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Foreword

This Technical Specification (TS) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE 1: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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The Eureka Project 147 was established in 1987, with funding from the European Commission, to develop a system for the broadcasting of audio and data to fixed, portable or mobile receivers. Their work resulted in the publication of European Standard, ETSI EN 300 401 [1], for DAB (see note 2) which now has worldwide acceptance.

NOTE 2: DAB is a registered trademark owned by one of the Eureka Project 147 partners.

The DAB family of standards is supported by World DAB, an organization with members drawn from broadcasting organizations and telecommunication providers together with companies from the professional and consumer electronics industry.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document defines rules of implementation for certain service information features. These rules have been developed to provide a reliable and consistent experience for digital radio listeners; they provide implementation details for how the Fast Information Channel (FIC) signalling is used and how receivers will interpret and behave in response to receiving the FIC signalling. The rules defined in the present document supersede the informative guidance given in ETSI TR 101 496 [i.1] for the Fast Information Groups (FIGs) contained herein. In addition, some clarifications are provided for ETSI EN 300 401 [1] where a number interpretations may appear equally valid: in each case this is mentioned specifically. Future versions of ETSI EN 300 401 [1] will be modified to include these clarifications.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 300 401: "Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers".

[2] ETSI TS 101 756: "Digital Audio Broadcasting (DAB); Registered Tables".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 101 496 (all parts): "Digital Audio Broadcasting (DAB); Guidelines and rules for implementation and operation".

[i.2] ISO 10646: "Information technology -- Universal Coded Character Set (UCS)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Change Event Indication (CEI): set of FIG fields with particular values to indicate a change of database content for certain service information features

database entry: part of the service information addressed by a database key

database key: set of FIG fields that sub-divide a database for certain service information features

linkage set: description of a network configuration consisting of lists of identifiers which carry the same (hard link) or related (soft link) content

service element: the smallest addressable part of a service; a service component, either primary or secondary

NOTE: In a service that consists of only the primary service component, the term service element refers to the entire service.

service following: process for maintaining the same audio or data content that the user has selected in spite of the varying reception conditions that occur, for example, when travelling by car or train

service list: feature of a radio receiver where a list of service elements is used for service selection

service list entry: one item in a service list that represents a single service element

part-time service element: service element that cycles between an on-air and an off-air status

user controls: all elements of a user interface of a radio receiver that are used to display service information and provide for user control

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAC	Advanced Audio Coding
AM	Amplitude Modulation
AMSS	Amplitude Modulation Signalling System
C/N	Current/Next
CA	Conditional Access
CAId	Conditional Access Identifier
CEI	Change Event Indication
DAB	Digital Audio Broadcasting
DMB	Digital Multimedia Broadcasting
DRM	Digital Radio Mondiale
ECC	Extended Country Code
EId	Ensemble Identifier
F	Frequency
FI	Frequency Information
FIB	Fast Information Block
FIC	Fast Information Channel
FIG	Fast Information Group
FM	Frequency Modulation
Id	Identifier
IdLQ	Identifier List Qualifier
ILS	International Linkage Set
LA	Linkage Actuator
LSN	Linkage Set Number
LTO	Local Time Offset
MCI	Multiplex Configuration Information
MFN	Multi-Frequency Network
MJD	Modified Julian Date
MPEG	Moving Pictures Expert Group
MSC	Main Service Channel
OE	Other Ensemble
P/D	Programme/Data service flag
PI	Programme Identification code (RDS)
R&M	Range and Modulation
RDS	Radio Data System
Rfa	Reserved for future addition

Rfu	Reserved for future use
S/H	Soft/Hard
SC	Service Component
SCI	Service Component Information
SFN	Single Frequency Network
Shd	Shorthand indicator
SI	Service Information
SId	Service Identifier
TII	Transmitter Identification Information
UCS	Universal Character Set
UTC	Universal Temps Coordindee
UTF	Unicode Transformation Format

4 Overview of service information FIGs

Service information in DAB is carried in the Fast Information Channel (FIC) as a series of Fast Information Groups (FIGs) carried in Fast Information Blocks (FIBs). Different FIGs are used for different service information, and several different FIGs may be needed to implement a particular service information feature, such as service linking or announcements. The present document provides rules of implementation for service information ***features*** and so groups the usage of the required FIGs together. Some FIG types are used by a number of different features and the rules are designed so that the FIG is always coded and decoded consistently.

The FIC also carries Multiplex Configuration Information (MCI). This information describes the current multiplex in terms of services, service components and sub-channels. When the multiplex is reconfigured, the MCI also describes the next multiplex configuration.

Service information in DAB essentially fits into two categories: unique information and list information. The unique information category includes the service component language: each time the service component language is decoded, a receiver knows that it shall replace whatever it has stored with what is received because a service component can only have one language set at any given time.

The type 0 FIGs in the unique information category are as follows:

- FIG 0/5 - service component language, ETSI EN 300 401 [1] clause 8.1.2;
- FIG 0/10 - Date and Time, ETSI EN 300 401 [1] clause 8.1.3.1;
- FIG 0/13 - User application information, ETSI EN 300 401 [1] clause 8.1.20;
- FIG 0/16 - Programme Number, ETSI EN 300 401 [1] clause 8.1.4;
- FIG 0/17 - Programme Type, ETSI EN 300 401 [1] clause 8.1.5;
- FIG 0/19 - Announcement switching, ETSI EN 300 401 [1] clause 8.1.6.2;
- FIG 0/20 - Service component information, annex F;
- FIG 0/26 - OE announcement switching, ETSI EN 300 401 [1] clause 8.1.10.5.2;
- FIG 0/28 - FM announcement switching, ETSI EN 300 401 [1] clause 8.1.11.2.2;
- FIG 0/31 - FIC re-direction; ETSI EN 300 401 [1] clause 8.1.12.

The type 1 and 2 FIGs, which define the various labels, are also in the unique information category.

The list information category includes the list of frequencies for an ensemble, or a list of ensembles which carry a service. This type of information has a variable number of items in the list, and there may be more than one list, since there may be several ensembles or services, or whatever. DAB handles the transfer of this kind of information from ensemble provider to receiver by use of FIGs using a database mechanism.

The type 0 FIGs in the list information category are as follows:

- FIG 0/6 - service linking information, ETSI EN 300 401 [1] clause 8.1.15;

- FIG 0/9 - Country, LTO and International table, ETSI EN 300 401 [1] clause 8.1.3.2;
- FIG 0/11 - Region definition, ETSI EN 300 401 [1] clause 8.1.16.1;
- FIG 0/18 - Announcement support, ETSI EN 300 401 [1] clause 8.1.6.1;
- FIG 0/21 - Frequency Information, ETSI EN 300 401 [1] clause 8.1.8;
- FIG 0/22 - TII database, ETSI EN 300 401 [1] clause 8.1.9;
- FIG 0/24 - OE Services, ETSI EN 300 401 [1] clause 8.1.10.2;
- FIG 0/25 - OE Announcement support, ETSI EN 300 401 [1] clause 8.1.10.5.1;
- FIG 0/27 - FM Announcement support, ETSI EN 300 401 [1] clause 8.1.11.2.1.

The total set of information for each FIG is called a database, but since it may carry information from different service providers, it is divided into smaller portions to allow better management. Each portion of the database is addressed by the use of a database key so that it may be updated independently of the rest of the information. The database key is defined for each FIG and the information addressed by the database key is called a database entry.

The information carried by FIGs using the database mechanism is generally very stable, often relating to a transmitter network configuration. Since it is unknown when any particular receiver will tune to a DAB ensemble, the information needs to be transmitted cyclically. Each FIG using the database mechanism has a long form for carrying database entries and a short form for signalling that changes are to be made to a particular database entry.

Each database entry may require many FIGs to completely signal all of the information. The first FIG carrying information for a particular database entry is signalled with the C/N flag in the FIG type 0 header field (see ETSI EN 300 401 [1], clause 5.2.2.1) as the "start of database" entry; all subsequent FIGs needed to complete the database entry are signalled as "continuation of database" entries.

Over time, database entries will need to be changed, and this is done by means of the short form of the FIG - the Change Event Indication (CEI), which is defined separately for each FIG. The CEI mechanism works by sending a burst of short form FIGs to alert receivers of imminent changes. The short from is transmitted once per second for five seconds. When a database entry is changed, it is generally useful to send the new information for that entry more quickly than the overall repetition cycle for that database.

The FIG type 0 header field also contains the Other Ensembles (OE) and Programme/Data (P/D) flags. The OE flag is used to indicate if the information carried is for a service in the tuned ensemble or another ensemble. The P/D flag is used to indicate if the information is for a programme (audio) service or a data service. It is not possible to mix start of database with continuation of database, tuned ensemble and other ensemble information, or audio service and data service information within a single FIG since the three header flags apply to all the information in the FIG.

5 Service following

5.1 Introduction

5.1.0 General

Service following is the term applied to maintaining the same audio or data content that the user has selected in spite of the varying reception conditions that occur, for example, when travelling by car or train. Many broadcast network topologies are possible, and the tuned service may be carried on an ensemble with multiple tuning frequencies, on more than one ensemble, may carry common programming with other DAB services, and for audio services, also be carried on FM-RDS or another bearer. The best service following experience for the listener is achieved when the broadcaster minimizes the timing differences between different bearers, taking into consideration the different coding and decoding delays of the different systems. Reliable service following also requires that all the identifiers used are properly allocated in such a way as to make them unique within their respective scope.

DAB provides signalling that enables service providers to inform receivers about the broadcast networks and service configurations that allow service following to take place (much of which is static, since it refers to transmitter network configurations that change only infrequently), and also provides dynamic information to control which of that information is used at any given time to take account of changes during the day. Three types of information may be involved with service following - service linking information, Other Ensembles Services information and Frequency information. Service following generally provides information to allow precisely the same service to be followed, and when linking information is needed this is called hard linking. Service providers are also able to indicate suitable alternative content - related services - and this is called soft linking. Receivers shall investigate all possible hard links before checking for soft links, and since the content is not identical for a soft link, shall request user intervention before following the link.

Figure 1 shows the FIGs used for service following.

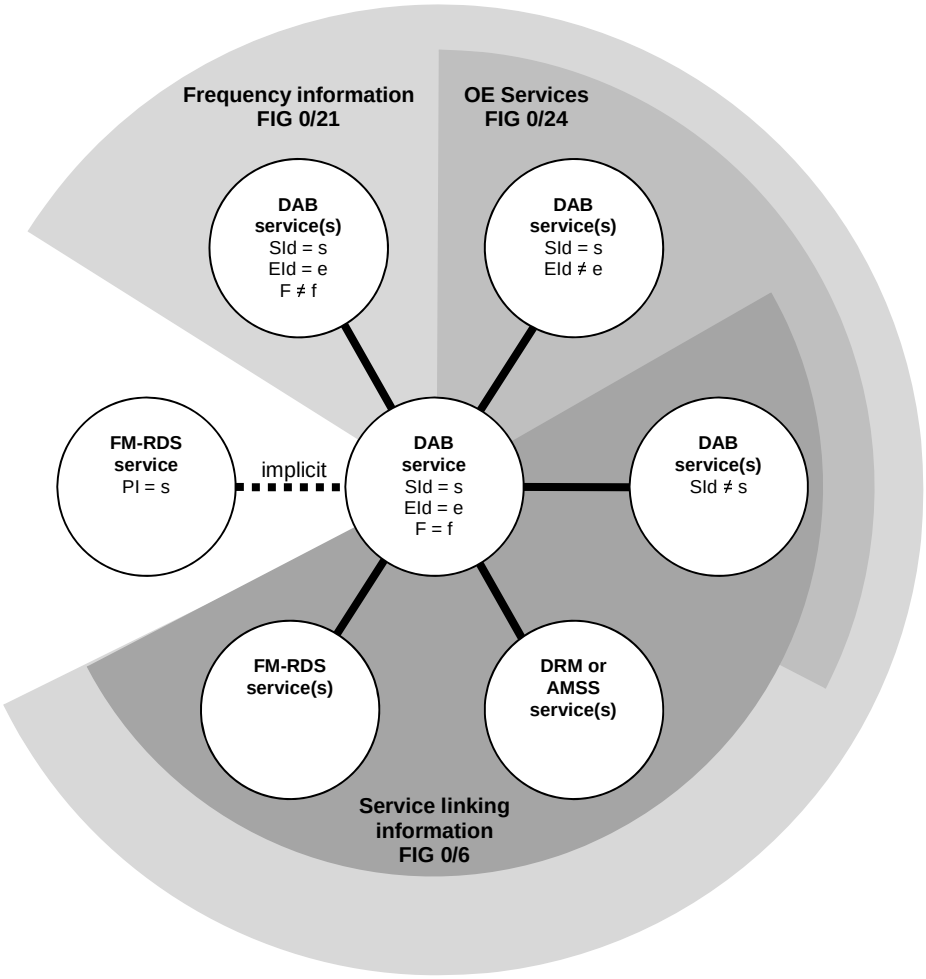

Figure 1: Service following and supporting FIGs

The DAB service at the centre of figure 1 represents the tuned service and it may have one or more of the alternate sources represented by the surrounding circles.

5.1.1 Service linking information

Service linking information allows the service provider to establish one or more sets of identifiers that carry identical, in the case of a hard link, or related, in the case of a soft link, content. The set of identifiers is called a linkage set. There may be several linkage sets that are valid at different times of day. Each linkage set is identified by the Linkage Set Number together with a set of flags, and by use of the Linkage Actuator, linkage sets can be activated and deactivated.

The receiver uses these linkage sets during service selection and following to determine a set of candidate services, potentially on different bearers, that are equivalent or related to the selected service. The receiver selects an appropriate service from these candidates based on criteria such as service availability and quality.

Receivers may cache linkage sets for services of interest (e.g. the currently selected service and other recently or frequently selected services) across power cycles, radio frequencies and locations so that the information is available immediately when the receiver is turned on and when it switches from one radio frequency to another. The benefits of caching may be negated if different ensembles carry inconsistent or incomplete linkage sets. It is therefore important that linkage sets are signalled completely and consistently (including the state of the Linkage Actuator) in all locations and on ensembles carrying any of the linked services.

5.1.2 OE Services

In order to assist the receiver, the service provider may signal a list of geographically adjacent alternative ensembles using FIG0/24 on which the current and other services can be found.

The receiver may use this information to identify ensembles carrying a service when it is selected by the user and during service following. This may reduce the number of radio frequencies that a receiver scans before it locates an ensemble carrying the service. This helps minimize the time delay between the user selecting a service and the start of audio output, particularly when selecting a service on another ensemble in a mobile environment. It also helps minimize the duration of any interruption to the audio output when service following occurs, especially in single tuner receivers.

It is therefore recommended that service providers signal OE Services to enable the best possible user experience during service selection and following. This information is especially useful when provided together with Frequency Information for other ensembles in the same or an adjacent coverage area.

5.1.3 Frequency information

In order to assist the receiver, the service provider may signal a list of alternative frequencies using FIG0/21 on which the current ensemble and other ensembles may be found. FIG0/21 may also signal frequency information for other bearers such as FM-RDS, DRM and AMSS.

The receiver may use this information to identify frequencies carrying an ensemble during service selection and service following. It may also use it to identify frequencies carrying linked FM-RDS, DRM or AMSS services during service following. This may reduce the number of frequencies that the receiver scans before it locates a service when it is selected by the user and during service following. This helps minimize the time delay between the user selecting a service and audio output and, especially in single-tuner receivers, the duration of any audio interruption during service following.

It is therefore recommended that service providers signal Frequency Information to enable the best possible user experience during service selection and following. This information is especially useful when provided together with OE Services for other ensembles in the same or an adjacent coverage area.

Where the same ensemble is available on different radio frequencies with overlapping coverage areas, it is also advantageous for the transmissions to be synchronized and for the continuity flag to be signalled in the frequency information. This enables the receiver to maintain continuous audio output during service following without any re-synchronization delay in the de-interleaver and audio decoder.

5.2 Service linking

5.2.0 General

The FIG0/6 consists of a header field and one or more service linking fields.

The service linking fields can take the short form or the long form and this is determined by the state of the Id list flag.

The database key for FIG0/6 consists of the OE and P/D flags from the header field and the S/H, ILS, and LSN fields from the service linking field.

In the preparation of these rules of implementation it was decided that some functionality permitted by ETSI EN 300 401 [1] should not be used. Therefore, the situation where OE = 1 shall not be signalled, although receivers should still check that this bit is set to 0 since it may be redefined in the future. The IdLQ field shall not take the value 10 since indicating services without the ability to identify themselves does not produce a good user experience. The situation where Shd flag = 1 shall not be signalled; instead each identifier shall be explicitly listed.

5.2.1 Short form - Activation state and change event indication

The short form has the Id list flag set to 0. It is used for signalling change: either change to the state of the Linkage Actuator (LA) flag of a linkage set or changes to the database content of a linkage set. The C/N flag in the FIG0/6 header is used to determine which type of change is being signalled.

When a service provider wishes to change the state of the LA flag - to activate or deactivate service following within a linkage set - the C/N flag is set to 1.

NOTE: This use of the C/N flag is not clearly described in ETSI EN 300 401 [1].

When a service provider wishes to change the content of the database associated with a particular linkage set - due to a network configuration change, for example - the C/N flag is set to 0.

Therefore it is not possible to indicate both types of change in the same FIG0/6 field; if both changes are required then separate FIG0/6 fields need to be sent with the C/N flag set correctly. However, it is possible to indicate the change of the LA flags for multiple linkage sets in one FIG0/6 field, and indeed this is required when a service changes which other services it is grouped with and so one linkage set is de-activated and another is activated (see clause 5.2.4.3).

5.2.2 Long form - Database definition

The long form has the Id list flag set to 1. It is used to build up the database of identifiers that are linked together to form linkage sets. The C/N flag is used in the database definition mode and the flag indicates the start of the database definition when set to 0 or a continuation of the database definition when set to 1. Every database definition requires a service linking field with a start of database indicator; depending on the number of bearers and number of identifiers, there may be one or several service linking fields with a continuation of database indicator. There shall be only one service linking field for the start of database for each database key.

NOTE: It is not possible to mix start of database definition and continuation of database definition service linking fields in the same FIG since the C/N flag applies to the entire FIG.

Each bearer requires a separate service linking field since it is identified by the IdLQ field. The order of identifiers signalled in the linkage set has significance. All DAB SIds shall be signalled first (IdLQ = 00), followed by all FM-RDS PI codes (IdLQ = 01) and finally service identifiers for DRM and AMSS (IdLQ = 11).

The sole exception is when there is a **single** DAB SId in the linkage set. In this case there is no need to signal the DAB SId separately since *"when the version number of the type 0 field is set to "0" (using the C/N flag, see clause 5.2.2.1), the first entry in the Id list of each Service linking field shall be the SId that applies to the service in the ensemble."* see ETSI EN 300 401 [1], clause 8.1.15.

The order of transmission of the identifiers shall be kept constant so that receivers may build confidence in the information they store.

To allow receivers to determine quickly if the service linking information in any particular linkage set is of interest, when there is more than one SId in the linkage set, all the SIds for services carried in the current ensemble shall be transmitted in the FIG indicating the start of database (C/N = 0, IdLQ = 00).

5.2.3 Linkage sets

A linkage set is a collection of identifiers (DAB SIds, RDS PI codes, etc.) that correspond to alternative sources of the same content (hard link) or similar content (soft link) - effectively a linkage set represents a particular transmission network configuration and so is essentially static. However, a particular service may have different alternative sources at different times of the day. Each of these different situations can be represented by a different linkage set, each corresponding to a particular network configuration.

The linkage set representing the current network configuration is activated, whilst all other linkage sets for that service are deactivated. A linkage set may be activated for 24 hours a day (and so represents the *only* network configuration for that service), or may be activated for only 30 minutes on weekdays, for the duration of an advertisement break, or any other such time period. Each linkage set is uniquely identified by a combination of flags and the Linkage Set Number (LSN). The LSNs shall be co-ordinated between all broadcasters in a particular country such that they are unique in combination with the flags. The activation state of all the defined linkage sets in the ensemble is signalled every 10 seconds, and more frequently when changes are made. When a linkage set is activated receivers may switch to one of the alternate sources of the content; when it is deactivated they shall not. This feature allows service providers to signal linkage sets in advance of their use and control the receiver linkage behaviour by changing the state of the LA flag for each linkage set.

EXAMPLE 1: A service provider has a service carried on four geographically adjacent DAB ensembles. For most of the day, the audio content is the same throughout the total coverage area of the four ensembles, but for four hours in the morning and three hours in the evening he produces different content for each ensemble area. When the audio content is identical the service provider wants receivers to freely switch between the ensemble areas so that a mobile listener (in a car or train) gets continuity throughout his journey, but when the audio content is different, the service provider does not want receivers to switch since they would then be playing different audio and this would be very annoying in the overlap zone between ensemble areas as the signal strength variation favours one and then another ensemble. Since the content is not identical throughout the day, the service will have a different SId on each of the four ensembles. By signalling a linkage set with all four SIds and using the LA flag, the service provider can signal to receivers when to link the services and when not to. This example is explored in more detail in clause A.3.

