an AF list using Method-A. (*Source:* EBU.)

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appropriate to each transmitter within the network. As the complete list of frequencies carried by Method-B may be very long, a complete cycle of information may take up to two minutes (or even longer in poor reception conditions) for a receiver to acquire.

Clearly, receivers must be able to detect and use AF lists coded in either the Method-A or Method-B protocols. The rules governing Method-B transmissions are complex and beyond the scope of this book, but Figure 3.8 gives a flavour of the possibilities.

The presence of a frequency within an AF list does not guarantee that the frequency will provide a suitable signal in any particular area, and especially does not guarantee that a transmission on a frequency will be that intended by the broadcaster. In areas where frequency planning or regulation of broadcasting is inadequate, a particular frequency may be reused for quite different services in close proximity. It is essential therefore that the receiver, before accepting a new frequency, tunes to the intended frequency to check and confirm the PI code is the one expected. Only if the PI code matches the one intended, should the receiver accept the frequency as the new tuned frequency. Receivers should reject frequencies where there is no detected PI code or the wrong PI code.

When retuning to an alternative frequency, a receiver will inevitably produce, in the case of a single front-end unit, a short audio interruption on the

F_1	F_2	Explanations
# 11	89.3	Total number (11) of frequencies for tuning frequency: 89.3 MHz
89.3	99.5	$F_2 > F_1$: 99.5 MHz is an AF of tuned frequency 89.3 MHz and is the same programme
89.3	101.7	$F_2 > F_1$: 101.7 MHz is an AF of tuned frequency 89.3 MHz and is the same programme
88.8	89.3	$F_2 > F_1$: 88.8 MHz is an AF of tuned frequency 89.3 MHz and is the same programme
102.6	89.3	$F_2 < F_1$: 102.6 MHz is an AF of a regional variant of tuned frequency 89.3 MHz
89.3	89.0	$F_2 < F_1$: 89.0 MHz is an AF of a regional variant of tuned frequency 89.3 MHz
# 9	99.5	Total number (9) of frequencies for tuning frequency: 99.5 MHz
89.3	99.5	$F_2 > F_1$: 89.3 MHz is an AF of tuned frequency 99.5 MHz and is the same programme
99.5	100.9	$F_2 > F_1$: 100.9 MHz is an AF of tuned frequency 99.5 MHz and is the same programme
104.8	99.5	$F_2 < F_1$: 104.8 MHz is an AF of a regional variant of tuned frequency 99.5 MHz
99.5	89.1	$F_2 < F_1$: 89.1 MHz is an AF of a regional variant of tuned frequency 99.5MHz

Figure 3.8 Examples of AF lists using Method-B, along with their meaning. (*Source:* EBU.)

order of a few milliseconds. Checking a PI code, however, will take at least 100 milliseconds, during which time it is possible for a burst of incorrect programme to be heard, should the particular frequency being tested be other than the intended programme. Manufacturers should adopt an intelligent process as a background activity to validate each frequency in the AF list. This will ensure that a receiver has available for use, when required, a frequency with an optimum audio quality and with the correct PI code. Unwanted bursts or breakthrough from other programmes (of the wrong PI code) and audible mutes should be avoided. Dual-tuner receivers may have an advantage in AF list evaluation as the checking of PI codes may be done by the second tuner while the first tuner continues to provide an uninterrupted audio programme for the listener.

Some broadcasters may include frequencies of services in their AF lists—simultaneously broadcast on AM perhaps, where there is no suitable FM transmission. In this case, it is not possible to confirm the frequency that carries the intended programme as no PI code is transmitted on normal AM frequencies. Use of AM frequencies is probably only viable where the AM tuner part of the receiver is separate from the FM one. This would allow a receiver, while the AM tuner is providing an audio programme, to use the FM tuner to perform RDS processing and remain active to allow the earliest possible return to an FM transmission.

3.6 Traffic Programme (TP) Flag

The RDS traffic information service allows listeners to receive traffic reports even if listening to a CD/cassette, or with the receiver volume turned down or muted. This service makes use of two flags: the TP and TA flags. The latter is described more fully in Chapter 6; here, the tuning aspect of the TP flag is considered. The TP flag is carried in block 2 of *every* group type and in block 4 of type 15B groups. If the TP flag is set to /1/, this indicates that the tuned programme service provides the RDS traffic service. Broadcasters must *not* set the TP flag to /1/ unless the TA is also *dynamically* controlled [1].

Programme services that do *not* provide traffic services with a switched TA flag, but instead cross-reference via EON services that do, indicate this by setting the TP to /0/ and the TA to /1/ on the service. When a listener selects the RDS traffic service feature, the receiver uses the status of both the TP and the TA flags to determine whether or not the tuned service can provide the traffic information service itself, or alternatively in the case of an EON-capable receiver, via a cross-referenced service.

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The TP flag can be used by an RDS receiver, since it is in every RDS group, to easily evaluate the availability of the RDS traffic service when checking a frequency as part of the automatic tuning capability. If the tuned service does not provide the RDS traffic service feature, an RDS receiver should indicate this to the listener in some way. Options include the following:

- Visually on the display or audibly by a bleep. This is particularly useful when going away from a service and signal strength weakens to the point where the TP flag status is becoming uncertain.
- The receiver may automatically start to seek for an alternative service able to provide a traffic service.

Alternatively, the receiver could allow the user the option of continuing to listen to the currently tuned service without the traffic service, or manually initiating a search for an alternative service. The options provided might be different, depending on how the user is currently operating the receiver. For example, a routine may be as follows:

- If the RDS traffic information service is selected while the user is listening to a CD/cassette, the receiver may automatically seek and tune to a service capable of providing a traffic service, without either beeping or requiring a listener to manually initiate a search.
- If listening to the radio when traffic information is selected, the receiver should alert the listener visually or with a brief audible warning if the traffic service is unavailable, but not automatically retune. The user then has the option to initiate a seek for another traffic service programme, if required, or to continue listening to the tuned service but without a traffic service.

The same routine should be adopted if, while tuned to a service that was offering a traffic information service, the status of the TP/TA flags changes and indicates that a travel service is no longer available. Interference on areas of poor reception will mean that the TP and/or the TA flag may at times be read unreliably. It is important that the status of TP and TA flags be evaluated over several groups, and that momentary switching be avoided as the result of short-term signal fluctuations.

A full description of the interaction of TP flags, TA flags, and EON is given in Chapter 6.

3.7 Slow Labelling Codes

The RDS specification contains some additional slow labelling codes that are used to support various features. These are specified to be carried in the type 1A group at a much slower rate than the main feature groups; for example, once per minute. The type 1A group also contains the functionality of the PIN feature (see Chapter 5), as shown in Figure 3.9.

3.7.1 Extended Country Code (ECC)

The ECC feature was built into the RDS specification some time after the original publication of the specification, because originally it had been designed only for Europe and the limited number of country identifier codes (only 15 different codes, 1-F hex) could easily be shared across the geographical area considered. Note, for example, in Figure 3.5 that E hex is shared between Sweden and Spain. The use of RDS has grown considerably since then and, indeed, the need to accommodate newer emerging countries has resulted in the ECC feature, which is now an important part of the full implementation of several other features. When widely implemented, this feature allows receivers to initialise automatically for country-specific applications; therefore, broadcasters are being encouraged to implement this feature.

The ECC feature, when read in conjunction with the country code part of a PI code, forms a *unique* Country Identifier. This may be used by a receiver to automatically select country-specific applications; for example, PTY language tables, which are different according to the broadcaster's choice of RDS or RBDS. To support this functionality, the ECC, which consists of 8 bits transmitted in block 3 of type 1A group's variant 0 (as shown in Figures 3.9 and 3.10), should be transmitted at least once per minute.

Returning to the example of Spain and Sweden, Romania also uses E hex in the allocated country PI code. However, each country is assigned a different Extended Country Code: Romania = E1, Spain = E2, Sweden = E3, which taken together with the country code element of the PI code provides a unique Country Identifier. Full listings of the ECC and PI country/area codes are given for European countries in EN 50067:1998 Annex D, and for the rest of the world in Annex N (see also Appendix G of this book) [1].

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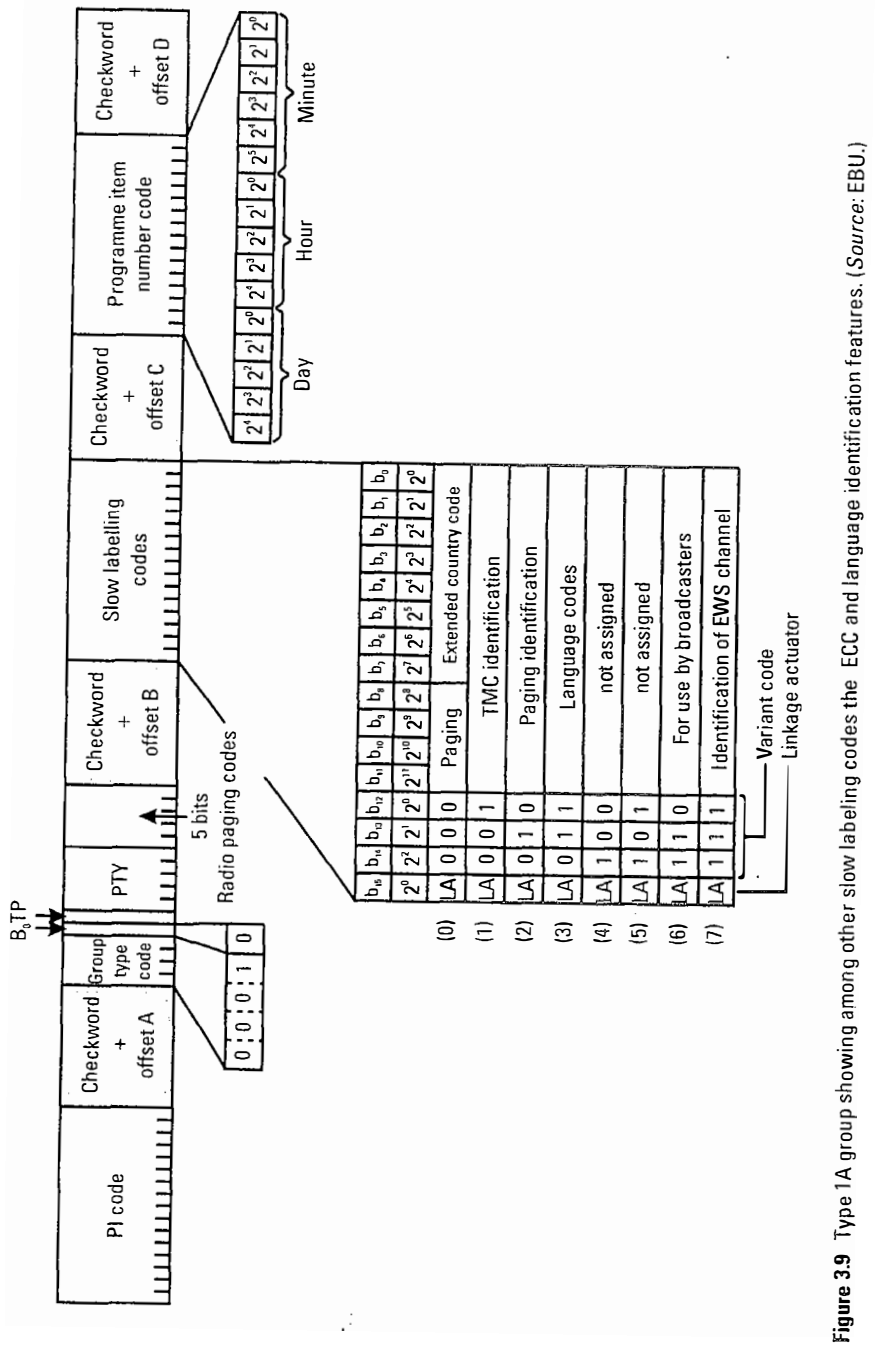


Figure 3.9 Type 1A group showing among other slow labeling codes the ECC and language identification features. (*Source:* EBU.)

Usage	Bit allocation in Block 3															
Group type 1A	b_{15}	b_{14}	b_{13}	b_{12}	b_{11}	b_{10}	b_9	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Variant code 0	LA	0	0	0					Extended country code							

Paging
Variant code
Linkage actuator

Figure 3.10 ECC bits in type 1A groups, variant 0. (*Source:* EBU.)

3.7.2 Language Code

Another enhancement that remains optional, but which is easy to transmit and could lead to enhanced receiver performance, is the language code, also carried using 8 bits in type 1A groups, variant 3 (as shown in Figure 3.11). Language identification may be used to signal the spoken language of the current programme on a service. The feature may be of interest not only in multilingual countries but also for visitors to help locate programmes in their preferred language.

Broadcasters may automatically control the language code by including a data field in their RDS programme scheduling system, and this could then be used to control their RDS encoders automatically. They should be aware that the normal repetition rate for type 1 groups to convey the PIN feature is approximately once per minute and that the expected rate for language identification will go down if several variants of type 1 groups are utilised. It is, however, recommended to transmit variant 3 if the language code is implemented at least once every two seconds. This makes the feature unsuitable for search tuning.

The language codes, described as two hex numbers, are specified in EN 50067:1998, Annex J [1].

Usage	Bit allocation in Block 3															
Group type 1A	b_{15}	b_{14}	b_{13}	b_{12}	b_{11}	b_{10}	b_9	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Variant code 3	LA	0	1	1	X	X	X	X	Language identification code							

Reserved
Variant code
Linkage actuator

Figure 3.11 Language code bits in type 1A group, variant 3. (*Source:* EBU.)

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References

[1] CENELEC, EN 50067:1998-Specifications of the Radio Data System (RDS.) for VHF/FM broadcasting, European Committee for Electrical Standardisation (CENELEC), 35B rue de Stassart, B-1050 Brussels, April 1998.

[2] EBU /RDS Forum: BPN 009-Radio Data System (RDS) Guidelines, to be published in Autumn 1998.

[3] RDS Forum Statement, sent with letter DT/969-S/DK dated Feb. 26, 1996, RDS Forum Statement, sent with letter DT/3255-S/DK dated Dec. 9, 1997

4

Radio Programme-Related RDS Features

4.1 Introduction

This chapter provides a description of the original features and some new features that are related to the programme content in the audio channel of the FM transmission.

RDS was originally designed with a strong view that it should provide features that would let the user benefit from information related to broadcast programmes. In Chapter 3, it was noted that type 0A groups contain both tuning features and programme-related features. One of these programme-related features, Programme TYpe (PTY), was foreseen by the original developers to be significant for tuning purposes, so PTY information is conveyed in *all* RDS groups. But PTY did not become an early success for RDS; nevertheless, it is being implemented by more broadcasters and receiver manufacturers alike now that the capabilities offered are better understood—and now that other features are also demanding dynamic control over the RDS encoders. More recently, the possibilities of an additional feature, PTYN, has been developed and added to the RDS specification. [1].

PTY can be used to help the user with the programme selection process and so too can the PIN feature. Other dynamic features to be discussed in this chapter are RadioText—which has many uses, giving both programme-related information and many other possibilities. Finally, the support features Decoder Identification/Programme TYpe Identification (DI/PTYI) are described.

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4.2 Programme TYpe (PTY)

The PTY codes are transmitted, using five bits in block 2 of *every* single RDS group. Additionally, the type 15B group—providing fast basic tuning and switching information—carries a second opportunity for decoding the PTY code, which is also transmitted in block 4 (see Figure 4.1). Furthermore, the code may also be carried in type 14A groups, variant 13 from transmissions cross-referencing a programme service.

The PTY codes are given in the RDS specification EN 50067:1998, Annex F [1]. These codes provide standardised descriptions for broadcasters to depict their programmes according to a short list of 29 standardised choices. Although simple in nature, this feature has been complex for broadcasters to implement because they do not find it easy to narrow their programme descriptions down to a short list. Indeed, it is claimed to be a living issue, with categories gradually changing with broadcasting trends and styles. Table 4.1 shows the PTY codes, decimal number, the five bits listed, and a very short description for each, together with a recommendation for both 8- or 16-character displays in English. The RDS specification has introduced the possibility of 16-character displays now that receiver technology is more able to use so many characters. Displays in other languages have been developed and agreed upon by experts for many languages through the RDS Forum, and are detailed in Appendix H. In Chapter 2, Table 2.2 shows the RBDS PTY codes list adjacent to the RDS codes list—the differences in the meanings of the same transmitted codes must be allowed for by RDS receivers being built for the RBDS or RDS markets, or by a receiver making use of automated code table switching (when it can detect the ECC feature, which is described in Chapter 3).

Great care is needed when considering PTY coding in order to conform with either one specification or the other (e.g., RBDS or RDS). This is because the same defining words intended for display, such as Oldies Music, have subtly different meanings according to the specifications and different codes used (i.e., RDS uses PTY code 27 for Oldies and RBDS uses PTY code 11) [1, 2].

As shown in Table 4.2, three of the PTY codes are harmonised in both RDS and RBDS, since they have special meaning.

Although any PTY code can be used in any mode, some categories are more suited to one particular mode of operation than another. Programmes that are generally listened to in their entirety (to receive coherent information) are best matched to receivers offering the PTY-STANDBY mode of operation. This applies to many speech programmes such as news, weather, and drama.

Some broadcasters use PTY to indicate the general nature of their service as a whole, with no changes at programme junctions (static PTY); others assess

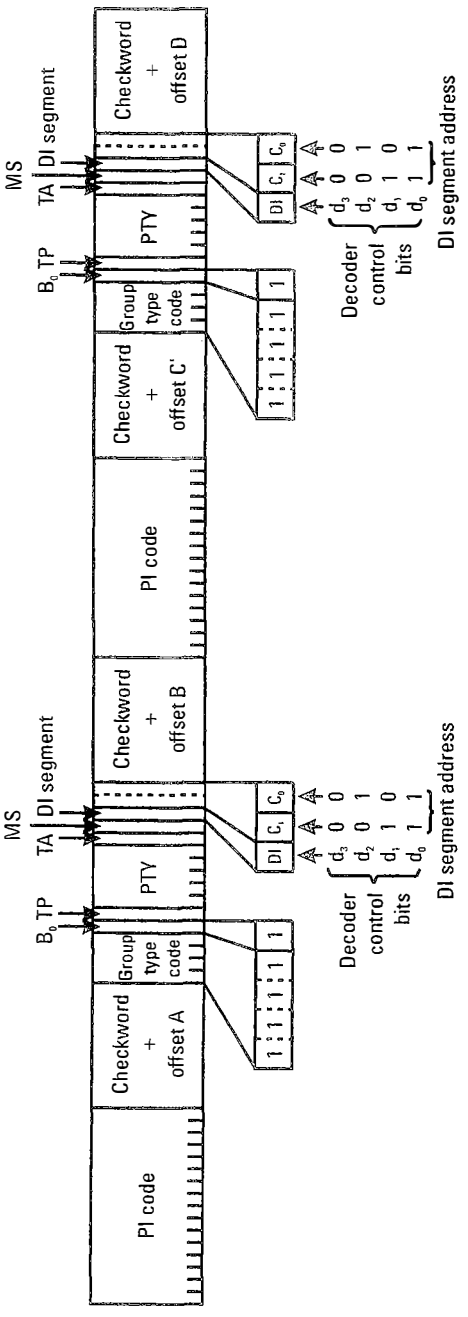


Figure 4.1 Type 15B group, showing the PTY bits. (*Source:* EBU.)

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Table 4.1
Programme Type Codes

Number	Code	Programme Type	8-Character Display[1]	16-Character Display[1]
0	00000	No programme type or undefined	_ _ None _ _	_ _ _ _ _ _ None _ _ _ _ _ _
1	00001	News	_ _ News _ _	_ _ _ _ _ _ News _ _ _ _ _ _
2	00010	Current affairs	Affairs _	Current _ Affairs _
3	00011	Information	_ _ Info _ _	_ _ Information _ _ _
4	00100	Sport	_ Sport _ _	_ _ _ _ _ Sport _ _ _ _ _
5	00101	Education	Educate _	_ _ _ Education _ _ _ _
6	00110	Drama	_Drama _ _	_ _ _ _ _ _ Drama _ _ _ _ _ _
7	00111	Culture	Culture _	_ _ _ _ Cultures _ _ _ _
8	01000	Science	Science _	_ _ _ _ Science _ _ _ _
9	01001	Varied	_ Varied _	_ Varied _ Speech _ _
10	01010	Pop music	_ Pop _ M _ _	_ _ _ Pop _ Music _ _ _ _
11	01011	Rock music	_ Rock _ M _	_ _ _ Rock_Music _ _ _
12	01100	Easy listening music[2]	_ Easy _ M _	_ Easy _ Listening _
13	01101	Light classical	Light _ M _	Light_Classics_M
14	01110	Serious classical	Classics	Serious _ Classics
15	01111	Other music	Other _ M _	_ _ Other _ Music _ _ _
16	10000	Weather	Weather _	_Weather _ & _ Metr _
17	10001	Finance	Finance _	_ _ _ _ Finance _ _ _ _ _
18	10010	Children's programmes	Children	Children's _ Progs
19	10011	Social affairs	_ Social _	_ Social _ Affairs _
20	10100	Religion	Religion	_ _ _ _ Religion _ _ _ _
21	10101	Phone In	Phone_In	_ _ _ _ Phone _ In _ _ _ _
22	10110	Travel	_ Travel _	Travel _ & _ Touring
23	10111	Leisure	Leisure _	Leisure _ & _ Hobby _
24	11000	Jazz music	_ _ Jazz _ _	_ _ _ Jazz _ Music _ _ _
25	11001	Country music	Country _	_ Country _ Music _ _
26	11010	National music	Nation _ M	_ National _ Music _
27	11011	Oldies music	_ Oldies _	_ _ Oldies _ Music _ _
28	11100	Folk music	_ Folk _ M _	_ _ _ Folk _ Music _ _ _

Table 4.1 (continued)

Number	Code	Programme Type	8-Character Display[1]	16-Character Display[1]
29	11101	Documentary	Document	_ _ Documentary _ _ _
30	11110	Alarm test	_ _ TEST _ _	_ _ _ Alarm _ Test _ _ _
31	11111	Alarm	Alarm _ ! _	Alarm _ - _ Alarm _ ! _

1) These short terms are recommended for the 8- or 16-character display of the radio in English. Other language versions are available from the EBU and the RDS Forum.

2) In earlier versions of the RDS specification, the term MOR music was used for this code, but Easy listening is now more frequently used.

The symbol "_" is used to represent a space in the display

Table 4.2
Special PTY Codes and Meanings

Number	Programme Type	Description
0	No programme type or undefined	Indicates a particular programme is undefined
30	Alarm test	Indicates a test transmission and may be used by a consumer receiver for display
31	Alarm	Indicates a transmission of great importance, carrying information about a national or local emergency and must always be combined with a spoken message

PTY codes 1–29: Allow receivers to offer several modes of operation, which have been more clearly defined in the last few years.

PTY-SEARCH: Allows a listener to request the receiver to find a particular type of programme, if available.

PTY-SELECT: Allows a listener to request that the receiver indicate which particular Programme TYpes are currently available, and which could be selected.

PTY-STANDBY (or WATCH): Allows a listener to request that the receiver standby or watch out for a particular Programme TYpe to begin, switching to it when it does.

PTY-STORE: Allows a listener to request that the receiver (incorporating a means of recording audio) store a programme by matching requested PTY code, allowing later listening by the use.

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and use PTY on a programme item by programme item operational basis (dynamic PTY).

The PTY-STANDBY mode of operation of a receiver is only viable with dynamic PTY operation, which must be flagged in the DI /PTYI feature (see Section 4.5).

When broadcasters use dynamic PTY, two codes (01—news and 16—weather) are principally expected to be used for short-duration programmes of no more than 5 or 10 minutes. Figure 4.2 shows a car receiver with a news selection button. They should not be used to describe longer programmes, such as 30-minute news bulletins that inevitably include much comment (and would be more appropriately coded as current affairs). Similarly, a longer feature programme about the weather should be coded as science.

Dynamic control of the PTY code requires that a broadcaster have a means for controlling the PTY code via a data connection to the RDS encoders at each transmitter. Ideally, PTY codes should be controlled directly from the on-air studio in real time, but control from a computer-based programme schedule is also possible provided audio programmes run completely and accurately on time.

Broadcasters operating more than one programme service that are cross-referenced via EON need to consider the interaction between services when controlling and allocating PTY codes. For example, at the "top of the hour," more than one service may transmit a news bulletin. The broadcaster should decide whether it is appropriate for each service to be signalled as news simultaneously or whether only one service at a time should be designated as the news service for the benefit of receivers in the PTY-STANDBY mode of operation. The use of PTY should always be made with the interests of the listener in mind.

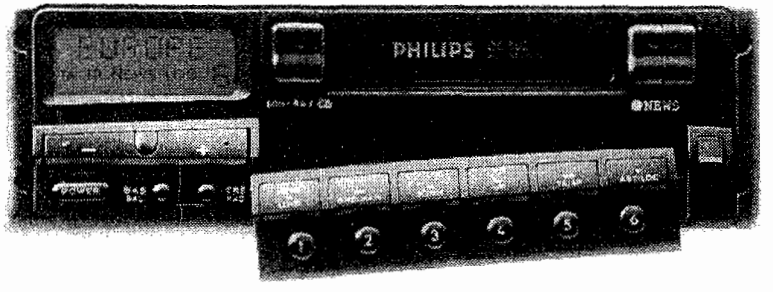


Figure 4.2 Philips car receiver with PTY featuring a news selection button. (*Source:* Philips.)

4.2.1 PTY-SEARCH Mode

This is the mode most often provided on early RDS receivers, but on its own (i.e., without PTY-SELECTION or PTY-STANDBY modes, described below), it may have contributed to some customer dissatisfaction. In the PTY-SEARCH mode, a listener requests their desired PTY code by choosing from all the types specified and theoretically possible; the receiver then searches the band to see if the required PTY code is being broadcast at that time. When the requested code is unavailable, the listener may feel frustrated, and either has to request another choice or repeat the search until eventually successful.

