

A tall radio tower with a spherical antenna at the top, set against a bright blue sky with scattered white clouds. The tower is positioned on the left side of the frame, extending vertically.

A silent revolution - RDS for FM radio



RDS Forum authors team

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*This book is dedicated to all colleagues within the EBU and the RDS Forum, who helped to make this RDS success story happen.
Thanks for the many opportunities we had to work with you.*

Dietmar Kopitz

About the co-ordinating author:

Dietmar Kopitz is one of the two founders (the other is Johnny Beerling) of the RDS Forum and since 25 years its Chief Executive. He is also the editor of the RDS standard, published by the IEC in its most recent version in October 2018, IEC 62106 -1 to -6.

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Forward for the first ebook on RDS

When my predecessor Johnny Beerling wrote his introduction for the RDS e-book in 2013, it was assumed that FM would be phased out in the next 15-20 years and be replaced by DAB in Europe. Today we see that radio in Europe is based on 3 pillars: FM, IP and DAB or HD radio for North America. Thanks to huge progress made in DSP technology, RDS has made an enormous step forward with RDS2. The new RDS specification IEC 62106 with RDS2 is now adopted by the IEC. FM RDS has obtained its full place in the European radio landscape and also in the USA. RDS2 with an increase of a factor 6 in data capacity allows for state of the art product applications like a full colour station logo instead of an 8 character station name.

In this new edition you will learn more what is RDS2 all about.

I wish you happy reading

Frits de Jong , Chairman of the RDS Forum.

Back in 1985 my boss, the Managing Director of BBC Radio, Richard Francis, sent for me and said that I was to take charge of the programme development and promotion of RDS. Not just for the UK, but through the European Broadcasting Union, for the whole of Europe.

“What is RDS?” I asked.

“It will be the most important development in radio since the invention of the transistor” was Richard’s reply and that started my love affair with the system which has revolutionised FM radio listening over the last 27 years.

In retrospect, I see now that the broadcasters who started down the RDS road all those years ago were creating a silent revolution in radio.

In cars in particular, if you are driving across your country and you wish to remain tuned to the same national station you will have to retune many times. This is due to the fact that overlapping coverage areas from the network of transmitters carrying the same programme have to broadcast on different frequencies to avoid interference.

With RDS you can find the station by name and the clever radio does the rest for you, and to avoid traffic hold ups you can receive travel news relevant to the local area through which you are driving.

All by courtesy of RDS.

Today, thanks to the enthusiastic take up by chip manufacturers, nearly every radio in Europe has the capability to decode the RDS data and take advantage of what is on offer. Not just radios but smart phones too have integrated RDS and so there are many 100 millions of radios out there which offer the useful features. These days it is not just automatic tuning and travel news but text messages about the programmes and information about the music being played.

It really has made FM radio so much better and easier to use. All over the world people are using it without being aware and yet there are few who understand how it works.

In this book, edited by Dietmar Kopitz, you will find an explanation of the whys and wherefores of the Radio Data System, set out in an easy to understand, non-technical way. You will see how the system developed and understand why the transition to digital radio is happening so slowly.

Modern radios don't wear out and with a good RDS Radio there is little incentive to throw it away in favour of a DAB one, especially as few new cars offer the alternative of a DAB radio as standard. There is little to be gained by switching from FM except where radio stations are offering unique programming on DAB.

Governments are keen to shut down the FM broadcasts so that they can sell off access to that spectrum to meet their budget deficits. However the public, by not switching over to DAB, are making this option very difficult and I foresee that it will be at least another twenty years before more people are listening on digital than on FM. In the meantime RDS sails on into the sunset with clear enjoyable listening for everyone. Long may it continue.

Now switch off your radio for a while and sit back and enjoy this electronic publication which gives you the whole inside story of RDS, the Radio Data System, by one of the founding fathers, Dietmar Kopitz, and other RDS Forum members.

Johnny Beerling, former Chairman of the RDS Forum.



In 1988 RDS was implemented on the BBC FM transmitter network. Johnny Beerling (former Chairman of the RDS Forum) presented the innovation at the opening ceremony in London.



1990: The BBC's RDS crew on the road for an EBU meeting on RDS in Torino, Italy. From left to right: Mark Saunders, Bev Marks and Johnny Beerling.



RDS Forum 2012 at Glion/Montreux (Switzerland). From left to right: Dietmar Kopitz, Kent Adeborn, Johnny Beerling. Kent and his team had designed the first commercial RDS car radio, the Volvo SR-701, introduced into Volvo cars during 1987/8.



2017: The RDS Forum management Committee. From left to right: Dietmar Kopitz, Chairman Frits de Jong, Vice-Chairman Mark Saunders and Attila Ladanyi.

The RDS development history by Dietmar Kopitz

This Chapter gives a detailed overview about

- ▶ The RDS and RBDS standards
- ▶ the UECP specification and
- ▶ the RDS Guidelines.
- ▶ The current RDS standard is IEC 62106-1 to IEC 62106-6 from October 2018.
- ▶ The current RBDS US standard is NRSC-4-B from 2011. It will become IEC 62106-7.
- ▶ The RDS receiver measurement standard is IEC 62634 ed.2 from 2013.
- ▶ The Universal Encoder Communication Protocol UECP is published by the RDS Forum and the current version is 7.05 from 2010. Updated to include RDS2 it will become IEC 62106-8.
- ▶ The RDS Guidelines are also published by the RDS Forum and are available for free from the RDS Forum's web site.
- ▶ The RDS-TMC standards are ISO 14819 - all parts.



The EBU Specialists Group testing first RDS proposals at Bern/Interlaken (Switzerland) in 1980.

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 1950's 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 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 ARI-system. ARI stands for "Autofahrer Rundfunk Information" which means "broadcast information for motorists" (note: The ARI system was

discontinued in Europe in the years 2004 - 2006). 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 is 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 sales 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 to obtain then a recommendation from the EBU that this system should be generally used all over Western Europe.

The EBU is a European professional association of mostly public broadcasters, in Western Europe at that time, but it now also includes the broadcasters of Central and Eastern Europe. The EBU is in fact the authority to establish or harmonize operational broadcast practices 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 ITU, CENELEC, IEC, ISO and ETSI to create the necessary standards, normally before any recommendation, relating to an operational practice for broadcasting, is issued.

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 large 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, whereas regionalisation, though quite useful for road traffic information, was not a common practice 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 were being asked, such as:

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

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.

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, i.e. alternative frequency lists are required instead.

This criticism 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 sub-carrier frequency (57 kHz or 76 kHz, both integer multiples of the 19 kHz pilot-tone) for the purpose of achieving a minimum of interference from the data signal to the stereophonic audio programme or, the required coverage area (the same as for monophonic reception), the ARI compatibility and, also very important, to aim at 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 specialist group of experts in data broadcasting. In most European countries, in the late seventies, 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 countries, 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 and

also being responsible for organising the work decided 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 Dr. Kari Ilmonen's thesis in 1971 was all about, and what kind of research work he had then initiated in consequence within the Technical Department of Yleisradio. One of his collaborators had also joined the EBU specialist group and he so contributed to the work being then undertaken, already on the basis of the background thus gained. Dr. 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, then one could also in addition make an identification for programme type. He then drew up a list that closely resembles those PTY lists now used in RDS and DAB. He also 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, Dr. 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.

How did the EBU specialists then proceed in their work? In 1976, already there were several different radio data systems proposed from Finland, the Netherlands and Sweden. The specialists tried to identify what these systems had in common and 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 in Switzerland. Representatives from the European receiver manufacturing industry (EUROTECH, later EACEM) were invited to join. A questionnaire was sent to broadcasters and industry to determine the desirable features of the up-coming system. The data broadcast tests in the region of Bern/Interlaken were then recorded by various research laboratories and analysed with the view to optimise the mobile reception.

In 1981, there was subsequently agreement of co-ordinated applications and the principles to be used in baseband coding. Test transmissions then started in several countries such as France, Finland, Germany, Netherlands, Sweden and 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.

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 in addition a field test in Stockholm. Out of this evaluation, the Swedish 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.

Subsequently, an ad-hoc group was created to meet at the BBC Research Department with the task of fixing the base-band coding for all known applications that one had wished 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. Once the data were evaluated by the research laboratories involved, the RDS specification was drawn up in a final technical specification, called RDS, 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 passing successfully a

field trial to confirm that compatibility to those manufacturers putting it into doubt had to be taken. Of course, such a field trial had to be carried out in Germany, in an area of equally difficult mobile reception as the one encountered in the Bern/Interlaken area. Munich/Berchtesgaden was chosen for this field trial to take place in 1983 and RDS passed successfully this rather critical test.

As a consequence the RDS specification was then adopted by the EBU and EUROTECH in 1984, published and also submitted to the ITU and CCIR Study Group 10 in particular. 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 and most recently updated in the third version of 2011.

All the above shows clearly how RDS has emerged over the time and exactly within the years 1975-1984. In the retrospective of all said above, we saw in this 10 year long development appearing:

- ▶ The desire to universally identify each FM programme; this created the PI and PS features.
- ▶ The desire to identify broadcasts for motorists more universally than ARI; this created the TP and TA features.
- ▶ The desire to hand-over a mobile receiver within a network; this created the AF feature.
- ▶ The desire to identify programme type; this created the PTY feature.

A system was now designed for the mobile listener who had needed, without any doubt, much 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; and also, an emulation of the ARI system used in Austria, Germany, Luxembourg and Switzerland which 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 whilst 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 to expect future enhancements has allowed RDS to mature over the following years; really a “silent revolution” for FM radio to establish itself as the main radio distribution medium, even under the challenges of digital radio, already with DAB around since 1993 and regretfully still not a market success when compared to FM/RDS radio.

In 1985, EUROTECH agreed with the EBU the general introduction of RDS and promised, on the condition that the EBU

would give their support towards the development of the 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, these receivers would then be marketed in all those countries where RDS was already introduced.

Given the fact that the RDS development was so well co-ordinated by the EBU and broadcasters in all European countries were, through this activity, fully aware of the benefits created for their listeners (some said they could now “surf” the radio waves), the introduction of RDS, European-wide was quite fast. So fast, indeed, that some then called it the “silent revolution”.

Broadcasters started to implement RDS transmissions, with a mixture of self- built RDS encoders and there was a beginning 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 pre-service 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.



The first commercial RDS car radio on the European market was the Volvo SR-701 in 1987.

In 1988/9, when receivers were ready to conquer the European market, RDS was already on-air almost all over Western Europe.

EVOLUTION OF THE RDS STANDARDS

The first RDS “standard” was published in March 1984, titled: EBU Tech 3244: Specifications of the radio data system RDS for VHF/FM sound broadcasting, and it contained some 14 different RDS features.

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 were far over one billion FM/RDS receivers (the mobile phones with FM/RDS radio in-

cluded) worldwide in the hands of consumers by the end of 2012 and a very high proportion of those use the abbreviations like AF, TP, TA, RT for example on their front panels or in their displays. Did the standards writers realise the impact their work would have? These abbreviations, we 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 observe later.



*The Volvo car radio SR-701 designers
Adeborn and
Gudmandsen (RDS Project leader).*

It is true to say, that up to 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, anxious to improve car-safety by the introduction of several automatic features which an RDS receiver could provide. Of course, almost all well-known commercial car receiver companies now produce RDS 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 Alternative Frequencies: Methods A and B; Radio Paging (RP); Programme Type Codes (PTY) definitions and Enhanced Other Networks (EON). With the perspective of that epoch there is no doubt that the EON development was a major change to the standard, that had come about from the joint efforts of broadcasters and receiver designers attempting to implement a system which allowed signalling from one radio programme network belonging to a broadcaster to another radio programme network of the same broadcaster. Experience had shown that the earlier ON mechanism of the original standard just did not work well enough and thus had to be abandoned.

After much thought, at an EBU meeting held in July 1987 and a number of subsequent meetings to distil the details, several new concepts were developed including EON which could

give a receiver a full "picture" of a broadcasters networks within a 2 minute interval. Then dynamic signalling could vector a receiver to specific services as needed, for example a travel bulletin could be received from another local transmission in the area of reception, something that DAB has great difficulty to offer now.

By common consent, BBC Radio agreed to become the field test site for the EON techniques and implemented EON then during 1988 with signalling associated to five local radio services and referenced by the BBC Radio networks. That trial was very successful and the UK became then a continuing test site for many RDS receiver designers from all over the world, who came to test their software implementations of EON for second generation RDS receivers (see also Chapter 6).

Over the years RDS has also attracted a number of different RDS encoder manufacturers and 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 of the RDS features. But gradually the need for features such as TA flag control and more recently the PTY feature and after all RadioText (RT and RT+) which have recently been more and more frequently implemented in RDS receivers, car radios and mobile phones included, 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 (see Chapter 4).

With significant development work going on in European industrial manufacturing companies, it became clear that a better recognised international standard would serve well to publicise the RDS system and to ensure consistent design activity in the diverse organisations now working on RDS products. So, in 1988 CENELEC, began in close cooperation with the EBU, to transcribe EBU Tech 3244 and its four supplements into a European standard, EN 50067. This was published in December 1990 and established the definitive standard for Europe.

EN 50067:1990 became the “solid rock” which the RDS system needed both, from a broadcaster’s stand point to ensure reliable transmissions, but also from the RDS receiver designers point of view. Both these 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 these cases the broadcasters had similar structures to those already found in Europe, so the RDS standard requirements fitted their networks well and virtually no adaptation was forced upon them.

If a standard has been well designed, then additions to it will offer enhancements that industry and consumer alike want. However the timing of such enhancements has to be considered carefully to ensure that the revised standard does not destabilise the market place. Accordingly the EBU issued a proposal, SPB 482 which contained certain enhancements to EN 50067:1990, which were made to clarify to a greater level of detail certain coding issues which had become necessary. That work was ready for the next issue of the standard and completed well in advance of the market place needing them standardised. This was to prove also valuable in the developments that were taking place in the USA. 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 ECC proposals for the worldwide implementation of RDS and their output was published, in August 1992, by the EBU as SPB 485 (rev 1992) covering: Allocation of country/area identification codes in RDS.

In the meantime CENELEC EN 50067:1992 has been published. The new revised text which was first published in September 1996 by CENELEC, was prepared by the RDS Forum with full involvement of experts from the EBU. Certain elements of text were revised to accord with experience gained with the RDS system and changes in broadcasting practice since the initial specification was published. An interesting example were 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 CEN standards, defining the RDS-TMC feature.

Receivers produced to accord with the new specification were, of course, compatible with RDS broadcasts which conform with previous editions of the RDS specification. This fundamental principle has also to be met today.

The resulting new European Standard EN 50067:1998, replaced as from April 1998 onwards the old EN 50067:1992 and all earlier versions as well.

In the year 2000 RDS became a world standard of the IEC with the reference IEC 62106 ed.1.

In 2009 a new feature was added, RadioText Plus, and enhanced RadioText with an extended character set was specified. RT+ and eRT are both public ODAs.

In 2013 IEC 62634 ed.2 is published, defining methods of measurements for RDS receivers.

In October 2018 a totally re-structured version of the RDS standard was published as IEC 62106 -1 to -6. This included RDS2 which was developed by the RDS Forum since 2014.

RDS-TMC

In the mid-1980s, the EBU RDS experts were prompted by European car radio manufacturers, and EUROTCH 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 just 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 navigation systems could interpret. This was a simple idea, but unfortunately many complex issues were associated with this feature and the European Commission had then funded much research into the application.

In this process, many new standards about messages, dictionaries for all the languages needed and their management were developed. The coding of RDS-TMC has been undertaken by many workers co-ordinated by the EC projects. Field trials in the mid-1990s showed that RDS-TMC would work well, but significant infrastructure requirements were needed to implement RDS-TMC fully across Europe and by now this is all in place, to a large extent funded by the relevant EC projects.

The RDS-TMC standards, using the RDS ODA protocol, are published by ISO under the reference ISO 14819 (all parts). The body in charge of maintaining these specifications is TISA in Brussels. This activity they coordinate to a certain degree with the RDS Forum.

For more details about RDS-TMC see Chapter 7.

RBDS

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

In the USA the radio environment, most notably radio networks and relay transmitters or transposers, as they are called in America, are more infrequently found, quite different from Europe, so RDS clearly needed some adaptation. But the NRSC sub-committee, which had elected to call the American standard “Radio Broadcast Data System - RBDS”, realised that RDS would be more quickly implemented in the USA 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 USA 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 prob-

lem. 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 US 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 USA. This was the other significant demonstration 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, because the original RDS specification had only considered countries that were members of the EBU and now expansion to the whole world became a distinct necessity.

In the USA, the RBDS specification was first 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 system, and European receivers could easily be modified for use in the USA. In the large majority of cases, they would even work well unmodified, especially with the five basic features PI, PS, AF, TP and TA.

Simultaneously, as the European RDS standard was upgraded in the years 1995-97, an up-graded RBDS specification was completed by the end of 1997 within the NRSC, the National Radio Systems Committee which is jointly sponsored by CTA,

the Consumer Technology Association and NAB, the National Association of Broadcasters.

RBDS was now drawn up with the view to harmonize, to the largest extent possible, the RBDS specification with the RDS features specified in Europe.

In the USA, since about 1995, RBDS is only the name for the American standard. When implemented in receivers, the system has been also called RDS, as indeed anywhere else in the world. RDS in the US is identified with the same logo as specified in the IEC standard, and as once developed for the EBU by the BBC.

The NRSC followed the updating process of the RDS standard with the help of the RDS Forum. The latest version of the RBDS standard has the reference NRSC-4-B, published in 2011. It contains only the differences with respect to the IEC standard IEC 62106 and references to the IEC standard for all other details. It is planned to add the RBDS specification to the IEC 62106 standard as Part 7.

The NRSC had up to October 2018 an RBDS Subcommittee that dealt with RDS issues in North America. Now this committee has been replaced with a new Radio Data Service Subcommittee. It has a wider scope: metadata used for radio using all its distribution media.

UECP

Under the auspices of the EBU, many major RDS encoder manufacturers have cooperated to develop the Universal Encoder Communications Protocol, which is nowadays managed and maintained by the RDS Forum. It has reached, during 2010,

Version 7. 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 all existing RDS encoders.

It is planned now to make the UECP part of the RDS standard IEC 62106 as Part 8. The UECP is in the process to be adapted to fully support RDS2.

RDS Guidelines

Successful standards are in use by the few people who helped develop them, then 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 then, the intentions, not fully or well specified, 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, in these circumstances, the EBU and later the RDS Forum published Guidelines for the implementation of the RDS system, which are intended to encapsulate the knowledge and the experience gained by the first implementers on the transmission side as well as at the receivers end.

With all the developments that have taken place over recent years, it was necessary to prepare a new edition of the RDS Guidelines document, version 5.1, and the RDS Forum undertook that work during the years 2010-2013. This was already differently focussed, namely to cover the transition to digital radio and DAB in particular.

The RDS Forum constantly updates the RDS Guidelines and makes them freely available for downloading from its web site. For RBDS in North America specific Guidelines exist as well (NRSC-G300): They can be downloaded for free from the NRSC's web site.

RDS FORUM - a world-wide association of RDS users

The RDS Forum was formed in 1993 as a self-funded non-profit organization to represent the interests of consumer electronics manufacturers and broadcast service providers, and to foster and develop the best practice and implementation of the Radio Data System.

It grew out of some 20 years of development supported by the European Broadcasting Union.

Quite simply, the RDS Forum provides the mechanism whereby many experts share their knowledge about the RDS system through occasional and regular meetings, the medium of the internet and by the distribution of an extensive annual electronic document collection.

In the last ten years the RDS Forum has proved its worth many times over by:

- ▶ drafting and maintaining the worldwide IEC RDS standard updated in 2009 with the new features RT+ and eRT (now, in 2012, under update review again);
- ▶ developing a new IEC standard 62634 of 2011 to measure the RDS performance of receivers;
- ▶ writing detailed RDS guidelines to show users how RDS should be implemented and how the transition to digital radio can be handled by mobile receivers;
- ▶ advising developers how to best implement all the

RDS features and how to test them with existing and new receivers;

- ▶ showing how to compatibly extend the limit of the RDS data transmission capacity by adding RDS2;
- ▶ showing how to add multimedia and hybrid radio enhancements to FM radio;
- ▶ updating the Universal Encoder Communication Protocol for broadcast service providers (UECP) that ensures connectivity with the transmitter network, permitting the use of RDS encoders from different manufacturers within the same transmitter network.

Furthermore the RDS Forum is in a strong position of knowledge to resist any unjustified patent claims that may arise.

The RDS Forum continues an ongoing vital development role, running the Open Data Applications (ODA) registrations office required to register new applications within RDS and secure their compatibility with the standardised RDS features.

The RDS Forum maintains a comprehensive website too. This ensures that worldwide interests are well informed and kept up to date on all developments.

