NRSC GUIDELINE

NATIONAL RADIO SYSTEMS COMMITTEE

NRSC-G300-C
Radio Data System (RDS) Usage Guideline
April 2018

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Co-sponsored by the Consumer Technology Association and the National Association of Broadcasters
http://www.nrscstandards.org

NOTICE

Published by
CONSUMER TECHNOLOGY ASSOCIATION
Technology & Standards Department
1919 S. Eads St.
Arlington, VA 22202

NATIONAL ASSOCIATION OF BROADCASTERS
Science and Technology Department
1771 N Street, NW
Washington, DC 20036

FOREWORD

The first Radio Data System (RDS) Standard was developed in Europe in 1984, followed by the NRSC version, the RBDS Standard (known now as NRSC-4), in 1992. Since then, numerous updates to these Standards have been published. RDS technology has proliferated and is now widely supported by both broadcasters and receiver manufacturers. The NRSC, in publishing the most recent version of NRSC-4, NRSC-4-B (see [1]), has achieved a greater level of harmonization with the European version of the Standard (IEC-620106) and adopted a new, simpler format for the document which highlights the remaining differences between these two Standards.

With the advent of digital radio systems, most notably the FCC's authorization of in-band/on-channel (IBOC) digital radio in the U.S. in 2002, broadcasters began upgrading their infrastructures to support data broadcasting at an accelerated rate. One consequence of this was a dramatic increase in the use of the RDS FM subcarrier. Recognizing this, the NRSC first published this Guideline in September 2012 with the goals of helping broadcasters and receiver manufacturers to make the best use of RDS technology and providing a more useful and consistent RDS experience for consumers. Publication of the –A version of this Guideline in 2014 continued this process by augmenting and refreshing the original content of the document and by expanding the material on use of RDS for emergency alerting. This latest version, the –B version, adds additional information to the Guideline regarding RDS encoder security.

The information contained in this NRSC Guideline is the work of the RDS Usage Working Group (RUWG), a subgroup of the Radio Broadcast Data System (RBDS) Subcommittee of the NRSC. The principal author of the first version of this document was Alan Jurison, Senior Operations Engineer – Engineering and Systems Integration with Clear Channel Media and Entertainment (now iHeartMedia, Inc.). Some of the material included was originally developed by Mr. Jurison and published in a series of trade journal articles and presentations at the NAB Broadcast Engineering Conference (BEC). At the time of first adoption of this Guideline, the RUWG was chaired by Steve Davis, Clear Channel Media and Entertainment, and for adoption of NRSC-G300-B, the RUWG was chaired by Mr. Jurison. For adoption of NRSC-G300 and the subsequent –A, -B and –C versions, the RBDS Subcommittee was chaired by Dan Mansergh, KQED Public Radio, and the NRSC chairman was Milford Smith, Greater Media, Inc.

The NRSC is jointly sponsored by the Consumer Technology Association and the National Association of Broadcasters. It serves as an industry-wide standards-setting body for technical aspects of terrestrial over-the-air radio broadcasting systems in the U.S.

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RDS USAGE GUIDELINE

1 SCOPE

This is an informative Guideline document which sets forth recommendations on the use of the Radio Data System (RDS) FM data subcarrier in the U.S. for broadcasters, broadcast equipment manufacturers, receiver manufacturers, and data service providers.

2 REFERENCES

2.1 Normative References

This is an informative specification. There are no normative references.

2.2 Informative References

The following references contain information that may be useful to those implementing this Guideline document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and users of this Guideline document are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

[1] *NRSC-4-B United States RBDS Standard – Specification of the Radio Broadcast Data System*, National Radio Systems Committee, April 2011, http://www.nrscstandards.org/sg/NRSC-4-B.pdf.[1]

[2] *IEC 62106/Ed.3, Specification of the Radio Data System (RDS) for VHF/FM sound broadcasting in the frequency range from 87.5 MHz to 108.0 MHz*, International Electrotechnical Commission (IEC), Edition 3.0, 2013.

[3] *NRSC-G200-A, Bandwidth Harmonization of RDS and IBOC Program Service Data (PSD) Guideline*, National Radio Systems Committee, September 2007, http://www.nrscstandards.org/sg/NRSC-G200-A.pdf.

[4] *Coding of RadioText Plus information (RT+)*, RDS TS – Annex P, RDS Forum TS 2008, R08_008_3

[5] *Radio Data System (RDS) – Receiver Products and Characteristics – Methods of Measurement,* IEC 62634/Ed.2, 2015.

[6] *NRSC-R300 Program Associated Data (PAD) Field Length Study*, National Radio Systems Committee, November, 2011, http://www.nrscstandards.org/Reports/NRSC-R300.pdf.

[7] *Information Technology - 8-bit single-byte coded graphic character sets - Part 1: Latin Alphabet 1*, ISO/IEC 8859-1:1998, International Organization for Standardization (ISO), https://www.iso.org/standard/28245.html.

[8] *Broadcaster Traffic Consortium web site*, www.radiobtc.com.

[9] *Total Traffic Network web site*, www.totaltraffic.com.

[10] *Alert FM web site*, www.alertfm.com.

[11] *IPAWS Radio Broadcast Data System (RBDS) Study*, Federal Emergency Management Agency, May 13, 2014, http://www.fema.gov/media-library/assets/documents/90051.

[12] *NRSC-5-D, IBOC Digital Radio Broadcasting Standard*, Reference Document 1028s rev. E (Program service data), National Radio Systems Committee, April 2017, http://www.nrscstandards.org/sg/nrsc-5-d-reference-docs/1028s.pdf.

[1] As of the adoption of NRSC-G300-C, the NRSC was working in conjunction with the RDS Forum and the IEC to unify these changes in an expected upcoming release of IEC 62106 as “Part 7” of that document; the NRSC anticipates withdrawing NRSC-4 in that event in preference to IEC 62106.

[13] *NRSC-G301, Creation and Distribution Practices for Audio Program Metadata Guideline*, National Radio Systems Committee, April 2013, http://www.nrscstandards.org/sg/NRSC-G301.pdf.

[14] *2010 Data Breach Investigations Report*, Verizon, July 2010, http://www.verizonenterprise.com/resources/reports/rp_2010-data-breach-report_en_xg.pdf.

[15] *RDS: The Radio Data System*, Dietmar Kopitz and Bev Marks, Artech House Publishers, 1999

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

[17] *NRSC-5-D, IBOC Digital Radio Broadcasting Standard*, Reference Document 1020s rev. J (Station Information Service), National Radio Systems Committee, April 2017, http://www.nrscstandards.org/NRSC-5-D.asp.

2.3 Symbols and abbreviations

In this Guideline the following abbreviations are used:

AID	Application Identification
BTC	Broadcaster Traffic Consortium
CAP	Common Alerting Protocol
CMAS	Commercial Mobile Alert System
CTA	Consumer Technology Association
EAN	Emergency Action Notification
EAS	Emergency Alert System
EOT	End of transmission
FCC	Federal Communications Commission (U.S.)
FEMA	Federal Emergency Management Agency (U.S.)
FM	Frequency Modulation
HMI	Human-Machine Interface
IBOC	In-Band/On-Channel
IP	Internet Protocol
IPAWS	Integrated Public Alert Warning System
LTN	Location Table Number
LTCC	Location Table Country Code
NAB	National Association of Broadcasters
NASBA	National Alliance of State Broadcasting Associations
NRSC	National Radio Systems Committee
NWS	National Weather Service
ODA	Open Data Application
PAD	Program Associated Data
PI	Program Identification
PICC	Program Identification Country Code
PRSS	Public Radio Satellite System®
PS	Program Service
PSD	Program Service Data
PTY	Program Type
PTYN	Program Type Name
RDS	Radio Data System
RDS2	Radio Data System 2
RBDS	Radio Broadcast Data System
RUWG	RDS Usage Working Group
RT	RadioText
RT+	RadioText+ ("plus"), an industry-standard ODA extension to RT
SCA	Subsidiary Communications Authority
SMS	Short Message Service
STL	Station-Transmitter Link
TCP	Transmission Control Protocol

TMC	Traffic Message Channel
UDP	User Datagram Protocol
UECP	Universal Encoder Communication Protocol
VHF	Very High Frequency
VPN	Virtual Private Network
WEA	Wireless Emergency Alerts

3 BACKGROUND

The purpose of this Guideline is to provide broadcasters, receiver manufacturers, data service providers and other users with information that will help them make the best use of RDS technology and provide a more useful and consistent RDS experience for consumers. The material which follows was discussed at length over many months in meetings of the NRSC's RBDS Usage Working Group (RUWG) and represents the consensus opinion of that group.

RBDS is the US version of a European standard, RDS. In this document, we generally use the term "RDS" unless specifically referring to the U.S. version or history.

While the use of RDS in the U.S. only became widespread with the rollout of digital radio services starting in the mid-2000's, RDS was developed by the public broadcasters collaborating within the European Broadcasting Union (EBU) from about 1975. The first specification was issued by the EBU in March 1984. RDS technology take-off in radio receivers was relatively slow, as the first RDS car radios were all high-end models that were fairly expensive. However within 10 years, there were already over 50 million RDS car radios sold, and by 2004 the total had reached 200 million (these units were mostly sold outside of the U.S.).

In February 1990, discussion started about standardizing RDS for the U.S. under the auspices of the NRSC. The RBDS Standard was adopted by the NRSC on January 8, 1993, consisting of the major components of the European RDS Standard but also with some important differences, including the following:[2]

- Program Type definitions – Due to differing broadcast styles, some of the program type (PTY) code definitions (i.e. Jazz, Rock, etc.) differ between RDS and RBDS;
- Program Identification coding – North American program identification (PI) codes differ in functionality in three ranges. This affects alternate frequency switching and regionalization;
- "Dynamic" Program Service name – The RBDS Standard allows "nondistracting" changes to the program service (PS) field, while the RDS Standard strictly forbids dynamic changes to the PS;
- ID Logic feature (IDL)/RDS updates to In Receiver Database (IRDS) – a licensed feature which allowed the receiver to identify the call sign and format of non-RDS FM and AM broadcast stations via a built-in database. This database may be updated via an Open Data Application (ODA);
- AMRDS – The original RBDS standard reserved a section for a possible AM equivalent to FM RDS.
- Emergency Alert System (EAS) ODA – An ODA was developed ("Annex Q") to carry emergency information compatible with the U.S. Federal Communication Commissions (FCC) EAS protocol. This public ODA also offered increased consumer receiver functionality with emergency messaging.

Outside of the U.S. the major RDS-focused group is the RDS Forum (www.rds.org.uk), created in 1993, which is a non-profit international professional industry association that has the objective to promote and maintain RDS technology. The RDS Forum serves its members and also acts as an efficient contact network for experience exchange regarding the use and correct implementation of the RDS technology in

[2] Note that many of these differences, including ID Logic, AM RDS, and the "Annex Q" EAS ODA were removed from the NRSC version of the Standard starting with the NRSC-4-B version, so as to achieve greater harmonization with the European version of the Standard and in recognition of the fact that these features were not in use or were never developed.

the many different countries involved. The RDS Forum has been the leader in Europe in advancing the technology and has been successful in gaining CENELEC and IEC adoption of the RDS specification.

Since the adoption of the original RBDS Standard, the NRSC has adopted modifications in 1998, 2004 (the official designation was changed to NRSC-4 with this version), 2005 (NRSC-4-A), and 2011 (NRSC-4-B, the current version; see [1]). NRSC-4-B differs from the earlier versions in that it is written in a "difference" format, only including those portions of the Standard which differ from the European version. As of the adoption of NRSC-G300-C, the NRSC was working in conjunction with the RDS Forum and the IEC to unify these changes in an expected upcoming release of IEC 62106 as “Part 7” of that document; the NRSC anticipates withdrawing NRSC-4 in that event in preference to IEC 62106-7.

4 RDS INSTALLATION

4.1 Hardware installation

RDS is a component of FM broadcasting that uses an encoder to create a signal which is combined with other components of the FM baseband including the mono (L+R) and stereo multiplex (L-R) program audio-derived signals. The RDS signal, also called the RDS subcarrier, is a 1,187.5 bits per second (bps) data stream (with approximately 670 bps of usable data) encoded into a 4 kHz-wide suppressed-carrier AM subcarrier centered at 57 kHz.

The hardware that creates the RDS signal is called an RDS encoder. It is installed in the FM program chain either between the audio processing/stereo generator and the (analog) baseband input of an FM exciter (Figure 1), or, the encoder is connected to a separate input on the FM exciter designed for an RDS encoder or for subcarriers (Figure 2). Both these installation methods provide for the feeding of a sample of the 19 kHz pilot to the encoder. The 57 kHz RDS subcarrier frequency is the third harmonic of the 19 kHz pilot and therefore performs in similar fashion as the stereo L-R signal. Receivers should detect the 19 kHz pilot then use multiples of that frequency to demodulate the L-R as well as the RDS subcarrier.

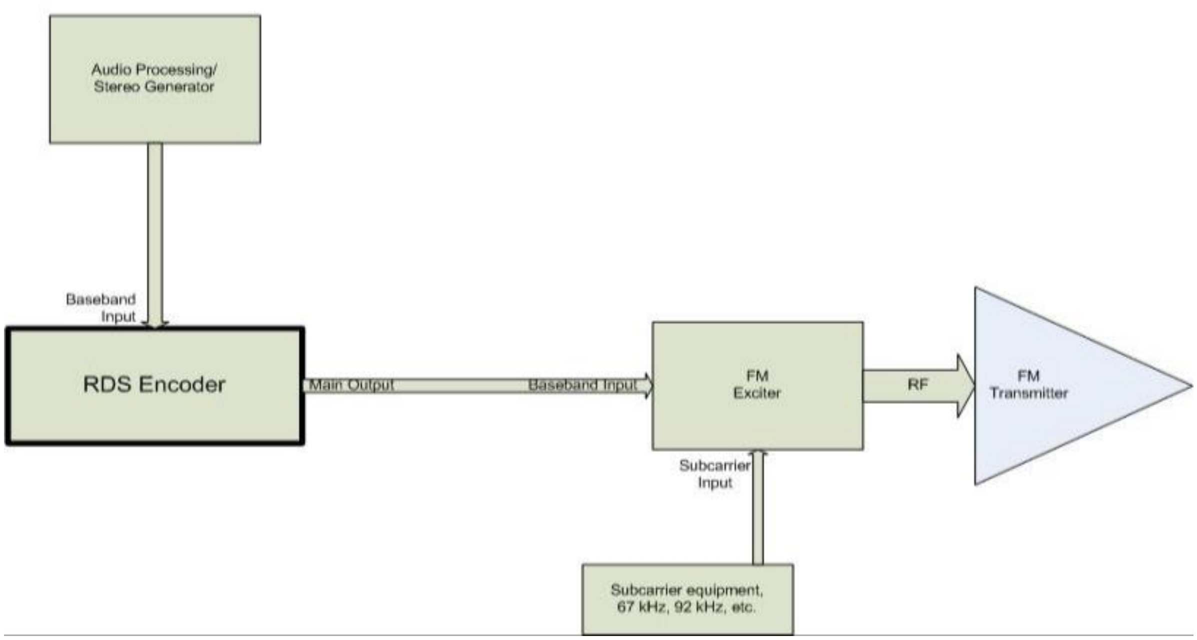


Figure 1. RDS encoder installation – loop-through method

When using the discrete input or “sidechain” method shown in Figure 2, it is important to confirm that the RDS encoder is configured NOT to feed the baseband input signal to its output. It is possible to install an RDS encoder as shown in Figure 2 without connecting the FM baseband to the RDS encoder. Improvements in frequency stability and quality of both transmitting and receiving equipment can allow the RDS encoder to “free run” or use an internal 19 kHz reference but this is not an optimal installation practice.

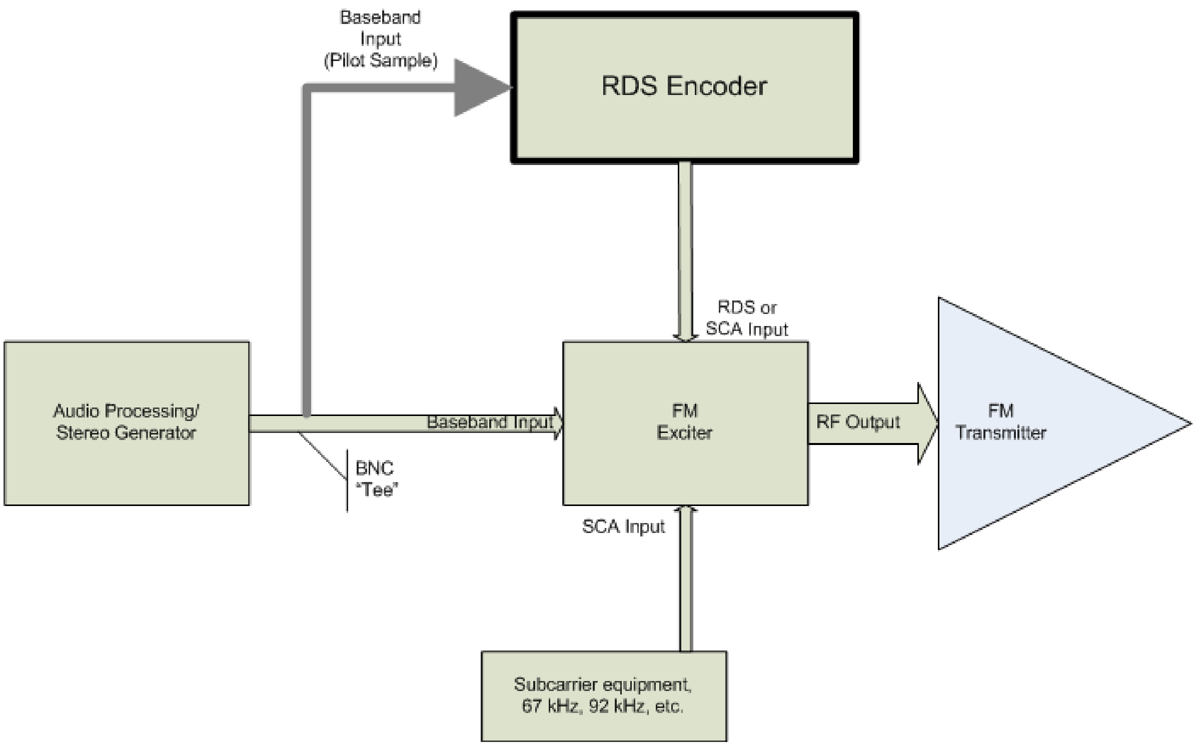


Figure 2. RDS encoder installation – discrete input with sample or “sidechain” method

RDS encoders are typically installed at the transmitter site; however, the physical location of the equipment will largely be based on the type of studio-to-transmitter link (STL) that is in use and the data connectivity available between the sites.

4.2 RDS injection and pilot synchronization

The RDS signal exists as a low power (with respect to the main channel audio), 57 kHz amplitude-modulated data subcarrier on an analog or hybrid IBOC FM signal. When installing an RDS encoder, there are configuration options to control the overall output level. The NRSC-4 Standard does not include a recommended subcarrier injection level.

This Guideline recommends a nominal RDS injection level of 6% (4.5 kHz) of the 75 kHz total modulation of an analog FM signal (or the analog portion of a hybrid IBOC FM signal). Values below this have been found to be acceptable for mobile receivers; however, smaller, portable receivers tend to work with an injection level closer to 6% or even higher, generally not to exceed 7% for most conditions.

Setting RDS injection levels is best done with a calibrated modulation monitor that supports RDS injection level measurement. It is important to be precise about setting of modulation and injection levels, so broadcasters should make sure the proper test equipment is used. It is worth the effort to be precise. When establishing an injection level operating point, broadcasters should listen to the demodulated main-channel audio signal, and any analog subcarrier audio signals, to ensure the RDS signal is not causing audible interference.

It is recommended to follow the instructions for the specific RDS encoder used to synchronize and align the RDS signal with the 19 kHz pilot. There are stations where RDS encoders are not synchronized or have become unsynchronized, and this has been known to cause issues with RDS reception. It is recommended that broadcasters observe the RDS encoder's status regarding the pilot sync over time. If the 19 kHz pilot sample into the encoder is marginal, there have been situations where an encoder was going in and out of sync as a result. When an encoder is going in and out of sync, it can cause RDS reception errors, thus creating a bad end-user experience by delaying the decoding of the RT and skipping of PS frames.

Another added benefit of going through the RDS encoder manufacturer's synchronization process besides better RDS performance at the receiver is that a properly synced RDS encoder will utilize a subcarrier signal that is in quadrature with the 19 kHz pilot; this will slightly reduce the modulation peaks of the subcarrier without reducing their actual levels, providing for more room for the main channel modulation (see Figure 3).

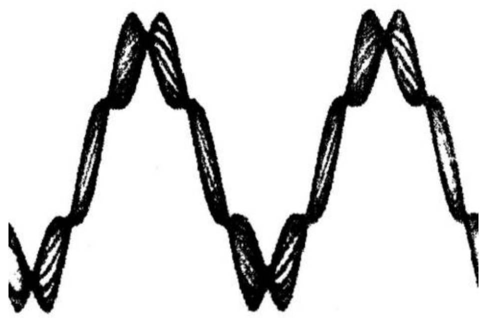


Figure 3. Oscilloscope view of a synchronized RDS subcarrier in quadrature with the pilot (Source: Inovonics 730 user manual)

4.3 RDS Injection for stations with 67 kHz analog subcarriers

Stations that utilize 67 kHz analog subcarrier need to be aware that higher injection levels may result in increased crosstalk from RDS into the 67 kHz subcarrier audio. A study was done in 2002 by Modulation Sciences (under a contract with Minnesota Radio Talking Book) to test a wide variety of 67 and 92 kHz analog subcarrier receivers and how their performance was impacted by RDS and multipath interference. The RDS tests were done using two levels of RDS injection, 11.1% and 16%. It was found that the 11.1% injection level operation increased crosstalk into virtually all of the 67 kHz analog subcarrier receivers tested, from 7 to 20 dB.

Stations that are also broadcasting HD Radio digital subcarriers also need to be aware that operating at increased analog subcarrier injection levels may have a negative impact on the performance of the digital subcarriers. This is especially true for HD Radio service modes MP2, MP3, MP5, MP6, and MP11, where some or all of the extended subcarriers are active. And as with all broadcast operations, carrier injection must comply with applicable regulations.

4.4 Initial programming

RDS encoders typically have on-board memory which allows configuration settings, encoder programming and certain other data to be saved on-board. In locations where data connectivity is difficult or impossible, stations should use this on-board memory to take advantage of RDS features and even create a scrolling display of messages.

Certain RDS data, like PI, PTY, TP, AF and M/S are programmed into the encoder during installation, even if the station is using a live data feed. In older encoders this data may need to be factory-encoded using firmware although most encoders now allow changes to be made in the field using a computer and a serial or IP connection to the device.

Many RDS encoders allow RadioText (RT) messages to be loaded into memory, allowing FM stations to send data for display on RDS receivers, even if the station is not able to send live now-playing or program associated data. Many encoders even allow such messages to be scheduled so that, for example a different message could be scrolled during each program or could be used to identify the scheduled on-air talent.