4.2.2 PTY-SELECTION Mode

In this mode, a receiver presents the listener with a display of all PTY codes currently available on-air. On a receiver with a large display, all codes may be shown at once so that the listener is able to make an instant selection. On other receivers, the PTY codes available could be presented sequentially. The listener is able to make a selection from those codes actually available.

4.2.3 PTY-STANDBY Mode

This mode (also known as Watch or Wait mode) allows the listener to program a receiver to standby for a particular PTY code to become available. It may only be used reliably when the DI-d_3 bit is set to indicate that dynamic PTY is available. When tuned to a non-EON service (or using a non-EON receiver), the only possibility is for a receiver to monitor the PTY code on the "tuned" service and interrupt CD/cassette operation when the desired PTY code becomes available.

When tuned to an EON service (and using an EON receiver), the receiver should also monitor the PTY carried in block 3, variant 1 of type 14A groups being received, and this will allow the receiver to offer programmes matching the user's preselected PTY.

When the required PTY code is no longer available, the receiver may either return automatically to the original service or remain tuned to the current one. If the latter option is chosen, an easy means should be provided to allow a listener to return to the original service (e.g., pressing the PTY button). The same mechanism may be used to allow a listener to return to the original service partway through a programme (e.g., after the sports news headlines but before the sport in detail).

A receiver in standby mode should not switch across to a service once the programme has started (i.e., the receiver should only switch at a PTY transition).

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4.2.4 PTY-STORE Mode

This is a further refinement of the PTY-STANDBY mode of operation, where programmes of the requested type are stored in memory or on tape, allowing a listener to replay them when requested. A dual-tuner RDS receiver could store the news bulletin (PTY code 01) on one service while the user is listening to a programme item on another service. The user then has the opportunity to listen to the news at a convenient time. A similar feature is possible with a single-tuner receiver while the listener has chosen to listen to a CD or cassette.

A receiver (dual-tuner) could offer a particularly attractive PTY implementation by combining all these modes of operation into a single routine. For example, say a listener requests a sports programme. The receiver *searches* for PTY code 04 (Sport). It is currently unavailable, so the receiver automatically goes into the PTY-STANDBY mode. The receiver then offers the listener the *selection* of categories currently available from which to choose while the receiver is standing by. The receiver switches across to a sports programme on a service when it begins. If no sports programme occurs while the user continues to listen, the receiver remains in the PTY-STANDBY mode and automatically *stores* sports bulletins when they occur, ready for the listener to replay on demand.

4.2.5 PTY-ALARM Function and Testing

PTY code 31, ALARM, indicates a transmission of great importance, carrying information concerning a national or local emergency. Therefore, all receivers should detect this code, sound an alarm, and turn up the volume.

Broadcasters need to occasionally test the broadcast chain to confirm that it can perform dynamic PTY switching and that they can fully use PTY code 30. This code is thought to be particularly useful in testing the system functionality without causing unnecessary public concern. Consumer receivers should neither use this code for searching nor to cause dynamic switching. Receivers may, if desired, display: >_TEST_< when detecting a PTY code 30 on a programme service.

4.3 Programme Type Name (PTYN)

The PTYN feature has been added to the RDS specification to allow a broadcaster to transmit an eight-character additional description that depicts the programme content. This can be used to enhance the PTY code description and is expected to help address the broadcaster's attitude that the standardised PTY codes are too limited.

It is intended to aid *selection* of listening more precisely than using the PTY code alone. It cannot be used in PTY-SEARCH, PTY-STANDBY, or PTY-STORE modes of operation (see Section 4.2).

The PTYN feature is transmitted in type 10A groups, four characters at a time; hence, two groups are required to complete the eight-character description. The use of PTYN to transmit text other than to a single eight-character description is not permitted, and it must not be used to provide sequential information. Figure 4.3 shows the type 10A group structure, which is designed to convey the eight characters for reconstruction into the normal eight-character display constraint of RDS receivers. The bit format follows that specified for RadioText, but only using eight characters (see Section 4.4).

The PTYN feature is capable of adding more precise descriptions about programme content than that provided by PTY alone and is particularly useful to distinguish between different services that use the same general PTY description. For example, if there are three services carrying PTY coded as SPORT, the PTYN feature can be used to add the descriptions: >Cricket_<, >_Golf_< and >_Tennis_< to each.

A single-tuner receiver could use PTYN to provide a second-level description of the tuned programme service. For example, after a listener makes a primary selection of SPORT, a receiver tunes to each of the services coded as SPORT in turn and is able to decode and present the PTYN description to the listener for final selection.

An attractive implementation in a dual-tuner receiver would be to use PTYN to provide a submenu. Such a receiver could present a complete list of both available PTY codes plus PTYNs, if any. For example, if there are three services broadcasting SPORT, the PTYN feature would provide details enabling a listener to chose his or her favourite sport directly from the menu.

4.4 RadioText (RT)

The RT feature is primarily designed for the broadcaster to transmit text messages of up to 64 characters at a time, for display by the fixed-location home receivers. As shown in Figure 4.4, RadioText uses blocks 3 and 4 in type 2A groups or block 4 in type 2B groups to transmit text messages of up to 64 and 32 characters, respectively. A further four bits in block 2 are used as address bits, and one bit is used as a Text A/Text B flag which toggles every time a new message is transmitted.

The message is transmitted four characters at a time in the type 2A groups and two characters at a time in the type 2B groups. The text is coded in

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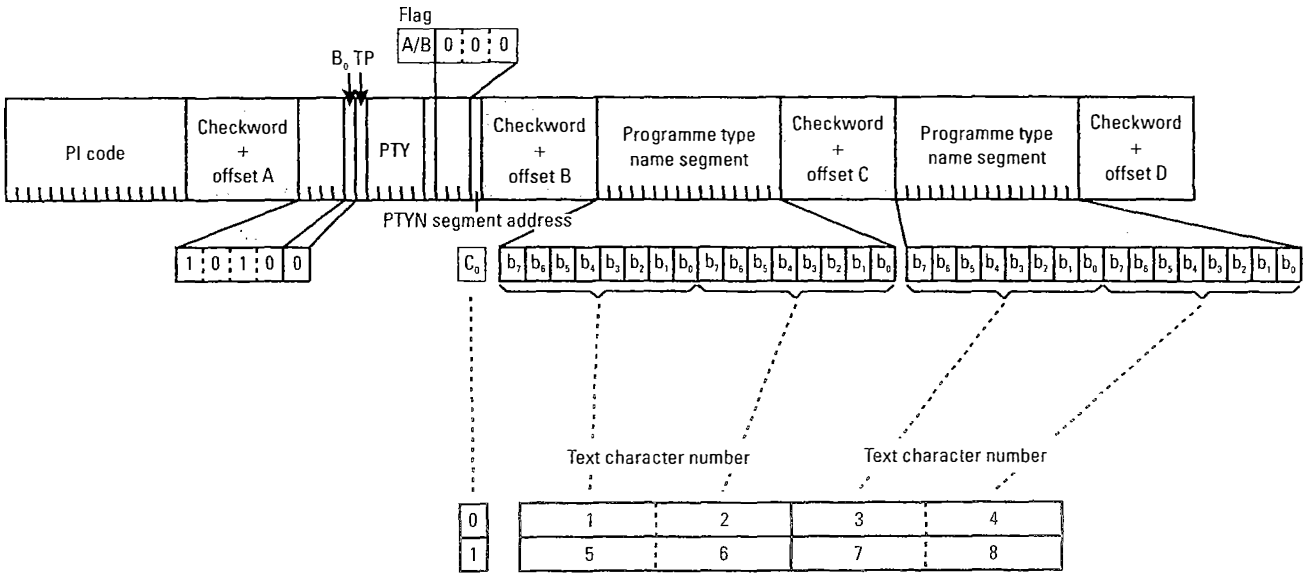


Figure 4.3 Type 10A group, showing the PTYN bits. (*Source:* EBU.)

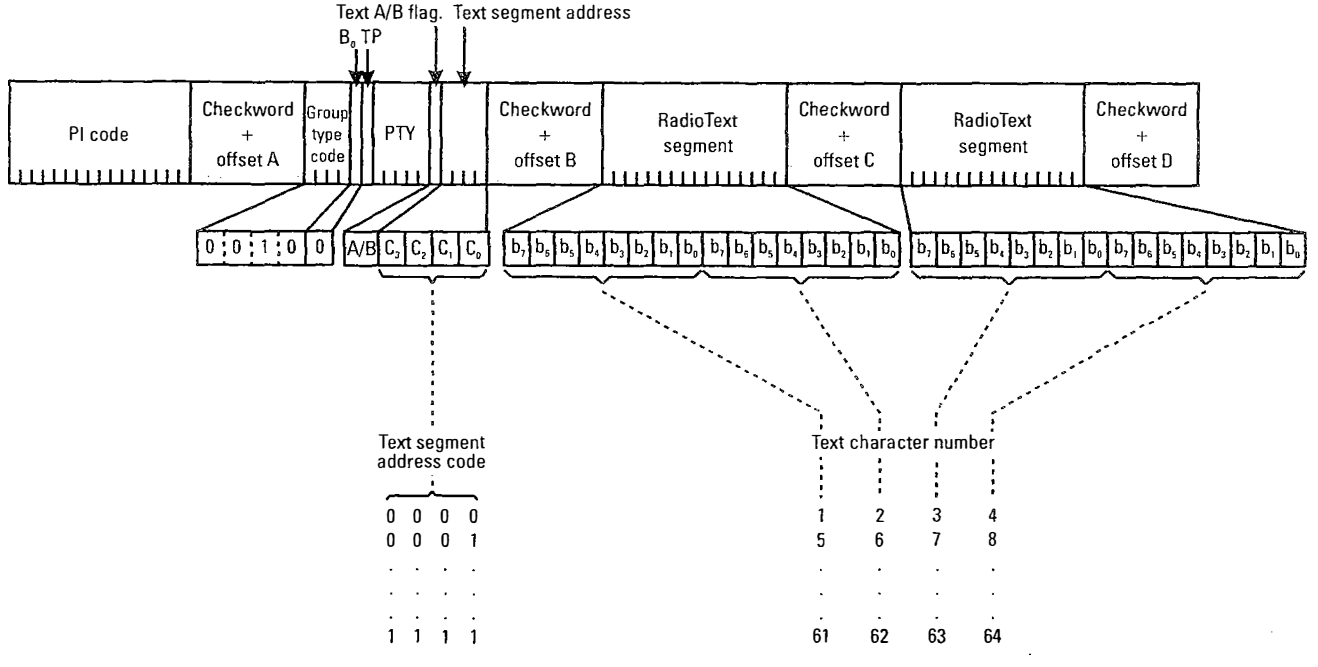


Figure 4.4 Type 2A groups showing the disposition of the RT feature. (*Source:* EBU.)

accordance with the character tables given in the RDS specification, Annex E. Some of theses codes are reproduced in Appendix I.

A RadioText message is compiled by the broadcaster and then downloaded to the RDS encoder, which will manage the transmission of the message, repeating it cyclically in sequence using at least one type 2 group per second for as long as the message is valid. When a new message is sent, the Text A/Text B flag is toggled to the opposite state and the new message sent, starting with address segment /0000/ and using as many segments as required up to 16. If the message requires fewer than 16, the message must terminate with the code 0D hex (carriage return). When a new message is sent, it is recommended that the repetition rate of type 2 groups be increased to three or four per second for at least the first two cycles of the new message. The Text A/Text B bit *must* remain static until a new message (i.e., message with new content) is sent.

To allow time for a receiver to receive, decode, and display a message, and to allow time for it to be read by the user, it is recommended that messages generally be changed no more frequently than about once every 10 seconds. This assumes each is transmitted at least twice—and type 2A groups are transmitted at the rate of three per second.

Although the primary responsibility for presentation of the message rests with the receiver manufacturer (who should tailor the presentation to suit the display provided), a number of control characters may be included within the text. They have been defined to have specific meanings, which manufacturers may choose to adopt if desired. As noted above, the 0D hex code is used to indicate the end of a message. Additionally, the code 0A hex is used to indicate a preferred line break. This marker indicates positions in the message where the author of the text would prefer a line break to occur in order to structure the text in a particular way. It is primarily useful for multiline displays. It may stand in place of a space character in the text string. Receivers choosing not to use control code or 0A hex should substitute a space at the position of the control code when displaying the message. A space should be substituted by the receiver display for any other unrecognised character.

Of course, receiver displays vary enormously, ranging from a single eight-character display on many RDS receivers to the display possibilities afforded by PC monitors or LCD screens. Because of the wide range of display types possible, it is up to the receiver manufacturer to develop software to optimise the presentation for the particular display chosen. For example, multiline displays should use normal word processing techniques to provide word wrap (to prevent breaking a word wherever possible). Such displays will need to accommodate more than 64 characters to allow for word wrapping and still show the message completely.

Similarly, displays with less than 64 characters, which rely upon scrolling the text to show the complete message, should apply intelligent routines to present the message in the best possible way. For example, receivers could remove unnecessary spaces inserted by the broadcaster as padding before display to prevent users scrolling through strings of blank spaces. If the resultant text length is shorter than or equal to the number of characters in the display, the display could show the message statically, without scrolling.

A RadioText message should be received in full *before* it is displayed. A receiver will know when a message is complete because it will be terminated by an 0D hex code or all 16 segments will have been sent. When a change in the Text A/Text B (new message) flag is detected, the receiver should begin to acquire the new message, which, when complete, should replace the former message, erasing it *entirely* from the display.

The RadioText feature can provide a wide range of additional information to the listener, including radio station information, such as telephone numbers, and programme-related information such as the CD numbers of the music being played, as shown in Figure 4.5. As a result, the safety issue of car receivers must be carefully considered, and some manufacturers are beginning to offer RT displays in car receivers. In this case, it is particularly important that users in vehicles are not distracted by RadioText messages. For example, users are permitted to switch RadioText deliberately "on" while "off" should be the default mode.

4.5 Decoder Identification (DI) and Programme TYpe Identification (PTYI)

The DI feature is used to indicate to the RDS receiver different operating modes to switch individual decoders on or off. The dynamic PTY indicator feature is used to indicate if PTY codes in the transmission are dynamically switched by the broadcaster. These two features are suitable for PTY-STANDBY and PTY-STORE modes of operation. (see Section 4.2).

DI is coded using a total of four bits, sent one bit per group over a *four group sequence* carried in type 0A, 0B, and 15B groups, in the same positions in each type.

The DI segment bit itself is carried in block 2, and the segment address is shared between PS and DI in two bits, as shown in Figure 4.6, to indicate which actual bit—d_0, d_1, d_2, or d_3—is being signalled in that particular group. At the recommended repetition rates, the status of each DI bit is signalled at

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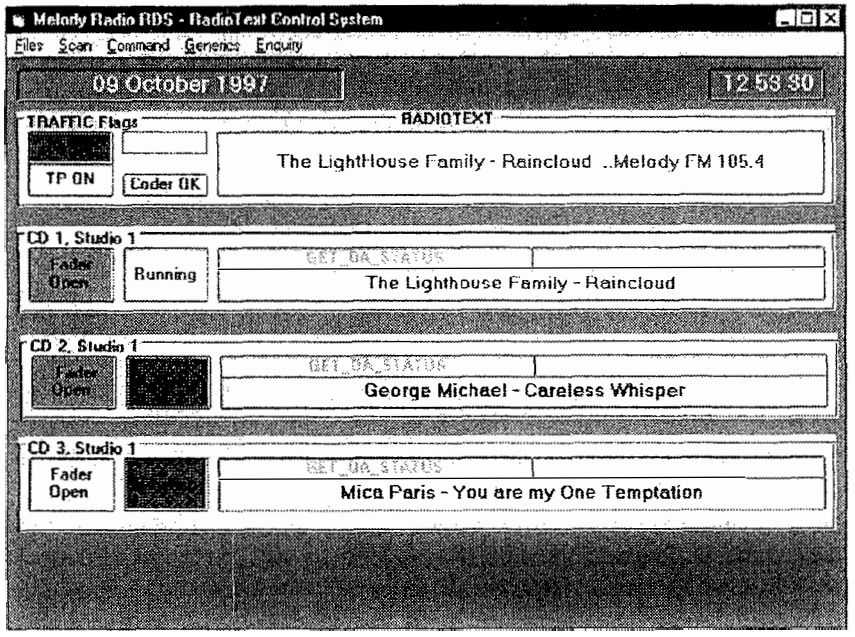


Figure 4.5 RadioText computer display: showing on-air RT messages and those cued for transmission. (*Source:* EBU.)

least once per second. In the case of type 15B groups, the segment address is solely used for DI addressing, as shown in Figure 4.7.

Table 4.3 shows the meaning of the DI bits. To date, bits d_0, d_1, and d_2 have not been popular with broadcasters. But some broadcasters have chosen to indicate that certain programmes (e.g., news) are signalled as mono by the d_0 bit, to allow a receiver to optimise audio performance.

However the RDS specification EN 50067:1998 now describes the use of the d_3 bit, which is assigned to signal static/dynamic PTY status. This helps an RDS receiver to assess the transmission and therefore determine how it will perform [1]. A broadcaster setting this bit to 1 is informing the receiver that the broadcaster has in place the infrastructure to manage and control the PTY codes broadcast on that and/or EON cross-referenced services. This will help prevent a receiver from remaining in PTY-STANDBY mode and staying indefinitely on a service that does not control PTY code switching. If d_3 is set to 0, the receiver should inform the listener that PTY-STANDBY mode is unavailable on that service—this can be done, for example, by displaying the information >No_Stby_<.

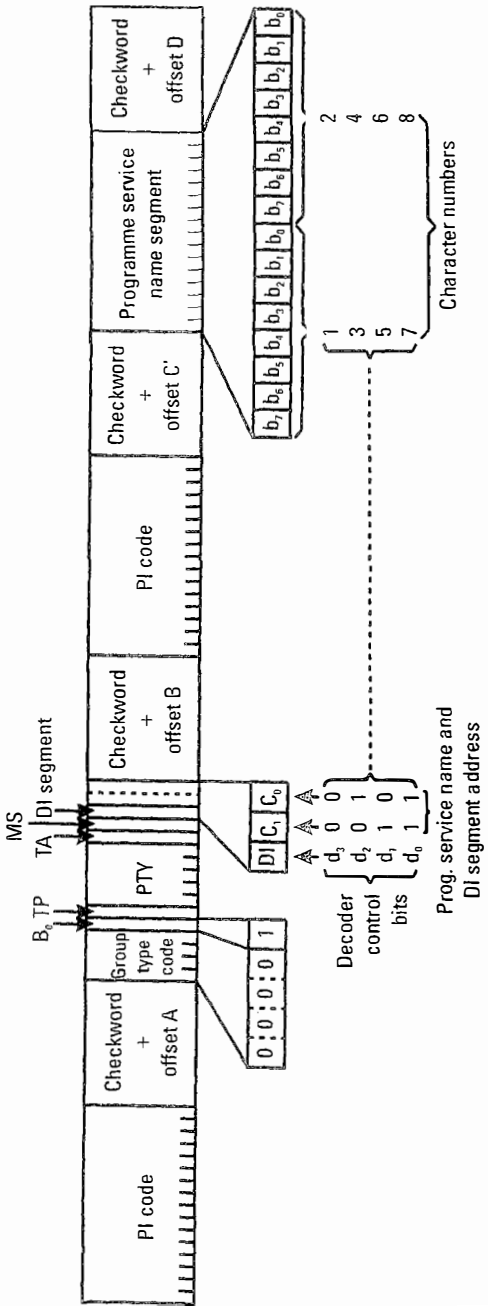


Figure 4.6 Type 0B groups, showing the DI segment and shared segment address bits. (*Source:* EBU.)

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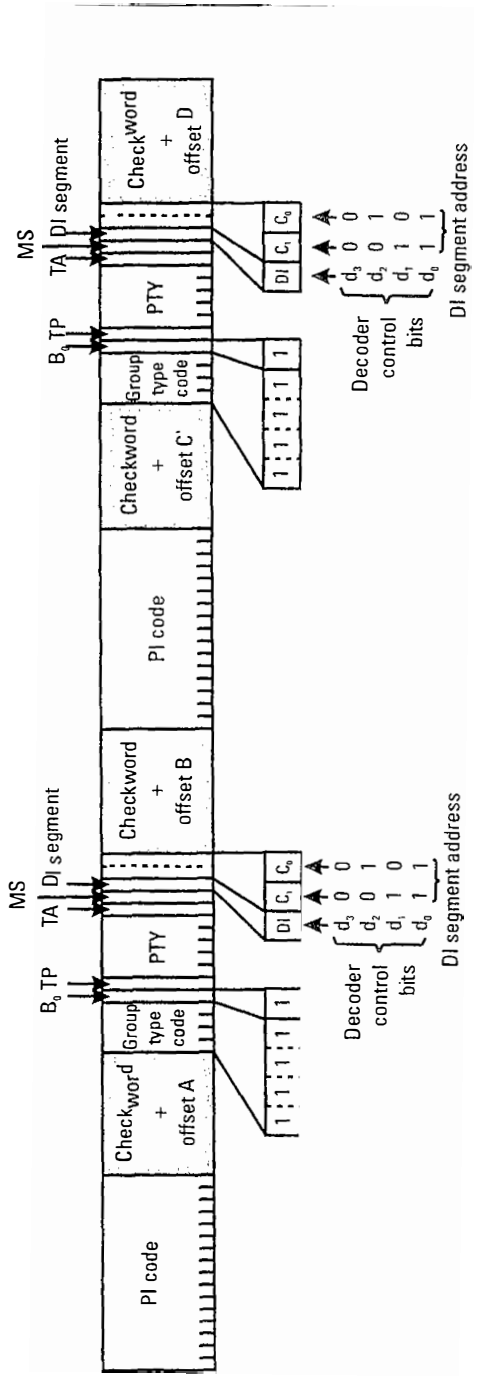


Figure 4.7 Type 15B groups, showing two DI segment address bits. (*Source:* EBU.)

Table 4.3
DI Bits: Meanings

Bit	Set to 0	Set to 1
d0	Mono	Stereo
d1	Not artificial head	Artificial head
d2	Not compressed	Compressed
d3	Static PTY	Dynamic PTY

Dynamic PTY indicates that the PTY on the tuned service or PTY referenced in type 14A groups, variant 13, is assessed at programme junctions and may be switched.

4.6 Programme Item Number (PIN)

The PIN feature is a machine-readable code assigned to each programme or programme item. Taken together with the PI code, it provides a unique reference for every programme. It may be used to automate receiver switch-on and/or recording.

PIN is encoded as 16 bits in block 4 of type 1 groups. The code may also be carried in variant 14 in the type 14A groups (EON) from transmitters cross-referencing this programme service. The PIN code expresses the published, scheduled start time of the programme, using the first five bits to represent the day of the month, the next five bits the hour, and the final six bits the minute, as shown in Figure 4.8.

The PIN feature should be transmitted at the rate of at least once per minute; however, when a programme number changes, the repetition rate of these groups (and the corresponding type 14A groups in other services) should be increased to transmit a burst of at least four groups in order to aid receiver responses.

So that the PIN may be used to properly control switch-on and automatic recording of programmes, the PIN code should accurately follow the on-air audio programme to take account of schedule changes or programmes overrunning their scheduled time. Valid PIN codes are those that have date information in the range 01–31, hours in the range 00–23, and minutes 00–59. Values outside the ranges indicate that no valid PIN code is being transmitted.

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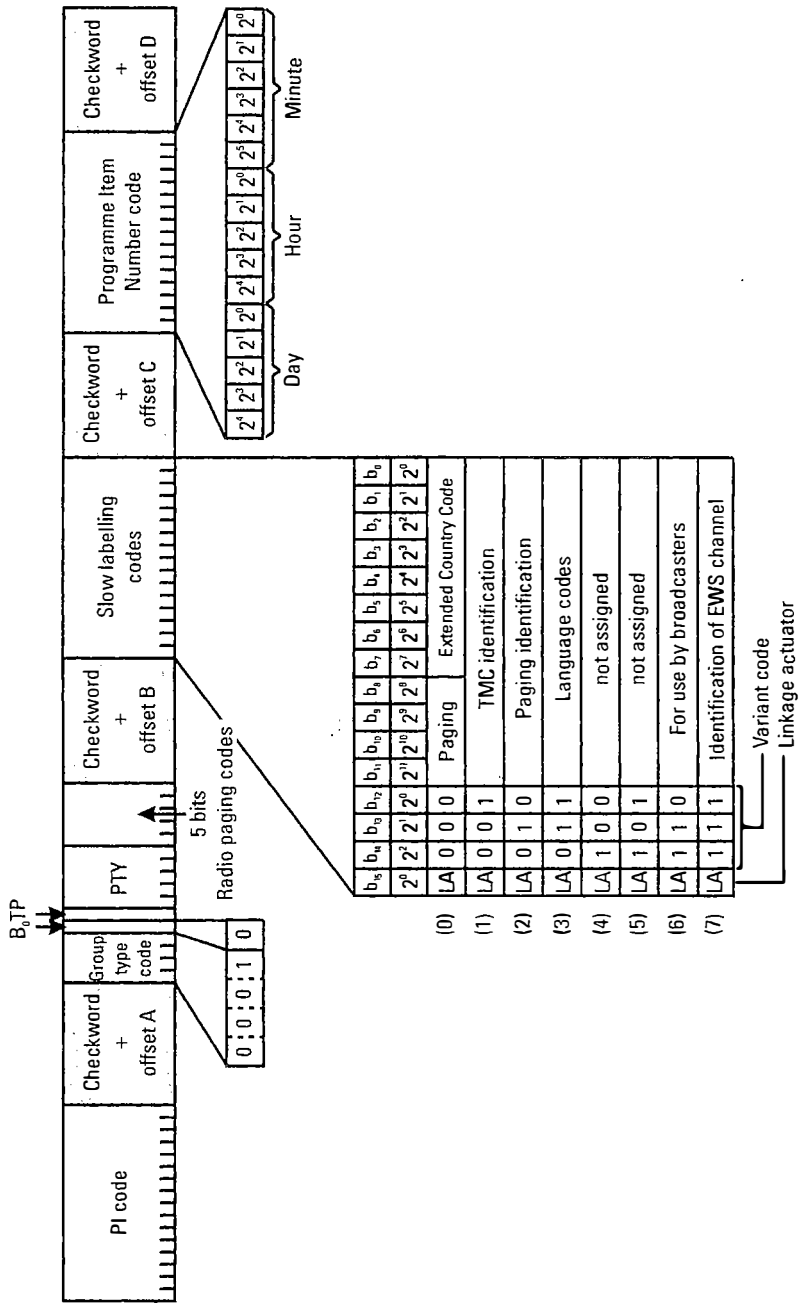


Figure 4.8 Type 1A group: showing the PIN feature in block 4. (*Source*: EBU.)