The linkage set definitions reflect different broadcast network configurations. If for a particular service, the alternative sources remain the same throughout the day, week and year, then only one linkage set is needed and it will be activated at all times. For other services there may be different alternatives at different times of day that reflect the programming needs of the service provider. Each broadcast network configuration can be represented by a different linkage set, and each of these should be defined and allocated an identifier - the LSN in combination with certain flags. As the day progresses and each configuration becomes valid, a different linkage set is activated to inform receivers of the valid alternatives. In this way the database information built up by the receivers remains static, but the validity of a particular broadcast network configuration is controlled dynamically by indication which linkage set is active.

The database key for FIG0/6 consists of the OE and P/D flags from the header field and the S/H, ILS, and LSN fields. Eight different types of linkage sets are available and these are differentiated by use of three flags: the P/D flag, the Soft/Hard (S/H) flag and the International Linkage Set (ILS) flag (rather confusingly, all eight types use the LSN field to carry the Linkage Set Number, so it is essential to always correctly set and determine the state of the P/D, S/H and ILS flags in combination with the LSN when assembling the databases. Also note that the OE flag, whilst part of the database key - and therefore used to divide the database into manageable pieces - does not create separate linkage sets for tuned and other ensembles.). This means that there are four Programme (audio) and four Data linkage sets, each having Hard National linkage sets, Soft National linkage sets, Hard International linkage sets and Soft International linkage sets. In fact the terms National and International can be misleading - the ILS flag for programme (audio) services switches between 16-bit fields and 24-bit fields for identifiers.

A service can only be active in one Hard linkage set and active in one Soft linkage set at a given time. A service can only be active in either a National Linkage set or an International Linkage Set at a given time.

Linkage sets may contain identifiers for services transmitted using DAB, FM (with RDS), DRM, and AM (with AMSS). These different bearers are distinguished by use of the Identifier List Qualifier (IdLQ) field, and each bearer requires a separate service linking field (or fields if there are many identifiers to signal).

EXAMPLE 2: A service provider has services with identical audio content for a particular period on two DAB services and three FM services, all with different audio content at different times and he wishes to link them together. He transmits a service linking field with the C/N flag = 0 [start of database] with the IdLQ set to 00 [DAB SIds] with Id1 and Id2 indicating the SIds of the two DAB services, and transmits a second service linking field with the C/N flag = 1 [continuation of database] and the IdLQ set to 01 [RDS PI codes] with Id1, Id2 and Id3 indicating the PI codes of the three FM-RDS services.

Implicit linking requires no service linking information to be sent. It provides the equivalent case to an activated hard linkage set in which the only entries are a DAB SId and an RDS PI code with the same value. This linkage set exists for all DAB services unless it is deactivated by defining and activating a hard linkage set which includes a service linking field with IdLQ = 01 [RDS PI codes]. Such a linkage set may contain zero PI codes in which case all service following to FM-RDS is prevented (the so called "dead link").

NOTE: If a network configuration exists where the DAB SId is linked to more than one PI code but includes the PI code that has the same value as the DAB SId, then the defined linkage set will include that PI code too.

5.2.4 Signalling a link

5.2.4.0 General

There are different phases to signalling a link. The database shall be defined (using the long form), activated and deactivated (using the short form) and may be redefined (changed) using first the CEI (short form) and then the long form. Database changes should be kept to a minimum. Listeners may tune to an ensemble at any time and therefore the database definition shall be repeated continually.

5.2.4.1 Defining and redefining a linkage set

Each definition or redefinition is handled in the same way. First a CEI shall be signalled to inform receivers that a database is about to be defined (a redefinition is simply a definition of an existing linkage set with changed content).

The CEI is signalled at least once per second for a period of five seconds. CEI is defined as the short form service linking field with the C/N flag set to 0 and the database key - the OE flag, P/D flag, S/H flag, ILS flag, and LSN - defining which database entry of the linking database is being changed.

Next, the database definition begins using the long form service linking field. The C/N flag is set to 0 for the start of the database definition and if more FIGs are required to complete the database, these are sent with C/N set to 1. The complete database entry for each database key should be transmitted within 10 seconds.

Services in the current ensemble shall be signalled in the FIG0/6 service linking field which indicates the start of database; this enables receivers to determine quickly if the linkage set is of interest or not. The other identifiers follow, in any order.

5.2.4.2 Maintaining the linkage set

Once defined, the identifiers in each linkage set shall be transmitted in the same order on each repetition, and shall be transmitted every two minutes to maintain the database and allow newly tuned in receivers to acquire the information. The state of the LA flag shall always be consistent with the activation state of each linkage set on each repetition.

The activation state of the defined linkage sets are signalled by using the short form of the service linking field with the C/N flag set to 1. The activation state of all the linkage sets in the database shall be signalled every 10 seconds.

5.2.4.3 Changing the activation state of linkage sets

Defined linkage sets are activated and deactivated by using the short form of the service linking field with the C/N flag set to 1. Each service can only be in one activated hard linkage set and in one activated soft linkage set at any one time (although can feature in several deactivated hard linkage sets and several deactivated soft linkage sets).

When a network configuration change needs to be signalled for a service, additional signalling is provided to alert receivers to the changes. If the activated hard linkage set for the service is changing, a short form service linking FIG is sent which contains two service linking fields; the first carries the details of the hard linkage set being deactivated, the second contains the hard linkage set that is being activated. If the activated soft linkage set for the service is changing, a service linking FIG is sent which contains two service linking fields; the first carries the details of the soft linkage set being deactivated, the second contains the soft linkage set that is being activated. If both the activated hard linkage set and the activated soft linkage set for the service are changing, a service linking FIG is sent which contains four service linking fields; the first carries the details of the hard linkage set being deactivated, the second contains the hard linkage set that is being activated, the third carries the details of the soft linkage set being deactivated, the forth contains the soft linkage set that is being activated. In this way, all changes are signalled in the same FIG ensuring that only one hard and one soft linkage set are activated at any one time. These FIGs are sent once per second for five seconds to enable rapid linking and delinking.

The state of the LA flag shall always be consistent with the activation state of the linkage set.

5.2.5 Receiver behaviour for a link

5.2.5.0 General

When a receiver initially tunes to a particular ensemble, it shall begin to assemble the service linkage database entry associated with each key- OE flag, P/D flag, S/H flag, ILS flag, LSN. Some linkage sets may be activated, others deactivated, as indicated by the LA flag for each key. FIG0/6 in the long form carries the lists of identifiers. During this phase, it is necessary to wait for the FIG0/6 in the long form with the C/N flag set to 0 indicating start of database in order to determine the SId(s) in the tuned ensemble to which the linkage set relates, although linkage sets may be built up whenever they are received. The receiver will never know that the database is complete, and receivers should act upon the information in the database whenever it needs to. There is a limit of 128 Ids (SIds, PI codes, etc.) in each linkage set (OE, P/D, S/H, ILS, LSN).

5.2.5.1 Reaction to CEI

When the CEI is received, that is a FIG0/6 in short form with the C/N flag set to 0, receivers are informed that the part of the linkage database corresponding to the database key - OE, P/D, S/H, ILS, LSN - is about to be changed or deleted. The database entry corresponding to the database key is deleted (if present) and the receiver makes whatever preparation is needed to begin to build a new database entry for the indicated database key.

5.2.5.2 Reaction to definition

Following a CEI period, a new database entry corresponding to the linkage information for the database key indicated in the CEI may be sent. Receivers shall begin to assemble the information when they receive a FIG0/6 in the long form with the C/N flag set to 0, indicating the start of the database entry corresponding to the key - OE, P/D, S/H, ILS, LSN. The receiver shall watch for FIG0/6 in the long form with the C/N flag set to 1, indicating a continuation of the database entry, and aggregate the identifiers according to the bearer information indicated by the IdLQ.

NOTE: Care should be taken to recall that when a FIG0/6 is received where the P/D flag is 0, the OE flag is 0 and the C/N flag is 0 that regardless of the IdLQ field, the first identifier is a DAB SId.

5.2.5.3 Reaction to activation and deactivation

Reception of the short form of FIG0/6 with the C/N flag set to 1 provides information on the activation and deactivation of defined linkage sets. Each service can only be in one active hard linkage set and in one active soft linkage set at any one time. The activation state of all linkage sets is transmitted every 10 seconds. When changes to the activation state take place, the activation state of the affected linkage sets is sent more frequently.

The flags OE, P/D, S/H, ILS and the LSN define which database entry is being activated or deactivated and the LA flag indicates the activation status - LA = 0 means deactivated and LA = 1 means activated. The receiver determines the activation status of a linkage set by the last received LA flag. It is the responsibility of the service provider to ensure the LA flag always correctly indicates the activation state.

5.3 OE Services

5.3.0 General

The FIG0/24 consists of a header field and one or more OE Services fields.

The OE Services fields can take the short form or the long form and this is determined by the state of the Number of EIds field.

The database key for FIG0/24 consists of the OE and P/D flags from the header field and the SId field from the OE Services field.

5.3.1 Short form - Change event indication

The short form has the Number of EIds field equal to 0. It is used for signalling changes to the database entry of the service indicated by the database key. The C/N flag is set to 0.

5.3.2 Long form - Database definition

The long form has the Number of EIds field not equal to 0. It is used to build up the database of EIds that also carry the service indicated in the SId field. The C/N flag is used in the database definition mode and the flag indicates the start of the database definition when set to 0 or a continuation of the database definition when set to 1. Every database entry requires an OE Services field with a start of database indicator; depending on the number of EIds there may be one or more OE Services fields with a continuation of database indicator. The order of transmission of the EIds shall be kept constant so that receivers may build confidence in the information they store.

5.3.3 OE Services fields

The P/D flag determines the length of the SId field that corresponds with a service in the tuned ensemble when the OE flag = 0, or in another ensemble when the OE flag = 1. It is most probable that the information will change very infrequently with a network configuration change when a service is added to or withdrawn from an ensemble.

The database key for FIG0/24 consists of the OE and P/D flags from the header field and the SId field.

5.3.4 Signalling

5.3.4.0 General

There are different phases to signalling. The database shall be defined (using the long form) and may be redefined (changed) using first the CEI (short form) and then the long form. Database changes should be kept to a minimum. Listeners may tune to an ensemble at any time and therefore the database definition shall be repeated continually.

5.3.4.1 Defining and redefining the database

Each definition or redefinition is handled in the same way. First a CEI shall be signalled to inform receivers that a database is about to be defined (a redefinition is simply a definition using an existing database key).

The CEI is signalled at least once per second for a period of five seconds. CEI is defined as the short form OE Services field with the C/N flag set to 0 and the database key - the OE flag, P/D flag, and SId - defining which part of the database is being changed.

Next, the database definition begins using the long form OE Services field. The C/N flag is set to 0 for the start of the database definition and if more FIGs are required to complete the database entry, these are sent with C/N set to 1. The complete database entry for each key should be transmitted within 10 seconds.

5.3.4.2 Maintaining the database

Once defined, the EIds for each database entry shall be transmitted in the same order on each repetition, and shall be transmitted every two minutes to maintain the database and allow newly tuned in receivers to acquire the information.

5.3.5 Receiver behaviour

5.3.5.0 General

When a receiver initially tunes to a particular ensemble, it shall begin to assemble the OE Services database entry associated with each database key- OE flag, P/D flag, SId. The receiver will never know that the database is complete, and receivers should act upon the information in the database whenever it needs to.

5.3.5.1 Reaction to CEI

When the CEI is received, that is a FIG0/24 in short form with the C/N flag set to 0, receivers are informed that the part of the OE Services database corresponding to the database key - OE, P/D, SId - is about to be changed or deleted. The database entry corresponding to the database key is deleted (if present) and the receiver makes whatever preparation is needed to begin to build a new database entry in the database for the indicated database key.

5.3.5.2 Reaction to definition

Following a CEI period, a new database entry corresponding to the OE Services information for the database key indicated in the CEI may be sent. Receivers shall begin to assemble the information when they receive a FIG0/24 in the long form with the C/N flag set to 0, indicating the start of the database entry corresponding to the database key - OE, P/D, SId. The receiver shall watch for FIG0/24 in the long form with the C/N flag set to 1, indicating a continuation of the database entry, and aggregate the EIds.

5.4 Frequency information

5.4.0 General

The FIG0/21 consists of a header field and one or more Frequency Information fields.

The Frequency Information fields can take the short form or the long form and this is determined by the state of the Length of Freq list field.

The database key for FIG0/21 consists of the OE and P/D flags from the header field and the RegionId, Id field and R&M fields from the Frequency information field. The P/D flag is always 0 for FIG0/21.

5.4.1 Short form - Change event indication

The short form has the Length of Freq list field equal to 0. It is used for signalling changes to the database content of the service indicated by the RegionId, Id field and R&M fields. The C/N flag is set to 0.

5.4.2 Long form - Database definition

The long form has the Length of Freq list field not equal to 0. It is used to build up the database of frequency information about DAB ensembles, FM-RDS or other services. The C/N flag is used in the database definition mode and the flag indicates the start of the database definition when set to 0 or a continuation of the database definition when set to 1. Every database definition requires a Frequency information field with a start of database indicator; depending on the number of frequencies there may be one or more Frequency information fields with a continuation of database indicator. The order of transmission of the frequencies shall be kept constant so that receivers may build confidence in the information they store.

5.4.3 Frequency information fields

When the OE flag = 0 it indicates that the Frequency information is for the tuned ensemble or for any other bearer which carries identical content to the primary component of a service in the tuned ensemble. When the OE flag = 1 it indicates that the Frequency information is for other ensembles or services on any other bearer that are not carried in the tuned ensemble. It is most probable that the information will change very infrequently with a network configuration change when a service is added to or withdrawn from an ensemble, or introduced or withdrawn on another bearer.

If frequency information is transmitted divided by RegionId (i.e. RegionId ≠ 0) then service following may use the received TII information to determine which frequency information is applicable and therefore reduce the number of alternatives to be tested. If RegionId is not interpreted by the receiver then the service following process shall use all the frequency information provided.

The continuity flag shall be set correctly in order to assist receivers with making switching decisions. For DAB frequencies, the continuity flag indicates whether continuous (i.e. uninterrupted) audio output is possible or not when switching frequencies; for other bearers it indicates whether an appropriate time delay has been added to allow seamless, (or near seamless) audio output or not when switching frequencies. For DAB, the continuity flag should only be set when a DAB ensemble is transmitted on several frequencies with co-timed and synchronized signals. Synchronized means that the frame start (null symbol) is sent at precisely the same moment in time, the interleaving is identical and the guard interval is respected on all frequencies. See clause A.1 for a use case of an MFN which uses the continuity flag.

The database key for FIG0/21 consists of the OE and P/D flags from the header field and the RegionId, Id field and R&M fields.

5.4.4 Signalling

5.4.4.0 General

There are different phases to signalling. The database shall be defined (using the long form) and may be redefined (changed) using first the CEI (short form) and then the long form. Database changes should be kept to a minimum. Listeners may tune to an ensemble at any time and therefore the database definition shall be repeated continually.

5.4.4.1 Defining and redefining the database

Each definition or redefinition is handled in the same way. First a CEI shall be signalled to inform receivers that a database entry is about to be defined (a redefinition is simply a definition using an existing database key).

The CEI is signalled at least once per second for a period of five seconds. CEI is defined as the short form Frequency Information field with the C/N flag set to 0 and the database key - the OE flag, P/D flag, and RegionId, Id field and R&M - defining which part of the database is being changed.

Next, the database definition begins using the long form Frequency information field. The C/N flag is set to 0 for the start of the database definition and if more FIGs are required to complete the database entry, these are sent with C/N set to 1. The complete database entry for each database key should be transmitted within 10 seconds.

5.4.4.2 Maintaining the database

Once defined, the frequencies for each database entry shall be transmitted in the same order on each repetition, and shall be transmitted every two minutes to maintain the database and allow newly tuned in receivers to acquire the information.

5.4.5 Receiver behaviour

5.4.5.0 General

When a receiver initially tunes to a particular ensemble, it shall begin to assemble the Frequency information database entry associated with each database key- OE flag, P/D flag, RegionId, Id field and R&M. The receiver will never know that the database is complete, and receivers should act upon the information in the database whenever it needs to.

5.4.5.1 Reaction to CEI

When the CEI is received, that is a FIG0/21 in short form with the C/N flag set to 0, receivers are informed that the part of the Frequency information database corresponding to the database key - OE, P/D, RegionId, Id field and R&M - is about to be changed or deleted. The database entry corresponding to the database key is deleted (if present) and the receiver makes whatever preparation is needed to begin to build a new database entry for the indicated database key.

5.4.5.2 Reaction to definition

Following a CEI period, a new database entry corresponding to the Frequency information for the database key indicated in the CEI may be sent. Receivers shall begin to assemble the information when they receive a FIG0/21 in the long form with the C/N flag set to 0, indicating the start of the database entry corresponding to the database key - OE, P/D, RegionId, Id field and R&M. The receiver shall watch for FIG0/21 in the long form with the C/N flag set to 1, indicating a continuation of the database entry, and aggregate the information.

5.5 Transmission model

5.5.1 DAB / DAB service following

There is no such thing as a "standard" DAB network. Depending on very many variables, networks will be built that provide the radio services that are needed. Some examples are listed below. In all cases, it is essential that proper allocation of identifiers is made such that there are no conflicts of information within the country.

A DAB service may be carried in an ensemble which is transmitted on different frequencies. In this case, service providers may assist receivers by providing the Frequency Information for the ensemble using FIG0/21. Clause A.1 illustrates this use case.

Another DAB service may be carried on different ensembles. In this case, service providers may assist receivers by providing the EIds of the other ensembles using FIG0/24 and may provide the Frequency Information for each ensemble using FIG0/21. Clause A.2 illustrates this use case.

Another DAB service may have programme splits according to geography available on different ensembles. At some times of the day, all the ensembles carry the same audio, but at other times, the service splits into regional variants. In this case service linking information is provided with FIG0/6 to define the network configurations and activate and deactivate different combinations. The ensembles on which each service variation is carried is provided with FIG0/24 and the frequencies of the ensembles with FIG0/21. Clause A.3 illustrates this case.

Another scenario is that a service is provided in both DAB and DAB+ in the same ensemble and in DAB+ only on another ensemble. The service provider can assist receivers by providing service linking information that connects the SIds, ensemble information and frequency information as above. Clause A.4 illustrates this use case.

A service provider may have several related radio services which sometimes carry the same content but sometimes carry different content. The service provider would like to help his regular listener in one location to find a similar service when in another location, and for this he provides service linking information with soft links using FIG0/6. He may provide additional information to help receivers tune to the related services. Clause A.5 illustrates this case.

5.5.2 DAB / FM-RDS service following

In order to allow receivers to continue to provide a service carried on DAB when moving beyond the digital coverage area, service providers with the same content available from FM-RDS can provide service following information. In the special case that identical content is ALWAYS carried on DAB and FM-RDS and the SId and PI code are identical, then a service provider can chose not to signal any FM-RDS service linking information, relying instead on implicit linking. In this case no service linking information is signalled and the receiver may switch between the DAB and FM-RDS sources as determined by algorithms in the receiver. However, in the general case, FIG0/6 is used to provide the linkage between the DAB SId and the corresponding FM-RDS PI code or codes. Implicit linking cannot cope with the cases where the content on DAB and FM-RDS is not identical at certain times of day - for this case FIG0/6 can be used to define the linkage set that connects the DAB SId and the RDS PI code together, and the linkage actuator can be used for the dynamic activation and deactivation of the link.

Because the coverage of DAB and FM transmissions may be different, and service providers may localize or regionalize their content on one or both bearers, the relationship between services carrying identical audio content may vary during the day. Each possible combination of DAB SId and RDS PI codes is expressed by a linkage set and as the day progresses and the different combinations become valid, the LA of each linkage set is either activated or deactivated. In this way, the database entries remain constant, but the active alternative services are dynamically controlled.

There are very many possible combinations.

There may be situations where allocation of SIds and PI codes has not been coordinated and service providers with no FM-RDS services may find receivers that implement implicit linkage switch listeners from DAB to the wrong FM-RDS service. To prevent this condition, service providers may signal an FM-RDS link without any PI codes - this is referred to as a "dead link" and is illustrated in clause A.8. If the tuned service is in an active linkage set that includes an Id list of type IdLQ == 01 (RDS PI codes) then implicit linking to the FM service with PI code = SId is disabled. If the service provider wishes to link to a PI code which is the same as the SId and other PI codes, they shall include all PI codes in the Id list.

5.6 Receiver Reference Model

5.6.0 General

This clause describes a conceptual model of a receiver that implements service following according to these Rules of Implementation.

The purpose of the model is not to specify a particular receiver implementation, but rather to define the expected behaviour of a conformant receiver. It is expected that real receivers may differ from the reference model in their detailed design and implementation, but that they will exhibit the same user-visible behaviour as the model.

A broadcast receiver designed for mobile reception may implement a service following process to keep track of a changing broadcast signal environment. The service following process is determined by 3 design elements:

- Reception monitoring.
- Information base.
- Service following process.

The present document makes assumptions on key aspects of these design elements as described in the following clauses.

Conceptually the receiver consists of a control circuit that monitors the reception quality and selects another service using the information base to recover from a degradation or loss of signal. The service following process is designed such that it provides for the best possible user experience requiring least user intervention along a given travel route.

5.6.1 Reception Monitoring

A mobile receiver shall provide a means to monitor the received signal. This may include one or more aspects of signal reception, such as signal strength, carrier-to-noise ratio, bit-error rates, etc. For each quality indicator a threshold level allows detection of a reduction or loss of signal. The decision circuit may include hysteresis for the ON/OFF decision making.