4.5 Data Feeds

Most RDS encoders provide a means to send live data to the RDS encoder. This is achieved using either a serial data connection or an Internet protocol (IP) connection. Since the bandwidth of the entire RDS bit stream is only 1,187.5 bits per second, integrating the data into a station STL or transmitter site data connection will not require significant overhead. Typically stations feed live data using a data source like the radio automation playback system. Many radio automation providers can export live data based on the on-air programming and export this data to RDS encoders either as a function of the base automation system or as an extra option. Automation equipment manufacturers and RDS equipment suppliers should be able to provide guidance on appropriate means to interconnect the equipment.

The basic connection is illustrated in Figure 4, which illustrates a data feed from a station automation directly to the RDS encoder. Most automation systems can provide this using either an RS-232 Serial connection or using TCP/IP. The RDS encoder will be programmed with static parameters such as PI and repetition rate. Live data will typically appear as RT and/or a scrolling PS display.

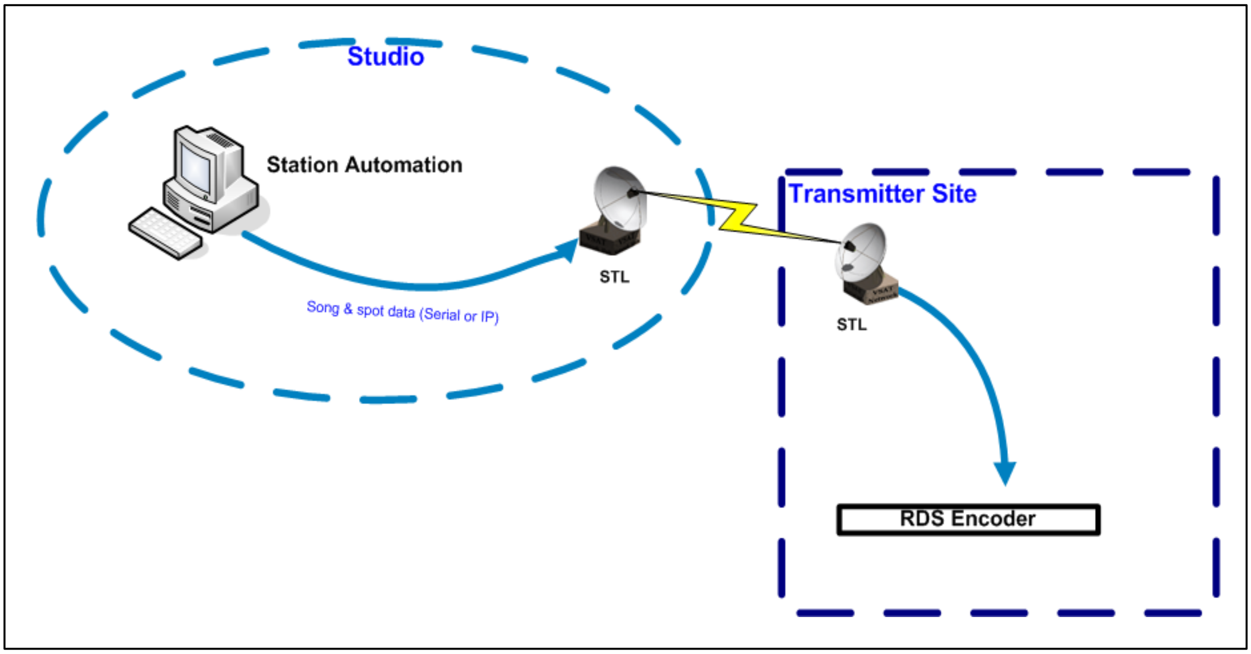


Figure 4. Direct automation – RDS feed

The native mode of communication of most RDS encoders is known as the Universal Encoder Communication Protocol (UECP). This is still the most effective means to access RDS features like RT+, song tagging, Traffic Message Channel (TMC) data, paging, etc. Most popular RDS encoders also offer access to RT and other more common live data features to be sent using ASCII (ISO 8859-1) format character data. Stations that wish to exploit more RDS features may find it advantageous to employ a device to aggregate data and convert it to UECP. This could be done using a computer on-site (Figure 5) or by establishing a connection to an outside service provider (Figure 6).

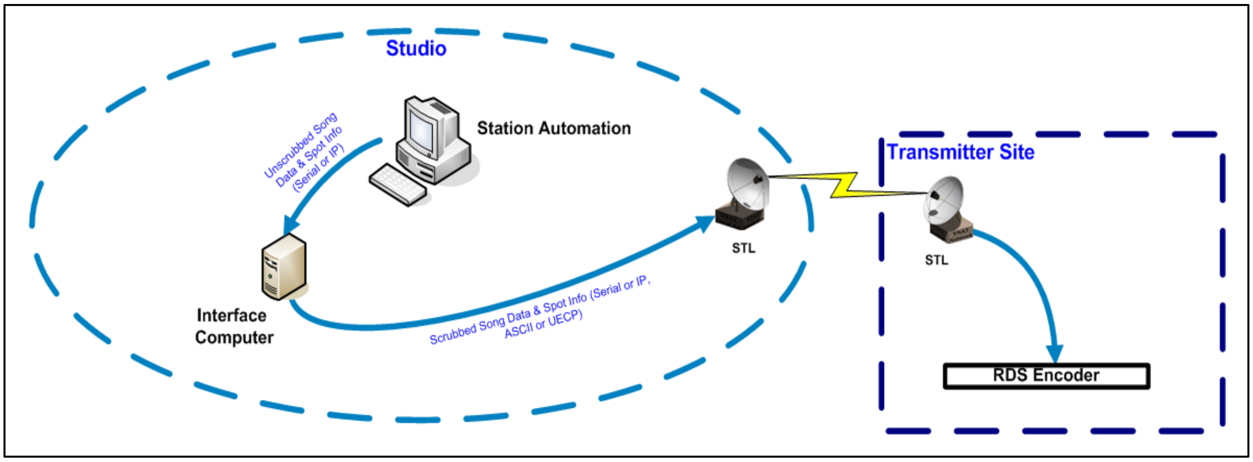


Figure 5. Local data management

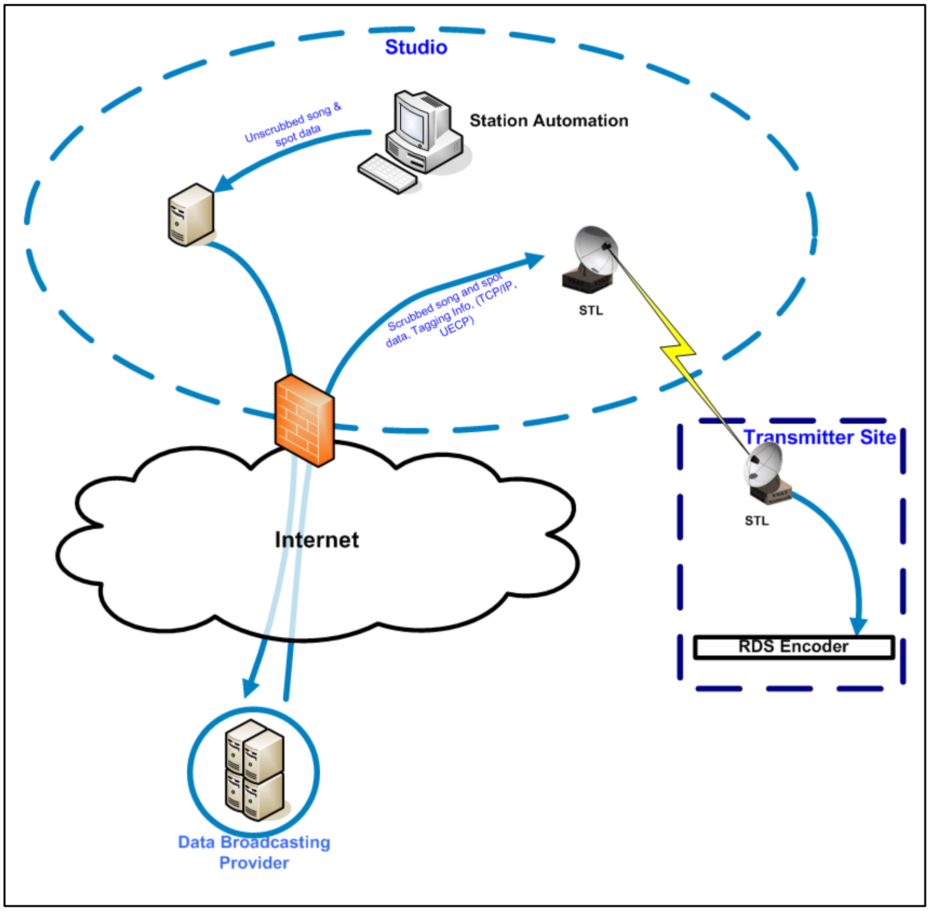


Figure 6. Service provider data management

The data management computer can provide a means to "scrub" or "sanitize" the feed from the automation system and optimize the data for RDS displays. The local computer or offsite data provider can be used to manage message scheduling, dayparting, and message repetition rates; and to provide access to RDS features like RT+. Outside data broadcasting providers can also provide a means to incorporate special features such as Apple iTunes song tagging, and news or traffic data.

When stations use a live data feed, special arrangements will be required to accommodate long form programming, live programming, and network feeds. During these periods most station automation systems will not be sending new data to the encoder so an RDS display will show the last live event, (*e.g.*, the last song played before a pre-recorded talk show or network program). During these circumstances the integrated message scheduling features of some RDS encoders can be used or an intermediate device, a service provider, or even a network data feed could be used to provide the relevant messages.

It should be noted that the NRSC has developed a guideline, NRSC-G301, which provides a data standard/framework which supports live or network programming feeds to communicate to the automation system the relevant program content [13]. For example, a syndicated music show from a network provider could publish the programs content (song title/artist) that the automation playback system could then export to the RDS encoder as if it were playing the music locally.

There are a number of data service providers that may offer hardware and services to manage RDS data. Each supplier will have individual requirements and capabilities that will have an impact on the data paths as displayed above. A reference list of providers appears in ANNEX 2: RDS Providers List.

4.6 RDS Encoder Security

Stations should immediately review their RDS encoder security at existing installations, and all new RDS encoder installations have security planned in the design phase. The industry has seen small scale security attacks or compromises of RDS encoders which have typically involved the station transmitting false or profane information in the PS or RT fields. There have been several published reports in the media about these occurrences. Private reports indicate there have been unpublished attacks as well.

The documented compromises were of RDS encoders directly attached to the Internet without any protection devices such as a firewall or router. However, the discussion below analyzes many other avenues for compromise.

RDS encoders are designed to be easy to configure and access. How to address these devices is widely known. Instruction manuals for most RDS encoders are available online to assist engineers installing these devices. This same information is available to people who may be looking to compromise an RDS signal.

When considering the security of an RDS encoder, various physical and logical security techniques should be employed. Moreover, a multi-layered approach should be considered. Multiple layers can reduce the probabilities of a successful attack. Some items discussed below may work for your organization; some may be prohibitive from an operational or cost standpoint.

4.6.1 Security Risks

It is important to recognize the “hard” and “soft” ways adversaries breach security. In this context, the hard methods involve using physical and logical methods of intruding into a system (discussed with respect to RDS in following sections). The soft methods relate to the people involved (wittingly and unwittingly) in an attack. In a 2010 Data Breach Investigations Report conducted by Verizon in cooperation with the U.S. Secret Service, a generalized assessment of the relative risk of various breaching methods was reported.[14] This section is based on Verizon and U.S. Secret Service investigations of about 900 business-related data breaches (involving the stealing or compromising of business data records – and RDS data is essentially business data in this context). These statistics relate primarily to Verizon business customers and may not exactly correlate with RDS related risks, but they are still instructive.

As can be seen in Table 1, the “inside job” involving company personnel or company partners, vendors and the like is implicated in more than half the cases. Thus, while securing the network from external intrusion is a top priority, it is also important to implement internal controls to protect the system from those closest to it.

Table 1. Threat Agents by Percent of Breaches in 2009 (derived from 2010 report fig. 7)

External Only	Internal Only*	Internal and External
45%	28%	27%

*Includes 27 % personnel and 1% business associates

Table 2 illustrates that the most prevalent ways into a system involve the misuse of privileges granted to a user of the system, often in concert with other tactics. Most internal breaches involved deliberate actions on the part of an internal agent (90%), while the remainder was facilitated accidentally by inappropriate or unintentional behavior of an internal party.

Table 2. How Do Breaches Occur? (from 2010 report executive summary)*

Percent of Breaches	Type of Breach
48%	Involved privileged misuse
40%	Resulted from hacking
38%	Utilized malware
28%	Employed social tactics
15%	Comprised physical attacks

*Total greater than 100% due to breaches made via multiple methods.

This Guideline document does not go into detail on best practices in managing the “soft” (human) element of data security. Stations should develop systems policies that defend not only the RDS network, but the entire organization from internal network security threats. This Guideline document focuses on the “hard” aspects of network design and topology that can contribute to a more secure RDS operation.

4.6.2 Physical Security

Ensure the RDS encoder has restricted physical access – i.e., is in a locked equipment room or rack to prevent unauthorized persons to gain physical access to the encoder. At shared transmission sites, consider placing the RDS encoder in an enclosed rack with a lock, for instance. When the RDS encoder is physically available to an unauthorized person, they may be able to attach a computer to the device and program inappropriate messages or change other configuration items without your knowledge. Some RDS encoders do not require passwords to change their configuration.

The most prevalent unsecured interfaces are the RS-232 based interfaces where somebody with a laptop or similar device could physically connect to the RDS encoder. Depending on the RDS encoder design, anyone with physical access to the RS-232 interface may be able to gain access to the encoder to reprogram it as desired. Thus, restricting physical access to the equipment (including cabling) is an essential component to securing your RDS transmission.

4.6.3 Logical Security

Most known RDS encoder compromises are not physical attacks, they are logical security attacks. The RDS encoders as shown above in Figure 4, Figure 5 and Figure 6 are directly connected to the studio network through an STL. As mentioned above, the methods used are typically via RS-232 or via TCP/IP.

4.6.3.1 Encoder Security for RS-232 interfaces

Attaching the RDS encoders directly to the automation system via RS-232 is arguably one of the most secure methods of communicating with the RDS encoder, as the automation system workstation would have to be compromised and overtaken in order to update the encoder. Of course, if the source of RDS data is a personal computer running an encoder control program, the security of that personal computer becomes an issue as well.

Also secure would be RS-232 extensions from the automation system to the RDS encoder, such as those shown in in Figure 4 and Figure 5 using STLs with RS-232 based extension features. Generally speaking, these devices are difficult to compromise in the first place, let alone to then intercept the RS-232 bit stream and inject commands to the encoder. While not impossible, this would be a highly sophisticated and selective attack typically impacting a single station.

However, RS-232 connected RDS encoders are not desirable in many situations as they are not flexible to meet many new broadcast needs. For instance, the RDS encoder may need to be addressed by several different computers on a LAN or WAN. Such applications include primary and backup audio server workstations, and primary and backup STL or other data links. In larger networks some systems may be focused on encoder metadata (updating title, artist in the PS or RT) while other systems may be communicating with the encoder for some advanced ODA features (such as RDS TMC). Moreover, many new STL products on the marketplace have implemented TCP/IP based connectivity options and RS-232 based solutions are declining.

4.6.3.2 Encoder Security for TCP/IP LAN/WAN connections

TCP/IP connected RDS encoders offer enormous flexibility. This approach also requires the greatest attention to logical security.

The RDS encoders shown in Figure 4 and Figure 5 are directly connected to the studio network through an STL. As depicted in these figures, the STL typically acts as an Ethernet LAN bridge extending the segment of the studio network to the transmitter site. RDS security will be compromised if any computer on the studio network is compromised.

For example, if a studio network computer acquires malware enabling remote access to an outside party, the intruder would be able to search the network for and compromise RDS encoders, including across the STL Ethernet LAN bridge. Or more simply, if any device on this network is remotely accessed by an outside person – whether or not the system was configured for remote use – the security is compromised.
Using such methods, the hacker could address the RDS encoder manually through a web browser or telnet command line. To mitigate these risks, employ strict security techniques on your studio LAN.

- Consider eliminating Internet access to these networks if possible.
- Ensure computer systems are kept up-to-date with vendor patches.
- Run anti-virus software with frequent definition updates.
- Limit access to computers or workstations on this network.
- Eliminate or reduce remote access to this network.

Unauthorized remote-control access of the RDS encoder in Figure 4 or Figure 5 would be a selective attack typically impacting a single station. However, the potential for malware/viruses could be a more widespread untargeted attack simply looking for any RDS encoder it may find. The more isolated the RDS encoder is; the less likely it is to be attacked.

Another avenue for interception would be to compromise the STL acting as a TCP/IP LAN bridge, but as discussed above, these devices are highly proprietary and difficult to compromise. This would be a highly sophisticated and selective attack typically impacting a single station or stations sharing this data link. Stations concerned about this type of attack could employ VPN or Ethernet/TCP/IP encryption techniques to harden the link and prevent unauthorized access. Or perhaps seek a LAN bridge STL solution that offers encryption, if available.

4.6.3.3 Encoder Security for TCP/IP Internet-based connections

The RDS encoder connected as depicted in Figure 6 requires some special attention. As such, the RDS encoder is being addressed by a data broadcasting provider via the Internet. Note that this connection from the provider to the RDS encoder traverses a firewall. While this connection in Figure 6 is drawn for simplicity, there are several different methods that can be used to make this connection. In some cases, providers use additional devices or software instances which encrypt these transmissions for added security. However, it is possible to have unencrypted updates to the encoders and use simple port forwarding in the firewall to route access from an external source (the data broadcasting provider) to the

RDS encoder. In configurations like this, it is highly recommended that source IP restrictions be employed to limit what public addresses can access your RDS encoder. Without these types of restrictions, any host on the Internet may be able to address the RDS encoder.

Many stations have been seeking low cost ways of implementing dynamic RDS solutions. In some cases, stations looking to do this on a budget may not be able to purchase a new STL that offers TCP/IP connectivity. There are other situations that could prevent configuration of RDS encoders like that shown above. Many studio locations already have a connection to the Internet. In some cases, an inexpensive Internet connection to the transmitter site is added. Many of the known compromised RDS encoders were configured as depicted in Figure 7.

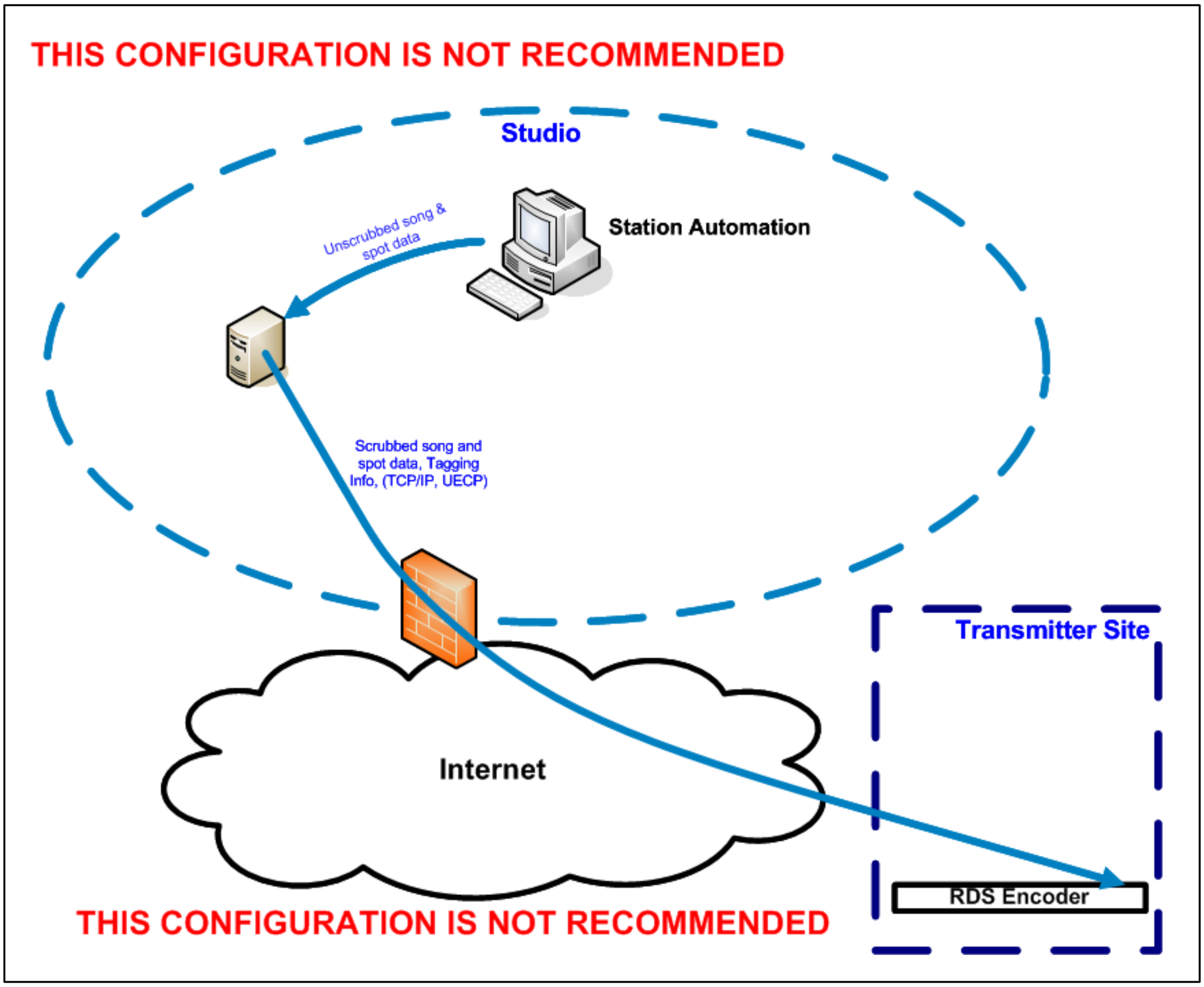


Figure 7. Not Recommended: RDS Encoder directly attached to the Internet

In these situations, it is recommended that the transmitter site be supplied with a VPN based router, and a VPN be established from the studio to the transmitter site, offering a secure means of communicating with the RDS encoder along with other equipment that may be located at the site, as depicted in Figure 8. The creation of the VPN privatizes the RDS encoder.