Although implementation of the PIN has generally been very slow to come to the market, it could be used as a feature that equates to radio on demand by allowing the listener to enter a PIN into an RDS receiver/cassette unit that could then record a programme for later recall. The PIN may be implemented in a receiver in a similar way to the PTY used in the PTY-STANDBY mode. In this case, it would be important that the scheduled start times published for programmes are presented consistently in all journals and programme guide listings so that the user can accurately enter programming, thus ensuring that the right program is recorded.

References

[1] EN 50067:1998-Specification of the Radio Data System (RDS) for VHF/FM sound broadcasting in the frequency range from 87.5 to 108.0 MHz.

[2] EIA/NAB-National Radio Systems Committee: United States RBDS Standard Version 2.0, Specification of the Radio Broadcast Data System (RBDS), 1997.

[3] EBU /RDS Forum: BPN 009-Radio Data System (RDS) Guidelines, to be published in Autumn 1998.

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5

Additional Information Features

5.1 Introduction

This chapter explores several optional RDS features originally developed to widen the information-carrying ability of the Radio Data System. The original developers realised that once an RDS receiver was designed with an eight-character display, some additional features could be added very economically, such as the Clock Time feature. RDS is also ideally suited for carrying other features requiring very low data capacity needs, such as the in-house and emergency warning systems, which are intended for special closed user group purposes.

However, the most important additional information feature, added to the RDS standard in 1992, is the EON feature, which has the amazing ability to keep an RDS receiver fully informed about other transmissions and help the receiver tune to those transmissions for services previously requested by the user.

5.2 Clock Time (CT)

The Clock Time feature is designed to enable a receiver to set and maintain accurate time and date, both for display and for control purposes. Clock Time is transmitted in a type 4A group using a total of 34 bits, as shown in Figure 5.1. A single 4A group is transmitted once per minute, inserted into the dynamic RDS multiplex data stream so that the minute edge will occur within ±0.1 seconds of the end of the Clock Time group. If transmitted, Clock Time

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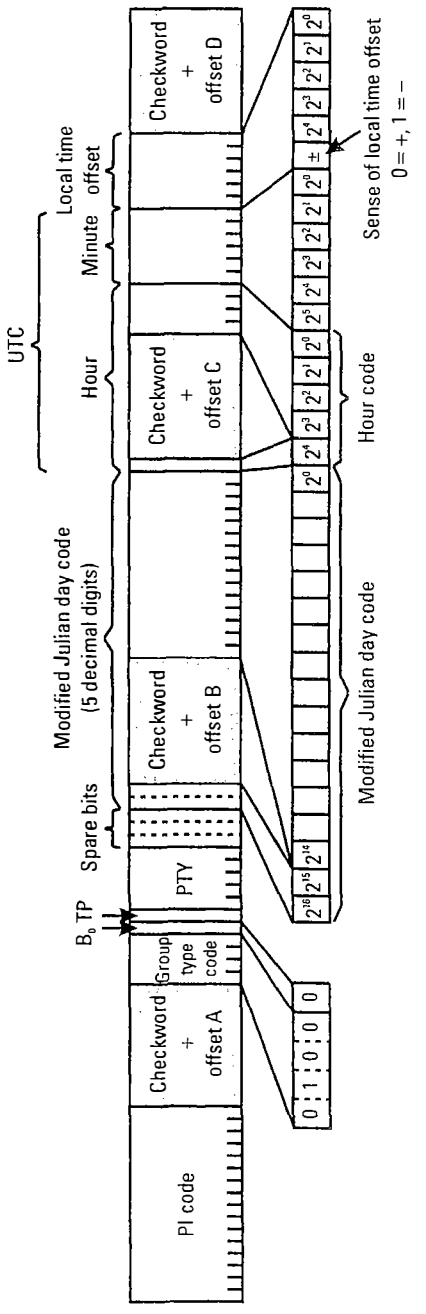


Figure 5.1 Type 4A group, showing the bits used for the CT feature. (*Source:* EBU.)

information must be accurately set *and* maintained. The CT information relates to the epoch immediately following the start of the next group.

Clock Time is expressed as coordinated universal time (UTC) plus local time offset. The local time offset is *expressed in multiples of half hours*, in the range −12 hours to +12 hours, and is coded as a six-bit binary number. The sense of the offset is indicated by a single bit, where /0/ = positive offset (east of zero degrees longitude) and /1/ = negative offset (west of zero degrees longitude). For example, 15.00 hours during the summer in the Central European time zone should be expressed as 13.00 hours (UTC) and have a positive offset of 4. Special care should be taken with the offset values when changing from daylight savings time (summer time) to winter time and vice versa to ensure the accuracy of transmitted data.

The date is expressed in terms of a modified Julian day. Note that the date changes at midnight UTC, not midnight local time. Conversion of time and date conventions are all described in Annex G of the RDS specification EN 50067:1998 [1]. It is noted that the formulae are applicable between March 1, 1900 to February 28, 2100.

As CT must be accurate, it is usual for a broadcaster to synchronise their CT transmissions to one of the national or international time references such as DCF (77.5 kHz) in Germany or MSF (60 kHz) in England. These time references are available over wide areas and relatively simple, highly reliable receivers can be installed wherever there is an RDS encoder—to feed it with an adequately accurate time code signal. When accurate time reference is lost, RDS encoders should automatically suppress transmission of type 4A groups—or they may set all bits to zero—until an accurate time has been reestablished.

Clock T is transmitted infrequently (only once per minute), and is not intended for direct display use by a receiver. The CT feature is used to set and update a free-running clock provided in the receiver. The receiver should usually present the user with a display of the local time by calculating it from the UTC data and the offset information. It is essential that the free-running clock continues to function without regular type 4A groups being received. For example, a user may choose to listen to a service not providing CT information, but he or she would still expect the clock to continue to display the correct time.

RDS receivers will often be operating in areas where reception of programme services in two different time zones is possible. Some portable receivers have implemented an update on/off switch to disable automatic updating of the clock by CT. This is done to avoid the clock showing different times, depending upon the tuned service.

The CT feature must be implemented to support some other RDS features. Both Radio Paging (see Chapter 8) and Traffic Message Channel (see Chapter 7) require CT as specified in EN 50067:1998, and some Open Data

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Applications (ODAs, see Chapter 9) may also require CT to be implemented [1].

5.3 Enhanced Other Networks (EON)

The EON feature was designed to allow RDS to become "intelligent," especially from the perspective of large network broadcasters (e.g., the ARD companies of Germany, the BBC in the United Kingdom, and Swedish Radio) that each operate several national radio networks.

EON information allows the updating of a considerable number of features: AF, PIN, PS, PTY, TA flag, TP identification, and linkage information for programme services other than that of the currently tuned service. According to the features supported by the broadcaster and the RDS capacity available, some or all of this cross-reference information may be included. It is intended to allow the broadcaster to cross-reference information about *all* his or her services and, if mutual agreement can be reached, also about the services of *other* broadcasters.

EON information is transmitted in type 14 groups, which has 16 variants identified by four bits in block 2. The information itself is carried in block 3 of the group, and block 4 carries the PI code of the service to which the data in block 3 relates. This is shown in Figure 5.2. The variants may be transmitted in any order, but the repetition rate of these groups is arranged so that all data for all cross-referenced services is transmitted within a maximum of a 120-second cycle. Not more than 20 other services should be cross-referenced by any one service. This limit and the maximum 120-second cycle time are important factors in EON receiver design for achieving timely responses. In most areas, the total number of services available will not exceed 20. As a receiver changes location, the services within an RDS data stream may change, with new services being added and others removed; however, no more than 20 will ever be cross-referenced by EON from any one transmitter. By keeping note of the time since a service was referenced in EON, a receiver will be able to "mark for deletion" services that are no longer valid.

Each EON group is entirely self-contained so that the information can be used without reference to any other group.

Although type 14A groups are usually transmitted in a regular cycle, when the status of any information on a referenced service changes (e.g., PTY or PIN changes), three or four repetitions of each appropriate group type variant should be transmitted in rapid succession to assist an RDS receiver in responding quickly to the changed information, if required (e.g., for a receiver in the PTY-STANDBY mode).

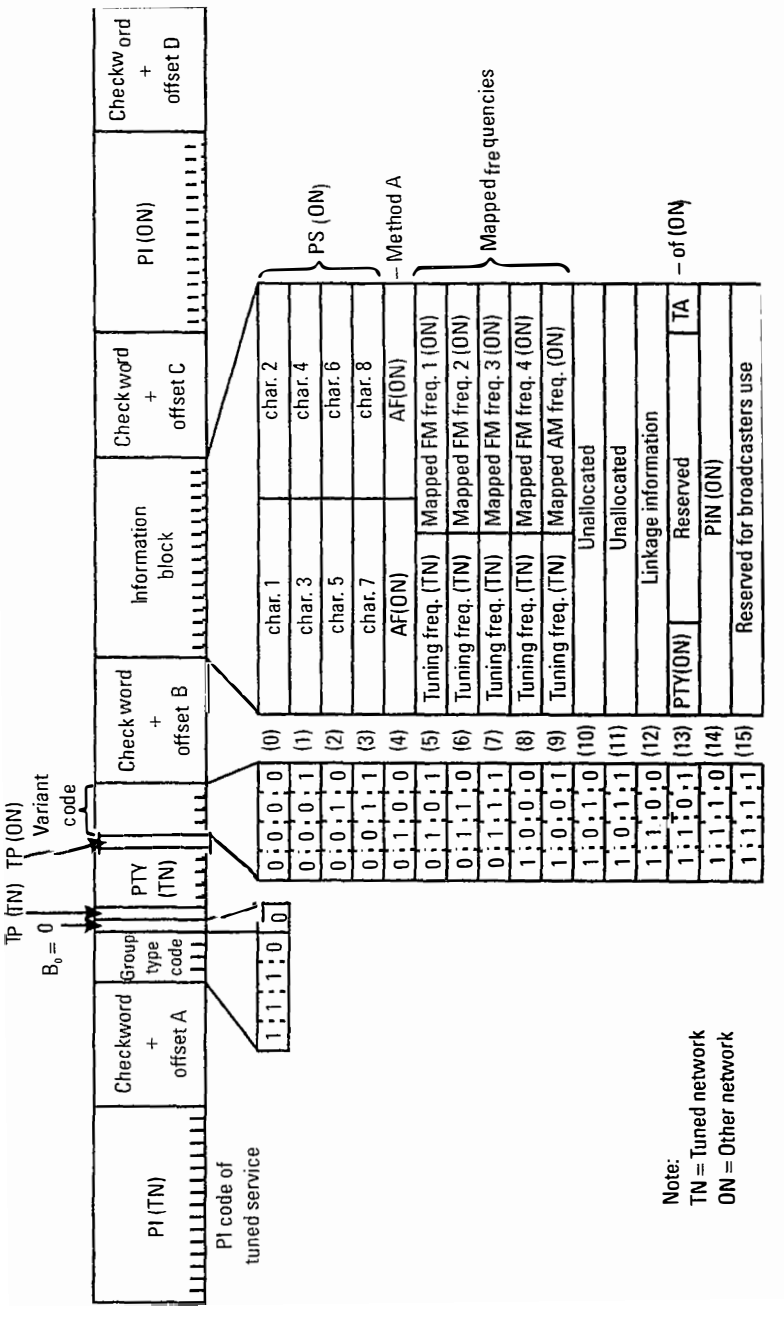


Figure 5.2 Type 14A groups: showing the many components contained (*Source*: EBU)

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A different mechanism is used to indicate changes in the status of TA flags of referenced services—the type 14B group (see Chapter 6).

5.3.1 Alternative Frequency Information

Alternative Frequencies of cross-referenced services are transmitted to enable an EON-capable RDS receiver to build up a complete frequency table for all the services in memory. This allows an RDS receiver to respond immediately to a request for another service already memorised on a preset button, even if the user is well away from the original transmission used to source the preset information. It can do this because it will have been updated in the background, thus avoiding a PI search that may take a considerable amount of time in the increasingly crowded FM band. There are two transmission methods specified to convey the AF information.

Method-A (using variant 4) is identical in structure to the Method-A coding used in type 0A groups for tuned network AFs (see Chapter 3). Although theoretically the number of AFs transmitted by this method may be as many as 25, it is common to restrict the number to only a few.

The mapped-frequency method pairs the frequency of the tuned service with the corresponding frequency of the referenced service with similar coverage areas. The tuned service frequency is transmitted as the first byte in block 3, and the frequency to which it is paired is transmitted as the second byte. Each frequency in the tuned network AF list is paired in turn with the corresponding frequency for every other service being referenced. This method provides enhanced performance whereby a broadcaster transmits several services at the same powers, from the same transmitter masts. If a receiver is providing good reception of a service from one transmitter, it is usual to assume that switching to another service from that same transmitter will also provide good reception.

The mapped-frequency method uses variant 5 of type 14A groups to map one referenced service frequency to the tuned frequency. Occasionally, a frequency for the tuned network may be reused some distance away, and there may be more than one corresponding frequency for one of the referenced services. In this case, for the pairing of the second occurrence of the tuned frequency, variant 6 is used instead of variant 5. Use of this different variant explicitly indicates that more than one frequency is paired with this particular frequency in the tuned network AF list. Similarly, two further variants, 7 and 8, may be used to indicate a third and fourth frequency, respectively, in the exceptional circumstances that they are required.

The purpose of the Alternative Frequency information transmitted by EON is to ensure that a receiver maintains an up-to-date list or database of appropriate frequencies for all of a broadcaster's other services—not just the currently tuned one. This ensures that a receiver can switch quickly to the optimum frequency when a listener changes the preset selection. Figure 5.3 shows a conceptual model RDS receiver with a preset button memory array and additional "pool stores," which together use AF information derived from type 0A and type 14A groups. The PI codes and frequencies used are fictional but based on services available in the London area.

In the case of AFs transmitted by the mapped-frequency method, each frequency for a service is paired with one in the AF list of the tuned service. Because the receiver is presumably using the optimum frequency for the tuned service, it already "knows" the optimum frequency to use for the other service, should the listener choose to select the preset for it. In the case of AFs delivered by Method-A, although no direct correspondence exists, the receiver has only to quickly evaluate the AF list. Method-A lists delivered by EON are likely to be short, with no more than four or five frequencies, so evaluation of these frequencies can be almost instantaneous.

5.3.2 PIN and PTY Information

It is necessary to provide an EON-capable receiver with other information to enhance the performance; the "intelligence" that EON brings and which can be used to allow current listening to be interrupted by information or programmes from other services.

PTY is signalled in type 14A group, variant 13, and PIN in variant 14. Changes to either are indicated by immediately inserting three or four of the appropriate variants into the regular cycle of type 14A groups. This assists the receiver in responding promptly to changes, particularly when reception conditions are not perfect, which is usually the case since the repeated variants of type 14A groups increase the chance of "first time" decoding of the changed status of the feature.

When a receiver is in either PTY-STANDBY or PIN-STANDBY mode, a similar routine to that described above for EON traffic announcements should be followed (see Chapter 6). Switching to a programme should only occur at the start of a programme. Because the start (unlike traffic announcements) is not signalled by using a different group type, the start can only be reliably detected by monitoring and responding to a transition of PTY code or PIN received in type 14A groups.

5.3.3 PS Information

Perhaps the simplest EON feature is the inclusion of the PS feature carried in type 14A groups, variants 0 to 3, and the coding follows closely that used in the

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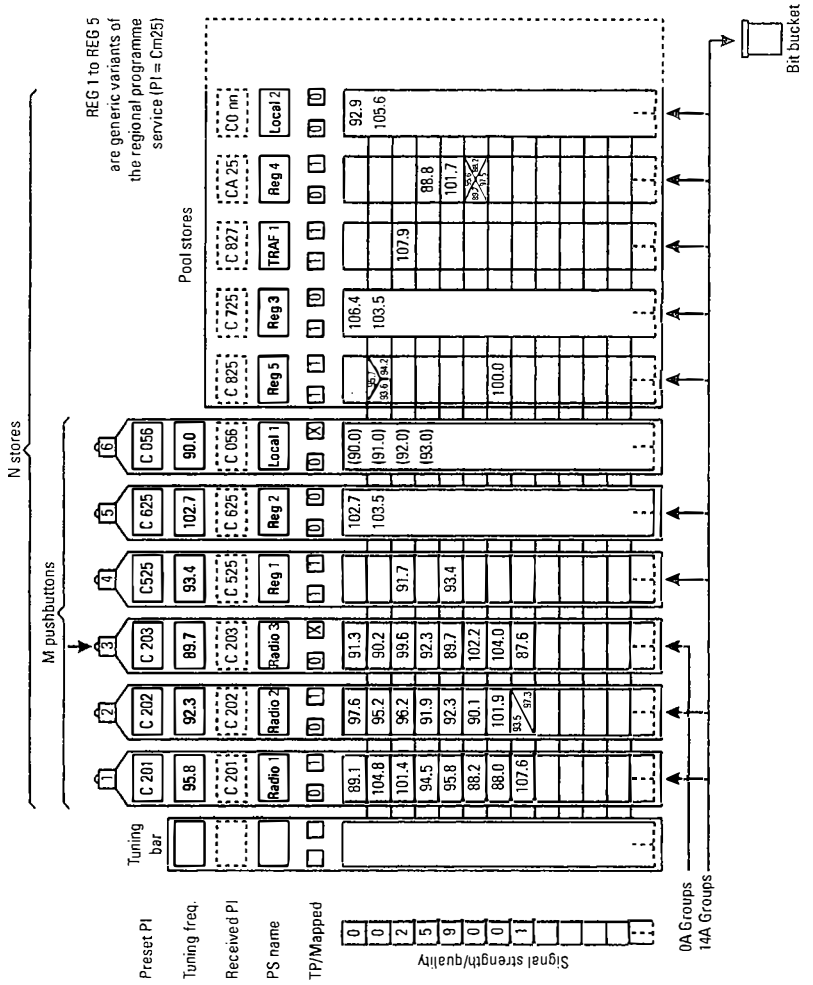


Figure 5.3 Conceptual radio with preset button and "pool store" memory. (*Source:* EBU.)

main PS feature described in Chapter 3. The eight characters are carried two at a time in these variants, so their display position is known to a receiver and they can be built up over the 120-second cycle period, to be placed in memory associated with any presets for instant recall.

5.3.4 TP/TA Information

Type 14A groups carry information in block 2 about TP flags of cross-referenced services in every group. Additionally, the type 14B group carries information about TA flags for cross-referenced services. Their use is described fully in Chapter 6.

5.4 In-House (IH) and Transparent Data Channel (TDC)

RDS can be used for completely nonprogramme-related data services, and these have been specified with the intention that consumer receivers do *not* respond in any way to their groups.

The IH data feature is reserved for data to be used solely by the service provider and/or transmission operator for their own applications.

In-House data is transmitted in the 37 bits reserved in the type 6A and 6B groups, as shown in Figure 5.4. The content of these bits is defined unilaterally by the service provider and/or transmission operator. The repetition rate is chosen to suit the application and available channel capacity.

Now that the RDS specification includes the ODA feature, the introduction of new data applications previously intended for IH or TDC should be considered carefully for registration as ODAs in preference to using these features, because the signalling associated with ODA is more flexible [1].

The Transparent Data Channel feature allows data to be sent to any of 32 addresses. The data is essentially free-format and may be for display, control, or computer applications.

TDC is transmitted in type 5 groups, as shown in Figure 5.5. Five bits in block 2 are used for up to 32 addresses. The data is carried as 16 bits in block 3 (type 5A group only) and 16 bits in block 4. The repetition rate for these groups must be chosen to suit the application, subject to maintaining a minimum rate for the basic RDS features.

5.5 Emergency Warning System (EWS)

The Emergency Warning System has been designed to take advantage of RDS FM transmissions—which already cover large broadcast service areas—to

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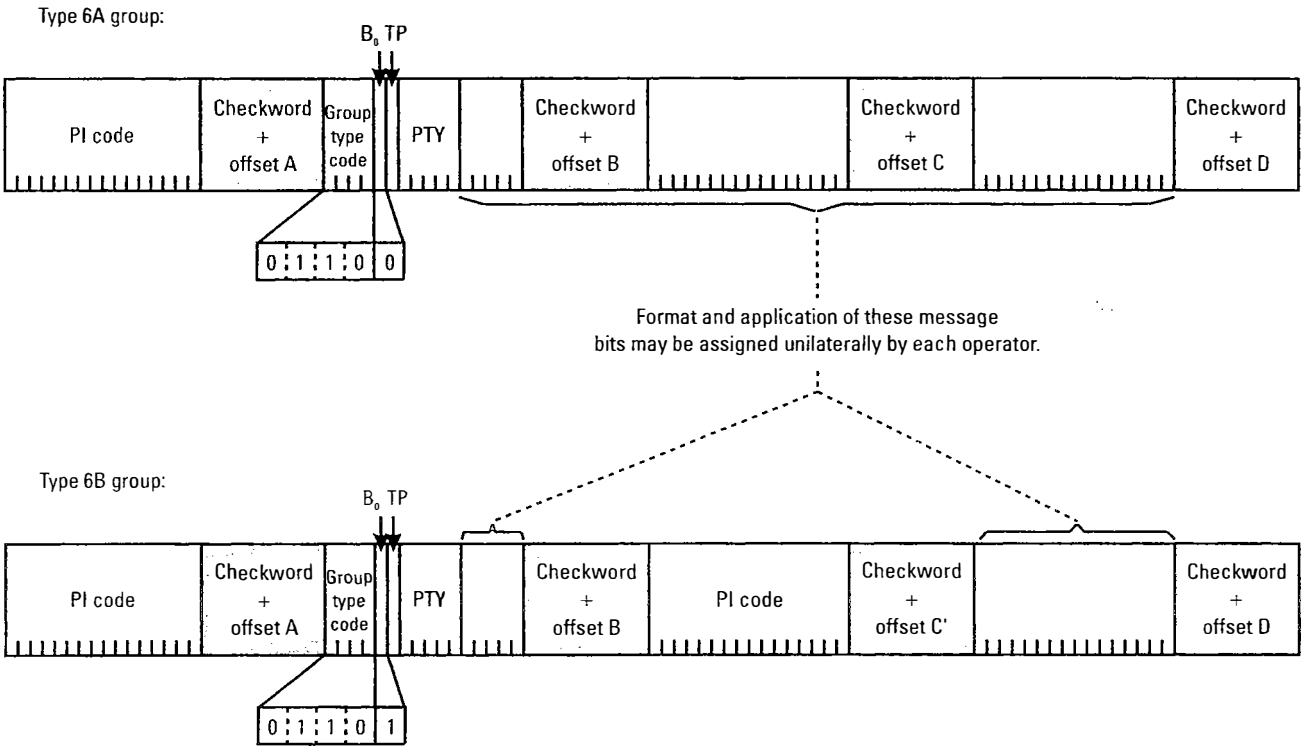


Figure 5.4 Types 6A and 6B groups, used for IH data. (*Source:* EBU.)

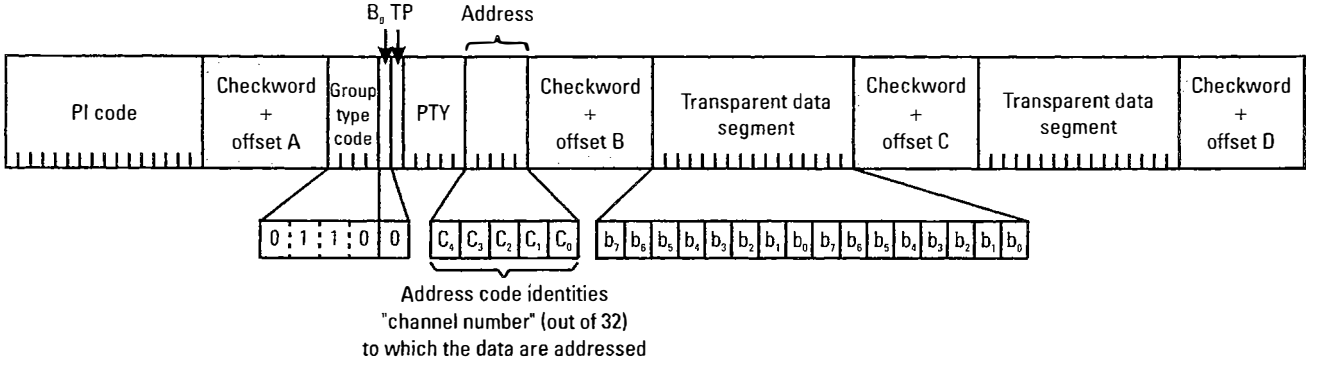


Figure 5.5 Type 5A group used for TDC, showing the addressing bits and data bits. (*Source:* EBU.)

occasionally convey emergency status data to specialised receivers. EWS data is carried in type 9A groups, which will be transmitted very infrequently unless an emergency or test transmission is required. The 37 bits in blocks 2, 3, and 4 are available for unilateral allocation in each country, as shown in Figure 5.6.

If the EWS feature is implemented, it must be signalled (say, once per minute) using type 1A groups, variant 7, and the transmission must also have the ECC feature implemented using type 1A groups, variant 0; these are shown in Figure 3.9.

References

[1] EN 50067:1998-Specification of the Radio Data System (RDS) for VHF/FM sound broadcasting in the frequency range from 87.5 to 108.0 MHz.

[2] EIA/NAB-National Radio Systems Committee: United States RBDS Standard version 2.0, Specification of the Radio Broadcast Data System (RBDS), 1997.

