RECOMMENDATION ITU-R BS.1350-1

SYSTEMS REQUIREMENTS FOR MULTIPLEXING (FM) SOUND BROADCASTING WITH A SUB-CARRIER DATA CHANNEL HAVING A RELATIVELY LARGE TRANSMISSION CAPACITY FOR STATIONARY AND MOBILE RECEPTION

(Question ITU-R 71/10)

(1998)

The ITU Radiocommunication Assembly,

considering

a) there is an increasing requirement worldwide for a suitable means of multiplexing FM sound broadcasting with a sub-carrier data channel having a relatively large transmission capacity for stationary and mobile reception;

b) that FM sound broadcasting will support higher capacity data transmissions;

c) that the capacity of current data systems in common use in FM sound broadcasting is limited;

d) that technical developments in large capacity data systems for multiplexing with FM sound broadcasting have demonstrated the technical feasibility of larger capacity data systems;

e) that field trials and demonstrations have confirmed the feasibility of large capacity data systems for use in FM sound broadcasting;

f) that compatibility has been achieved between the FM stereophonic services including the Radio Data System (RDS) services according to Recommendation ITU-R BS.643 and any new additional sub-carrier system has been demonstrated;

g) that a much larger data capacity may be needed for some applications;

h) that sub-carrier data radio channel systems can provide relatively large transmission capacity compared to RDS and are capable of meeting compliance requirements of Recommendation ITU-R BS.412;

j) that several relatively large transmission capacity data systems according to Recommendation ITU-R BS.1194 have already been put into operation,

recommends

1 that systems for multiplexing FM sound broadcasting with a sub-carrier data channel having a relatively large transmission capacity for stationary and mobile reception:

1) must comply with current ITU policy on intellectual property rights;

2) must not interfere with:

   – the main broadcast on the same carrier or on adjacent carriers as stated in Recommendation ITU-R BS.412;

   – RDS and/or other sub-carrier services on the same or adjacent carriers as stated in Recommendations ITU-R BS.412 and BS.643;

   – aeronautical radio navigation services as stated in ITU-R IS.1009;

3) should be evaluated for selection taking into consideration the following characteristics and features relative to the needs of the particular application:

   a) system performance characteristics such as:

      – data reliability in Gaussian noise;

      – data reliability in multipath reception conditions;

      – data reliability with adjacent channel signals;

      – shortest end-to-end delay;

      – message error rate for various message lengths in multipath conditions;

      – synchronization acquisition time;

   b) additional features of the system such as:

      – minimum duty cycle for power savings;

      – receiver addressability;

      – conditional access;

      – support for various data types;

      – ability to operate in a network of data services;

      – possibility for additional sub-carrier services;

      – ability to operate independently of the radio network;

      – multiple station access;

      – capability for rebroadcasting;

   c) system compliance with Recommendation ITU-R BS.450;

   d) the ability of the system to minimize possible degradation to the audio main channel and/or RDS in multipath reception conditions;

   e) results of field tests of the system;

4) should be selected and specified with at least the following general features being identified:

   – sub-carrier frequency;

   – bandwidth;

   – channel data rate;

   – information data rate;

   – modulation method;

   – packet structure and framing (data structure);

   – forward error correction and interleaving approach;

   – error detection capability;

   – injection level;

   5) should be selected depending on the application.

NOTE 1 – These requirements, considerations and applications are discussed further in Annex 1.

ANNEX 1

Systems requirements for multiplexing FM sound broadcasting with a sub-carrier data channel having a relatively large transmission capacity for stationary and mobile reception

1 Introduction

1.1 Purpose

The purpose of this document is to assist in the selection of a specific system for providing relatively large data transmission capacity using sub-carriers multiplexed with FM sound broadcasts. This document presents a set of system characteristics that should be considered when selecting a system for the above purpose. These characteristics are divided into four aspects as follows:

– **General Features** is an overview of the basic parameters of the data systems (Section 3).

– **Additional Features** describes specifics of each data system that will tend to make it more or less suitable for special features of each system (Section 4).

– **Compatibility characteristics** which relate to the quantitative impact of the data system on existing services, both on the broadcast channel using the same carrier as well as on adjacent channels (Section 5).

– **System performance characteristics** which relate, in various terms, to the performance of the data system itself (Section 6).

It is recognized that compatibility characteristics of a system are important regardless of the application. The system performance characteristics are dependent on the specific requirements of the intended application. This document identifies the important system performance characteristics for a number of different applications.

1.2 Special requirements

As for all systems recommended by the ITU, the system chosen should comply with the current ITU policy on intellectual property rights (see Annex 1 to Resolution ITU-R 1). In addition, proposed systems should be field tested prior to selection.