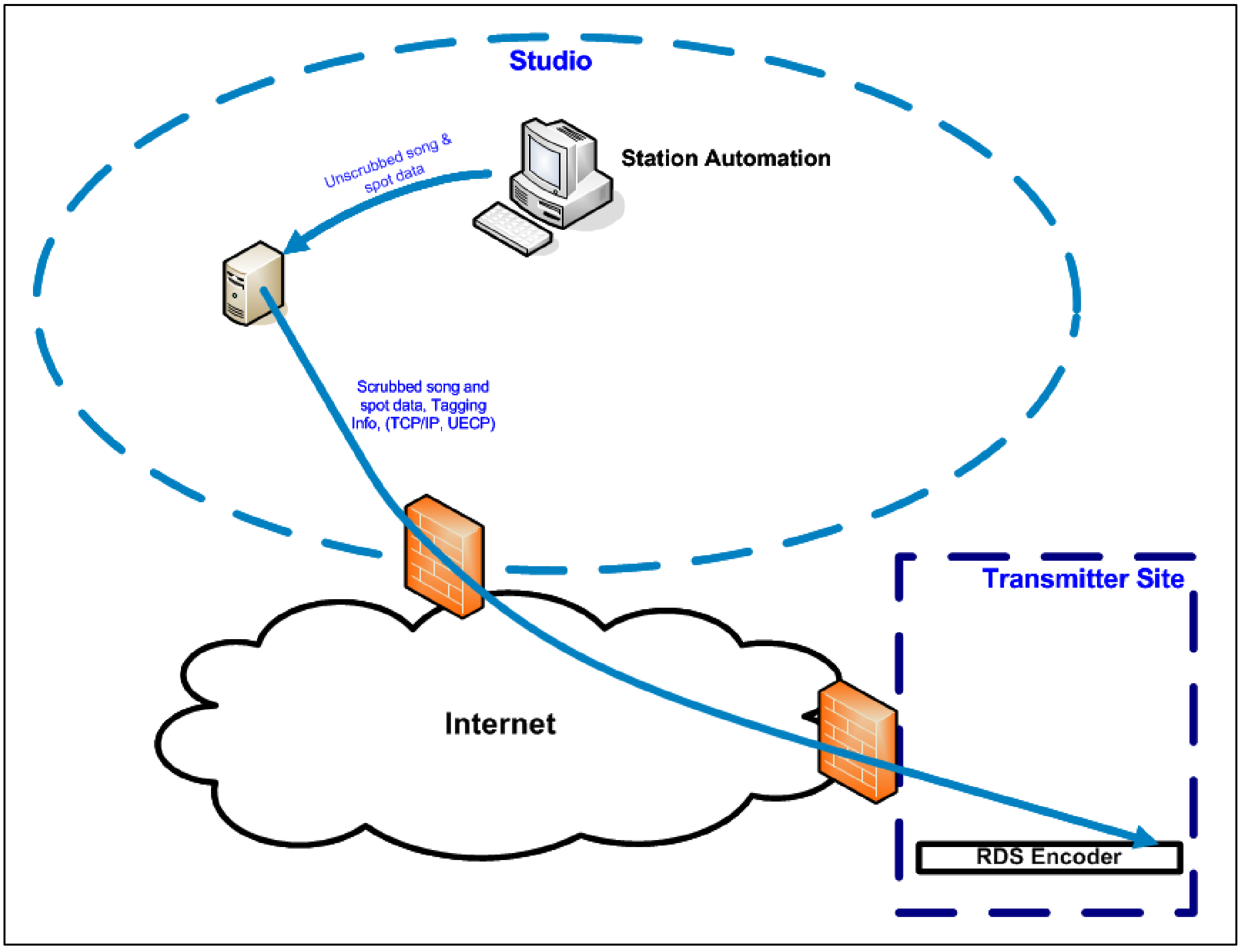


Figure 8. Recommended: RDS Encoder protected by Firewall or VPN Router

However, in situations where cost is a major concern, it is strongly recommended a low cost firewall be installed at the transmitter site. When searching for this type of firewall, you are looking for a firewall that supports port forwarding with IP source restrictions. Not all inexpensive firewall/routers support this feature, so it is best to do some research and perhaps some experimentation. Using a similar configuration topology as Figure 8, the firewall would be configured to only permit and pass through traffic from known sources to known ports. So, for instance consider this sample firewall configuration in Table 3.

Table 3. Example TCP/IP Firewall Configuration for RDS Encoders on the Internet

Location or Port (Protocol) Rules	Example IP addresses
Studio / Automation Network RDS Encoder	Public IP 100.1.1.1 Private IP 192.168.0.1
Permit TCP 23 (Telnet)	Source IP 100.1.1.1 to 192.168.0.1
Permit TCP 80 (HTTP)	Source IP 100.1.1.1 to 192.168.0.1
Permit UDP 5400 (UECP UDP example port)	Source IP 100.1.1.1 to 192.168.0.1
Permit TCP 5401 (UECP TCP example port)	Source IP 100.1.1.1 to 192.168.0.1
Deny All Others	

This would permit the configuration and updating of the RDS encoder remotely from the public IP of 100.1.1.1 but deny all others hosts from publicly accessing the device on the Internet. Your IP source and destination addresses will vary from this example, as will your UECP port number(s) and type (UDP vs TCP). However, Table 3 is offered as a general guideline as to how to configure network access to an RDS encoder.

This particular concept offers good protection, however there are techniques that could be employed by an attacker such as IP address spoofing. The use of such techniques could be considered a targeted selective attack, which presents a higher degree of difficulty to the adversary and reduces the likelihood that an adversary with such skills would employ them merely to seize control of or deny service to an RDS encoder.

4.6.3.4 Common Encoder Security for all connections

It is recommended that the RS-232 TCP/IP interfaces of the RDS encoders be secured with strong passwords whenever possible. This feature varies on design by the RDS encoder manufacturer. TCP/IP based security is more common. Also, different interfaces are used, e.g. telnet vs http (web browser). These should be evaluated and secured with different usernames and passwords. Where applicable, always change from the default username and password entries to a unique username and password combination. This will limit who or what can access the encoder using these interfaces. For added security, remove the standard username altogether, i.e. remove “root” or “user” or “admin” or “administrator” from being an account altogether if possible.

However, username/password security should not be considered a very effective method of securing the device. While it certainly offers an added layer of protection, most communications to RDS encoders are unencrypted, i.e. via telnet and http. These protocols may send the username and password data in clear text format which can easily be captured.

When configuring an RDS encoder, sometimes various ports are customizable. It may be advantageous to not use default ports whenever possible. If the RDS Encoder itself does not offer the ability to change port configurations, the use of a low-cost firewall/NAT device could enable port forwarding for different port numbers to add another layer of protection. However, without IP source restrictions, an attack that uses port scanning could still locate the alternative port you have relocated to.

Some encoders, like the Audemat (Worldcast) FMB80, have numerous network services activated by default that may never be used by the station and could provide another pathway for unauthorized access to the encoder. Services like the FTP server, the SMTP agent for mail and SNMP agent for network management should be disabled if they are not being used. The FMB80 also has a "NETCOM" system that can be used to connect extra TCP and UDP ports to internal software processes that can be disabled. Even though a firewall will block outside access to these services, they could still be a threat if an attacker has gained access to another system on the same network. For the Audemat FMB80, the following commands are recommended:

FTP_SERVER	=	OFF
SMTP.ENABLED	=	OFF
SNMP.AGENT	=	OFF
SNMP.TRAPS	=	OFF
COM0.PORT	=	OFF
COM0.NETCOM	=	OFF
COM1.PORT	=	OFF
COM1.NETCOM	=	OFF
COM2.PORT	=	OFF
COM2.NETCOM	=	OFF
COM3.PORT	=	OFF
COM3.NETCOM	=	OFF
COM4.PORT	=	OFF
COM4.NETCOM	=	OFF

These are manufacturer-specific suggested commands. Note that these are not sufficient to completely secure the encoder; other steps outlined in the sections above will also be required, such as correct firewall installation and setup.

If you can use the RS-232 or telnet interface to the RDS encoder rather than the web page interface, and the manufacturer allows you to disable the web page interface, you can add an additional layer of security. For the FMB80, the command would be, “WEB_SERVER=OFF”.

5 SELECT FEATURES OF RDS

While the RDS Standard provides for a host of features, there are some features that are more widely used than others. Discussed in this section are details about and considerations regarding usage of some of the most frequently used RDS features. Most of those features are included in Table 4 (taken from the NRSC-4-B standard).

Table 4. Main feature repetition rates[3]

Main Features	Group types which contain this information	Appropriate repetition rate per sec.
Program Identification (PI) code	all	11.4[a]
Program Type (PTY) code	all	11.4[a]
Traffic Program (TP) identification code	all	11.4[a]
Program Service (PS) name	0A, 0B	1
Alternative frequency (AF) code pairs	0A	4
Traffic announcement (TA) code	0A, 0B, 14B, 15B	4
Decoder identification (DI) code	0A, 0B, 15B	1
Music/speech (M/S) code	0A, 0B, 15B	4
RadioText (RT) message	2A, 2B	0.2 [b]
Enhanced other networks information (EON)	14A	up to 2 [c]

[a] Valid codes for this item will normally be transmitted with at least this repetition rate whenever the transmitter carries a normal broadcast program.
[b] A total of 16 type 2A groups are required to transmit a 64 character RadioText message and therefore to transmit this message in 5 seconds, 3.2 type 2A groups will be required per second.
[c] The maximum cycle time for the transmission of all data relating to all cross-referenced program services shall be less than 2 minutes.

5.1 Program Identification (PI)

The original purpose of the PI code was to identify the station in a unique way. NRSC-4-B stipulates the method for calculating the appropriate PI code, to generate a hexadecimal number that would be entered into the encoder. There are a few software utilities available that will convert the station call letters to the 4-digit hex PI code. Most RDS encoder manufacturers should be able to provide information on this calculation.

Those interested in implementing PI code translation on the receiver side need to be aware that there are a number of PI code encoding methods used by broadcasters in the United States:

1) "Call letter conversion" encoding method, as described in NRSC-4-B Section D.7.1.
2) An optional method for use with traffic information systems, as described in NRSC-4-B Section D.7.4.
3) PI codes for FM translators are assigned by the National Association of Broadcasters using an algorithm developed by the NRSC to optimize use of available codes and be usable by the RadioDNS service which requires every carrier frequency/PI code combination to be unique (see Section 5.1.1 of this document).

Consequently, there are many stations that do not send call letters through PI codes. In other words, the receiver cannot rely on PI codes to provide call letters for U.S. broadcast stations. For this reason, it is

[3] NRSC-4-B [1], Table 4.

recommended that receiver manufacturers decode the RadioText Plus (RT+) StationName.Short field in place of back-calculating the call sign using PI codes.

Besides situations where the method described in NRSC-4-B Section D7.4 is used, there may be other cases where stations are not able to use a PI code derived from call letters. In such cases, an appropriate PI code must be assigned. Original PI code creation may need to follow to station or company agreements or may need to follow additional technical requirements.

For example, if an FM station uses translators and boosters and that station employs the Alternate Frequency (AF) capabilities of RDS, then RDS encoders at the booster and translator sites would send the same PI code as the main station transmitter and not the PI codes corresponding to the particular booster's and/or translator's call signs. A receiver with the ability to use the AF feature would then be able to recognize that the booster or translator was the appropriate alternate signal because of the matching PI codes. This is an RDS capability that is used more commonly in Europe but has not been used widely in the U.S to date.

5.1.1 Selecting Program Identification (PI) codes for boosters, translators, and simulcasts

Increasingly, FM translators are used for cross-service stations (AM, FM hybrid IBOC multicast channels, etc.). In such cases, PI code selection or creation may not be obvious under the original NRSC-4-B standard.

For stations which follow the following conditions:

1) Translator or booster carrying primary stations' FM analog/IBOC main channel;
2) Translator carrying FM hybrid IBOC multicast of primary station which is simulcast of an AM with unique call letters for market;
3) Main FM station or translator programming of an in-market AM with unique call letters.

The NRSC recommends using the PI code calculated from the call sign of the primary AM or FM station originating programming, as defined in Section D.7.1 of NRSC-4-B.

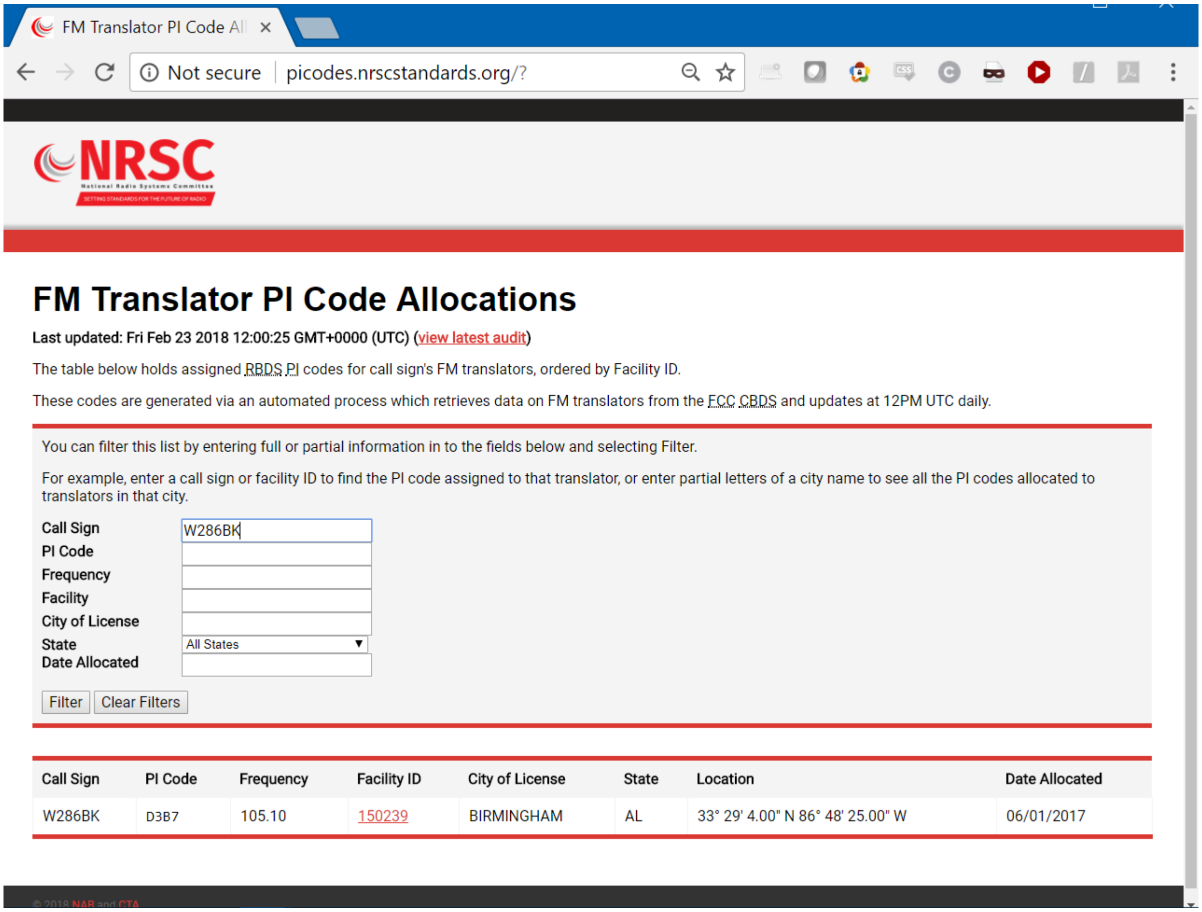
For stations that exhibit any of the following conditions:

4) Translator carrying FM hybrid IBOC multicast channel of a primary station that is a simulcast of an in-market AM with non-unique call letters (i.e., the primary is WXXX-FM but is a simulcast of AM station WXXX);
5) Main FM station or translator carrying programming of an in-market AM with non-unique call letters (the AM is WXXX, but there is already an WXXX-FM that is not the main FM station or translator under consideration);
6) Translator carrying the FM hybrid IBOC multicast channel of a primary station which is a unique program non-associated with any existing station.

The NRSC developed an algorithm to assign PI codes for these FM translators. These assignments are optimized use of available codes and be usable by the RadioDNS service which requires every carrier frequency/PI code combination to be unique. These assignments are hosted by the National Association of Broadcasters (NAB).

To locate the assigned PI code for a translator, visit the web site at http://picodes.nrscstandards.org.

Locate the assignment by entering the callsign associated with the translator in the filter data entry area of the webpage. Following the example below, type in the callsign of W286BK and then click "Filter".



The web site will then filter the PI code assigned to this specific translator. In addition to this, for confirmation and reference, be sure to select the correct translator. Verify the frequency, FCC Facility ID, City and State of License and coordinates (NAD 27 format) are correct. Clicking on the Facility ID will link you to the FCC database entry. It is highly recommended that you use these additional visual cues to confirm you have obtained the correct PI code for the station.

The filter offers other search features as well to help find translators.

Once you have obtained the PI code for your translator, you should enter it in the configuration of your RDS encoder.

One item to note, the Date Allocated column shows when the algorithm was last run for this station. For many translators they will have a date of 06/01/2017, the first day the assignment website was made public.

FM translators change transmission sites/locations and change frequencies, if your translator is involved in one of these changes, you should revisit the assignment tool to determine if the PI code has changed. The "Date Allocated" field will have a date shortly after the FCC database has reflected the new changes.

If the code does change, the allocation date will change. This means the algorithm detected the change would conflict with another broadcaster in one of two domains. If a conflict is detected geographically – i.e., the translator facility move is too close to another on the same frequency – a new code is assigned.

This is to avoid the conflict of a duplicate PI code causing inadvertent AF switching. If a conflict is detected via frequency, i.e. the frequency change of the translator would conflict with another station using the PI on the same frequency anywhere in the United States, the algorithm assigns a new code. This is done to maintain compatibility with RadioDNS, a system that permits hybrid metadata and audio streaming capabilities to hybrid FM + Streaming radios.

The database is updated daily and is dependent on the FCC database also being updated. The webpage itself indicates when the last update of the database and algorithm was completed. An audit log is also provided for users to see recent PI assignment changes. It can be accessed at http://picodes.nrscstandards.org/audit.html.

The process above was designed to be simple for most station level engineers to determine their translator PI code. For larger group owners, contact the NRSC via email at nrsc@nab.org to request information on obtaining this list as an Excel spreadsheet. For equipment and software providers an API is available on the NRSC PI code web page allowing for automation of retrieval and setting of PI codes in transmission equipment.

5.1.2 Recommended actions for encoder manufacturers

The NRSC is encouraged by the increasing adoption of RDS encoding by U.S. broadcasters. However, the NRSC is aware of dozens of incidents involving misconfigured RDS encoders having a negative impact on listeners.

At issue is the use of default PI codes in the configurations of RDS encoders. Many encoder manufacturers have a default value for the PI code. The documentation is generally clear that this should be set before adding the encoder to a radio station's air chain for transmission. However, the NRSC is aware of multiple instances across the country where this was not done. At issue is when two stations in the same geographic area have made this mistake, two stations are identifying as the same PI code. Some receivers use this as a method to determine alternate frequency (AF) switching (see section X) even though no AF list is transmitted. This has caused many incidents where a listener is intending to listen to Station A, but the receiver automatically switches to Station B, which has different programming. To the listener, this is not something they can control, and they complain either to the radio or vehicle manufacturer or the radio station.

Upon careful deliberation the NRSC issues the following guidance to all RDS encoder manufacturers world-wide:

- Update documentation references to make it clear that a unique PI code must be provided. Provide resource links to this document, the NRSC-4-B callsign calculation method (or provide a calculator), and also a link to the new NRSC PI Code Assignment for FM translator website at http://picodes.nrscstandards.org.
- In addition to discussing these items thoroughly in your product manuals, include a one sheet "quick start guide" and include this issue in that instruction set.
- Create a mechanism in the encoder whereas if the PI code is the factory default, an error is very visible in the user interfaces of your product. This could be an LED status indicator, LCD front panel, telnet/serial interfaces, or web browser user interfaces.
- When the encoder is in this mode where the factory default PI code is in configuration, defeat the 57 kHz RDS subcarrier output from the unit.

Employing this updated guidance in your current and future products will ultimately reduce your support burdens and educate broadcast engineers about this very important issue.

5.2 Program Type (PTY)

The PTY code should be used as a format description for the station. Receivers that fully support PTY use the code to categorize stations and provide ways for listeners to search for radio programming. It's not unusual for stations to choose a PTY code that doesn't strictly adhere to their format definition. The PTY code will often more closely match a marketing position or public image, as opposed to a strict, industry definition of the station's format.

The Nielsen Audio (formerly Arbitron) format list was used as the basis for developing the PTY codes defined in NRSC-4-B. Nielsen Audio uses terms of art that may or may not reflect listener's understanding or listening. For example, the format "Urban" is not necessarily an accurate description. Likewise, Spanish-formatted stations will likely not want their stations to appear on public radios under the label "Language" or "Foreign Language." With the release of the NRSC-4-B standard, the PTY codes for "Hip Hop", "Spanish Talk", and "Spanish Music" were adopted and receivers are now beginning to appear on the market that recognize these new PTY codes. Stations using these codes may appear as "Undefined" on older radio displays.

Table 5 is a list of Nielsen Audio formats (from a Spring 2013 listing) with a suggested PTY assignment. Note that some formats are shown with multiple possible PTY codes. It's best to consider this list as a starting place for discussion with station programming and marketing departments to decide on a station's appropriate PTY classification. It should also be noted that the program types listed are compatible within the corresponding definitions in the HD Radio™ digital radio system, and considerations should be made to synchronize the PTY settings in the appropriate configuration sections of an HD Radio Importer and Exporter.[4]

[4] See Section 8.1, Appendix A of [12] for a list of genres supported by the NRSC-5-C Standard.