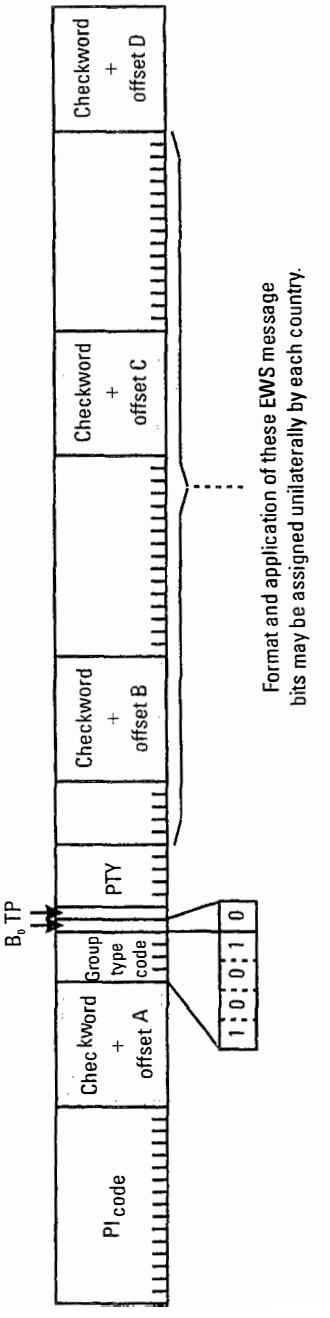


Figure 5.6 Type 9A groups used for EWS, showing the 37 available data bits. (*Source:* EBU.)

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6

Traffic Information Services

6.1 Introduction

This chapter brings together the features needed to provide both simple and more comprehensive RDS-based traffic services. It was noted in Chapter 1 that the TP and TA flags have their origins in an earlier signalling system known as Autofahrer Rundfunk Information (ARI). In essence, it was designed for FM broadcasting using a 57-kHz subcarrier to signal just two parameters, which are directly modelled by the TP and TA features in the RDS specification. Additionally, it included the ability to indicate regionalisation, which RDS provides in the PI feature [1].

The fundamental aspects of the TP feature, which is used as a key tuning feature, are explained fully in Chapter 3. In this chapter, the use of both traffic service flags, TP and TA, together is explored. Then, an improved application of the RDS traffic service is described using the enhanced other networks (EON) feature in conjunction with the TP and TA flags by using a driver scenario. This scenario covers the circumstances of generating and transmitting all the RDS features from several radio stations to make up an overall RDS traffic service for the user.

6.2 RDS Traffic Services: Using the TP/TA Features

The RDS traffic service, which uses both TP and TA flags, is designed to allow listeners to receive and hear traffic reports even if listening to a CD/cassette, or with the receiver volume turned down or muted. Some receivers make use of

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the flags to make an unattended recording of the traffic information, so it is ready for replay by the driver upon request.

The TP flag is carried in block 2 of *every* group type and in block 4 of type 15B groups. The TA flag is carried in block 2 of type 0A and 0B groups; additionally, the TA flag is carried in blocks 2 and 4 of type 15B groups. (See Chapter 3, Figures 3.1 and 3.2 and Chapter 4, Figure 4.1) The use of these flags, so-called because they can be set to either /0/ or to /1/, is shown in Table 6.1.

Broadcasters must *not* set the TP flag to /1/, unless the TA flag is *dynamically* controlled. Furthermore, broadcasters must only set the TA flag to /1/ while a traffic announcement is in progress, although it may be necessary for transmission operational reasons to set it a few seconds (perhaps no more than three seconds) before the announcement starts. Delays inevitably occur in both the broadcast infrastructure *and* in RDS receiver processing, such that up to about two seconds may elapse between a studio setting the TA flag and a receiver responding as described above. The traffic service identification jingle, which is played from a source that can be used to trigger the mechanism, is often used to provide the very short advance time required to achieve the flag setting.

Even more importantly, broadcasters should ensure that mechanisms are in place to monitor the status of the TA flag, to assist in resetting it to /0/ immediately after traffic announcements have ended. This is very important to ensure that RDS receivers, having been automatically controlled by the broadcaster, are able to return to their previous *listener* setting (such as CD listening).

When tuned to a frequency with an RDS data stream indicating that both TP = /1/ and TA = /1/, a traffic announcement *is* in progress, so an RDS receiver should pause CD/cassette listening and revert to tuner listening. It must also increase volume, if necessary, to a predetermined volume level to ensure the announcement is audible. This receiver aspect is easiest to understand as follows: the volume level setting is automatic in the sense that it will be set at whatever level it was set at while listening to a previous announcement.

Table 6.1
TP and TA Flags Meanings

TP	TA	Meaning
0	0	No traffic service possible at all on or via this service
0	1	Traffic service provided via one or more EON cross-referenced services
1	0	Traffic service provided on this service and also possibly via EON services
1	1	Traffic report in progress on this service

Users can then adjust the volume level for their normal traffic announcement listening requirements, which may be different from other listening needs.

6.3 RDS Traffic Services: Using the EON and TP/TA Features

The EON feature opens the opportunity to large network broadcasters to signal to RDS receivers that traffic announcements are available and may be receivable, and to provide the listener with these announcements, even though they are being transmitted on *another* frequency. The basic function of EON, described in Chapter 5, is to build up a database of information about other transmissions (over a 120-second period) and, if appropriate, to place it into receiver memory. In the case of the traffic service, EON is used to provide dynamic information to an RDS receiver so that it can act very quickly to retune to a specific frequency; it knows from the database where a traffic announcement is taking place.

Type 14B groups are transmitted only when there is a change in status of the TA flag of the referenced service. This is signalled by a minimum of four (and up to eight) type 14B groups transmitted within two seconds, with the objective of causing rapid switching by the receiver to a traffic announcement on another service. In order to improve reception reliability, these groups should be spread over the two-second period in order to avoid a contiguous burst of groups being lost due to multipath propagation. Figure 6.1 shows all the TP and TA flags in both the type 14A and 14B groups.

6.3.1 A Traffic Event Scenario

The EON traffic service therefore uses quite a complex set of interactions between information being transmitted in the background, which will take some time for an RDS receiver to acquire, and information that must be acted upon immediately. The following explanation of these interactions is based on the situation found in the southeast of England. In this area, the BBC uses a combination of national and local services to deliver the necessary data for the RDS receiver and the local services are used to actually make traffic announcements on a regionalised basis. These transmissions cover county-based areas (a county is an administrative area that can normally be traversed in about 60 minutes of driving time). This arrangement offers relatively locally focussed information delivered by traffic presenters who have good knowledge about the area they are covering. This explanation is fictional but uses a broadly realistic idea to describe the interactions and includes some clever strategies used by the broadcaster to achieve an economic signalling system [2].

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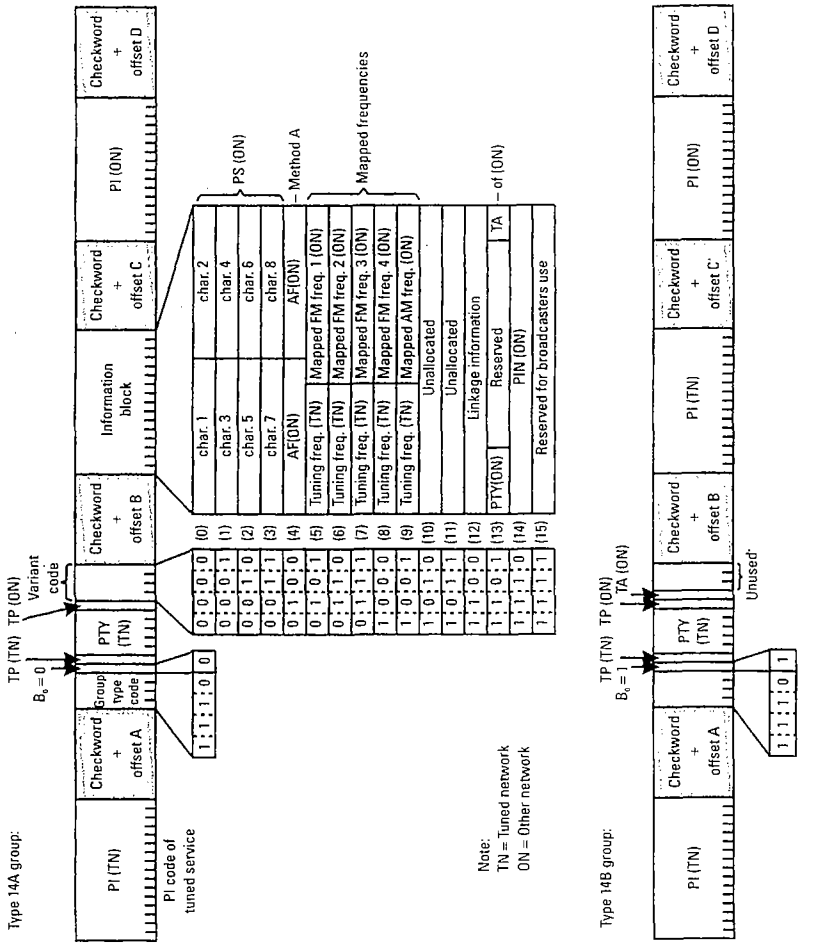


Figure 6.1 Type 14A and B groups: showing the all the traffic service flags. (*Source:* EBU.)

Figure 6.2 shows the scene in the southeast of England with a driver leaving Folkstone, near Dover, and travelling towards London via Maidstone. Our driver (1) is using his EON-capable RDS receiver to listen to a BBC service from the Dover transmitter (2). This transmitter actually transmits R2, R4, and Radio Kent. Our driver is now listening to BBC R4—the national news and current affairs network, which has transmitters all over the U.K.

The driver plans to use the Motorway M20 for his route, but an accident occurs on the M20 between Folkstone and Maidstone before he leaves the Folkstone urban area. He needs to know about this problem rather quickly in order to replan his route and take another road towards Maidstone. An event of this sort will quickly be attended to by the local traffic police patrol in a car that allows them to be in radio contact with their control room (3). The police will radio details about the event to the control room and, in this case, they will have to shut the motorway in the London-bound direction until the accident can be safely cleared.

The police control room will have a busy time managing an incident of this sort, but they realise that the various traffic and travel information (TTI) service providers need to be informed quickly about the event. Depending on the time of day, radio stations in the area use different TTI service providers,

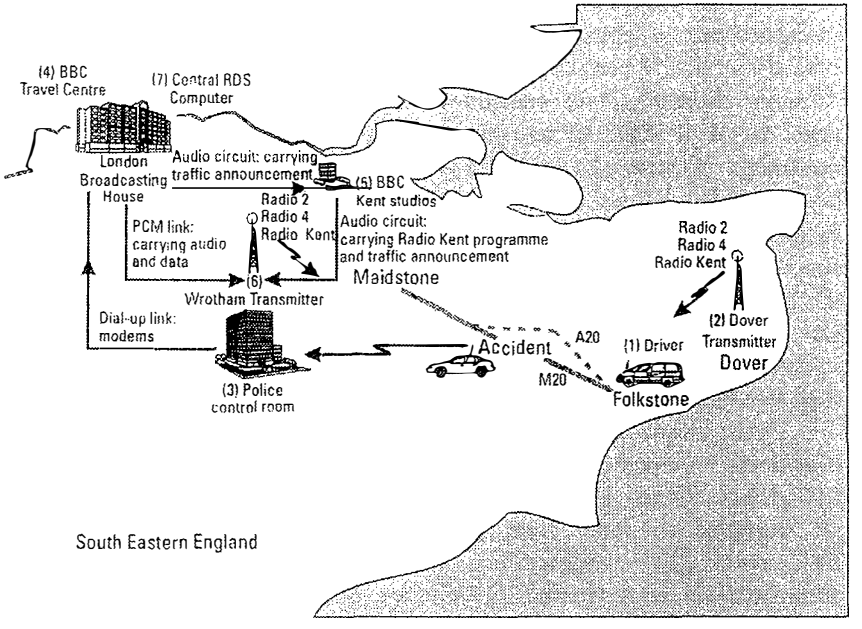


Figure 6.2 RDS EON traffic service in operation. (*Source:* EBU.)

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including the BBC Travel Centre (4), based at Broadcasting House in London, and the Automobile Association Roadwatch service. In order to keep this example clear, it is assumed that the BBC Travel Centre is informed about the accident by the police control room. The information may be sent to the traffic presenter by dial-up modem link, fax, or a phone call, but this will depend upon operational circumstances.

So, now the BBC Travel Centre is aware of the accident and they will talk to the Radio Kent on-air studio to agree on the timing for a suitable traffic announcement to be broadcast. This announcement may be held for a few minutes until a suitable programme break occurs and, until a scheduled traffic announcement time slot comes up, or it may be given urgent status. In any case, the Radio Kent presenter will hand over control to the traffic presenter, who then can give the traffic announcement to Radio Kent listeners. It is already known that there is a Radio Kent transmitter near Dover, and there are others around the county to ensure good coverage, so the driver should be within range of a transmitter that will carry this announcement.

When a traffic announcement is being made with RDS implemented, the Radio Kent transmitters must have their TA flag set to /1/, but this will only help the user who is already tuned to a Radio Kent transmission, as described in Section 6.2. In this case, the driver is listening to Radio 4. However, he had preset his EON-capable RDS receiver to EON traffic service reception mode, so the receiver has already started to build up a database in memory from the BBC R4 service. When the driver started his journey, he was tuned to the BBC R4 service from the Dover transmitter (2). He may have already unknowingly made use of the RDS AF and PI features and been retuned to the Wrotham transmitter (6), also transmitting BBC R4. It does not matter which signal is being received, because both are carrying the background EON information. By now, the EON-capable RDS receiver has acquired considerable information about the BBC transmissions in the Kent area; indeed, it would know everything necessary in 120 seconds if good reception conditions are present. In this case, it needs to have acquired the data specifically about Radio Kent and either updated a preset button-related memory or placed the information in a pool store (see Figure 5.3).

Now, it is necessary to go back and look at the signalling systems used to provide both dynamic TA flag control and dynamic control of the EON type 14B groups. Firstly, assume that just as the starting traffic "identification jingle" is played, the Radio Kent on-air studio sends a command signal to the BBC central RDS computer (7) to indicate the situation: "BBC Kent traffic announcement starting now." (A message of this type has to be generated by every on-air studio that is designed to control the system so that traffic announcements can still be voiced by service providers from outside the BBC,

who are feeding their audio into BBC on-air studios.) The central RDS computer receives this message and places it into a complete database of all BBC RDS data. From this database, the computer is able to generate appropriate update messages for RDS encoders wherever they may be. This is done by a suitable addressing system (see Chapter 11 for more details of studio to encoder communications and the UECP). These update messages are sent to all possible transmitters, including the Wrotham transmitter site in North Kent (6).

6.3.2 Clever Signalling

At this point, it is desirable to take a short diversion from the story and discuss the data circuits that are used, because this is where a clever use of RDS comes in. Between BBC Broadcasting House and the main transmitter sites such as Wrotham (6), there are wideband digital distribution circuits capable of carrying many audio channels and data. Thus, the Wrotham site has transmitters for the national services, fed by high-quality audio from London, and dynamic RDS is directly controlled from the central RDS computer. But the BBC Radio Kent transmitters at Wrotham and Dover, giving the county coverage across Kent, do *not* have direct control from the central RDS computer. For example, the Dover transmitter receives RDS update data from off-air RDS signals by using an off-air receiver tuned to BBC R2 and then decoding the EON data about Radio Kent. The RDS decoder is connected to the RDS encoder, and this in turn is commanded to change the TA flag on the local Radio Kent transmission. Thus, the cost of data circuits is greatly reduced by this on-air signalling technique.

6.3.3 Update Messages Content

Now, consider the update messages and their content. The update command from the central RDS computer instructs encoders referencing Radio Kent as an "other network" to set the TA flag in Radio Kent EON groups, which results in the required transmission of up to eight type 14B groups within two seconds. This data is carried on-air to the Radio Kent transmitter at Dover, of course, and it is also transmitted on BBC R4 from Wrotham (6). In addition, it is transmitted on BBC R4 from Dover (2), which is a rebroadcast transmitter.

As a result, the driver whose EON-capable RDS receiver is tuned to BBC R4 somewhere in the Kent area and receiving an RDS data stream with EON information receives a specific vector command. The type 14B groups vector a receiver to a particular PI code, probably held in memory; if it is memorised, either in preset button memory or in a pool store memory, then associated alternative frequencies (AFs) will already have been noted for particular signal

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strength/quality. Thus, appropriate frequencies for Radio Kent are already known, and the EON receiver can just check the known frequencies for suitable signal strength and switch to the traffic announcement if the PI code match is satisfied. Once tuned directly to a Radio Kent transmitter for a traffic announcement, the receiver monitors the TA flag in the type 0 and 15B groups until it is set to /0/, whereupon it retunes to the original frequency and volume level setting.

Thus, the driver is able to hear the traffic announcement from BBC Radio Kent even though he had been tuned to BBC R4, and after the announcement the receiver is retuned back to BBC R4. He heard about the accident and diverted onto the A20 main road!

6.3.4 Receiver Reactions

An EON-capable RDS receiver will be controlled to give the listener a requested response by commands from the broadcaster. So, it must be certain that it does this well, and a number of steps should be followed when set into the EON traffic mode.

Cross-referenced services that provide traffic announcements are indicated as such by setting the TP (ON) bit (in block 2) to /1/ in the tuned service type 14A groups. This bit identifies the cross-referenced service as a traffic announcement service to the receiver, the purpose of which is to ensure that data for this service is stored in receiver memory prior to it being required for a traffic announcement.

The traffic announcement is on the service referenced by the PI code in block 4 of the type 14B group. The receiver should check the signal strength of the stored frequency for that service. If unacceptable, it should check, in turn, any others in the AF list for that PI and tune to the best frequency, if any others are receivable in that area. It should also check that the PI code matches that in block 4 of the type 14 B group, and then wait for a few seconds to establish that the TA flag has been set to /1/.

When a traffic announcement takes place, the broadcaster sends up to eight type 14B groups with the TA (ON) bit set to /1/ in rapid succession. Although a receiver only requires a single type 14B group to switch to a traffic announcement on the service indicated by the PI code in block 4, sending several groups increases the likelihood of detection by the receiver. To allow the receiver some response time to switch, these type 14 B groups should begin a few seconds prior to the start of the traffic announcement's spoken content. Of course, the TA flag in type 0A (or 0B and 15B) groups of the service providing the traffic announcement must also be set.

At the end of the traffic announcement, the TA flag in the traffic announcement providing service must be promptly cleared (reset to /0/). Optionally, type 14B groups with TA (ON) set to /0/ may be sent. They are *only* used by the broadcaster for internal network management purposes, which may be part of the complex scenario painted before to reduce the number of dedicated circuits within the transmission systems, to facilitate all the commands required.

References

[1] CENELEC, EN 50067:1998-Specifications of the Radio Data System (RDS.) for VHF/FM broadcasting, European Committee for Electrical Standardisation (CENELEC), 35B rue de Stassart, B-1050 Brussels, April 1998.

[2] Howe, P., "RDS-The Engineering Concept," BBC Radio, 1990

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7

Intelligent Transport Systems and RDS-TMC

7.1 Introduction

Since the European Commission has chosen the RDS-TMC as a priority technology to be introduced for the provision of traffic and travel information on the major roads within the European Union member states, those involved in transport telematics have given much attention to RDS. In this chapter, we explain the strategic and policy issues that surround RDS-TMC—the market trends for telematics equipment in general and RDS-TMC in particular. The resulting human/machine interface problems and safety aspects that this poses are also covered.

The objectives to be achieved, and the history of RDS-TMC development (which started some 15 years ago), are analysed. We can see that in spite of this long development effort, RDS-TMC is not yet meeting the expectations that the politicians had for this technology.

The standardisation and institutional implementation issues, together with the basic principles of RDS-TMC coding, are explained, with some examples that help to better understand the technical detail of how RDS-TMC works. We show aspects of existing RDS-TMC receivers and where the problems are in their implementation.

Finally, we refer to alternative technologies and services that make it possible to see RDS-TMC in a much wider context—that it is in a long-term development leading to a significant improvement of the infrastructures required to provide better information services to the mobile road users.

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7.2 Strategic and Policy Issues

In Europe, Japan, and the United States, huge transport telematics technology research and development programmes have been underway for several years. Their main focus is to coordinate the deployment of intelligent transport systems, which requires that a certain number of technical standards be developed. On the European level, this is undertaken by CEN (TC 278), CENELEC, and ETSI, and on a world level by the International Standards Organisation (ISO, TC 204), IEC, and the International Telecommunication Union (ITU). The term "telematics" is derived from the terms "telecommunications" and "informatics," and describes the fact that information processed by means of computers is being distributed to assist users to better cope with different transport modes for which the complexity, interdependence, and density is ever increasing. In other words, information and communication technologies are increasingly used to improve the delivery of general interest services [1]. Figure 7.1 shows one view of the telematics scene.

Traffic and travel information (TTI) is one of the general interest services that is being developed under these programmes. The use of RDS technology to deliver TTI messages within the European Union has long been recognised by the European Commission. This is in line with the resolutions of the European Conference of Ministers of Transport (ECMT) and the Council of the European Union, who have recommended, as a priority action, since 1995, the introduction of a new language-independent TTI service called RDS-TMC, where TMC means Traffic Message Channel [2, 3].

7.3 Market Trends for Telematics Terminal Equipment

The equipment we are particularly interested in is the RDS-TMC receiver—as part of a car radio designed to present improved traffic and travel information services to the end user. We are also interested in navigational units that can be autonomous or connected (also called dual-mode) to information services operated via mobile telephones (GSM), or RDS-TMC receivers for the dynamic updating of the route guidance information used on a particular trip.

The market potential for navigational systems can simply be considered as gigantic, and the evolution becomes obvious from the figures published in [5] and reproduced in Table 7.1.

We can note several trends. In Japan, this market is already very big, but the European and U.S. markets are following. In Europe today, the biggest market is Germany where two-thirds of all upper-class car models are already factory-fitted with navigational systems.

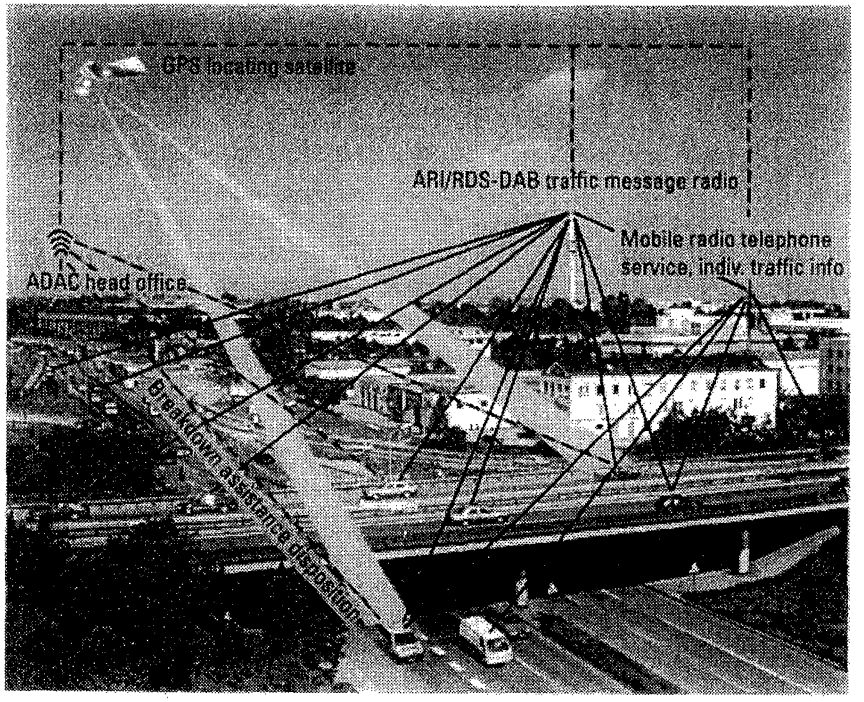


Figure 7.1 The German automobile club ADAC's view of a number of upcoming transport telematics road information services, among which is RDS-TMC. (*Source:* ADAC.)

Table 7.1
1995–2000, Number of Annually Sold Car Navigational Units

	1995	1996	1997	1998	1999	2000
In Europe	12,000	50,000	155,000	350,000	700,000	1,000,000
In Germany	12,000	40,000	110,000	200,000	320,000	500,000
In USA	5,000	20,000	200,000	500,000	—	—
In Japan	600,000	800,000	1,000,000	1,200,000	1,500,000	—

In 1997/98 alone in Japan, many of the navigational systems sold already had functionality for dynamic updating via the Vehicle Information and Communication System (VICS) using DARC FM-multiplex data broadcast technology. In Europe, similar systems first came onto the market in 1997, using

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RDS-TMC for the dynamic updating; however, GSM and digital audio broadcasting (DAB) are likely to be used as well before the year 2000.

We can also note another trend. In the past, traffic information receivers were essentially car radios for which there was a significant aftermarket—supported by more than 50 different consumer electronic manufacturers, mainly from Europe and the Far East, supplying a wide range of products.

Since RDS has been on the market, car manufacturers have tended more and more to integrate the car radio in conjunction with multifunctional displays on the dashboard, and these will be increasingly used together with other telematics functionality. Additionally, they order original equipment manufacturer (OEM) equipment meeting their own interface requirements, opposing any standardisation of these interfaces.

Most recently, the German mobile telephone provider Mannesmann-Autocom acquired VDO, a large company that manufactures vehicle instruments and car dashboards. Then it acquired Philips Car Systems, one of the major car radio manufacturers and also an important supplier of telematic terminals and navigational systems. All this indicates that the aftermarket for all these products may gradually shrink and that a number of different telematic systems, as accepted by the market, will coexist through telematics equipment that is delivered with the car to the end user. On the other hand, due to the rapid progress in telematics technology, it is reasonable to assume that the predicted lifetime of the terminal equipment will be significantly shorter than that of a car (11.5 years, on average, in Germany). This trend opens new opportunities for the shrinking aftermarket.

In Germany in 1996, 60% of the three million GSM telephones already in use were, according to a study made by the German automobile industry association VDA, in one way or another also used in cars, which means that 1.7 million cars in Germany are equipped with mobile communication terminals. Some 96% of the units sold in 1996 were handheld units, of which 70% were supplied with optional equipment for fixed car installation. There is also a trend to integrate a GSM telephone with the car radio [6].