The RDS Forum has been an enormous success; RDS is now widely implemented with well over several billion RDS radios in use worldwide.



The RDS Forum meeting in Glion, June 2017.

In the nineties the prediction was made that DAB technology would replace FM soon. However, in the meantime we see that the reality is completely different. The RDS Forum believes that FM radio has its firm position next to radio over IP and DAB and in addition, FM/RDS radio is increasingly used since more than 10 years in the large majority of mobile phones.

The RDS Forum spent a lot of time in considering service following with switching forth and back between FM/RDS and DAB for mobile reception with car radios.

Using the RDS/RT+ feature it is increasingly popular for broadcasting music items to provide 'titles' and 'artist' information over RadioText, in both, Europe and the USA.

New markets and broadcasters are constantly emerging with a need to develop RDS for their own use. The RDS Forum has recently recognised the need to address displays for non-Latin characters. Enhanced RadioText (eRT) was designed specifically for the countries in Central and Eastern Europe, so that all their languages and character sets are supported.

A key role of the RDS Forum is to safeguard a proper implementation in order to avoid problems like:

- ▶ unregistered ODA Applications;
- ▶ non-conforming PI codes causing chaotic receiver performance, producing undesirable effects outside national borders;
- ▶ wrong injection levels causing widespread interference in receivers;
- ▶ Radio Text and Radio Text Plus delivered incompatibly with receiver display ability;
- ▶ "dynamic PS" display causing driver distraction, resulting in accidents;
- ▶ FM-RDS/DAB tuners randomly switching between radio programmes;
- ▶ no support for multi-standard radio programme service following, very important for car radios travelling large distances.

This sort problems will only grow without the authority of the RDS Forum monitoring, and where possible, the RDS Forum will give support for correcting such errors and help to maintain a proper implementation of the RDS standard.

The operational expenses of the association are shared among all those interested to join it. Members pay for each registered representative an annual fee. 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/

Over 40 years of RDS development and maintenance work

The years before the RDS Forum existed

1975	Pre-development start within EBU
1980	First field trial at Bern/Interlaken, Switzerland
1982	Test to choose modulation system for RDS in Stockholm, Sweden RDS baseband coding agreed at BBC Research Centre, Kingswood Warren, UK Second Field Trial at Bern/Interlaken
1984	First presentation of RDS in Detroit, USA Ford starts RDS car radio development at Detroit First RDS Specification EBU 3244 published
1985	Large scale pre-operational broadcasting trial in Germany EBU recommends RDS introduction Industry/Broadcasters agree first receivers market launch for IFA Berlin 1987
1986	First presentation of RDS at NAB Dallas, USA RDS CCIR Recommendation 643_1 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
1988	Austria, Belgium, Denmark, Germany, Italy and United Kingdom introduce RDS Blaupunkt, Grundig and Philips mass produce RDS car radios
1990	Norway, Netherlands, Portugal and Switzerland introduce RDS Presentation of RDS in Washington DC and NAB Las Vegas, USA First presentation of RDS at BroadcastAsia at 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 at New Orleans to US Public Radio Hong Kong introduces RDS
1992	New version of CENELEC RDS Standard published South Africa introduces RDS USA: NRSC RBDS standard completed
	...

	... over 40 years of RDS development and maintenance work
	The years since the RDS Forum exists
1993	RDS Forum created to promote RDS implementation and to maintain the RDS standard Grundig: Presents at IFA Berlin first portable RDS receiver
1994	European Commission recommends RDS-TMC for Trans-European Road network First version of Universal Encoder Communication Protocol published by EBU
1995	RDS Paging Association created EIA activates RDS promotion in USA First RDS Forum meeting in the USA
1996	RDS Forum enhances RDS CENELEC standard NRSC in the USA agrees with RDS Forum to harmonize RBDS and RDS
1997	New NRSC RBDS US voluntary standard published UECP enhanced to conform with new RDS CENELEC standard Germany - First country to introduce RDS-TMC
1998	New RDS CENELEC standard version published First RDS-TMC pre-standard published by CEN
2000	New RDS world standard IEC 62106 ed1 (replaces European standard CENELEC EN 50067) FM/RDS receiver chip market much expands because of usage in many mobile phones
2003	RDS-TMC standard ISO 14819 published
2008	New RDS features RT+ and eRT specifications agreed by RDS Forum
2009	IEC RDS standard 62106 ed2 published (new features RT+ and eRT and revised character tables) Kenwood RBDS car radios with RT+ feature Apple iPod nano 5G with first FM/RDS radio and RT+ feature
2010	Fully updated UECP version 7 published by RDS Forum to conform with IEC 62106 ed2 Nokia phones (N8, E7, C7 and C6) with FM/RDS radio and RT+
2011	New RDS receiver measurement standard IEC 62634 published New version of RBDS standard NRSC-4-B published New version of ITU Rec 643-3 published to conform with IEC 62106 ed2 FM/RDS receiver chip market exceeds annual production of 1 billion FM/RDS receiver ICs
2012	RDS Guidelines (version 5.1) updated by RDS Forum (to support transition to digital radio)
2013	IEC publishes updated versions of the IEC standards 62106 ed.3 and 62634 ed.2
2014	RDS experts meet in Budapest and recommend to RDS Forum to go ahead with RDS2
2015	First RDS2 Info Day meeting in Berlin
2016	Second RDS2 Info Day meeting at Radio France in Paris
2018	IEC publishes the re-structured RDS standard IEC 62106-1 to -6 which includes the RDS2 option

RDS on the basic subcarrier - What is it all about ? by Dietmar Kopitz

This Chapter gives a detailed overview about RDS and RBDS. It provides much of the necessary background that will help to better understand the details given in later chapters about RDS and RDS2 and their implementation options.



RadioText Plus is used in some recent car receiver that display for RT-music items the title and the artist's name. BMW has such a product.

OBJECTIVES TO BE ACHIEVED WITH RDS

The Radio Data System, RDS, offers broadcasters a flexible data-transmission channel accompanying VHF/FM sound broadcasts. Additionally, RDS offers the possibility for data service providers to introduce new data services. Thus, RDS can accommodate a wide range of possible implementation options. Optional RDS2 with the three additional subcarriers extends these possibilities.

Following a long period of systems development in the 1970s and early 1980s, and field trials in several European countries, RDS is now implemented in over 50 countries worldwide, in

Europe, in some Asia Pacific region countries, South Africa, Latin America and in North America (USA, Canada and Mexico, using RBDS).

SYSTEM CHARACTERISTICS

RDS development had started with a number of functional requirements to be fulfilled. These were:

The radio data signals must be compatible; they must not cause interference to the reception of sound programme signals on existing receivers.

The data signals must be capable of being reliably received within a coverage area as great as that of the monophonic main programme signal.

The usable data rate provided by the basic 57 kHz data channel should support the requirements of station and programme identification and provide scope for future developments.

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.

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.

The multiplex spectrum of a stereophonic FM broadcast signal comprises 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 the subcarrier was critical for meeting the requirement to minimize data signal interference to the audio channels for existing receivers. The other parameter that is critical to achieve the same goal is the injection level of the data. The higher it is, the more rugged is the data service but 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 is usually virtually no interference from the data channel detectable during radio listening.

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.

The bit rate of the basic RDS 57 kHz subcarrier 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.

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 com-

ponents can easily swamp the data signal. When a vehicle moves along a road characterized 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 (the RDS groups of 104 bits), 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.

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. The groups 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 checkword to which is added an offset word that creates the fly wheel synchronisation mechanism that makes RDS so rugged under severe multipath receiving conditions.

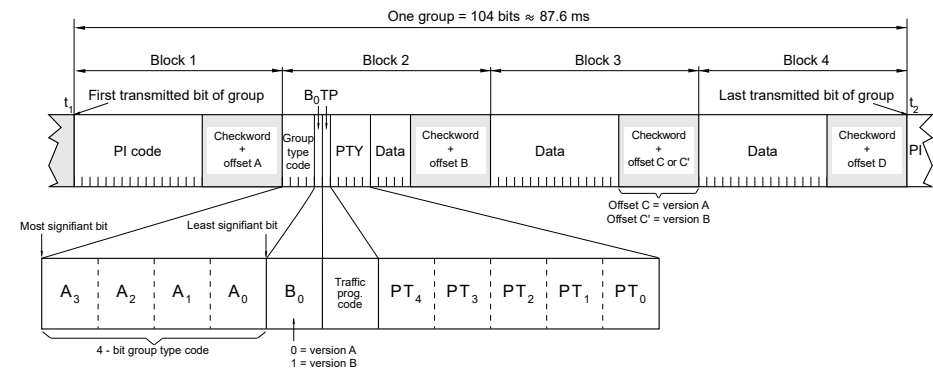
Message format and addressing

The RDS coding is structured so that the messages to be 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 containing the information. The first block of

each group always contains a Programme Identification (PI) code; the Programme Type (PTY) code and the Traffic Programme (TP) flag occupying fixed positions in block 2 of every group.

The group type code is specified by a 4-bit code which 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 block 1 and 3.

Groups are, in general, reserved for a particular application or message type, e.g. RadioText, Clock Time and Date, Traffic Message Channel, etc.



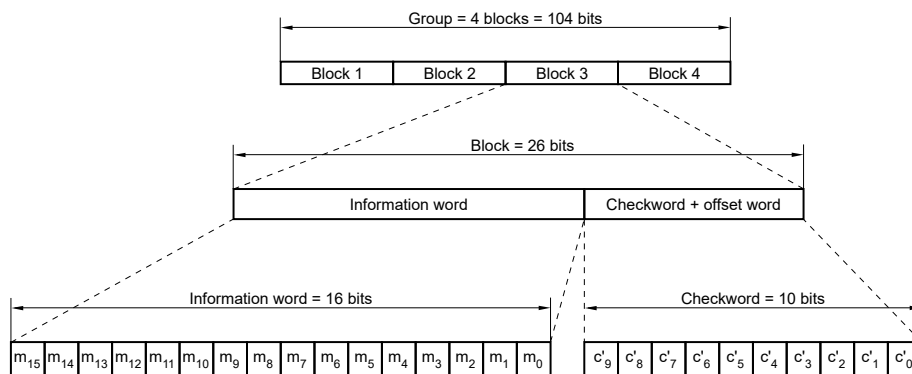
The above two figures explain the coding of the message format and the group addressing on the basic subcarrier 0.

APPLICATIONS OF RDS

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

Programme Service name (PS) - comprising eight alphanumeric characters from an uppercase and lower-case basic character set, and serving to give the listener information about the name of the programme.



RadioText (RT and RT+) - 32 or 64 characters of text for display by receivers.

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 programed.

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 which, from time to time, carry messages addressed to motorists.

Traffic Announcement (TA) signal - switches a traffic announcement to a pre-set volume level and, if the motorist is listening to recorded audio rather than the radio, TA stops the playback and switches the radio on to receive the traffic message instead and after the announcement goes back to the playback audio mode.

Enhanced Other Networks Information (EON) - RDS information relating to other broadcast services. The information includes the PI, AF for quick retuning to the service referenced and TP, TA, and PTY of these services.

Clock Time and date (CT) - a code, usually originated from standard time transmissions, to enable receivers to display the current time and date and used to synchronize various receivers.

Most of the following other features are optional:

Decoder Information (DI) - indicates whether the PTY is dynamic or not.

Programme Type (PTY) - an identification code to be transmitted with each programed item and which is intended to specify the current Programme Type within 31 possibilities. This code could be used for search tuning.

Enhanced RadioText (eRT) - Using an extended character set optimized to suit all countries in Europe with 64 characters of text for display by receivers

In-House (IH) - A data channel for use only by the broadcaster.

Emergency Warning System (EWS) - a feature using a very small amount of data for emergency warning services such as national disasters.

An additional and very universal feature is the ODA

The ODA - Open Data Application - permits new applications to be designed and implemented in still available data groups with an Application Identification (AID) registration using the ODA registration service from the RDS Forum or the NAB. Interesting ODA examples are RDS-TMC, RT Plus and eRT. Using the optional upper subcarriers for RDS2, the ODA feature offers a lot of development options, most of which will come up in the near future and offer enhanced radio data to enhance the listener experience with FM receivers using a

graphical display like the smart phone.

DATA CAPACITY IMPACT ON APPLICATIONS

Attention is drawn to the fact that the RDS data transmission capacity is rather limited, specifically on the basic subcarrier of 57 kHz. On each of the subcarriers the system can accommodate only 11.4 data groups per second. On the basic subcarrier of 57 kHz this corresponds to only 673 usable information bits per second. This takes into account that each information word contains 16 bits per block and that data group has five address bits that are used for the group type identification.

SYSTEM PERFORMANCE AND RELIABILITY

Field tests carried out by a number of broadcaster's research laboratories all came to the same conclusions.

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 of the reliability for a correct reception of the applications. All depends at the end of whether the data are sufficiently often repeated in the data stream. In ODA applications, additional CRC checkwords may also be considered to better protect the

data transmission application that one wants to implement.

Studies usually confirm the ruggedness of the fixed format PI codes compared for example with the variable addressed format of the PS codes. Therefore often consumer receivers 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 at maximum eight characters to the radio listener cannot be recommended.

Repetition of message elements transmitted within RDS is a general requirement. This applies to, for example, PS and TMC messages, but to a lesser degree to RadioText 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, as for example, RadioText, i.e. when an error caused exceptionally by the correction system is not perceived as being critical.

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The RDS features in detail by Dietmar Kopitz

This Chapter describes the RDS features in a general manner.

AFs	A lternative F requencies list
CI	C ountry I dentifier
CT	C lock T ime and date
DI	D ecoder I dentification for dynamic PTY indicator
ECC	E xtended C ountry C ode
EON	E nhanced O ther N etworks information
eRT	enhanced R adio T ext
EWS	E mergency W arning S ystem
ODA	O pen D ata A pplication
PI	P rogramme I dentification
PIN	P rogramme I tem N umber
PS	P rogramme S ervice name
LPS	L ong P rogramme S ervice name
PTY	P rogramme T Ype
PTYN	P rogramme T Ype N ame
RT	R adio T ext
RT+	R adio T ext P lus
TA	T raffic A nnouncement flag
TMC	T raffic M essage C hannel
TP	T raffic P rogramme flag

DESCRIPTION OF THE RDS FEATURES

Alternative Frequencies list (AF)

The list(s) of alternative frequencies give information on the various transmitters broadcasting the same programme in the same or adjacent reception areas, and enable receivers equipped with a memory to store the list(s), to reduce the time for switching to another transmitter. This facility is particularly useful in the case of car and portable radios.

Clock Time and date (CT)

Time and date codes shall use Coordinated Universal Time (UTC) and Modified Julian Day (MJD). Details of using these codes, which are intended to update a free running clock in a receiver, are explained in the RDS standard. If $MJD = 0$, the receiver shall not be updated. The listener, however, will not use this information directly and the conversion to local time and date will be made in the receiver's circuitry. CT is used as time stamp by various RDS applications and thus it must be accurate.

Decoder Identification (DI) and dynamic PTY Indicator (PTYI)

These bits indicate if PTY codes are switched dynamically.

Extended Country Code (ECC)

RDS uses its own country codes. The first most significant bits of the PI code carry the RDS country code. The four bit coding structure only permits the definition of 15 different codes, 0x1 to 0xF. Since there are many more countries to be identified, some countries have to share the same code which does not permit unique identification. Hence, there is the need to use the Extended Country Code which is transmitted in Variant 0 of Block 3 in type 1A groups and together with the country identification in bits b_{15} to b_{12} of the PI code render a unique combination. The ECC consists of eight bits.

Enhanced Other Networks information (EON)

This feature can be used to update the information stored in a receiver about programme services other than the one received. Alternative frequencies, the PS name, Traffic Programme and Traffic Announcement identification as well as Programme Type and Programme Item Number information can be transmitted for each other service. The relation to the corresponding programme is established by means of the relevant Programme Identification. Linkage information, consisting of four data elements, provides the means by which several programme services may be treated by the receiver as a single service during times a common programme is carried. Linkage information also provides a mechanism to signal an extended set of related services.

Emergency Warning System (EWS)

The EWS feature is intended to provide for the coding of warning messages. These messages will be broadcast only in cases of emergency and will only be evaluated by special receivers .

Nowadays EWS shall be implemented as an ODA.

In House application (IH)

This refers to data to be decoded only by the operator. Some examples noted are identification of transmission origin and remote switching of networks. The coding may be decided by each operator itself.

Nowadays IH shall be implemented as an ODA.

Open Data Applications (ODA)

Open Data Applications are a very effective and flexible way for adding additional applications to an RDS service. A number of different ODAs may exist on any service, subject to capacity. ODAs may be transmitted constantly, or only when required (e.g. an application which provides an alert in the case of extreme weather, etc.). The Open Data Application feature is conveyed in an allocated group in an RDS transmission. On the basic subcarrier 57 kHz the group allocated is indicated by the use of type 3A group which is used to identify to a receiver the data application in use in accordance with the registration details in the Open Data Applications Directory.

Programme Identification (PI)

The Programme Identification (PI) is a code enabling the receiver to distinguish between audio programme content. The most important application of the PI code is to enable the receiver in the event of bad reception, to switch automatically from the currently tuned frequency to an alternative frequency – the criterion for the change-over to the new frequency would be the presence of a better signal having the same Programme Identification code or if Regionalisation is used a regional variant of it. It follows therefore that the PI must be allocated in such a way that it uniquely distinguishes each audio programme content from all others in the same area.

The actual values of the PI code are largely unimportant as it is not intended for direct display. Of importance, however, is that a methodology exists within a broadcast area (i.e. a continent), to ensure uniqueness of PI code allocations to programme services.

In Europe for example, the ‘pool’ of the theoretical 65536 unique values have been allocated firstly at international level, and thereafter at national and regional levels for allocation by the appropriate authorities. Hence, there is a structure to PI code allocations in Europe.

North America with RBDS uses a different approach.

The primary purpose of the PI code is to facilitate automatic tuning between different transmitters all carrying the same audio content, the physical location of the transmitter itself is immaterial in determining the PI code. It is the location of the origin of the audio programme which decides the value of the PI code to be used. Hence, transmitters broadcasting an international programme originating in one country and being relayed by transmitters in other countries would carry the same PI code, regardless of their locations, or otherwise automatic tuning between transmitters cannot occur. Additionally, as the relay transmitter will relay the RDS data, as well as the audio content, it is obvious that the PI code allocated to the transmitter at the ‘head’ of the chain of transmitters will simply be re-broadcast by all transmitters in the relay chain. As the PI has a unique value in each area, it may be thought of as a ‘primary key’ to which all other RDS parameters about a particular service are referenced. For this reason, on the basic subcarrier the PI code appears in every RDS group type, and when referring to other services as in EON.

Short-range transmitting devices connected to audio sources, when additionally using RDS features, require also the use of a specific PI code.

Programme Service name (PS)

This is the label of the programme service consisting of not more than eight alphanumeric characters coded with a special RDS character set, displayed by RDS receivers in order to inform the listener what programme service is being broadcast by the station to which the receiver is tuned. An example for a name is 'Radio 21'. The Programme Service name is not intended to be used for automatic search tuning and shall not be used for giving sequential information.

Long Programme Service name (LPS)

The Long PS, using group type 15A, is an alternative to the PS. It allows use of more than eight characters (up to 32 bytes of UTF-8 coded characters). As UTF-8 coding is supported, the range of languages covered is increased. For backwards compatibility with existing RDS receivers, the PS shall also be transmitted using group type 0A or 0B. The use of LPS to transmit text other than a static Programme Service name is not permitted. RT or eRT shall be used for other programme-related information. The Long PS is complementary information to the PS and it may be used to replace the PS on a display. While the acquisition of the PS is time critical, the acquisition of the Long PS is not. The Long Programme Service name is STATIC identifying the name of the radio programme or station. If less than 32 bytes are to be sent, then the LPS shall be terminated with control character 0x0D. All bytes following the control character shall be ignored by the receiver.

Programme TType (PTY)

This is an identification number 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. The code will, moreover, enable suitable receivers and recorders to be pre-set to respond only to programme items of the desired type. The last number, i.e. 31, is reserved for an alarm identification which is intended to switch on the audio signal when a receiver is operated in a waiting reception mode.

Programme TType Name (PTYN)

The PTYN feature is used to further describe current PTY. PTYN permits the display of a more specific PTY description that the broadcaster can freely decide (e.g. PTY=4: Sport and PTYN: Football). The PTYN is not intended to change the default eight characters of PTY which will be used during search or wait modes, but only to show in detail the programme type once tuned to a programme. If the broadcaster is satisfied with a default PTY name, it is not necessary to use additional data capacity for PTYN. The Programme Type Name is not intended to be used for automatic PTY selection and must not be used for giving sequential information.