Table 5. List of Nielsen Audio formats with suggested PTY codes defined in NRSC-4-B

Nielsen Audio Format	PTY Code Binary	PTY Code Decimal	Program Type	8 Character	16 Character	Definition
80s Hits	00111	7	Adult Hits	Adlt_Hit	Adult_Hits	An up-tempo contemporary hits format with no hard rock and no rap
Active Rock	00101	5	Rock	Rock	Rock	Album cuts
Adult Contemporary (AC)	01000	8	Soft Rock	Soft_Rck	Soft_Rock	Album cuts with a generally soft tempo
Adult Hits	00111	7	Adult Hits	Adlt_Hit	Adult_Hits	An up-tempo contemporary hits format with no hard rock and no rap
Adult Standards/MOR	01101	13	Nostalgia	Nostalga	Nostalgia	Big-band music
Album Adult Alternative (AAA)	00101	5	Rock	Rock	Rock	Album cuts
Album Oriented Rock (AOR)	00110	6	Classic Rock	Cls_Rock	Classic_Rock	Rock oriented oldies, often mixed with hit oldies, from a decade or more ago
All News	00001	1	News	News	News	News reports, either local or network in origin
All Sports	00011	3	Sports	Sports	Sports	Sports reporting, commentary, and/or live event coverage, either local or network in origin
Alternative	00101	5	Rock	Rock	Rock	Album cuts
Blues	01101	13	Nostalgia	Nostalgia	Nostalgia	Big-band music
Children's Radio	10101	21	Personality	Persnlty	Personality	A radio show where the on-air personality is the main attraction
Christian AC	10011	19	Religious Music	Rel_Musc	Religious_Music	Music programming with religious lyrics
Classic Country	01010	10	Country	Country	Country	Country music, including contemporary and traditional styles
Classic Hits	00110	6	Classic Rock	Cls_Rock	Classic_Rock	Rock oriented oldies, often mixed with hit oldies, from a decade or more ago

Table 5 (continued). List of Nielsen Audio formats with suggested PTY codes defined in NRSC-4-B

Nielsen Audio Format	PTY Code Binary	PTY Code Decimal	Program Type	8 Character	16 Character	Definition
Classic Rock	00110	6	Classic Rock	Cls_Rock	Classic_Rock	Rock oriented oldies, often mixed with hit oldies, from a decade or more ago
Classical	01111	15	Classical	Classicl	Classical	Mostly instrumentals, usually orchestral or
Comedy	00100	4	Talk	Talk	Talk	A radio show where comedy is the main attraction
Contemporary Christian	10011	19	Religious Music	Rel_Musc	Religious_Music	Music programming with religious lyrics
Contemporary Inspirational	10011	19	Religious Music	Rel_Musc	Religious_Music	Music programming with religious lyrics
Country	01010	10	Country	Country	Country	Country music, including contemporary and traditional styles
Easy Listening	01100	12	Soft	Soft	Soft	A cross between adult hits and classical, primarily non-current soft-rock originals
Educational	10110	22	Public	Public	Public	Programming that is supported by listeners and/or corporate sponsors instead of advertising
Family Hits	01100	12	Soft	Soft	Soft	A cross between adult hits and classical, primarily non-current soft-rock originals
Gospel	10011	19	Religious Music	Rel_Musc	Religious_Music	Music programming with religious lyrics
Hot AC	01001	9	Top 40	Top_40	Top_40	Hits, often encompassing a variety of rock
Jazz	01110	14	Jazz	Jazz	Jazz	Mostly instrumental, includes both traditional jazz and more modern "smooth jazz"
Latino Urban	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Mainstream Rock	00101	5	Rock	Rock	Rock	Album cuts

Table 5 (continued). List of Nielsen Audio formats with suggested PTY codes defined in NRSC-4-B

Nielsen Audio Format	PTY Code Binary	PTY Code Decimal	Program Type	8 Character	16 Character	Definition
Mexican Regional	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Modern AC	00111	7	Adult Hits	Adlt_Hit	Adult_Hits	An up-tempo contemporary hits format with no hard rock and no rap
New AC (NAC)/Smooth Jazz	10001	17	Soft Rhythm and Blues	Soft_R&B	Soft_ R_&_B	Rhythm and blues with a generally soft tempo
New Country	01010	10	Country	Country	Country	Country music, including contemporary and traditional styles
News/Talk/Information	00010	2	Information	Inform	Information	Programming that is intended to impart ad
	00100	4	Talk	Talk	Talk	Call-in and/or interview talk shows either local or national in origin
Nostalgia	01101	13	Nostalgia	Nostalgia	Nostalgia	Big-band music
Oldies	01011	11	Oldies	Oldies	Oldies	Popular music, usually rock, with 80% or greater non-current music
Other	00000	0	No program type or Undefined	None	None	
Pop Contemporary Hit Radio	01001	9	Top 40	Top_40	Top_40	Hits, often encompassing a variety of rock
Religious	10100	20	Religious Talk	Rel_Talk	Religious_Talk	Call-in shows, interview programs, etc. with a religious theme
Rhythmic AC	10001	17	Soft Rhythm and Blues	Soft_R&B	Soft_ R_&_B	Rhythm and blues with a generally soft tempo
	10000	16	Rhythm and Blues	R_&_B	Rhythm_and_Blues	A wide range of musical styles, often called "urban
Rhythmic Contemporary Hit Radio	11010	26	Hip-Hop	Hip hop	Hip hop	Popular music incorporating elements of rap, rhythm-and-blues, funk, and soul
	01001	9	Top 40	Top_40	Top_40	Hits, often encompassing a variety of rock

Table 5 (continued). List of Nielsen Audio formats with suggested PTY codes defined in NRSC-4-B

Nielsen Audio Format	PTY Code Binary	PTY Code Decimal	Program Type	8 Character	16 Character	Definition
Rhythmic Oldies	10000	16	Rhythm and Blues	R_&_B	Rhythm_and_Blues	A wide range of musical styles, often called "urban
Smooth AC	10001	17	Soft Rhythm and Blues	Soft_R&B	Soft_ R_&_B	Rhythm and blues with a generally soft tempo
Soft AC	01100	12	Soft	Soft	Soft	A cross between adult hits and classical, primarily non-current soft-rock originals
Southern Gospel	10011	19	Religious Music	Rel_Musc	Religious_Music	Music programming with religious lyrics
Spanish Adult Hits	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish Contemporary	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish Contemporary Christian	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish Hot AC	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish News/Talk	11000	24	Spanish Talk	Habl_Esp	Hablar_Espanol	Call-in shows, interview programs, etc. in the Spanish language
Spanish Oldies	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish Religious	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish Sports	11000	24	Spanish Talk	Habl_Esp	Hablar_Espanol	Call-in shows, interview programs, etc. in the Spanish language
Spanish Tropical	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Spanish Variety	11000	24	Spanish Talk	Habl_Esp	Hablar_Espanol	Call-in shows, interview programs, etc. in the Spanish language

Table 5 (continued). List of Nielsen Audio formats with suggested PTY codes defined in NRSC-4-B

Nielsen Audio Format	PTY Code Binary	PTY Code Decimal	Program Type	8 Character	16 Character	Definition
Talk/Personality	00100	4	Talk	Talk	Talk	Call-in and/or interview talk shows either local or national in origin
	10101	21	Personality	Persnlty	Personality	A radio show where the on-air personality is the main attraction
Tejano	11001	25	Spanish Music	Musc_Esp	Musica _Espanol	Music programming in the Spanish language
Urban AC	10001	17	Soft Rhythm and Blues	Soft_R&B	Soft_ R_&_B	Rhythm and blues with a generally soft tempo
Urban Contemporary	11010	26	Hip-Hop	Hip hop	Hip hop	Popular music incorporating elements of rap, rhythm-and-blues, funk, and soul
Urban Oldies	10000	16	Rhythm and Blues	R_&_B	Rhythm_and_Blues	A wide range of musical styles, often called "urban
Variety	00000	0	No program type or Undefined	None	None	
World Ethnic	10010	18	Foreign Language	Language	Foreign_Language	Any programming format in a language other than English
	10110	22	Public	Public	Public	Programming that is supported by listeners and/or corporate sponsors instead of advertising
	10111	23	College	College	College	Programming produced by a college or university radio station
	11101	29	Weather	Weather	Weather	Weather forecasts or bulletins that are non-emergency in nature

5.3 Program Type Name (PTYN) codes

While PTYN is part of the European RDS Standard, the NRSC believes it is not commonly used in receivers designed for the U.S. Given the finite bandwidth available for RDS applications, it is recommended to not encode PTYN and instead use the available bandwidth for more useful features like RT+ song tagging, and for increasing RT transmission rates which can be of benefit to a large number of receivers.

5.4 Traffic programming (TP)/Traffic Announcement (TA) flags

While stations are encouraged to encode the Traffic Programming (TP) flag if they provide traffic reports, and receiver manufacturers are encouraged to display that information, automatic receiver switching using the Traffic Announcement (TA) flag is discouraged. The NRSC understands that there have been complaints and confusion from listeners when the TA flag has been used to automatically switch a receiver.

Since the development of the TP/TA feature set in RDS, more efficient and advanced traffic reporting features have been made available to the general public. Instances of these include Global Position Systems (GPS) navigation devices with embedded FM or HD Radio receivers that can decode traffic incident data and display it on a map and provide re-routing assistance. Also, out-of-band data provided on the Internet and viewed on smartphones provides another way in which to convey this information to the public.

5.5 Music/Speech (MS)

Stations are encouraged to set this switch appropriately according to the programming being broadcast. A value of 0 indicates speech is present and a value of 1 indicates that music is present.

5.6 Decoder Identification and Dynamic PTY indicator (DI)

These bits indicate audio modes that are appropriate for use with the broadcast and to indicate if PTY codes are being switched dynamically. Typically in the U.S., a value of 0 on bit d_0 is used if the audio on the station is monaural, and a value of 1 is used if the station's audio is in stereo.

5.7 Alternative Frequency (AF)

AF is frequently implemented in Europe, but AF has not been a widely used feature in the U.S. AF is primarily intended to enable receivers to find simulcast stations automatically. The PI code still controls whether a receiver will automatically switch. The PI code is the broadcaster's indication that the receiver should automatically switch, if this feature is enabled on the receiver. The same PI code transmitted on multiple stations means identical audio program content is being broadcast on those frequencies. RDS encoders are programmed to transmit a list of frequencies directing a compatible receiver where to receive the same programming. Its intended application in the U.S. would be to associate fill-in translators and boosters, or full-service FM stations that fully simulcast another station in the area. AF-compatible receivers should verify that the station on the alternate frequency is transmitting the identical PI code as the current station and should not switch if the code is not the same.

It is important to stipulate that the purpose of the AF feature is not to control receivers in such a way that the equipment will switch between co-owned full-service FM stations that broadcast different content, or to link stations airing similar but not identical programming. The program content should be identical (*i.e.,* simulcast) between the AF frequencies. Stations should consider carefully the listener experience when employing AF and ensure that the associated signals are transmitting the identical programming and to limit the time offset (delay) of simultaneous programming to under 1-2 seconds.

Stations that implement AF to link full-service, booster, or translator stations must not only set the list of alternative frequencies into the primary station’s encoder but should also program complimentary values into encoders feeding all associated stations. Stations that choose to implement AF to link stations that air common programming only during certain times should not publish on any of the stations' encoders any AF channel numbers that refer to stations whose programming is not currently identical. If there are no stations whose programming is currently identical, then the AF list should be deactivated until such time as another station is again transmitting identical programming.

The European standard specifies two methods to transmit AF lists. The methods are called A and B. In the U.S., only method A is used. Method A can carry up to 25 alternative frequencies for an identical program. Information about this method is contained in IEC 62106 [2] beginning in Sections 6.2.1.6.2 and 6.2.1.6.3.

If a station is not explicitly using the AF feature it is recommended that the AF list be empty.

5.8 Clock Time (CT) Group

This group is sometimes sent if a station is sending a time/clock and date reference. To conserve bandwidth, a single 4A group packet is sent every sixty seconds. If a station is not explicitly using this feature it is recommended that the group not be sent. For stations electing to send the 4A CT group, ensure that the RDS encoder is properly and continuously time synced to a reliable external time source. Also be sure that the CT local offset is correctly set to the local time zone. These offsets must also be adjusted in accordance with Daylight Saving Time changes. Stations transmitting inaccurate time or that have improper local CT offset settings can cause issues with receivers that use the CT to display time. Information about CT is contained in the IEC 62106 [2] beginning in Section 6.1.5.6.

6 USING RDS FOR PROGRAM ASSOCIATED DATA

6.1 Overview

Program Associated Data (PAD) is a term used to describe data (usually textual) that is associated with an audio program on the radio. PAD can vary depending on the type of material being aired on the radio station. The most common use of PAD currently via RDS is the current song title and artist data. However, there are many other types of PAD that can be encoded via RDS and displayed such as the song's album data, or in the case of non-music related programs, more information about the program. For example, a radio station running a live talk show may include the show's name, topic being discussed, the name of the guests and, perhaps the phone number to call in and participate in the show. The examples above are just some of the current and potential uses of PAD for RDS.

The importance of transmitting PAD data via RDS cannot be overstated. Broadcasters need to present a consistent user experience to listeners across all stations in a given market. When only a few stations in a market are transmitting PAD then this puts radio at a competitive disadvantage compared to other audio services, in particular Satellite Digital Audio Radio Service (SDARS) and Internet-based streaming audio services that consistently provide PAD. The NRSC recommends that every station implement dynamic PAD over RDS.

Increasingly, more radios are being sold that include RDS including smartphones with FM radio capability. As these radios continue to be adopted by consumers; it is vital that broadcasters provide information to the listener about the current programming on the air. The ability to make this information available to the receiver display keeps terrestrial radio relevant with other forms of technology, such as portable music MP3 players, satellite radios, and Internet streaming audio applications via a computer, portable device or phone. For those stations also employing hybrid IBOC transmissions (both AM and FM), many of the concepts here also apply to the HD Radio system's Program Service Data (PSD) capability and can result in an overall improvement of PAD/PSD implementation across multiple platforms.

As outlined below, it is recommended that stations encode PAD in the RT field, and optionally in the Program Service (PS) field, as described in Sections 6.8 and 6.9 below.

6.2 Receiver display length considerations

For guidance on receiver alpha-numeric display length, and information on how many characters are required to display artist and title information over a typical over-the-air broadcast RDS data stream, receiver manufacturers are encouraged to consult the companion document to this Guideline, NRSC-R300. NRSC-R300 is entitled Program Associated Data (PAD) Field Length Study. [6] This report provides valuable information on song title, artist and album usage to help guide decisions when designing receiver displays.

6.3 Confusion between PS and RT

PS and RT are different fields in the RDS Standard and can be treated differently by each receiver. While the general listening public does not necessarily need to know what they are looking at (PS or RT), radio stations encoding RDS should understand how both fields relate to the end-user experience.

It is important to know that there are newer radios that support RT equally, if not better than they do PS. These new receivers display the RT in a more prominent manner. While so much of the emphasis in the past within the U.S. has been on the dynamic PS and its scrolling/framing effects, broadcasters need to be equally as aware of RT. Ignoring RT is ignoring the end-user experience that listeners on the newer devices now have, and this could be detrimental to the future of RDS-enabled radio displays.

Given that many feature-rich hand-held and portable receivers and advanced automotive receivers are already on the market, the future should bring more receivers that display RT in a prominent way, and the broadcast industry needs to make sure as much value is being placed on RT as on PS.

The NRSC has noted some stations that are doing dynamic PS scrolling/framing for PAD data but are not transmitting PAD data in the RT field. It is recommended that stations in this situation should transmit PAD data in the RT field as well.

6.4 Album name data

All stations encoding RDS and supporting song title and artist are encouraged to transmit the album name (if applicable) using RT. Satellite radio, digital cable radio and Internet streaming stations often include the album name of the song they are currently playing. Many of the radio industry's web-sites and streaming initiatives show album name data. With RDS, broadcasters have the ability to provide the same information about the songs playing and achieve parity with other competing mediums.

It should be noted, due to space limitations, that the inclusion of album name information in the shorter, scrolling/framing/dynamic implementations of PS is not recommended.

6.5 Data formatting, truncation, and capitalization

Similarly, broadcasters are encouraged to review the quality of the data they are transmitting via RDS. Look for music libraries that have truncated, incomplete or inaccurate title/artist/album data. Stations may need to "groom" the music libraries to make sure the data is accurate.

When RDS was first implemented, it was the general consensus to capitalize everything sent because some radios did not support lower case characters. The majority of receivers in use today do not have this problem, so the use of proper capitalization is encouraged. If capitalization beyond what is grammatically correct must be used, the recommendation is to use it sparingly (and appropriately).

6.6 Extra text ("Now playing…by…on")

Some stations add the phrases "Now playing", then insert the title of the song, then "by" followed by the artist name, and then "on" and the station name. This practice is discouraged as discussed in NRSC-R300 (reference [6], pages 18-19). This extra text will lengthen the time it takes for a driver to observe the real information being conveyed on the display (i.e., Title, Artist, Album). "Now playing" adds 12 characters to the required text length and removes the key information (i.e., the Title) from the prime location (the beginning of the text string on the display).

6.7 Data and song timing

For stations that are running an audio delay, whether it be for purposes of synchronizing analog and digital audio in a hybrid IBOC transmissions, and/or for profanity deletion, it is strongly recommended that adjustments be made in the RDS PAD data transmission delay so that the audio and corresponding PAD are properly aligned at the receiver. Some hardware and software products on the market have this ability, and it is best to research this and spend some time "fine tuning" it. If this is ignored, it is possible that a song's PAD could show up before the song is on the air. When transitioning into another song, the new song's data can be displayed for a period of time while the old song is still playing, which is also an issue. For stations running in real-time (no delay) this alignment process is likely to be less of a factor, as the data is likely being sent to the RDS encoder at the same time the song is changed.

6.8 Using RadioText (RT) for PAD

RadioText (RT) is a 64-character field which can be transmitted via an RDS encoder to receivers. As mentioned above, the PAD content of the RT field can vary depending on the program that is currently airing on the radio station.

6.8.1 RT formatting

In the case of music, it is suggested to have the radio station's name, along with the song's title, artist and album information (if applicable) sent via RT. A separator between each of the fields is recommended, to give better readability for the listener. In the example below, a single hyphen character is used, - (ASCII Decimal 45, Hex 2D), although other delimiters could be used, such as a foreword slash, / (ASCII Decimal 47, Hex 2F).

Uses may vary, but here are some suggested combinations:

Station Name – Song Title – Song Artist – Song Album

or

Song Title – Song Artist – Song Album – Station Name

or

Station Name Song Title/Song Artist/Song Album

or

Song Title/Song Artist/Song Album Station Name

In some cases, the song's album information is not available. This can be omitted, however, if the means to provide this information are available, it is recommended that album information should be listed.

National Public Radio (NPR) has conducted studies that indicate for informational/topical/spoken word formats, the suggested text might be:

Station Name – Program Name – Topic

Using a "live" example:

WZZZ – All Things Considered – Deficit Reduction

6.8.2 RadioText send rate

As discussed earlier, many newer receivers are displaying the RT in a more prominent manner. Almost every RDS encoder has an adjustment controlling how frequently the RT is sent compared to other data fields. The default settings of existing units are not necessarily set the best for a good end-user experience and require attention.

When an RDS receiver first tunes to a station with RDS and RT, it locates the RDS data signal and starts decoding. Many receivers are designed to wait until the RT has been sent twice before displaying to make sure it was received without any errors. If RT is not being sent frequently, this can take some time and result in excessive delay for displaying of RT information. RDS encoder defaults typically have a very slow RT send rate setting. Many encoders dedicate 75% of the bandwidth to the PS and 25% to RT. These default settings could take up to 15 seconds for the receiver to decode the RT under optimal conditions. If there are any impairments such as multipath or a weak signal during those 15 seconds the process of displaying the RT can take longer. This, in turn, creates a bad end user experience. Couple this with the addition of the new RadioText+ (RT+) tagging standards (to be discussed later in Section 6.10) and it is clear that the RT transmission rate is an important component to check and consider optimizing.

It is recommended that the RT transmission rate be increased from the default values. The more frequently the RT is sent, the faster a receiver can decode and display it to listeners. This is even more important when it comes to the new portable RDS receivers on the market, because they prominently display the RT. These receivers are also more likely to be operating at lower signal levels due to antenna design (*i.e.*, just a headphone cable instead of a better antenna found in mobile receivers). These portable receivers are also more likely to be used in areas where there is multipath or other signal impairments (*i.e.*, inside buildings).

Before adjusting the RT send rate on the RDS encoder, the consequences of this should be considered. By increasing the send rate, a trade-off is being made on other RDS functions. As previously mentioned, the RDS signal operates at a low bit rate, with a useful capacity of approximately 670 bps. When the RT rate is increased, other data types may suffer as fewer bits will be available for these functions. For instance, the PS will be sent less frequently, and, accordingly, adjustments should be made to that field to maintain a good user experience. For stations that use other RDS “specialized” features contained in ODA groups, such as Traffic Message Channel (TMC), make sure the settings being changed do not impact these services. Stations in this situation may need to reduce their RT sending rates down as a compromise between a better RT experiences for the listener and making sure the station is meeting its ODA obligations.

A recommended RT sending rate has been developed based on field testing with various RDS receivers on the market. The benchmark for developing these recommended settings was to get the information sent using RT to display in optimal reception conditions 3-4 seconds after tuning to the station, or after the RT data had been changed (i.e., a new song or program element had come on). See the encoder-specific recommendations in Table 6.

A display of RT in 3-4 seconds is the optimal experience. Under bad signal conditions, display will take longer. Even with the recommended settings, under poor reception conditions, it can take 10 or more seconds for RT to display. If the RDS encoder has factory default RT send rates a receiver may take 30 (or more) seconds and/or perhaps never resolve RT in these environments. The NRSC encourages RDS encoder manufacturers to consider using these recommendations below as the default settings for new units.

It should be noted that the RT message should not change for a minimum of three times the transmission time. With the settings below, it is recommended that the RT remain the same for a minimum of 15 seconds. Longer durations are preferred. Automation playback systems or other RDS metadata solutions should not update the RT too often.

If making adjustments to your encoder, be sure to read Section 6.9 about Program Service (PS) scrolling delay adjustments that should also be considered when making this change.

Table 6. Recommended RadioText (RT) send rates for stations with no significant ODA use

Note: these settings may interfere with any special ODA groups being transmitting such as leased traffic or other data. When transmitting ODA data, it is best to consult with the station's corporate engineering staff or the company that is leasing the data to ensure there is no interference with these services.

		RDS group type / feature			
Encoder Type(s)	**Recommended Setting**	**0A PS (%)**	**2A RT (%)**	**3A (%)**	**RT+ ODA (%)**
Inovonics 711 Audemat FMB1, FMB10 †	RT_RATE=1	45	50	1	4
Inovonics 712, 713 †	DRTS=9	63	32	1	4
Inovonics 720, 730 *	DRTS=9	24	71	1	4
Audemat (Worldcast) FMB-50, FMB-80 †† Burk RDS Master † BW Broadcast RDS3 †† Kvarta RDS1000 ††	GS=0A,2A,2A,2A	24	71	1	4
Pira32 ††	GRPSEQ=0222	24	71	1	4
DEVA SmartGen Mini, 4.1, 5.0††	SQC=2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 11A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 11A, 2A, 2A, 0A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 11A, 2A, 2A, 0A, 3A	25	69	1	5
2wcom C02, C04 †††	2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 11A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 11A, 2A, 2A, 0A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 2A, 2A, 2A, 0A, 11A, 2A, 2A, 0A, 3A	25	69	1	5

† Many legacy encoders do not support integrated RT+ from the manufacturer, but 3rd party hardware or software solutions exist to enable these features.

** Requires firmware upgrade of 2.6 or higher to achieve desired group sequence.*

†† May require firmware or software upgrade to enable integrated RT+ features.

††† Requires ARCOS configuration software. Encoder -> Dataset -> General -> Group Sequence. GS= string, not required. Replace 11A with desired RT+ ODA location. Encoder needs RT+ AID configured and 3A and RT+ ODA specifically shown in Group Sequence and AUTO_RTPLUS enabled to use integrated RT+ transmission feature.

Table 7. Recommended group sequence percentages for stations with TMC Traffic ODA use

Note: These group sequencing benchmarks are suggested for stations running Traffic Messaging Channel (TMC). Generally, TMC requires 25% of RDS bandwidth to be allocated to its specific ODA. Specific providers will likely have a customized group sequence setting specific to their service and encoders. The NRSC encourages TMC providers to provide optimized group sequencing for RT 2A transmission.