In 1994, the TELTEN project of the European Commission estimated the probable market penetration for RDS-TMC receivers for two scenarios: an optimistic one and a pessimistic one. Estimated market penetration in motor vehicles within Europe for RDS-TMC receivers was, in the optimistic case, 2% in 1998, 10% in 2000, and 61% in 2005. In the pessimistic case, estimates were 1% in 1998, 5% in 2000 and 48% in 2005. The latter, translated into absolute figures, predicts for RDS-TMC a European market of 31,000 units in 1998, 235,000 units in the year 2000 and 2.3 million units in the year 2005 [7].

7.4 Safety Aspects of Presentation of Traffic and Travel Information in Moving Vehicles

As more and more in-vehicle services come to the market, equipment add-ons might not be as thoroughly researched as equipment fitted in factories. There is also reason for concern that multiple in-vehicle services might jeopardise safety. There can be many different devices that communicate, and that in turn will present new information to the driver, distracting attention from the traffic around the vehicle on the road. For example, using a handheld GSM telephone while driving a car is generally considered to be dangerous. A study conducted in 1997 for the German automobile club ADAC shows that even using a hands-free fixed telephone distracts a lot the driver's attention from the traffic, and statistics about driver behaviour have indicated that all sorts of mistakes are being caused by distracted drivers [8].

As we have seen, telephones, navigational devices, and RDS-TMC units will be increasingly used. In such a case, designers will have to give particular attention to human/machine interface aspects. It will be necessary to integrate several communication functions into the same unit; also, the same display in the dashboard for presenting the driver with stress-free information will be used. Driver information will be presented in sequence, and not simultaneously, about several of these functions: GSM information services to be called up or based on automatic call-back, navigational information, and RDS-TMC message presentation.

More and more types of in-vehicle equipment thus require interoperability studies to be conducted so that guidelines can be established to reduce stress and distraction to the motorist when driving. Although the ECMT and the EC are fairly active in researching these issues, clear European guidelines on these safety issues and related certification and labelling mechanisms did not exist before 1998 for transport telematics terminal equipment. However, in the United Kingdom, there is already a draft for development prepared by the Department of Transport, and in Germany, the public and private sectors have agreed on a code of practice on the functions and security of in-vehicle systems [9–11]. During 1998, this matter has received urgent EC-supported investigation and has become a key research issue.

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7.5 RDS-TMC

7.5.1 Objectives to be Achieved

The objective of RDS-TMC is to broadcast traffic and travel information (TTI) messages on VHF/FM broadcast transmissions using RDS. The messages are digitally coded in such a way that they are language-independent. The coding also permits users to receive only those messages that are relevant to their needs. Thus, it may be possible for a tourist to travel, for example, from London to Rome, through Belgium, Germany, Switzerland, France, and Italy, always getting the traffic announcements via RDS-TMC in his or her own language, the location codes being on a smart card that was purchased in London. But for this objective to be achieved, apart from a European standard specifying the system, a large number of harmonised administrative arrangements have to be agreed to among the countries concerned.

The TTI messages that are distributed will, of course, be conveyed to a variety of media that may include traffic announcements presented via speech synthesis in the language required. The messages will be filtered on the basis of criteria derived from the needs of the end user (e.g., location, direction, route). This filtering is aimed at enabling the user to receive only relevant information, selected from all the messages that are available on an RDS-TMC service at any given time.

The importance of filtering is demonstrated in this example. Given the maximum capacity of RDS-TMC, it will be possible to transmit about 300 different messages per hour. If the same messages were spoken and each only took 15 seconds, the total announcement time would be 75 minutes—an obvious information overload! In addition, RDS-TMC messages could be used to provide assistance for route planning, use of alternative transport facilities and routes, and dynamic updating of electronic maps and systems used for navigational aids.

In other words, RDS-TMC will be provided to simply give assistance to the question of how to get safely and efficiently from point A to point B.

7.5.2 History of the RDS-TMC Development

The possibility of using digitally coded traffic information within the RDS data stream was first mentioned by Bosch/Blaupunkt in 1984 at the Eurotravel conference in Grado, Italy. Bosch/Blaupunkt immediately started the technical development in Germany, and Philips in the Netherlands followed shortly afterwards. One year later, the European Association of Consumer Electronics Manufacturers, known then as Eurotech (now European Association of Consumer Electronics Manufacturers (EACEM)), proposed to the European Broadcasting Union (EBU) to support the development of the TMC feature, called at that time Comprehensive Information for Motorists (CIM).

The EBU accepted this offer and created a group of RDS specialists, in which the interested manufacturers participated. In 1986, Philips and Blaupunkt submitted a common proposal that became the basis for further development of the TMC transmission protocol, defined in the EC/DRIVE I project as ALERT-C in 1991. A list of events was first issued by the EBU, and by 1988, it already covered seven languages. The list, now extended, is standardised by CEN as prENV 12313-2, but only officially existed in 1997 in the so-called CEN "Euro-English" version. The translations to be used in the various member states of the EU were still under development or, in 1997, available as a draft through the FORCE/ECORTIS projects of the EC.

In the years 1992–1994, a number of RDS-TMC field trials (14 Euro-regional projects in total) took place as part of the EC/DRIVE II programme on advanced transport telematics to test the feasibility of the service. The experience gained was largely positive, so that in September 1995, the Council of Ministers, meeting in Essen (Germany), recommended the general introduction of RDS-TMC in all EU member states.

In addition, in the summer of 1995, the EC Directorate DG VII committed itself to financially support an action plan covering the years 1995–1999 that will stimulate with "seed money" the introduction of RDS-TMC (see Table 7.2, which gives the total budgets for all RTI projects, including RDS-TMC). Since 1996, DG VII agreed to fund several RDS-TMC implementation initiatives, among them two European projects (FORCE/ECORTIS and EDEN) and several Euro-regional (VIKING, CENTRICO, CORVETTE, SERTI, and ARTS) projects, as well as national

Table 7.2
European Commission—DG VII Budget Line to Support RTI Implementation

	DG VII TEN Budget Line Support (in Million ECU)					
	TEN-T allocation	Scenario as input to discussions with Financial Assistance Committee				
	Decision 95	96	97	98	99	95–99
Total for 14 priority projects	182	210	268	324	366	1,350
Traffic management	45	54	67	82	92	340
Other important projects	13	16	17	24	38	108
TEN transport budget line	240	280	352	430	496	1,798

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projects that all together involve Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. This led to many regional RDS-TMC implementations on important sections of the Trans-European Road Network (TERN), concerning the main trunk roads in the in European Union.

The year 1997 was when the first RDS-TMC introductions started in a few EU member states (or parts of them), on a preoperational basis in most cases. The others have firm plans to follow this plan up to the year 2000. As a priority, these new RDS-TMC services intend first of all to cover all major roads belonging to the TERN.

Since a public and open service is generally expected to become available all over the European Union, it is hoped within the EC that public/private partnerships (i.e., partnerships between road authorities, police, automobile clubs, industry, broadcasters, etc.) will become possible within the EU member states, and that these states will then work together actively towards achieving RDS-TMC implementation, supporting the policy addressed in the resolution from the Council of EU Ministers.

7.5.3 The Pan-European Service Objective and the Memoranda of Understanding

The European Commission requested, in line with the European Council Resolutions of September 1995 and March 1997, that EU member states should promote the introduction of RDS-TMC and implement their services according to the proposed prestandards to ensure continuity and interoperability.

In the autumn of 1997, to better achieve this objective, the European Commission launched two Memoranda of Understanding (MoU), one encouraging the introduction of RDS-TMC services and the other recommending the DATEX protocol for communication between traffic information centres. Both were to be further developed and implemented following the recommendations of the EDEN project for transborder TTI data exchange.

Previous to these MoUs, the European Commission pursued the objective of providing to the people of Europe, a free Pan-European TTI service (PES) covering the traffic situation on the Trans-European Road Network (TERN) using RDS-TMC as the transmission mode. However, during the drafting of the MoUs, the term PES was dropped to favour a number of different but compatible services and without insisting that the services should be free to the end user on a European scale.

7.5.4 Institutional Challenges of RDS-TMC Service Provision

7.5.4.1 General Considerations

In order to achieve a European-wide service, a number of institutional agreements appear to be necessary, in particular on smart cards and location databases. There also needs to be coordination of the updating of these databases on the European scale, including the availability of the data to any service provider, the identification of the service, and the automated or assisted handover to a corresponding service in an adjacent region. Also, a European-wide service should be freely available everywhere, and if smart cards are used, they should be the same all over Europe—with a sufficient memory capacity so that a driver travelling large distances does not have to swap smart cards too often.

The TMC information to be distributed requires extensive data collection facilities to be installed, with traffic information centres to be created on a regional level and with a standardised data exchange protocol being used in operations between them. DATEX-NET is recommended, for which a standard is being elaborated on by CEN 278. This standard will be further developed through the EC-funded EDEN project.

Any RDS-TMC service provider should be given access to this data, so that they can offer a high-quality service from the end-user's point of view. When such data is not available because of a lack of infrastructure, which is still the case on many sectors of the TERN, the RDS-TMC service will not be very interesting for the end user. There are a number of private companies that are prepared to become involved in the data collection and operation of travel and traffic information centres, but they will have to recover their operational costs and would be reluctant to contribute to an open and freely available Pan-European service. The alternative, then, is data encryption and the provision of the service against payment of a subscription fee. The implementation and operation of this concept on a European scale appears to be impossible, however, because too many different interest groups are involved. A kind of patchwork of different RDS-TMC services is then more likely because of too little direction being given by the European Commission.

While public service broadcasters in the EBU are generally not against the formation of public and private sector partnerships, they won't, in the majority of cases, seek to become involved in the provision of an encrypted RDS-TMC data broadcast service.

In the following section, we describe in more detail the coding of RDS-TMC and the institutional requirements relating to the management of location databases and smart cards. Some of the models described were

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developed in 1996 for the European Commission. This was done within the EPISODE project that the EBU undertook in support of the broadcast sector with the view of assisting the implementation of RDS-TMC.

7.5.4.2 The Pan-European Management of TMC Location Databases

The location code database is central to the operation of any TMC system, in essence providing one of the two main keys to the encoding and decoding of data (the other being the event list). The following reviews the function of the database, identifies the roles and responsibilities of its owner, and makes recommendations that will enable the rapid development of a Pan-European system with fair competition among operators.

In any TMC system, it is necessary for the *same* location database information to be used at all traffic information centres (TICs), by all service providers (SPs), and by all devices that receive information from those sources. Such a system is depicted in Figure 7.2, which introduces the role of a card provider, translating the available database to a physical and marketable form. If any of the system elements have a database that differs from the others, performance will be less than optimal. For example, if the receiver were to have an old database missing new location codes, then messages relating to these locations could not be received and presented to the motorist. Such omission may be regarded as simply unfortunate, but could even have some safety implications.

Within the system described above, there can only be *one* database per area or country, and all system elements (TIC, SP, card provider, and user)

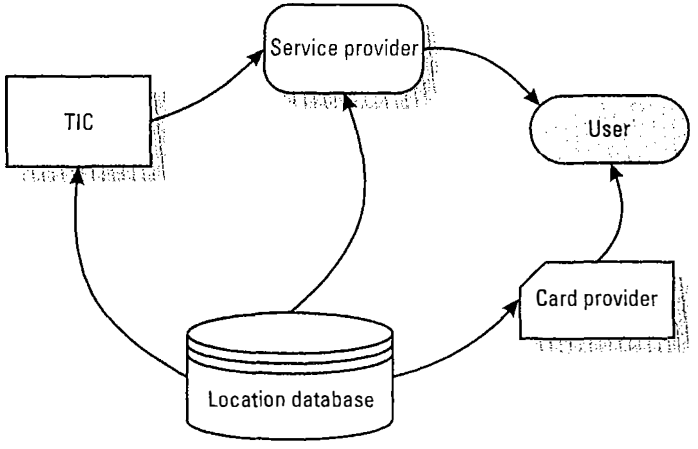


Figure 7.2 Location database influence diagram. (*Source:* EBU.)

must derive their individual databases from this one source. It is not possible for more than one location database to be used within this system, whereas it is possible for TICs, service providers, card providers, and receiver manufacturers to operate competitively. Clearly, the owner of the location database is, and must be, in a monopoly situation.

If fair competition and reasonable access is to be given to all operators, providers, and manufacturers, it is imperative that strict regulations and guidelines be imposed on database owners. We believe that such databases should be owned by nonprofit organisations, preferably by public authorities, and maintained by contractors. Costs may be offset by reasonable charges for acquisition of the database, which may be licensed for a period (to maintain system integrity) to operators, service providers, and card providers.

The task of the location database owner is to provide a fully maintained database, accessible on fair and equal terms to all who may request it and is updated at regular and declared intervals. In order to ensure that all system components are kept to the latest possible standard, it will be necessary for database owners to declare in advance when a new update is to be made available so that, for example, card providers may ensure that mass production is suitably synchronised.

The Pan-European vision of TMC foresees that a traveller can buy or rent a smart card in Italy that has location codes for London but with events pronounced in Italian. Such a card needs to be assembled using information derived from the U.K. database. This principle extends all over Europe, and it is clear that each database needs to be made very widely available.

Technical standards for information exchange need to be developed, such that any potential operator/supplier can obtain information from any database owner. Possibly the best way of achieving such interchangeability is to use open database communication (ODBC) protocols, which will permit operators to derive whole or defined subsets of a database at ease—for example, just locations in the northeast of France.

As memory sizes increase, card providers will wish to market products that cover larger geographical areas, and it will be possible and necessary to include locations derived from more than one location database. Clearly, there are distinct advantages in encouraging database owners to synchronise their updates so that it is possible to manufacture products containing the latest information from several sources. Such a situation is depicted in Figure 7.3.

With such an aim in mind, a nonprofit-making European database exchange organisation should be considered that coordinates and collects information from individual database owners and makes this available to all—subject to appropriate licences being issued.

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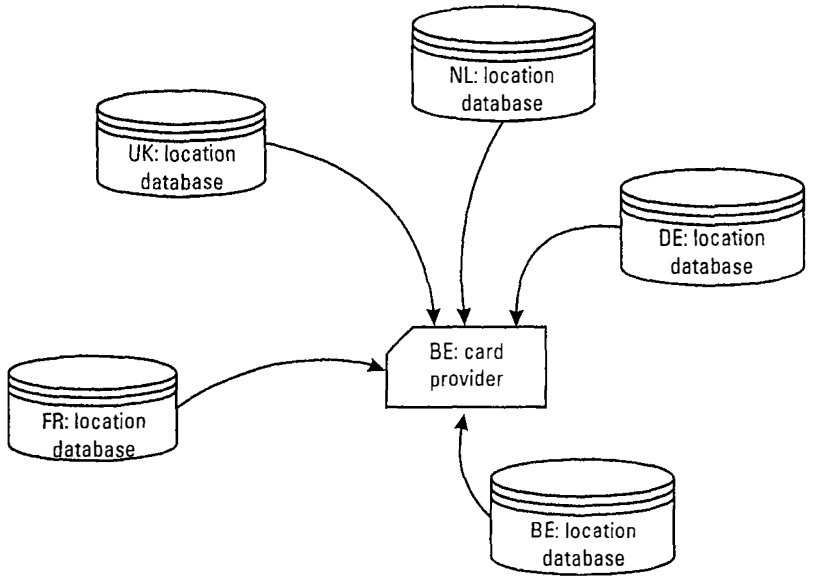


Figure 7.3 Card provider: example of location database information sources (partial example). (*Source:* EBU.)

7.5.4.3 Considerations Concerning the Use of Smart Cards and CD-ROMs as Storage Devices for the Location Codes

The access to the TTI messages will be enabled through an integrated circuit (IC) memory chip card using the ISO 7816 standard for the physical support (initially, 512-KB ROM). It will use a proprietary data recording and management format jointly developed by Bosch and Philips (also called the "TMC Chip Card," offered as one possible European industry standard in the so-called Blue Book, which is also an RDS-TMC technology licence package from Bosch/Philips to other receiver manufacturers). The TMC Chip Card is designed to contain appropriate location databases. The alternative solution to storing location databases on the TMC Chip Card is the use of a CD-ROM. Because no specification for recording the database has been internationally agreed to, manufacturers will have to use their own formats which, given the confusion that this will create for the end user, could well result in a rejection of RDS-TMC products by the consumer.

7.5.4.4 Pan-European Requirements for Smart Cards and Payment Methods

A smart card or CD-ROM is destined to become the means by which database information is loaded into the receiver, and by which it is updated as roads are

improved. In the following, the function of these products is reviewed. The requirements for payment in a genuine Pan-European system are identified, and a simple and effective mechanism is proposed for deriving an income from the sale or rental of devices that may be distributed by or on behalf of service providers who cannot attract public support.

Each TMC receiver needs to have access to both a location code database and an event database coded in the user's language. Without these databases, the data stream arriving is meaningless. Each user will wish to acquire a series of databases, covering the areas in which he or she will travel. These are expected to be distributed in the form of a smart card, CD-ROM, or some other exchange media.

It is expected that smart cards or CD-ROMs will be supplied by a variety of providers, formatted to appropriate standards using data derived from national databases. In order to ensure that a high quality of service is maintained, it is imperative for these storage devices to have a version number and an expiration date, guaranteeing that out-of-date versions are no longer usable.

Each and every service provider will need to fund the costs of service provision in some way. In many countries, this will be by public grant. However, some countries are unwilling to support these services, and thus a mechanism must be included to generate a cash flow to pay for the service. This will enable a genuine Pan-European TMC service to be realised.

The simplest means of providing payment for a service is to derive income from the sale of cards to the user. These cards will need to be replaced periodically in order to ensure consistent service quality, and thus a source of regular income can be realised.

The profit on the sale or rental of cards may be used to finance the costs of obtaining the databases used, and to finance the service provider offering the data being delivered to the user.

It is expected that in many areas an RDS-TMC service may be available from more than one service provider (e.g., in the United Kingdom through both automobile clubs, the Automobile Association (AA), and the Royal Automobile Club (RAC)), permitting competition to push quality up and costs down. The RDS-TMC standards require broadcasting a service identification code to be within the data stream that will enable a receiver to locate the service operated by a preferred provider. To enable such a system to operate to the benefit of the consumer, cards need to have the ability to carry one or more service identification (SId) codes (rather in the same manner as a GSM card does today), allowing a TMC receiver to automatically find the required service(s). Relationships could be established between service and card providers, permitting one card to give access to more than one service, as shown in Figure 7.3.

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Figure 7.4 shows an example of a card produced that offers access to the services of service providers SP 1 and SP 2, but not to those of SP 3. Service providers SP 2 and SP 3 are from one country, and SP 1is from another.

The card depicted in Figure 7.4 uses elements from the databases of both countries. It is expected that money to be allocated to the respective service providers could be distributed in proportion to the number of codes used from each country, the area of coverage, or some other method. In any case, the card provider is supplying a product that is licensed by both countries' location database owners and by both of the service providers.

7.5.5 RDS-TMC Standards

7.5.5.1 Introduction to RDS-TMC Standards

Because TMC services will be conveyed by the RDS subcarrier, and added to the baseband multiplex signal of FM Band II transmissions, it is usual to consider the RDS standard EN 50067:1998 as the core specification. This

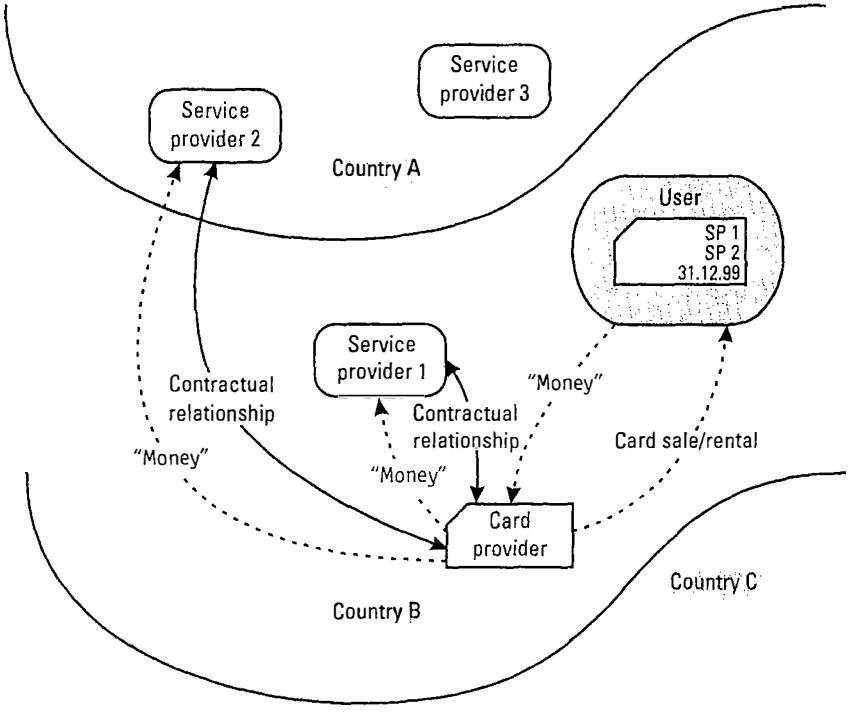


Figure 7.4 Service and card provider relationships and payment mechanisms. (*Source:* EBU.)

specification, when first published in 1990 and updated in 1992, already contained references to the RDS-TMC feature, mentioning both type 8A groups and a variant of the type 1A group that would be used for TMC identification.

However, the needs of a TMC service were not well defined at that stage, and work over recent years by CEN TC 278 SWG 4.1 and by the EC-funded FORCE Project has clarified the situation, resulting in the need to define more aspects of RDS-TMC in additional standards.

7.5.5.2 The Specification of the RDS System (CENELEC EN 50067:1998): the Core RDS Standard

The upgraded RDS standard EN 50067:1998 was developed by joint work in the RDS Forum and CENELEC TC 207, using a very wide range of experts. This version of the standard now fully includes the new open data application (ODA) feature (see Chapter 9), originally suggested for RDS-TMC purposes. It also includes specific references and "hooks" to ENV 12313-1: June 1997, where necessary. The former RDS-TMC references were kept to leave the door open for non-ODA implementations of RDS-TMC in the short term, but it is recommended that these implementations no longer are recommended to be maintained.

7.5.5.3 The Coding Protocol for RDS-TMC (ENV 12313-1): the So-Called ALERT-C Protocol

The coding protocol for RDS-TMC is defined in ENV 12313-1, which was accepted by voting within CEN in early 1996, but was the subject of an addendum and corrigendum. This addendum was originally issued in June 1996, mainly in response to comments from CEN TC 278. In view of this, ENV 12313-1, Version 2.20, dated September 1996 ,was redrafted to include all previous editorial changes noted in the addendum and corrigendum, and this has been subsequently further improved to become ENV 12313-1, Version 3.0, dated June 1997. Therefore, this should now be taken as the main standard describing the so-called, ALERT-C protocol. This document contains both the TMC message protocol and the RDS-TMC-related coding used by the RDS-TMC feature, using type (1A), 3A, and 8A groups to convey the TMC messages with event and location codes and network and service layer information.

7.5.5.4 Event and Information Codes for RDS-TMC (prENV 12313-2): the ALERT-C Event List

The event and information codes for RDS-TMC required by the ALERT-C protocol are specified in prENV 12313-2, FINAL DRAFT, dated May 1997. Although this standard does not actually require any further work to operate a

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service, it is seen as necessary to adopt versions for each European country/language. For example, in the United Kingdom, it is normal to describe distances in miles, but distance is described quite differently in other countries (in kilometres), so an agreed upon definition is useful to help uniform message generation and TMC decoder presentation.

7.5.5.5 Location Referencing Rules for RDS-TMC (prENV 278/7/3/0005 DRAFT)

Location referencing has been one of the most contentious issues, and rules for RDS-TMC are available as a draft dated March 1997. However, progress on CEN TC 278 SWG 7.3 has been rather slow and many workers are now aware that there needs to be considerable effort put into resolving the outstanding issues. In particular, location database development which had begun using a former draft has shown that considerable variation of interpretation results, and the FORCE Project has established a subgroup ("Interpretation of the Location Referencing Rules") to resolve these problems.

7.5.6 Data Formats of the TMC Feature

Coding of TMC makes use of the ODA concept. Two coding protocols exist: ALERT-C, which will generally be used for the Pan-European service (PES) and which is described in ENV 12313-1, and ALERT-Plus with ALERT-C, which will be used in France and of which, in 1997, only a draft specification existed (prENV 278/4.1.1/0004).

The PES will operate in two different ODAs:

- The first ODA, dealing with ALERT-C only;
- The second ODA, allowing operation of a mixed ALERT-Plus with ALERT-C service described in the draft specification prENV 278/4/1.1.1/0004 or updates of it.

For this reason, the ALERT-C structure using type 8A groups is the same for both types of protocol—both applications have the same application group type 8A but a different application identifier code (AID). Table 7.3 illustrates the situation.

Figure 7.5 shows the format of type 8A groups when used for RDS-TMC. This group carries the TMC messages, service provider name, and tuning information.

The coding of ALERT-C messages is shown in Figure 7.6.

Table 7.3
Parameters for RDS-TMC Coding

Parameter	ALERT-C	ALERT-C With ALERT-Plus
ODA-AID in type 3A groups	CD46 hex	4B02 hex
Transmission modes	Basic or time windowing	Basic
Service	PES	ALERT-Plus and PES

When T (X4) = 0, the message data fields are either carried within single (X3 = 1) or multiple groups (X3 = 0), as shown in Table 7.4.

When T (X4) = 1, the 8A groups carry tuning information (variants 6 to 9) or the service provider name (variants 4 and 5), as shown in Figure 7.7. The service provider name is comparable to the PS name and it also has eight alphanumeric characters. To enable the TMC equipment to switch to another transmitter when the signal becomes weak, the tuning information indicates other networks (ON) that carry the same or another RDS-TMC service for a controlled handover.