5.6.2 Information base

To identify a suitable alternative service or frequency resource, a mobile receiver can make use of various information sources. These may include service following information received through the FIC, learning memory and pre-stored data to build the information base. The information base consists of information elements combining frequency information, service identifiers and ensemble identifiers to unambiguously identify a broadcast signal. Since LSNs are allocated on a national basis, it is necessary to store the country code from the ensemble identifier along with the LSNs (and ideally the ECC too if available) in order to eliminate errors in the information base in areas where ensembles from more than one country are receivable.

The present document discusses solely information provided via the FIC forming the service following information. This may take some time to acquire and thus receivers benefit from storing in memory relevant service following information. It is assumed that the service following information represents the dominant part of the information base.

5.6.3 Service Following Process

5.6.3.1 Overview

The service following process deploys a multi-stage algorithm to keep track of a selected service and signal and where this fails, to identify and select an alternative signal and/or service. The service following process is an automated routine controlling tuning and decoding units to maintain and (re-) establish a minimal service reception.

When a loss of signal is detected, the service following process starts to test each element in the information base for signal and service availability. The service following process continues until service reception is re-established or a user intervention occurs. The process should prioritize a DAB service such that it is always selected while available.

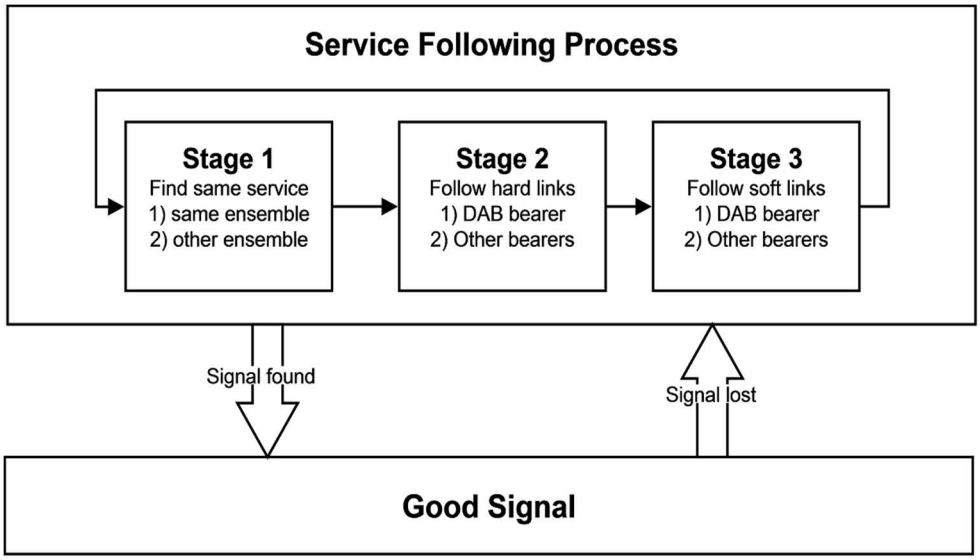

Figure 2: Service following process flow diagram

The service following process takes three stages, each stage is executed if the previous stage fails.

Stage 1 tries to recover the selected service 'as selected', testing only information elements that identify 'exactly the same' service at another frequency. The receiver should only change to services having the same service Id, as the user selected service. This should prioritize frequencies that transmit the same ensemble as the user selected.

Stage 2 searches for hard linked services as given in the information base. The receiver tries to identify services that are hard-linked with the selected service on either the DAB bearer or other bearers. This will allow a change of service, but will present the same audio content.

Stage 3 performs a search for soft-linked services on available bearers. 'Soft linked' services may represent various logical relationships to the reference service and may require user intervention to select. As in Stage 2, DAB-system service alternatives should be prioritized and other bearers should be evaluated secondly.

The Service Following Process has a cyclic design to account for the receiver moving randomly within the signal coverage, where no assumptions on signal availability can be made. The process always starts at stage 1, when the user selected service is not available. This may happen following a user action such as a preset call, or when a mobile receiver has moved out of the reception coverage area.

Subsequently the receiver will try to find a broadcast signal that contains the user selected service or, if this fails, a suitable alternative according to the service following information. The process ends, if a suitable service can be presented to the user. If in the course of this process, the receiver has tuned to a bearer other than the DAB system, it is expected to return to a DAB system service with priority.

It shall be noted here that a prioritization of DAB system reception will cause the receiver to return to a DAB system signal as soon such signal can be recovered. This may occur independently of the signal availability on other bearers.

This description provides only a rough outline of a factually implemented service following process. Any optimizations are implementation specific.

5.6.3.2 Stage 1: Find same service

The service following process begins at stage 1. This may happen, when the user selects the service that they wish to listen to, for example by pressing a preset button or by selecting a service from a list on the receiver's display.

The stored DAB SId of the selected service represents the Target SId. In this stage, the receiver attempts to locate a DAB ensemble containing a service with SId equal to the Target SId.

It may use Multiplex Configuration Information and Other Ensemble Service Information and observed information from previously-tuned ensembles to determine a list of candidate ensembles. From that list the receiver attempts to identify an ensemble that carries the target SId.

The receiver may use any available quality information and any criteria it chooses to filter or determine the priority order of candidates. For example, different receiver implementations may make different trade-offs between maximizing the initial reception quality and minimizing the initial selection time. Similarly, different receiver implementations may have different resources available (e.g. number of tuners, processing power, storage) that influence such trade-offs.

Note that information from previously-tuned ensembles may be incomplete or out-of-date and that previously-tuned ensembles may or may not be receivable at the current location. Different receiver implementations may use different strategies for determining how much information to store and when to refresh it. For example, a single-tuner receiver performing a service following decision may make a first quick pass using cached information and then perform another slower pass during which all information is refreshed, whereas a dual-tuner receiver with sufficient storage may cache all information and operate continuously in the background. Similar considerations apply to the following stages, with the difference that the target Sid represents a different service that has a linkage relationship to the selected service.

5.6.3.3 Stage 2: Follow hard links

At this stage, the receiver has failed to select the Target SId on any DAB ensemble. The receiver next attempts to find a service that is hard-linked to the Target SId and is therefore carrying identical audio content to the Target SId.

Stage 2.1

The receiver uses linkage information received for the selected service to assemble a list of target DAB SIds. From that list the receiver attempts to identify ensembles and frequencies that carry a linked SId. The receiver uses broadcast provided and observed information for this task. The receiver may use any available quality information and any criteria it chooses to filter or determine the priority order of candidates. Finally it will select an available service according that order.

Stage 2.2

The receiver uses Linkage Information from previously-tuned ensembles to determine a list of candidate services on FM-RDS or other bearers that may be hard-linked to the Target SId.

This includes implicitly linked RDS services.

Then the receiver uses Frequency Information from previously-tuned ensembles and observed information from previously-tuned frequencies to determine a list of candidate frequencies for each candidate linked service.

From that list, the receiver attempts to select each candidate service on each candidate frequency in turn.

The receiver may use any available quality information and any criteria it chooses to filter or determine the priority order of candidates. Finally it will select an available service according that order.

5.6.3.4 Stage 3: Follow soft links

At this stage, the receiver has failed to select the Target SId on any DAB ensemble and has also failed to select an equivalent hard-linked service on DAB or other bearers. The receiver next attempts to find a service that is soft-linked to the Target SId. This means a service with the same audio content is not available and a related service may represent the best alternative service according to the users expectations. A related service may be a regional variant of the selected service, it may be a language variant, a similar service on another network or another service within the same network.

Stage 3.1 and 3.2 are identical to stage 2.1 and 2.2 respectively, with the exception that stage 3 uses soft-linked services where stage 2 uses hard-linked service identifiers. As soft-linked services have generally different audio content, the receiver needs to avoid confusion over a possible change of service. Therefore soft-links should generally not be activated in a fully automated manner, this may require user interaction upon activation.

5.6.3.5 Handling of bearer system transitions

The service following process is designed to present the best available alternative to the user selected service. In the course of this process the alternative service may represent a significant departure from the initial user selection. The process shall be designed in a way that the receiver respects the initially user selected service at all times.

In the case of a bearer transition the receiver has moved away from the DAB system and is receiving a service on another bearer system, e.g. FM-RDS. If service following rules on the other bearer system are inconsistent with the rules applicable to DAB, it is left to the discretion of the implementer how conflicts or ambiguities are best handled in the interest of the user.

For example on FM-RDS a service may be regionalized. The user selected DAB service may only be linked to a particular regional variant of that service. Within the FM-RDS, a receiver may select another regional variant as part of the service following. As regionalization does not exist on DAB, returning to DAB on the other regional variant would represent a change of service and could conflict with the user expectation.

E.g. the user has selected SId = 0xD311, by implicit linkage the receiver selects PI code = 0xD311 as the DAB signal is lost. During a regional broadcast the tuned service changes to PI code = 0xD411. The implicit link would allow the receiver to return to SId = 0xD411, but this could represent a change of service and could conflict with the user expectation or the broadcasters intention. It is recommendable to require an explicit link being signalled on DAB to allow the change from PI code = 0xD411 to SId = 0xD411.

A similar situation may occur, when linkage information is temporally dynamic. After having followed a link, the receiver should ensure the validity of the linkage information. It may restart the service following process, if the currently selected service does not represent a valid alternative of the user selected service any more, e.g. if changes of the linkage information on DAB have occurred.

5.6.4 Stored services ("presets")

If the user stores a service as a preset on the receiver, and the service is not found when the user subsequently selects the preset, the receiver shall attempt all service discovery and linking methods to locate that service, or an alternative service advertising the preset service as a link.

Since relevant linkage information may not be available on the current ensemble, when a service is selected from memory, the receiver may store available linkage information related to the selected service at the time the service is stored.

EXAMPLE: A Service is stored on a preset with SId = 0xC586, EId = 0xC181, ECC = 0xE0, F = 227 360 kHz.

The user moves to a different location, and recalls the preset.

The receiver attempts to locate ensemble EId= 0xC181, ECC = 0xE0 at F = 227 360 kHz and fails.

The receiver should then attempt to discover SId = 0xC586 on alternative ensembles/frequencies. If that fails, the receiver should examine Linkage Sets (either acquired or stored) to locate SId = 0xC586 as a destination.

The receiver finds a linkage set with service SId = 0xC386 as the originating service, hard linked to 0xC486, 0xC586, 0xC686, 0xC786. As 0xC586 exists in this list, any of the services in this list (0xC386, 0xC486, 0xC686, 0xC786) are acceptable alternatives.

The receiver has recently acquired SId = 0xC686, EId = 0xC194, ECC = 0xE0 at F = 218 640 kHz and therefore tunes to this service as an acceptable alternative.

This behaviour is necessary to emulate the behaviour of recalling an FM preset when REG PI code following is enabled.

5.6.5 Linkage sets

The receiver maintains a number of Linkage Sets as part of an information base used for Service Following decisions.

Each Linkage Set contains the Identifiers for a set of one or more services, possibly on different bearers, that are equivalent (hard linked) or related (soft linked).

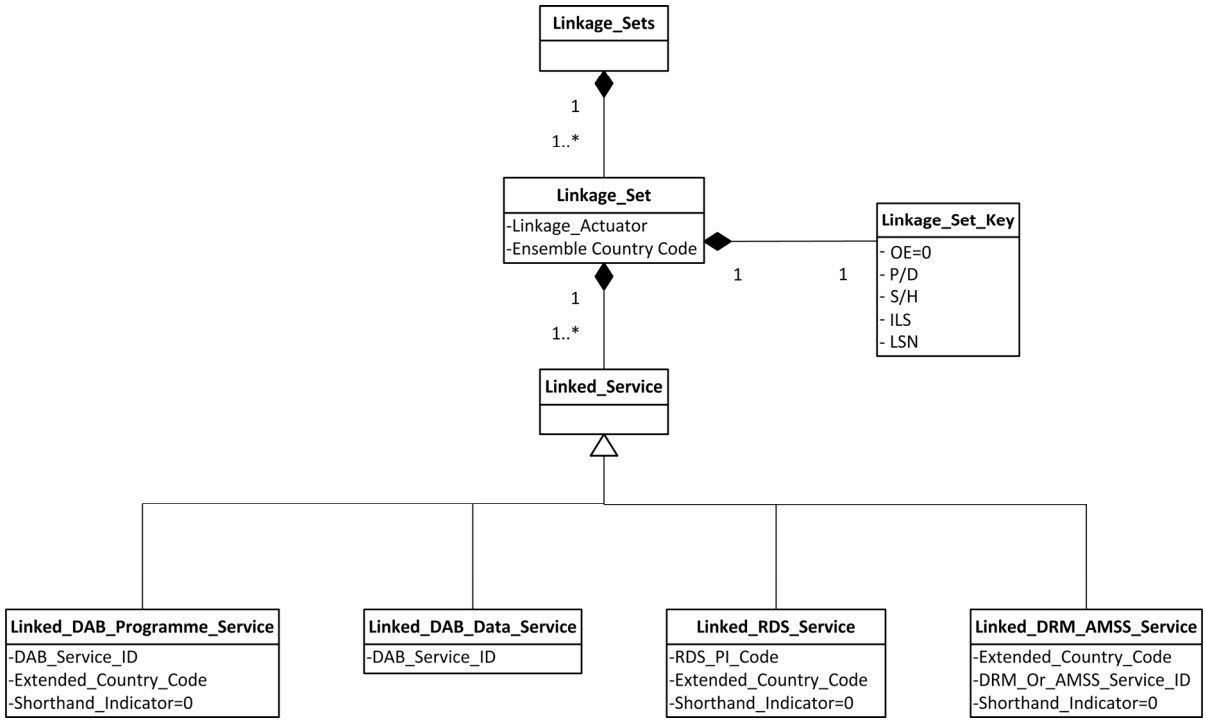

Figure 3: Structure of linkage sets

Each linkage set is uniquely identified by a database key comprising the Programme/Data flag, Other Ensemble flag, Soft/Hard flag, International Linkage Set flag, and Linkage Set Number.

Each linkage set contains one or more services which carry the same (in the case of hard links) or related (in the case of soft links) content.

Each service in a Linkage Set may be either a DAB Programme service, a DAB Data service, an FM-RDS service, a DRM service or an AMSS service.

Depending on its type, each service contains the information required to identify the corresponding service on its respective bearer; for example a DAB Service Id or RDS PI Code, and optionally, an Extended Country Code.

Any service can only be active in one hard linkage set and active in one soft linkage set at a time. A service can only be active in either a national linkage set or an international linkage set at a time.

If a receiver detects a conflict, and a service becomes active in more than one linkage set, the receiver may inactivate all linkage sets cached on the receiver containing that service, identified by the SId. Receivers are not required to detect conflicts and broadcasters shall not depend on them doing so.

5.6.6 Linkage set management

The receiver obtains the linkage sets from information supplied by service providers and signalled in FIG0/6.

Figure 4 defines the process by which a receiver may obtain and manage all of the linkage sets transmitted on the current ensemble.

Figure 4: FIG0/6 process tree

Receiver implementations may differ in the number of linkage sets they can store at any one time. As a minimum, a basic receiver shall maintain the currently active linkage set for the currently selected audio programme service. A more advanced receiver with additional storage capacity may maintain additional linkage sets - for example those associated with services stored on presets or otherwise determined to be of interest to the user.

A receiver implementation need only store the identifiers for bearers that it is capable of receiving and intends to use for service following. For example, a receiver that does not support service following from DAB to DRM need not store any DRM service identifiers in the linkage sets.

6 Service lists

6.1 Introduction

The efficient maintenance of the list of service elements that a listener may choose is an important aspect of the satisfaction that a user gains from using a digital radio. It is important that the options available to the listener are up to date, following the changing broadcast schedule, the roll-out of the transmission networks and the current location of the receiver. However, maintenance of the service list is quite a complex task and proper signalling by broadcasters and proper decoding and behaviour by receivers is required to make this happen well.

This clause 6 describes in detail the correct signalling and behaviours to enable efficient maintenance of service lists in receivers.

Managing the list of service elements comprises several requirements: automatically adding new service elements when they appear; removing those no longer available; following changes to the Service Identifier, changes to labels or the ensemble on which a service is carried; dealing correctly with part-time or "pop-up" service elements.

6.2 Managing ensemble changes

6.2.1 Describing an ensemble

A DAB ensemble carries a number of services, each of which has one (and only one) primary service component and may have one or more secondary service components. The current arrangement of the services carried in the ensemble is described by the FIG 0/2 with the C/N flag set to 0 (Current). FIG 0/8 provides additional information to correctly identify secondary service components.

When changes are to be made to these services at a reconfiguration, the next arrangement of the services is described by the FIG 0/2 and FIG 0/8 with the C/N flag set to 1 (Next) in the period of six seconds before the change actually occurs (both current and next are signalled during this period). The precise timing of the reconfiguration of the ensemble is signalled using the FIG 0/0, which also carries two flags to indicate the nature of the reconfiguration: change to the service organization, change to the sub-channel organization or change to both.

The service labels and service component labels are the mechanism by which users select the content they wish to consume. It is essential that these labels are signalled and decoded. FIG 1/1 shall be used for all audio services and FIG 1/5 shall be used for all data services that may be user selected. FIG 1/4 shall be used for all secondary service components that may be user selected. Additionally, FIG type 2 labels may also be provided.

In order to help devices to properly maintain the service list, broadcasters need to correctly signal the current service organization and all reconfigurations. In addition to the MCI and SI, the SCI, carried in FIG 0/20 (see annex F), shall be used to signal all changes to service elements in advance. In this way, the addition and removal of service elements, both continuous and part-time, the change to the SId of a service, or the transfer of a service to another ensemble, can be properly managed in receivers, including update of internal memory and presets.

In the subsequent clauses 6.3 to 6.5, the required signalling and receiver behaviours are described.

6.2.2 What is the service list

The service list is a feature of a digital radio receiver and the primary means for accessing, viewing and selecting all available services. An available service can be received at the place of the receiver with clear undisturbed audio. As a minimum the service list shall show all available service elements and provide a means to select any service element for consumption. Selecting a service element results in the tuner accessing the service element's ensemble and presenting the associated service element's content.

The service list consists of service list entries. Each service list entry represents one service element. A service list entry consists at least of a label associated with the service element; it should display the full length label with 16 characters. Each service list entry is associated with the service element identity (SId, SCIdS) and relevant tuning information, e.g. EId(s) and frequency. Additionally service list entries may show further information such as ensemble label, audio quality or programme type.

The service list shall show all service elements for which full MCI/SI has been received. It shall additionally show all service elements that are signalled as part-time, even when off-air. The service list shall not show service elements that the receiver cannot decode or present.

A receiver may provide optional means to mark a service list entry as "tentative", "end-of-life" or "part-time". Such marking may be shown in the service list to help the user understand the dynamic nature and current status of service schedules.

- **Tentative marking:** a service element that will commence service in the future is signalled in the SCI as to be added (**Change flags** set to 01) with the Date-time of the service start. A receiver may show the service element in the service list based on this information, if it can mark it suitably to indicate the service is not available at present but will commence service in the future. The receiver should show the provided Date-time to inform the user when the service will start. A receiver shall not show a service element before it has commenced service in the service list unless marked as 'tentative'. When a service list entry marked as tentative is selected by the user, the receiver shall attempt to tune the service element and if not available update the SCI status and date-time from the on-air signal.

- **End-of-life marking:** a service element about to cease service in the future is signalled in the SCI (with **Change flags** set to 10 or 11) as to be removed. A receiver may mark the service element as 'end of life' to indicate it will cease service in the future. A service list entry marked as such should show the date-time of the service ceasing. When a service list entry marked as end-of-life is selected, the receiver shall update the SCI status and date-time from the on-air signal; if transfer information is given, the alternative service shall be preferred for tuning.

- **Part-time marking:** a service element with a regular, cyclic on-air/off-air schedule is signalled as 'part-time' in the SCI (**Change flags** set to 01 or 11, **Part-time flag** set to 1). It shall be represented by a service list entry at all times, even during off-air periods. A receiver should mark the service list entry as to indicate the current on-air status, it should also show the Date-time (if available) of the next change of status. When a service element marked as part-time is selected by the user, the receiver shall attempt to tune it, during the off-air period the receiver shall update the SCI information and date-time from the on-air signal.

It is recommended that a receiver supports part-time marking on service list entries.

For the purposes of describing service reconfigurations, a distinction shall be made between the service transport mechanism on a digital radio system and its audio content. This can be referred to as a container-content relationship. Throughout this clause 6 the terms 'service' or 'service element' refer to the container, the term 'programme' refers to the content. In many cases 'service' and 'programme' can be used interchangeably, as a service element always carries only one programme and each programme is only carried in one service element. However under specific circumstances, different service elements may carry the same programme, e.g. for part-time regional programmes. In the use cases described in clause 6.5 a service may change its identity, while carrying a single, unchanged programme.

6.2.3 Establishment of the service list

When a receiver is switched on for the first time, it has no entries in the service list. Generally, in this condition, the receiver will begin an automatic scan of all the DAB channels in the receiver's tuning range and look for DAB ensembles. As each ensemble is found, the receiver will discover new service elements which it will add to its service list.

In some cases a service element will already have been found on another frequency or another ensemble: in this case the receiver should add the new frequency and/or new ensemble to the stored information as this represents an alternate source of the same service.