RadioText (RT)

This refers to text transmissions coded in accordance with the *basic RDS character set* addressed to receivers, which are equipped with suitable display facilities.

Enhanced RadioText (eRT)

This is an enhanced RadioText alternative to enable text transmissions that are UTF-8 coded and addressed to receivers, which are equipped with suitable display facilities. eRT uses an ODA and is thus not incompatible with old receivers incapable of response to using this feature.

RadioText Plus (RT+)

This allows to tag specific elements of RadioText and permits, among many other possibilities, to improve the presentation on a display for RT or eRT. This way of presenting, for example, music titles and artist names is more user friendly than scrolling the same information through a display, as it is often done with RT. Presenting the tagged items on separate lines permits the listener to read the information at a glance and in cars this is important as the driver should not be distracted. The tagged RadioText elements can also be stored as a list that could be searched by the end user, for example when an FM/RDS radio is implemented within a mobile phone. A popular application also is to list the radio programme's home page web address so that a smart phone could automatically bring it up on the display and permit the listener to browse for complementary background information or the programme being listened to. RT+ is an ODA and is thus not incompatible with old receivers not using this new feature.

Traffic Announcement identification (TA)

This is an on/off switching signal to indicate when a traffic announcement is on air. The signal could be used in receivers to

- ▶ switch automatically from any audio mode to the traffic announcement;
- ▶ switch on the traffic announcement automatically when the receiver is in a waiting reception mode and the audio signal is muted;
- ▶ switch from a programme to another one carrying a traffic announcement.

After the end of the traffic announcement the initial operating mode will be restored.

Traffic Message Channel (TMC)

This feature is intended to be used for the coded transmission of traffic information. The coding for TMC is separately specified in the ISO 14819 series. It is an ODA. The feature can be open or encrypted for conditional access.

Traffic Programme identification (TP)

This is a flag to indicate that the tuned programme carries traffic announcements. The TP flag must only be set on programmes which dynamically switch on the TA identification during traffic announcements. The signal shall be taken into account during automatic search tuning.

The new RDS standard edition IEC 62106:2018 includes the following significant technical changes with respect to the previous version IEC 62106:2015:

- The standard has been totally re-structured:

Part 1: RDS system overview: Modulation characteristics and baseband coding

Part 2: RDS message format: Coding and definition of RDS features

Part 3: Coding of Open Data Applications

Part 4: Registered code tables

Part 5: Marking of RDS1 and RDS2 devices

Part 6: Compilation of technical specifications for Open Data Applications in the public domain

Planned are:

Part 7: RBDS

Part 8: Universal Encoder Communication Protocol - UECP (with support for RDS2)

- Provision has been made to carry RDS on multiple data-streams (RDS2).
- Data in the additional data-streams is using a newly defined group type C data structure.
- AF coding below 87.6 MHz (down to 64.1 MHz) using ODA-AID 0x6365 (see IEC 62106-6).
- Long PS (UTF-8) support has been added using group type 15A.
- Coding for the following applications is no longer detailed in the RDS standard as these can use in future the ODA concept: EWS, TDC, IH and RP.
- Translated PTY terms for 20 languages were added.
- New are receiver profiles, conformity requirements, certification and compliance test.
- Obsolete and no longer part of the RDS standard are: MS (Group 0A, 0B and 15B) certain DI codes (mono/stereo, artificial head, compression), Language code, and PIN (Group 1A).

The RDS Encoder Communication Protocol UECP by Dietmar Kopitz

This Chapter explains the need for a communication protocol to be used between broadcaster's RDS data server (studio) or data service provider (e.g. for TMC) and RDS encoders at the FM transmitter sites. The EBU had developed a specification for this protocol which is commonly called the UECP (Universal Encoder Communication Protocol). It is continuously updated by the RDS Forum and it will become Part 8 of the RDS standard. It is recommended to use it, especially when RDS is implemented within a network of several transmitters.

WHY DO RDS ENCODERS NEED A COMMUNICATION PROTOCOL?

Transmission operators who want to implement an RDS service need to install RDS encoders. They are normally installed at transmitter sites adjacent to the stereo encoder, which generates a 19 kHz signal that the RDS encoder uses to synchronise its output RDS data stream.

Two "types" of RDS can be provided: Static RDS services can be provided by an RDS encoder simply using PI, PS and a fixed AF list, from internal memory; whereas dynamic RDS services, such as RadioText, require a data communication protocol for input to an RDS encoder. Even static RDS services may have to be changed from time to time, depending upon the network configuration and the type of radio programme on air.

Dynamic RDS is needed for a number of reasons. RDS data related to the radio programme content require a high degree of control from the on-air studio. In the case of a data service such as TMC, an operator specific implementation under ODA, then a high degree of control is required from the service provider to supply the data to the RDS encoder, either to a single broadcast transmitter or to a network of broadcast transmitters.

Simple, but numerous different commands from the on-air studio or the service provider have to be sent via a suitable data link to the RDS encoder. For example, the on-air studio could change the status of the TA flag for a traffic announcement.

A number of proprietary update protocols were implemented on data links between RDS servers and the RDS encoders; several of them were encoder manufacturer specific. These protocols were used to send data messages from an RDS controller/management system (or simply an RDS encoder server) to the RDS encoders. Acknowledgements from the encoder were not essential and, instead, it was arranged to send repeats of each message in order to ensure their receipt. In this way a whole range of dynamic RDS features could be used by the broadcaster to enhance RDS performance for the listener.

WHY THE EBU DEVELOPED, WITH ENCODER MANUFACTURERS, THE UECP?

In the early nineties, the EBU studied a requirement that the various existing and implemented RDS encoder communication protocols should be harmonized. Such harmonization would then enable broadcasters to purchase RDS system components (eg RDS encoders, RDS server computers and software) from a variety of sources. This would permit significant economies in network operation and it would offer the necessary high flexibility to implement, in successive stages, enhancements to already existing RDS implementations, specifically within transmitter networks. RDS system component manufacturers would then also be able to integrate their products with those from other manufacturers, enabling more complex systems to be produced than those that would otherwise have been impossible.

These proprietary update protocols had similar functional elements, however they differed significantly in their environmental models. The structure, functionality and addressing of their intended networks and the data structures within each RDS encoder are often quite different. Therefore the Universal Encoder Communication Protocol (UECP) specification, now very widely accepted, was based on *harmonized* environmental and encoder models.

The UECP is a layered communication protocol which is in line with on the commonly used OSI reference model (ISO Recommendation 7498). The UECP in its current version 7.05 (February 2010) has been updated by the RDS Forum since 1993. Now, for the RDS standard IEC 62106-8 it will be enhanced to support RDS2.

The UECP model and protocol provides a template specification upon which new products may be based and most specifically it permits other existing encoder communication protocols to be enhanced. Thus many existing devices can be adapted to meet the RDS functionality required. The specification can now be freely obtained from the RDS Forum by downloading it from its website www.rds.org/uk.

Organizations and manufacturers that have contributed within the EBU and later within the RDS Forum to the elaboration of the UECP specification included: Aztec, Auditem/Worldcast Systems, BBC, Deutsche Telekom, Ericsson (formerly Teli), IRT, Qbit, RE Technology, Rohde & Schwarz, TDF, Telefunken Sendertechnik and Teleray.

In the RDS Forum 2018 we have the following encoder manufacturers that all use the UECP version 7.05:

2wcom (Germany) and

Auditem/Worldcast Systems (France).

UECP CONCEPT Addressing method

Communication to RDS encoders needs to be capable of many levels of addressing:

- ▶ To all encoders.
- ▶ To specific sets of encoders or to a particular device.

This may be accomplished by a suitable logical addressing method.

In defining an environmental model for the UECP, the following assumptions were made:

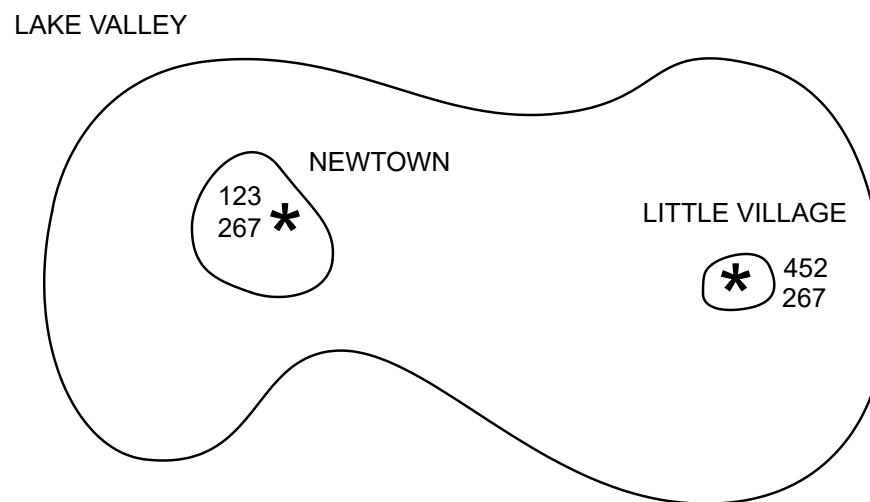
The data stream will feed one or more transmitter sites. Each site will have a unique address, known as the *site address* (a number in the range 1-1023). All encoders at a particular transmitter site share the same site address.

An encoder will possess one or more site addresses. One of these must be unique to the particular physical site location. Additional site addresses are permitted for a particular area, region, or country.

To clarify this concept, an example is given. All encoders at the NEWTOWN site have the unique site address "123". Other encoders in the system are not permitted to use this address. Encoders at the NEWTOWN site also have the site address "267", which is allocated to all encoders in the LAKEVALLEY area. Messages arriving at the NEWTOWN site with either of these two site addresses will be accepted. Messages arriving at the LITTLEVILLAGE site (address "452"), also in the LAKEVALLEY area, will not be accepted if they carry the NEWTOWN site address, but will be accepted if they carry either the LITTLEVILLAGE or the LAKEVALLEY site address. This example described the first level of the addressing system.

A second level of addressing is now introduced, the *encoder address* (in the range 1-63). Several RDS encoders are installed at each transmitter site, serving a number of programme services. Backup equipment is sometimes provided, sometimes not. A single backup encoder may even be provided for several programme services. Whatever the situation may be,

each encoder at the site needs to be individually addressable.



Fictitious example of site addressing with the UECP.

An encoder will possess one or more encoder addresses. One must be unique to the encoder at that site. Additional encoder addresses may be assigned according to the encoder's usage or manufacture. However, the site and encoder addresses are not intended to specify a particular radio service. The specification of a particular radio service, a third level of addressing, is accomplished by using a *Programme Service number*. The site and encoder addresses should be thought of being entirely physical, and are used only to address a certain "box" at a certain location. The functionality of the "box" is irrelevant in this context.

It is expected that many messages will be sent to all RDS encoders. Thus, the *global* number of “0” is defined for both the site and encoder addresses. Messages bearing the global site address are deemed to be acceptable at all sites in the system. Messages bearing the global encoder address are deemed to be acceptable at all RDS encoders at sites specified by the accompanying site address.

An RDS encoder will have two address lists, one of acceptable site addresses and the other of acceptable RDS encoder addresses. The site address list includes “0” (the global site address), the unique site address and any additional site group addresses.

The RDS encoder address list includes “0” (the global encoder address), the unique encoder address and any additional en A message is acceptable to a particular RDS encoder only if the site address is contained within its site address list and coder group addresses.

The RDS encoder address is contained within its RDS encoder address list.

RDS Encoder conceptual model

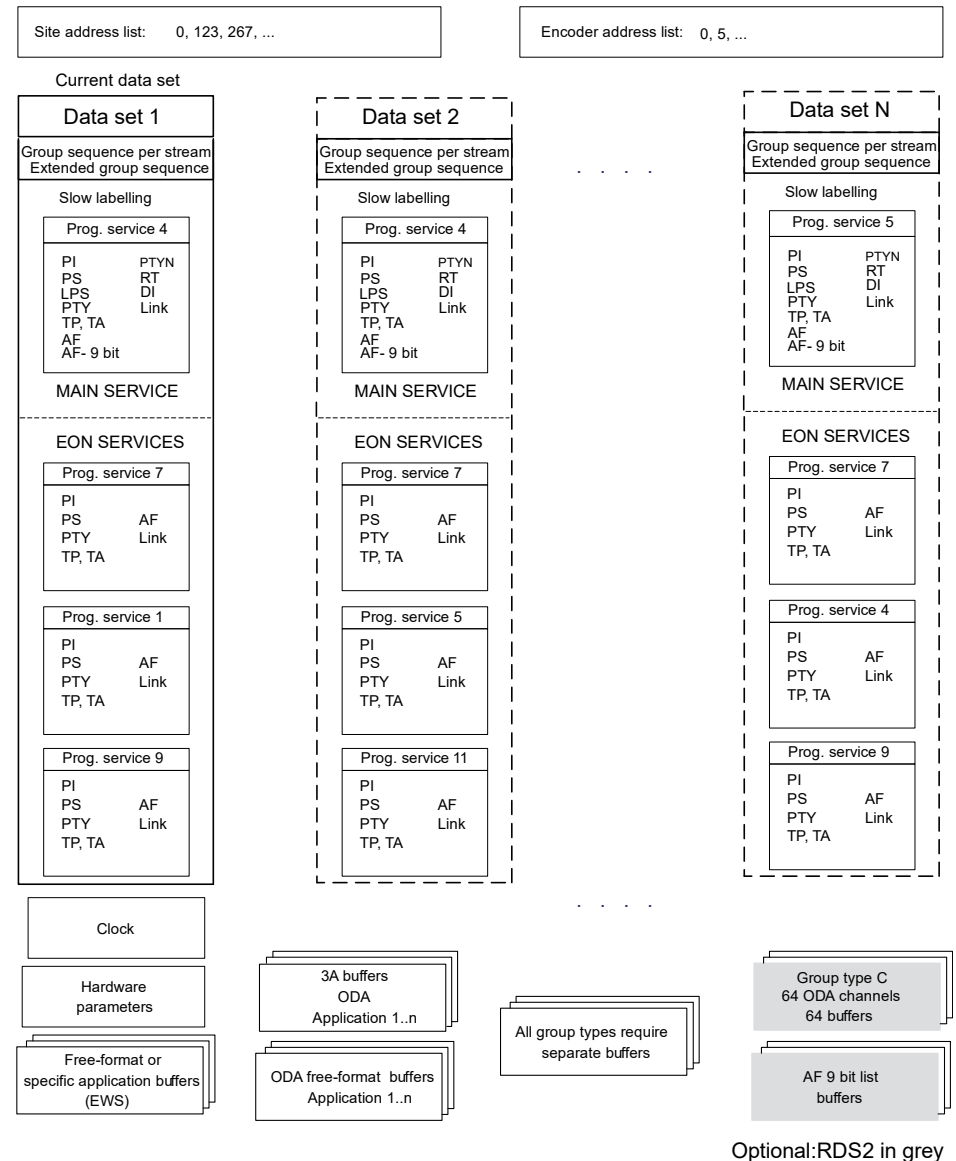
Software model

Messages are accepted by the RDS encoder in accordance with the addressing method described above. Applicability is further determined by optional fields within the message itself. This permits addressing of the following structures within an RDS encoder:

Data sets: An encoder will have one or more *data sets*, each of which results in a particular RDS output. Each data set may refer to many programme services using the RDS EON feature. Only one data set is responsible at any one time for the encoder's output and is known as the current data set. Data sets are addressed by the protocol as described below.

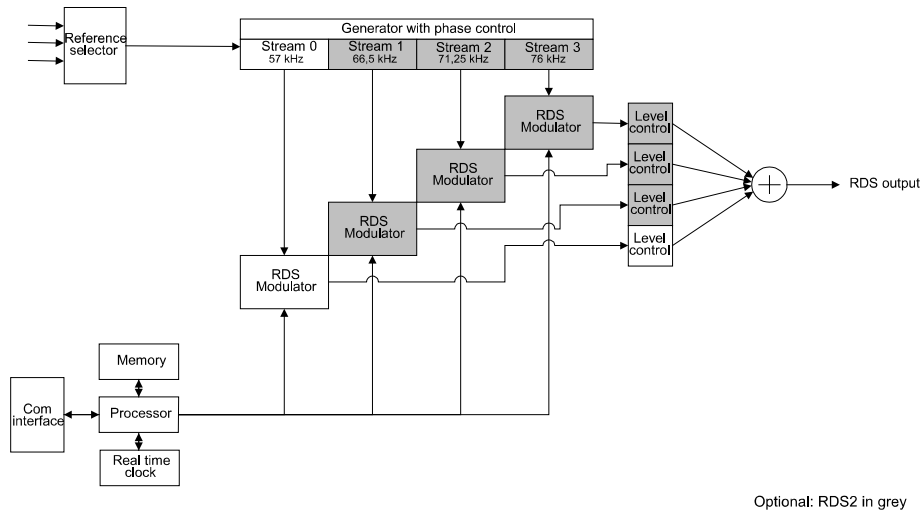
Programme services: All programme services are identified by a unique *Programme Service number* which is used to label data within RDS networks. In a network providing the EON feature, data for several programme services will be sent to an encoder which may then identify that the data refers to one or more of the data sets and elements within the data sets used by that encoder. Programme services are addressed by the protocol as described below. There is a specific memory area in each data set for each programme service.

Buffers: Some information is buffered, for example ODA, RT, TMC and Free Format Groups. This means that the received information is placed in a queue awaiting transmission. It is possible to configure a buffer for cyclic transmission.



RDS UECP encoder software model.

Hardware model



RDS UECP encoder hardware model

A simplified hardware model of an RDS encoder has been used in the development of the UECP. The model does not include such obvious or necessary components as a power supply or a control panel, but includes only the blocks necessary to understand and develop the protocol itself. These are:

- **Processor:** The central processing unit of the encoder, a micro-processor, with access to input and output devices, the real-time clock, and memory.
- **Memory:** Comprises ROM and RAM necessary for the operating software of the encoder, and appropriate RAM and ROM for stored data.

- **Serial communication interface:** Data, according to the UECP, is received and transmitted using the serial communications interface, also with a suitable adaptation to the Internet.

- **RDS modulator:** Produces the RDS bi-phase signal, I in accordance with Part 1 of the RDS standard.

- **57 kHz oscillator:** Frequency and phase locked to the third harmonic of the selected 19 kHz pilot-tone reference source.

- **Reference selector (optional):** Selects one source of 19 kHz reference signal, out of a maximum of six, to lock to the internal 57 kHz oscillator.

- **Level and phase control:** The level and phase of the RDS signal may be adjusted by the processor under the appropriate commands.

- **Real time clock:** Maintains the current time of day and calendar date. Used to generate type 4A groups (CT).

UECP transmission modes

The UECP is designed to operate in various communication modes as follows:

- **Uni-directional mode:** This mode is used on one-way communication links. Data is transmitted to one, a group or all RDS encoders. Answer-back is not required.
- **Bi-directional mode, requested response:** This mode uses a two-way communication link to transmit data to one, a group or all RDS encoders. It enables the server to request data, status, and error report from RDS encoders.

- *Bi-directional mode, spontaneous response:* A two-way communication link enables a server to transmit data to RDS encoders, and request data from RDS encoders. RDS encoders are also able to spontaneously generate status and error messages.

UECP protocol description

At the physical level it is necessary for the UECP specification to ensure electrical and mechanical compatibility of equipment. Interfacing to the RDS encoder is accomplished with a serial interface based on the well-known standard EIA RS 232C. This is a full-duplex interface with hardware handshaking, able to operate with modems.

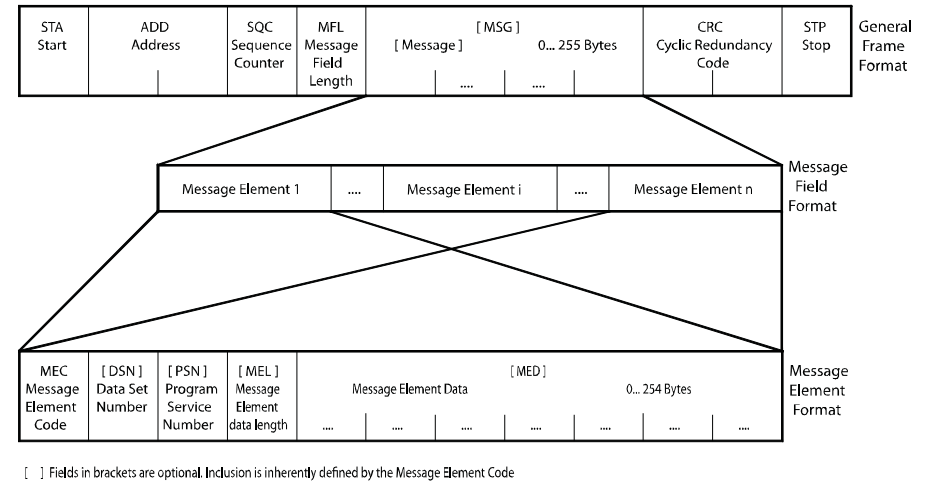
UECP data frames are built and then byte-stuffed prior to transmission. The check field consists of two bytes (prior to byte-stuffing) which represent the result of a 16-bit cyclic redundancy check (CRC) calculation.