2 System applications

System applications are based on receiver characteristics, data types and transmission characteristics. These are discussed in Sections 2.1, 2.2 and 2.3 respectively. A particular system application involves the transmission of one or more data types from transmitters having various characteristics, to receivers with one or more characteristics. Because of the particular data types, transmitter characteristics and expected receiver characteristics which distinguish any given application, certain system performance characteristics will be more important than others.

2.1 Receiver characteristics

Receiver applications are distinguished in terms of the following characteristics. Some receivers may be good enough to meet low data rates or reliability requirements, but will not be adequate where high data rates and reliability are required.

2.1.1 Physical characteristics of the receiver application

– availability of prime power to the receiver (battery size and capacity);

– receiver antenna performance;

– receiver mobility and speed of motion;

– receiver noise figure;

– ambient electrical noise.

2.1.2 Data requirements of the receiver application

– required data integrity;

– receiver addressability options;

– data traffic types;

– networking functions.

Several receiver applications have been identified as shown in Table 1.

TABLE 1

Receiver applications

Application	Power availability	Receiver antenna performance	Mobility
Vehicular	High	Fair to good	0-150 km/h
Portable	Low	Fair	0-5 km/h
Personal	Extremely low	Poor	0-300 km/h
Fixed	Very high	Good to excellent	0 km/h

2.2 Data types

There are two data types. Firstly, packetized data which involves communication of information that is naturally separated into data segments or messages for some reason. Usually this segmentation is associated with a header of some type which may be used for addressing the data to a specific user or otherwise designating something unique about that segment of information. Packetized data may be further categorized based on the length of the message. Some may be as short as a few tens of bits while others may be as long as hundreds or thousands of bytes.

Secondly, continuous data, which involves the communication of data at a fixed rate in a way that presumes that, if there is any segmentation of the data, it is accomplished in a higher layer in the protocol stack and frequently consists of a sequence of packets.

2.3 Transmission system characteristics

– signal strength and intended service area;

– ability of transmitters to address specific receivers;

– transmitter networking functions.

3 General features and parameters

The following general characteristics should be considered when selecting a system:

– sub-carrier frequency;

– bandwidth;

– channel data rate;

– information data rate;

– modulation method;

– packet structure and framing (data structure);

– forward error correction and interleaving approach;

– error detection capability;

– injection level.

4 Additional features

The following additional features should be considered when selecting a system:

– minimum duty cycle for power savings;

– receiver addressability;

– conditional access;

– support for various data types;

– ability to operate in a network of data services;

– possibility for additional sub-carrier services;

– ability to operate independently of radio network;

– multiple station access;

– rebroadcasting capability.

5 Compatibility characteristics

The following compatibility characteristics should be considered when selecting a system:

– interference to main broadcast service (on the same carrier);

– interference to RDS and/or other sub-carrier services (on the same carrier);

– protection ratio for broadcast services (on adjacent channels);

– protection ratio for RDS and/or other services;

– Recommendation ITU-R BS.450;

– protection ratio for aeronautical radio, Recommendation ITU-R IS.1009;

– degradation to audio main channel in multipath reception conditions.

6 System performance characteristics

The following system performance characteristics should be considered when selecting a system:

– data reliability in the presence of Gaussian noise;

– data reliability in multipath reception conditions;

– data reliability in the presence of impulse noise;

– data reliability with adjacent channel signals;

– shortest end-to-end delay;

– message error rate for various message lengths in multipath conditions;

– synchronization acquisition time.

Data reliability deserves some discussion. These characteristics are determined by the methods of modulation and coding as well as other features of the system. Data reliability performance is typically characterized in terms of Bit Error Rate (BER), packet loss rate or Probability of Correct Message Received (PCMR) as a function of the conditions in the channel.

For noise, these conditions are normally described in terms of Signal to Noise Ratio (S/N). For multipath and noise, the conditions are described in terms of the multipath delay spread profile and fade rates as well as average S/N. For impulse noise, the channel is described in terms of peak pulse powers, pulse width and pulse repetition rate. Data reliability in general determines the coverage area and will be affected by the injection level.

7 Example applications

A number of items have to be considered as the minimum features required for defining a generic specification of an FM data broadcasting service.

– **I1 Service channels**: A service channel offers a powerful way of managing access to a given service by an end-user terminal (automatic tuning, service roaming, ...).

– **I2 File transfer services**: It is desirable that transparent file transfers are managed by the system in order to provide a large range of applications using, for instance, standard software on Personal Computers.

– **I3 Real-time services**: Some services may need real time or assured maximum delay (Differential Global Positioning System (DGPS)).

– **I4 Conditional access**: Conditional access is a key feature for commercial services.

NOTE – Service multiplexing: A service identification and management system offers flexibility for broadcasting several services together.

Compatibility with future DSB services has to be taken into account.

If we consider the generic definition of any broadcasting system (according to the ISO Open Systems Interface, seven layer model), these seven key items can be achieved by having a common understanding about the interfaces on layer 3 (I1), 4 (I3, I4) and 5 (I2).