Table 7.4
Bit Allocation for TMC Message Data

Data Field	Options	MSB	LSB
T(1 bit) :0	2	X4	—
F: Single/multiple group message identifier (1 bit)	2	X3	—
X3 = 1 single group			
X3 = 0 multiple groups			
DP: Duration and persistance (3 bits) for X3 = 1	8	X2	X0
CI: Continuity index (3 bits) for X3 = 0			
D: Diversion (1 bit) for X3 = 1 (single group)	2	Y15	—
Set to 1 for X3 = 0 (multiple groups)			
+ / –: Direction (1 bit)	2	Y14	—
Extent (3 bits)	8	Y13	Y11
Event (11 bits)	2,048	Y10	Y0
Location (16 bits)	65,536	Z15	Z0

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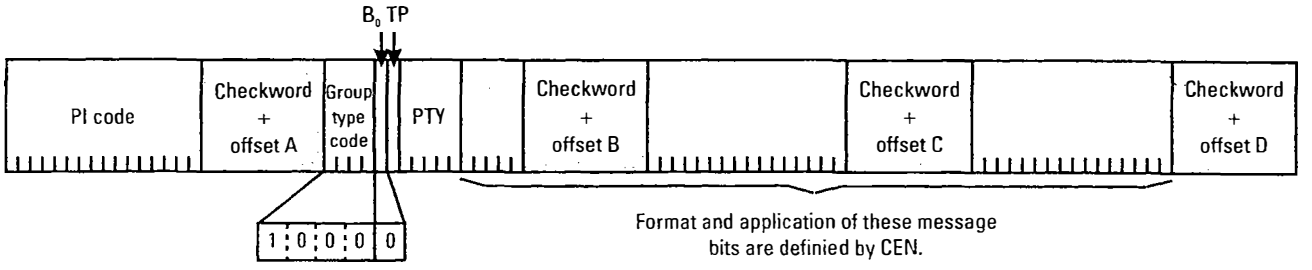


Figure 7.5 Type 8A group Traffic Message Channels. (*Source:* EBU.)

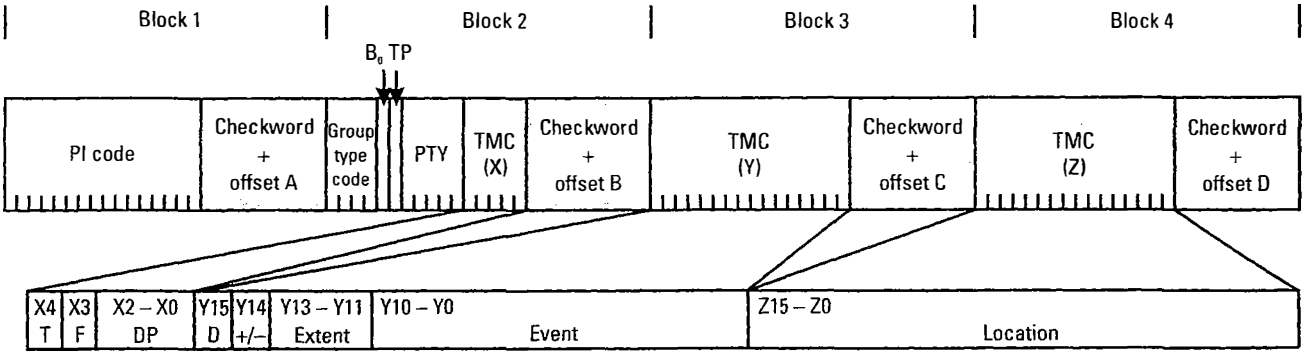


Figure 7.6 Coding of ALERT-C single group messages. (*Source:* EBU.)

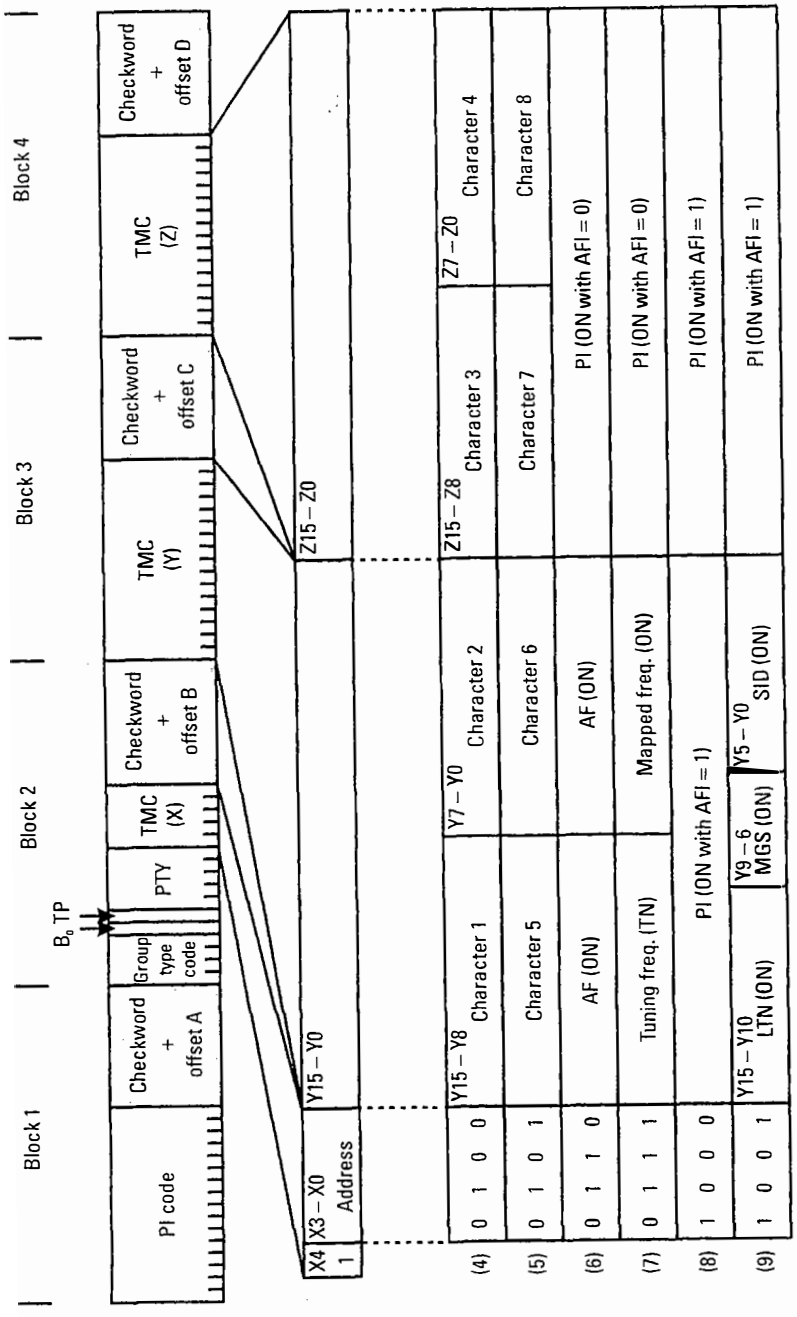


Figure 7.7 Data format for tuning information/service provider name. (*Source:* EBU.)

Variants 0–3 and 10–15 will be used for the ALERT-Plus protocol and are not further explained because of the still provisional nature of that specification.

The system information is coded in block 3 of group type 3A, as is shown in Figure 7.8.

The parameters used for system information are detailed in Table 7.5.

7.5.7 Principles of RDS-TMC Event Coding

Coding of road transport events for transmission in RDS-TMC is described in the CEN prestandard prENV 12313-2: May 1997. This specification contains the event list in the form of a database. The maximum number of events that can be coded is 2,048, but in that specification only 1,375 events have so far been coded.

Table 7.5
Parameters Used for System Information (Figure 7.8: Type 3A Group/Block 3)

Variant Code 00:		
LTN	6 bit	Location table number
AFI	1 bit	Alternative frequency indicator
M	1 bit	Transmission mode indicator
MGS:		Message Geographical Scope
I	1 bit	International (EUROAD)
N	1 bit	National
R	1 bit	Regional
U	1 bit	Urban
Variant Code 01:		
SID	6 bit	Service IDentifier
Transmission Mode Parameters:		
G	2 bit	Gap parameter
T_a	2 bit	Activity time
T_w	2 bit	Window time
T_d	2 bit	Delay time

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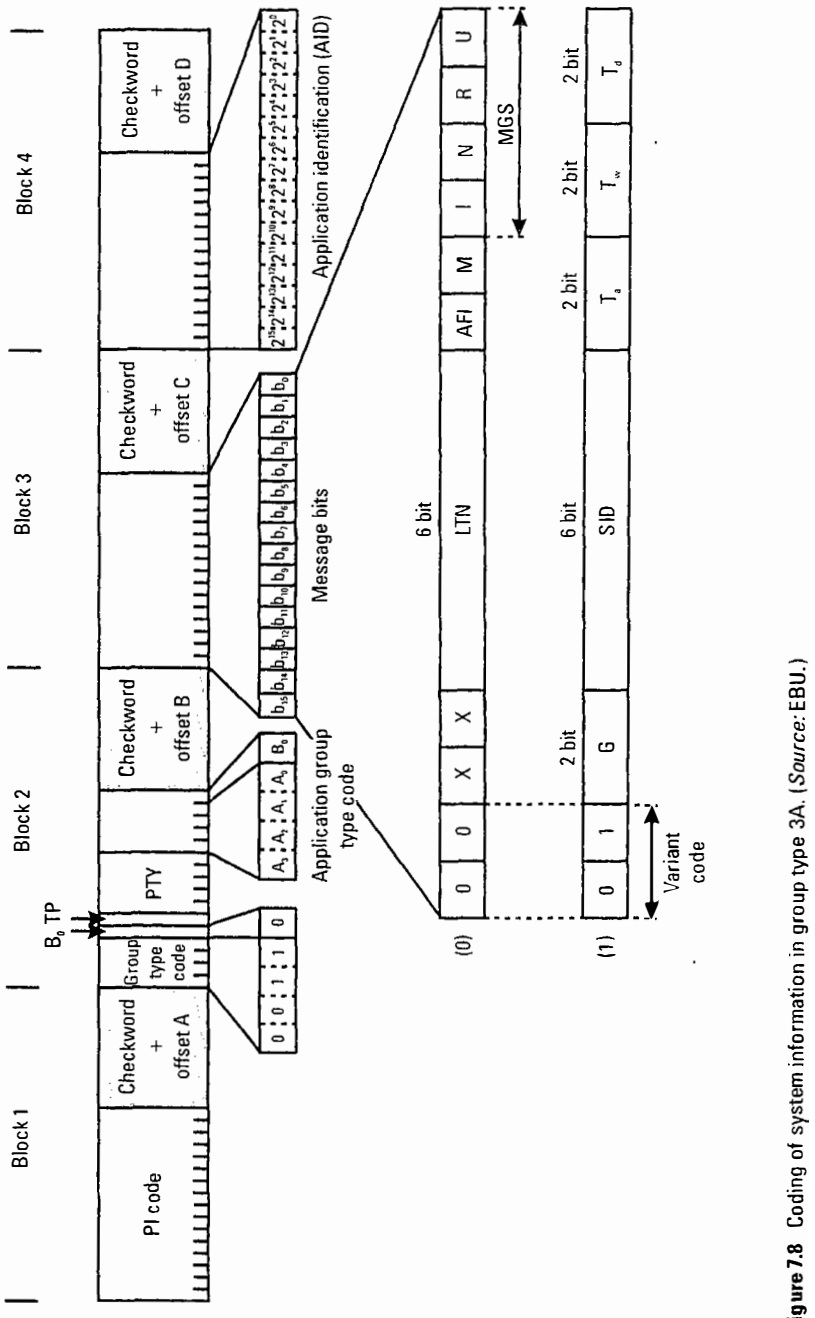


Figure 7.8 Coding of system information in group type 3A. (*Source:* EBU.)

To describe an event, we want to use an example: A passenger car had an accident and when the car parked at the roadside waiting for assistance to arrive, two dogs jumped out and ran on the motorway. With the ongoing traffic, the owners were not able to catch them and bring them back into the car. Passengers from other cars passing by noticed the hazard and informed the traffic service of the automobile association of the incident. The automobile association forwarded the message to the regional broadcaster, who sent out a message about this event using the appropriate location code. The message sent has the code 922, meaning "animals on roadway." The coding system does not permit specifying that the animals were dogs, or what kind of dogs. The same code is used for one or several animals and independent of the kind of animal—mouse, cat, dog, crocodile or elephant.

Because there are 1,375 possible codes, the database has been structured into 31 categories (also called update classes) with the view of assisting the message generation operator in quickly finding the right code—in this case, 922. This message belongs to category 13: Dangerous situations.

Table 7.6 contains the list of event categories used and also how many events are foreseen in each of these categories. One can see from the list that the editing software used by the operator for TMC coding can then be hierarchically structured along the line of these categories.

7.5.8 Principles of RDS-TMC Location Reference Coding

Most messages provide information about a location (e.g., a stretch of road, an intersection, or a region) and they refer to it by using a location reference. This is an identifier that can be interpreted without ambiguity by the receiving system. In RDS-TMC, locations are predefined and precoded, and the codes are stored in location code tables. The maximum number of codes in one table is determined by the field length for location codes in RDS-TMC; that is, 16 bits, which corresponds to 65,536 possible codes. The disadvantage of these tables is that they need to be created and maintained as was explained above, and the receiving system must use exactly the same table as the one used for encoding of the message. Otherwise, the message is not receivable.

The rules for location reference coding are specified in CEN prestandard prENV 278/7/3/0005: May 1997. These rules apply to ALERT-C messages only. ALERT-Plus uses a different system. Because of the provisional nature of ALERT-Plus in 1997, no further reference is made to that particular coding method, and all details that follow are extracted from the prestandard and apply thus to ALERT-C messages only.

Predefined locations are referenced by their location code, which is the tabular address of a number of prestored location details. Each table of stored

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Table 7.6
List of Event Categories (Update Class) Used to Structure the Event Database and Number of Event Codes Falling Into Each of These Classes

Update Class	Events
1. Level of service	418
2. Expected level of service	58
3. Accidents	28
4. Incidents	14
5. Closures and lane restrictions	123
6. Carriageway restrictions	19
7. Exit restrictions	12
8. Entry restrictions	6
9. Traffic restrictions	56
10. Carpool information	11
11. Roadworks	30
12. Obstruction hazards	70
13. Dangerous situations	17
14. Road conditions	54
15. Temperatures	8
16. Precipitation and visibility	58
17. Wind and air quality	13
18. Activities	41
19. Security alerts	13
20. Delays	142
21. Cancellations	31
22. Travel time information	9
23. Dangerous vehicles	15
24. Exceptional loads / vehicles	20
25. Traffic equipment status	30
26. Size and weight limits	11
27. Parking restrictions	5
28. Parking	29
29. Reference to audio broadcasts	8
30. Service messages	22
31. Special messages	4
Number of events (max. 2048)	*1375*

locations must be given a unique location table number by one unique agency in each country or state. A country code (note: RDS-TMC uses the RDS country codes given in Appendix G) identifies the agency responsible for location reference coding and which one defined the location table and its number.

Many location references extend through several adjacent areas or road sections. The concept of primary and secondary locations is then used to indicate the extremities of the affected sections without having to list all the intervening places. For example, if an accident occurs at km 14.2 on the E15 (A26 road in France) and the resulting queue extends back to km 10.9, the situation location can be defined as E15, "km 14.2–10.9," where km 14.2 is defined as the primary location and km 10.9 is the secondary location. The primary location is taken to be where the cause of the problem can be found, whenever a cause can be pinpointed geographically. However, both primary and secondary locations will lie on the same road.

For the primary location, the location reference is the nearest downstream location in the direction of travel. The secondary location is indicated in terms of extent; that is, the number of steps back along the road through other predefined locations. Alternatively, a distance marker may be used.

All location codes belong to a unique location table. Within any particular location code table, each location has one unique number in the range 1–63,487. The other 2,048 numbers are reserved for EUROAD, an agreed upon concept used for coding messages to international travellers on the Trans European Road Network (TERN).

RDS-TMC uses a hierarchical structure of predefined locations. A system of pointers provides upward references to higher level locations containing the specified location. For example, Kent would have an upward area reference to southeast England, which will be upwards referenced to the United Kingdom, then the British Isles, then Europe.

Junction 25 on the M1 motorway in the United Kingdom would have a section of route referenced to a motorway segment (e.g., Leicester–Sheffield). This segment will then be referenced upwards to the whole road (i.e., the motorway M1).

Also, Junction 25 on a motorway may be offset to Junction 26 in the positive direction, and to Junction 24 in the negative direction.

In many cases, events affecting road traffic cover a number of locations, such as where an accidents results in long tailbacks. The ALERT-C protocol defines such occurrences by addressing the location of the accident as the primary location, then identifying the end of the tailback by using the direction and extent fields. These fields consist of four bits in total: one direction bit and three extent bits. The direction bit indicates the queue growth and not the direction of traffic flow. The extent bits identify the number of locations along

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the road that are affected by the problem, with a maximum of eight (primary location and seven related locations). An extent of 1 would identify the secondary location (the end of the event's extent) as being the next location along the same road from the primary location. An extent of 3 would force the receiver to search the database for the third location along the same road from the primary location as is illustrated in the example given in Table 7.7.

Three additional optional columns exist. These are the motorway exit number and the deviation reference road number in positive and negative directions to give diversion advice.

Table 7.7
Coding Example for Location Referencing

Location Code	Type	Road Number	Name 1	Name 2	Ref A	Ref L	Neg. Offset	Pos. Offset
949	L3	E1	X-town	Y-town	2009	—	948	950
2009	A6.2	—	Greater neighbourhood	—	1	—	—	—
4420	P3.2	E1	Bridge	—	2009	949	4456	4423
4423	P1.3	E1	Place A	N207	2009	949	4420	4459
4459	P3.3	E1	Parking	—	2009	949	4423	4460
4460	P1.3	E1	Place B	—	2009	949	4459	4461

Location code: Identifier in the range 0 to 65,536 describing a stretch of road, an intersection or a region;

Type: Defines the kind of location in three main categories and a number of sub-categories: Areas (A), Linear locations (L), and Points (P). In the example given above, L3 means a road link, A6.2 a metropolitan area, P3.2 a bridge, P1.3 a motorway junction, and P3.3 a service area;

Road number: The road reference number;

Name 1: Name of the primary location that will be presented by the receiver;

Name 2: Name of a secondary location—required to describe a road segment;

Ref A: Pointer to the area to which the location belongs;

Ref L: Pointer to the stretch of road to which the location belongs;

Negative offset: Pointer to the previous area or location (e.g., on the same stretch of road);

Positive offset: Pointer to the next area or location (e.g., on the same stretch of road).

7.5.9 Example for Constructing an RDS-TMC Message

The message:

> Motorway A9 Munich-Nuremberg, direction Nuremberg, stationary traffic between exit Pfaffenhofen and motorway interchange Holledau. Deviation recommended via the U31 from exit Pfaffenhofen,

requires the following message elements, which are given here as decimal numbers and which will then be binary coded:

- *Duration:* 0 for no specific duration specified;
- *Diversion:* 1 for deviation being recommended;
- *Direction of event:* 1 for negative;
- *Extent of event:* 2 for two locations backward in the location code list;
- *Event:* 101 for stationary traffic;
- *Location code:* 12735 for motorway interchange Holledau.

The coded type 8A group for this example is shown in Figure 7.9.

The corresponding part of the location code list is given in Table 7.8. For simplification of understanding, all numbers are given as decimal numbers, but in reality these are coded as binary numbers.

7.5.10 RDS Encoders and the EBU/UECP

After editing the RDS-TMC messages in the broadcasting house, they are sent to the transmitter or the transmitter network for insertion into the RDS data stream. This task is achieved with the help of RDS encoders that receive the messages in a specified format, as shown in Figure 7.10.

RDS encoders certainly need software adaptation to allow RDS-TMC to be implemented as it is now specified. One of the protocols of interest from the European point of view is the EBU Universal Encoder Communication Protocol (UECP), which required an urgent enhancement to include all the newly defined possibilities specified.

The EBU document SPB 490 (version 5.1) is an upgrade to achieve the same enhanced functionality (especially for ODA and TMC) as offered by EN 500067:1998 and the most recent RDS-TMC specifications. This work was started within the RDS Forum in 1996 and completed during 1997.

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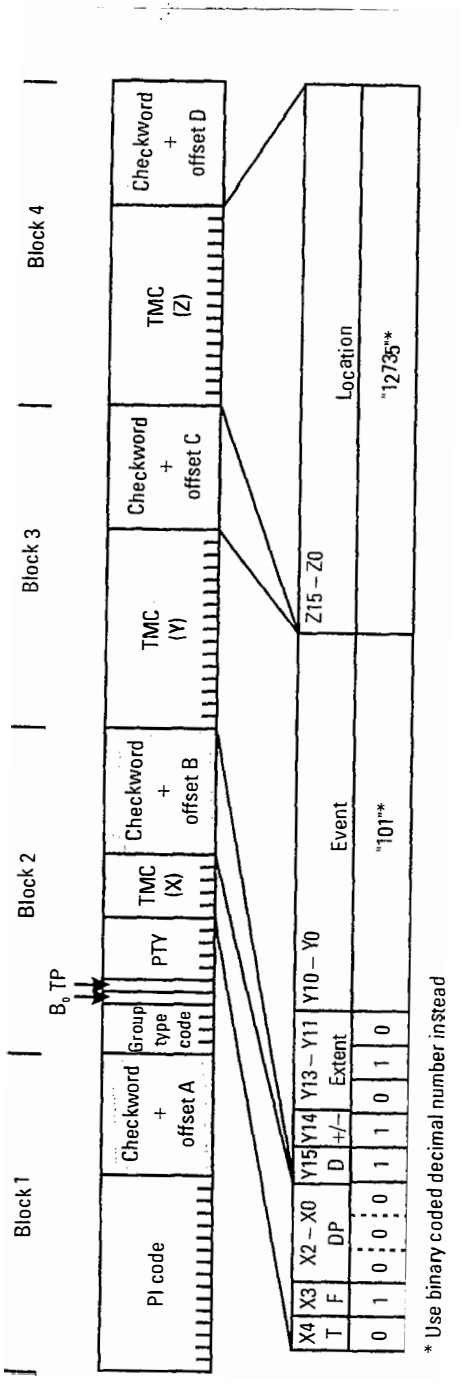


Figure 7.9 Coding of the example in type 8A group. (*Source*: EBU.)

Table 7.8
Extract From the German Location Code List (The bolded terms are those used in the example)

Location Code	Type	Road No	Sub Type	Name 1	Name 2	RefA	RefL	Off+	Off–	Exit No	U+	U–
256	BL			Schleswig-Holstein		1						
257	BL			Hamburg		1						
258	BL			Niedersachsen		1						
259	BL			Bremen		1						
260	BL			Nordrhein-Westfalen		1						
261	BL			Hessen		1						
262	BL			Rheinland-Pfalz		1						
263	BL			Baden-Württemberg		1						
264	**BL**			**Bayern**		**1**						
265	BL			Saarland		1						
266	BL			Berlin		1						
267	BL			Brandenburg		1						
268	BL			Mecklenburg-Vorpommern		1						
269	BL			Sachsen		1						
270	BL			Sachsen-Anhalt		1						
271	BL			Thüringen		1						
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
292				Münster		260						
293				Niederbayern		264						
294				**Oberbayern**		**264**						
295				Oberfranken		264						
296				Oberpfalz		264						
297				Rheinhessen-Pfalz		262						

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Table 7.8 (continued)

Location Code	Type	Road No	Sub Type	Name 1	Name 2	RefA	RefL	Off+	Off–	Exit No	U+	U–
299				Schwaben		264						
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
602				**Pfaffenhofen a. d. Ilm**		294						
603				Pforzheim		284						
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
7219	**SEGME**	**A9**	**LINE**	**München**	**Nürnberg**	**264**	**264**	**7220**				
7220	SEGME	A9	LINE	Nürnberg	Halle/ Leip.	264	270	7221	7219			
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
12725	POINT	A9	AS	München-Kieferngarten		549	7219	12726	12724	73		
12726	POINT	A9	AK	München-Nord		549	7219	12727	12725	72		
12727	POINT	A9	AS	Garching-Süd		549	7219	12728	12726	71	25	78
12728	POINT	A9	AS	Garching-Nord		549	7219	12729	12727	70	25a	76a
12729	POINT	A9	AS	Eching		418	7219	12730	12728	69	27	76
12730	POINT	A9	AK	Neufahrn		418	7219	12731	12729	68		74
12731	POINT	A9	TR	Fürholzen		418	7219	12732	12730			
12732	POINT	A9	AS	Allershausen		418	7219	12733	12731	67	29	74
12733	**POINT**	**A9**	**AS**	**Pfaffenhofen**		**602**	**7219**	**12734**	**12732**	**66**	**31**	**72**
12734	POINT	A9	TR	In der Holledau		602	7219	12735	12733			
12735	**POINT**	**A9**	**AD**	**Holledau**		**602**	**7219**	**12736**	**12734**	**65**	**33**	**70**
12736	POINT	A9	AS	Langenbruck		602	7219	12737	12735	64	35	68
12737	POINT	A9	AS	Manching		602	7219	12738	12736	63	37	66
12738	POINT	A9	AS	Ingolstadt-Süd		477	7219	12739	12737	62	39	64
12739	POINT	A9	AS	Ingolstadt		477	7219	12740	12738	61	41	62

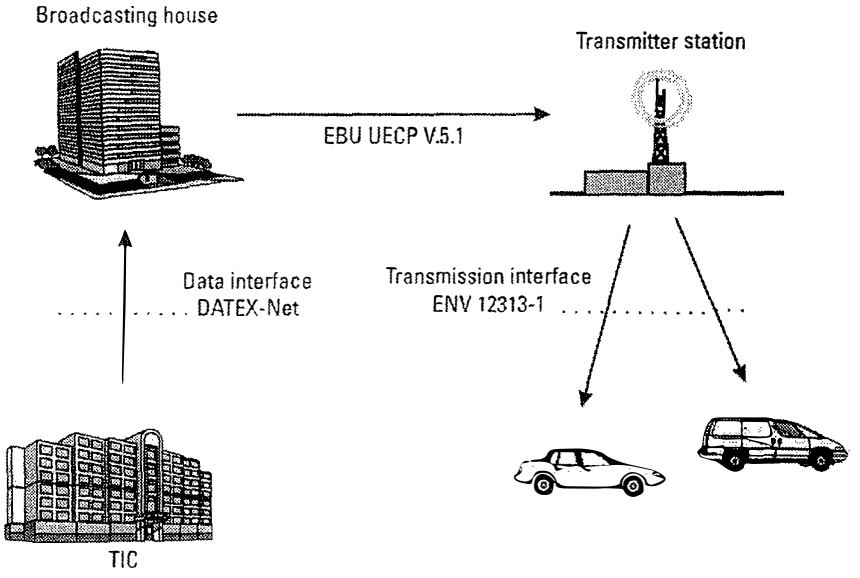


Figure 7.10 Routing of RDS-TMC messages from the TIC to the end users. (*Source:* EBU/IRT.)