RDS group type / feature				
0A PS (%)	**2A RT (%)**	**8A TMC (%)**	**3A (%)**	**RT+ ODA (%)**
24	45	25	2	4

6.8.3 RT length padding

To combat display problems on legacy receivers, some RDS encoders give the option to always send 64 characters in RT. If enabled, when the encoder sends something under 64 characters, it adds spaces to the RT data so as to always transmit 64 characters. It is believed that few, if any, receivers still need this option. For encoders with this ability, it is recommended that this padding feature be turned off.

The longer the RT is, the longer it takes to transmit. By always transmitting 64 characters, there will always be the maximum delay. Most receivers do not display the RT data until it has been fully received without errors twice. The process of displaying RT data to the receiver is being slowed down unnecessarily in many cases. Look for settings related to short RT versus long RT. Unfortunately, with some legacy encoders, this option cannot be turned off.

6.9 Using scrolling Program Service (PS) for PAD

NRSC-4-B does not support using the Program Service (PS) field for PAD, as it is a single, static 8 character field. However, use of a “dynamic,” “framing,” or “scrolling” PS is a common practice within the U.S. Provided here is some best practice information for those stations that elect to provide PAD data via dynamic PS.

The PS is an 8-character field that was designed to describe the radio station and remain static (*i.e.*, never change or change only intermittently). Many of the early RDS receivers displayed *only* this field prominently on the display. Over time, the use of the PS has evolved into a dynamic (*i.e.*, changing) “scrolling” or “framed” display. Many stations in the U.S. frequently change what is in this PS field to interleave (or scroll) not only the station name but song artist, title, advertisements, promotional and other messages.

Because there is a limitation of 8 characters in this field, many of the messages stations want to display do not fit. RDS hardware and software vendors have developed solutions to take a long string of characters and put it into the PS field 8 characters at a time, with a delay in between, creating a “scrolling” or “framing” effect. The interval between these frames is the PS scroll delay. This delay is an adjustable setting in most RDS hardware and/or software products. It should be clear, in this specific section, that this delay is the time a particular 8-character PS field remains unchanged, and not the number of individual 0A PS packets that are sent out during this time. This could also be described as the PS field change rate.

Stations with low PS field change rates may have found the radio receiver dropping the 8-character PS frames periodically. It has been found that many stations have this scrolling delay set too low (*i.e.*, not enough delay) and when the receiver has impairments (such as multipath) the PS frames drop. With RDS encoder defaults, stations running a delay on their PS at under 2.0 (two) seconds were already prone to this.

In addition, because PS was originally intended to be 'static' some receivers interpret a changing PS to be a fault and suppress any PS display until at least three receptions of the same text have been received.

When the recommendations above in Table 6 and Table 7 for an aggressive RT send rate are followed, then the receivers that prominently display the PS may start dropping frames, even under optimal conditions. Again, this is due to the data rate limitations of the RDS signal. Given this, a minimum delay of 4 seconds between PS frames is recommended. For more multipath-prone stations, or for stations that have chosen to have their RDS subcarrier injection level below 6% (4.5 kHz), this could be set closer to 5 seconds to improve PS performance.

The NRSC recommends a minimum delay of 4.0 (four) seconds between PS frame updates to be the most compatible with many new receivers. Many newer automotive receiver designs have large displays which can display much more information than previously. The value of an eight-character PS display questionable on many of these new designs. However, most broadcasters will continue to employ PS framing for backwards compatibility with older radio designs.

For receiver manufacturers working on future designs, the NRSC offers some guidance based on its experience with the use of RDS amongst many broadcast stations in the U.S. Using the NRSC's suggested guidelines above will give the receiver the best possible user experience given the level of metadata offered by the radio station.

Suggested logic, from highest priority to lowest:

1. Internet enhanced metadata
2. HD Radio™ PSD metadata such as Current Program SIG Service Name/Station Name Universal/Station Name Short, Title, Artist, Album, Album Art/Artist Experience, Station Logo
3. RDS RT+/RadioText parsed metadata
4. RDS RadioText metadata
5. RDS PS metadata
6. No metadata – just frequency/dial position stated in MHz; i.e., 88.1 MHz, 98.5 MHz, 107.9 MHz.

Suggested decision matrix:

- If an FM + Internet Hybrid Radio, on acquisition of a station, detect if RDS/HD Radio is present. If so, use the HMI specifications of the service provider.
- If HD Radio is present on acquisition of a station, use HMI specs of the HD Radio system (Xperi, DTS, iBiquity). Consider RDS guidelines below when HD Radio lock is lost.
- If HD Radio is not present, detect if RDS/RBDS is present.
    - Before displaying the PS (0A) groups, look for presence of RadioText RT (2A) groups and RadioText Plus RT+ tagging ODA (3A = AID 4BD7) groups.
    - If PS (0A) is present but (2A) is not present, then it is encouraged to display the PS in its entirety on the display. To reduce the possibility of errant information being displayed to the listener, ensure the same PS is received in its entirety at least twice before display.
    - If RadioText Plus RT+ tagging ODA (3A = AID 4BD7) groups are detected, open the group that is referenced in the 3A AID. Broadcasters may select any group from 5A-13A, so do not hard code your RT+ decoding to a specific group. Start looking for RT+ tags that may identify the content type of the information in the RadioText (2A).
    - If RT (2A) is present, hold off displaying any information until the RadioText has been received in its entirety at least twice before display, to avoid errant information being displayed.

- If RT (2A) has been fully received twice and there is RT+ tagging data available, parse the information. Common fields used in the United States to date are StationName.Short, StationName.Long, Item.Title, Item.Artist, Item.Album. Populate the information on the appropriate portion of the display. Use of other RT+ content types are encouraged in more enhanced designs.
- If RT (2A) has been fully received twice and there is not any RT+ tagging data available, then display the full 64-character RadioText on the display.

6.9.1 PS formatting

In the case of music, it is suggested to have the radio station's name, along with the song's title, and artist information. Because of the limited amount of characters in the PS field, sending the song's album information via the PS field is not recommended.

Uses may vary, but here are some suggested combinations:

```
Station Name Song Title Song Artist
```

Using a "live" example:

```
WZZZ Fireflies Owl City
```

This would be broken up into several PS frames, which will be changed after the PS delay:

```
WZZZ
Fireflie
ireflies
Owl
City
```

Note, in the example above, the song title "Fireflies" has a length of 9 characters. The PS only supports 8 characters, so a framing technique has been employed.

National Public Radio (NPR) has conducted studies that indicate for informational/topical/spoken word formats, a suggested text might be:

```
Station Name Program Name Topic
```

Using a "live" example:

```
WZZZ All Things Considered Deficit Reduction
```

This would be broken up into several PS frames, which will be changed after the PS delay:

```
WZZZ
All
Things
Consider
nsidered
Deficit
Reductio
eduction
```

Note, in the example above the word "Considered" has a length of 10 characters, and "Reduction" has a length of 9 characters. The PS only supports 8 characters, so a framing technique has been employed.

6.10 Using RadioText+ (RT+) for PAD

In Section 6.3 above, the importance of implementing PAD data within the RT field was stressed. Broadcasters are also encouraged to adopt the RadioText+ (RT+) tagging standard for PAD data in the RT field [4].

RT+ is an additional ODA data stream defined in IEC 62106 Annex P that can be added to an RDS stream, identifying the text being encoded in the RT field. Until the RT+ Standard was developed, there was no way to know what the specific parts of the RT data were, from a hardware or software standpoint, and this is important for song tagging. RT+ offers the ability to classify different types of information (such as title) and their location within the RT field.

Because the RT field is so flexible, the receiver cannot make any assumptions as to what information is contained within, but RT+ bridges the gap and essentially allows for definition of what each part of the RT actually is. It also gives radio stations an “MP3 player feel” by making it possible to consistently show title, artist, and album on separate, defined areas of the display. That in turn makes for better readability for the listener.

The RT+ Standard was developed in 2005, by IRT, Nokia and WDR in Europe. It is an open standard, free of charge for use and implementation. This standard has been improved since 2005, it is now adopted by the RDS Forum, and, in the past few years several RT+ receivers have come to market in the U.S.

Perhaps the most widely known unit was the Apple iPod 5th generation Nano series that was introduced in 2010. This continued through their 7th edition of the product, but the entire line was discontinued in 2017. Other models such as the Microsoft Zune were short-lived and discontinued as well. The implementation of RT+ on these devices was done fairly well and allowed FM radio to have that “MP3 player feel” and provide the current title, artist and album information to the listener. As technology moves on, the dedicated “MP3” portable music player has left the marketplace for the most part. That functionality is built directly into our phones and our automotive infotainment systems now.

The automotive receiver aftermarket has continued to support RT+ in their designs. Because of the loss of the Apple Nano product, broadcasters for the most part have thought of RT+ as not being adopted as well as expected by RDS receivers. However, that is changing.

In factory installed automotive radios, BMW started supporting RT+ in 2012 and still does in many current models. Most recently, Toyota has introduced RT+ in some of its models in 2018.

RT+ gives automotive manufacturers a way to take the RadioText provided by RT and parse the station name, title, artist, album and other information, and present it in a more organized and consistent fashion. This is yet another way to keep traditional analog FM radio relevant and provide the same “look and feel” as some of the other new digital audio entertainment offerings in the dash.

It is recommended that all broadcasters deploy RT+ tagging for Item.Title, Item.Artist, Item.Album, as well as StationName.Short and StationName.Long. These are the most commonly used RT+ fields in receivers today.

While most of today’s available receivers in the U.S. support just artist/title/album tagging, there are some other promising things that can be tagged. There are over 60 content types available for use. Looking at the list available, RT+ gives broadcasters the ability to tag phone numbers, websites, SMS text messaging campaigns, addresses and times and dates. As more smart receivers with RDS/RT+ support come to market, it is not hard to conceive a time when receivers will be able to act on other RT+ fields.

6.10.1 RT+ implementation for broadcasters

To add RT+ to an existing RDS stream, two Open Data Application (ODA) packets need to be broadcast in the RDS stream from the RDS encoder. The first type of packet is the 3A packet which identifies to an RT+ capable receiver that the station is encoding the RT+ standard. These packets shall be broadcast at least once every 10 seconds by the station as per IEC 62106 Annex P.6. By encoding with Application ID (AID) 4BD7, receivers that support RT+ know this station supports the RT+ standard. The contents of this 3A packet identify the ODA group that the RT+ tagging packets are located in.

The second ODA packet is where the RT+ tagging data is located. ODA is part of the regular RDS Standard and is a way to add additional functionality. These packets shall be broadcast at least once every 2 seconds as per IEC 62106 Annex P.6. Multiple ODA's can be running on a single RDS stream, but they must each be in a different "logical" numbered location. In the U.S., the NRSC-4-B Standard specifies valid ODA group locations of 5A, 6A, 7A, 8A, 9A, 11A, 12A, 13A.

It is important to note, if a station is broadcasting any traffic or other leased data applications using RDS, the ODA group(s) these services are using should be confirmed with the station's corporate engineering staff, or the vendor who is leasing the data. RT+ must be put on a different ODA, or there will be a conflict.

In the RT+ ODA packet, there are three important fields:

- **Item Toggle bit** is an important concept to understand in the RT+ Standard. In brief, every time a new "Item" changes, this bit should be toggled. It is a single bit, meaning there are only two values for it, 0 and 1. Essentially, this bit should only change when a programming element is changing. The best way to relate to this is a song. When a song comes on, this bit should be set to 0 for the entire duration of the song. When the song is over, and the next song is aired, the bit should be set to 1. Changing the toggle bit signals the receiver to purge anything in memory related to ITEM. This clears content types 1-11 which includes title, artist, album, and other song data from the receiver. The next song played will have newer content types and start/length markers that it would then apply.

- **Item Running bit** essentially states that the current Item being displayed in the RT+ and RadioText is actually running, or "on the air." In most cases, this is set to 1.

- **Content Types and Markers** – each RT+ ODA tag allows for two "tags." Each tag consists of a Content Type, Start Marker and Length Marker. The Content type is a number from 0-63 that identifies what type of tag the text is. The Start and Length markers define where in the RadioText (RT) that field begins and where it ends. These are both 0 based numbers, so the counting has to start from zero. Alternatively, these can just be counted and then from the result, subtract one.

6.10.1.1 Tag 2 length logic inversion

Note that in the RT+ Standard the Length on Tag 2 is 5 bits instead of 6 (like Tag 1) which limits Tag 2 to 32 characters. It is recommended that when developing RT+ solutions to keep this in mind and dynamically flip the tags if the second one exceeds 32 characters but the first is under 32. Given that the RadioText is only 64 characters in length, if Tag 2 had 33 or more characters, then the length of Tag 1 must be 32 or smaller and could easily fit in the second tag. The RT+ standard in Annex P of NRSC-4-B calls for this action in Section P.5.2; however, this point can be easily overlooked.

6.10.1.2 RT+ interleaving – having multiple RT+ tags per single RT

By understanding the Item.Toggle bit, it can be seen that a receiver will cumulatively store to memory any supported RT+ field. This can occur on multiple RT+ tags on a single RT line, and even across multiple RadioText transmissions, so long as the Item Toggle bit is held constant. The interleaving feature of the RT+ Standard allows for tagging of more than just two fields at once.

In fact, having only 2 RT+ tags per a single RT is very limiting, especially when encoding information in all of the 60+ RT+ tags is considered.

For example:

```
WZZZ – Fireflies – OWL CITY – CD: Ocean Eyes
```

In the case above, 4 RT+ tags could be used: StationName.Short, Item.Title, Item.Artist, Item.Album:

```
WZZZ
Fireflies
OWL CITY
Ocean Eyes
```

All RDS encoder manufacturers and software solution providers are encouraged to support RT+ Interleaving in their products. This will encourage broadcasters to encode more than just standard Item.Title, Item.Artist, and Item.Album – and use the other 60+ RT+ content types. As broadcasters tag additional RT+ fields, this will also encourage receiver manufacturers to support the additional content types as well.

7 USING RDS FOR TRAFFIC INFORMATION

7.1 Overview

Broadcasters in the U.S. (and much of the world) use TMC for providing traffic information. In the U.S., TMC services are offered on a commercial basis by two service providers - Broadcaster Traffic Consortium (BTC) and Total Traffic Network (TTN). Most of the top 100 U.S. markets are covered by both services. For additional information go to www.radiobtc.com and www.totaltraffic.com.

7.2 Traffic using RDS-TMC

NAVTEQ's TMC uses Service Identifier (SID) = 7 for its TMC services which are transmitted in accordance with the latest version of the RDS-TMC Standard (14819 parts 1,2,3,& 6). The data is encrypted according to the conditional access specification. Single and multi-group messaging are supported, and the service includes Incident data (*e.g.*, accidents, road closures, road construction etc.), real-time flow data derived by road sensors and GPS probe sources, and basic road-related weather conditions.

The maximum rate of data transmission is used, with type 8A groups being sent out every fourth RDS group using 25% of the available bandwidth, and tuning variants are used to reference other transmitters in the same and adjacent market areas. The data is sent to the RDS encoders using the Universal Encoder Communications Protocol (UECP).

7.2.1 Location Table Country Code (LTCC) definitions – old and new

In RDS-TMC, each Location table is identified by a Location Table Number (LTN) together with a Location Table Country Code (LTCC).

In Europe, when RDS-TMC started, it was assumed that it was not necessary to transmit the LTCC as in all cases would be the same value as the first element of the PI code, which in Europe indicates the country of origin of the program audio (Program Identification Country Code, PICC). This assumption did not hold in the U.S., however. As a result, the RDS-TMC standard was modified and since 2009, LTCC should be explicitly transmitted, independently of PICC. All new RDS-TMC receivers must use LTCC and not derive the LTCC from PICC, unless LTCC is not broadcast by the RDS-TMC Service Provider.

8 Using RDS for Emergency Alerting

8.1 Overview

RDS and its ODA capability can be used for FM radio-based emergency alerts that enable first responders to create and send text-based digital alerts and messages to targeted recipients.[5] These messages will typically require a dedicated RDS-equipped FM receiver (or an FM radio-equipped smartphone with an "app") for reception; the messages will not generally be receivable over standard FM receivers that consumers typically have in their cars, homes or work places. The single point to multi-point messaging functionality of the broadcast of RDS utilizes the overlapping data signal of local FM radio stations to provide redundant emergency notification capability (see Figure 7). These RDS emergency alerts can deliver emergency information using RDS ODA messaging to fixed or mobile receivers, mobile phones, and other devices.

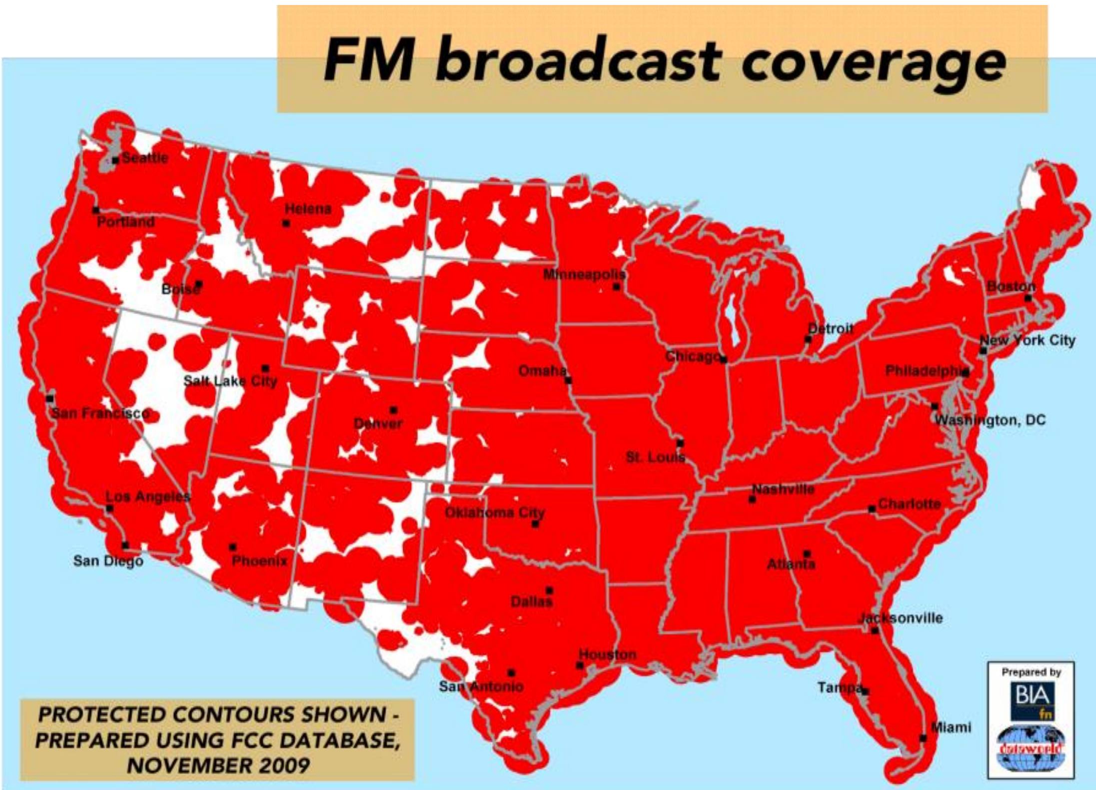


Figure 7. FM broadcast coverage in the United States

RDS emergency alerts can be designed as addressable, low-latency, high-value messages that can be received across local, county, state or nationwide coverage areas, depending upon which broadcasters are sending out the messages. A major design principle for RDS emergency alerts is typically to balance message delivery speed with non-interference to other uses, especially considering the limited effective throughput of the RDS data "pipe". RDS emergency alerting parameters can be structured to allow implementation of emergency alerting without disabling standard broadcast station operation of song title and artist info or traffic information.

[5] The RDS-based emergency alerting described here is supplemental to the audio-based emergency alerts that broadcasters transmit as part of their participation in the Emergency Alert System (EAS).

Systems that generate RDS emergency alerts are a complement to cellular telephone-based systems, the most common of which is the Wireless Emergency Alerts (WEA), as well as outdoor warning sirens or telephone-based mass notification systems. Note that the performance of cellular telephone-based systems can be adversely affected by network capacity issues and power outages which occur in emergency situations. By contrast, the FM terrestrial radio stations that are used to transmit RDS emergency alerts are significantly more robust and have a much greater probability of staying operational during emergency situations.

8.1.1 Brief history of RDS Alerting in the United States

In 1997, Sage Alerting Systems implemented RDS using 9A blocks to send out alert messages.

In 2005, the State Office of Homeland Security for Mississippi (following Hurricane Katrina) implemented the first statewide RDS emergency alerting system, which included installing broadcast equipment on 35 local FM radio stations and receivers in all 82 county emergency operations centers.

In 2008, the U.S. Federal Communications Commission released the First Report and Order on the Commercial Mobile Alert System (CMAS), adopting technologically neutral rules, specifically mentioning the use of RDS emergency alerts.[6] As a consequence, CMAS participants were free to adopt FM-based technologies for use of alerting on mobile devices-Part of the H.R. 5556 (109th): Warning, Alert, and Response Network Act.[7]

In 2010, the Federal Emergency Management Agency (FEMA) included FM-based RDS as a dissemination path for emergency alerts as part of the Integrated Public Alert and Warning System (IPAWS) architecture. The addition was a result of an one year study contract conducted by Northrop Grumman (reference: FEMA Contract No. HSFEMW-09-F-053.

In 2011, CEA (now CTA) published CEA-CEB25, Best Practices for Implementing Common Alerting Protocol (CAP) based Alerts for Consumer Electronics (CE) Devices (November, 2011). The best practice is used as a guideline for consumer electronics manufacturers to integrate and receive FM-based RDS alerts in common consumer electronic devices such as alarm clocks, smoke detectors.

Over the years, FM-RDS-based emergency alerting has gained support from the National Association of Broadcasters (NAB) and National Alliance of State Broadcast Associations (NASBA).

8.1.2 Use of RDS for Emergency Alerting Overview

The only authorized emergency alert originators are first responders with credentials issued and maintained by Federal and State governments.[8] To issue an emergency alert, typically the alert originator will use a secure, web-based portal that allows emergency officials to create personalized Common Alerting Protocol (CAP)-formatted alerts and distribute them to multiple alerting paths including (but not limited to) EAS, WEA, and RDS emergency alerts. Messages can be geographically or organizationally targeted based on the scenario. Messages can include alert originator-generated information as well as automated information directly from FEMA or the National Weather Service (NWS).

The typical methods of sending RDS emergency alert information to broadcast facilities are satellite and/or Internet communications systems. These methods can provide economical and reliable voice and/or high-

[6] The Commercial Mobile Alert System First Report and Order, PS Docket No. 07-287, *First Report and Order*, document FCC 08-99, file FCC-08-99A1.pdf

[7] Note that as of April 2014, no cellular service providers are known to have elected to implement CMAS alerts using RDS, however, a number of cellular handsets that include FM radio functionality can support RDS emergency alerts in limited areas using "apps" designed for this purpose.