Several message elements may be packed together into one message field (the UECP frame), subject to a maximum message field length of 255 bytes. An individual message element must not be split between different message fields.

The complete message field may be represented as follows:

MEC,[DSN],[PSN],[MEL],[MED],[[MEC,[DSN],[PSN],[MEL],[MED]]], ...

Fields and whole message elements shown in square brackets are optional. Message elements may be concatenated freely, subject to a maximum message field length of 255 bytes.



UECP data frame format consisting of a stream of bytes.

The Data Set Number (DSN) permits a message to be targeted to the following within an encoder

- ▶ a specific data set,
- ▶ the current data set,
- ▶ all data sets.

The Programme Service Number (PSN) permits a message element to operate a number of services within one or more data sets.

Message Element data consist of one byte describing the length (number of bytes that follow as data) and the data which are all coded as bytes. Different classes of message commands (MECs) are defined such as RDS message commands, Open Data Application commands, Clock setting and control and Remote and configuration commands (RDS adjustment and control, Control and set-up commands, Bi-directional commands and Specific message commands).

Remote and configuration commands permit to control the various functionality options of RDS encoders or permit request messages to be given from the RDS encoders in the case of a bi-directional transmission mode.

RDS message commands permit to communicate all the RDS features which have to be processed by an RDS encoder.

The data are transmitted to the RDS encoder using the specified command structure and are stored in memory according to the encoder software model. The RDS encoder must also be told the group type sequence to be transmitted on each of the four subcarriers. This is achieved with the "Group sequence" command, which is treated by the encoder like a group enable command. When a specific group is encountered in the sequence, data relating to that type is transmitted if available. If no data for a specific group type are received, then the group type is not generated and the next group type in the sequence is used instead. With this method also the desired repetition rate for every group type is implicitly defined in a very flexible way for the broadcaster or service operator.

The components of each UECP data frame are:

Field Description	Descriptor	Field Length
Start	STA	1 byte
Destination address	ADD	2 bytes
Sequence counter	SQC	1 byte
Message field length	MFL	1 byte
[Message]	[MSG]	0...255 bytes
CRC-16 checkword	CRC	2 bytes
Stop	STP	1 byte

UECP data frame components.

The format of each Message Element is:

Field description	Descriptor	Field length
Message element code	MEC	1 byte
[Data set number]	[DSN]	0...1 byte
[Programme service number]	[PSN]	0...1 byte
[Message element data length]	[MEL]	0...1 byte
[Message element data]	[MED]	0...254 bytes

The symbols [] indicate that this field is optional. They are used, as required by the specific MEC command.

UECP Message Element format.

RDS signal monitoring, analysing and testing by Dietmar Kopitz

This chapter gives some practical advice about how to use a new product to look into the details of the RDS signal performance of any new or existing RDS receiver and analyse the content of the FM/RDS and RDS2 signals found on air.

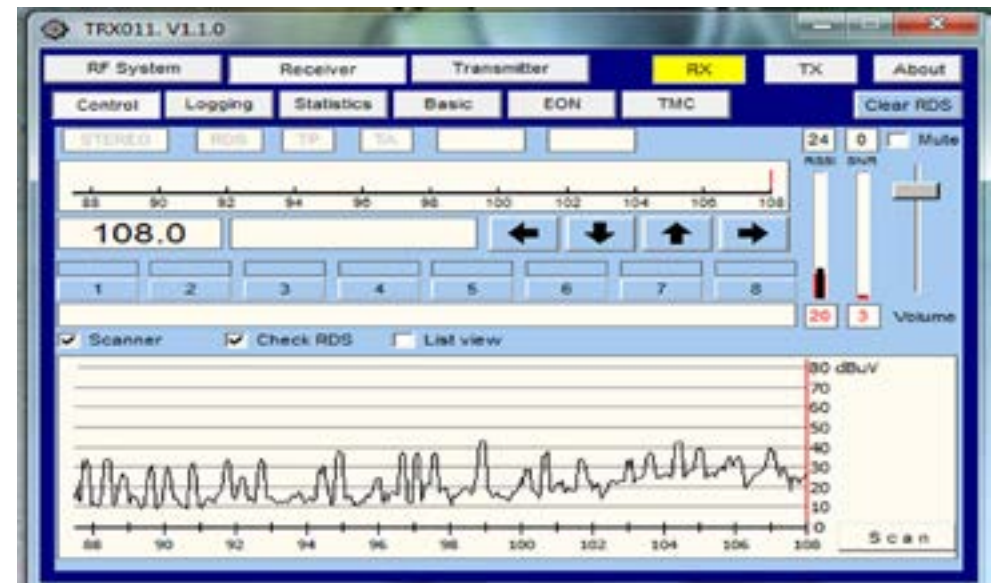


On screen we can see the band scan result. It only took a minute to get the complete picture about RDS on air. The TRX011 box with its rod antenna is visible on the left.

I think, everyone interested in RDS would like to know what RDS signals are really on air. Here is the solution. In June 2012 RDS Forum Member Catena (in the Netherlands) presented a new product, the TRX011 that I immediately perceived as a “wonder box”. The new product is relatively inexpensive and has the size of about a cigarette box. It is designed to be used with a Windows PC and it has to be connected to the PC via USB and no separate power supply for the box is needed. The software for analyzing and setting the transmitted RDS data is part of the package. Note specifically that you can transmit with this wonder box your own RDS data. It has implemented all RDS features (except one: eRT) including those that use the ODA, such as RDS-TMC and RT+. As eRT is an ODA, you can test it as well, but not display the text as a string of characters.

The wonder box was designed by Joop Beunders, who is one of those RDS design engineers that have the longest professional experience with RDS. Joop started his RDS development work in the late seventies with Philips in Eindhoven (Netherlands) building hardware for the Dutch RDS candidate system SPI. To enable his TRX011 product to receive and transmit RDS data, he is using an integrated circuit designed some years ago by another RDS Forum Member, Silicon Labs in Texas. They brought this chip, Si 4721, to the market to permit small add-on products to be made for the many iPod and MP3 players available then. This was to permit these music players to transmit within a short range of a few meters distance the music and data (mainly titles and artist names) via FM/RDS to supply them to a free FM channel to which the car

radio could then be tuned (examples of such device suppliers are Belkin, Gear and many more). The IC can transmit any of the RDS data features so that, if the add-on device is well designed, such a short-range transmitter could signal via AFs an alternative free FM channel when the car is driven over a long distance. The information where such a free channel will be available would be obtained from a band-scan performed during the journey, carried out at frequent intervals by the receiver part of this IC.



The band scan result can also be displayed as a list showing the PI code and the PS name.

The first thing one wants to know is how many FM stations can be received in the location where one is. More recently, if you use the DS016 docking station with the RX014 (two later products from MacBe), you can even remotely monitor RDS and RDS2 at any location using the Internet for the RDS data transfer to your own location.

We start to make a band-scan and my particular monitoring result is that in Geneva (in my office) we can receive about 30 FM stations; some of them transmit the same programme on different FM channels. In terms of radio programmes available, the scan result tells us that there are over 20. The complete band scan took only one minute. We want of course to know whether these stations all use RDS. To find that out we just have to look up the scan list report provided by the TRX011 box. We found that all the FM transmitters receivable in the Geneva region use RDS.

Number	Frequency	Signal	SNR	Offset	Valid	PI code	PS name
1	87.80	36	24	0	Y	43B1h	DRS 1
2	88.40	37	24	1	Y	4F17h	TREE
3	89.60	34	19	1	Y	F203h	MUSIQUE
4	90.00	23	3	-49	Y		
5	90.10	27	11	0	Y	F219h	VIRGIN
6	90.20	21	2	39	Y		
7	90.80	34	20	1	Y	43D4h	l'autre
8	91.80	32	2	0	Y		
9	92.20	28	10	-1	Y		
10	92.70	34	20	0	Y	F22Bh	ORIENT
11	94.40	29	11	0	Y		

Save scan
List options:
☒ Show only valid stops
Scan

Here we see the scan result as list giving for RDS the PI code and the PS name.

Now we would like to investigate a special problem related to the static PS name feature. We put the emphasis here on “static” as the PS name has in the RDS data stream the function to serve as an identifier to the listener of the name to the tuned programme (or any other alternative radio programme on air). The PS name is composed of eight alphanumeric characters and some examples are

BBC R1, RADIO 21, MUSIQUE, BR INFO.

Here in the Geneva region, where we can receive Swiss and French radio programmes, we have noticed that the majority of

FM stations use dynamic text instead of the static PS name identifier required by the RDS standard. Why? The reason is that in RDS for any text transmission one should use the RadioText (RT) feature. However in the early years of RDS, most car radios did not implement RT for a number of reasons, also not to distract the driver (responding to a traffic safety statement for moving vehicles, issued by the European Commission – which is the Recommendation 2007/78/EC) and also to save on the need to use a larger display to better present the text information. The latter condition has changed a bit now due to the fact that a large display is needed anyway for a number of other reasons already and thus it could then also be used for RT, and therefore most newer car radios have implemented the RT feature, but by default and for the above mentioned safety reasons it is disabled. It would be for the driver then to switch the RT feature intentionally on or off when appropriate and depending on whether the car moves or not. So, when the car is not moving and for example in a traffic jam, RT can be enabled.

Broadcasters found a way to circumvent those constraints to receiving RadioText in cars and more than 15 years ago already and they started to use PS dynamically to convey short text messages to the driver. However not always the regulators would tolerate such an abuse of the RDS standard, and for example in the UK this way of operation is simply just not permitted. receivers, would make it redundant anyway.

In France the dynamic PS as, in 2012, the subject of an experiment with a number of constraints put on the text that the interested broadcasters may implement using the PS feature. No advertising with such text elements is permitted and it

must be totally related to the programme item content on air or to an upcoming programme item. The broadcasters are mostly interested to transmit the music title and the artist name along with any music item. An additional requirement is that at least 50% of the time the PS text shall be static and convey the PS name. Additionally all dynamic text transmitted over the PS feature must also be transmitted using the RT feature, but here also more other programme related details may be given in addition.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N				
1	TRUCK1 406 truck information.																	
2	PT code		C04H		Music Speed		Music		Date		12-09-02							
3	PS name		LAURIST		Compressed		No		Time		12:58							
4	PTV		NONE		Stereo		No		BCL									
5	PTV name				Artificial Head		Yes		Campaign									
6	TR		Yes		Dynamic PTV		No		PIS									
7	TIA		No		Link Activator		No		Dist ID									
8	AP		8, 14 bits		Link ID													
10																		
12	Received Program Service names: 32																	
13																		
14	PS name		#		%		PS name		#		%		PS name		#		%	
15	WOLFG		2045		60		REFUSE		36		1		POUR UN		36		1	
16	PS name		#		%		PS name		#		%		PS name		#		%	
17	POU -		36		1		JEMER		36		1		WALL OUT		36		1	
18	PS name		#		%		PS name		#		%		PS name		#		%	
19	JW AUTG		60		2		MOND -		60		2		TELEPHON		60		2	
20	PS name		#		%		PS name		#		%		PS name		#		%	
21	BEACH		58		2		OUT ALL		58		2		BE THERE		58		2	
22	PS name		#		%		PS name		#		%		PS name		#		%	
23	THE FOUR		56		1		TOPS		56		1		CITY		60		2	
24	PS name		#		%		PS name		#		%		PS name		#		%	
25	OUT -		60		2		OLYMPIC		60		2		COMMENT		47		1	
26	PS name		#		%		PS name		#		%		PS name		#		%	
27	TI DING		47		1		ADU -		44		1		PARADIS		44		1	
28	PS name		#		%		PS name		#		%		PS name		#		%	
29	HARDY		46		1		SANCING		60		2		QUEEN -		60		2	
30	PS name		#		%		PS name		#		%		PS name		#		%	
31	ABA		60		2		SAREMO		60		2		GARY		60		2	

The TRX011 Excel report giving the PS results for NOSTALGI, showing also that 60% of the time the PS name NOSTALGI was used.

Now with the wonder box I wanted to check of whether the French radio station NOSTALGI complies with these CSA regulations and we have carried out this analysis as follows: we stayed tuned with the TRX011 to the radio programme NOSTALGI for about 45 minutes and then stored a log of the data received. The wonder box already delivers the log in the form of an Excel spreadsheet where everything of a general interest is already analysed and properly reported. So, what I wanted to know is the proportion of the time used to transmit a static PS name, I just could read that out straight away, i.e 60%. Then 40% is used for dynamic text messages and the ones that were transmitted during the time of my monitoring are all listed as a sequence. I can see that the radio programme gives the programme service name followed by the music title and artist name and nothing else.

TRX011 RDS RT and RTplus overview.

RT:	NOSTALGIE -> REQUIEM POUR UN FOU - JOHNNY HALLYDAY
RT:	NOSTALGIE -> UN AUTRE MONDE - TELEPHONE
RT:	NOSTALGIE -> REACH OUT I'LL BE THERE - THE FOUR TOPS
RT:	NOSTALGIE -> C'EST DIT - CALOGERO
RT:	NOSTALGIE -> COMMENT TE DIRE ADIEU - FRANCOISE HARDY
RT:	NOSTALGIE -> DANCING QUEEN - ABBA
RT:	NOSTALGIE -> BAMBINO - DANY BRILLANT
RT:	NOSTALGIE -> MY SONG OF YOU - LAURENT VOULZY

The TRX011 Excel report gives also the RadioText records for NOSTALGI during the 45 minute interval of monitoring.

Another interesting function of the TRX011 box is its capability to transmit your own audio programme accompanied by RDS data of your choice. This possibility can well be used to test under static receiving conditions any RDS receiver and one could find out which RDS features are implemented in

the receiver and whether their usage is correct or not. Isn't this a fantastic possibility offered by our wonder box?

One could even test a receiver for a new ODA, still under development, and where the receiver will need to use specially developed software to decode these new ODA messages. Thus it is possible to develop and test with the help of the TRX011 box new applications for RDS, before one would register them as an Open Data Application with the RDS Forum. The ODA registration procedure, described and required by the RDS standard – Part 3, has the aim to ensure that a registered ODA remains worldwide absolutely unique.

The tool TRX011 is also great to check whether RT+ is correctly implemented. One of the more subtle things in RT+ is of course that there exist in the RDS standard very many different tags and not just the two always used for music items, namely "item title" and "item artist". All these other possible RT+ tags are listed in the RDS standard IEC 62106 Part 6.

The interesting question then would be how the TRX011 then will identify these "tags"? Will it also give the tag the relevant code number?

The answer is: If one runs the TRX011 software program in demo mode (no TRX011 box yet USB attached), it will play a pre-recorded RDS file. In the receiver tab "Basics", one can find then which tags are being "received" (the name and the number). In the RT presentation "Tag 1" is always colored red and "Tag 2" is colored blue.

Another good feature of the TRX011 is that one can transmit one's self-defined RDS signal content. If, for example, one wanted to do that for RT+ and for all those possible 64 tags

and be able to test, for example, what any given receiver might be able to decode (if any RT+ at all, most probably only a few of those many tags listed in the RDS standard, and perhaps then only “item title” and “item artist” and apart of these two nothing else), one can then easily imagine that this would be a lot of work to carry out such a test. However, the reality is that it is really not difficult at all to create the complete RT/RT+ file for this kind of test.

In the “Transmitter” tab: “RT(plus)” one can already define eight different RT entries. Each entry can then contain two different tags, thus in total, with only one single setup, one can already make 16 different tags visible. Since there are only 64 tags defined, one would need altogether only four different RadioText pages. In the software program settings these can be saved and restored.

How to make any RT+ line is also very easy: First enter the RT content (the actual “text”) in one of the eight entries. Then, highlight with the mouse the part that should become tagged 1 (or 2). When you release the mouse button, you will get the options to select tag 1 or 2 and the tag number you want, out of a choice of 64. That’s all then what you would have to do, and this is also just what you would expect from a “wonder box” like the TRX011.

The TRX011 can also be used for a mobile reception test in a car. To do so, one would need an additional VHF/Band II antenna on the roof of the car, preferably a passive rod antenna that could be attached to the car body with a magnet to avoid that it moves during the drive. The antenna cable can be led through the door and on the back seat it can be

connected to the TRX011 box which itself is USB connected to a Windows laptop PC that can log the RDS data received during the journey. The Excel report of the log provides you with a complete analysis including the proportion of errors received in the RDS stream.

Up to here I have described only a few obvious tests to be done. To test the FM/RDS r.f. signal performance of any RDS receiver, static or mobile, more tests are needed. To help developers to do so, the RDS Forum has developed a measurement standard which was published by the IEC in 2011, the IEC 62634. This standard was conceived for three receiver categories: static home receivers, mobile portable receivers and car radios. The standard describes how to test the RDS performance of the receiver under well-defined strong and weak input signal conditions on co-and adjacent channels. There is also a section describing more tests regarding the TP & TA features. I highly recommend to all receiver manufacturers to make use of this new IEC standard to ensure that their products comply with those minimal performance requirements proposed by the RDS Forum.

The RX014 is ideal to test likewise RDS2. It is the first receiver on the market that is capable to analyse RDS2 signals.

If you want to know more about the RDS/RDS2 evaluation tools from RDS Forum member MacBe, please consult the RDS Forum’s web site describing these products.

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RDS in the world of Automotive by Frits de Jong

In Chapter 1 we have seen that a replacement from the existing ARI system to a pan-European traffic information system (TP/TA) was an important issue for the car-industry to support RDS. The ARI system was limited to Germany, Austria, Switzerland and Luxemburg and no further plans existed to extend the system to other European countries. In addition the AF feature, which made it possible to follow a radio programme throughout a large geographical area or even an entire country without the need for manual re-tuning, created a lot of enthusiasm. RDS gave a huge contribution to driver safety which was the trigger for the car industry to design RDS radios in their new car models, first in the high-end cars, soon followed across the entire car products range.

BASIC AUTOMOTIVE REQUIREMENTS

In essence safe driving was the focus at the introduction of RDS car radios. Car radios capable to ensure undisturbed listening without the need of manual retuning of the radio programme. Traffic announcements could hardly be missed since TA was cross-linked over the entire network by EON. In other words the mental workload for the driver decreased significantly since RDS did all these things automatically.

PS - Programme service name

The PS is the most obvious visual identification of a radio programme. Ideally this name should stay on the display even if RDS synchronization is lost. The RDS sensitivity is generally 10dB lower than the FM sensitivity. In practice one can still listen to the radio programme, while RDS can no longer be received.

In order to ensure that the PS remains visible on the display even when RDS data is lost, the PS is memorized under the radio programme preset button.

Since it started all some 35 years ago the well-known 8-character programme service name PS is used as a visible identity to the listener. But broadcasters may wish to use more than an 8 character PS. RDS2 allows with enhanced character coding UTF8 a 16 character PS. To serve regions like Asia and China. The increased data capacity of RDS2 by a factor 5 makes it possible to transmit a station logo as an attractive addition to enhance the identity of the programme. The reception of a station logo is not a time critical issue. Once it has been received it may be stored in memory and linked to the PI code to be displayed immediately once the programme has been recalled.



AF Automatic program retune

An ideal RDS radio switches over inaudibly and in time to an alternative frequency (AF) with the best audio quality. Variations in sound should not occur. This is easier said than done!

A number of parameters are deterministic for the audio quality of the signal:

► Signal strength

The signal level is the most important parameter to select a new AF with a better audio quality.

► Multipath distortion

Multipath distortion occurs when RF signals reach the car antenna, both in a direct path from the transmitter and via reflections as known in mountainous areas. Signals from reflections arrive with a time delay, which causes an audible distortion.

To reduce the influence of multipath distortion, a system using multiple antenna's has been used: antenna diversity. In this system the tuner can switch to or even combine the signals from multiple antennas in order to reduce the multipath effect.

► Adjacent Channel

In areas with a high density of FM transmitters, a strong adjacent FM station may be present at a distance of +/- 100 kHz of the tuned radio programme. The effect has become less noticeable since the selectivity of car radios has been improved significantly over years.

Dynamic selectivity is almost a standard feature nowadays.

Nevertheless, when driving higher up in the mountains and near the borders, like the Black forest area in Germany or around large metropolitan regions like Paris, distortion of the audio may still frequently occur.

In principle the AF list of a radio programme is regularly validated on the above mentioned parameters. While listening, the tuner jumps shortly to an AF and measures the signal

quality. During this short period the radio is muted. This short tuning action takes for modern well- designed tuners only 4-6 msec. Although this short update mute is almost inaudible for the listener, it is obvious that AF lists must be kept short in order to manage this AF list update process well.