Receivers shall limit the service list to those service elements that are supported for user presentation; for example, a receiver that only supports audio service elements shall not include data service elements in the service list.

A receiver shall provide a function to update the service list upon a user action. This function shall perform the same full scan of all DAB channels as in the initial scan. In this process a clean list shall be created of all service elements that can be received at the time of scanning, including part-time service elements in off-air state.

6.2.4 Maintenance of the service list

After the initial establishment of the service list, maintenance processes are required to ensure the user is able to select all available services and is not confused by services that are no longer broadcast. As the user tunes to different services, the receiver shall check its service list against the received MCI and SI FIGs and make appropriate updates.

Receivers with multiple tuners may be able to check the status of other ensembles, even when the user is consuming a service. Otherwise, a rescan of all DAB channels should be performed periodically in order to discover newly launched ensembles. It is recommended that receivers with single tuners should also check known ensembles and perform a rescan of all DAB channels on an occasional basis at a time that the receiver is not in use.

A receiver can only discover a change to the configuration of an ensemble when it has a tuner that is tuned to the ensemble. This applies to single tuner and multiple tuner receivers alike. Changes to the configuration of an ensemble that happen when the receiver is turned off, out of the coverage area or tuned to another ensemble cannot be discovered, but the SCI provides advance information which shall be decoded and cached for later use.

Changes to the configuration of an ensemble may be discovered in the following ways:

- a tuner detects a reconfiguration of the ensemble by the decoding of FIG 0/0 and the corresponding "next" MCI;
- a tuner changes the tune frequency, either by user action or in an automatic process, or re-selects a previously selected ensemble after a resume from a power cycle or signal loss and discovers changes of configuration by comparing the "current" MCI against the ensemble configuration stored in the device memory.

At these points, referred to as "discovery points", the receiver shall use the MCI/SI, in combination with the SCI, to immediately update its service list information for all services in the ensemble, including those that are not selected. The SCI and associated label provides the necessary information to maintain a part-time service element in the service list even when it is off-air.

The SCI also provides information that allows a receiver to check whether it already has an entry in its service list that corresponds to a service that has changed its identity or moved ensembles. The detailed behaviour required for combining the MCI and the SCI is given in clauses 6.3 to 6.5. If there is no SCI information for a service element then the service list is updated according to the MCI alone.

Generally, SCI is used to provide information on pending ensemble reconfigurations ahead of time. Receivers should make use of advance information for user information, e.g. an upcoming service being added to the service list with a date and time of its coming into operation. SCI can also provide information on ensemble reconfigurations that have occurred already, in some cases this information is essential to a receiver to discover the change after the fact.

In some cases, SCI provides the only means of creating or maintaining a service list entry, e.g. part-time service elements during off-air periods or services that change their identity. In these cases the receiver shall use SCI for maintenance of the service list, of service memory such as presets and for general tuning behaviour. In particular, usage of SCI is required to minimize service interruptions in the case of a service changing its identity or moving to another ensemble.

As SCI provides a date-time that may change at any time and that is only an indication of a time an ensemble reconfiguration will occur, the receiver should apply special care when updating user controls by SCI alone. The event of an ensemble reconfiguration and the updated MCI establishes the facts about the changes in the ensemble. It is only after updated MCI has been received and evaluated that a receiver can make reliable changes to the operational controls.

In order to maintain the cache of SCI events, receivers shall decode the SCI information and store it. Receivers may optimize the storage, e.g. by not storing information for data service elements if the receiver is not able to decode the indicated data application.

Receivers shall limit the service list to those service elements that are supported for user presentation; for example, a receiver that only supports audio service elements shall not include data service elements in the service list. Changes to labels are only required to be transferred to the user controls at one of the discovery points.

6.2.5 Signalling conventions

SCI provides a means to provide information on ensemble changes ahead of time.

For service elements being introduced or off-air temporarily, full MCI/SI is not available. Then SCI is the only means to discover a service element and it shall always be accompanied by an associated label. This will allow receivers to create and maintain a proper service list entry. For service elements being removed or changing source or identity, SCI is provided in parallel with full MCI. In these cases the service component identification in the SCI refers to an existing service element in the same ensemble.

The **Date-time** field in the SCI indicates the future point in time at which the ensemble reconfiguration will occur. The **Date-time** field may also contain the special value (see Annex F) to indicate a past or unknown future date-time depending on the value of the **Change flags** field.

Part-time services alternate between an on-air and an off-air state. During the on-air period the service carries full MCI/SI. It is distinguished from a full-time service by the constant presence of an SCI field with the **P-T flag** set to one. The **Date-time** field and the **Change flags** follow the on-air/off-air cycle respectively. During an off-air period, while MCI/SI is absent, the SCI and label allows receivers to create and maintain service list entries.

In those cases when at least one of the **SId flag** and **EId flag** is set to 1, SCI provides information to the receiver of recommended sources for continuing a service element in the case of the service element being ceased or changing source and/or identity. This information may be essential to a receiver when the same or a linked service is not available. The **Transfer SId** will represent a different programme for ceased services and the same programme when a service changes its identity.

Broadcasters are recommended to provide transfer information whenever possible. It should remain on air after the reconfiguration (with **Date-time** field set to the special value) for a minimum period of time. This is to allow receivers returning to a service after the reconfiguration to take note of the past change and use the transfer information for service list update and continued service presentation.

It is recommended to schedule planned ensemble reconfigurations affecting the service list to a time of reduced listening, e.g. early morning hours, to reduce the chance of service disruptions. This applies in particular to services changing source or identity.

The permissible time-window for the date-time information is 28 days, to allow for an unambiguous interpretation of the date in the receiver. Broadcasters may decide freely how long in advance SCI should be provided. It is recommended to use a minimum of 7 days to allow users to take note of impeding changes in receiver displays and for receivers to store provided information in memory.

NOTE: The limitation of the time window implies that service elements with a regular on-air/off-air schedule that is longer than 28 days need to be signalled as continuous service element additions and removals, leading to repeated service list updates.

The SCI signalling occurs in three phases:

- the **preparation phase** occurs in the period (of up to 28 days) before the reconfiguration is signalled;
- the **reconfiguration phase** occurs during the reconfiguration signalling;
- the **consolidation phase** occurs after the reconfiguration has completed.

6.3 Adding service elements to an ensemble

6.3.1 Introduction

A service element is added to an ensemble that is a new programme and has not existed before. A receiver shall create a new service list entry or maintain an existing service list entry.

When a new service element is initially launched, there will usually be some promotion activity from the broadcaster, which may start some time before the actual introduction of the service element into the ensemble. Broadcasters shall provide advance information by using the SCI. The service introduction itself will require a multiplex reconfiguration to add the new service element and this is signalled appropriately.

Part-time service elements are repeatedly removed from and returned to the ensemble. In order to allow receivers to maintain the entry in the service list for such part-time elements, the SCI and labels shall be provided during off-air periods.

6.3.2 Signalling

6.3.2.1 Preparation phase

For up to 28 days before the introduction of a service element into the ensemble, the broadcaster shall provide advance information by the use of FIG 0/20. The respective service label or service component label shall also be signalled.

When a service with several service components is brought to life, each service component shall be added using a dedicated SCI field.

The fields of the SCI shall be used as follows:

- The **SId** and **SCIdS** fields shall be used to identify the service element;
- The **Change flags** shall be set to 01 to indicate the service element will be added to the ensemble;
- The **P-T flag** shall be set to 0 for the initial introduction of a service element, or 1 for a returning part-time service element;
- The **SC flag** shall be set to 1 since the SC description is required;
- The **SC description** shall be present and the fields set according to the needs of the service component;
- The **Date-time** field shall be used to indicate, to the nearest second in UTC, when the reconfiguration will occur that adds the service element to the ensemble; after the reconfiguration the **Date-time** field shall assume the special value to indicate the reconfiguration has occurred.
- The **SId flag** and **EId flag** shall be set to 0; **Transfer SId** and **Transfer EId** fields shall be absent.

The service label or service component label shall be signalled as appropriate. For data service elements, FIG 0/13 shall be signalled.

Part-time services

For a returning part-time service, when the **P-T flag** is set to 1, the **Date-time** field should be set to the date-time of the next reconfiguration when the service element commences service. When the **Date-time** field is set to the special value this date-time is unknown.

After the reconfiguration, the **Date-time** field should be set to the date-time of the beginning of the next off-air period and the **Change flags** shall be set to 11 (see clause 6.4).

NOTE: The initial launch of a part-time service element is signalled as a continuous service element, i.e. the **P-T flag** shall be set to 0.

6.3.2.2 Reconfiguration phase

During the six second period before the introduction of the service element into the ensemble, the broadcaster shall signal a reconfiguration. The necessary Next MCI for the service element shall be provided.

The SCI shall be signalled as for the preparation phase. The respective service label or service component label shall be signalled.

6.3.2.3 Consolidation phase

There is no consolidation phase.

6.3.3 Receiver behaviour

6.3.3.1 General

A receiver adds a new service to the service list typically when creating the service list or when it finds a new service element has been added to an ensemble that was previously tuned. In both cases the same set of rules applies.

A service shall be added the service list when the full MCI is detected to identify a service element and the receiver does not have a service list entry corresponding to that service element. An existing service list entry corresponding to that service element shall be updated with the newly received information. The receiver shall add service list entries for all service component types it supports. A service element for which incomplete MCI is provided, shall be ignored by the receiver.

An exception to this rule is a service element that is temporarily off-air. It lacks full MCI and is only represented by SCI given by FIG 0/20 and an associated label. A receiver shall add or maintain a service list entry for such service components, so that the service list entry is readily available when the service resumes at a later time.

A receiver may create a service list entry ahead of time, when SCI is detected for a new service. During the preparation phase the receiver should clearly mark the service list entry for the user to understand the service list entry cannot be selected. As the SCI also provides date-time information, this may be shown to the user. However as the signalling of date-time information in the SCI might be subject to change, the receiver should attempt to keep this information updated.

A service list entry shall at least be made of the label. For primary service components, the service label shall be used. For secondary service components the associated service component label shall be used. The sorting of service list entries shall be consistent and shall not change without user intervention to explicitly change the sorting order of the service list.

For the identification of a service element only the SId/SCIdS fields in MCI shall be used; other means, such as labels shall not be used. Service elements with different SId/SCIdSs, but the same label shall be treated as different service elements with separate service list entries. A service element with different labels (i.e. from more than one source) shall be represented by a single service list entry; the receiver chooses one of the provided labels as appropriate.

6.3.3.2 Response to signalling

When the receiver decodes the SCI with the **Change flags** set to 01, it is informed that a service element is to be added to the ensemble. When the **P-T flag** is set to 0 it indicates that a new service element will be added at the **date-time** indicated. The receiver should create a tentative service list entry with the information provided by the SCI and the associated label; it should further indicate the date-time of the service element coming to life in the service list entry. The service list entry shall be created at or after the ensemble configuration when the receiver discovers MCI for the inserted service element for the first time.

When the **P-T flag** set to 1 it indicates that a service element that has been on-air previously is currently off-air and will return at the date-time indicated. The receiver shall create or maintain the service list entry with the information provided by the SCI and the associated label. It may additionally indicate the date-time of the service element coming to life again. It is recommended that a receiver marks a temporarily off-air service element in the list to indicate its part-time nature.

The **SC description** field provides information on the service element to enable a receiver to determine if it can decode the content (FIG 0/13 is also required for a data service element). Receivers shall not present to the user service elements that cannot be decoded.

6.4 Removing service elements from an ensemble

6.4.1 Introduction

A service element is removed from one of several ensembles on which it is broadcast or it is removed from all ensembles. A receiver shall make sure it removes the associated service list entry unless it continues to receive the service element.

When a service element will no longer be broadcast, then it shall be removed from the ensemble. If there is a requirement to change the Service Identifier (SId) of a service, or if the service is moved to a new ensemble, then clause 6.5 shall be followed instead.

Since the user may not be tuned to the ensemble at the time the service element is removed, advance information shall be provided. If an alternative service element is available, the broadcaster shall also indicate the service that the receiver shall select if the user is tuned to the service when it is removed.

Broadcasters shall provide advance information by using FIG 0/20. The removal itself will require a multiplex reconfiguration.

Part-time service elements are repeatedly removed from and returned to the ensemble. In order to allow receivers to maintain the entry in the service list for such part-time elements, the SCI and labels shall be provided during off-air periods.

NOTE: The final removal of a part-time service element is signalled as the removal of a continuous service element.

6.4.2 Signalling

6.4.2.1 Preparation phase

For up to 28 days before the removal of the service element from the ensemble, the broadcaster shall provide advance information by the use of FIG 0/20.

The fields of the SCI shall be used as follows:

- The **SId** and **SCIdS** fields shall be used to identify the service element; when the **SCIdS** is 0 for the primary service component, the entire service with all its service components is being removed. When the **SCIdS** refers to a secondary service component, only this service component is removed.
- The **Change flags** shall be set to 10 to indicate the service element will be removed from the ensemble (but will remain available from other ensembles, local removal), or to 11 to indicate that the service element will be removed from **all** ensembles (global removal);
- The **P-T flag** shall be set to 0 for the final removal of a service element, or 1 for a part-time service element that is to return later;
- The **SC flag** shall be set to 0 since the SC description is not required;
- The **SC description** shall be absent;
- The **Date-time** field shall be used to indicate, to the nearest second in UTC, when the reconfiguration will occur that removes the service element from the ensemble; if the **P-T flag** is set to 1 and **Date-time** field is set to the special value, the date-time of the service element going off-air is unknown. The service element will go off-air within 28 days from the start of the on-air period.
- When the **P-T** flag is set to 0, the **SId flag**, **EId flag, Transfer SId** and **Transfer EId** fields shall be used as indicated in table 2. When the **P-T flag** is set to 1, the **SId flag** and the **EId flag** shall be set to 0.

Table 1: Settings for selecting post-reconfiguration service

Condition	SId flag	EId flag	Transfer SId field	Transfer EId field	Local removal	Global removal
No transfer service indicated	0	0	absent	absent	No information	
Transfer to same service (same SId) in another ensemble	0	1	absent	EId of other ensemble	Same service exists on other ensemble	Not used
Transfer to another service in same ensemble	1	0	SId of other service	absent	Other service in this ensemble	
Transfer to another service in another ensemble	1	1	SId of other service	EId of other ensemble	Other service in other ensemble	

For part-time service elements (**P-T flag** set to 1), the **Change flags** shall be set to 11, indicating a global removal.

Local removal

In the case of a local removal (**Change flags** are set to 10), the service element continues to exist on other ensembles.

A **Transfer SId** may be provided to point to services on other ensembles to allow those receivers to continue the service presentation that cannot receive an ensemble on which the service continues. The **Transfer SId** identifies a different programme in this case.

When only a **Transfer EId** is provided, transfer shall be made to the same service on another ensemble.

NOTE: A local removal shall only be signalled in situations where a service is available on more than one ensemble but the removal does not affect all ensembles. When a service element is removed from all its ensembles at the same time or when a service elements exists only in one ensemble, a global removal is signalled.

6.4.2.2 Reconfiguration phase

During the six second period before the removal of the service element from the ensemble, the broadcaster shall signal a reconfiguration. The next MCI shall not include the service element that is being removed.

The SCI shall be signalled as for the preparation phase. The service label or service component label shall be signalled.

6.4.2.3 Consolidation phase

There is no consolidation phase for a temporary removal (P-T flag is set to 1) since the service element will resume later (see clause 6.3).

After the reconfiguration has occurred for a permanent removal (**P-T flag** is set to 0), the broadcaster may provide confirmation information by the use of the SCI. It is recommended that the SCI remains on-air for at least 7 days after the reconfiguration.

The SCI shall be signalled as for the preparation phase, except that the **Date-time** field shall carry the special value to indicate that the change has occurred.

The service label or service component label shall not be signalled.

NOTE: Keeping the SCI on-air after the permanent removal of a service element allows receivers attempting to return to the removed service to take note of the configuration change and take appropriate action for service continuation.

6.4.3 Receiver behaviour

6.4.3.1 General

When a service element is removed from an ensemble this could affect the service presentation and the service list entry of the service component. When the selected service component is removed, the continuation of service is a primary concern. Reflecting a removed service component properly in the service list helps keep the service list up-to-date without the need for a full re-scan.

Updating the service list

A service component that is removed from an ensemble may continue to exist on another ensemble. Before deleting a service list entry, the receiver should ensure, that no other known ensemble carries the service component being removed.

If a service component is removed with the SCI indicating **Change flags** '11', this implies the service component is removed from all ensembles and the service list entry can safely by deleted in the receiver.

Continuing the service presentation

A service component shall be counted as removed, if no or incomplete MCI is given and no SCI is given indicating a temporary off-air period. Service presentation shall stop immediately and the receiver should start a process to continue service presentation using available alternatives in the following order:

1) For a removed secondary service component, the service shall continue with the primary service component.

2) The selected service element on another ensemble. The SCI may contain a **Transfer EId** without a **Transfer SId** to support this selection. An EId provided in Other Ensembles Services (FIG 0/24) may also be used.

3) A service that is linked by an active hard link. The linked service may be on FM.

4) In SCI for the removed service component, the broadcaster may indicate a 'preferred alternative' by means of a **Transfer SId**. This alternative represents a different service, and leads to a change of the audio programme. If a **Transfer EId** is given, the alternative is on another ensemble, a change of service requires re-tuning.

5) A service that is linked by an active soft link.

If by the above methods a continuation of service cannot be established, the receiver shall stop the service. It should display a 'service ceased' message as appropriate. When a service element is removed and the SCI has the change flags set to '11', the above process omits step 2.

When changing to another service in step 4. the audio programme will change, a receiver shall present a service referred to by a **Transfer SId** in the same way as a soft-linked service to the listener, prior to changing the audio programme (see also clause 5.6.3.4.)

6.4.3.2 Response to signalling

When the receiver decodes the SCI with the **Change flags** set to 10, it is informed that a service element is to be removed from the tuned ensemble, *but continues on other ensembles*.

When the receiver decodes the SCI with the **Change flags** set to 11, it is informed that a service element is to be removed from the tuned ensemble *and from all other ensembles.*

If the **P-T flag** is set to 0, a permanent removal is signalled; after the reconfiguration no MCI is present for the removed service. The receiver shall update the service list at the reconfiguration as applicable. As the same service element may continue to exist on other ensembles, the receiver shall not remove a service entry when the **Change** flags are set to 10, when it is aware of the service on another ensemble.

If the **P-T flag** is set to 1, a temporary removal is signalled; after the reconfiguration no MCI is present for the removed service, but an updated SCI will be present indicating the next service resumption. The receiver shall not modify the service list. It may update the date-time information in the display to the time the service element goes off-air.

If the **P-T flag** is set to 1, transfer information shall be ignored.

If the **Date-time** field contains the special value, the date-time of the service element going off-air is unknown. The service element goes off-air at an unknown time within 28 days after the beginning of the on-air period.

6.5 Changing the identity or source of a service

6.5.1 Introduction

A service element undergoes a technical reconfiguration for administrative purposes. A service list entry shall not be modified. A receiver shall minimize any service disruption that may occur to the selected service element.

When a service requires to change its Service Identifier (SId), usually due to regulatory reasons, or to move from one ensemble to another, usually for commercial reasons, broadcasters wish to complete the change without disruption to their audience.

To allow receivers to store or display information for later use, advance information shall be provided.

Advance information shall be provided by using FIG 0/20. The change itself will require a multiplex reconfiguration. In the case where a service element moves to another ensemble, SCI shall also be provided in the other ensemble to indicate the change of source and possibly identity of the service element. A receiver can discern the source and destination ensembles by the presence of MCI for the referenced service element.

6.5.2 Signalling

6.5.2.1 Preparation phase

For up to 28 days before the change of SId or move of the service to another ensemble, the broadcaster shall provide advance information by the use of FIG 0/20.

The fields of the SCI shall be used as follows:

- The **SId** and **SCIdS** fields shall be used to identify the service. The **SCIdS** field is set to 0 since the change affects the whole service.
- The **Change flags** shall be set to 00 to indicate the service will receive a new identity or be moved to another ensemble.
- The **P-T flag** shall be set to 0 for a continuous service or 1 for a part-time service.
- The **SC flag** shall be set to 0.
- The **SC description** shall be absent.
- The **Date-time** field shall be used to indicate, to the nearest second in UTC, when the reconfiguration will occur that changes the SId of the service or moves the service to another ensemble.
- The **SId flag**, **EId flag, Transfer SId** and **Transfer EId** fields shall be used as indicated in table 2.

Table 2: Settings for changed SId or service moved to another ensemble

Condition	SId flag	EId flag	Transfer SId field	Transfer EId field
Not used	0	0	absent	absent
Service is moved to another ensemble (SId is unchanged)	0	1	absent	EId of destination ensemble
SId of service is changed (same ensemble)	1	0	New SId for service	absent
Service is moved to another ensemble and changes SId	1	1	New SId for service	EId of destination ensemble

The service label or service component label shall be signalled as appropriate. The label shall appear for the new SId or on the other ensemble at the same time as the SCI with **SId flag** and/or **EId flag** set to 1 respectively.