[8] The principle authority for the IPAWS Program is Executive Order (E.O.) 13407, *Public Alert and Warning System*, dated June 26, 2006.

speed data delivery to multiple locations. Satellite data delivery typically occurs much quicker than delivery using "daisy chain" communications among broadcast stations, as has been traditionally done by radio broadcasters to distribute audio alert messages using EAS. With EAS, if the daisy chain is broken, all stations below the broken link fail to get the critical alert information. Internet connectivity to broadcasters has been used in some cases.

Figure 8 is a diagram of the RDS emergency alert implementation of the Mississippi Emergency Management Agency in Jackson, Mississippi. The Figure shows how alert information flows from the Police/Sheriffs Operations Center, through the FM and satellite infrastructure, through to a Global Security Systems communications server.

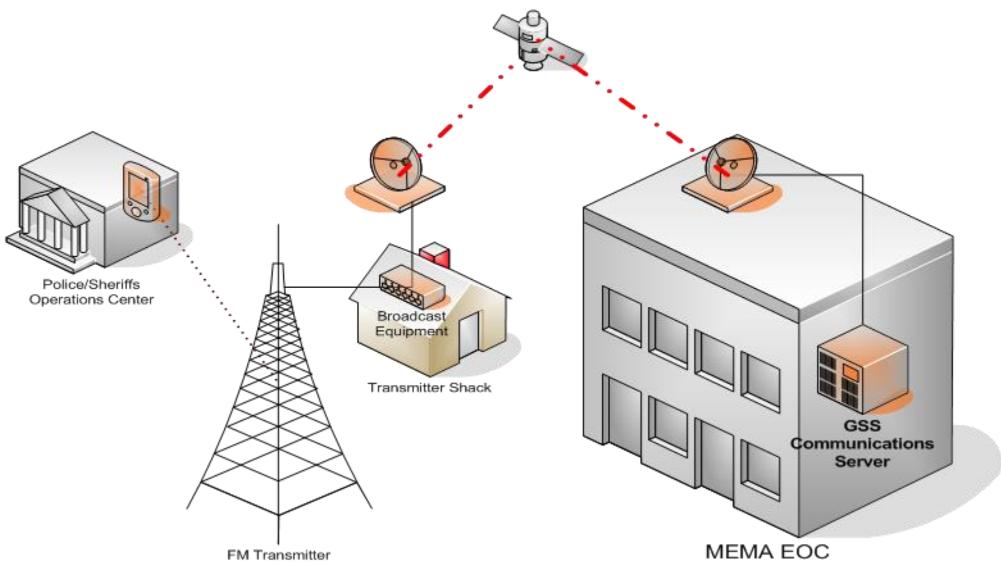


Figure 8. Example of how RDS emergency alert message information flows (Example is taken from an implementation by the Mississippi Emergency Management Agency Emergency Operations Center)

8.1.3 Typical Radio Station Installation and Testing

The Internet connection or satellite receive dish used to pass along emergency alert message information in an RDS-based system will be run through various tests to ensure correct operation. For a satellite system, the proper installation and mounting of the satellite receiver and dish will be reviewed to ensure optimal signal strength and reception. All grounding, external and internal wiring of the satellite dish and weather-proofing will be checked and integrity confirmed. Receiver indicator lights will be checked and confirmed functionally operational. The message loop test including the command center (from which RDS emergency alerts will emanate) will be tested to verify reception from command center interfaces.

The FM Radio Station configuration (see Figure 9 below) will then be run through various tests to ensure correct operation, including the following:

- Interface cables and connection to the transmitter
- Transmission levels
- Signal-to-Noise ratio
- Injection levels
- Functional operations

A test RDS emergency alert from an authorized alert portal such as IPAWS or local/state CAP-based web portal will be sent for broadcast system testing, verifying receipt by the receive-only satellite dish and receiver, processing by the RDS encoder and broadcast over the FM signal. The RDS emergency alert message will be verified with a designated wireless device held by the installation engineer.

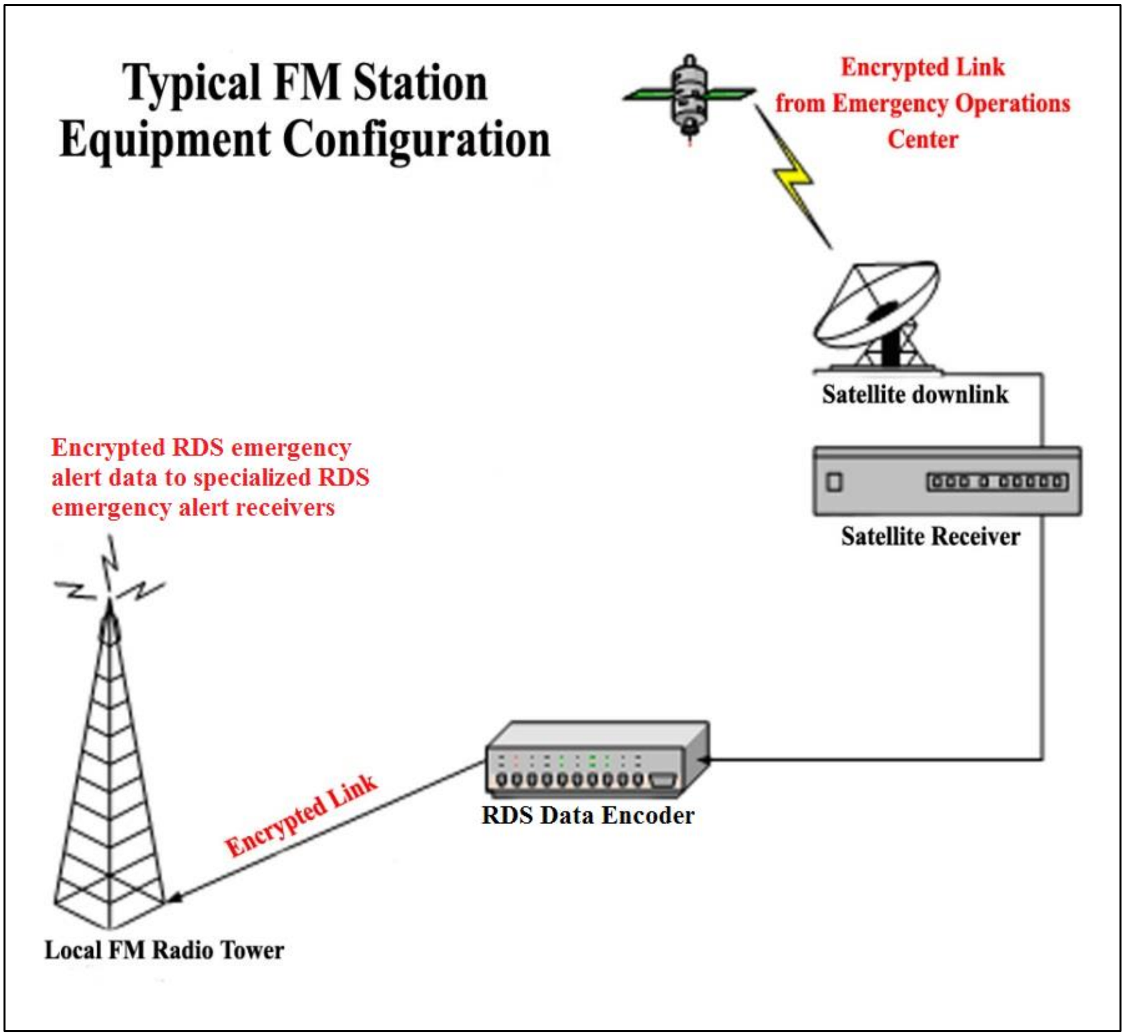


Figure 9. Station-specific alerting overview

8.2 Alert FM system

One example of a system that generates RDS emergency alerts is the Global Security Systems ALERT FM system.[9] Alert FM has a network of affiliated FM stations that have agreed to transmit Alert FM RDS emergency alerts. With Alert FM, RDS emergency alert messages are transmitted via RDS group 7A, formerly used by "RP" (RDS Radio Paging). An important attribute of using the heritage 7A RP RDS protocol is the ability to use battery saving features for handheld devices. The content of timing groups 4A and 1A indicate an ALERT FM station. Alert messages up to 240 characters are typically delivered in less than 60 seconds.

[9] See the Alert FM web page at www.alertfm.com.

8.2.1 ALERT FM data input flow to the RDS encoder

Similar to other RDS applications, messages intended for ALERT FM RDS emergency alerting are ingested, authenticated and prepared for transmission via centralized, off-site servers. Connectivity into the RDS encoder is nominally via satellite-delivered, one-way Multicast IP, using the UECP standards mentioned in Section 4.5. Use of satellite delivery keeps this "backhaul" alerting data private and offers high security, while use of Multicast IP allows for an addressing scheme that insures that each station's FM RDS encoder only transmits alerting messages appropriate to that station's coverage area – again in keeping with the design goal of system bandwidth efficiency and minimal intrusion into other RDS usages.

8.2.2 Typical radio station installation for ALERT FM

As noted above, ALERT FM data is delivered via the IP output of a small satellite data receiver, which is normally placed on the same IP subnet as the IP address of the RDS encoder(s) at the transmit site, following the networking convention that Multicast packets traditionally do not "cross" a router. The affiliate FM station is either provided with a new industry-standard RDS encoder, or the existing RDS encoder is programmed to accept ALERT FM RDS alerting data. A proviso for using an existing RDS encoder is that it must have the ability to ingest Multicast packets, to read input data delivered via standard UECP2 protocols, and also be able to emit group 1A and 7A packets conforming to the latest CENELEC standard protocol IEC 62106/Ed.3.

8.2.3 Programming of the RDS encoder's Group Sequence with ALERT FM system

Another benefit of being based upon the heritage RP standard is that when there is no alerting data present, there are no data-bearing Group 7A packets emitted. Therefore, once a station has selected a proper ratio of "public" (0A and 2A) and ODA packets (discussed in the following section), that Group Sequence (GS) has to be overlaid with an interlace of 7A packet "placeholders". Considerations include group ratios, alerting priorities and the unique programming language needed to accomplish this within each encoder, as discussed below.

8.2.3.1 Group Sequence ratios

The target ratio of RDS emergency alerts in the Alert FM system is a one-to-one interlace of alert message-bearing RDS 7A Groups with all other data-bearing groups, such as 0A (PS), 2A (RT) and ODA users like TMC (traffic info). Since it is possible that in the event of an emergency all such users may have something to contribute over their data channel, the design goal is to get the 7A-carried alerting message emitted as fast as possible, while still allowing other data users to emit their data, and while maintaining minimum recommended levels of throughput.

7A alert message-bearing groups only appear in the RDS data stream for the duration of the RDS alert message. Immediately on completion of the message, the order of RDS groups reverts back to the normal sequence, with no 7A groups added. Blank, null or filler 7A groups are not emitted.

Depending on the priority of the RDS alert message (see Section 8.2.3.2), 7A groups are normally sent at the start of each minute (as indicated by the output of a 4A clock time group) until a maximum of about 70 7A groups are emitted, or about 15 seconds, whichever comes first. While a one-to-one interlace of alerting groups may at first appear to indicate that 7A alerting takes up 50% of the RDS throughput, the normal use of only the first 1/4 of each minute drops the real per-minute throughput impact to a maximum of 12.5%.

Again, this assumes that each alerting message takes up a maximum possible length of around 240 characters. In the real world of 140-character-based Twitter and SMS messages, lengths approach half of that maximum RDS message length – or even less – which would again drop the throughout impact down to the single digits. And finally, it is noted that Alert FM RDS emergency alert messages do not occur every minute, so the 7A alerting group impact as measured over hourly, daily or weekly timeframes starts to approach zero.

8.2.3.2 Alerting priorities

In addition to the normal Alert FM RDS emergency alert message activity described above, there is a special alerting mode wherein 7A groups are emitted throughout the entire minute, with messages starting at each 6 seconds. This is reserved for the highest-order (and shortest) alerts, similar to an Emergency Action Notification (EAN)-level warning in the broadcast EAS system, and allows for the fastest alerting response time, typically measured in the single-digit seconds.

There is also the possibility of deploying a slower, lower-priority 7A alerting system message, such as would be used for background information or some of the larger data fields in the FEMA IPAWS system. By design, this would have a slower 7A rate to prevent deleterious impact on other users as it would, in effect, be always on for the longer time period of a large message. This would require dynamically-switching the programmed Group Sequence inside each RDS encoder to a different sequence – with the goal of dropping the 7A ratio down to the low level of other ODA groups – unless a high-priority alert required immediate switching back to a higher 7A rate.

Again, due to the unique method that 7A groups are interlaced on-demand, as of this writing it appears that a slow-throughput feature would require an RDS encoder to have the ability to switch between two separate "switchable group sequences." That is a feature that does not currently appear to be offered by the major manufacturers of today's RDS encoders without at least the need of a reboot (system initialization) or other drastic measures.

8.2.3.3 Group Sequence programming example

Since different makes of RDS encoders have unique means of programming the actual as-aired sequence of RDS groups, it is important to note the difference between the programmed "Group Sequence" – as defined as a setup list of RDS groups in a certain order – and the actual order of the RDS groups that are sent out by the encoder.

An example would be of one popular RDS encoder which takes the programmed "Group Sequence" (GS) list and automatically adds other groups, such as the top-of-the minute 4A and top-of-the-second 1A timing groups. This encoder also interprets the entry of basic groups in the GS list – specifically 0A and 2A groups – as a simple ratio or repeating "wheel". This allows easy entry for a station which only carries PS and RT information, for example a simple GS of 0A,2A,2A would create a 33%-66% 0A-to-2A throughput ratio. Unfortunately, the same encoder interprets literally the number of requested groups for other uses such as TMC and RDS emergency alerts. For this encoder, Alert FM writes out the entire as-transmitted sequence of groups for the first 15 seconds, including the interlace of 7A alerting as well as any other ODA groups, in order to maintain the proper throughput balance for each user.

Therefore, each radio station may require a separate style of "Group Sequence" program or setup list in order to maintain a proper balance among normal users while still allowing proper entry and interlace of alerting-on-demand packets.

8.3 HD Radio Emergency Alerts

In addition to using RDS for alerting purposes, radio broadcasters are taking advantage of the HD Radio digital radio platform to provide enhanced emergency alerting services to the listening public. A brief description of the HD Radio Emergency Alerts service is provided here as an example of how digital radio can be utilized in this regard. Refer to reference [17] for details.

8.3.1 Definition

The HD Radio Emergency Alerts service may provide the public with time critical and lifesaving information over *FM* and *AM* radio stations utilizing the built-in capabilities of HD Radio technology.

Important points regarding Emergency Alerts over HD Radio:

- The service is an *Add-on*. It can be enabled without changing existing analog system Audio configuration or existing HD Radio System Audio and Data configurations.
- When the service is enabled, the station's digital signal (FM and AM) indicates its support of the service (even when no alert is in effect), allowing receivers informing the listeners of such station.
- The featured message (CAP or legacy) can support up to 374 text characters and target locations.
- The weekly/monthly EAS tests will also pass through HD Radio Emergency Alerts, with added text.
- IP network connection (low bit rate) between the alert processor and HD Radio Exporter is required.
- The alert processor is the sole controlling device (already implemented by leading manufacturers of alert processors including SAGE, COMLABS). Enabling the service is done in the alert processor.
- Extremely low false alarm (expected less than once per 10 years). High probability of detection within audio coverage area (expected ~95% within a single cycle; ~99% within only 2 cycles).
- 4-layers error protection in the protocol prevent data corruption.
- Earthquake alert suitable. Allows delivering ultra-time critical alerts in as little as ~200mS.
- Uses the standard ISO 8859-1 character set.
- Complies with Geo-location requirements.
- Common messaging format for AM and FM (via the SIS channel).

8.3.2 How it works at the station

A block diagram highlighting the hardware and connectivity elements necessary for supporting HD Radio Emergency Alerts at a radio station is shown in Figure 10. Of particular interest are the Alert Processor and the HD Radio Exporter:

Alert Processor:
- Receives alert content (CAP or legacy) and converts it to HD Radio alert message format.
- Sends formatted alert message to the HD Radio Exporter (via station's IP network).

HD Radio Exporter:
- Broadcast alert service indication
- Broadcast alert message

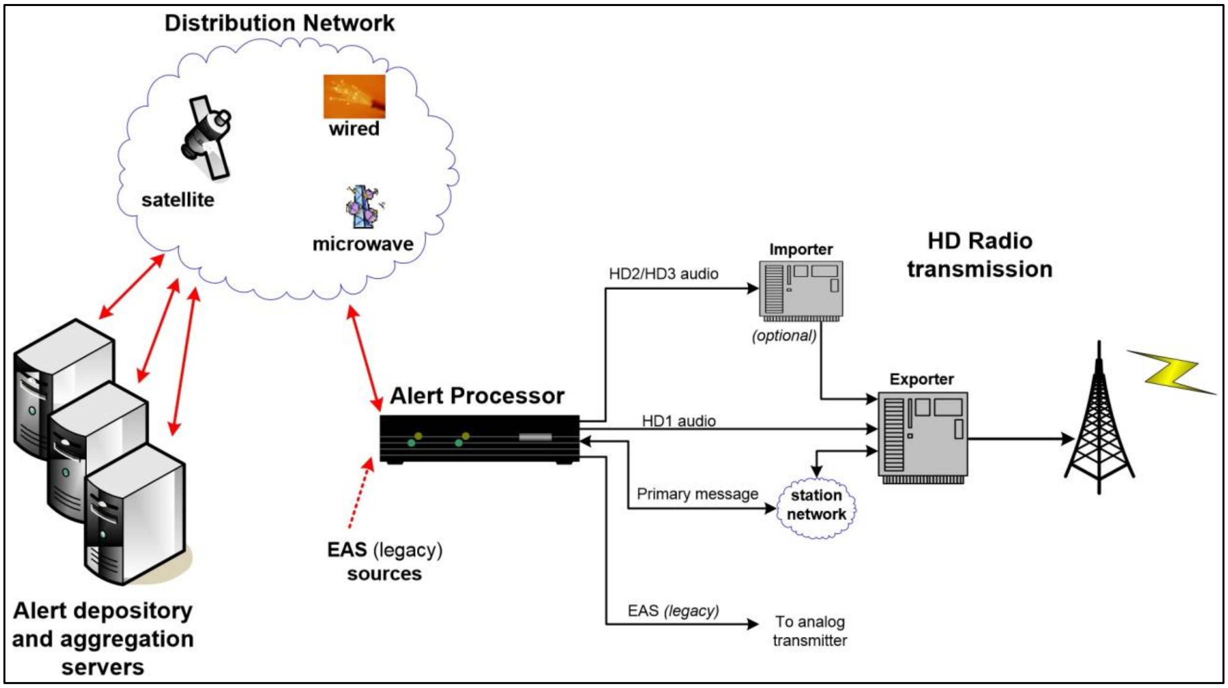


Figure 10. Block diagram showing hardware elements utilized in supporting HD Radio Emergency Alerts at a radio station (source: DTS, Inc.)

8.3.3 How it works in the receiver

When an alert message is received on an HD Radio Alerts-compatible receiver, it will “breakthrough” current programming and the alert message will appear on the receiver’s display as text along with a locally generated (*i.e.*, generated within the receiver) alert tone. The alert includes a header regarding the nature of the alert (example: ‘Weather Alert’). Along with the alert text, the receiver also displays the station call sign (or frequency).

The receiver provides the user with the option to ignore (“snooze”) the alert and resume normal operation. Once the alert message is “snoozed” or no longer available, the receiver resumes normal display rendering. The receiver also maintains a history of the alert messages allowing the user to browse or view the alerts at any time.

8.3.4 Timing Characteristics

Message transmission time is 100% dedicated to conveying useful information, without requiring start (i.e. preamble) or end (EOT) overhead. Additionally, message transmission time is identical to message receiving time, as a receiver may start reception anywhere in a message cycle and complete reception as the transmission gets again to the point where the receiver tuned in and started reception. Thus no time is wasted.

The actual message transmission cycle depends on the message length and on the service channel (SIS) utilization (i.e. sharing percentile between alert data and regular service data). Table 8 provides high level timing information

Table 8. HD Radio Emergency Alerts Message Transmit Times

	FM		AM	
	Maximum utilization	Minimum utilization	Maximum utilization	Minimum utilization
Longest message (parameters + 374 characters/locations)	8 sec	12 sec	13.6 sec	20 sec
Shortest message (parameters + 2 characters)	0.2 sec	0.4 sec	0.4 sec	0.6 sec

Comments:

- Longest message refers to a message that uses the maximum supported single message length. It is defined by the alert issuer. It includes parameters (type, urgency, category, etc.), and may include locations and full-length text (in one or multiple languages).
  It may be used for any alert matter/topic
- Shortest message refers to a message that uses the minimum supported message length. It is defined by the alert issuer. It includes parameters (type, urgency, category, etc.), and may include 2 text characters/symbols.
  It is suitable for time-critical alert, such as Earthquake Alert, where transmit time for alerting the listener is required to be as short as possible.

9 RDS AND CHARACTER/FONT SETS

9.1 Overview

The RBDS and RDS Standards share a common font or character set, which is defined in a table in the RDS Standard. That is, radios compliant to either standard display the same character image (or glyph) for a given character code value.

However, this RDS character set is not the same as any character set used in the computer world, such as ASCII, ISO-8859-1 (Latin 1), Unicode, Arial font, etc. RDS was being designed approximately during the birth of the PC age, and at that time there was no clear need to use exactly identical font sets.

The RDS character set has many characters in common with ISO-8859-1, especially in the first 128 positions (lower 7-bit characters). The differences can be a problem, unfortunately.

Automation data is entered and stored in computer formats, so typically this is done in the character font set used in that country. Obviously, these data must be translated to RDS character set data for transmission, and the RDS receiver must be designed using the RDS character set as well.

9.2 Dollar sign display problems

The most common character translation problem is that some radios display the wrong character for the dollar sign (“$”).

Table 9 shows the character maps for various standards. Two values are involved in the dollar sign: 0x24, which is where computer character sets locate the “$”, and 0xAB, where RDS has this character located.

Table 9. Character set translations for common dollar sign characters

Character Set	0x24	0xAB
RBDS/RDS (IEC 62106 Table E.1)	**¤**	**$**
ASCII / ISO 646 1994 / ECMA 6 7-bit Char Set	**$**	*n/a*
ISO-8859-1 Latin 1	**$**	**«**
Arial font set (or various other font sets)	**$**	**«**

The two most common faulty behaviors are due to the following:

1) Receivers sometimes are displaying the ISO-8859-1 or Arial font equivalent graphic for 0xAB (which is ‘«’) rather than the RDS Standard graphic at 0xAB (the U.S. dollar sign, “$”). However, other character sets have also been observed on radios;

2) Broadcasters sometimes are using the ISO-8859-1 value of 0x24 for transmission of ‘$’, leading to RDS-compliant radios displaying the international currency symbol, “**¤**”. Broadcasters should be transmitting 0xAB for the U.S. dollar sign ‘$’ in the RDS character map.