As a result of this, a new AF will be available to switch to when the currently tuned frequency becomes weaker and the audio quality is degrading. A golden rule after switching to a new AF is checking the PI code. It may happen that an AF from the list is valid in another part of the country or region while the AF at the current location belongs to a local transmitter with a different program. During the PI code check the radio will be muted. This mute period is audible, because it is defined by the RDS system and may take up to 200 msec under good conditions. Clever designed RDS radios will limit the audible PI checks to a minimum by making use of historical and statistical data.

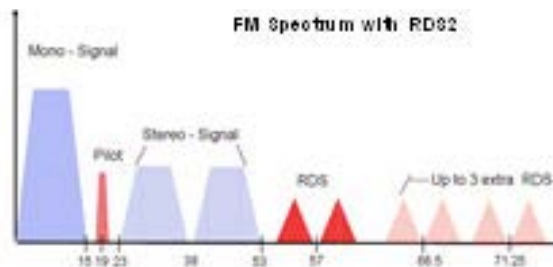
Car radios with RDS2 will continue their programme switching strategy by evaluating the audio quality of the AF's in data-stream 0.

Automotive requirements

The performance of this automatic re-tune system has been considered as a core feature by the car industry. Over the years millions of test kilometers were driven to develop and optimize algorithms to improve the system. At that time car radios were mostly single-tuner products. Undisturbed listening under difficult reception conditions at one hand and a clever AF list update mechanism in order to ensure reliable

AF switching at the other hand were a major challenge. Both tasks had to be done by one tuner. Also compromises had to be made to keep this update process almost inaudible.

RDS2 uses three additional subcarriers higher up in the FM



MPX signal. The RDS propagation in the upper carriers may differ somewhat from the propagation in the 0 carrier.

However in practice the effect is negligible.

In case of a dense FM spectrum with stations at 100kHz spacing, there is the option to use subcarrier 1 and 2 only and not the 3rd one on 76kHz.

RDS test locations

We have seen which parameters are decisive for an optimal reception. A logical choice of areas to test the RDS performance on the road is where these conditions will be continuously available.

Mountainous regions in **Germany** like the Schwarzwald (Black Forrest) and Bavaria near the Austrian border are good examples. These areas are characterized by a number of high power FM transmitters of more than 100 kW and there are also a large number of low-power gap fillers in order to guar-

antee interference free reception without multipath distortion in small valleys.

In **France**, the region roughly 25 to 50 km South and East of Paris shows AF lists which are generally spoken rather long with up to 25 AF's. Sometimes only a few AF's are relevant and it may also occur that none of these AF's offers a decent quality. This sets tough requirements on a car radio in order to show a good dynamic performance.

In **Norway** the region North of Oslo is extremely challenging. One could almost say: when the automatic re-tune feature works well in this area, it will work well everywhere.

A particular case in **Austria** needs some special attention and is described below.

On the Tauern motorway (Autobahn) A10 from Salzburg, 30 km South of Salzburg in the direction to Villach, where only the program OE-3 is re-transmitted in the numerous tunnels. This programme carries traffic and weather information. Between the tunnels the OE-3 programme can be normally received off air by a number of transmitters. However in the tunnels this programme is available on one frequency only. One can imagine that the propagation changes drastically each time when entering and leaving the tunnel. A sort of "Tunnel detection" mechanism is needed in order to select within less than a second the optimal AF when entering and leaving these tunnels.

The recommended route for testing is between the petrol station Golling, 30 km South of Salzburg, and exit Hüttau.

Below, the figure and the map show this 35 km test-route



TP/TA - Traffic Announcement, Traffic Programme

We have seen already that the TP/TA feature became the pan-European successor of ARI.

For broadcasters it was not attractive to give traffic information on all national or supra regional programmes.

In addition the BBC in the UK had the vision to give traffic information for regions like Kent or Oxford, only regional. These regional programmes have their own transmitters and do not share the national transmitters from BBC Radio 2, 3 and 4.

But how to signal traffic events to a single-tuner car radio then? E.O.N (Enhanced Other Networks) provided the solution. When the car radio is tuned to any programme within the BBC network, then all relevant programme information is distributed by the RDS group type 14A. The receiver is then able to identify the programme which will carry the traffic information upcoming announcements.

When a traffic announcement is sent and properly signaled by a number of 14B groups, the receiver can react immediately and switch-over temporarily to the radio programme currently sending the traffic information.

The feature can be tested and validated well in the areas of Kent and Oxford.

For the UK we have seen that traffic announcements are frequently distributed by regional programmes and cross-referenced via EON to all national programmes. The transmitter towers of the national programmes are not the same as the ones of the regional programmes and are situated on other locations. As a consequence the signal level and coverage of a regional programme and national programme can be different most of the time. In addition the receiver may get 14B groups from a programme launching a traffic announcement which may concern another region, hence not relevant for the traveler. It may even be the case that the traffic announcement cannot be received at all. Thresholds have to be built-in to offer the relevant traffic bulletins only. For this reason it will be obvious that the UK is a mandatory test area for the RDS TP/TA feature.

PTY

Programme TYpe (PTY) has proven to be a popular feature. The PTY search feature was present already in the first generation aftermarket products. The PTY feature became more attractive when PTY codes changed dynamically to represent well the flavor or genre of the radio programme and were cross-referenced by EON in variant 13 of the 14A type groups. The PTY standby mode became a powerful feature. The listener could select a programme type while the receiver was able to signal the start of the programme with the corresponding PTY on either the tuned program or the ones cross-linked via EON.

News and Weather

Two programme types “News” and “Weather” became a special case. There was a strong requirement to signal News and/or Weather as an event like TP/TA. The respective PTY could bring up a short announcement item of up to a maximum of 5 minutes.

It is important that the receiver can switch instantly to the correct programme sending the news bulletin if set in the standby mode for news. For EON, when at the junction of a PTY change at least four and up to eight groups of type 14A, variant 13, are sent in rapid succession for the service whose code is changing. The solution was found by means of the RDS Guidelines to describe this special situation as follows:

“When Broadcasters use Dynamic operation of PTY, two categories (01 - News), and (16 -Weather), are principally expected to be used for short duration reports and announcements.

As such, these codes should not be used to define longer programmes, and a suitable alternative code should be used instead

(example code 02 - Current Affairs - should be used for a 30 minute news programme, and code 08 - Science - should be applied to a feature programme about the Weather).”



MULTIPLE TUNER CONCEPTS

RDS background scan

We have seen already that RDS-EON is an extremely powerful feature for single tuner products, when relevant information is instantly required to react on events like traffic announcements.

In the meantime huge progress was made in miniaturization and tuner design. Double and triple tuner concepts have become feasible for in dashboard products.

The car industry in particular identified the strength and added value of multiple tuner products.

Quality checks and processes can be done now fully in the background, which improves the dynamic performance significantly.

Living band

The so called living band feature became rather popular in line-fit products with multiple tuners. A background tuner scans continuously the FM landscape. Products with a large color screen are often used for both, navigation and the radio display, and they can offer the driver within a short glance which radio programmes are available at the driving location. However, due to increased usage (abuse) of the “scrolling PS feature”, this system has lost a lot of its strength as stations are increasingly harder to identify.

An obvious feature for a background tuner in integrated radio-navigation products is TMC (see Chapter 7). TMC may be handled by either a separate tuner or in a time sharing process with other functions to be carried out.

Phase diversity

The phase diversity system is to date the most advanced system to optimize the signal quality which is presented to the user. Two tuners, each with their own antenna are tuned to the same radio programme and an advanced digital system either combines or uses only one of the signals from either tuner.

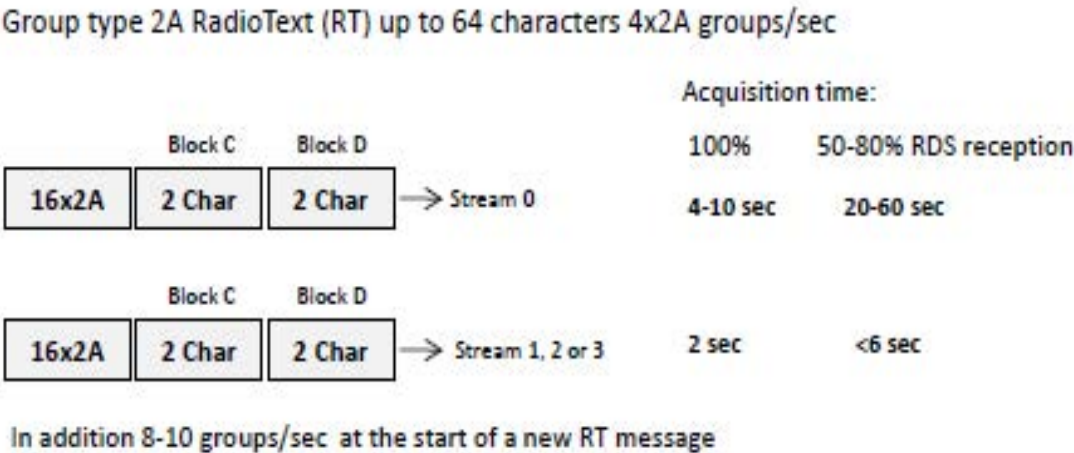
RDS2 improves performance of basic RDS features in automotive

Particularly in automotive applications the reliability of RDS data acquisition remains an important issue to deal with. When driving near the border of the coverage area, where RDS reception is at its limit, we immediately can notice that RadioText (RT) for instance is no longer present. In a few cases some text remains on the display for longer, which does not match anymore the content of the current programme. RDS2 is mainly developed with a focus on new added value applications via ODA and to transmit objects with a larger size up to 163 kB such as a station logo or cover art for music items. However, RDS2 is also extremely suitable to improve the reception quality of the well-established programme features such as RT significantly.

The example below may visualize the issue. A RadioText message may contain up to 64 characters. 16 groups of type 2A are needed to transmit a complete RadioText message with 64 characters.

When we use 4x2A groups per second on the basic subcarrier 0, it will take at least 4 seconds ($64/(4 \times 4)$) to receive the complete text message at 100% reliability for correctly received RDS data. It takes 10 to 12 seconds for the receiver to put the text message on screen after it has been received correctly twice.

The reception reliability of RadioText (RT) in a car will drastically increase, if the same information is also sent over one of the upper carriers in RDS2 as can be seen from the diagram below:



RT+

RT+ is a valuable and powerful RDS feature. As an extension on the existing radio text (RT) RT+ offers significant added value particularly for car drivers. The key elements from a radio text message are tagged like track title and artist. This will allow to present to the car driver these elements in a structured and quasi static way without the need to read a 64 character text scrolling to the end.

RT+ is an ODA signaled in group type 3A. the corresponding application group carries the necessary RT+ information. As a minimum requirement the 3A group must be transmitted every 10 seconds and the RT application group every 2 seconds.

About the author: Frits de Jong worked as systems engineer and product manager for Philips Car Systems, Siemens-VDO and TomTom. Now he is a freelance consultant. He is chairman of the RDS Forum since 2016.

RDS-TMC: The Traffic Message Channel by Mark Saunders

Although RDS was primarily developed by Public-Service broadcasters as an aid to listeners in station selection and identification, RDS has also been widely and successfully used for commercial applications. The most implemented of these is Traffic Message Channel (TMC), where RDS transports densely coded information about driving conditions.

In the early 1990s, RDS became fitted as standard equipment in many new vehicles, especially in Western Europe, and a few years later Satellite-Navigation and route guidance systems started to become realistic consumer devices. Satellite-Navigation systems at their basic level are able to calculate the optimum route between two points, either the shortest route, or the quickest, but only become really useful if they take into account the traffic conditions between the points, and use that information in the route calculation process. Even without the aid of Satellite-Navigation, drivers themselves are able to pick the best route, or at least estimate how long their journey will take if fully appraised of accidents, roadworks, other factors, or simply sheer volume of traffic, that will affect their progress.

Spoken traffic information has for many years been the primary method of imparting information to drivers, but is extremely limited in the amount of information that can be conveyed by an announcer who typically will report ten or so incidents three or four times an hour during peak times, and even less frequently at other times. For drivers, spoken traffic information especially on national or large regional stations, is mostly irrelevant anyway.

The proven reliability of RDS to deliver information to vehicles became an obvious technology to use to deliver a better, more comprehensive and relevant traffic service to drivers.

ESSENTIAL ELEMENTS OF TRAFFIC INFORMATION

Traffic information, however communicated, needs to provide essential elements of information:

- ▶ what is being reported;
- ▶ where the problem is;
- ▶ what the effect is;
- ▶ who is being affected;
- ▶ how long the situation likely to last; and
- ▶ what can be done to avoid or ameliorate the situation.

To communicate this information would require a considerable bandwidth (more than the entire capacity of RDS) if transmitted as text (which would be fundamentally dangerous in a vehicle anyway), so instead the information is broadcast as a series of codes, which consume very little RDS bandwidth, and can be used directly by the in-vehicle systems. When presentation of messages is necessary, as codes rather than text are used, the service is language and unit independent, allowing the end-user his choice of presentation of the information.

TMC transmits the following core 'elements' in every message:

LOCATION: The point at which the problem has occurred, the beginning and end of the road stretch affected, a particular 'link' on the road network (for example an exit slip from a motorway), or an area.

EVENT: This is the part of the message which describes what is being reported; an accident, a road closure, road construction, traffic congestion, dangerous driving conditions, adverse weather conditions etc. Events broadly fall into one of two types – 'flow' which details the average speed of traffic on a road section, either explicitly with a km/h value, or comparatively using phrases such as 'slow traffic' or 'stationary traffic' or 'flowing freely' – or 'incident' which is the non-flow event messages, such as accidents, road construction etc. The incident messages can be split further into 'planned' and 'unplanned' incidents. Road Construction is an example of a planned incident, an accident however is unplanned.

Often, an incident causes a problem, with slow traffic flow be-

ing the result, so a message often contains both an 'incident' element and the resulting 'flow' element – an accident (incident) has caused traffic to move at only 20 km/h (flow).

DURATION: With some incidents, especially planned road construction, there is a specific scheduled time at which the incident is expected to have been cleared and conditions returned to normal, so a duration if known is also given or simply 'unknown' is sent.

Most traffic messages need just these three fundamental elements to adequately convey the information required, but TMC also allows several option details to be included when necessary. The most common example is to add specific time information for planned incidents. It is desired to notify in advance a road closure occurring over-night, so the start time of the closure (23:00 Thursday) until the re-opening (05:00 Friday) can be explicitly communicated too.

TMC IN DETAIL

TMC is the most-widely used example of an ODA (Open Data Application) within RDS. ODAs by design make use of one of the many specified 'un-used' RDS group types in a particular transmission, but by de facto, due to the fact that TMC slightly pre-dates the ODA concept, they always use type 8A groups to transmit the data. The necessary ODA type 3A group is of course also transmitted which gives the AID of RDS-TMC - CD46 - or an extension of TMC (as yet not realized anywhere) – CD47. The detail of both the information in the 8A groups and

3A group is given below.

Above was described the two core elements of a message, essentially Location and Event.

They differ is that a Location has geographical relevance, whereas largely an Event (or at least a core set) can occur anywhere. The principle adopted is that all TMC Service Providers use the same standardized 'Event List', but Location codes are determined locally.

EVENT

The Event List is standardized (ISO 14819-2) and consists of around 1,500 'phrases' that provide descriptions about what is being conveyed. The messages are both for convenience and technical reasons arranged into thirty-nine 'classes' of message, according to their content.

- ▶ Level of Service
- ▶ Expected Level of Service
- ▶ Accidents
- ▶ Incidents
- ▶ Closures and Lane Restrictions
- ▶ Exit Restrictions
- ▶ Entry Restrictions
- ▶ Traffic Restrictions
- ▶ Carpool Information
- ▶ Roadworks
- ▶ Obstruction Hazards
- ▶ Dangerous Situations
- ▶ Temperatures
- ▶ Precipitation and Visibility
- ▶ Wind and Air Quality
- ▶ Activities
- ▶ Security Alerts
- ▶ Delays
- ▶ Cancellations
- ▶ Travel Time Information
- ▶ Dangerous Vehicles
- ▶ Exceptional Loads and Vehicles
- ▶ Traffic Equipment Status
- ▶ Size and weight Limits
- ▶ Parking Restrictions
- ▶ Parking
- ▶ Reference to Audio Broadcasts
- ▶ Service Messages
- ▶ Special Messages
- ▶ Level of Service Forecast
- ▶ Weather Forecast
- ▶ Road Conditions Forecast
- ▶ Environmental
- ▶ Wind Forecast
- ▶ Temperature Forecast
- ▶ Delay Forecast

► Cancellation Forecast

In each class of message, there exist a few or hundreds of descriptive messages, compounded from a smaller number of 'core phrases'.

Below is an example from the beginning of the 'Level of Service' class

	Reference English (Metric)	Code	N	Q	T	D	U	C	R
	EVENT LIST								
	1. LEVEL OF SERVICE								
1	traffic problem	1			D	1	U	1	A50
101	stationary traffic	101			D	1	U	1	A1
102	stationary traffic for 1 km	102			D	1	U	1	A101
103	stationary traffic for 2 km	103			D	1	U	1	A102
129	stationary traffic for 3 km	129			D	1	U	1	A103
104	stationary traffic for 4 km	104			D	1	U	1	A104
105	stationary traffic for 6 km	105			D	1	U	1	A106
106	stationary traffic for 10 km	106			D	1	U	1	A110
130	danger of stationary traffic	130			D	1	U	1	A1D
108	queuing traffic (with average speeds Q)	108		4	D	1	U	1	A2
109	queuing traffic for 1 km (with average speeds Q)	109		4	D	1	U	1	A201
110	queuing traffic for 2 km (with average speeds Q)	110		4	D	1	U	1	A202
131	queuing traffic for 3 km (with average speeds Q)	131		4	D	1	U	1	A203
111	queuing traffic for 4 km (with average speeds Q)	111		4	D	1	U	1	A204
112	queuing traffic for 6 km (with average speeds Q)	112		4	D	1	U	1	A206
113	queuing traffic for 10 km (with average speeds Q)	113		4	D	1	U	1	A210
132	danger of queuing traffic (with average speeds Q)	132		4	D	1	U	1	A2D

- At its most basic, Code 1 simply conveys that there is a 'traffic problem' (no other details being available)
- Code 101 is a little more helpful in that it warns that there is 'stationary traffic'.
- Code 102 adds further detail that the stationary traffic stretches for 1 km.
- Code 108 is slightly different in that here the description is 'queuing traffic'.
- Code 109 adds more detail that the queue length is 1 km. This code and many others allows the addition of the information shown in parentheses ('with average speeds 'Q') to be added to further quantify the incident. The quantifier (in this case a specific speed) is taken from another table of speed values (the speed value table is table 4 – which is signified by the 4 in the Q Quantifier column.)

The significance of the other columns and values in the table will be explained a little later.

To transmit an event (without a quantifier) by this method of using a look-up code table requires 11 bits, which technically allows for 2048 separate phrases, so with approximately 1,500 phrases defined, there is ample scope to add more phrases should the need ever arise, although the list is already extremely comprehensive.

The code table is standardized in the English Language using SI (metric) units, with TMC Service Providers creating local tables according to need. Below is an example how Code 106 has been translated by HERE Traffic for presentation in some other languages and units.

Code	Language/units	Presentation
106	Reference English (Metric)	stationary traffic for 10 km
106	North-American English (US Units)	Stopped traffic for 6 miles
106	North-American French (Metric)	Embouteillage sur 10 km
106	Latin-American Spanish (Metric)	Tráfico detenido por 10 km
106	Latin-American Spanish (US Units)	Tráfico detenido por 6 millas.
106	Portuguese (Metric)	ráfego congestionado com 10 km
106	Brazilian Portuguese (Metric)	10 km de trânsito parado
106	Russian (Metric)	дорожный затор 10 км
106	Ukrainian (Metric)	дорожній затор на 10 км

Note that the code transmitted is the same everywhere, but the presentation is determined by the end-user, in his selection of preferred language and units. For example, three drivers in the Niagara area of North America all receive the same transmission, but the driver from Quebec has chosen presentation to be French/Metric (km), the American driver has selected North-American English/US Measures (miles), and the Spanish-speaking American has selected Latin-American Spanish/US measures (miles) - each receives the information in the most natural presentation for them from the same broadcast.

LOCATION

Conceptually the location is handled in the same way as the event: a code is sent, and the device retrieves that from a table in the receiver. It is rather more complex than this simple description infers, in that Location Tables are more than a list of phrases; they contain geo-referenced data that allow precise alignment with digital maps on which satellite-Navigation systems operate.

Location Tables themselves are not standardized as such, but how the Location Tables are compiled is, and ISO specification 14819-3 provides the methodology by which Location Tables have to be compiled, and maintained.