Part-time services

For a part-time service element the **P-T flag** is set to 1, the change of SId and/or EId shall take place at the end of an off-air period. This is to minimize possible service disruptions. The reconfigured service will resume its service in the reconfiguration under the new identity and/or source. Therefore the SCI group with **Change flags** set to 00 replaces the SCI group with the **Change flags** set to 01, which would be signalled during the cyclic off-air period normally.

NOTE: When the **Change flags** are set to 00 while the **P-T flag** is set to 1, the signalling is for a permanent change of service configuration. Services shall not use **Change flags** set to 00 for cyclic reconfigurations.

Signalling on the other ensemble

When the **EId flag** is set to 1, the service will move from its current ensemble to another ensemble. For this SCI shall be present on both ensembles with the **SId** and **SCIdS** fields, **Change flags**, **P-T flag**, **SId flag** and **EId flag** all set to the same values. The **Date-time** field shall be set as required on each ensemble. The SCI shall appear at the same time on both ensembles. If the respective removal from the originating ensemble and the insertion at the destination ensemble do not occur at the same time, then the insertion shall occur first.

6.5.2.2 Reconfiguration phase

During the six second period before the change to the SId or the service or the service being removed from the ensemble, the broadcaster shall signal a reconfiguration.

For a service that changes its SId, the next MCI shall not include the existing SId and shall include the new SId. For a service that is moving to another ensemble, the next MCI shall not include the service that is being moved.

The SCI shall be signalled as for the preparation phase.

The service label shall be signalled for the service. For a service that is changing its SId, the service label shall also be signalled for the new SId. For a service that is changing its EId, the service label shall be present on the new ensemble.

6.5.2.3 Consolidation phase

After the reconfiguration has occurred, the broadcaster may provide confirmation information by the use of FIG 0/20. For a service that has changed its SId, the current MCI shall be signalled using the new SId. For a service that has moved to another ensemble, no MCI will be present for the service.

The SCI shall be signalled as for the preparation phase, except that the **Date-time** field shall carry a special value to indicate that the change has occurred. The **Date-time** field shall be set to the special value.

For part-time services in the on-air period following the source and/or identity change, SCI for the new SId shall be present (in the new ensemble in case of a source change) after the reconfiguration with date-time of the next off-air period and the **Change flags** set to 11 (see clause 6.4 for details).

SCI with **Change flags** set to 00 should remain on-air (in the old ensemble in case of a source change) for a minimal period of time to allow receivers attempting to return to the removed service to take note of the configuration change and take appropriate action for service continuation. This applies in particular if transfer information is provided. It is recommended that the SCI remains on-air for at least 7 days after the reconfiguration.

6.5.3 Receiver behaviour

6.5.3.1 General

The evolution of broadcast networks may from time to time cause purely administrative changes to ensembles. A service may change its identity, but continue as the same programme. A service may be moved from an ensemble to another, thus changing transmit frequency and possible coverage area, but otherwise remain the same programme. A service may also undergo an identity change, while being moved between ensembles.

These situations have in common a complex service and ensemble reconfiguration that shall not cause an update of the service list and should be handled by the receiver in an automated process that minimizes service interruptions.

Continuing the service presentation

While other means to continue the service presentation may exist, the transfer information in the SCI shall take precedence. Therefore the process of continuing the service presentation here is different from the case where a service is removed from an ensemble. The **Transfer SId** field points to the same audio programme. It is recommended that a receiver stores transfer information for an eventual later use. The process shall take the following order:

1) Continue service presentation with new identity and/or source as given in **Transfer SId** and/or **Transfer EId** fields respectively. Retuning may be required.

2) A service that is linked to the selected service by an active hard link. The linked service may be on the same or another ensemble. The linked service may be on FM.

3) A service element that is linked by an active soft link. The linked service element may be on the same or on another ensemble.

Generally the receiver shall not use linkage information instead of transfer information, unless the service moves to a new source that cannot be received by the receiver. The change of source and/or identity affects all service components of the changed service in the same way. Therefore continuation of service presentation shall occur with respect to the selected service component. Receiver memory shall be updated for all affected service elements.

6.5.3.2 Response to signalling

When the receiver decodes the SCI with the **Change flags** set to 00, it is informed that a service will change its Service Identifier (SId) and/or move to another ensemble. The change will affect all service components of the service in the same way. This setting may occur in a variety of broadcast scenarios, determined by the value of the subsequent fields of the SCI. All these scenarios have in common, that the service content remains the same and that new service list entries shall not be created.

When the **SId flag** is set to 1, the **Transfer SId** field contains the SId of the service the service is transferred to. This is the new SId of a service going through an identity change with all its service components. The receiver shall use the **Transfer SId** to update its internal memory for the service list, so that existing service list entries will point to the new identity. From the time indicated in the SCI, the new identity shall take precedence when service selection is performed. The receiver should also update associated internal memory such as presets accordingly.

When the **EId flag** is set to 1, the **Transfer EId** field contains the EId of the ensemble the service is transferred to. This indicates the service changes ensembles and will eventually cease to exist on the originating ensemble. Receivers shall update the internal tuning memory so that the new source takes precedence in tuning, when service selection is performed.

The **Date-time** field indicates the time point at which the reconfiguration takes place. When the receiver detects SCI with **Change flags** set to 00 for a future time point, when selecting a service element from that service, it should attempt to select the new identity immediately. If the **Date-time** field contains the special value, indicating the change has already occurred, the receiver when selecting a service element from the affected service shall attempt to select the new identity at the new source immediately. If MCI can be detected for the new identity, the receiver shall update internal memory and the new identity and source shall take precedence for service selection.

Table 3: Interpretation of transfer information

Condition	SId flag	EId flag	Interpretation
Not used	0	0	-
Transferred from another ensemble, same SId	0	1	The service changes it source, it is transferred between ensembles.
Change of SId within an ensemble	1	0	An administrative change of SId takes place, but the service continues as the same audio programme.
Transferred from another ensemble, different SId	1	1	The service changes it source while going through an identity change.

When updating existing service list entries, all receiver memory should be updated, so that presets created by the user are reassigned.

If the **P-T flag** is set to 1 and the **Change flags** are set to 00, the service element is currently off-air and will resume service under the new source and/or identity. The receiver shall use the **Date-time** field as the date-time of the beginning of the next on-air period. In this special case, the receiver shall additionally use the SCI in the same way as it would when the **Change flags** are set to 01 and **P-T flag** set to 1.

6.6 Changing the label of a service element

6.6.1 Introduction

For listeners, the service label or service component label is used to select the content they desire. Therefore, broadcasters should be very careful about changing these labels. Labels may be changed at any time and do not require a multiplex reconfiguration, but good practice is to retain the same label for as long as possible and only change it occasionally. It is likely that promotion of the new label and on-air advice will be needed. To ensure consistent behaviour in receivers, label changes will not always be presented to users immediately.

6.6.2 Signalling

The new service label or service component label shall be signalled. No other changed signalling is needed.

6.6.3 Receiver behaviour

The receiver shall update the internal memory with new label information, when a changed label is detected (see clause 6.2.4). When an updated label has been detected all user controls shall be updated.

When a receiver detects different labels for a single service element on different ensembles, only one service list entry shall be created. The receiver shall use one of the available labels to mark this service list entry.

Annex A (informative): Service following - use case examples

A.1 DAB to DAB link in Multi-Frequency Networks

A.1.1 Problem Description

The same ensemble is transmitted on channel 5A and channel 5C (174 928 kHz and 178 352 kHz). Both areas are adjacent. The transmission mode is I. The signals are co-timed and synchronized.

Users may expect almost seamless switching between the different frequencies when the ensembles are identical and synchronized.

Synchronized means that the frame start (Null symbol) is sent at precisely the same moment in time, the interleaving is identical and the guard interval is respected. A synchronized MFN is managed like an SFN, the only difference being that the signal is modulated on more than one frequency.

A.1.2 Concept

A dual tuner device will find the alternative by scanning in the background.

A single tuner/decoder device should try to monitor the signal strength at all the frequencies indicated by the frequency information in FIG0/21. If a signal is available on another frequency it might try to retune the tuner while keeping the decoder pipeline in operation. Confirming the EId of the chosen frequency before switching reception of the MSC should provide for seamless switching.

A.1.3 Signalling

A.1.3.1 FIG0/6 Service linking information

Not required for this use case.

A.1.3.2 FIG0/24 OE Services

Not required for this use case.

A.1.3.3 FIG0/21 Frequency Information

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned Ensemble
P/D	0	not used for Frequency Information
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	9	Length in bytes of the following FI list
Id field (Identifier field)	0xD201	EId
R&M	0b0000	Range and Modulation, DAB ensemble.
Continuity flag	1	The ensemble is co-timed and synchronized
Length of Freq. list	6	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x02AB5	The multiplier of 16 kHz of the centre frequency 174 928 kHz
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x02B8B	The multiplier of 16 kHz of the centre frequency 178 352 kHz

A.1.4 Receiver Behaviour

A.1.4.1 Single tuner device

A single tuner decoder device should try to monitor the signal strength of the frequency it is not tuned to; so when tuned to 5A it should monitor the signal strength of 5C and vice-versa. If the receiver can also determine the EId of the signal at the other frequency it can confirm if the correct ensemble is present.

If the signal strength on the other frequency is better it should retune while keeping the decoder pipeline in operation.

If the EId of the newly acquired ensemble does not match the original then the receiver should retune to the original frequency.

A.1.4.2 Dual tuner device

A dual tuner will synchronize the second tuner to the second frequency. In case of signal loss on the first frequency he might switch the tuner or retune the foreground tuner keeping the decoder pipeline in operation.

A.2 Linking to the same service on different ensembles

A.2.1 Problem Description

The same programme service (same SId) is available on multiple ensembles (differing EIds), and those ensembles are on a variety of frequencies.

The following example represents a case in Switzerland in 2011.

Figure A.1 illustrates the coverage areas of three different ensembles. The example explains service following for one service that is available in all ensembles. The bold line illustrates a possible travelling route between the different coverage areas.

The ensemble with EId 0x4001 is geographically adjacent to the ensemble with EId 0x4041 and some areas have coverage from both ensembles, for example, when travelling from point A to point B. The ensemble with EId 0x4081 is surrounded by high mountains and has no overlapping coverage areas with any of the other ensembles. This region can only be reached via tunnels or passes. So travelling from any of the other ensembles to the coverage area of ensemble 0x4081 will result in lost DAB reception.

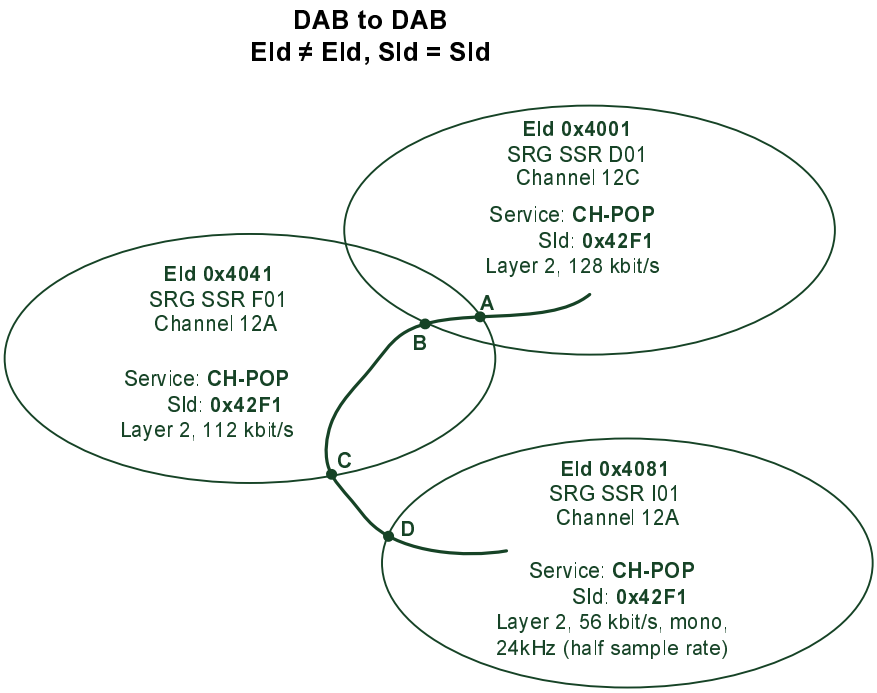

Figure A.1: Ensemble coverage schematic

A.2.2 Concept

Signalling of FIG0/24 will help a single tuner to identify alternative ensembles carrying the same service.

Signalling of FIG0/21 will help a single tuner to find the frequencies of the alternative ensembles.

A dual tuner may detect the same service on a different ensemble and frequency by periodic analysis of received signals.

A.2.3 Signalling

A.2.3.1 FIG0/6 Service linking information

Not required for this use case.

A.2.3.2 FIG0/24 OE Services

Signalled in all ensembles, EIds in the same order.

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned ensemble (the service exists in the tuned Ensemble)
P/D	0	Programme service
SId	0x42F1	Service for which ensemble information is being signalled
Rfa	0	
CAId	0	No Conditional Access applicable
Number of EIds	3	3 Ensemble Ids to follow
Ensemble Identifier	0x4001	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x4041	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x4081	Ensemble Id of an ensemble carrying the Service

A.2.3.3 FIG0/21 Frequency Information

Signalled *differently* in each ensemble since this is the OE frequency information. Signalled in Ensemble **0x4001** as below.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the frequencies belong to other ensembles)
P/D	0	Not used
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	12	Length in bytes of the following FI list
Id field (Identifier field)	0x4041	EId of the other ensemble
R&M	0b0000	Range and Modulation, DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz
Id field (Identifier field)	0x4081	EId of the other ensemble
R&M	0b0000	Range and Modulation, DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00011	Not adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz

A.2.4 Receiver Behaviour

A receiver should decide a point at which the currently received signal is inadequate. For a single tuner device this may be through use of a fixed reference point, and for a dual tuner by comparison with the quality of signal being received from other frequencies.

The receiver should attempt to locate the current service on an alternative ensemble. It may use the OE services and frequency information provided by the broadcaster, using Region Information when supplied to reduce the number of alternative ensembles to try to just those in the current Region.

If this fails, or no OE services information is being signalled, the receiver will attempt to locate the current service by scanning all possible frequencies and analysing all the services on the ensembles found.

E.g. travelling from point A to C in the picture above. Between A and B, both Ensembles are available and in both Ensembles FIG0/24 and FIG0/21 are signalled. Switching between the Ensembles may occur at any time.

A.3 Linking regional variations of a service on different ensembles

A.3.1 Problem Description

A programme service is broadcast across multiple regions, on different ensembles. At certain times the programme service is identical on all ensembles, and at other times the content is different. As the programme content is not always identical on all ensembles at all times, each regional variation has a different SId code. The periods of non-identical content may be of only a few minutes duration, such as commercial breaks or news bulletins, or may be for the duration of a programme segment.

At times when the programme service is identical, the broadcaster wants the listener to experience continuous coverage, as if the service was transmitted with the same SId code on all ensembles.

At times when the programme service is not identical, the broadcaster does not want the listener to be switched between regions automatically by the receiver.

The broadcaster can control whether linking is active or inactive, and can do so quickly and often.

In figure A.2 the four related services are carried on four ensembles. On weekdays the following schedule applies: from midnight until 06:00, the four services carry the same audio; from 06:00 until 10:00, the four services are all separate; from 10:00 until 16:00 the four services again have identical audio; from 16:00 until 19:00 the two services in the west share one programme and the two services in the east share a different programme; from 19:00 until midnight all four services are again identical. On Saturday schedule has all four services carrying the same audio except between 14:30 and 17:00 when the two services in the north carry one football match, whilst the two services in the south each carry their own football match. On Sundays, all services carry the same audio.

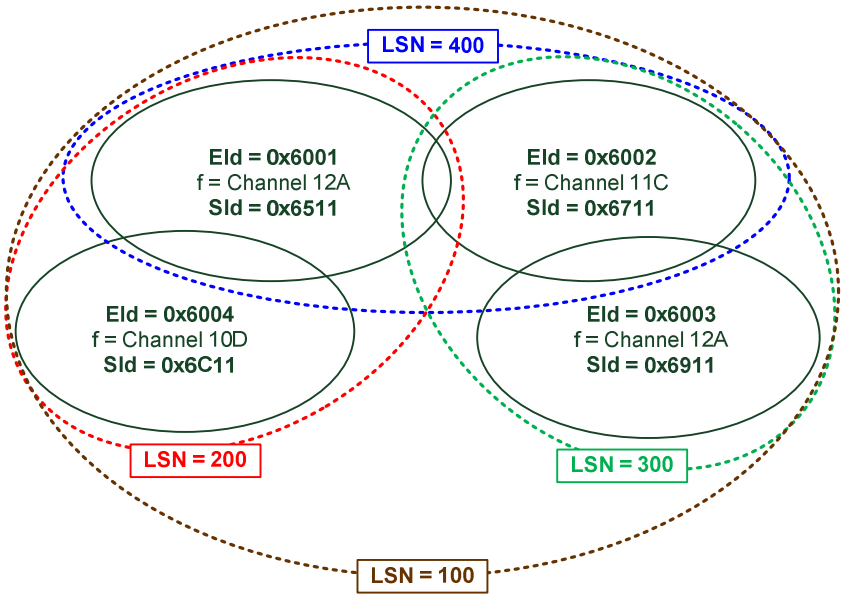

Figure A.2: Service and ensemble configuration

A.3.2 Concept

There are four network configurations with services that need to be linked and each is represented by a linkage set. The linkage sets are signalled in each ensemble that has a service that is linked, so all ensembles include the linkage set for all four services linked together and the two western ensembles also have the linkage set for the two western services linked whilst the two eastern ensembles also have the linkage set for the two eastern services linked. In addition, the two northern ensembles have the linkage set for the two northern services linked. FIG0/6 in the long form is used to repeat these definitions throughout the day. According to the time of day, the appropriate linkage set is activated or deactivated using FIG0/6 in the short form.

To assist single tuner devices, the OE Services (FIG0/24) and frequency information (FIG0/21) may be signalled. OE Services links the SId and EId and frequency information provides the centre frequency of the ensembles.

A dual tuner may detect the linked services on other ensembles by periodic analysis of received signals.

A.3.3 Signalling

A.3.3.1 FIG0/6 Service linking information

The information describing the linkage set for all services linked together (LSN = 100) is signalled on all four ensembles and the order of the SId list is the same on all four. The information describing the linkage set when the western services are linked together (LSN = 200) is signalled on the two western ensembles; again the order of the SId list is the same on both ensembles. Similarly, for the eastern (LSN = 300) and northern (LSN = 400) linkage sets. Therefore each ensemble will signal three linkage sets at all times. The state of the link actuators will always be set in accordance with the linkage schedule both in the slower cyclic repetition of the long form database definition FIGs and the faster cyclic repetition of the short form activation state FIGs. When the activation states change then a burst of short form FIGs are sent.

The following information is sent on ensemble 0x6001; the linkage actuator settings are according to the time of day. This snapshot was taken at 18:00 on a Wednesday when the "western" linkage set is activated.

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	4	Number of SIds in the list
Id1	0x6511	SId of service
Id2	0x6711	SId of service
Id3	0x6911	SId of service
Id4	0x6C11	SId of service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of SIds in the list
Id1	0x6511	SId of service
Id2	0x6C11	SId of service
Id List Flag	1	Long form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of SIds in the list
Id1	0x6511	SId of service
Id2	0x6711	SId of service

The activation state of all the linkage sets in the ensemble is sent regularly. Some examples are given below, again for a Wednesday.

At 05:07, 11:13, 14:58, 20:03; 23:45, the following information was sent.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set

At 06:27, 07:53, 09:59 the following information was sent.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set

At 16:00, 17:13, 18:54 the following information was sent.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set

At 19:00:00 the network configuration changes from the western services being linked to all services being linked. The following change information was sent in a short burst.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	Western linkage set
NOTE: The deactivated linkage set is signalled first, the activated linkage set is signalled second.		

A.3.3.2 FIG0/24 OE Services

The information describing the OE Services is signalled on each of the four ensembles for the three related services. The information is different on each ensemble because each has a different set of three other ensemble services.

The following information is sent on ensemble 0x6001.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	Programme service
SId	0x6711	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x6002	Ensemble Id of an ensemble carrying the Service
SId	0x6911	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x6003	Ensemble Id of an ensemble carrying the Service
SId	0x6C11	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x6004	Ensemble Id of an ensemble carrying the Service

A.3.3.3 FIG0/21 Frequency Information

The information describing the Frequency information is signalled on each of the four ensembles for the three related ensembles. The information is different on each ensemble because each has a different set of three other ensembles.

The following information is sent on ensemble 0x6001.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	not used for Frequency Information
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	18	Length in bytes of the following FI list
Id field (Identifier field)	0x6002	EId
R&M	0b0000	Range and Modulation, DAB ensemble
Continuity flag	0	The ensemble is not co-timed and synchronized
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x035CC	The multiplier of 16 kHz of the centre frequency 220 352 kHz
Id field (Identifier field)	0x6003	EId
R&M	0b0000	Range and Modulation, DAB ensemble.
Continuity flag	0	The ensemble is not co-timed and synchronized
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00011	Non-adjacent area, transmission mode I
Freq	0x036AC	The multiplier of 16 kHz of the centre frequency 223 936 kHz
Id field (Identifier field)	0x6004	EId
R&M	0b0000	Range and Modulation, DAB ensemble.
Continuity flag	0	The ensemble is not co-timed and synchronized
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x03482	The multiplier of 16 kHz of the centre frequency 215 072 kHz

A.3.4 Receiver Behaviour

If the receiver has determined that it needs to switch to an alternative service, it should refer to the FIG0/6 information.