Note that the dollar sign is not the only character that is not the same in RDS vs. computer fonts; see the later sections for more examples.

U.S. broadcasters are using PS and RT text transmission for advertising, which sometimes include information about price. Prices in the U.S. are, of course, most commonly presented in U.S. dollars. The singer Ke$ha spells her name with a dollar sign, and her popularity at her peak also helped highlight this issue.

9.2.1 Recommended actions for equipment vendors

The majority of receivers tested show correct RDS behavior. Best results for broadcasters in the current installed base can be obtained by using the RDS character tables in transmission. This is best achieved by:

- RDS equipment manufactures providing the feature (via original design, or if necessary by firmware upgrades) to have an option in their encoders to translate 0x24 to 0xAB. It is recommended that this setting be enabled by default on RDS encoders destined for use in the U.S.

- RDS software vendors providing the feature (via original design, or if necessary by software upgrades) to have an option in their encoders to translate 0x24 to 0xAB. It is recommended that this setting be enabled by default on all software destined for the United States.

Broadcasters encoding with RDS should be advised to upgrade their encoder firmware (option 1). If their encoder is no longer supported with firmware upgrades, broadcasters should seek software upgrades (option 2).

9.2.2 Recommended actions for broadcasters

First, determine whether the automation system or the RDS encoder is responsible for changing ISO-8859-1 characters to RDS characters. Check with the equipment or software makers to determine this.

It is also a good idea to verify what the transmission system is actually sending. Note that the fifth, sixth, and seventh generations of the iPod Nano from Apple exhibit the correct behavior.

Some test cases will also need to be constructed to verify both PS behavior and RT behavior. The strings in Table 10 may be inserted at the automation text interface to send text over PS and RT.

Table 10. Test strings for testing dollar sign behavior
Text is inserted at the automation system user interface.

<table>
<tr><th>Desired string (as displayed in Arial font)</th><th>As encoded on computers</th><th>Intended transport</th><th>Correct result on RDS receiver</th></tr>
<tr><td>“$«”</td><td>0x24, 0xAB</td><td>PS</td><td rowspan="2">The automation system or encoder should change the computer’s 0x24 “$” character to 0xAB for RDS, and the receiver should display it correctly as a dollar sign; the automation system or encoder may keep the second character as 0xAB, or substitute another character (the “«” character is not defined in RDS/RBDS)</td></tr>
<tr><td>“$«”</td><td>0x24, 0xAB</td><td>RT</td></tr>
</table>

For equipment that is not correctly following the specification, the equipment provider should be contacted. It may be necessary to work with both the automation system and the RDS encoder manufacturers to determine where the fault lies and whether a fix is possible, but this will of course depend on the specific equipment and software being used.

9.2.3 <u>Recommended actions for receiver manufacturers</u>

Receiver makers are also encouraged to follow the RDS standard (IEC 62106 Table E.1 a/b) for decoding RBDS/RDS and getting the correct results onto receivers in the marketplace.

9.3 Other 7-bit character map differences

Table 11 shows some important seven-bit characters which will show up incorrectly if encoded or decoded with a computer font set instead of the RDS standard.

Table 11. Important seven-bit characters that may show up incorrectly on receivers

Hex	Dec	Arial	Courier New	ISO-646	RBDS / RDS†
24	136	$	$	$	¤
5E	129	^	^	^	—
60	130	`	`	`	‖
7E	131	~	~	~	¯

†Closest Times New Roman equivalent

9.4 Selected 8-bit character map differences

Table 12, below, shows some eight-bit characters which might be used, and their RDS equivalents. Note that RDS font images (simulated here with Arial font) in the right-most column do not match Arial or Times New Roman. Computer fonts are not at all suitable for use in rendering RDS character transmissions. Receiver makers and app developers on smartphones must follow the RDS standard (IEC 62106 Table E.1 a/b) in order to get the correct display.

Table 12. Important eight-bit characters and their RDS equivalents

Hex	Dec	Arial	Courier New	RBDS / RDS†
80	128	€	€	á
85	133	…	…	ì
8B	139	‹	‹	Ç
91	145	‘	‘	ä
92	146	’	’	ê
93	147	“	“	ë
94	148	”	”	î
95	149	•	•	ï
96	150	–	–	ô
97	151	—	—	ö
98	152	˜	˜	û
99	153	™	™	ü
9B	155	›	›	ç

†Closest Arial font equivalent

This is not intended to be an exhaustive list; these tables are intended to show that there are reasonably likely characters which cannot be transliterated directly from computer fonts to RDS radio fonts.

9.5 RDS character set and HD Radio character set

It should be noted that while the character sets above are for radios doing RBDS/RDS decoding, a separate character set (ISO-8859-1 Latin 1) is needed for radios processing iBiquity Digital HD Radio™ PSD/PAD messages (see [7]). RBDS/RDS uses the character set defined in IEC 62106 Table E.1 a/b. These character sets should not be confused between the two mediums.

ANNEX 1: BROADCASTER INFORMATION ON RDS USAGE – RDS USE CASES

Information in this subsection was either obtained from the Internet or provided by individual broadcasters. The NRSC is looking to expand this subsection and encourages broadcasters interested in sharing information about how they are using RDS to contact the NRSC by email at nrsc@nab.org.

Broadcaster Traffic Consortium

The Broadcaster Traffic Consortium LLC (BTC) is a coalition of sixteen radio organizations across the U.S. and Canada. Working together, these organizations have formed a coast-to-coast terrestrial broadcasting network to distribute local traffic, weather and other map-related data, via radio technology. Seven of the top ten U.S. radio organizations are BTC members.

BTC provides a single point of contact focused on building a North American HD Radio Data and RDS-TMC network that offers a standardized data distribution channel. From member obligations as to implementation and operations, BTC can add or subtract the best broadcasters and their station signals as needed to meet the needs of our customers.

BTC has partnered with NAVTEQ, the leading provider of in-vehicle navigation and real-time digital map data, to serve end users with up-to-the-minute traffic, weather, fuel prices and more. BTC strives to drive HD Radio data content development, spurring the investment of broadcasters in HD Radio technology and increasing the value of HD Radio technology for the radio industry by complimenting HD Radio audio with utilitarian HD Radio data services.

BTC continues to research and test additional uses for HD Radio data services with partners other than NAVTEQ. For additional information visit the BTC web site at www.radiobtc.com.

iHeartMedia / Total Traffic and Weather Network (TTWN)

iHeartMedia's Total Traffic and Weather Network (TTWN) is using RDS for a large variety of functions.

In 2002, IHeartMedia (formerly Clear Channel Communications) began to dynamically update the Program Service (PS) field to allow for display of Title and Artist to receivers which did not support the display of RadioText. This was in response to research showing that satellite radio subscribers (whose satellite radio receivers always display this information) found this function to be highly desirable. Subsequently, IHeartMedia purchased hundreds of RDS encoders and worked to custom-develop firmware that would allow for enhanced service. IHeartMedia also connected all of these devices to a centralized portal so that the consumer experience would be identical across all IHeartMedia stations.

In 2004, IHeartMedia launched RDS-TMC (Real Time Traffic) in cooperation with Siemens. Garmin, BMW and others soon followed. When IHeartMedia looked to bring RDS-TMC to the U.S., it had never been done before in North America. Unfortunately there was a conflict between the RBDS Standard at that time and the RDS-TMC standard that was primarily European.[10] The RDS-TMC standard required that when a device was tuning to find an RDS-TMC station, it would first look to find a station with a PI code whose country code matched the country code of the map data being used.

In the case of the U.S., TeleAtlas and Navteq had agreed that the U.S. would have a country code of "1," and therefore any RDS-TMC receiver which was to follow the standard would ONLY look for stations which start with a PI code of "1." Under the RDS Standard, the PI code is calculated from the call letters of the station, so no station east of the Mississippi could possibly have a 1xxx PI code.

[10] Note that with the adoption of NRSC-4-B in 2011, this conflict was resolved. See Section D.7.4 of the Standard [1].

IHeartMedia clearly could not operate under both standards, so after verifying with the NRSC that the RBDS Standard was voluntary and after some investigation of a variety of stations that did not have their PI code set to the calculated value (many were set to the factory default of FFFF), IHeartMedia chose to follow the RDS-TMC standard and carefully break IHeartMedia's compliance with the RBDS Standard in this one regard.

About two years after iHeartMedia's launch of RDS-TMC service, a few radios began to implement backward calculation of call letters from PI code. This created a problem since stations transmitting the RDS-TMC data with the "1" in the PI code (as just described) would likely not have their call letters calculated correctly. Primarily, these initial devices were test equipment like the Audemat Golden Eagle and not mainstream devices that were consumer focused. Then Microsoft launched ZUNE which also used back calculation to display call letters.

IHeartMedia had worked with Apple on implementing song tagging over the HD Radio system. Later, IHeartMedia worked with Jump2Go, Zune and Apple to develop song tagging over RDS using a combination of RadioText+ and another ODA for sending specific song IDs over the air in an encrypted format. While this song tagging ODA was being developed, IHeartMedia inserted the ability to transmit the correctly calculated PI code data over the air. While a "1" is still transmitted over the air as the first digit of the PI code, the extended country code and the calculated first two nibbles of the PI code are also transmitted in the ODA packet. This allows new devices to correctly decode and display the call sign for IHeartMedia stations using the modified PI code calculation method. IHeartMedia also employs RT+ tagging of StationName.Short, and in this document, the NRSC encourages receivers to use this field to display the station name instead of back calculating PI codes.

Currently, IHeartMedia operates about 450 stations with RDS. Of those stations, the vast majority are broadcasting RadioText+, Apple song tagging, MediaBase tagging (Zune and others), RDS-TMC, dynamic PS and RadioText with up-to-date Title and Artist data. IHeartMedia also has a few experimental applications running.

In 2001, RDS in the U.S. was not gaining in popularity. Car companies were starting to take the feature out of their vehicles as it was a function that was not consistently used across broadcast stations. Now, RDS is the strongest it has ever been in the U.S. IHeartMedia, through its development and implementation of services over RDS, believes it has helped to keep radio relevant for U.S. consumers and consumer electronics companies.

Cox Media Group

- Some of the Cox Media Group markets began broadcasting an RDS signal as early as 1993, mostly just displaying the call letters.
- In June 2006 Cox began to support broadcast of Title and Artist information using RDS, and within the year had at least one station in each market operating
- In 2006 Cox began to work with and roll out the BTC project in many markets. The last-contracted Cox stations went on the air with BTC in August 2009.
- In December 2008 - 1st quarter 2009, Cox rolled out the "Jumpgate" devices for song tagging. All Cox stations with active RDS are song tagging.
- Cox is sending Title and Artist and Station Name, scrolling this information using the PS field at a 2 second interval.
- Cox is also sending information for Featured Advertisers, scrolling on the PS during the spots.

- Cox is running the Station positioning statement, station web address, and featured advertiser additional information using the RT field.

Hawaii Public Radio

(Submitted by Mr. Don Mussell, Consulting Engineer)
Hawaii Public Radio (HPR) installed RDBS in the 2006 timeframe. It has really helped listeners identify HPR stations, and tourists know quickly where public radio can be found because most of the rental fleet in Hawaii has RDS equipped radios in their vehicles.

On Kaua'i, KKCR has had RDS since 1997, providing ID, scrolling slogans and announcements, and AF for repeaters and translators. Other HPR uses of RDS include the following:

- KHPR: Station ID, scrolling slogans and announcements, AF for translator, and using the RDBS for activation of selected receivers by the local civil defense for various emergency notifications.
- KIPO: Station ID, scrolling slogans and announcements
- KKUA: Station ID, scrolling slogans and announcements, AF for translator
- KANO: Station ID, slogan

Global Security Systems: Earthquake Early Warning using RDS Delivery

The objective of earthquake early warning is to rapidly detect the initiation of an earthquake, estimate the level of ground shaking to be expected, and issue a warning before significant ground shaking starts. First, a network of seismic sensors detects the first energy to radiate from an earthquake, the P-wave energy, and the location and the magnitude of the earthquake is rapidly determined. Then, the anticipated ground shaking across the region to be affected is estimated. The system can provide warning before the S-wave, which brings the strong shaking that usually causes most of the damage, arrives. Warnings will be distributed to local and state public emergency response officials, critical infrastructure, private businesses, and the public. EEW systems have been successfully implemented in Japan, Taiwan, Mexico, and other nations with varying degrees of sophistication and coverage.

Earthquake early warning methods provide warning times from a few seconds to a few tens of seconds, depending on the distance to the epicenter of the earthquake. This is enough time to slow and stop trains and taxiing planes, to prevent cars from entering bridges and tunnels, to move away from dangerous machines or chemicals in work environments, and to take cover under a desk, or to automatically shut down and isolate industrial systems. However, earthquake-warning notifications must be transmitted without requiring human-review and response action must be automated, as the total warning times are short.

The United States Geological Survey (USGS), in collaboration with University partners, is developing an earthquake early warning system for the west coast of the United States. The mission of USGS Earthquake Hazards Program is to mitigate earthquake losses in the United States. Citizens, emergency responders, and engineers rely on the USGS for accurate and timely information on where an earthquake occurred, how much the ground shook in different locations, and what the likelihood is of future significant ground shaking. A demonstration earthquake early warning system called ShakeAlert began sending test notifications to selected users in January 2012. While that system has demonstrated the feasibility of Earthquake Early Warning in California, the full system, from event detection to notification distribution, has not been sufficiently tested for robustness and reliability. In particular, robust and reliable notification pathways have not yet been sufficiently developed for the earthquake early warning system.

Global Security Systems, LLC (GSS) is working with the Department of Interior's U.S. Geological Survey (USGS) to integrate ALERT FM's broadcast-based alerting system with earthquake early warning alerts from the USGS ShakeAlert System. USGS and GSS signed a Cooperative Research and Development Agreement (CRADA) in 2014 to establish collaboration to test the use of Radio Data System (RDS) alerting provided by GSS ALERT FM system. With additional resources, the USGS system could provide limited rollout across the State of California and the West Coast of the United States next year. The USGS ShakeAlert System in California consists of sensors placed strategically throughout the state that detect seismic vibrations and will trigger the system to send out warnings. These warnings could be distributed across outdoor sirens, ALERT FM receivers, smartphone apps, and other notification pathways. (See article: *RDS Can Help Earthquake Warnings* at https://www.radioworld.com/news-and-business/rds-can-help-earthquake-warnings.)

In this CRADA, USGS and GSS will collaborate to test earthquake early warning notifications via the GSS FM-based alert system. An overall objective is to have USGS provided earthquake early warning notifications posted to GSS alert software and transmitted to a set of GSS receivers in the Los Angeles Basin during a week-long test period. USGS will provide XML EEW messages that include a detected earthquake's location, magnitude and likelihood. In addition, USGS will provide equations to estimate ground shaking and S wave arrival times given a particularly latitude and longitude. GSS will develop and implement a methodology to translate USGS XML messages into shaking intensities for a set of geographic regions (e.g., FlPS and/or GSS group code regions) in order to activate its. GSS receivers for the specified geographic regions. user defined thresholds for alerting. In addition, the USGS and ass will work collaboratively on system design and best practices for alerting different sectors, including utilities, emergency response personnel, and other industries.

Earthquake early warning will allow businesses to take actions to protect their employees, customers, and critical infrastructure from strong shaking. Even a few seconds of warning is enough to shutdown vulnerable processes, move people from unsafe places, and for people to drop, cover and hold on.

ALERT FM is unique since it operates a dedicated emergency notification system with the ability to deliver time-committed alerts unlike other cellular, telephone or broadcast systems, which are tied to Internet, or telephonic switched systems. These systems delivery times are non-committal due to switched networks and lack of prioritization and timing delays as a result of commercial commitments. ALERT FM is satellite-based wireless and switchless unencumbered by Internet connectivity and switches. ALERT FM is already being used in many southern states for tornados, hurricane evacuation. ALERT FM uses the digital data subcarrier of local FM radio stations, including Univision station in southern California and public radio station KQED in northern California, to distribute critical alerts in from as little of 6 seconds but less than 60 seconds. Information is received on addressable portable or fixed receivers that can be programmed for specific groups, counties, or areas. ALERT FM receivers automatically tune to and lock on to the strongest FM signal in the area. Once ALERT FM has been implemented in California as part of USGS system, receivers will be available for purchase by residents and businesses.

Global Security Systems is a systems integrator, service provider and manufacturer of the ALERT FM, Alert Studio and GSSNet, a satellite data delivery system. GSS has participated in the development of IPAWS based systems, is a member of the Commercial Mobile Alert Service systems committee, and is actively involved with several EAS and CAP committees. Global Security Systems (GSS) has developed a commercially available end-to-end notification platform based on FM radio broadcasts fed by satellite for distributing mass notifications. GSS has a nationwide satellite delivery system to originate and uplink Common Alert Protocol (CAP) based emergency audio and text alerts. GSS Alert FM receivers, cell phones equipped with a radio chip and software, and other consumer devices receive the alert messages. The GSS nationwide GSSNet satellite data delivery system for emergency alerts currently is in operation on over 500 radio stations in 17 states and Canada; is growing daily; and includes the ability to generate and deliver CAP messages. In addition, GSS has experience developing best practices for receiving and responding to emergency notifications Corporate website: www.alertfm.com.

Wisconsin Public Radio

The Emergency Alert System as an Input to an Metadata Management System - An RBDS Case Study

Introduction

Wisconsin Public Radio (WPR) is a statewide radio service with 3 networks airing on 34 stations. WPR has been successfully transmitting Program Associated Data (PAD) text to HD and FM-RBDS receivers via these stations for about two years. The metadata we are sending includes both static and dynamic information: station call signs, slogans, music title / composer / artist, talk show topics, names of shows and program hosts, weather reports and station promotional information.

As an active participant in our state Emergency Alert System, as well as a leading proponent of PAD transmission, it struck me that it would be a useful public service for listeners if text information for serious EAS alerts were visible on the radio receivers with RDS capability and HD capability. Our goal: If a listener hears the EAS alert tones but misses the audio message, a glance at the radio display would provide the important info.

Immediately the question arose as to whether or not we should include information related to weekly and monthly tests in the EAS data being fed into the WPR PAD stream. I weighed the options, and discussed the pros and cons with colleagues. Most felt that EAS testing is meant more for proof of system performance and less for education of listeners. For example, most stations conduct weekly tests with no announcements purely for confirmation that the technology is working. Monthly tests more often contain announcements, and in many areas do serve a secondary listener-education purpose – they sound more like alerts. Should EAS tests show up on radio data displays? Our decision was “no” - we would only transmit PAD data for actual emergency alerts - but the question remains open pending future feedback from listeners.

Getting Started

What would be our sources of appropriate emergency alert information? Where should it come from and where should it be sent? Given the geographically-coded nature of the EAS system, the WPR EAS encoder/decoder in each region of the state should be the source of the EAS text for the PAD data system serving the stations in that region. The EAS system would become another input source for our PAD system.

It seemed wise to shake out any kinks in this project using our flagship station WHA AM-970 in Madison, Wisconsin. WHA would be the guinea pig – especially handy since the equipment that would be involved would all be found in our Radio Operations Center just down the hall from my office!

So the first stage of the project would be to put EAS on the HD PAD stream for WHA and the RDS text signal going to WHA’s FM translators. If this proved successful, the next stage of the rollout would be to add EAS messages to the HD-PAD and RDS of our other Madison area stations. And eventually the project would grow to include our stations in Milwaukee, Green Bay, and other areas of the state.

WPR’S PAD System

Figure 11 shows the relatively complex system necessary for WPR’s transmission of Program Associated Data. To the left on the diagram you can see most of the inputs - the PAD information sources for networks. In the middle of the image is the main PAD sorting/routing system based on Arctic Palm’s “Center Stage” product, and to the right are the regional sorting/routing systems and examples of the outputs – the radio stations transmitting the data. Note that the geographically-coded Emergency Alert information is to be inserted into the “regional” data flow that serves clusters of stations in a given geographical area.

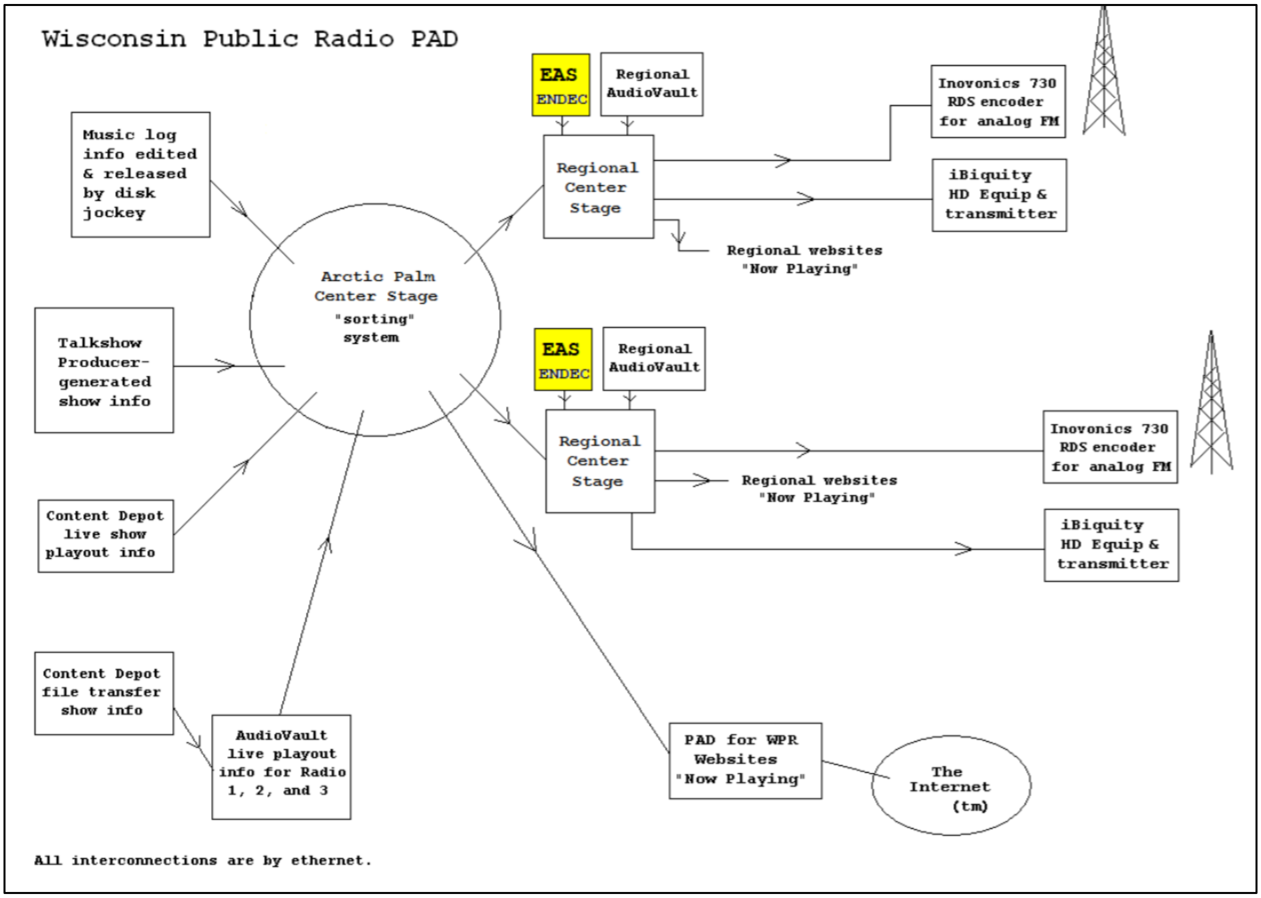


Figure 11. WPR's transmission of Program Associated Data

Interconnection of the various pieces of the existing system is provided by TCP/IP communications by wired Ethernet. I noticed that all the EAS devices involved had ethernet ports - wouldn't it be nice if the emergency information could move from the EAS encoder/decoder to the PAD sorting system by TCP/IP on the local area network? Networked connections could be especially useful given that in many instances our EAS equipment is not located in the same room or even the same building as the PAD server.