A Location Table is specific to a particular geographical area, and in essence every: road junction; link within a junction (e.g. the link between two highways); and area is allocated a code. Each Table can contain 64,000 codes, smaller countries needing just one Table, larger countries requiring several. (USA/Canada uses 33 Tables). The Table itself is identified by a combination of Location Table Number (LTN) and Location Table Country Number (LTCC), the combination of which provides a theoretical 942 valid unique Location Table identifiers.

Below is a simplified extract from one of the Location Tables – this one is LTCC=C, LTN=07, one of the tables used in the UK.

The columns indicate respectively:

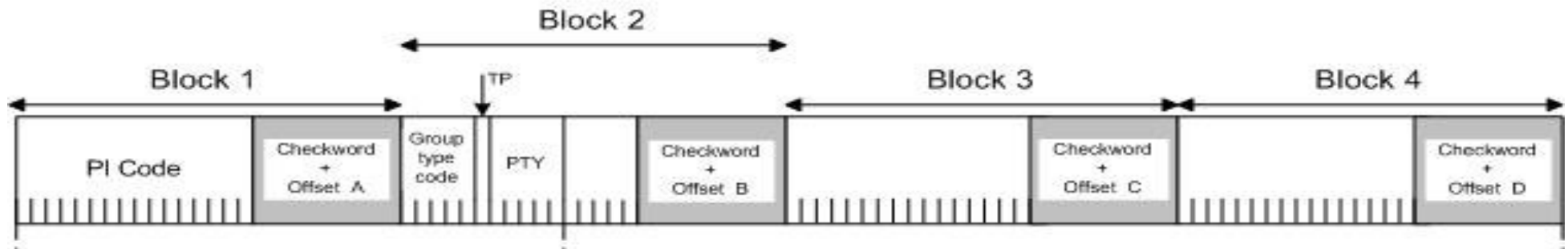
- ▶ The Location Code within this table;
- ▶ The type of location represented – L is a 'Link', P is a 'Point', A is an 'Area'.
- ▶ The location is described using the Road Number, and Road Names
- ▶ Precise Latitude and Longitude co-ordinates.
- ▶ Area and Linear References place each Location Code in context to other roads in the area.
- ▶ Negative and Positive offsets are pointers within the database to the next locations in both directions from any point. The need for this is explained below when the transmission of Location within TMC is described.

LOCATION CODE	TYPE	ROAD NUMBER	FIRST NAME	SECOND NAME	AREA REF	LINEAR REFERENCE	NEGATIVE OFFSET	POSITIVE OFFSET	LAT	LONG
314	L2.1	M25	LONDON ORBITAL DARTFORD		00004					
1091	L3.0	M25	DARTFORD CROSSING	J3 SWANLEY	00003	00314	01103	01092		
3274	P1.0	M25	J1A DARTFORD		00029	01091	03306	03275	51.453	0.24234
3275	P1.1	M25	J1B SWANSCOMBE		00029	01091	03274	03276	51.4379	0.23888
3276	P1.3	M25	J2 A2 INTERCHANGE		00029	01091	03275	03277	51.4263	0.2384
3277	P1.3	M25	J3 SWANLEY		00029	01091	03276	03278	51.3885	0.19386
1092	L3.0	M25	J3 SWANLEY	J5 SEVENOAKS	00003	00314	01091	01093		
3278	P1.3	M25	J4 BROMLEY		00029	01092	03277	03279	51.3468	0.1564
3279	P1.1	M25	J5 SEVENOAKS		00029	01092	03278	03280	51.2914	0.14306
1093	L3.0	M25	J5 SEVENOAKS	J7 M23 INTERCHANGE	00003	00314	01092	01094		
3280	P1.3	M25	J6 CATERHAM		00049	01093	03279	03281	51.2589	-0.0641
3281	P1.1	M25	J7 M23 INTERCHANGE		00049	01093	03280	03282	51.264	-0.1279
1094	L3.0	M25	J7 M23 INTERCHANGE	J10 BYFLEET	00003	00314	01093	01095		
3282	P1.3	M25	J8 REIGATE		00049	01094	03281	03283	51.2587	-0.1982
3283	P1.0	M25	J9 LEATHERHEAD		00049	01094	03282	03284	51.3092	-0.3245
3284	P1.3	M25	J10 BYFLEET		00049	01094	03283	03285	51.3221	-0.4504
1095	L3.0	M25	J10 BYFLEET	J12 M3 INTERCHANGE	00003	00314	01094	01096		
3285	P1.3	M25	J11 CHERTSEY		00049	01095	03284	03286	51.3749	-0.5091

To transmit a single Location Code requires 16 bits and a further 10 bits are needed to identify the Location Table identifier (LTN and LTCC) in which the code exists. Further, the majority of traffic messages require the use of two locations to mark the beginning and end of the road section being - these are termed the 'Primary Location' and the 'Secondary Location'. By agreement and for technical reasons, the Primary Location is the point furthest from the driver as he approaches the section of road (e.g. the point at which an accident has occurred), and the Secondary Location marks the point at which the driver will first encounter the resulting tail-back of traffic, caused by the accident.

CODING WITHIN AN RDS GROUP

An over-riding principle of RDS is that data integrity within a single group is excellent, and wherever possible data should not be split across groups. All RDS groups comprise 64 data bits, of which the first 27 have fixed defined usage, leaving 37 bits available for use application-specific use.



Identified above is that an EVENT code is 11 bits, and the Primary and Secondary LOCATION codes each require 16 bits, and the Location Table identification requires a further 10 bits. Event and Location codes therefore alone would require a total of 53 bits, with additional bits needed to code DURATION and START and STOP times and QUANTIFIERS etc. It becomes clear that several RDS groups sent in succession would be needed to transmit just a simple single message – with the need for the receiver to perfectly several RDS groups in succession before a complete traffic message could be received. For reliability of reception and data efficiency therefore it is necessary to reduce the number of bits sent to 37 or less such that message can be generally transmitted in a single RDS group.

The EVENT code cannot reasonably be reduced, so the majority of bit savings come from the LOCATION code. Firstly, within any area (in a single transmission) it is most usual that all locations will be from the same Location Table, so rather than transmit these 10 bits Location Table Identifier with each message, it is sent only periodically, and considered to apply to all messages subsequently transmitted. On occasions where a transmission area covers roads in two or more Location Tables there is a special mechanism to handle this relatively rare occurrence.

LOCATION CODE	TYPE	ROAD NUMBER	FIRST NAME	SECOND NAME	AREA REF	LINEAR REFERENCE	NEGATIVE OFFSET	POSITIVE OFFSET	LAT	LONG
3282	P1.3	M25	J8 REIGATE		00049	01094	03281	03283	51.2587	-0.1982
3283	P1.0	M25	J9 LEATHERHEAD		00049	01094	03282	03284	51.3092	-0.3245
3284	P1.3	M25	J10 BYFLEET		00049	01094	03283	03285	51.3221	-0.4504
1095	L3.0	M25	J10 BYFLEET	J12 M3 INTER-CHANGE	00003	00314	01094	01096		
3285	P1.3	M25	J11 CHERTSEY		00049	01095	03284	03286	51.3749	-0.5091

The need to transmit 16 bits for each of the Primary Location and Secondary Location codes is also not necessary, as the location of the Secondary Location will be relatively close to the Primary Location – typically further along the same road. The design of the Location Table therefore is not random, and in general each road is coded from one end to the other on successive lines in the database. In the example above, the M25 in the UK has been coded starting at junction 1A, then 1B, junction 2, junction 3... sequentially along its length. Rather than using 16 bits to transmit the Secondary Location explicitly, it is given as an 'offset' from the Primary location in the number of 'steps up' or 'steps down' (termed Positive or Negative direction) in the table.

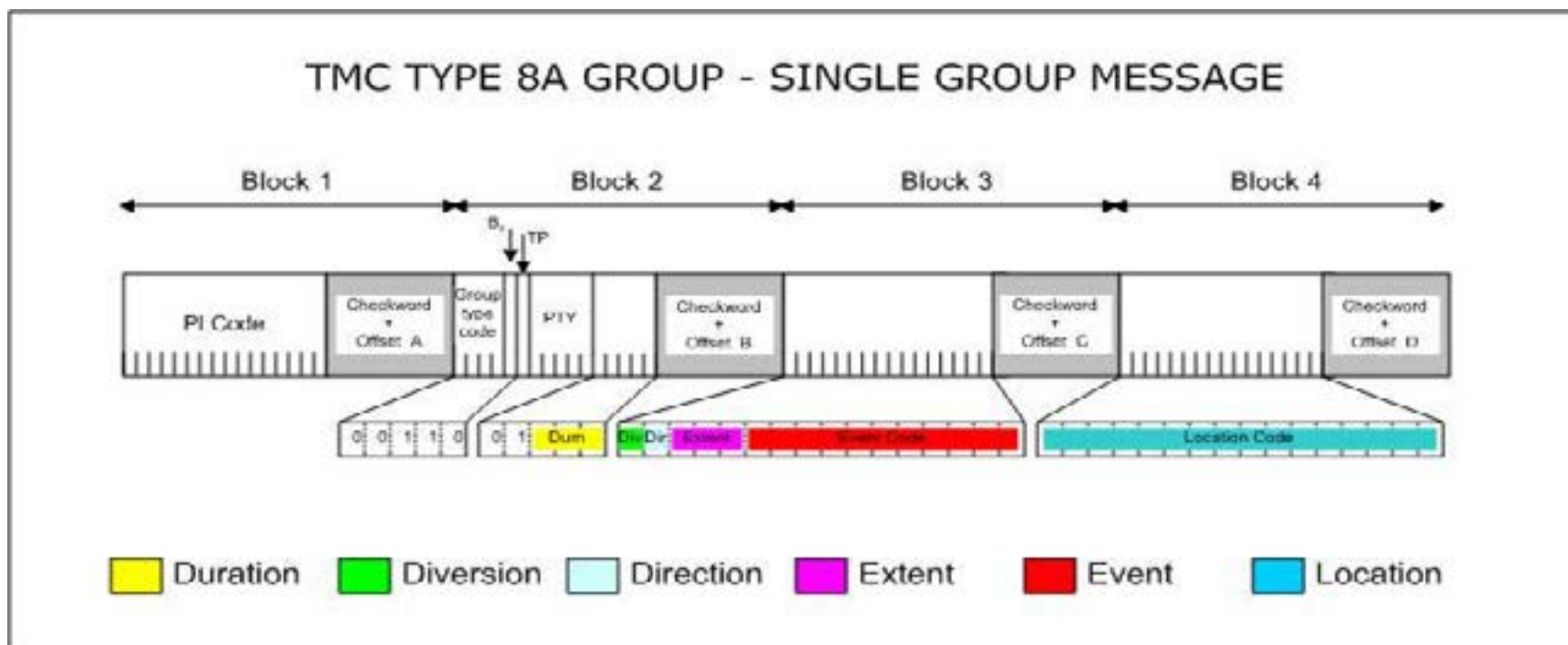
So to code an accident that has occurred on the M25 close to Junction 9 Leatherhead, causing slow traffic back to Junction 11 Chertsey, the Primary Location code 3283 is sent, an EXTENT code with value 2 and a Positive Offset bit.

The receiver determines the Secondary Location by stepping two locations in the database from the Primary Location in the positive direction. From the Table reproduced above, it can be seen that one step positive from primary location 3283 gives location code 3284 (Junction 10 Byfleet), and a second step from this point gives code 3285, which is Junction 11 Chertsey.

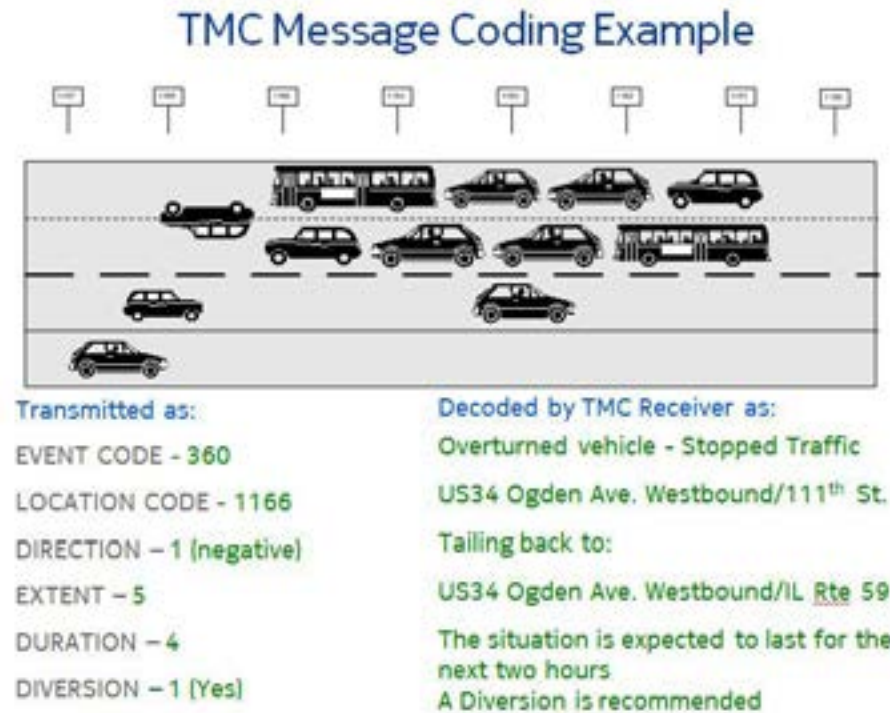
By this method of transmission, only four bits are needed to describe the Secondary Location: three bits provide an offset (of up to seven steps) from the Primary Location and a single bit is used to indicate either the positive or negative direction. This saves twelve bits in the coding of the Secondary Location reducing from sixteen to just four.

The fundamental elements needed for a TMC message, EVENT and LOCATION, together require therefore just thirty-one bits (Event-eleven bits, Primary Location-sixteen bits, Extent-three bits, Direction-one bit) which fits with six bits to spare into the thirty-seven available within the RDS 8A group. Three of these six bits are used to code one of eight DURATIONS, as defined in yet another look-up table, one bit is used to 'highlight' if the incident is so severe that a DIVERSION is necessary because the road is impassible, and the two remaining bits are used to indicate if this group has the complete TMC Message (a Single-Group-Message (SGM)) or if additional information for the incident (e.g. START TIME and STOP TIME, QUANTIFIER etc.) is in a subsequent 8A group, spreading the complete message across more than one group, becoming a Multi Group Message (MGM).

Standard ISO 14819-1 details the precise coding that TMC uses; below is illustrated how a Single-Group-Message uses the available bits.



Shown below is an example of the compactness of the coding achieved by RDS-TMC, using the basic six elements in the single group message.



More Information

When a traffic report is heard on the radio, spoken by an announcer, he or she can impart a sense of urgency to some messages; can indicate if an incident is affecting traffic travelling in just one or in both directions; advise if the problem is actually occurring 'now' or is 'forecast' to happen (e.g. there is expected to be traffic congestion later because there is a concert), can give an indication of whether the incident is a short-term event (an accident for example), or a major road construction project lasting many months; as well as imparting other information including advising of a specific diversion route.

All the above are possible with RDS-TMC, and every TMC message includes an indication of:

- ▶ Urgency;
- ▶ Now or Forecast;
- ▶ Affecting traffic in one direction or both; and
- ▶ Whether the incident is short-term (termed 'dynamic') or 'long-lasting'.

To avoid sending all this information for every message, which would certainly make every message a Multi Group Message, the above parameter information is implicit, with each pre-determined for each event code by default.

Below is another extract from part of the Event list, to illustrate this principle. To the right of each descriptive phrase are a number of columns – these indicate the 'default' values for the parameters listed above.

- Column N indicates: if blank, the event is happening 'now': if it has an 'F' the event is 'forecast'
- Column T indicates: if 'D' the event is 'dynamic': if 'L' then the event is 'long-lasting'
- Column D indicates: if '1' the event affects just one direction of traffic: if '2' affects both directions
- Column U indicates: if blank, 'normal urgency': if 'U' indicates 'urgent': if 'X' indicates 'extreme urgency'.

Code	English (UK) Plural Noun (Q>1)	N	Q	T	D	U	C
904	storm damage			D	2		12
986	storm damage. Danger			D	2	U	12
972	storm damage expected	F		D	2		12
905	(Q) fallen trees		0	D	1		12
906	(Q) fallen trees. Danger		0	D	1	U	12
973	fallen power cables			D	2		12
989	fallen power cables. Danger			D	2	U	12
907	Flooding			L	2		12
900	flooding expected	F		D	2	U	12
908	flooding. Danger			L	2	U	12
974	sewer overflow			L	2		12
990	sewer overflow. Danger			L	2	U	12
909	flash floods			D	2	U	12
910	risk of flash floods			D	2	U	12
991	flash floods. Danger			D	2	U	12
911	Avalanches			L	2		12
992	avalanches. Danger			L	2	U	12

So, by design, each message has implicit assumptions about to whom the message is targeted (drivers on one carriageway or both), the urgency of the message, and time frame to which the message applies.

If the assumptions implicit by the default values are not correct on any occasion, then by the use of 'control codes' in a Multi Group Message, then these can be changed for this particular occasion. By way of an example, code 905 details that there is a fallen tree, which by default is said to affect just traffic on one side of the road ('1' in the D column): if in this case the tree has fallen across both carriageways, a control code is sent to 'over-write' the default condition for this particular occasion.

Notice that code 905 also has a value in Column Q. This shows which 'quantifier table' this event uses; in this case it is table 0, which is a table of integer values allowing optionally the ability to send that there are a particular number (quantity) of fallen trees (e.g. three fallen trees). The value in Column C shows which 'class' the message is in – this is important to the message updating process explained later – the values in columns Q and C can't be changed.

The detail of the structure of the 2nd and subsequent groups of a Multi Group Message is outside of the scope of this article, suffice to say that these contain a series of labels, values and control codes, which are used to add quantifiers to certain messages, change default values, and add extra detail (specific diversion routes, start and stop times, extend the length of route affected, advise of temporary speed limits etc.).

3A Group Usage

Being an Open Data Application, RDS-TMC uses the 3A group to indicate the AID for TMC (CD46) using type 8A groups, (and optionally an extension with AID=CD47 using another group type), and also has a few 'application-specific' bits as well. In TMC, the application-specific bits are used to indicate the Location Table Country Code (LTCC) and Location Table Number (LTN) that by default this transmitter uses, as well as a Service Identifier (SID) which identifies the Service Provider for the TMC. A number of additional bits are defined, to indicate the 'depth' of the service – essentially if the service provides information is for all roads in the area, or (more likely) only motorways and other major roads. The information in the 3A group is static data, so needs to be repeated only every five seconds or so, and is used by the device only when first finding a service or as a check after changing frequencies.

Tuning Information

In the same way that it is a basic requirement for receivers to be able to 'follow' an audio programme from one transmitter to the next, which the audio RDS receiver does by using the Alternative Frequencies information in the 0A group, so too is it necessary for the TMC device to follow the TMC service. In some cases it may be that the network of transmitters used for TMC is the same as used for audio, but in most cases the TMC service will use fewer, more, or different transmitters to the audio service. Consequentially the TMC service can transmit its own 'Tuning Information' entirely independently of the audio AF list.

The frequencies on which the same (or even a different TMC service) can be found in adjacent areas are transmitted using the Tuning Information variants within the 8A group. Tuning Information contains the frequency information for a device to follow to an identical TMC service (another transmitter in the same region) or to a different TMC service in a neighbouring country or region when not only is the frequency indicated, but also the Location Table Identifier and Service Identifier and the other parameters the device will need. This information too is considered static, and sent only infrequently, the TMC receiver storing the Tuning Information, which it uses to check frequencies at it moves, in the same manner as an audio RDS receiver evaluates the transmitted AF list.