In each linkage set where the current SId is present in the Id list, and where the linkage set is activated (LA = 1), there is a list of alternative SId codes for the current service.

In conjunction with OE Services (FIG0/24) and Frequency information (FIG0/21) (where provided), the receiver should try the alternative SId codes in any sequence to locate the alternative service on a different ensemble, and with an acceptable signal quality.

The receiver should minimize the time taken to locate the alternative service.

If the receiver has current knowledge of which alternative ensembles and services can be received, for instance by using a dual tuner, then it should switch immediately to the alternative service with the best signal quality.

If ensemble information and frequency information is provided for the alternative services, then this should be used to initially try only frequencies where one or more ensembles carrying the alternative services may be received. In this case, multiple alternative services on multiple alternative ensembles may be checked on a fewer number of frequencies.

If an alternative service cannot be found on the ensembles and frequencies provided in FIG0/24 and FIG0/21, the receiver tries all possible frequencies to locate an alternative service.

On locating an alternative service, and concluding that the signal quality is better than the current service and all other alternatives, the receiver switches automatically and without user intervention.

After switching to the alternative service on a different ensemble, the receiver uses service linking information received from the new ensemble for further linking.

A.4 Linking technology variations of a service on different ensembles

A.4.1 Problem Description

The very same audio content may be distributed in different ensembles (different EId) with a different SId because on some ensembles the audio is coded as MPEG layer 2 (DAB), whilst on other ensembles the audio is coded as AAC (DAB+). Those ensembles may or may not have overlapping coverage areas.

The following example represents a case in Switzerland in 2011.

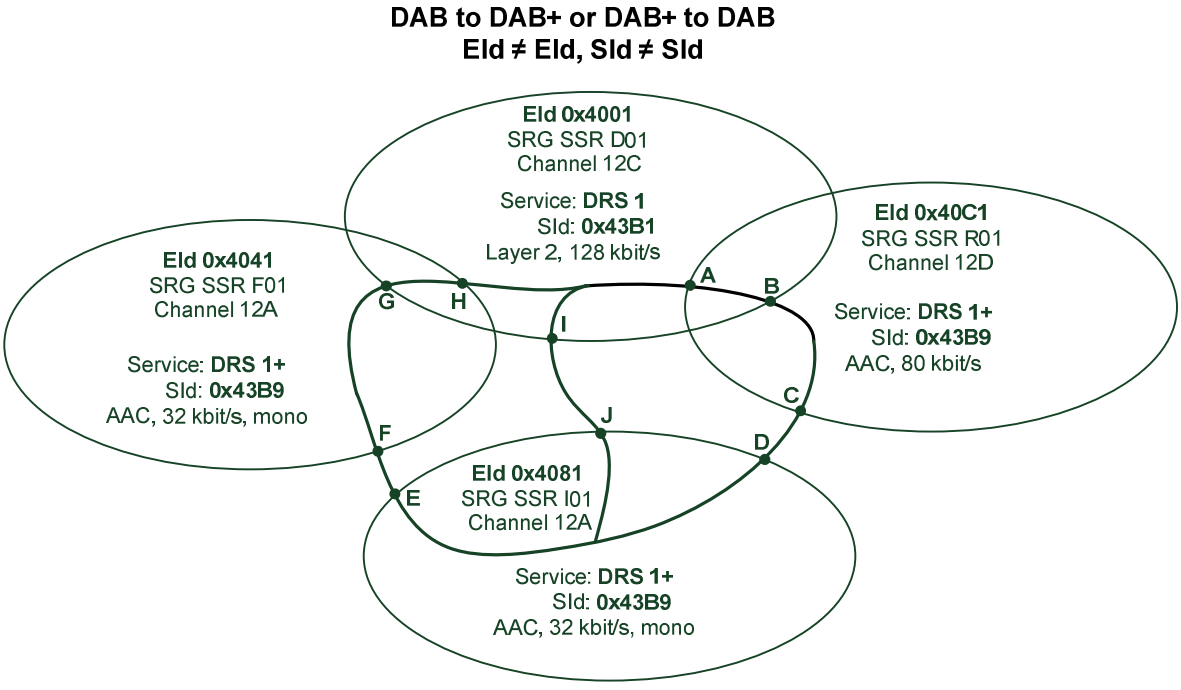

Figure A.3: Ensemble coverage schematic

A.4.2 Concept

Signalling of FIG0/6 in both/all ensembles is be provided to link those services together.

Signalling of FIG0/21 will help a single tuner device to find the alternative frequency.

Signalling of FIG0/24 will help a single tuner to identify the ensemble carrying the linked service.

A dual tuner device may find the alternative frequency by scanning all frequencies in the background.

A dual tuner may also detect the linked service in one of the scanned frequencies.

A.4.3 Signalling

A.4.3.1 FIG0/6 Service linking information

The same signalling is provided in all ensembles.

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Link is always active
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x3B1	Linkage Set Number
Rfu	0	1 bit reserved for future use
IdLQ	0b00	Each Id represents a DAB SId (2 bit)
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of SIds in the list
Id1	0x43B1	SId
Id2	0x43B9	SId

A.4.3.2 FIG0/24 OE Services

In ensemble **0x4001**

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	Programme service
SId	0x43B9	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	3	Number of Ensemble Ids to follow
Ensemble Identifier	0x4041	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x4081	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x40C1	Ensemble Id of an ensemble carrying the Service

In the other ensembles

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	Programme service
SId	0x43B1	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x4001	Ensemble Id of an ensemble carrying the service

A.4.3.3 FIG0/21 Frequency Information

In Ensemble **0x4001**

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the frequencies belong to other ensembles)
P/D	0	Not used for Frequency Information
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	18	Length in bytes of the following FI list
Id field (Identifier field)	0x4041	EId of the other ensemble
R&M	0b0000	DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Geographically adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz
Id field (Identifier field)	0x4081	EId of the other ensemble
R&M	0b0000	DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00011	Geographically not adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz
Id field (Identifier field)	0x40C1	EId of the other ensemble
R&M	0b0000	DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Geographically adjacent area, transmission mode 1
Freq	0x037ED	229 072 kHz

In each of the other three ensembles, the frequencies of the ensembles will be provided in the same way. The order of the frequencies in the list(s) does not have a meaning.

A.4.4 Receiver Behaviour

If the receiver has determined that it needs to switch to an alternative service, it should refer to the FIG0/6 information.

In each Linkage Set where the current SId is present in the Id list, and where the link set is active (LA = 1), there is a list of alternative SId codes for the current service.

In conjunction with OE Services (FIG0/24) and frequency information (FIG0/21) (where provided), the receiver should try the alternative SId code to locate the alternative service on a different ensemble, and with an acceptable signal quality.

E.g. travelling from point A to C in the picture above. Between A and B, two ensembles are available and in both ensembles FIG0/24 and FIG0/21 are signalled. Switching between the ensembles may occur at any time.

The receiver should minimize the time taken to locate the alternative service.

If the receiver has current knowledge of which alternative ensembles and services can be received, for instance by using a dual tuner, then it should switch immediately to the alternative service with the best signal quality.

If OE Services and frequency information is provided for the alternative services, then this should be used to initially try only frequencies where one or more ensembles carrying the alternative services may be received. In this case, multiple alternative services on multiple alternative ensembles may be checked on a fewer number of frequencies.

On locating an alternative service, and concluding that the signal quality is better than the current service and all other alternatives, the receiver switches automatically and without user intervention.

If an alternative service cannot be found on the ensembles and frequencies provided in FIG0/24 and FIG0/21, the receiver tries all possible frequencies to locate an alternative service.

If travelling from B to D in the example above, crossing an uncovered area, the receiver starts scanning at point C but the last received FIG0/6, FIG0/24 and FIG0/21 remain in the memory and is used when entering the other ensemble at point D.

After switching to the alternative service on a different ensemble, the receiver uses service linking information receiver from the new ensemble for further linking.

A.5 Soft linking of services

A.5.1 Problem Description

The broadcaster with a number of regional variations of a programme service illustrated in clause A.3 also wishes to indicate to his listeners when a *related* service is available during the times when the services are *not* hard linked together. He may do this by creating a linkage set that includes all his DAB services and his services on other bearers too, like FM-RDS, and signalling this as a *soft* link.

At certain times, some of the regional variations carry identical content, and are linked together using hard links, whilst others are either carrying exclusive content or linked to other regional variants. The regional variants with identical content will be present and active in one hard linkage set, but they may also be active in one soft linkage set at the same time. Therefore, when a receiver cannot find any alternative hard linked services, it may offer the listener a soft linked service that is available.

Figure A.4 illustrates the DAB services available from the example in clause A.3 and also adds the FM-RDS services. Note that LSN = 100 has again been chosen to represent the set of all services, but this is distinguishable from the linkage set in clause A.3 because of the associated Soft/Hard flag.

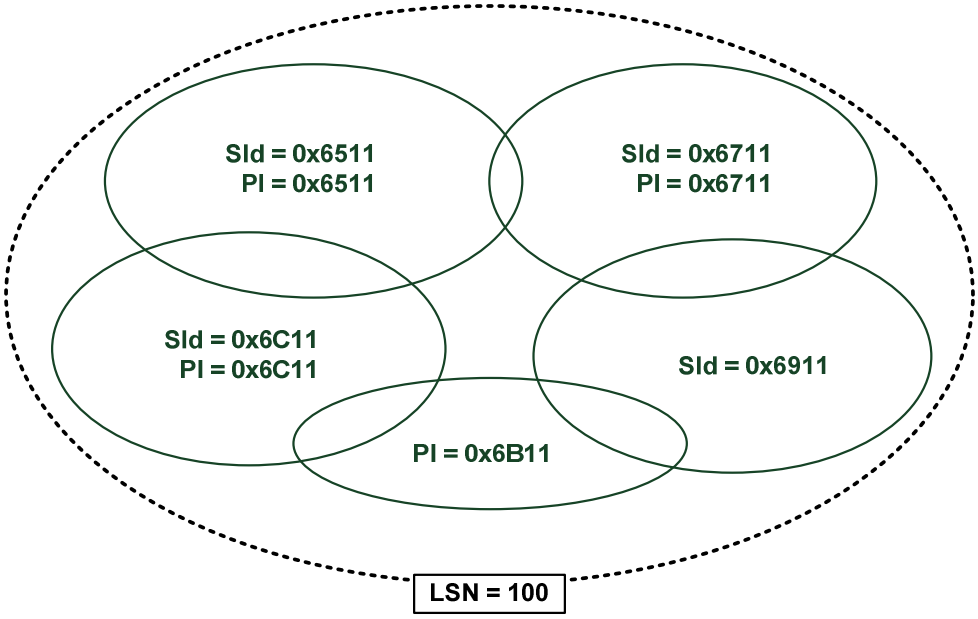

Figure A.4: Service configuration

A.5.2 Concept

All the regional variations of the programme service are contained in a single Linkage Set, with the S/H flag set to 0, indicating a soft linkage set. Some or all of the regional variations may also be in hard linkage sets, which are activated only when the programme content is identical.

The linkage set is transmitted by all the ensembles carrying the regional variations, and the order of the identifiers of the linkage set will be identical on all ensembles. The soft linkage set is always active.

To assist single tuner devices, the OE Services (FIG0/24) and frequency information (FIG0/21) may be signalled. OE Services connects the SId and EId and frequency information provides the centre frequency of the ensembles and the frequency of the FM-RDS services.

A dual tuner may detect the linked services on other ensembles by periodic analysis of received signals.

A.5.3 Signalling

A.5.3.1 FIG0/6 Service linking information

The FIG0/6 information describes all the similar regional variations of the programme service, both carried on DAB and FM-RDS. Each ensemble signals this linkage set at all times. Note that the same LSN is used in this example for the soft and hard linkage sets that represent all the services, but that these linkage sets are distinct because the one in clause A.3 is a hard linkage set and the one in this annex is a soft linkage set. However, different LSNs could also have been allocated.

Since the soft linkage set is always active no change FIGs will be sent. However, the linkage information will be sent every two minutes and the state of the linkage actuator will sent every 10 seconds.

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is active
Soft/Hard	0	Soft link
ILS	0	National link
LSN	0x100	Linkage Set Number for all regional variants
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	4	Number of Ids in the list
Id1	0x6511	SId of Service
Id2	0x6711	SId of Service
Id3	0x6911	SId of Service
Id4	0x6C11	SIf of Service

Field	Value	Description
C/N	1	Continuation of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is active
Soft/Hard	0	Soft link
ILS	0	National link
LSN	0x100	Linkage Set Number for all regional variants
IdLQ	0b01	Each Id represents an FM-RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	4	Number of Ids in the list
Id1	0x6511	PI code of Service
Id2	0x6711	PI code of Service
Id3	0x6B11	PI code of Service
Id4	0x6C11	PI code of Service

A.5.3.2 FIG0/24 OE Services

See clause A.3.

A.5.3.3 FIG0/21 Frequency Information

See clause A.3. Frequency information could also be provided for the RDS services.

A.5.4 Receiver Behaviour

If the receiver has determined that it needs to switch to an alternative service, and has already exhausted all possibilities to link to an identical programme service, it should refer to FIG0/6 information where the S/H flag is set to 0, indicating soft links.

The receiver should use the same strategy for locating alternative services as described in clause A.3.4 for hard links, but make it clear to the listener that they are being offered a similar service as an alternative, and require the listener to confirm the change rather than it happening automatically.

A.6 Linkage of DAB and FM-RDS services

A.6.1 Problem Description

In an area where DAB signal quality is too low, and the listened service is not available on another frequency signalled as use case 1, 2, 3, 4, a receiver may switch to FM.

In an area where DAB signal quality becomes receivable corresponding to a listened FM service, a receiver may switch to DAB.

The following example represents a case in Switzerland in 2011.

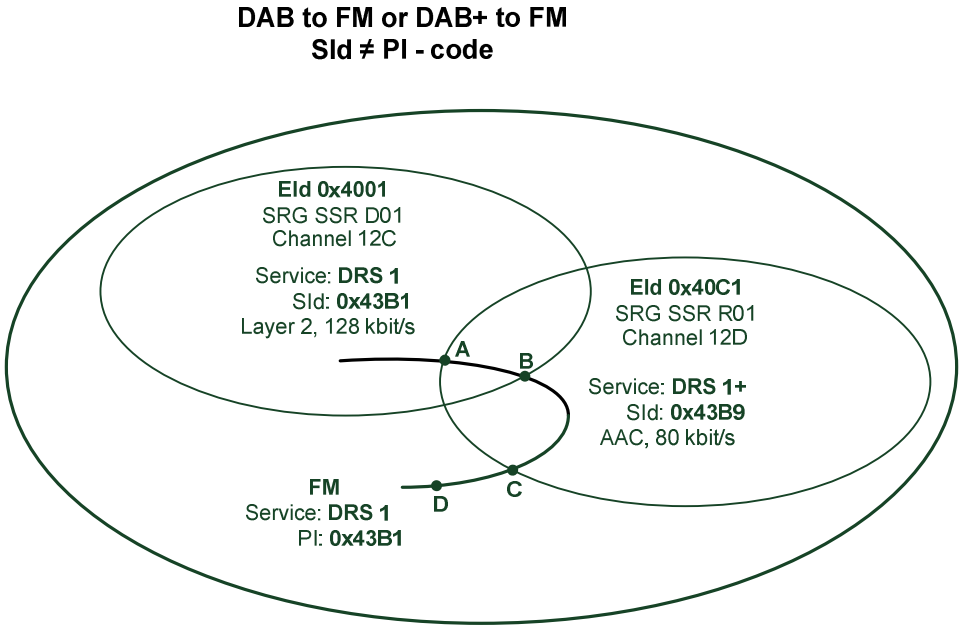

Figure A.5: Ensemble coverage schematic

A.6.2 Concept

In case of direct association PI/SId no additional signalling is needed be transmitted. FIG0/21 may be used to inform receiver about FM frequencies. Implicit linking is considered to be a hard link.

In the example above this applies to the Ensemble 0x4001 where SId and PI code are equal.

Other FIG0/6 may be used to create a link (hard or soft) between an SId and a PI which are not the same.

In the example above this applies to the Ensemble 0x40C1 where SId and PI code are unequal.

Only one hard link may be activated at any given time.

A.6.3 Signalling

A.6.3.1 FIG0/6 Service linking information

In Ensemble **0x40C1**, example above.

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Link in active
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x123	Linkage Set Number
Rfu	0	1 bit reserved for future use
IsLQ	0b01	Each Id represents an RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of Ids in the Id list
Id1	0x43B9	SId of the service in the current ensemble
Id2	0x43B1	PI code of FM services to link with

A.6.3.2 FIG0/24 OE Services

Not required for this use case.

A.6.3.3 FIG0/21 Frequency Information

Frequency Information may be provided but not mandatory for this case. It helps speed up tuning to the FM alternative on a single tuner device. In large FM networks one can end up in a very long list of FM frequencies.

The following list represents the signalling of just one frequency of the example above for the Ensemble 0x40C1.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the frequencies belong to other ensembles)
P/D	0	Not used for Frequency Information
RegionId	000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	4	Length in bytes of FI list
Id field (Identifier field)	0x43B1	RDS PI code
R&M	0b1000	FM with RDS
Continuity flag	0	Continuous audio output not expected (audio not co-timed)
Length of Freq. list	1	Length in bytes of the following Freq list
Freq	0x3F	93,8 MHz

A.6.4 Receiver Behaviour

Travelling from point B to D in the example above:

- When leaving point C the DAB reception fails and no other DAB Ensemble can be tuned to.
- If the receiver has determined that it needs to switch to an alternative service, it should refer to the FIG0/6 information.
- In conjunction with Frequency (FIG0/21) information the receiver should try the alternative FM frequency to locate the alternative service, and with an acceptable signal quality.
- The receiver should minimize the time taken to locate the alternative service on FM.

- The receiver should continue to follow the DAB service linking rules even when it has switched to an alternative on FM.

A.7 Linkage of DAB and FM-RDS services with time varying network relationships

A.7.1 Problem Description

In Bavaria, Germany, the service "B1" is provided on FM and DAB. At some times of the day, the same audio programme is provided throughout the region. However, at other times, the programming is split into regional variants. During the main service times all FM transmitters broadcast the same audio programme and share a common PI-code. During the regionalization times the FM transmitter network is split into several regional variants with different PI-codes. All regional variants are transmitted in parallel on a DAB ensemble as primary audio service components with different SIds.

The service "B1 Oberbayern" is simulcast via DAB and FM. The invariant SId of the service is 0xD411. During the regionalization times the PI-code changes from 0xD311 to 0xD411. To enable a receiver to follow the service from DAB to FM during the main service times and the regionalization times both PI-codes (0xD311 and 0xD411) are part of the linkage set (hard link).

Although the PI-code of the FM transmitters change several times throughout the day the linking mechanism can be achieved by a single static linkage set. During the main service times the PI-code 0xD411 is not on air and the receiver will be forced to follow the link indicated by the PI-code 0xD311. When the regional variant is broadcast there is no service with the PI-code 0xD311 transmitted, as consequence the receiver will choose the service with the PI-code 0xD411 as an alternative service.

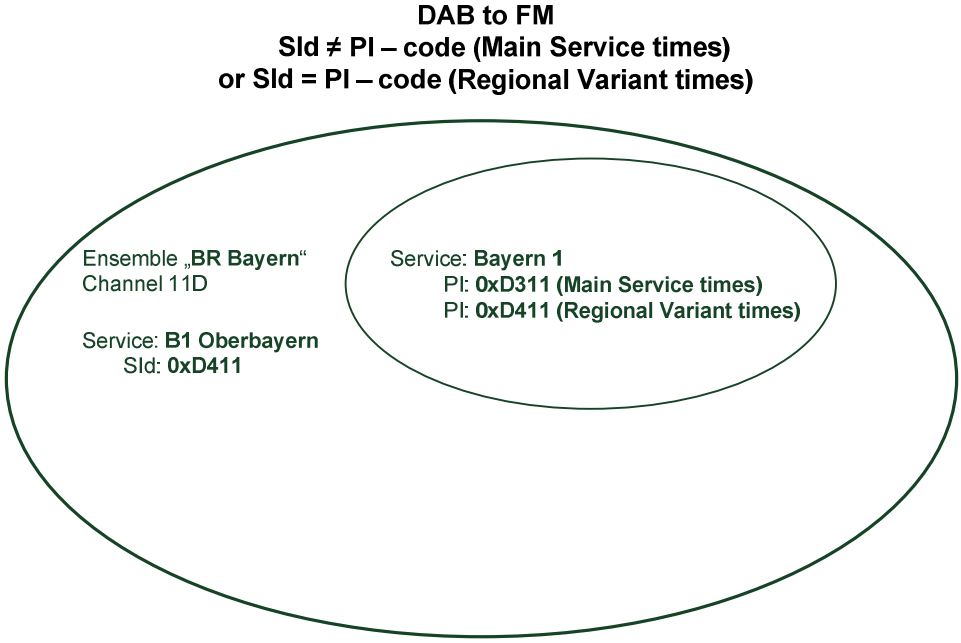

Figure A.6: Ensemble coverage schematic

The coverage areas of the FM regional variants are subsets of the DAB coverage area. All regional variants are always transmitted via the DAB ensemble in parallel. It is possible to receive regional variants via DAB that are not available on FM at a particular location. Therefore it might be useful to additionally soft link the DAB services with all FM regional variants.