The encoder model and protocol (see Chapter 11) provide a template specification upon which new products may be based and other existing encoder communication protocols may be enhanced. Thus, many existing devices could be adapted to meet the functionality required, and subsequently, a universal protocol may be implemented. However, encoders of the first RDS generation can generally only be upgraded with significant software modifications, and it is difficult, or even impossible, to achieve the full support of the present level (version 5.1) of the UECP protocol. For this reason, the introduction of RDS-TMC may also require substantial investments to be made on the side of the transmitter network to replace the older RDS encoders (e.g., about 800 for a large country like France). This is likely to lead to a further delay in the implementation of RDS-TMC.

7.5.11 RDS-TMC Receivers

7.5.11.1 European Industry Position

Major European car radio manufacturers have collaborated in the European Association of Consumer Electronic Manufacturers (EACEM) for many years to develop a European car radio technology meeting the objectives mentioned,

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but also with the objective to support car navigational systems using digital road maps in conjunction with updated TTI. These manufacturers require that European standards be used by the TTI information providers, the car manufacturers, and the authorities regulating the implementation of this new technology.

Car manufacturers in Europe also cooperated in the industrial research and development programme PROMETHEUS that originated in 1986, and that terminated at the end of 1994. This programme had long-term objectives going beyond the year 2000, especially aimed at the application of new (also electronic) technologies to improve a variety of things from the safety of car driving to all sorts of enhancements like improved vision (in bad weather), collision avoidance, vehicle communication, and navigational assistance. The RDS-TMC objectives described above have also been included in the development, and thus all car manufacturers in Europe have gained experience with RDS-TMC and are now prepared to support its implementation.

The expectation is that by the year 2000 it will be common practise that cars will be increasingly equipped with the new technology with various degrees of perfection, not only concerning the car radio but also navigational aids, electronic maps, onboard computers, and travel planning systems. Since the information to be distributed primarily concerns messages that need to be updated continuously—concerning millions of road users—it appears to be sensible to look at the use of broadcast technology for disseminating TTI to the user. The only relevant broadcast technology available now and harmonised on the European scale is RDS; hence, the expectation of using RDS-TMC as early and as widely as possible.

7.5.11.2 Receiver Requirements

Ideally, RDS receivers should have an interface with RDS data to permit devices with new services such as TMC or DGPS to be connected to existing RDS radios. Unfortunately, in the large majority of existing RDS receivers, such an interface does not exist, mainly because no agreement could be reached to standardise it—and an extension of existing RDS receivers to TMC functionality is therefore impossible.

New TMC receivers should have a double-tuner front end to permit the end user to freely choose a radio programme channel and then receive the TMC service in the background.

There should also be on all TMC receivers a standardised input for location code tables; that is, the smart card to be used should be standard or, alternatively, there should be an industry standard.

TMC receivers should implement message management; that is, deal with message presentation according to the corresponding degree of urgency

and automatically delete old messages, making use of the time stamp derived from Clock Time (CT) transmitted in type 4A groups.

A filter for relevant messages will have to be implemented in TMC receivers, where relevant means relevant to the journey undertaken.

The message presentation will have to take road safety requirements into account. Speech output needs to be of a sufficiently high audio quality—comparable to FM radio—to assist the perception of traffic announcements without additional stress. Scrolling text on a display is generally considered as dangerous because of the distraction that it can create for the driver, although it will be easy and inexpensive to implement it in less expensive TMC receivers.

7.5.11.3 First-Generation RDS-TMC Receivers

7.5.11.3.1 Car Radios

The only RDS-TMC car radio available in 1997/98 with speech output is the Blaupunkt model Viking TMC 148, as shown in Figure 7.11.

This radio tries to offer a reasonably well-designed TMC output, but to keep the price of this product down between USD $400–$500/



Figure 7.11 Blaupunkt Viking TMC 148. (*Source:* Blaupunkt.)

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DEM 700–900, retail), a number of technological constraints have negatively influenced the design. These are as follows:

1. Only a single tuner is used, which means for TMC that tuning to the TMC channel is obligatory.
2. The only available language is German, and other language versions were not announced at the initial launch date.
3. Speech output is limited to only 68 message types and only a few locations; other messages can only be presented on the eight-character display used by the car radio and also for the PS name.
4. The exit locations on motorways cannot be identified by name; exits are identified by numbers instead.

On the positive side, the radio can filter messages and select the desired motorways or national roads. This information has to be keyed in, which is a bit difficult to achieve for the driver. The speech output is of a reasonably high quality, since it uses recorded and not synthesised speech. The smart card for Germany contains location codes for all motorways and national roads, and also some major roads in urban areas (14,000 locations altogether stored on 512 Kb). The smart card is supplied with the receiver and is included in its price.

Given the technological limitations of this product, there will certainly be problems in marketing it on a European scale. Since the receiver was conceived only for the German market, it will probably be difficult to subsequently adapt it to the European market, which would be a necessity to achieve production in large quantities at a retail price that the end consumer will find attractive. It is thus possible that this product will remain a kind of demonstrator of the limited possibilities imposed by present state technology.

The limitations encountered with this product will most probably apply to the whole industry. It was confirmed in 1997 that it still was not possible to manufacture an RDS-TMC radio at a reasonably low price and meet the ideal requirements for such receivers that would correspond to the service possibilities offered by the RDS-TMC system that had been in development since 1984. This kind of problem was already anticipated some years before [12].

Philips Car Systems announced at IFA '97, also in Germany, their first RDS-TMC car radio, RC 579, shown in Figure 7.12. However, this radio cannot present TMC messages through speech; it generates corresponding icons that symbolise the traffic message content, which are sent to the CARIN 520 navigation system that inserts them on the map display. The CARIN navigational system uses a digital road map atlas stored on a CD-ROM that also contains the ALERT-C location codes. The announced retail price for the radio



Figure 7.12 Dynamic route navigation with RDS-TMC Philips RC 579 + CARIN 520. (*Source:* Philips.)

was approximately USD $500/DEM 800 and the CARIN navigation systems costs USD $3,000/DEM 4,800, in addition. The tuner has only one front-end, and, as in the case of the Blaupunkt radio, tuning to the RDS- TMC channel is compulsory if the dynamic route information is required by the driver.

7.5.11.3.2 Navigational Systems

A Volvo/Mitsubishi RTI product is one of the first navigational systems developed independent of the car radio that has dynamic updating via RDS-TMC (see Figure 7.13). This system is factory fitted as an option for Volvo cars and works like the Philips system described above. However, the receiver has two tuners, one for the car radio and another for RDS-TMC. This system was released in 1997 and its retail price is approximately USD $3,600/SEK 28,000. Different CD-ROMs are necessary for different European countries in which the system is marketed. Apart from the traffic information presented through icons, the system also displays some tourist information (hotels, petrol stations, Volvo workshops, etc.), which is also stored on the CD-ROM.

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Figure 7.13 Volvo / Mitsubishi RTI navigation system with RDS-TMC. (*Source:* Volvo.)

7.5.11.3.3 ALERT-Plus Receivers

During the years 1995–1997, there was a flurry of activity that was limited to France and that was aimed at developing the RDS-TMC ALERT-Plus protocol, which is status message oriented, requiring continuous updating. This has confused the situation about the availability in France of a Pan-European RDS-TMC service, but it now appears the plan is to operate it there in parallel with ALERT-C, which is event message oriented. ALERT-Plus is a proposal originating from the DRIVE II period, and was promoted in France to provide a TTI service carrying status information, such as car park capacity and anticipated route travel-time information. This nonevent-oriented service appears to require significantly more data capacity, and it has been suggested that it is more suitable for DARC or digital radio (DAB). But in France, particularly in Paris, several former CARMINAT partners (mainly Télédiffusion de France (TDF), Sagem, Renault, and the recently created consortium Médiamobile) appear to believe that the RDS capacity will be sufficient, at least for starting a service in the Paris region. In other locations where broadcasters use much more RDS capacity for their own programme-related needs, especially when RadioText is implemented, it is unlikely that such a service can be operated using RDS.

In early 1998, Médiamobile used approximately five RDS groups per second on each of three frequencies with high-power transmitters radiating from the top of the Eiffel tower. In this way, full coverage of the Paris metropolitan area is achieved. One of these transmitters carries travel time status data, and the other two carry the data about traffic flow/congestion for all the major roads in the Paris metropolitan area. That information is divided between two transmitters, one giving the information for the centre of Paris and the other for the outskirts (see Figure 7.14). The data transmitted by Médiamobile is prepared by combining the information from two sources. Firstly, data is collected by the city of Paris using magnetic loop detectors, which are installed every 500 to 750m on 2,000 km of all major roads in Paris. Secondly, floating car data is collected by one taxi operator that coordinates some 2,000 taxis.

The first ALERT-Plus receivers were presented by Sagem in 1997, as shown in Figure 7.15. Médiamobile started with these receivers: one handheld terminal called TM 2000 Visionaute, and the other available as a factory-fitted

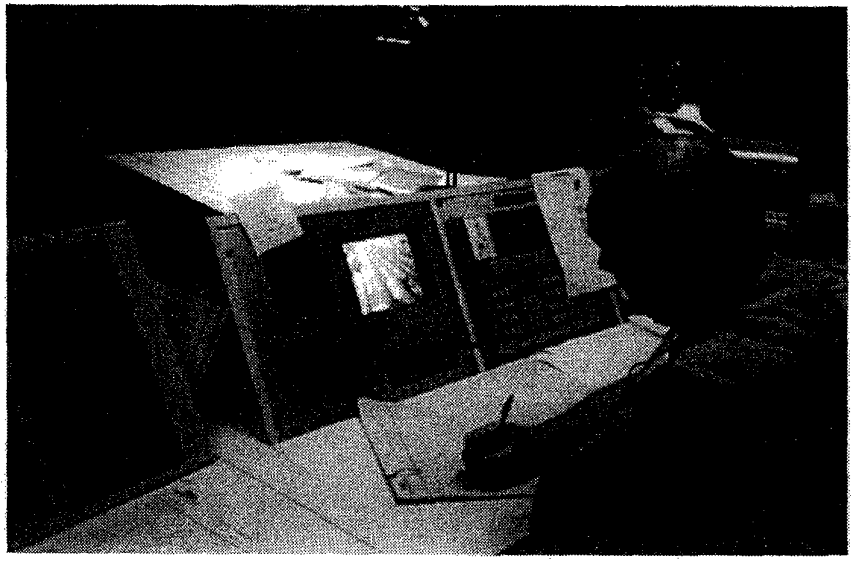


Figure 7.14 The traffic information centre from the city of Paris. (*Source:* EBU.)

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Figure 7.15 The Sagem/Médiamobile Visionaute is designed for a pay-service in Paris using the ALERT-Plus with the ALERT-C protocol. (*Source:* EBU.)

model for Renault's new car model Megane Scenic, a TTI pay service, as illustrated in Figure 7.16. This service started at the end of 1997 in the Paris metropolitan area and is planned to become available later in other major French cities. The price of the portable receiver is approximately USD $520/FRF 3,000, retail, and the integrated one was announced to cost approximately USD $1,400/FRF 8,000. The service subscription costs approximately USD $20/FRF 120 per month.

During 1997, the French car manufacturer PSA Peugot/Citroën and the French service provider CGEA/Eurolum presented their own ALERT-Plus system product, INF-FLUX. It has a modified protocol that they claim is less demanding on RDS capacity and achieves the same objectives as the Médiamobile service, with which it wants to compete.

7.6 Alternative Technologies

7.6.1 GSM

Studies to use the Global System for Mobile communications (GSM) for the provision of two-way communication between information centres and

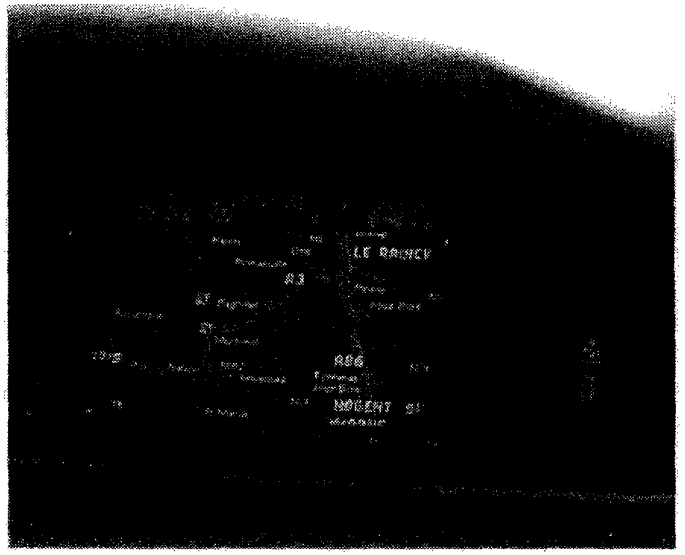


Figure 7.16 Renault's Megane Scenic receiver for the Médiamobile pay service. (*Source:* EBU.)

computers onboard equipped vehicles started in the European Commission's DRIVE I (1989-1991) project: System of Cellular Radio for Traffic Efficiency and Safety (SOCRATES) [4].

GSM includes the possibility for data communication such as the short message services (SMS) channel, which can be used for traffic message services, point-to-point and point-to-multipoint broadcast (cell broadcast), route guidance, and emergency calls. GSM also provides a full data call functionality that permits implementation of pre- and on-trip travel planning and also dynamic route guidance in a navigational system. The widely spread GSM technology is thus suitable for a large variety of ITS services, either using the bidirectional communication link or the inherent data broadcast features.

The switched GSM data service permits a user data rate of up to 9.6 kbps. SMS permits the transmission of short datagrams with a length of 140 bytes. The use of concatenated SMS permits transmission of even longer messages [13].

During the years 1996–1997, a new structuring of the SMS message service was introduced (user data header concept). This concept allows easy and efficient application protocol addressing by port numbers. Furthermore, this concepts allows fragmentation and reassembling of long messages, concatenating up to 255 SMS messages into one message. One example of a transport

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layer protocol that makes use of this data header concept is the narrowband socket (NBS) approach.

New solutions for higher data rates on GSM were already standardised in 1997. These standards included a high-speed circuit-switched data (HSCSD) service and a general packet radio service (GPRS).

Integration of Internet and GSM technology has been studied extensively in the EC-funded PROMISE project. This project is aimed at the development of a traffic and travel information service employing a new type of user terminal, the Nokia 9000 Communicator, using the data communication capabilities of the cellular GSM network [14].

Finally, the Universal Mobile Telecommunication System (UMTS) will represent the third generation of wireless mobile voice and data communication. This will probably attain a user data rate of 2 Mbps. The wide availability of GSM makes it a good starting platform for the introduction of UMTS services [15].

The European Telecommunication Standards Institute (ETSI) standardisation work provides for a phased approach of evolutional enhancements to the GSM technology with the view of ensuring a long lifetime for GSM products using earlier versions of the standards.

With particular regard to ITS services, in early 1997, ERTICO—which is a European ITS technology interest group formed by manufacturers, service providers, and road authorities—created an ITS services committee whose members were major European suppliers and service providers. The aim was to define a strategy for supporting ITS services via GSM [16]. In the report of this committee, two important developments were identified that enable GSM to carry ITS services efficiently:

1. The first development is the emerging industry standard (in 1997, forwarded to CEN TC 278) for telematics services, called Global Automotive Telematics Standard (GATS), which was jointly developed by two major European telematics service providers: Mannesmann Autocom and Tegaron (a company created jointly by Deutsche Telekom and Daimler Benz Interservices) [17]. The emerging standard was already implemented in systems offered in Germany 1997–1998. GATS makes it possible to offer a group of commercial ITS services on GSM. For data transmission, a modular message structure has already been specified on application-oriented layers of the air interface between the service centre and the mobile station. It is subdivided into a transport protocol, conditional access, a security layer, and application protocols containing service-related data.

2. The second development is a proposal on generic wireless information access, called Wireless Application Protocol (WAP) [18]. WAP can coexist with GATS and extends the functionality towards Internet-like information access, permitting the use of channels with a limited data rate. It thus provides a new access medium to ITS services on GSM. The first version of the standard was released in September 1997. A WAP Forum will be created to manage the further development and implementation of this standard.

The ERTICO committee identified a list of ITS services that can be provided via GSM. These are as follows:

1. Emergency and breakdown services/assistance and security services;
2. Traffic information;
3. Floating car data, based on individual measurements of telematics onboard units within individual cars. This can be seen as traffic monitoring which can be implemented at reasonable infrastructure cost;
4. Route guidance;
5. Fleet management applications;
6. Information services to provide the driver with individual information;
7. Vehicle theft detection and recovery;
8. Vehicle remote diagnostics.

GSM coverage is generally continuous and covers most of Europe. It is designed to operate in an urban and interurban environment. GSM permits easy implementation of commercial ITS services since the system permits roaming, handover, and SIM-based authentication. Examples of GSM integrated car receivers are shown in Figures 7.17 and 7.18.



Figure 7.17 Blaupunkt integrates in the GEMINI a car radio, GSM and GPS. (*Source:* Blaupunkt.)

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Figure 7.18 In 1997, Mannesmann-Autocom bought Philips Car Systems, now Mannesmann-VDO Car Communications, to market telematics car radios combined with telematic processors using GSM and GPS technology. (*Source:* Philips.)

In 1997, during the 4th World ITS Congress in Germany, a number of new German ITS services using GSM had already started regular operation or were announced [19]. These are as follows:

- *OnStar:* Buyers of new Opel cars can order an info set USD $800 (DEM 1,500) consisting of a mobile phone, hand-free equipment for fixed car installation, and a global positioning system (GPS) receiver. By the push of a button, the driver is connected with the German automobile club, ADAC, service centre. The vehicle position is automatically transmitted, and the driver can then be guided online to the desired destination. The monthly fee is approximately USD $16/DEM 30.00 and each connected minute costs approximately USD $1.30/DEM 2.50.
- *Mannesmann-Autocom 22666 or Passo:* Provides traffic information over the German D2 network through voice dialogue with a computer system. This service costs an extra fee of approximately USD $0.83/DEM 1.56 per minute. A special receiver with GPS (USD $800/DEM 1,500) will be launched, and via the VDO "mobility assistant" MobiMax, destination direction and distance will also be communicated.
- *Tegaron:* A new company formed jointly by Daimler Benz Interservices and Deutsche Telekom in cooperation initially with Blaupunkt and Mercedes Benz. In January 1998, automated emergency call and theft detection services started. The special equipment needed, which includes a GPS navigational unit, is offered as an option on certain Mercedes cars. The services offered are available as a pay service. Dynamic route guidance and individual traffic information are additional service options.

- *ADAC:* The German Automobile Club offers a service for its members providing traffic information and route assistance. The possibility of offering an attractive, reasonably priced receiver is being studied.

The scenarios for all these new TTI services and their inter-relationships are shown diagrammatically in Figure 7.19.

7.6.2 DARC (also previously known as SWIFT)

The System for Wireless Infotainment Forwarding and Teledistribution (SWIFT) was developed in the Eureka 1197 project. The aim was to develop a multiapplication data system using the FM radio network for mobile and portable receivers. In 1997, the SWIFT Forum decided to only use the name DAta Radio Channel (DARC) instead of SWIFT to avoid confusion with an international organisation using precisely that name.

The DARC system is actually seen as a system that has the potential to provide an interim data service during the transition period from RDS to DAB data broadcasting. DARC technology is inexpensive, and full advantage can be taken of the existing FM coverage. However, when FM networks are very

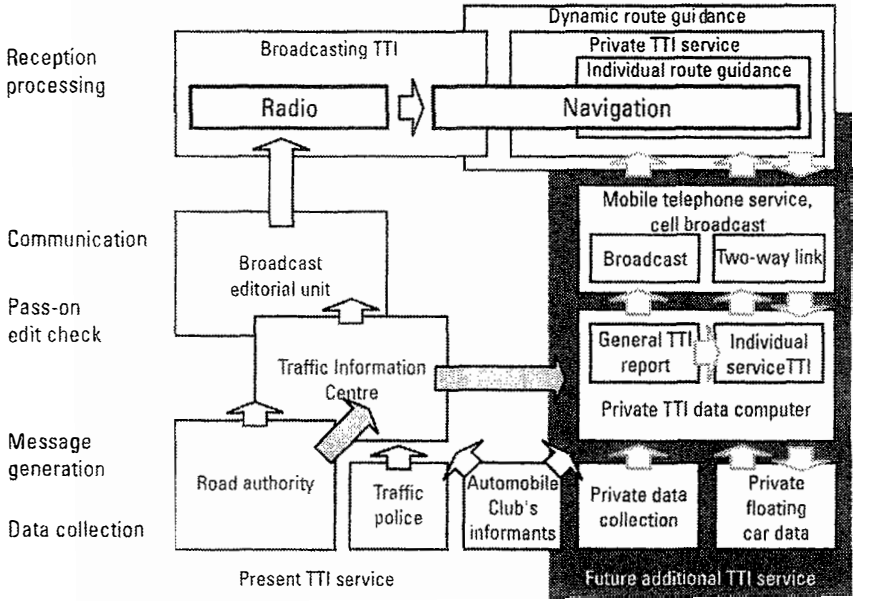


Figure 7.19 Upcoming new scenario for TTI service provision. (*Source:* EBU.)

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dense, DARC may create adjacent channel interference, a matter that is still under investigation, which is one of the reasons why the system is not yet very popular among the broadcasters operating large FM transmitter networks.

The SWIFT project adopted the physical and data link layer of the DARC system, developed by the Japanese broadcaster NHK and the Swedish transmission operator Teracom [20, 21].

DARC's modulation type is level-controlled minimum shift keying (LMSK). The –40-dB bandwidth is 44 kHz centred around 76 kHz, and the overall bit rate is 16 Kbps. Figure 7.20 shows the baseband spectrum of an FM sound broadcast multiplexed with RDS and DARC.

The subcarrier level is dependent on the level of the stereo difference signal. Because the amount of multipath interference has been shown to depend on the modulation level of the stereo signal, a high injection level of the subcarrier is required to provide good reception quality when the stereo sound modulation is high. Typically, a maximum injection level of ±7.5 kHz is used (RDS typically uses only ±2.0 kHz).

In 1997, the following European countries and transmission operators considered the introduction of regular data services using DARC as standardised by ETSI from 1998 onwards: Sweden (Teracom), Norway (Norkring), Germany (Deutsche Telekom), Austria (ORF), Netherlands (Nozema), and France (TDF).

Generally, no transport telematics services are yet planned, with the exception of France where the ALERT-Plus service will be tested using DARC to take advantage of the higher data capacity in comparison with RDS-TMC.

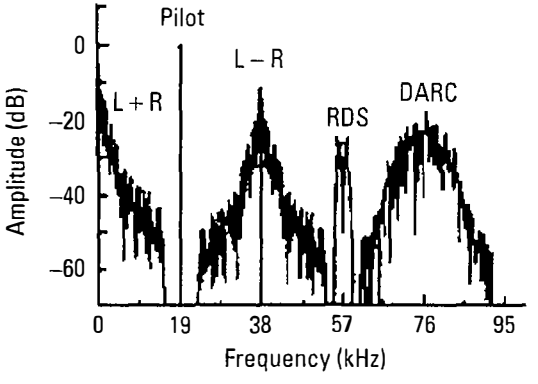


Figure 7.20 Multiplex spectrum of FM stereo sound broadcasting with RDS and DARC. (*Source:* EBU.)

In Japan, the DARC system is used in conjunction with radio and infrared beacons for the operation of the Vehicle Information and Communication System (VICS) service, which has provided traffic information to in-vehicle units since 1996 in three large metropolitan areas (Tokyo, Aichi, and Osaka) [22, 23].

Three different service levels are in operation:

- *Level 3:* Colour map display giving traffic density information;
- *Level 2:* Simple graphic display depicting traffic information;
- *Level 1:* Text information essentially giving travel time.

The system is very widely supported by some 27 consumer electronics manufacturers, offering 74 types of onboard VICS products in 1997. In 1996, many of the navigational systems sold in Japan (800,000 units) could use VICS for dynamic updating. There are no plans yet in Europe to use VICS, since RDS-TMC will give similar functionality.

7.6.3 DAB Delivery of TMC Messages

While Sweden expects to cease FM radio broadcasts in favour of digital broadcasting within 10 years, few other countries expect to make the change that quickly, even though most European countries are now launching digital radio services (as are Canada, Australia, and South America).

Digital audio broadcasting (DAB) promises broadcast audio quality close to that of compact disc and includes several data stream options that can be used for additional data services such as TMC. The message capacity of DAB is potentially as much as 1,000 times greater than RDS-TMC. Although the standards for DAB have been adequately developed for audio broadcasting, they have not yet been fully developed for additional data. In 1997, various field trials were undertaken to evaluate the use of road maps delivered by DAB using the multi-media object-transfer (MOT) protocol for presentation on LCD displays.

DAB-TMC, in particular, needs more work, and the European Broadcasting Union is coordinating that work in the B/TPEG project, which is supported by a wide range of consumer electronics manufacturers, navigation systems companies, and service providers.

It is interesting to note that the European Broadcasting Union Statement D81-1996 recommends that broadcasters should develop their infrastructures for RDS-TMC with the expectation that the infrastructure can be used for DAB later. Thus, it will be important to develop systems especially for TTI

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message generation that provide output to one or more transmission delivery possibilities and to include a smooth path for migration to DAB.