This is the basis of a further discussion. As a summary, a worldwide standard should fulfil the required interfaces.

The following sections provide some examples of specific applications in operation or under test, along with a list of the characteristics from preceding sections which are most important for each of these applications.

7.1 Intelligent Transportation System (ITS)

ITS requires several data types for transmitting transportation related information. Type 1 is for text, intended for portable receivers with small displays. Typically text ranges from 10-100 bytes in volume. Type 2 is for long textual or graphical information with simple road maps for traffic congestion and is intended for mobile receivers (vehicular). Typical data volumes range from 100 to 5 000 bytes. Type 3 is for transparent data and coded information intended for navigation, including large memory (CD-ROM) equipment having detailed road maps.

Data requirements vary greatly. DGPS is an example of Type 3 data requiring short delivery delay (< 10 seconds), at a rate of 10’s of bytes per second. A message of 10 to 20 bytes may be required for updating databases, perhaps of bus location or highway status. Since the database updates are used in the vehicle to help the driver determine the best route, and since delayed information can lead to incorrect route decisions for individuals and larger traffic problems for a highway network, end-to-end delay is an important metric for this ITS application. The database update messages will typically be repeated in a cyclic manner. However, since there is such a large volume of data, failure to receive a given update because of channel errors implies that the user must wait for the subsequent broadcasts. This would result in a larger effective delay, degrading vehicular traffic flow.

The following characteristics are most important to ITS applications:

– data reliability in multipath fading and noise;

– data reliability in the presence of impulse noise;

– end-to-end delay;

– information data rate;

– synchronization acquisition time;

– error detection and correction capability;

– implementation cost and risk;

– standardization.

Also, in order to achieve ITS network simplicity and reduce costs, the ability for a system to serve reliably a target area from a single transmitter is highly desirable. In addition, system capacity utilization should be kept as efficient as possible. Also, to encourage widespread use of ITS information, receivers for the system should be low cost. In evaluating candidate systems for this application, the characteristics above should be given high priority. A comparison of candidate systems should be made, paying particular attention to these characteristics.

7.2 Paging

Paging applications require the broadcast of relatively short packets to personal receivers. One of the critical characteristics for paging applications is the effectiveness of any power saving feature. This is important because of the severely limited prime power available for personal receivers.

Typically personal receivers also have very poor antenna performance. To provide reliable paging services, retransmission of the data is required, either on the same carrier or on other carriers. This reduces the effective throughput. However, the throughput requirements are not as stringent as for some other applications.

The following characteristics are important to paging applications:

– minimum duty cycle for power savings;

– implementation cost;

– receiver addressing;

– transmitter networking functions;

– error detection and correction.

7.3 Continuous data

For applications which may be characterized as “Continuous Data”, the data to be sent will not require any segmentation at the physical or data link layer. Segmentation, if it occurs, is at a higher layer in the protocol stack. This data segmentation, associated with the application, will be transparent at the natural boundaries of the data at the physical and data link layers as dictated by the systems considered here. Continuous Data applications often, but not always, provide strong signals from high power transmitters with high antennas and large service areas.

Important system performance characteristics include the following:

– information data rate;

– data reliability in the presence of Gaussian noise;

– data reliability in multipath fading and noise;

– data reliability with strong adjacent channel signals;

– receiver addressability;

– conditional access features.

7.4 File transfer

A file transfer interface provides for the conveyance of data via a point to (multi-)point transmission from the information providers to one (or more) receivers. It may be affected by the following characteristics:

– receiver addressability;

– information data rate;

– conditional access;

– ability to operate in a network of data services.

7.5 Text information

Textual information, such as news, weather, music related and other programme related information, is one of the important applications for an FM multiplex broadcasting system. These information services require a high level of reliability against transmission errors and hence powerful error correction and detection methods.

7.6 Emergency information

Emergency information that gives notice of an earthquake, severe weather or tsunami wave is one of the important applications for an FM multiplex broadcasting system. When emergency information is transmitted through an FM broadcasting path, a receiver that may be receiving another program automatically displays the emergency information.

7.7 Differential GPS

There are two classes of DGPS corrections that could be supported by FM sub-carrier transmissions. First, standard DGPS is based on code phase timing and requires several hundred bits per second or less of data throughput. For this class, overall delay through the communications channel, including the transmitter and receiver hardware, should be ten seconds or less. A second class of DGPS correction, which provides greater accuracy, is based on the RF carrier phase of the GPS transmission from the satellite. This class may require a few thousand bits per second of data throughput and an overall communications delay of 0.5 seconds or less. The following FM sub-carrier system characteristics are most important for DGPS applications:

– low throughput delay;

– low system error rate;

– good system coverage.

Also, effective error detection is essential, either within the data stream, or as part of the data transmission system. Since standard DGPS (i.e. DGPS based on code phase timing) is likely to play an important role in ITS applications, the characteristics described in Section 7.1 of this Annex are also important.