A.7.2 Concept

FIG0/6 is used to define a set of hard links to FM services.

FIG0/21 may be provided to give frequency information for those FM services. See clause A.6.

A.7.3 Signalling

A.7.3.1 FIG0/6 Service linking information

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is active
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x190	Linkage Set Number
Rfu	0	1 bit reserved for future use
IdLQ	0b01	Each Id represents an RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	3	
Id1	0xD411	Sld of the service in the current ensemble
Id2	0xD411	PI code of FM service to link with
Id3	0xD311	PI code of FM service to link with

A.7.3.2 FIG0/24 OE Services

Not required for this use case.

A.7.3.3 FIG0/21 Frequency Information

Not required for this use case.

A.7.4 Receiver Behaviour

As general hard linking behaviour - receiver will try both the PI which is equal to the SId code and try the other PI code which is not equal.

A.8 Preventing implicit linkage to FM-RDS

A.8.1 Problem Description

Normally identifiers for DAB and FM-RDS services are drawn from the same pool of codes and regulatory authorities ensure that DAB and FM-RDS services do not have the same identifier unless they are exactly the same service. However, there may be occasions when this is not the case and a broadcaster wants to prevent receivers from service following to FM. In this case the DAB service with SId = 0xC19F carries different audio to the FM-RDS service with the same PI code and the DAB service provider wishes to prevent implicit linking from DAB to FM.

A.8.2 Concept

The "dead link" mechanism is used.

A.8.3 Signalling

A.8.3.1 FIG0/6 Service linking information

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage is active, do not link
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x19F	Linkage Set Number
IdLQ	0b01	Each Id represents an RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	1	Only Sld is given
Id1	0xC19F	Sld of service that is being 'dead linked'

A.8.3.2 FIG0/24 OE Services

Not required for this use case.

A.8.3.3 FIG0/21 Frequency Information

Not required for this use case.

A.8.4 Receiver Behaviour

Receivers decoding this information disable implicit linking from this service to FM.

Annex B (informative): Service following - Transition from existing implementations

Prior to the adoption of the present document, service following implementations were created by various service providers and receiver manufacturers. These implementations may differ in small respects from the rules described in the present document. In general, these differences will not be significant, but in countries where service linking information has been provided for some time and which have a great number of DAB car receivers, special care needs to be taken when changing service following signalling. Some older receivers may not be able to follow all the rules defined in the present document, or may require additional information or information signalled in a different way. Therefore a service provider may choose to create a setup suitable for different generations of receivers for a transition period.

The following differences may occur:

- Some receivers follow a paradigm that if *any* service linking information is provided that *all* implicit linking is disabled. In this case the service provider can provide a linkage set with the SId and PI codes hard linked.
- Some receivers will always follow implicit links between DAB and FM-RDS. If this behaviour is not wanted then SIds should be allocated to avoid this problem.
- Some receivers require that linkage sets are defined with the same SId as the first Id in the list and as a subsequent Id in order to follow a service on different ensembles. Service providers can still provide this signalling under the rules defined in the present document, albeit with a slight signalling overhead.
- Some receivers do not follow soft links. This means that some users may not be linked to the related service and need to select a service manually.

Annex C (informative): Service lists - use case examples

C.1 New service on air

C.1.1 Use case description

A new audio service will be introduced to an existing ensemble. This service has never been on an ensemble before. After the insertion, the service is visible in the service list and can be selected by the listener. The service remains in the ensemble for the future. The broadcaster announces this service prior to the actual insertion to allow receivers not tuned to the ensemble at the time of the insertion to know when the new service will be available. Some receivers may display additional information.

C.1.2 Concept

To provide information about this service prior to the reconfiguration, FIG 0/20 is used. Using this signalling, the receiver knows the date and time of the insertion and can take action to enable selection of the service from that point onwards. Some receivers may display the date and time when the service will be available.

A reconfiguration of the ensemble is required to insert the service.

All the signalling can only be received if the receiver is tuned to that ensemble.

C.1.3 Signalling

C.1.3.1 Preparation phase

The Current MCI contains no reference to 0x1234.

The service label is signalled.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0x1234	The Service Identifier of the new service.
SCIdS	0	The primary service component.
Change flags	01b	The service will be *added* to the ensemble.
P-T flag	0b	The new service will be broadcast *continuously*.
SC flag	1b	The SC description field is required and present.
SC desc.	CA flag: 0b A/S flag: 0b SCTy: 111111b	The CA flag is set to 0 (No access control). The A/D flag is set to 0 (An ASCTy follows). The SCTy is AAC audio service (DAB+).
Date-time	Date: 01100b Hour: 01101b Minute: 000000b Second: 000000b	The new service will be added to the ensemble on 2016-01-01 at 13:00:00 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	0b	The Transfer SId field is absent.
EId flag	0b	The Transfer EId field is absent.

C.1.3.2 Reconfiguration phase

The Current MCI contains no reference to 0x1234.

The Next MCI contains reference to 0x1234.

The service label is signalled.

The FIG 0/20 is signalled as for the preparation phase.

C.1.3.3 Consolidation phase

The Current MCI contains reference to 0x1234.

The service label is signalled.

No FIG 0/20 is signalled.

C.1.4 Receiver behaviour

Receivers will use the information provided in FIG 0/20 to prepare for the addition of the new service. Some receivers will display this information to the user in an appropriate way.

After the ensemble reconfiguration, all receivers tuning to the ensemble will display the new service in the service list. Some receivers will display the new service in the service list even before tuning to the ensemble, but mark the entry as "tentative".

C.2 Continuous service is removed (with transfer)

C.2.1 Use case description

A service will be removed from all ensembles on the 10th of March 2016 at 14:30 (UTC). The broadcaster would like listeners to be transferred to another service which is available on the same ensemble when the original service has been removed.

C.2.2 Concept

To provide information about the removal of this service prior to the reconfiguration, FIG 0/20 will be used. Using this signalling, the receiver can, if the removed service is being listened to at the point of removal, automatically switch to the service indicated by the broadcaster. This action is also enabled if the service was being listened to when the receiver was switched off and is switched on again after the service has been removed.

A reconfiguration of the ensemble is required to remove the service.

All the signalling can only be received while the receiver is tuned to that ensemble.

C.2.3 Signalling

C.2.3.1 Preparation phase

The Current MCI contains reference to 0x1234.

The service label is signalled.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0x1234	The Service Identifier of the service.
SCIdS	0	The primary service component
Change flags	11b	The service will be *removed* from all ensembles. (Due to SCIdS = 0 the whole service is concerned - all secondary components, if any, will also be removed.)
P-T flag	0b	The service is a *continuous* service.
SC flag	0b	The SC description field is not present.
Date-time	Date: 10010b Hour: 01110b Minute: 011110b Second: 000000b	The service will be removed from the ensemble on the given time relative to the currently received MJD. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	1b	The Transfer SId field is present.
EId flag	0b	The Transfer EId field is absent.
Transfer SId	0x1278	Preferred transfer service ID

C.2.3.2 Reconfiguration phase

The Current MCI contains reference to 0x1234.

The Next MCI contains no reference to 0x1234.

The service label is signalled.

The FIG 0/20 is signalled as for the preparation phase.

C.2.3.3 Consolidation phase

The Current MCI contains no reference to 0x1234.

The service label is not signalled.

The FIG 0/20 contains a Service Component Information field with the following values, which is signalled for some days after the service removal:

Field	Value	Description
SId	0x1234	The Service Identifier of the service.
SCIdS	0	The primary service component.
Change flags	11b	The service will be *removed* from all ensembles. (Due to SCIdS = 0 the whole service is concerned - all secondary components were also be removed.)
P-T flag	0b	The service was a *continuous* service.
SC flag	0b	The SC description field is not present.
Date-time	Date: 11111b Hour: 11111b Minute: 111111b Second: 111111b	The service has now been removed.
SId flag	1b	The Transfer SId field is present.
EId flag	0b	The Transfer EId field is absent.
Transfer SId	0x1278	Preferred transfer service ID.

C.2.4 Receiver behaviour

Receivers will use the information provided in FIG 0/20 to prepare for the removal of the service. Some receivers will display this information to the user in an appropriate way.

After the ensemble reconfiguration, all receivers tuning to the ensemble will no longer display the service in the service list. Some receivers will mark the entry as "end of life" in the service list before tuning to the ensemble to confirm the removal.

C.3 New Part-time service on air

C.3.1 Use case description

A new part-time audio service will be introduced to an existing ensemble. This service has never been on an ensemble before. After the insertion, the service is visible in the service list and can be selected by the listener. The service remains in the service list even while it is temporarily off-air. The broadcaster announces this service prior to the actual insertion to allow receivers not tuned to the ensemble at the time of the insertion to know when the new service will be available. Some receivers may display additional information.

C.3.2 Concept

To provide information about this service prior to the reconfiguration, FIG 0/20 is used. Using this signalling, the receiver knows the date and time of the insertion and can take action to enable selection of the service from that point onwards. Some receivers may display the date and time when the service will be available.

A reconfiguration of the ensemble is required to insert the service.

All the signalling can only be received while the receiver is tuned to that ensemble.

C.3.3 Signalling

C.3.3.1 Preparation phase

The Current MCI contains no reference to 0x4444.

The service label is signalled.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0x4444	The Service Identifier of the new service.
SCIdS	0	The primary service component.
Change flags	01b	The service will be *added* to the ensemble.
P-T flag	0b	The new service will be added permanently.
SC flag	1b	The SC description field is required and present.
SC desc.	CA flag: 0b A/S flag: 0b SCTy: 111111b	The CA flag is set to 0 (No access control). The A/D flag is set to 0 (An ASCTy follows). The SCTy is AAC audio service (DAB+).
Date-time	Date: 01100b Hour: 01101b Minute: 000000b Second: 000000b	The new service will be added to the ensemble on 2016-01-01 at 13:00:00 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	0b	The Transfer SId field is absent.
EId flag	0b	The Transfer EId field is absent.

C.3.3.2 Reconfiguration phase

The Current MCI contains no reference to 0x4444.

The Next MCI contains reference to 0x4444.

The service label is signalled.

The FIG 0/20 is signalled as for the preparation phase.

C.3.3.3 Consolidation phase

The Current MCI contains reference to 0x4444.

The service label is signalled.

No FIG 0/20 is signalled.

C.3.4 Receiver behaviour

Receivers will use the information provided in FIG 0/20 to prepare for the addition of the new service. Some receivers will display this information to the user in an appropriate way.

After the ensemble reconfiguration, all receivers tuning to the ensemble will display the new service in the service list. Some receivers will display the new service in the service list even before tuning to the ensemble, but mark the entry as "tentative".

C.4 Part-time service is on-air

C.4.1 Use case description

The A part-time service is currently on-air. The service is shown in the service list. The broadcaster announces that the service is a part time service using FIG 0/20 and indicates the date-time when the part-time service will go off-air.

C.4.2 Concept

To provide information about when the part time service will go off-air, FIG 0/20 will be used. Using this signalling, the receiver can determine when the service is likely to be available, even when tuned to another ensemble.

A reconfiguration of the ensemble is required to temporarily remove the part-time service.

All the signalling can only be received while the receiver is tuned to that ensemble.

C.4.3 Signalling

C.4.3.1 Preparation phase

The Current MCI contains reference to 0x4444.

The service label is signalled.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0x4444	The Service Identifier of the service.
SCIdS	0	The primary service component.
Change flags	11b	The part time service will go off-air in all ensembles.
P-T flag	1b	The service is a part-time service.
SC flag	0b	The SC description field is not required.
Date-time	Date: 01100b Hour: 10110b Minute: 000000b Second: 000000b	The part time service will resume on 2016-01-01 at 22:00:00 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	0b	The Transfer SId field is absent.
EId flag	0b	The Transfer EId field is absent.

C.4.3.2 Reconfiguration phase

The Current MCI contains reference to 0x4444.

The Next MCI contains no reference to 0x4444.

The service label is signalled.

The FIG 0/20 is signalled as for the preparation phase.

C.4.3.3 Consolidation phase

There is no consolidation phase. As soon as the part-time service is off-air, preparation phase signalling is required to indicate when the service will resume, see clause C.5.

C.4.4 Receiver behaviour

Receivers will use the information provided in FIG 0/20 to prepare for the temporary removal of the part-time service. Some receivers will display this information to the user in an appropriate way.

After the ensemble reconfiguration, all receivers will continue to display the service in the service list, even though it is no longer on-air and not signalled in the MCI.

C.5 Part-time service is off-air

C.5.1 Use case description

The A part-time service is currently on-air. The service is shown in the service list even while it is temporarily off-air. The broadcaster announces that the service is a part time service using FIG 0/20 and indicates the date-time when the part-time service will come on-air again.

C.5.2 Concept

To provide information about when the part time service will come on-air again, FIG 0/20 will be used. Using this signalling, the receiver can determine when the service is likely to be available, even when tuned to another ensemble.

A reconfiguration of the ensemble is required to temporarily remove the part-time service.

All the signalling can only be received while the receiver is tuned to that ensemble.

C.5.3 Signalling

C.5.3.1 Preparation phase

The Current MCI contains no reference to 0x4444.

The service label is signalled.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
Sid	0x4444	The Service Identifier of the part-time service.
SCIdS	0	The primary service component.
Change flags	01b	The service will be *added* to the ensemble.
P-T flag	1b	The service is part-time.
SC flag	1b	The SC description field is required and set.
SC desc.	CA flag: 0b A/S flag: 0b SCTy: 111111b	The CA flag is set to 0 (No access control). The A/D flag is set to 0 (An ASCTy follows). The SCTy is AAC audio service (DAB+).
Date-time	Date: 01100b Hour: 10100b Minute: 000000b Second: 000000b	The part time service will resume on 2016-01-01 at 20:00:00 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	0b	The Transfer SId field is absent.
EId flag	0b	The Transfer EId field is absent.

C.5.3.2 Reconfiguration phase

The Current MCI contains no reference to 0x4444.

The Next MCI contains reference to 0x4444.

The service label is signalled.

The FIG 0/20 is signalled as for the preparation phase.

C.5.3.3 Consolidation phase

There is no consolidation phase. As soon as the part-time service is on-air, preparation phase signalling is required to indicate when the service will go off-air, see clause C.4.

C.5.4 Receiver behaviour

Receivers will use the information provided in FIG 0/20 to prepare for the return of the part-time service. Some receivers will display this information to the user in an appropriate way.

After the ensemble reconfiguration, all receivers will continue to display the service in the service list.

C.6 SId change within an ensemble

C.6.1 Use case description

The SId of a service needs to change for some reason. The service remains in the service list with only the SId changing. If the service is selected for playback it continues without interruption. The broadcaster announces the change of SId using FIG 0/20.

C.6.2 Concept

An administrative change is required but no impact should be experienced by users. FIG 0/20 is used to signal in advance that the SId will change to allow receivers to know that they should continue to present the service after the reconfiguration without user intervention and should reassign any presets, etc., so that the user is unaware of the change. The signalling continues after the reconfiguration to allow receivers that have not tuned to the ensemble for some time to still recognize that the "new" service is actually the same service with a new SId.

At the moment the SId changes, a reconfiguration of the ensemble is required.

All the signalling can only be received while the receiver is tuned to that ensemble.

C.6.3 Signalling

C.6.3.1 Preparation phase

The Current MCI contains reference to service 0xC123 and does not contain reference to 0xC177.

The service label is signalled for service 0xC123.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0xC123	The Service Identifier of the service before the reconfiguration.
SCIdS	0	The whole service is affected: all service components receive the new SId.
Change flags	00b	The identity or source of the service is changing.
P-T flag	0b	A continuous service.
SC flag	0b	The SC description field is absent.
Date-time	Date: 01100b Hour: 10100b Minute: 000000b Second: 000000b	The SId will change on 2016-01-01 at 20:00:00 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	1b	The Transfer SId field is present.
EId flag	0b	The Transfer EId field is absent.
Transfer SId	0xC177	The Service Identifier for the service after the reconfiguration.

C.6.3.2 Reconfiguration phase

The Current MCI contains reference to service 0xC123 and does not contain reference to 0xC177.

The Next MCI does not contain reference to service 0xC123 and contains reference to 0xC177.

The service label is signalled for service 0xC123 and for service 0xC177.

The FIG 0/20 is signalled as for the preparation phase.

C.6.3.3 Consolidation phase

The Current MCI does not contain reference to service 0xC123 and contains reference to 0xC177.

The service label is signalled for service 0xC177.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0xC123	The Service Identifier of the service before the reconfiguration.
SCIdS	0	The whole service is affected: all service components receive the new SId.
Change flags	00b	The identity or source of the service is changing.
P-T flag	0b	A continuous service.
SC flag	0b	The SC description field is absent.
Date-time	Date: 01100b Hour: 11111b Minute: 111111b Second: 111111b	The SId has changed already.
SId flag	1b	The Transfer SId field is present.
EId flag	0b	The Transfer EId field is absent.
Transfer SId	0xC177	The Service Identifier of the service after the reconfiguration.

C.6.4 Receiver behaviour

Receivers recognize that an administrative change to the SId is scheduled, or has already taken place. Receivers that have acquired the SCI prior to the reconfiguration make a change to the SId for all the affected service elements in the service list and any presets at the time of the reconfiguration. If the receiver is playing the service at the time of the reconfiguration, the service presentation is not affected in any way. Receivers tuning to the ensemble for the first time after the reconfiguration (i.e. during the consolidation phase) make a change to the SId for all the affected service elements in the service list and any presets as soon as they decode the information.

C.7 Service moves to a new ensemble with SId change

C.7.1 Use case description

A service moves from one ensemble to another and also gets a new SId. The service remains in the service list with only the EId and SId changing. If the service is selected for playback it continues with minimum interruption. The broadcaster announces the change of SId and EId using FIG 0/20.

C.7.2 Concept

An administrative change is required but minimal impact should be experienced by users. FIG 0/20 is used to signal in advance in both ensembles that the EId and SId will change to allow receivers to know that they should continue to present the service after the reconfiguration without user intervention and should reassign any presets, etc., so that the user is unaware of the change. The signalling continues after the reconfigurations (one in each ensemble) to allow receivers that have not tuned to the ensembles for some time to still recognize that the "new" service is actually the same service with a new EId and SId.

At the moment the service leaves the original ensemble, a reconfiguration of that ensemble is required.

At the moment the service enters the new ensemble, a reconfiguration of that ensemble is required.

All the signalling can only be received while the receiver is tuned to that ensemble.

In this example, there is an overlap period where the service is present in both ensembles for a limited period - the service enters the new ensemble at 02:00 but does not leave the original ensemble until 23:59:59. The period of overlap is chosen by the broadcaster to suit his needs and may be zero (i.e. the service move is instantaneous).

C.7.3 Signalling

C.7.3.1 Preparation phase

In the original ensemble, EId = C111, preparation phase signalling stops at 23:59:59 on 2016-01-01:

The Current MCI contains reference to service 0xC249.

The service label is signalled for service 0xC249.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0xC249	The Service Identifier of the service before the reconfiguration.
SCIdS	0	The whole service is affected: all service components receive the new SId.
Change flags	00b	The identity or source of the service is changing.
P-T flag	0b	A continuous service.
SC flag	0b	The SC description field is absent.
Date-time	Date: 01100b Hour: 10111b Minute: 111011b Second: 111011b	The service will leave on 2016-01-01 at 23:59:59 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	1b	The Transfer SId field is present.
EId flag	1b	The Transfer EId field is present.
Transfer SId	0xC262	The Service Identifier for the service after the reconfiguration.
Transfer EId	0xC222	The Ensemble Identifier for the ensemble that carries the service after the reconfiguration.

In the new ensemble, EId = C222, preparation phase signalling stops at 02:00:00 on 2016-01-01:

The Current MCI contains no reference to 0xC262.

The service label is signalled for service 0xC262.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0xC249	The Service Identifier of the service before the reconfiguration.
SCIdS	0	The whole service is affected: all service components receive the new SId.
Change flags	00b	The identity or source of the service is changing
P-T flag	0b	A continuous service.
SC flag	0b	The SC description field is absent.
Date-time	Date: 01100b Hour: 00010b Minute: 000000b Second: 000000b	The service will enter on 2016-01-01 at 02:00:00 UTC. At the nearest second to this point of time the multiplex reconfiguration occurs.
SId flag	1b	The Transfer SId field is present.
EId flag	1b	The Transfer EId field is present.
Transfer SId	0xC262	The Service Identifier for the service after the reconfiguration.
Transfer EId	0xC222	The Ensemble Identifier for the ensemble that carries the service after the reconfiguration.

C.7.3.2 Reconfiguration phase

In the original ensemble, EId = C111, reconfiguration phase signalling occurs between approximately 23:59:53 and 23:59:59 on 2016-01-01:

The Current MCI contains reference to 0xC249.

The Next MCI does not contain reference to 0xC249.

The service label is signalled for service 0xC249.

In the new ensemble, EId = C222, reconfiguration phase signalling occurs between approximately 01:59:54 and 02:00:00 on 2016-01-01:

The Current MCI does not contain reference to 0xC262.