In 1997, 100 million people in Europe could already receive pilot DAB transmissions if they had the appropriate DAB receivers—but the receivers are so expensive that the market has not generally accepted them, although they have been available for a number of years. Nevertheless, the development of DAB transmission networks will take a significant amount of time to achieve coverage that matches that of FM radio. For example, in the United Kingdom, the BBC plans to invest GBP 10 million/USD $16 million to achieve coverage for 60% of the population by the end of 1998. It could easily take another five years or more to reach 95% coverage, and even that is not as good as the present FM coverage.

7.7 The Longer Term Future of TMC

RDS-TMC was given a huge boost in 1997 when the European Union (EU) raised the issue of implementation of services to a high political level, giving very strong support to those involved in the final development phase of RDS-TMC. The first services were being announced in the same year, and in Germany, services were beginning to reach completion and were ready for consumer use. While it is difficult to predict how long TMC will be delivered by RDS, it can be assumed that this high-level EU concern will result in widespread adoption of the technology, and thus it can be expected that RDS-TMC will be available for many years to come. The possible development of TTI services delivery is shown in Figure 7.21.

However, the increased availability of the TTI data gathered for these new TMC services suggests that there will be a surfeit of messages, especially in the metropolitan areas, which RDS-TMC will not be able to handle due to the limited bandwidth available in RDS. Furthermore, there is now the possibility of using many different delivery mechanisms, such as DAB, DARC (also known as SWIFT), digital video broadcasting (DVB), GSM, Internet, and teletext in analogue TV. This new delivery environment expansion was recognised by the EBU in Statement D81-1996 [24], which recommends that broadcasters should develop their infrastructures for both RDS and DAB. But the EBU is taking an even more progressive step, having authorised a new development project known as B/TPEG, which is briefed to develop the Transport Programme Experts Group (TPEG) Protocol [25, 26]. In the short to medium term, the public broadcasters of the EBU support the B/TPEG activity to achieve a suitable protocol for DAB, and expect many other useful proposals to come from the B/TPEG project.

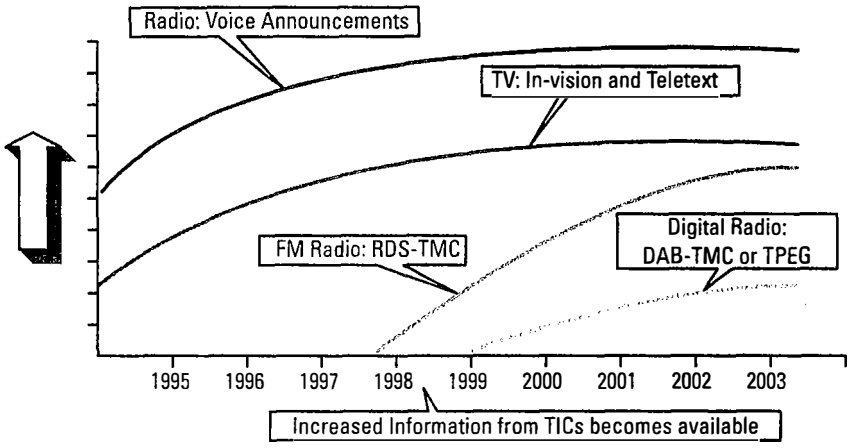


Figure 7.21 Possible development of broadcast traffic and travel information. (*Source:* EBU.)

The TPEG protocol will, in particular, enable broadcasters to develop their TTI services in nondelivery-specific databases, then undertake just one editorial activity and offer these TTI services via one or more delivery technologies, safe in the knowledge that no on-air conflicts of information will result. Use of a single TPEG protocol by all EBU members is expected to facilitate reduced production costs, which will be important for those broadcasters who continue to be TMC service providers as part of their public service portfolio.

A key idea of TPEG is to allow the generation of messages without the need for a location database, eliminating the need to carry location codes in a receiver. This will be designed so that various delivery technologies can carry the same message without further compression. However, low-bandwidth delivery technologies such as RDS could perhaps also be fed with TPEG messages via an adaptation layer, which will compress the information into messages that can be accommodated in the lower bandwidth.

The B/TPEG Plenary Group comprises a wide range of partners and includes EBU members, consumer electronics manufacturers, navigation systems companies, service providers, and transmission operators. It will first evaluate other related protocols and seek to use the best elements of all those known to be available. It will then produce a specification for the TPEG data stream as a draft standard, and produce a parallel guidelines document. Additionally, a TPEG messaging specification for event- and status-oriented road messages and a TPEG service identification and access control specification will be produced by late 1998, together with a parallel guidelines

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document. Then, the DAB adaptation layer will be produced in close collaboration with Eureka 147 and WorldDAB.

7.8 Other Examples for Using RDS in Transport Telematics

In transport telematics, RDS is occasionally used to update variable message signs, car park status information boards, (as shown in Figure 7.22) and boards at bus stops that signal bus arrival times. In any new implementation of this kind, one would nowadays generally use the ODA feature of the RDS system. An interesting example of such an implementation is the bus arrival time signalling system that was installed by AZTEC in Strasbourg, France during 1997.



Figure 7.22 Car park status information in Strasbourg updated via RDS-ODA. (*Source:* Info Telecom.)

7.9 Conclusions

As has been shown, RDS-TMC has a number of unresolved problems that explain to a certain degree the difficulties encountered in its general introduction. As it is generally known, each technology has an optimal time window where it can succeed; and after some time, other and better performing technologies will take over. When these appear on the horizon, it is false to conclude that the knowledge about the better technology is already the end of the so far believed good solution.

In consumer electronics, it takes years for the market to succeed with a new technology. Although receiver prices and profit margins for the industry are relatively low, competition and quality of the products is usually high and the lifetime of the equipment is long.

Success is only possible when well-coordinated standards exist, the technology to be used is mature, there is full consensus of all parties involved in service provision, and the whole industry is ready to go into mass production. In addition, there must be a high demand by the end users for a product that is attractive, safe for the driver, and really useful on the road. As we have seen, RDS-TMC remains surrounded by many open questions. Final answers about success or failure are not yet possible. The infrastructures required and built to collect traffic and traveller information with the view of RDS-TMC service provision will be needed anyway, regardless of the advent of new alternative technologies. Without any doubt, they represent useful long-term investments that are absolutely necessary for high-quality service provision over large areas such as the European Union or the United States.

For RDS-TMC to succeed, we need stable and widely agreed upon standards for the consumer electronics industry. The way their development has been coordinated by the European Commission has not, unfortunately, yet led to the success expected. What lesson can now be learned from 15 years of development effort put into this technological concept? One thing is certain: Those who have participated in this experience can now contribute to the development of better solutions that will use technologies such as DAB, DARC, and GSM.

References

[1] European Commission, Community Strategy and Framework for the Deployment of Road Transport Telematics in Europe and Proposals for Initial Action, Brussels, 20.05.97 COM(97) 223 final.

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Page 95 of 191

[2] Resolution on Standards for Traffic Messages broadcast using the Radio Data System Traffic Message Channel, The Council of Ministers of ECMT, Antalya, May 22-23, 1991.

[3] Council Resolution of the Sept. 28, 1995 European Commission, Official Journal 95/C 264.

[4] Catling, I., *Advanced Technology for Road Transport: IVHS and ATT*, Norwood, MA: Artech House, 1994.

[5] Bücken, R., "Verkehrsfunk auf Abruf," *Funkschau* No. 20, 1997, pp. 70–73.

[6] VDA: Tatsachen und Zahlen aus der Kraftverkehswirtschaft-59. Folge, Frankfurt/M., 1995.

[7] ERTICO, TELTEN Final Report Vol. 1, European Commission DG VII, Brussels, 1994.

[8] Ungerer, D., July 1997, not yet published.

[9] European Conference of Ministers of Transport (ECMT) document, New Information technologies in the Road Transport Sector-Policy Issues, Ergonomics and Safety.

[10] British Standards Institute, DD 235: Draft for Development-Guide to In-vehicle Information Systems, 1996.

[11] Agreement on Guidelines for the Design and Installation of Information and Communications Systems in Motor Vehicles, German Economic Forum on Telematics in Transport, Nov. 1996.

[12] Kopitz, D., "Development of the Traffic Message Channel in RDS," EBU *Technical Review*, No. 245, Feb. 1991, pp. 29–32.

[13] Redl, S. M., M. K. Weber, and M. W. Oliphant, *An Introduction to GSM*, Norwood, MA: Artech House, 1995.

[14] Geen. P., "Standardisation of Traveller and Traffic Information via Cellular Networks," *4th Word Congress on Intelligent Transport Systems*, Berlin Germany, Oct. 1997.

[15] Decker, P., A. Salomäki, and S. Turunen, "GSM and UMTS as a Platform for Transport Telematics Applications," *4th Word Congress on Intelligent Transport Systems*, Berlin, Germany, Oct. 1997.

[16] GSM based ITS Services-ERTICO Strategy for Implementation, V. 1.4, ERTICO, Rue de la Régence 61, B-1000 Brussels, Belgium, Nov. 1997.

[17] Vieweg, S., GATS, "Global Automotive Telematics Standard and Example of Implementation," *4th Word Congress on Intelligent Transport Systems*, Berlin, Germany, Oct. 1997.

[18] Lang, K. E., "Wireless Application Protocol," *4th Word Congress on Intelligent Transport Systems*, Berlin, Germany, Oct. 1997.

[19] "Online Motoring," Translated reprint from ADAC Motorwelt 04/97, *4th Word Congress on Intelligent Transport Systems*, Berlin, Germany, Oct. 1997.

[20] Scomazzon, P. and R. Andersson, "A high bit-rate data broadcasting system using the terrestrial FM radio network / SWIFT Eureka 1197 project," *EBU Technical Review*, No. 264, Summer 1995, pp. 4–12

[21] Kuroda, T., M. Takada, and O. Yamada, "Development of an FM multiplex broadcasting system having a large transmission capacity," *IBC*, Brighton, 1990, pp. 241–245.

[22] Isobe, T., et al., "Traffic Information Services using FM multiplex broadcasting," *IVHS Workshop on Communication with Vehicles*, July 1992.

[23] Kojima, H., T. Yamamoto, and Y. Kumagai, "VICS Information Broadcasting Service / FM Multiplex Broadcasting," 4th *Word Congress on Intelligent Transport Systems*, Berlin, Germany, Oct. 1997.

[24] EBU Statement D81-1996: RDS-TMC (Traffic Message Channel), *EBU Technical Review*, No. 270, Winter 199), p. 45.

[25] Parnall, S. J., "The longer term future of TMC," *Proceedings of the TMC-Now! Conference*, European Broadcasting Union, CP 67, CH-1218 Grand Saconnex (GE), Switzerland, March 1997.

[26] Parnall, S. J., "TPEG" - A strawman proposal for a stream format protocol for transport information, BBC Research and Development Department, R&D Technical Note 0747 (97)P, March 11, 1997.

[27] ADAC-The Active Partner of Road Transport Telematics, *4th Word Congress on Intelligent Transport Systems*, Berlin, Germany, Oct. 1997. Also published in German in *ADAC Motorwelt*, Dec. 1997, p. 46.

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8

Basic and Enhanced Radio Paging

8.1 Introduction

This chapter introduces the concept of FM Radio Paging. This technique offers the fastest way to provide a full paging communication coverage for a metropolitan area or even complete region or country. FM paging is growing quickly because it is cost-effective and it mostly uses an infrastructure already built for other communication purposes. FM Radio Paging puts the existing telephone system and FM broadcasting stations to more profitable use, providing a valuable service and generating revenue for the operator.

In addition to the paging system described in earlier versions of the RDS/RBDS standards referred to as "basic paging," the 1998 version of the new RDS/RBDS standards introduces the "enhanced paging" protocol while keeping full compatibility with the earlier one.

The aim of the enhanced paging protocol is to upgrade the battery lifetime of a pager, as well as to easily permit regional and international paging, and multioperator and multiservices operation.

8.2 What can be Achieved With Radio Paging?

The Radio Paging (RP) feature is intended to permit multiplexing of the paging signals (type 1A groups, 4A groups, 7A groups, and 13A groups—used only for the enhanced paging mode) into the (RDS) data stream containing any of the other RDS features. This technique permits the provision of Radio Paging using existing VHF/FM broadcasts as a transport facility, thereby avoiding the

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need for a dedicated network of transmitters and at the same time making use of the relatively large service areas of FM transmitters.

RDS Radio Paging has the great advantage that an existing VHF/FM broadcast network can be used to carry this service. This is especially true in developing countries, where it is difficult to implement a special radio transmitter network to only carry a paging service, as would be required for a POCSAG paging system. From an economics point of view, this is usually the most cost-effective solution for implementing a Radio Paging service, and for a broadcaster or transmission operator, there is also the opportunity to earn revenue from using RDS to provide such a service. The capacity of an RDS Radio Paging service is approximately 40,000 subscribers per broadcast network of transmitters. The capacity is strongly influenced by the mix of paging services that is provided to users. If the paging service carries only a bleep tone to alert the subscriber, the capacity will be higher; but if long alphanumeric messages are carried, then the capacity will, of course, be much lower since these require more paging data groups to carry the information.

Some of the countries already making extensive use of the RDS Radio Paging technique are France [1], Germany, Sweden, Bulgaria, Hungary, Slovenia, Croatia, the Czech and Slovak Republics, Ireland, Spain, Dubai, India, China, Indonesia, Russia, Ukraine, Tanzania, South Africa, Mexico, and the United States.

The full specification for the implementation of RDS Radio Paging is given in Annex M of the new RDS/RBDS specifications [2,3].

In comparison to former RDS/RBDS standards, significant enhancements were included, as follows:

1. A set of variable-length message types for numeric and function messages has been added to the RDS paging definition, enabling more flexible and efficient use of the transmission.
2. The new definition includes message types for both national and international paging. Previously, only fixed-length messages were defined for numeric paging.
3. A repetition flag has been added. This enables more intelligent processing of the received messages when messages are repeated to improve the reception reliability.
4. A paging call counter has been added. This is a running number for each individual message sent to a subscriber. This number permits the user to be alerted when a message could not be received.
5. The type 13A group concept was introduced for the enhanced paging mode.

6. A global addressing scheme was added for country, operator, and operator's service area management purposes, which permits several operators (15 operators per country; that is, operator codes (OPC), with 63 different service areas per country, which are paging area codes (PAC) to provide Radio Paging services for the same service area without any conflict among them). These codes are carried in type 1A groups, variants 0 and 2.
7. Roaming (international links) for international paging is also possible.
8. A paging network can now be defined without any connection to the PI code, as was previously the case. Only the country code component of the PI code is being used.
9. It is possible to design and manage a paging network completely unrelated to the radio programmes that the transmissions carry.
10. A new battery-saving mode has been defined that improves significantly (10 to 15 times) the power consumption of paging receivers (i.e., the pager is only fully powered during 0.3 seconds out of a two-minute cycle). This is achieved thanks to type 13A groups being placed at the beginning of the six-second interval, already defined in the basic paging mode. Battery life can be as high as up to 2,000 hours.
11. The address range of receivers was enhanced from one million to ten million subscriber address codes.

The enhancements described permit an easy upgrade of existing networks.

Radio Paging is intended to provide a broadcast paging service making use of the type 7A group for transporting the paging messages (see Figure 8.1), associated with the use of type 1A, 4A, and 13A groups (enhanced paging mode only). Subscribers to a paging service will require a special pocket paging receiver in which the subscriber address code is stored. Five types of call messages are possible:

1. A simple call (bleep tone) without additional message;
2. A 10- or 15-digit (international), or 18-digit numeric message;
3. An alphanumeric message of 80 characters, maximum;
4. Variable-length message;
5. Functions message.

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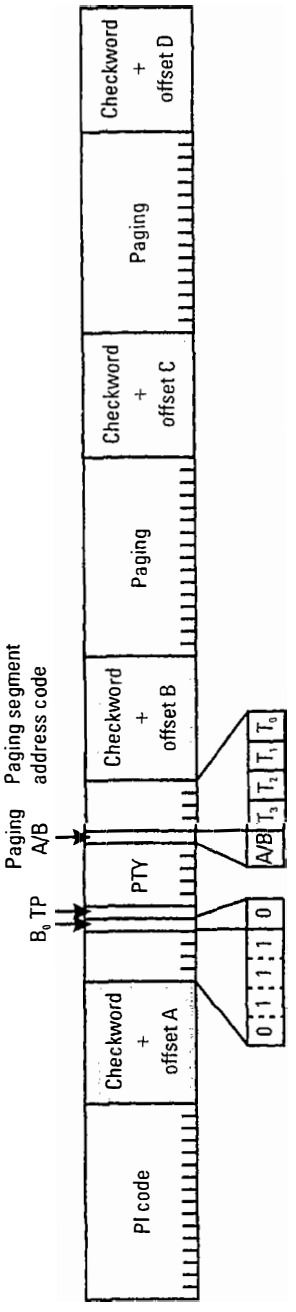


Figure 8.1 Type 7A groups convey the messages for Radio Paging, but other group types (1A, 4A, 13A) are also required for control and battery-saving functionality. (*Source:* EBU.)

In Figure 8.1, block 1 comprises the PI code found as the first block of every RDS group type. Blocks 3 and 4 are used to carry the paging message information. In block 2, the last five bits are used to control the paging information. Bit A/B is used as a flag that changes its value between different paging calls, thus indicating the start of a new or repeated call. Bits T_3–T_0 are used as a four-bit paging segment address code and to indicate the type of an additional message that follows.

8.3 RDS Paging Operational Infrastructure

The RDS paging network needs to bring together a paging service centre with the existing broadcast network to allow the paging data to reach the airwaves. Various configurations are possible, and Figure 8.2 shows many of the communication link options.

The public switched telephone network (PSTN) is used to relay request calls to the paging control terminal (PCT) and to send the required acknowledgements between the caller and the PCT. This requires the installation of a

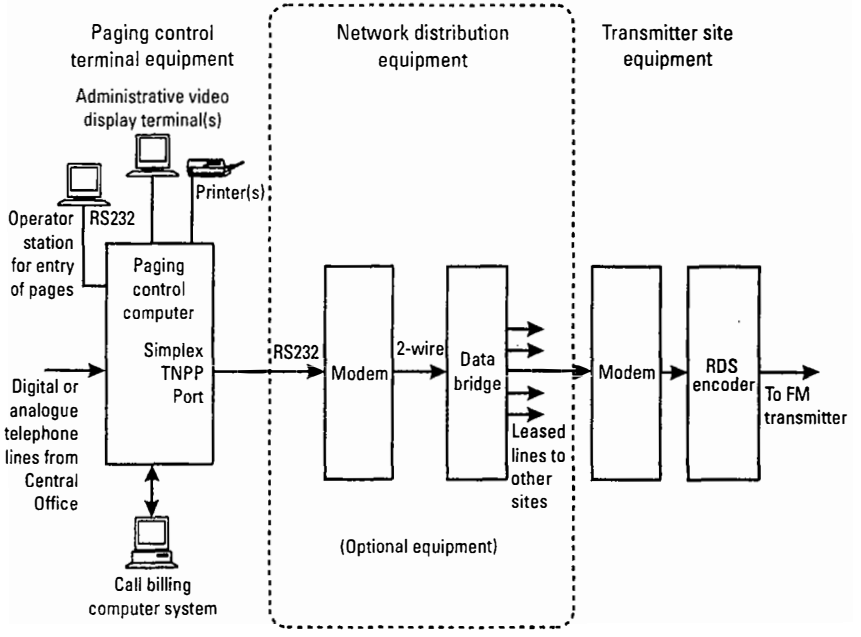


Figure 8.2 General description of an RDS paging system. (*Source:* EBU/RPA.)

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special exchange designed for use in paging operations, performing the basic functions of organisation, control, and billing. These exchanges are commercially available from several manufacturers and can be located almost anywhere.

The paging message is processed with the addition of routing codes and other system management codes and then is packaged into an appropriate protocol to be carried via a suitable high-quality data transmission network to the input point or points of the FM broadcast network [6].

Mainly, two protocols are used. Originally the Telocator Network Paging Protocol (TNPP) was developed for wide area networks serving single-frequency systems, and it has also been used in RDS networks. The European Broadcasting Union (EBU) developed the Universal Encoder Communication Protocol (UECP), which in its latest version, 5.1, (see also Chapter 11), contains all the necessary commands for dynamically controlling RDS data to be broadcast. It also "transports" paging messages for the operation of both the basic paging mode and the enhanced paging protocol from the new RDS/RBDS standards [2–4].

It is important for the broadcaster or FM transmitter network operator to ensure system reliability, and this is best served by amalgamating all data into a single stream between studio centre and transmitter. These protocols will allow the use of satellite links, microwave data links, and data circuits by telephone cables equipped with modems for data transmission, or any combination of these.

The input to the FM network may be connected at the broadcast studio centre or at one, several, or all FM transmitting stations. If the input is to one transmitting station, all others will receive the transmitted signal, including the subcarrier from the original transmitter. It will also be possible to rebroadcast the transmitted multiplex (audio and data subcarrier) from the original transmitter by modulating it onto another VHF frequency. However, generally speaking, an RDS encoder may be required at each transmitter site to modulate the data onto the subcarrier when only the baseband audio signal is rebroadcasted. In each FM transmitting station, the required configuration may be very similar.

When operating RDS paging, it is necessary to provide an even more rugged data signal than the one required for mobile reception with a car radio. This is achieved by increasing the subcarrier deviation for RDS from the normal value of ±2 kHz to a level of at least ±4 kHz, the reason being the very small antenna used in a pager. In addition to this, each paging message has to be repeated two or even three times at a sufficiently spaced time interval of several minutes, assuming that most pagers will be used by people that are on the move.

8.4 Paging Receivers

It is undoubtedly a real challenge to design a small autoscanning paging receiver that is easily accepted by the user and that can fulfil all the requirements of the RDS/RBDS standards. RDS pager development has to be optimised by trading off size/weight, sensitivity (most critical for the provision of a reliable service), displays, alerts, and battery lifetime. Initially, the prices for RDS pagers were relatively high, but now they can even be as low as USD $100.00. The potential to compete with POCSAG pagers thus has grown dramatically. Important RDS pager manufacturers are now Info Telekom (see Figure 8.3) and Cirkisys. Nokia sold its paging business unit to Info Telecom and is no longer active in this sector.

The RDS system allows both numeric and alphanumeric paging options. Pagers can receive 10 to 18 digits and are equipped with a memory that permits storage of 10 messages or more. Alphanumeric pagers can display messages of up to 80 characters, and usually offer extensive memory capacity as well (see Figure 8.4).



Figure 8.3 The 1997 model RDS FM 101 of a new pager from Info Telecom in France, permitting reception of 10- or 18-digit messages. (*Source:* Info Telecom.)

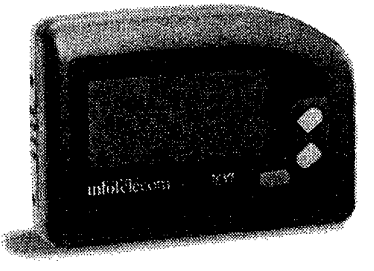


Figure 8.4 The 1997 model RDS FM 110 of a new pager from Info Telecom in France, permitting reception of 80 alphanumeric character messages. (Source: Info Telecom.)

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Each RDS Radio Paging transmission includes the country code and the group code of the pager, with which the pager synchronises itself. To preserve the battery life, the processor of the pager turns the pager on and off as required. The pager is only fully powered during the transmission of paging messages to its own interval.

8.5 Future Developments

All operators and manufacturers involved in RDS paging collaborate closely within the Radio Paging Association, which is part of the RDS Forum. These companies drive the technology and are thus the leaders in the worldwide market of FM Radio Paging. Apart from RDS paging, this market also uses some other technologies such as MBS [5], which is of special interest only to those who use FM broadcast transmitters that are operated outside the VHF/FM Band II (87.5–108.0 MHz); that is, mainly in countries of Central and Eastern Europe that still use the VHF Band I (66–74 MHz) for FM sound broadcasting and where RDS cannot be implemented.

Another proprietary system widely used in the United States and Canada is the system operated by Cue Network called MMBS, which consists of data multiplexed together with the RDS data stream using the offset word 0. This system can only be used in conjunction with the North American RBDS standard and is not included in the CENELEC RDS standard.

More recently, FM paging has also been implemented in a few cases on the DARC/SWIFT subcarrier system (see also Chapter 13), which offers a much higher usable data rate than RDS.

8.6 Conclusions

In a world where mobile communications embracing mobile telephone technology such as GSM are becoming a part of everyday life, one fact remains: there is invariably a cost versus coverage equation to be balanced for both operators and subscribers. Today, the RDS paging network can give the operator national and even international coverage when linked to other operators worldwide. RDS paging offers a very competitive communication service to potential customer groups who rely on keeping in contact within a wide area as they travel. Pocket pagers are easy to carry and have such a low power consumption that one single AA or two AAA battery cells can power them for as much as 1,000 hours or more. There are many other paging technologies around that seem to compete with RDS paging; however, with a recent sharp

fall in prices for RDS pagers, the potential to compete with other paging technologies has grown significantly. This paging system is also ideal for the developing world, which really has little or no interest in investing in multimillion dollar infrastructures that RDS paging simply does not require.

References

[1] Frossard, D., "RDS Paging in France," *EBU Review-Technical*, No. 245, Feb. 1991, pp. 22–28.

[2] CENELEC, Specifications of the Radio Data System, EN 50067:1998. European Committee for Electrotechnical Standardisation, Brussels, Belgium April 1998.

[3] EIA/NAB National Radio Systems Committee, United States RBDS Standard, Specification of the Radio Broadcast Data System (RBDS), Washington D.C, 1998.

[4] EBU Universal Encoder Communications Protocol UECP-Version 5.1, European Broadcasting Union, 17A Ancienne Route, CH-1218 Geneva, Switzerland, Aug. 1997.

[5] Swedish Telecommunication Administration (Televerket)-Paging Receiver for the Swedish Public Radio Paging System, 76-1650-ZE, 1976.

[6] RPA, News Bulletins No. 1 (1995) and 2 (1996) of the Radio Paging Association.

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