Details, Details

All the WPR stations are driven by Sage Alerting ENDEC equipment. Sage let me know that the ENDEC can send a file by FTP, and there are hopes for RDS encoders and HD gear will eventually be able to use that data directly. Unfortunately this idea would set up a one-to-one relationship between the EAS unit and its station's HD and RDS encoders, not suited to our more complex plans in which the emergency alert information from an EAS box would be merged into an already existing flows of metadata headed out to multiple stations in a given region.

Sage suggested that the serial port output from the EAS units would be another possibility. Most, if not all, of the manufacturers of EAS equipment provide a serial text output that is sometimes used to drive wall displays and video character generators (Figure 12).

Figure 12. Equipment interface panel

At the same time, Arctic Palm Technology responded to my inquiry and confirmed that their Center Stage Live software had a module in beta test for handling serial Emergency Alert System data. Arctic Palm had modified Center Stage's "CSWeather" program to create the capability to handle EAS text data received via serial port. These serial ports seemed like the most likely source of appropriate text information about the EAS alerts for our PAD stream.

Getting Around the Limitations of Serial

It appeared that the only practical option would be a serial connection. Unfortunately this is only convenient if the EAS box and the computer are relatively near to one another.

Since IP network connectivity was available near each system, I next envisioned using tunneling devices to carry the serial data via the Ethernet network. I have had considerable success sending both contact closure and serial data across the wide area network (WAN) that interconnects our various radio facilities around the state. For example, when we produce one of our network call-in talk shows at one of our bureaus I provide a remote profanity delay "dump" button that is a contact closure tunneled through the Ethernet network.

Serial tunneling enables you to establish a link across an Ethernet network for signals like contact closures or RS-232. The serial data is packetized in both directions into Ethernet TCP/IP packets by a converter device, an adapter of sorts, sometimes called a "serial device server". The packetizing allows a user to connect a serial device to another serial device via the Ethernet network in a way that is hopefully transparent to the serial devices and of little or no impact to other uses of the Ethernet network.

In my vision for the EAS PAD data connections, a serial-to-ethernet converter device would connect to the serial port on the Sage EAS unit and would make the serial data available via the existing local or wide area network. At the other end, the mating ethernet-to-serial converter could be used to send the data into a serial port on the PAD server.

A search for such products revealed numerous sources. One appealing unit was the Lantronix NET232+ devices offered by Grid Connect (Figure 3). The hardware is simple and the supporting software seemed to be well regarded. Ease of configuration and reliability in operation are important in on-air systems such as these.

Figure 13. Interface box

It was easy to imagine a pair of these NET232+ devices being used to tunnel the serial data across our ethernet network as shown in Figure 14.

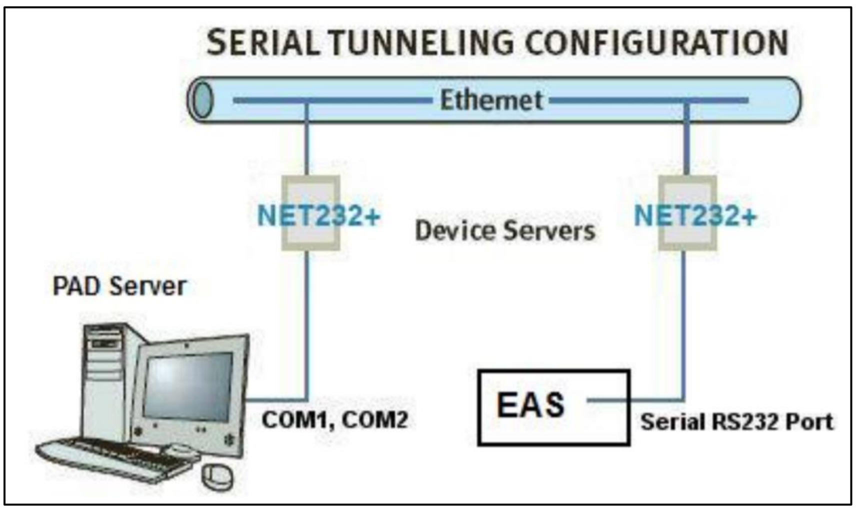


Figure 14. Serial Tunneling Configuration

An Even Better Idea

It occurred to me that the PAD server PC already had an ethernet connection. Could the server receive the tunneled serial data directly? Digging deeper I learned that the NET232+ could also be used to reach a "virtual serial port" directly in the computer, eliminating one of the converters. With this realization it was easy to imagine one NET232+ devices being used to tunnel the serial data from a Sage ENDEC across our ethernet network to the PAD server as shown in Figure 15.

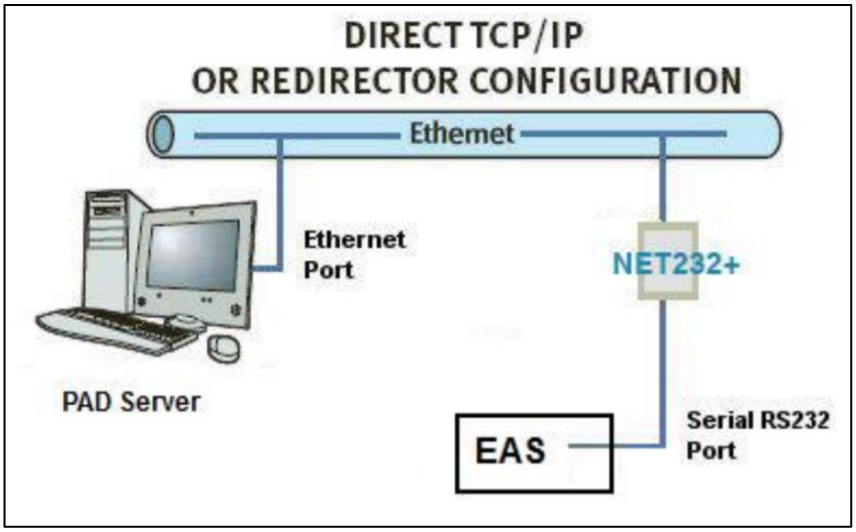


Figure 15. Direct TCP/IP or Redirector Configuration

“Com Port Redirector” is a free software utility available from Lantronix to send and receive serial data between a virtual Windows COM port and a NET232+ device. Most application programs should not know the difference between a real, hardware com port and the virtual port. As the Lantronix website describes it, Com Port Redirector (CPR) is software that maps ‘virtual COM’ ports on a PC platform. It redirects application data that would normally be intended for an attached device via the PC’s local serial (COM) port. Rather than going out the local serial port, the data is transmitted across the Ethernet network using TCP/IP. A device server attached to the network receives the data and transfers it from its own serial port to the attached equipment.

Likewise, data sent from the equipment to the serial port of the device server is transmitted back to the application software on the PC via Ethernet. Com Port Redirector receives the data and presents it to the control application in a virtual simulation, as though it came in from a COM port via a local serial connection.

But beware - some programs expect instant responses from serial ports when opening and closing com ports. To deal with this issue, “Com Port Redirector” can be set to keep the IP connection open even when the com port is closed, reducing latency and soothing these picky programs.

<u>Configuration</u>

Lots of details are important in setting both ends of the serial-over-ethernet link: The Sage EAS unit’s serial port must be selected and configured – baud rate, data format, etc. Likewise there are various settings for the virtual serial port in the server, and the static IP addresses assigned to the network side of the link.

The Sage EAS unit’s serial port must be selected and configured – baud rate, device format, etc. I chose COM4 and 9600 baud. The Sage ENDEC’s character generator serial output precedes each message with a number representing the “severity” of the emergency. This would be used by the Center Stage software to decide if the EAS information was to be sent through the PAD system, or not.

Level 1 message are direct threats to life and property like weather warnings, Level 2 are informational, like weather watches, and Level 3 messages are tests. This would be used by the Center Stage software to determine if the EAS information was to be sent through the PAD system. A given organization might prefer for everything to be sent through for display on HD and FM-RDS receivers, but there is an argument to be made for limiting the messages being transmitted to actual alerts.

We decided to configure the CSWeather-EAS software to pass along only EAS Level 1 messages, and edit the text down to just the type of alert, with the phrase “for our listening area” added. This allows the coverage area of the radio station to automatically limit the geography of the alert. Radio displays are limited in the number of characters displayed, so it is important to keep the total text string down a readable length. In our configuration an EAS text message on a WPR station would appear like this:

```
TORNADO WARNING FOR OUR LISTENING AREA
```

This message would continue to appear among the rotating PAD messages displayed for the duration of the emergency activation.

Testing

First and foremost, I patched the Sage ENDEC out of the WHA program path so I could generate test messages without annoying the listeners. Don't forget this step! I speak from painful experience back when we were first testing EAS gear in the 1990s.

With the redirector software installed on the PAD server computer and everything connected, I first used Windows own "HyperTerminal" program running on the PAD server computer to make the first connection and troubleshoot. There I was able to see test messages from the EAS unit.

Next I configured the CSWeather-EAS program to look to the same COM port and confirmed EAS test messages were being logged.

Then I configured the CS-Weather-EAS software program to forward warning-level 1 alerts, but not watches or tests, to the associated stations. For this first stage of the project the destinations are the HD PAD generator for AM station WHA and RDS encoder for its FM translator stations.

Level 3 Test - No PDS and PAD sent.	EAS Received:Tuesday, Jul 22,2014 10:59:18 ┐3A Broadcast station or cable system has issued a Required Weekly Test
Level 3 Test - No PDS and PAD sent.	EAS Received:Wednesday, Jul 30,2014 12:59:20 ┐3A Broadcast station or cable system has issued a Required Weekly Test
Level 1 Warning -	EAS Received:Friday, Aug 01,2014 16:29:54 ┐1The National Weather Service has issued a Severe Thunderstorm Warning
RDS and PAD sent.	RDS:Severe Thunderstorm Warning for Listening Area
Level 1 Warning -	EAS Received:Friday, Aug 01,2014 17:09:39 ┐1The National Weather Service has issued a Severe Thunderstorm Warning
RDS and PAD sent.	RDS:Severe Thunderstorm Warning for Listening Area
Level 1 Warning -	EAS Received:Friday, Aug 01,2014 17:13:17 ┐1The National Weather Service has issued a Severe Thunderstorm Warning
RDS and PAD sent.	RDS:Severe Thunderstorm Warning for Listening Area
Level 1 Warning -	EAS Received:Monday, Aug 04,2014 16:28:41 ┐1The National Weather Service has issued a Flash Flood Warning for Dane
RDS and PAD sent.	RDS:Flash Flood Warning From:4:28PM To:7:58PM for Listening Area

Figure 16. Log of Results

Results

The CSWeather-EAS program keeps a log of all the EAS messages received and transmitted. Figure 6 shows a sample page of this log showing of various tests and alerts. For each entry I've noted the type and whether or not the RDS and HD PAD text message was forwarded. This confirms that only Level 1 alerts are being sent to the radio receivers.

Summary

Wisconsin Public Radio has successfully added Emergency Alert System messages to the mix of metadata being transmitted via our Program Associated Data (PAD) system for display on HD and FMRDS receivers. Our initial tests on our flagship AM station WHA and its FM translators proved the reliability of the system, and it has since been expanded to serve our other Madison, Wisconsin area stations. The next phases will bring this service to WPR stations in Milwaukee, Green Bay, and other areas of the state. Cost for this project is low, listener feedback has been positive, and the effort involved has paid off in useful public service. Our goal has been reached: If a listener hears the EAS alert tones but misses the audio message, a glance at the radio display will provide the vital info.

For more information, contact Steve Johnston, Director of Engineering and Operations, Wisconsin Public Radio, Madison, Wisconsin.

ANNEX 2: RDS PROVIDERS LIST

UPDATED 2018-02-21

The providers listed in this Annex are known service providers or they have been **self-notified** as providing hardware and/or services to manage data for RDS applications. The suppliers listed herein have completed the form included in Annex 3 of the Guideline and submitted it to the NRSC, requesting inclusion in this list. An updated list is published as new items are added.

IMPORTANT ADVISORY FOR USERS OF THIS LIST

Neither the NRSC nor its members, participants or co-sponsors make any claim as to the suitability of this services or equipment for use in managing or transmitting RDS data. Parties interested in managing RDS data need to verify for themselves that the provider, service and/or equipment is in fact suitable for their needs.

Providers that are *NOT* on this list may very well be suitable for use managing RDS data.
Suppliers that have submitted valid self-notifications are included here. The NRSC acknowledges that other providers may also be suitable, and encourages all service providers and manufacturers who offer suitable products or services to self-notify with the NRSC.

Anyone wishing to provide information to the NRSC as to the suitability or unsuitability of these suppliers should send an email to nrsc@nab.org. Please include in this email the supplier's name and product or service(s) being discussed.

(continued on next page)

Company	Website / Contact Information	Nature of business	Description of services or product(s) provided	Date of Notification
Arctic Palm Technology, Inc.	www.arcticpalm.com csbuck@arcticpalm.com	Software developments specializing in solutions for Broadcasters	Specializing in software for radio, Arctic Palm Technology, Inc. was founded in 1997 in London, Ontario, Canada. In 2016 we were acquired by DTS Inc (now XPERI) whose commitment to Radio is equal to our own. We have several paperless studio products for contest management, work flow and call screening but, we are best known for our award-winning Data Casting Center Stage Live (CSRDS) package. Capturing metadata from over 70 different input sources, the data is reformatted as required and posted to any combination of RDS\RBDS Encoders, HD Radio including The Artist Experience, DAB/DRM Web Sites, Streaming services, Web services such as Tag Station, TuneIn, as well as a number of other devices and services. With over 3,300 licensed stations in Canada, USA and around the world using one or more of our products, we continue to provide broadcasters with the tools they need to ensure the best possible listener experience.	2018-02-15
Audessence Ltd.	www.audessence.com tech@audessence.com	Equipment manufacturer	RDS encoders, audio processors, etc.	2016-08-15
DEVA Broadcast	www.devabroadcast.com office@devabroadcast.com	Broadcast equipment manufacturer	DEVA Broadcast develops and manufactures a wide range of RDS/RBDS encoders and decoders, modulation monitors, remote controls, off-air monitoring receivers and other systems for the broadcasting industry. The company was established in 1997 and is nowadays well known as a market leader and international provider of user friendly, cost effective and innovative broadcast products. According to the company, all RDS/RBDS encoders developed and manufactured by DEVA Broadcast are in compliance with the latest EBU (IEC) and NRSC Standards.	2016-08-13
GatesAir	www.gatesair.com	Broadcast Equipment Manufacturer	The GatesAir Flexiva line of products includes RDS functionality built in as standard product. RDS provides your audience with the ability to identify your station format, station's name and/or call letters, Alternative Frequencies (AF), and Radio Text (RT). In addition, song and title information can be displayed.	2017-02-10

Company	Website / Contact Information	Nature of business	Description of services or product(s) provided	Date of Notification
Global Security Systems, LLC	www.alertfm.com mstraeb@gssnet.us	Broadcast-based emergency alerts using RDS	Global Security Systems, LLC (GSS) is the systems integrator and service provider of GSSNet (satellite CAP-based EAS data delivery), ALERT FM (FM RBDS broadcast-based text emergency message system) and Alert Studio (web-based CAP-compatible audio/text/image alert origination portal). ALERT FM is a personal alert and messaging system that enables company emergency management officials to create and send digital alerts and messages, including NOAA weather warnings, workplace evacuation instructions, and other company emergency information to employees, board members, and other company officials based on geographic or organizational groupings. GSS has participated in the development of IPAWS-based systems, is a member of the Commercial Mobile Alert Service systems committee, and is actively involved with several EAS and CAP committees. The GSS nationwide GSSNet satellite delivery system for emergency alerts currently is in operation at over 300 locations in 16 states and growing daily, and includes the ability to generate and deliver CAP messages.	2017-02-10
Inovonics, Inc.	www.inovonicsbroadcast.com sales@inovonicsbroadcast.com	Broadcast equipment manufacturer	● Model 730 RDS/RBDS Encoder: full featured RDS encoder with LCD front panel display for setup and verification of information. Accessible via USB, RS232, TCP/IP, and UDP for remote updating of dynamic song title, artist information, ODAs, RT+, clock time and all RDS data functions. ● Model 720 RDS/RBDS Encoder: RDS encoder with LCD front panel display for verification of information. Accessible via USB and RS232. Can be remotely updated to display song title, artist information and many other RDS data functions. ● Model 703 RDS/RBDS Encoder: Basic functions of RDS supported. Programmed via USB, the Model 703 is meant to give stations an RDS presence with station identification and promotional text.	2016-08-13

Company	Website / Contact Information	Nature of business	Description of services or product(s) provided	Date of Notification
Kvarta	www.kvarta.net tmanev@kvarta.net	Radio & TV equipment	Kvarta is widely considered as a reliable producer of radio and TV equipment. Our RDS/RBDS encoders are growing in popularity due to their reputation of reliability, quality and functionality at exceptional prices. All our RDS/RBDS encoders have been designed for professional broadcast use and are fully compliant with the standards. We are supplying the following RDS/RBDS encoder models: RDS300, RDS500 and RDS1000. All our encoders support UECP protocol. Besides the dynamic PS and RT text display features that you can get from RDS300 and the RT+ and SNMP capabilities of RDS500, the RDS1000 our top class RDS/RBDS Encoder supplies all the other ODA applications (TMC, EWS, paging, etc.). RDS1000 also supports configuration and monitoring of the RDS/RBDS encoder from multiple points.	8/31/12
PIRA Digital s.r.o.	www.pira.cz mail@pira.cz	Production of complementary FM broadcast equipment	● RDS/RBDS encoders ● FM analysis equipment ● RDS/RBDS analysis and consultancy	2016-08-13

ANNEX 2 - NRSC-G300-C, RDS Usage Guideline
RDS Providers List – UPDATED 2018-02-21

Company	Website / Contact Information	Nature of business	Description of services or product(s) provided	Date of Notification
2wcom Systems GmbH	www.2wcom.com wdrews@2wcom.com	Development and production of broadcast products	Basic and full-featured RDS/RBDS encoders with more than 15 years of experience in the market, fulfilling specifications like IEC 62106 and UECP 7.05. Additional features like automation system support, RDS/RBDS decoder (incl. full text TMC / TMC Pro) integrated in the RDS Encoder for easy control and set-up as well as multi IP-Port access available to run different services. Excellent references worldwide. Highly sophisticated RDS/RBDS decoders for measurement and control of all FM and RDS/RBDS parameters (incl. full text TMC decoding). Alarm support via email (SMS), SNMP and relay. Streaming of FM and RDS/RBDS data. Arcos Network Server Software to control medium and large RDS/RBDS networks. OCTO IP – RDS Data Multiplexing Solution for managing RDS Networks effectively. Satellite Receivers (IRDs) for distributing dynamic RDS/RBDS data to the transmission sites as embedded data or in separate PIDs. New: FM-MPX over IP or E1 (2 Mbit-line), incl. RDS/RBDS distribution. New: Audio over IP Codecs incl. RDS Data distribution New: RDS 2.0	2017-02-08
Worldcast Systems Inc./ Audemat	www.worldcastsystems.com peterle@worldcastsystems.com	Broadcast equipment mfg. / RBDS generation, analysis and monitoring	RBDS encoders including the world class FMB50 and the affordable RDS Silver. RBDS analysis equipment including the highly accurate FM-MC5. 24/7 RBDS performance FM Monitor and FM Monitor Silver. Expert assistance for all types of RBDS deployment including TMC, RT+, and other ODA's. Member of the RDS Forum since its inception.	2016-08-13

ANNEX 3: RDS PROVIDERS LIST SELF-NOTIFICATION FORM

The “RDS Usage Guideline RDS Providers List Self-Notification Form” begins on the following page.

RDS Providers List Self-Notification Form

Please submit completed form to:

National Association of Broadcasters
1771 N Street, N.W.
Washington, DC 20036
Attn: Technology Department
Email: nrsc@nab.org
Fax: 202-775-4981

This form is for suppliers of services and equipment managing and delivering RDS and/or HD Radio Program Associated Data (PAD) in accordance with the techniques discussed in the NRSC-G300-C Guideline. Please complete this form and submit it to NAB by mail, fax, or email, using the contact information above. Completed forms will be reviewed by the NRSC and if found complete, the equipment described therein will be added to Annex 2 of the next update of NRSC-300, which lists providers of RDS data management services or equipment.

Company information:

COMPANY				
NATURE OF YOUR BUSINESS				
ADDRESS				
CITY			STATE	ZIP CODE
PHONE (MAIN NUMBER)	FAX	WEBSITE		

Contact information:

NAME				
TITLE				
ADDRESS				
CITY			STATE	ZIP CODE
PHONE	FAX	EMAIL ADDRESS		

Description of services or product(s) provided (**150 WORDS OR LESS**):

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By signing and submitting this form I certify that:

- I am authorized to make this submission on behalf of (company name) ________________________________
- I understand that the inclusion of this equipment in Annex 2 of NRSC-G300 is at the sole discretion of the NRSC and that the NRSC may remove it from this list at any time.

SIGNATURE	DATE

NRSC Document Improvement Proposal

If in the review or use of this document a potential change appears needed for safety, health or technical reasons, please fill in the appropriate information below and email, mail or fax to:

National Radio Systems Committee
c/o Consumer Technology Association
Technology & Standards Department
1919 S. Eads St.
Arlington, VA 22202
Email: standards@cta.tech

DOCUMENT NO.	DOCUMENT TITLE:	
SUBMITTER'S NAME: COMPANY:	TEL: FAX: EMAIL:	
ADDRESS:		
URGENCY OF CHANGE: _____ Immediate	_____ At next revision	
PROBLEM AREA (ATTACH ADDITIONAL SHEETS IF NECESSARY): a. Clause Number and/or Drawing: b. Recommended Changes: c. Reason/Rationale for Recommendation:		
ADDITIONAL REMARKS:		
SIGNATURE:	DATE:	

FOR NRSC USE ONLY	
Date forwarded to NAB S&T:	____________________
Responsible Committee:	____________________
Co-chairmen:	____________________
Date forwarded to co-chairmen:	____________________

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