Encryption

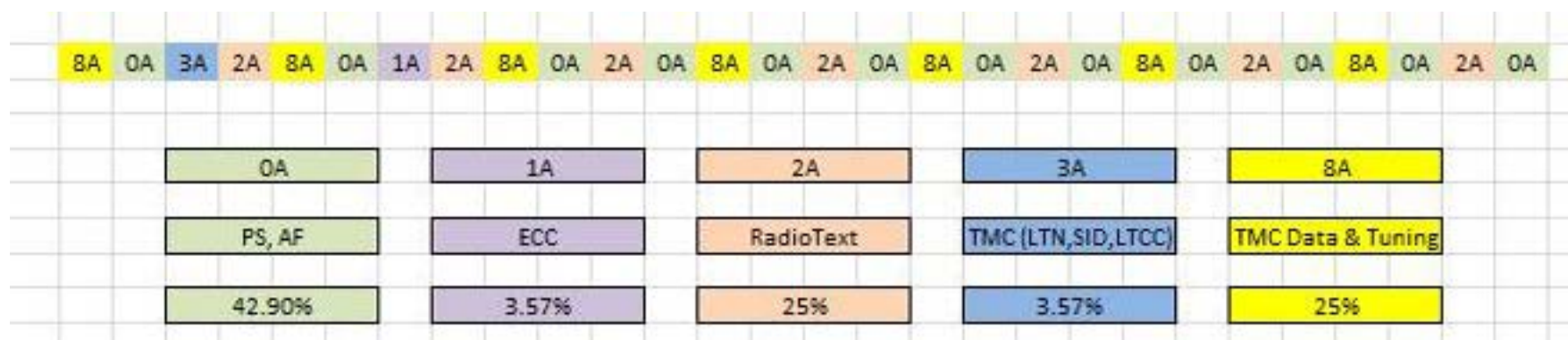
To provide a high quality TMC service requires considerable expenditure for the Service Provider. The cost of mapping the country or region, of creating the specific Location Table, and the collection, processing and transmission of the TMC data, all are costly. For these reasons all the premium quality TMC services are operated commercially, with the Service Provider selling its TMC service, either directly to the end-user, or more usually to a device manufacturer who sells his devices to end-users.

The coding of RDS-TMC is in the public domain and as it is a broadcast service, any device that understands the coding can make use of the data. To protect and control the usage of the broadcast TMC service either of two mechanisms is used. The simpler one is that the Location Table is licensed for use by the Service Provider, as clearly without access to the Location Table, all information is worthless. The downside of this approach is that there becomes a multitude of different Location Tables in areas where there is more than one TMC service. Each table has to be integrated into the digital map and stored within

devices. The TMC device manufacturers were not happy with this approach, so instead a method of encrypting the TMC data was standardized. The process is easy to explain, and again uses the simple premise that without Location information, all other data has no value. In TMC encryption the sixteen bits that are used to transmit the Location Code are transformed using a three-stage bit manipulation process, using one of 256 sets of values. The 256 values are described by an Encryption Identifier (ENCID) and a Service Key (SVK). Although the 256 sets of values are standardized, they are not made public, and the particular SVK a Service Provider chooses to use is NOT broadcast and only exchanged in confidence between a Service Provider and his customers (device manufacturer). Information in the 3A group indicates the TMC service is encrypted, so the device knows it has to apply the decryption algorithm (the inverse of the encryption process) in order to produce correct information – the values used for encryption may change daily giving added levels of protection.

Group Sequence with TMC

The maximum rate allowable for 8A TMC Data groups within an RDS stream is one TMC data group per four RDS groups (i.e. every fourth RDS group is an 8A) – this equates to 2.85 x 8A groups/second. Whether this rate will be possible is entirely dependent upon if there are any other ODA applications in use, or if heavy use is made of for example EON. However assuming a typical RDS transmission using the Basic 0A group and 2A RadioText, and a 1A group to provide ECC, this maximum 8A TMC insertion rate is easily possible: below is a typical group sequence to be programmed into the RDS encoder. This sequence achieves the objective of maximum TMC data groups, each variant of the 3A ODA group being sent in less than 5 seconds, a realistic throughput of RadioText, and a complete PS transmission is less than 1 second – all in accordance with the guiding principles in the RDS specification, and fully in conformance with the TMC specification. The encoder will automatically insert a 4A (Clock Time) group into the sequence at the top of each minute.



Note also that in this sequence the 8A groups are sent precisely every fourth group – this isn't just for cosmetic reasons – but is a useful factor in receiver design. As explained above, it is essential for the TMC tuner to follow the TMC service across transmitters as the vehicle moves, and by providing predictable gaps between TMC groups – in this case a three group gap – the gap can be exploited by the receiver for checking the Alternative Frequencies for the TMC service. The three-group gap between successive 8A groups (approx. 300 ms.) is more than ample time to sample the signal strength and check the PI code of one or more of the frequencies contained in the Tuning Information. Using these gaps for frequency evaluation means that no TMC data is lost during the process. Although of course the receiver is able to determine the gap size from observation of the group sequence, it is also explicitly given in the 3A group information.

Although RDS is robust with good error detection, in poor reception conditions errors can occur, as witnessed by an occasional incorrect character in a PS or RadioText message. Errors in PS or RT are not too important, but in TMC, no errors at all can be tolerated, as a single bit error can for example, show a serious accident on the wrong carriageway or in a completely wrong location. For this reason the same TMC message is sent more than once: preferably three times in total but certainly at least twice, with the receiver having to receive the same message identically twice before presenting and using the data. So in practice it takes three 8A groups to transmit a single (Single Group Message) TMC event. At this maximum insertion of TMC data groups into the RDS Group Sequence (25%), $171 \times 8A$ groups/minute are transmitted, so a theoretical total of $171/3 = 57$ TMC messages per minute are possible. In practice as some 8A groups carry Tuning Information, the practical throughput of TMC messages is realistically 50 messages per minute. It is the aim to update information at least every five or six minutes, so each transmitter can broadcast up to 300 TMC messages in total, before updating the information.

The screen-shot below shows the 2wcom RDS Lab monitoring software, decoding the information from one of their C02 model RDS encoders configured for RDS TMC, providing the HERE Traffic service to Russia.

RDS Lab V1.07
Page Decoder Logs Help

RDS Lab
Version 1.07 Build 1051

DOPO*HOE **C0x** PI: 7ADC Country: Russia
ECC: E0 Coverage: Regional 7

Service Details
TP: 0
TA: 0
MS: 1 - Music
LA: -

Decoder Identification
DI: 1 - Stereo
Not Artificial
Not compressed
Static PTY

CT / PIN
Date: 7/11/2013
UTC: 8:14 AM
Offset: +0 (half hours)
PIN: -

Program Type
PTY: 0
No programme type
PTVN: -

RadioText
A REKLAMA 264-106-9
B

Base Statistics Group Data TA RT RT+ AF EON TMC

Group Sequence Pause

8A	0A	2A	0A	8A	0A	1A	0A	8A	0A	2A	0A
8A	0A	2A	0A	8A	0A	2A	0A	8A	0A	2A	0A
8A	0A	2A	0A	8A	0A	3A	0A	8A	0A	1A	0A
0A	0A	2A	0A	0A	0A	2A	0A	0A	0A	2A	0A
8A	0A	2A	0A	8A	0A	2A	0A	8A	0A	3A	0A
8A	0A	1A	0A	8A	0A	2A	0A	8A	0A	2A	0A
8A	0A	2A	0A	8A	0A	2A	0A	8A	0A	2A	0A
0A	0A	0A	0A	0A	0A	1A	0A	0A	0A	2A	0A

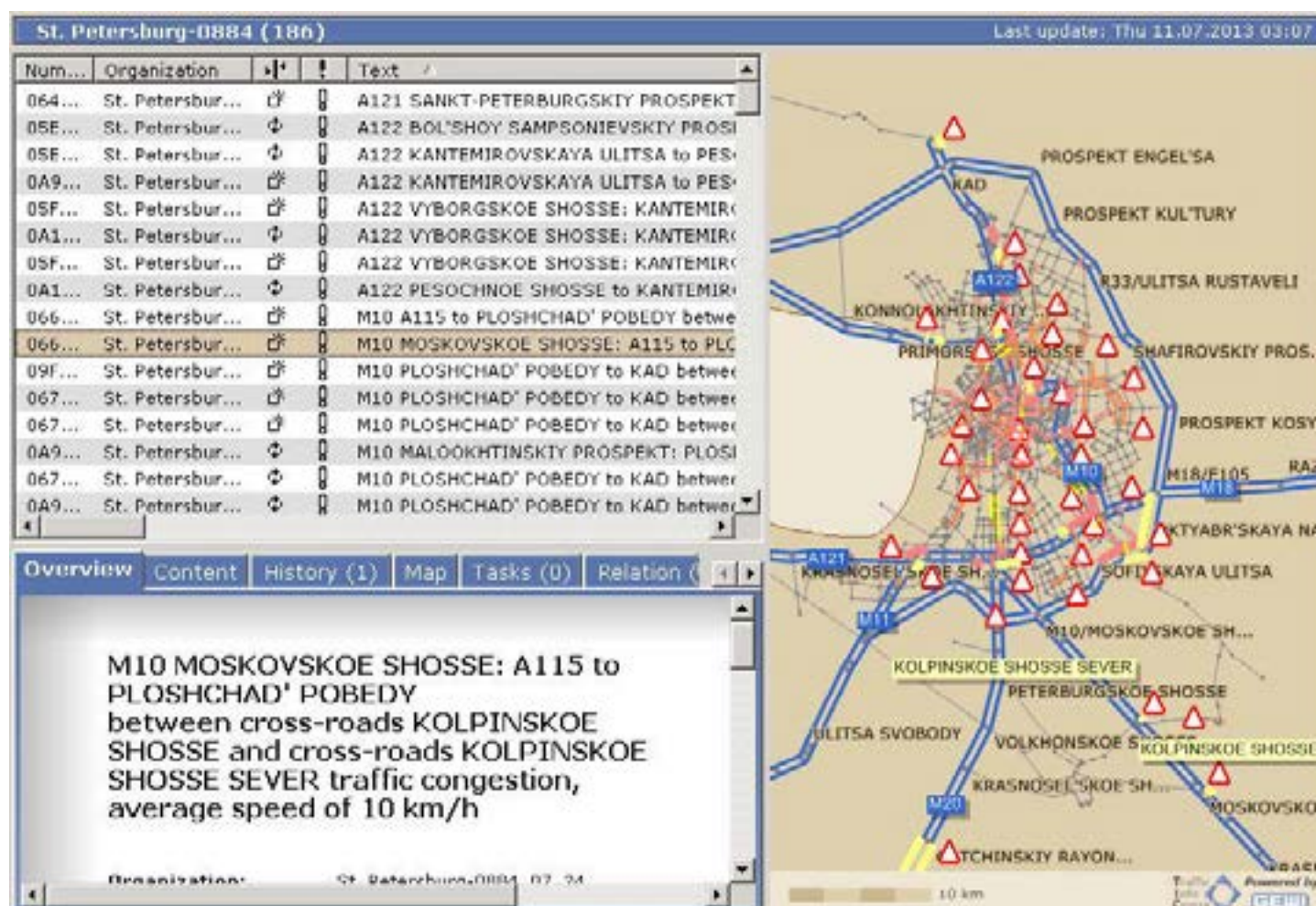
Block Error Rate
Max: 0%
Act.: 0%
Unc.: 0%

Bit Errors
1-2: 0%
3-5: 0%
6+: 0%

ODA

AID	Group	Message	Repetition rate	Application
CD46	0A	41C7	2 s	TMC (Traffic messages)

The second screen-shot below is using GEWI's TIC software to fully decode the TMC information and display by means of road colouring and icons the TMC information.



Updating information and Message Management

It is important that changing road conditions are communicated quickly to the driver and his navigation system, with messages updated or cancelled efficiently.

The principle in TMC is simply that a new message overwrites an old message in the receiver memory as soon as it is received. When a message arrives that matches in regard to Primary Location, Direction, and Message Class, a message already in memory, the new information simply replaces the old message. Similarly each class has its own 'cancellation message' which causes a message to be deleted from memory. The Message Class is important, as at times there will be two messages at the same location (for example an Accident (class 3) and the resulting congestion (class 1)) and it is necessary to update or cancel just one of these messages.

Summary

The above is a comprehensive but simplified description of how the Open Data Application has been used by the Traffic Message Application to provide detailed real-time traffic information to millions of in-car fitted and portable PND devices worldwide.

Although the TMC receiver is usually expected to receive updates and cancellation messages, there is no certainty that it will, as the receiver could momentarily drive out of coverage area, or be switched off – perhaps when the vehicle stops to re-fuel – meaning the message is not updated or cancelled. To prevent messages remaining indefinitely in memory, it is required that messages automatically expire in the receiver after a period of time. The best approach is that simply a message is deleted from a receiver fifteen minutes after it was received. Of course, if a cancellation message is received before the fifteen minute period, it is deleted immediately, but the fifteen minute serves as a useful 'back-stop' to ensure the receiver does not retain old information.

Although RDS is considered by some to be a relatively low-tech way of getting data into vehicles, given that some high-end models have two-way connectivity, it is expected that RDS-TMC will continue to be used well into the 2020s (and possibly beyond) as the most ubiquitous bearer for traffic information.

Broadcast technologies (RDS, DAB) have clear cost advantages over connected solutions, as the latter require end-users to buy all-inclusive data plans from their cell-phone providers, and in addition require the Service Provider to continually add more servers and processing power for each new customer. Although in terms of data rates possible, there is a clear advantage over RDS in the capacity on DAB, the design of DAB is such that it is engineered to provide nationwide (or at least supra-regional) coverage, so as such the DAB technology is fundamentally at odds with the need to provide any service with local content, including traffic and weather information. In other words, on a national DAB multiplex, the majority of information transmitted will be irrelevant for the end-user. RDS in comparison is broadcast using transmitters with a

smaller coverage footprint, each providing only information relevant to the transmitter coverage and reasonable driving range beyond. Sensibly implemented therefore, the combined capacity of a network of FM transmitters can easily exceed that of the capacity available to allocate for traffic information on DAB.

The low cost and low power consumption of RDS chipsets mean that RDS-TMC devices are inexpensive to produce, and as such have spread, and will continue to spread, to less-affluent consumers, especially in developing countries where there are no plans to replace FM broadcasting because of the high costs of alternatives.

TMC and RDS2

In order that the 'basic' (PS, AF, Radiotext etc.) features of RDS are transmitted with regularity, not more than 25% of the capacity on the main RDS subcarrier can be devoted to TMC; and as stated above this imposes a maximum of about 50 TMC messages per minute per transmitter. This may seem a substantial number, but as in recent years traffic information providers have details of traffic movement along all roads, not just Motorways and Highways, and there is more information available than there is capacity on the main sub-carrier to transmit.

RDS2, with its additional sub-carriers offers a terrific opportunity for TMC. A realistic scenario is that the whole of one of the additional sub-carriers could be used exclusively for TMC.

TISA is the organization that standardizes the coding and use of TMC, and in 2018, two options were suggested to them as to how an upper sub-carrier could be used.

1. TISA could advise that the upper sub-carriers could be used for TMC, using the same protocol as the main sub-carrier (i.e. retaining the 37-bit structure, ‘tunnelled’ into a Type ‘C’ group. This would be easy for both a Service Provider and Device Manufacturer to implement as the structure remains the same on both the main and additional sub-carriers. Using just a single upper sub-carrier in its entirety for TMC would give an immediate four-fold increase in TMC message throughput – 200 messages per minute per transmitter.
2. A further option could be to define a different protocol for use on the upper sub-carriers, taking advantage of the 56 bits available there (the main sub-carrier has only 37 bits available). The 50% extra coding space available on the upper sub-carriers could be used to simplify the TMC coding, eliminating for example most cases where a ‘multi-group-message’ needed to be transmitted, further increasing message throughput. The disadvantage is that the new coding utilizing 56 bits would have to be defined – relatively easy – but manufacturers would also have to apply different protocols for the main and upper subcarriers.

Either option could be used to enhance existing RDS-TMC services: there would be no change to the existing service and coding on the main sub-carrier, so that all existing receivers would continue to work unaffected. New devices capable of using the upper sub-carriers would additionally gain details of traffic flow and incidents on the urban and secondary roads, this information, which for reasons of capacity limitations on the main sub-carrier are filtered out, would be transmitted on one of the upper sub-carriers.

In 2018, TISA was re-submitting its TMC specifications (ISO 14819 series) for re-standardization by ISO and TISA were encouraged to consider both options to include in the re-submissions. There was unfortunately no decision taken by TISA. A number of manufacturers were quite opposed to any enhancement of TMC which they felt was unlikely to expand significantly and without a Service Provider committing to introduce a service using an upper sub-carrier, were unwilling to even consider options; so the use of TMC on the upper sub-carriers is not even mentioned in the updated TISA and ISO specifications. Whether RDS2 upper sub-carriers are used for TMC will consequently be driven by an agreement between a Service Provider and its customers, and the method chosen will become de-facto, rather than by TISA.

Regardless of no decision being taken by TISA, the use of RDS2 sub-carriers provides a tremendous low-cost option for the broadcasting of densely-coded real-time traffic information that easily competes and, in most cases, surpasses possibilities offered by other broadcast bearers and protocols.

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The Future of FM radio with RDS by Dietmar Kopitz

During the past 25 years, the usage of RDS in FM radio receivers has tremendously increased.

Nevertheless, specifically among European public broadcasters, there is an attitude now that FM and RDS are “not alive and kicking” any longer. I think that in spite of their age FM radio, which is now over 65 years old and RDS, which is almost 35, in combination, both remain very attractive and totally mature radio broadcast technologies that cannot be easily replaced by digital radio. This is in Europe already confirmed by the fact that DAB had compared with FM/RDS radio, within the 25 years since it is available, only a relatively modest market acceptance and this in spite of all the ongoing digital radio promotion.

When the RDS Forum came into being in 1993, it comprised mainly broadcasters and there were only a few major car radio manufacturers in the Forum. Nowadays it is the opposite; the Forum consists of mostly industry members and there are only a few broadcasters still active in further developing RDS. To get the best out of RDS, however both are needed. It is the well known “chicken and egg” relationship, which needs to be fully understood in the RDS context. We need more broadcasters to join the RDS Forum and I shall now explain the benefits.

In the RDS Forum we have many experts, who can contribute to raising the awareness of the broadcasters about what RDS still has to offer. We are not talking about the basic RDS features that are used everywhere these days, but about the dy-

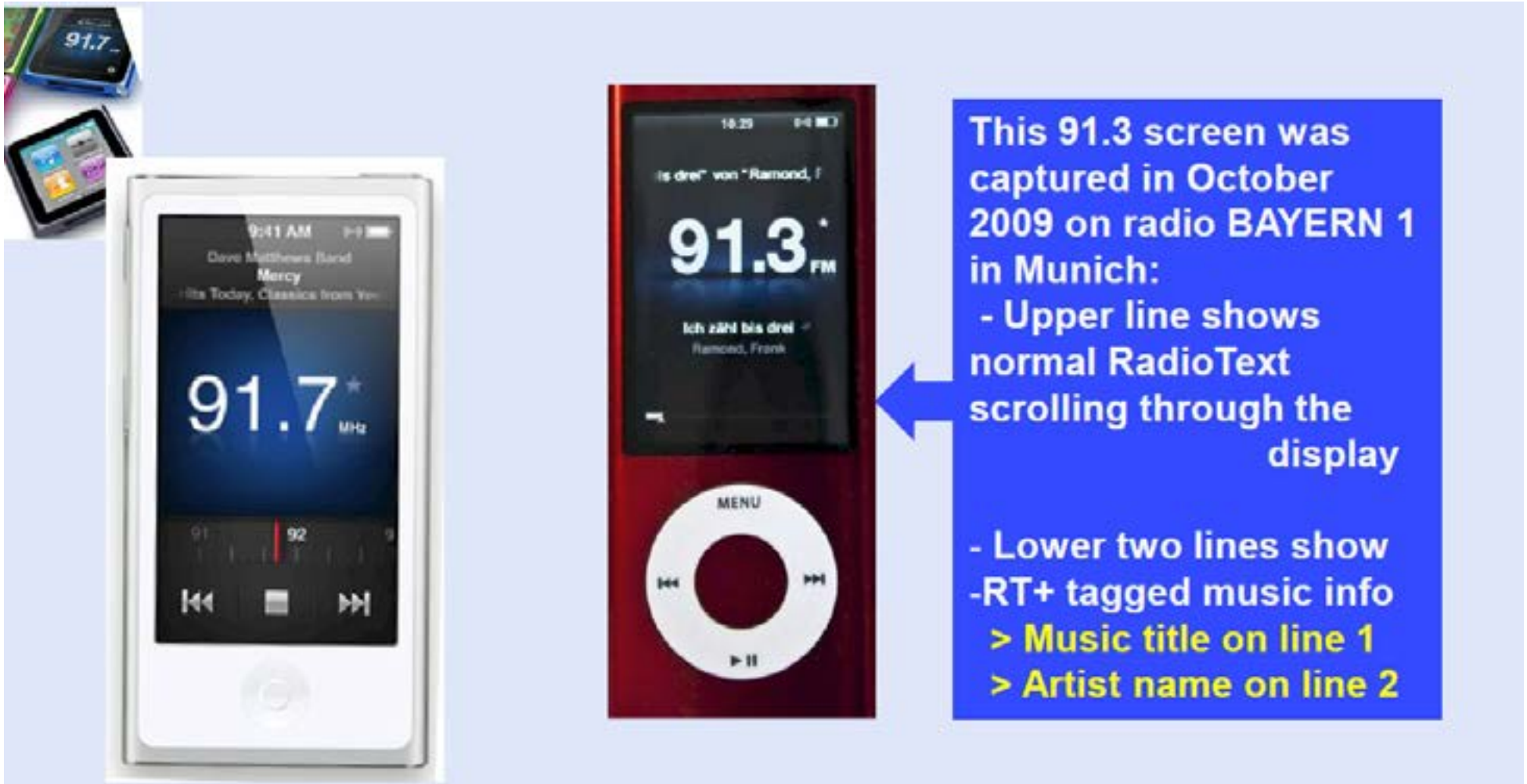
namic programme related RDS features, which are still much underused.

Manufacturers in the RDS Forum are very quick to add more features to RDS radios, if these are needed in the market, but we can only develop this together with an alliance of broadcasters and manufacturers. Remember, we, in the RDS Forum, have the eggs, but we need the chicken !!!

The RDS Forum holds the view that the RDS technology is firmly established nowadays. Within the industry and for FM radio broadcasters it still has many attractions to offer, particularly now in the mobile environment with smartphone and tablet devices and by particularly using the possibilities offered now by the new RDS2 options.

In the years 2005 to 2008 the RDS Forum had added to the RDS standard two new RDS - Open Data Application (ODA) features: RadioText Plus (RT+) and enhanced RadioText (eRT). The use of the ODA means in RDS that the new feature is backwards compatible with old receivers. Any new RDS-ODA feature will not disturb them, as it cannot be decoded. But new ODA features can then be used by newly designed receivers that intend to implement them.

There are not yet many receivers on the European market that support RT+, simply because broadcasters do not yet widely use RT+ and thus the market is not yet big enough. However, in the USA broadcasters increasingly use RadioText Plus to tag ‘music titles’ and ‘artist names’.



Apple had well implemented in its music player iPod nano (models 5G, 6G, 7G) which had also an FM/RDS receiver incorporated, the RDS-RT/RT+ feature for the display of broadcast “Music titles” and “Artist names.” These RT+ tags are much used by broadcasters in Germany and the USA. In 2017, the iPod nano line was discontinued. As the iPod nano was relatively inexpensive, it was a quite attractive RDS receiver product that one could use to monitor broadcasts using the RT+ feature. It is still possible to purchase those old iPod nano models on eBay, if needed.

Since September 2009 the Apple iPods nano (5G, 6G and 7G) had an RDS FM radio incorporated and it had the RT+ feature well implemented, so that it could display 'music title' and 'artist name'. However in 2017 this kind of MP3 player, no longer popular, was discontinued given the fact that music listening now uses increasingly Internet streaming services such as Spotify etc.

In Germany the public broadcasters have implemented RT+. Up to now 25 regional FM programmes use RadioText Plus.

In the USA over 450 stations implemented RadioText Plus nationwide since 2008, which creates an important market there.

Many small portable RDS devices also transmit on FM, within a short-range distance of a few metres, audio and RDS data to the car audio system, e.g. MP3 music – an application covered by the RDS standard. In 2008, the RDS Forum agreed such an implementation option, in order to avoid industry outside the Forum using RDS for this particular application in an uncontrolled manner.

When RDS Forum Members exchange their experience about RDS, one important issue which often comes up, is the correct usage of RDS. Sometimes corrective action in respect of the broadcasters can be taken with quick success. Often the manufacturers within the RDS Forum take the initiative to point out what is wrong with some of the signals on air. The listener will only blame the product maker and not the broadcaster, if something is wrongly working.

The RDS Forum carries out work to also raise the awareness of the broadcasters. This, that they are encouraged, to use RDS for FM broadcasting in the best possible manner and for the benefit of their listeners.

Broadcasters could also benefit from the observations made by the industry members of the RDS Forum who want their products to work correctly in response to the RDS features put on air by the broadcasters and also explore the dynamic features specified in the RDS standard.

Yet, the listener is the final target. The RDS Forum wants everything to work smoothly and correctly. The chicken and egg relationship is important. Broadcasters and manufacturers should communicate, about implementations – as RDS is very important and is fundamental for a well functioning FM radio.

In March 2019, RDS will turn 35 - not the RDS Forum, which started only in 1993 (so it just got 25), but the RDS specification, published by the EBU in March 1984.

RDS has been and still is a 'silent revolution' and not all broadcasters are fully aware of its success.

Nowadays, almost 35 years after that technology was created, nearly all FM radios in Europe use RDS. ICs have become available that have an FM receiver and an RDS decoder on the same chip and the price for such a chip, if bought in quantities, is now extremely low, say to give the magnitude, only one to a few USD. The trend of this price is still falling and the quantity of such chips sold on the world market is still much

increasing, nowadays over one billion units per year. Many applications of RDS are now already within mobile phones and portable network devices. The more traditional car radios may still have a separate RDS decoder IC, but nowadays RDS decoding is also very often an integral part of a dedicated multi-purpose DSP, necessary for the product even without RDS. In these products the RDS function price is then almost zero, as it is done in software only and RDS2 can be equally supported without significantly increasing the price of the IC. Like RDS also RDS2 was created as an open technology and for using it there is no licence fee to be paid.

In Europe at least, it was actually RDS that made FM broadcasting very successful and extremely widespread. Thus RDS technology will continue to live as long as FM broadcasting. Thanks to the RDS2 development the RDS Forum is convinced that FM has regained its firm position in the radio broadcast world.

Radio listening is still a very popular activity – everyone listens to the radio on average two to three hours per day. It is entertaining and a secondary activity so that the listener can do other things while being entertained, which is not at all the case for TV.

Thus, if we continue to use FM for another 10 years or more, the question really is: ***“Why then not offer FM radio at its best?”*** By this I mean to use all the features that RDS and RDS2 can offer. For example, as described earlier, RadioText Plus with music titles and artist names and also CD cover art.

When RDS was in its infancy, there were only few data links between broadcast studios and transmitters, but with the

onset of DAB, HD Radio, digital satellite radio and the Internet these data links exist now for most broadcasters' stations, and so it will be very easy to do many dynamic RDS programme features now.

There are some home receivers already on the market that have a large screen to display the Internet via a WiFi connection. Then such radios could be sent by RDS the URL of the broadcaster's web site. The radio will then display right away complementary content to the audio signal on air. This mode of operation, also called “Hybrid Radio”, is simple and will definitely enhance the radio programme content, specifically for a younger audience.

With an appropriate ODA this could be easily done for FM. Another well-known alternative is of course the RadioDNS hybrid radio project with visual radio, interactivity and an electronic programme guide that would even more enhance FM radio, even if not linked via RDS. For RadioDNS there is almost nothing to be developed in addition and therefore the RDS Forum is now much interested to investigate how to use their specified options in the best way.

The same technology options can also be used for digital radio. They already are all internationally agreed, but remain so far almost totally unused on FM radio, probably because broadcast managers often believe that digital radio could do it anyway, but if it did, it would do it exactly the same way as FM radio can do it now.

I share the view with most RDS Forum members that FM and digital radio will thus co-exist still for a long period of time.

The freely available data capacity with RDS, not using RDS2, is relatively low. In an FM broadcaster network, up to 40% of the RDS capacity is mandatory programme information like PI, PS, PTY and AF lists, all in the 0A type groups. When in addition RadioText RT and EON information are transmitted, only about 25% of the data capacity can be used for services carried by ODAs, such as TMC.

Often then choices have to be a trade-off and must be made between those applications that can be implemented in one RDS channel. For example, to choose between a rich RadioText (RT) service or a full TMC service, it is not always possible to have both simultaneously in the same FM radio programme.

However, with RDS2 this issue can now be solved completely.

ODA groups on the upper carriers will be using a specific byte-oriented ODA data transfer protocol (C-type group coding) which is great for the development of future applications.

A real milestone was taken within the RDS Forum 2018 with the development of the RDS2 file transfer protocol RFT. The file transfer protocol was designed to have nothing to do with the content of what is being transferred, just as with the well-known Internet FTP protocol. One can compare this with the action when you press a download button on some web page to download a file. A “mechanism” will retrieve the file and store it somewhere on your system. Your OS will not know what to do with this file until you call an application (ODA) like Word, ... to open the file. These future RDS2 ODA applications will thus know the structure of the downloaded file and deal with the content accordingly.

The RDS Forum now considers the following use cases for file transfers and it is foreseen to validate them for vehicle reception as soon as possible:

- station logo,
- programme logo,
- cover art for music items,
- weather information
- alarm messages, etc.

(continued on p. 84)



Smart phones like here the Samsung Galaxy and Tablets also be used as mobile radio receivers. The display, if well used by the broadcaster, can provide by means of an appropriate “App” a lot of complementary information to the programme on air. Specifically younger audiences will find this attractive. Radio France had started, nationwide, a hybrid radio trial called “Hybradio” on its FM radio programme “France Inter”.

This is for Internet radio:



Many broadcasters have started to offer free “Apps” for Smart phones and Tablets. These Apps deliver via the Internet interesting background information for the radio programme on air. This example from the BR (“Bayerischer Rundfunk”) is interesting because it provides a lot of detailed information such as the radio programme logo, the EPG, programme item details, RadioText and also the last newscast.

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When will RDS2 be ready for the market? This question is not yet easy to answer. The speed of that new development will clearly depend on the magnitude of interest that it can generate among all industrial partners involved. If they all would push that technology to deploy it quickly on the market, then 2-3 years appear to be realistic for to be ready on the transmission and on the receiver side.

In 2018 one RDS Forum member (Worldcast Systems in Bordeaux) launched an RDS2 encoder already for almost the same price as their normal RDS encoder, but now fully supporting also the three additional subcarriers for RDS2.

The RDS Forum is in the process now of adapting the UECF to include everything needed to transmit all the RDS2 possible options still under development.

A major objective since the RDS Forum started was to in 2010 to consider the enhancement of RDS with all the RDS2 options and to include them into the RDS standard. This aim was reached in October 2018 with the publication of the re-structured new RDS standard. Its new modular form will from now on much facilitate the future maintenance that has been simplified as any updating that will be required for the RDS standard will now have to deal only with the respective RDS standard part concerned.

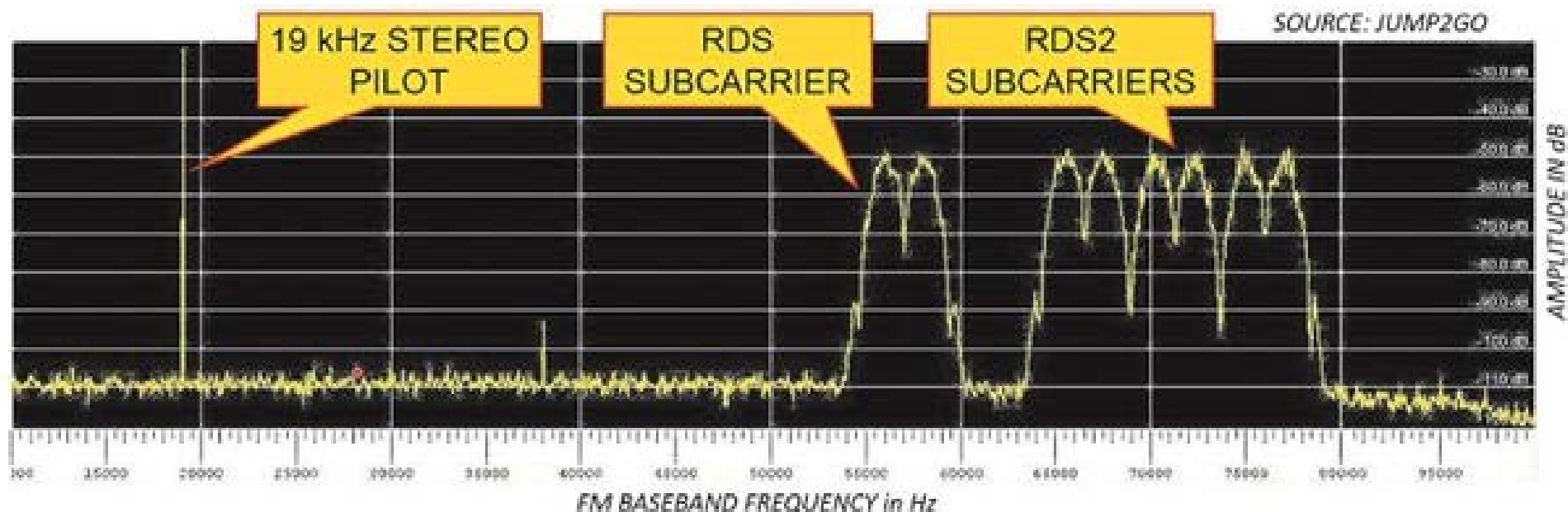
To make RDS2 quickly happen, it will be also necessary to promote widely the new possibilities offered by RDS2. The RDS Forum is prepared to give its full support to this task.

More information on the ongoing RDS2 development is available on the RDS Forum's web site. (continued on p. 87)

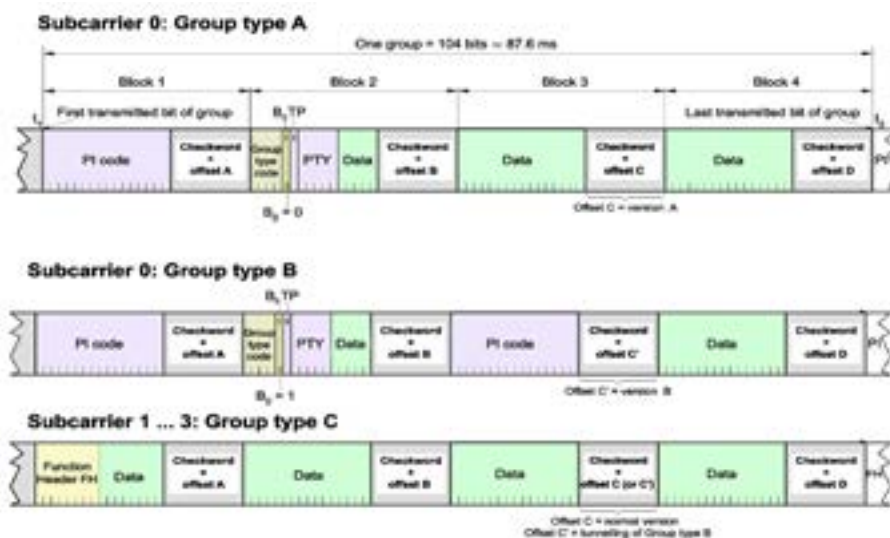


At the RDS Forum 2013 examples were considered about what kind of data could be used by broadcasters to serve receivers with a large display such as on smartphones or those now increasingly used in vehicles. Here we see how attractive programme logos could be and how one could present the weather information with RDS2.





RDS2 - The modulation and demodulation characteristics as defined in the RDS standard since 1984 are also valid for the three additional carriers. Both sidebands around 57 kHz with RDS are repeated up to a maximum of four in total. These are centred on additional carriers higher up in the FM multiplex. The technique to achieve this is simple: Just duplicate the RDS data stream a few times and use for the coding of the additional capacity the RDS-ODA feature with the new byte-oriented RDS group type C, as shown below. Each group type C can carry 7 bytes.



Comparison between previous RDS (previous standard versions) and current RDS/RDS2 (standard version 2018)

Feature	Previous RDS	New RDS/RDS2
Alternative Frequencies /AFs	87.5 to 108 MHz	Extended: 64 to 108 MHz
Programme Service name (long)	PS 8 characters max	LPS: up to 32 Byte, UTF-8 coded
File transfer	No	Yes - Any file format up to 163 KByte size ¹
Service Following	FM & Digital Radio	FM & Digital Radio & Internet Radio streaming ²
Enhanced Radio Text / eRT	Up to 64 characters / Latin based or UTF-8 coded	Up to 128 byte / UTF-8 coded / Multilingualistic
Enhanced Radio Text Plus / eRT+		RT and eRT can be used at the same time
Traffic Message Channel / TMC	Few messages (max. 50 messages/minute) Consequence mainly motorway oriented	Many more messages (using a second subcarrier about 250 messages/minute) More detailed TMC based on more road classes
Open Data Application / ODA	ODA - 21 and 37 bit structure Types A and B	Types A and B can be tunnelled in new 7 byte ODA structure with "C" groups
New RDS2/ODA - 7 byte structure (new group type C)		Open for many new applications
Number of subcarriers	one	up to 4
Number of parallel active Open Data Applications	up to 20 (8-Type A; 12- Type B)	up to additional 64 (Type C) (of which 16 can be used to transfer files using the RFT protocol ¹)
Implementation cost	low	Insignificant increase
IPR free	yes	yes
Backwards compatibility ³		yes
Open for future applications and Program features	Limits of available RDS data capacity reached	Open for added value programme features and many new applications by ODA

1 Under development using the RDS2/ODA concept. The RDS Forum 2018 developed a new file transfer protocol RFT to be added to the RDS standard (Part 2).

2 Under development using the RDS2/ODA concept.

3 This means that all existing features PI, PS short, Traffic Programme and Traffic announcement TP; TA; Clock Time and date CT, Program Type and Programme Type name PTY and PTYN, Radio Text (Up to 64 Latin based characters)and Radio Text plus (tagging of RT elements) RT; RT Plus Enhanced Other Network EON remain unchanged.

Obsolete and no longer part of the RDS standard are: MS (Group 0A) certain DI codes (mono/stereo, artificial head, compression), Language code, and PIN (Group 1A). Coding for the following applications is no longer detailed in the RDS standard as these can use in future the ODA concept: EWS, TDC, IH and RP.



For the next decade it will definitely be FM-RDS radio that will dominate the market.

Why?

The technology is well established, works perfectly and is much less expensive to maintain. Therefore, under these particular circumstances, RDS2 would have a good chance and the RDS Forum could well help to make it happen. From a technological point of view RDS2 appears to be a very attractive extension in the mature FM-RDS landscape.



The three illustrations on this page show well the future potential of RDS2 for using a station logo and a graphic label for the programme item on air as well as more detailed local traffic information with RDS-TMC distributed on the upper sub-carriers.

The unanswered question remains of course of whether broadcasters and data service providers will go for this option.

In the USA - will FM radio with RDS also continue there?

Yes - without any doubt as there are no digital radio switch-over plans at all yet. DAB will not be used in the USA and HD Radio is the preferred solution there for digital radio.

HD Radio uses a wide-band data stream that is part of the FM multiplex and thus it is complimentary to FM radio, then providing the possibility to offer additional radio programmes and data services. The technology is very mature and in 2018 is used by over 2400 FM stations in the USA with more than 45 million car receivers already sold and supported by the whole automotive industry with most cars being delivered with line-fitted HD radio capable receivers or at least available as a consumer option. Also, Mexico and Canada now follow this trend.

FM radio with RDS will of course continue there for long as well.

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RDS Forum - the association of RDS users

There are more RDS Forum Publications available:

The RDS Forum Implementation Guidelines provide assistance to broadcasters and receiver manufacturers to implement the RDS features correctly. The following RDS Implementation Guidelines are available now for free to non-members of the RDS Forum:

- ▶ About the Programme Service name - PS (static & dynamic)
- ▶ About the Programme Identification - PI & Extended Country Codes ECC
- ▶ About Programme Type coding PTY & PTYN
- ▶ About Radiotext – RT/RT+
- ▶ About EON & Linkage
- ▶ About the Alternative Frequencies (AFs)
- ▶ About the Clock Time & Date feature
- ▶ About the Open Data Applications ODA
- ▶ About RDS receiver concepts
- ▶ About RDS receiver profiles
- ▶ About an RDS & DAB feature comparison
- ▶ About Regionalisation
- ▶ About Traffic Programme & Announcement coding TP/TA
- ▶ About Service Following for FM/RDS & DAB
- ▶ About RDS in Smart phones and Tablets
- ▶ About broadcasting and reception in road tunnels

To order any of these publications, please consult the RDS Forum's web site

<http://www.rds.org.uk/>

Since 25 years, in addition to maintaining and updating the RDS technology, the RDS Forum is pre-occupied by the digital radio switch-over developments.

For Europe, the Forum also studies the conditions that will help new multi-standard car radios to work with minimal user intervention within a multistandard radio listening environment, where the transition to digital radio DAB/DAB+ has turned out to be extremely slow. In fact it lasts already over 20 years.

This eBook was written by a team of RDS Forum members who are closely involved in the RDS development since more than 25 years. Thus this book comprises an enormous amount of collective knowledge and information. It generally informs the reader about the possibilities seen now, within the RDS Forum, to use this well proven and much updated FM radio technology at its very best, well taking into account the transition to digital radio in Europe and the USA. This book gives an overview on the history of the RDS technology, describes generally the RDS system and all RDS features, explains the UECP and why it is needed, also explains how to monitor and generate RDS signals on air, RDS in the world of automotive applications, the fundamental principles of RDS-TMC, the possibility to extend RDS and makes a prediction of the future use of FM radio and RDS.

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