The Next MCI contains reference to 0xC262.

The service label is signalled for service 0xC262.

The FIG 0/20 is signalled as for the preparation phase in each ensemble.

C.7.3.3 Consolidation phase

In the original ensemble, EId = C111, consolidation phase signalling starts at 23:59:59 on 2016-01-01:

The Current MCI does not contain reference to service 0xC249.

The service label is not signalled for service 0xC249.

The FIG 0/20 contains a Service Component Information field with the following values:

Field	Value	Description
SId	0xC249	The Service Identifier of the service before the reconfiguration.
SCIdS	0	The whole service is affected: all service components receive the new SId.
Change flags	00b	The identity or source of the service is changing
P-T flag	0b	A continuous service.
SC flag	0b	The SC description field is absent.
Date-time	Date: 01100b Hour: 11111b Minute: 111111b Second: 111111b	The service has moved already.
SId flag	1b	The Transfer SId field is present.
EId flag	1b	The Transfer EId field is present.
Transfer SId	0xC262	The Service Identifier for the service after the reconfiguration.
Transfer EId	0xC222	The Ensemble Identifier for the ensemble that carries the service after the reconfiguration.

In the new ensemble, EId = C222, consolidation phase signalling starts at 02:00:00 on 2016-01-01:

The Current MCI contains reference to service 0xC262.

The service label is signalled for service 0xC262.

The FIG 0/20 contains a Service Component Information field with the following values.

Field	Value	Description
SId	0xC249	The Service Identifier of the service before the reconfiguration.
SCIdS	0	The whole service is affected: all service components receive the new SId.
Change flags	00b	The identity or source of the service is changing
P-T flag	0b	A continuous service.
SC flag	0b	The SC description field is absent.
Date-time	Date: 01100b Hour: 11111b Minute: 111111b Second: 111111b	The service has moved already.
SId flag	1b	The Transfer SId field is present.
EId flag	1b	The Transfer EId field is present.
Transfer SId	0xC262	The Service Identifier for the service after the reconfiguration.
Transfer EId	0xC222	The Ensemble Identifier for the ensemble that carries the service after the reconfiguration.

C.7.4 Receiver behaviour

Receivers tuning to either ensemble recognize that an administrative change to the EId and SId is scheduled, or has already taken place.

In this example there is an overlap period during which the service is available in both ensembles, but this may not always be the case. Receivers tuned to the original ensemble can determine from the SCI that the service will move to a new ensemble and know the date-time after which the service will no longer be available in this ensemble but will definitely be available on the new ensemble.

Similarly, receivers tuned to the new ensemble can determine from the SCI that the service will move to this ensemble and know the date-time after which the service will be available in this ensemble; however from this SCI alone they do not know when it will no longer be available on the original ensemble nor do they know the identity of the original ensemble.

Receivers that have gathered the SCI from both ensembles know the service origin, new identity and the date-times when the service enters the new ensemble and leaves the original ensemble. These receivers can therefore make the best decisions on when during the overlap period to change the information in their service list to minimize the impact on the user. When the overlap period is zero, the reconfigurations in the two ensembles will happen simultaneously.

If the receiver is tuned to the original ensemble and is playing the service at the time of the reconfiguration, the receiver retunes to the new ensemble, selects the service (now identified by the new SId) and resumes presentation - multi-tuner receivers are able to pre-tune and so minimize audio interruptions.

If the user selects the service during the overlap period, the receiver tunes to the new ensemble. Receivers tuning to either ensemble for the first time during the respective consolidation phase make a change to the EId and SId for all the affected service elements in the service list and any presets as soon as they decode the information.

Annex D (informative): Service lists - presentation

D.1 Entries in the service list

The service list is in fact a list of all the service components that can reasonably be expected to be available to the user of the device at the location and time that the user is looking. Different devices will have different implementations of what the designers considered to be "reasonable".

Different implementations may be expected for automotive, domestic, hand-held, etc., because these different types of devices have different usages and different capabilities. For example, mobile receivers (either automotive or hand-held) will pass through different ensemble coverage areas and may accumulate a great many service components over time, but only some will be tunable at a given location. In addition, some service components are only broadcast on a part-time basis and so are only tunable at certain times. New services are launched, and old services close down. To deal with these various possibilities, device manufacturers need to develop a strategy to present the service components that are available in an understandable and consistent way, so as to provide the best user experience.

Devices should only display to the user those service components that the device can present (for example DMB-tv services should not be selectable on an audio only receiver).

Devices should ensure that when a service component is available from more than one ensemble that only a single selection is presented to the user - all the alternatives should be kept hidden, but the best source should be chosen at the time and location that the user makes the selection. The definition of "best" may vary amongst implementations, but factors to consider are reception quality, audio bit-rate, etc. Devices need to ensure that they do not just pick the highest or lowest frequency that the service is available on!

D.2 Handling of part-time service components

The SCI provides a mechanism for maintaining part-time service components in the service list. During off-air periods devices may display a suitable message to the user. The date-time field allows an indication to be made of when the service component will be available again, but the information may be outdated if the device has not been able to tune to the ensemble for some period.

If the part-time service component is a secondary service component, then if selected when off-air then the device will play the primary service component instead.

D.3 Automatic updates to the service list

Whenever the receiver is tuned to an ensemble, it should update the stored information about service components within the tuned ensemble. The receiver should update all information needed to build the service list, as well as all information needed to access a service element. This information will usually contain: EId, SId, labels, sub-channel addresses, SCId/SCIdS, ASCTy/DSCTy/UAId information. This may also include PTy, service linking information, announcement information, etc. All information the receiver stores about ensembles and their service components should be automatically kept up-to-date.

If the receiver detects a reconfiguration of the currently tuned ensemble, then this information is also updated.

If the receiver fails to tune to an ensemble, it may apply a service following process to continue the service presentation. This may include a change to other ensembles, linked services or to other bearers. However, the information stored about the unavailable ensemble should remain unchanged. This means that if an ensemble is no longer broadcast (or the receiver is outside its reception area), all its service elements will remain in the list.

After a "manual frequency scan" (see also clause 6.2.3) information about ensembles that can no longer be received will be removed from the service list.

If the receiver tunes to an ensemble and then finds another ensemble (e.g. if the receiver is moved to another location), the receiver should automatically store information describing this new ensemble.

NOTE 1: In this case the receiver will then have information about two ensembles on the same frequency. The combined service list may show service elements from both these ensembles even though only one ensemble can be tuned.

The list shown to the user is derived from all information collected on all ensembles.

NOTE 2: Receivers with a single tuner will not be able to detect changes outside the currently tuned ensemble. So it is possible that some services are listed although they are no longer broadcast. Only after tuning again to the ensemble that signalled that it carried this service will the receiver be able to determine whether the service is removed from this ensemble.

If the user selects a service and upon tuning the receiver detects that this service is no longer broadcast in any ensemble that it can currently receive, the receiver shows a suitable error message.

NOTE 3: A receiver with multiple tuners will be able to automatically and continuously update the information describing all available ensembles, so such a receiver can provide an up-to-date service list.

In order to minimize the risk of showing an outdated service list, a receiver might choose to automatically update the service list every now and then, e.g. before the receiver shuts down it might automatically attempt to tune to all known ensembles and/or tunable frequencies and retrieve the information about all currently receivable service elements.

D.4 Character sets in the service list

The part of a service list entry that is presented to the user, at a minimum, consists of the relevant label for the service element, i.e. the service label or the service component label. For a useful representation of a service element in the service list, the receiver will need to provide a glyph set suitable to fully support the DAB services in the target market.

Broadcasters should be aware that although the DAB system allows all ISO 10646 [i.2] characters to be transmitted, it is likely that only a sub-set of these characters will be presented on receivers. Care should be exercised to ensure that the labels used to identify service elements will be presented well by receivers in the market.

Detailed specifications may be in force in some markets. Where these do not exist, the following gives a best practise recommendation on handling character encoding for transmission and representation of labels.

FIG type 1 labels carry 16 bytes of character data. When used with an 8-bit character set (e.g. "the EBU Complete Latin based repertoire", ETSI TS 101 756 [2]), this corresponds to 16 characters. However, when either the UCS-2 (2 bytes per character) or UTF-8 (1 to 3 bytes per character) encoding methods are used, fewer characters can be carried. In regions where either of these encoding mechanisms is needed (i.e. when characters not available in an 8-bit character set need to be displayed), longer labels may be provided by the use of FIG type 2, which carries labels of 16 characters in length, but with a variable length in bytes.

Receivers should provide appropriate FIG support and character decoding mechanisms to support the range of glyphs that they can display. For products that connect to another display device (e.g. a mobile phone via a wireless technology), a very wide range of characters are likely to be displayable and so support for both FIG type 1 and FIG type 2 labels, and for UCS-2 and UTF-8 character decoding, should be provided.

Whenever possible, labels should be displayed fully. If the display does not support the display of 16 characters, then the short form label may be displayed by using the character flag field. No other shortening of the label should be performed.

D.5 Sorting of the service list

The sorting of the service list is implementation dependent. Various strategies may be applied for sorting. It is recommended to apply a lexicographical sorting of labels based on the character code used for display. It is essential that the sort order is independent of the character encoding used in label transmission.

The sort order of the service list should be static and consistent across ensembles. It should be predictable to the end user, so that a service can be found by its name. A receiver may provide an option to change the sorting order, e.g. from a lexicographical order top-down to bottom-up or v.v. Other than by user action, the sort order should not be changed.

D.6 Presentation of secondary service components

If a service uses secondary service components, then all secondary service components that the receiver is able to decode are shown in the service list and are directly accessible to the user in the same way as primary service components.

D.7 Updating an ensemble from one frequency to another

It may become necessary to move an ensemble from one frequency to a new frequency.

It is desirable for the receiver to automatically update the stored frequency without user intervention - i.e. the user should not be required to rescan the receiver.

To achieve this, the broadcaster should use FIG 0/21 to signal the new frequency as an alternative frequency for a period of up to 30 days before the switchover.

Capable receivers will store this alternative frequency alongside the current received frequency for the ensemble. After the switchover these receivers will attempt to select on the new frequency once the original frequency is no longer available. To a user; this switchover will not be apparent.

D.8 Handling of unavailable service elements

After a valid service list entry has been created, the associated service element may become unavailable for a number of reasons. A service element is unavailable if it cannot be received on any of the ensembles it was previously received on and the receiver cannot re-establish reception of this or an alternative service element in another ensemble or at another frequency. Situations that result in a service element becoming unavailable include the following:

- A receiver is moved out of the coverage area of the ensemble transmission. Then all service elements of the ensemble become unavailable at the same time. The same ensemble may be available on another frequency.
- An ensemble stops being transmitted on its frequency and all its service elements become unavailable. The ensemble may have been moved to another frequency.
- A service element changes to an encoding scheme that is not supported by the receiver. It may be available with a supported encoding scheme on another ensemble.
- A service element changes its identification.
- A service element is moved from its ensemble to another ensemble.
- A service element stops transmission temporarily without signalling as part-time using SCI.

A service element is unavailable if one of the following cases applies:

- none of its ensembles can be received;
- no MCI can be found in its known ensembles referring to the service element;
- no SCI can be found in its known ensembles indicating a part-time service element in off-air status.

The service list entry of an unavailable service element should be retained and should remain selectable; it should be marked as unavailable. If the user attempts to select an unavailable service element, the receiver should make an attempt to re-establish reception, e.g. running the processes described in clauses 5 and 6. Once reception can be re-established, all unavailable marking should be removed.

D.9 Combined service list from multiple bearer systems

A combined FM-RDS and DAB receiver could list FM-RDS and DAB services in one combined service list. When creating a combined FM-RDS and DAB service list, the following points should be considered:

Implicitly linked services

- If FM-RDS and DAB are implicitly linked (i.e. no FIG 0/6 with FM-RDS information for the DAB service is broadcast), this means that if an FM-RDS service using the same PI-code as the DAB service identifier is broadcast, then FM-RDS service and DAB service can be considered the same service and only one service list entry might be shown. If the user selects this service list entry, the receiver would then determine the "best" source and play it.

Services linked by hard-links

- If a hard linkage set is signalled with one FM-RDS service and one DAB service within it, and the link is active, then the two services are carrying the same audio content at this time and a single service list entry could be shown. However, the link may become inactive at a later point, meaning that these services no longer carry the same content and will need separate service list entries.

- If the user selects this service list entry, the receiver would then determine the "best" source and play it. However, if the service linking information dynamically changes and these service are no longer hard linked, then both FM-RDS and DAB service would have to be shown individually in the service list.

- Linkage sets with more than one FM-RDS PI code and one DAB SId are unlikely to be reducible to a single service list entry without confusing the user.

- Another problem for the receiver is that it will only detect changes to the service linking information if it is tuned to the ensemble that carries the service linking information. Cached service linking information of other ensembles might be outdated and incorrect. Using service linking to combine service list entries is difficult and will lead to a dynamically changing service list. Therefore combining hard-linked DAB and FM-RDS services into one service list entry is generally discouraged.

Annex E (informative): Service lists - expected receiver behaviour

E.1 Domestic receiver implementations

E.1.1 Introduction

This annex addresses how a domestic receiver is able to present a service list that reflects what services the receiver can receive at a given time and location. Implementations in automotive or other sectors may differ. Depending on the receiver's architecture, different strategies can be used to achieve this goal.

Most domestic receivers will provide "presets" - buttons which allow quick access to a particular service element. In this context, two types of "preset" can be distinguished:

- Explicit preset: the user manually configures a preset. In addition to the SId/SCIdS, the receiver will usually store additional information such as service/service component label, frequency information and service linking information. If this preset is selected by the user, the receiver tunes to the configured service element.
- Implicit preset: if the receiver is powered on, the receiver will usually tune to the service element that was tuned at the time the receiver was powered off. Also in this case, the receiver might store additional information such as frequency information and service linking information.

Most domestic receivers have a single tuner. SCI information is particularly valuable for these types of receiver.

A single-tuner receiver can only decode the currently tuned ensemble. All information it has about service elements in other ensembles therefore tends to get out-of-date, and the longer the receiver has not tuned to an ensemble, the more out-of-date the information is likely to be.

Domestic receivers cache information about other ensembles so that they can present a full service list to the user. The receiver continues to play the currently selected service while the service list is shown, allowing the user to make a new selection whilst still listening to the current programme. This means that only the information shown about service elements in the currently tuned ensemble is sure to be accurate. Information about service elements in other ensembles might be outdated.

When the single-tuner receiver tunes to an ensemble, it automatically updates the cached information for the tuned ensemble. It adds all newly available service elements and removes all services and service elements that are no longer available, using the MCI and SCI. In addition, it updates the cache of SCI relating to future changes. By caching the SCI for this ensemble, the receiver is able to update its service list at the right time for service elements in this ensemble even if at that time the receiver is tuned to another ensemble.

The single-tuner receiver only knows for certain about the on-air status of service elements in the tuned ensemble. When the user selects a service element from the stored service list that is carried in another ensemble, the receiver tunes to the ensemble and inspects the MCI to determine if the service can be played. If the service element is off-air then a message will be provided to inform the user, and if the service element is part-time, then the expected on-air time may be displayed.

E.1.2 Addition of service elements

SCI with the change flags set to 01 provides information about the future addition of service elements to the tuned ensemble for up to 28 days in advance. The information is cached by the receiver to allow it to update its service list with an entry for the added service element at the date-time indicated when tuned to a different ensemble.

A service list entry created from SCI alone (before the respective MCI has been received) is termed a "tentative" service list entry. It should be marked as such to allow the user to understand it represents a service element that has not yet come into existence.

If a tentative service list entry is added to the service list, it should from then on be shown in the service list until the receiver can confirm that the new service element is broadcast. At that time the service list entry becomes permanent, any tentative marking is removed. This tentative service list entry should also be shown while the receiver is tuned to another ensemble than the ensemble that carried the SCI.

A tentative service list entry should be created at least at the date-time indicated in the SCI. If the receiver is not turned on at this date-time, then a tentative service list should be created after the receiver is turned on. This tentative service list entry should be created even and especially if the receiver is not tuned to this ensemble at this time.

NOTE: It is important that the receiver shows the tentative service list entry after the indicated date-time especially when not tuned to the ensemble because otherwise the listener would have no means to tune to this ensemble and detect and confirm the newly broadcast service element.

The tentative service element may also be created ahead of the indicated date-time. In this case, the receiver should also indicate when the service element will go on-air.

At the date-time indicated in the SCI, the new service element will be broadcast and a receiver tuned to this ensemble at or after the indicated date-time will receive the MCI information for the new service element and can then create the permanent service list entry.

If the receiver can successfully tune to the ensemble that should carry the service element, but the service element is not yet on air (i.e. SCI information was updated to a different date-time), then the receiver should update the date-time when this service element goes on-air.

If the service element is not broadcast and no SCI for this service element is broadcast or SCI indicates that the service element was removed, then the tentative service list entry should be removed.

If the user selects a tentative service list entry, then a message should be shown to the user if the selected service element is not yet broadcast or already removed again.

For part-time services, the information is used to update an existing service list entry with the time the service element will be back on-air, or, if there is no service list entry, to create one. If the date-time field contains the special value, it indicates that the on-air time is not known.

E.1.3 Removal of service elements

SCI with the change flags set to 11 provides information about the removal of service elements from *all ensembles* for up to 28 days in advance. This is the "normal" case for removal.

For continuous service elements, the information is cached by the receiver to allow it to update its service list by deleting the entry for the removed service element at the date-time indicated if tuned to a different ensemble. When the primary service component is removed from the service list, all secondary service components are also removed because they cannot exist in isolation.

For part-time services during the on-air period, the information is used to update an existing service list entry with the time the service element will go off-air. If the date-time field contains the special value, it indicates that the off-air time is not known.

SCI with the change flags set to 10 provides information about the future removal of service elements from *the tuned ensemble only* (local removal) for up to 28 days in advance. This is used by broadcasters when the service is removed from the tuned ensemble, but remains on-air on other ensembles. Those ensembles may or may not be receivable by the receiver at its current location.

For continuous services, the information is cached by the receiver to allow it to update its service list for the removed service element at the date-time indicated when tuned to a different ensemble. However, care needs to be used since the service element will continue to be available in other ensembles than the tuned ensemble and so the service list entry may remain if the receiver is able to tune to any of those other ensembles.

The signalling for local removal is not used for part-time service elements.

If the receiver is playing the affected service element at the time of the removal then it will try to present the listener with the best alternative. If the service element is only removed from the tuned ensemble (change flags = 10) then the service element may still be available on another ensemble. In order to continue service presentation, the receiver needs to run a process with several stages, see clause 6.4.3.1. If through that process no suitable alternative is available, the receiver will display a message.

E.1.4 Changed identity or ensemble

SCI with the change flags set to 00 provides information about changing the identity of services in the tuned ensemble for up to 28 days in advance. If the service is moving ensembles then this SCI appears in both ensembles.

For continuous services, the information is cached by the receiver to allow it to update its service list by updating the entry for the changed service identifiers (SId and/or EId) at the date-time indicated when tuned to a different ensemble.

For part-time services, the information is signalled during the off-air period prior to the new identity being used (i.e. in place of the usual 01 addition signalling). It allows an existing service list entry to be updated with the new identity. The service list entry is immediately updated with the changed service identifiers and the date-time indicates when the service will be back on-air. If no service list entry exists then one is created with the new identity. If the date-time field contains the special value, it indicates that the on-air time is not known.

If the receiver is playing the affected service element at the time of the identity change and the change is within the same ensemble, then it will continue to play the service with no interruption.

If the receiver is playing the affected service element at the time of the identity change but the change is to another ensemble, then it will retune to the new ensemble and continue to play the service with minimal interruption. If the receiver cannot play the service it will try to find a hard-linked service instead.

E.1.5 Multi-tuner domestic receiver

A domestic receiver with more than one tuner is able to maintain its service list with greater accuracy, since it is able to decode the FIC from other ensembles whilst still playing the user's chosen service element.

The "background tuner" continuously scans the tuning range and compares the MCI and SCI received from each ensemble with the information stored in the service list. The on-air status of part-time services can be properly reflected and any updates to the date-time field for identity changes can also be followed.

If the receiver has two complete tuning and demodulation chains then the playback of user selections can also be improved, for example, during and identity change from one ensemble to another, the handover can be made virtually seamless.

Annex F (normative): Service Component Information

In the present document a new FIG is defined to provide additional information to help with the management of service lists in receivers. This annex F contains the definition of FIG 0/20, and this definition will be added to future revisions of ETSI EN 300 401 [1].

The new FIG is a type 0 FIG carrying SI. It provides information about changes to service elements in the tuned ensemble only - there is no OE usage. FIG 0/20 is in the "unique information" category. The three flags C/N, OE, P/D (see ETSI EN 300 401 [1] clause 5.2.2.1) are therefore used as follows:

Current/Next (C/N): Rfu;

Other Ensemble (OE): Rfu;

P/D: used and is valid for both the SId field and the Transfer SId field.

FIG 0/20 shall be signalled at a repetition rate of once per second.

The Service Component Information (SCI) feature is used to signal information about service elements to assist in the construction of a service list. The feature is encoded in Extension 20 of FIG type 0 (FIG 0/20). Figure F.1 shows the structure of the Service Component Information field which is part of the Type 0 field (see also [1] figure 4).

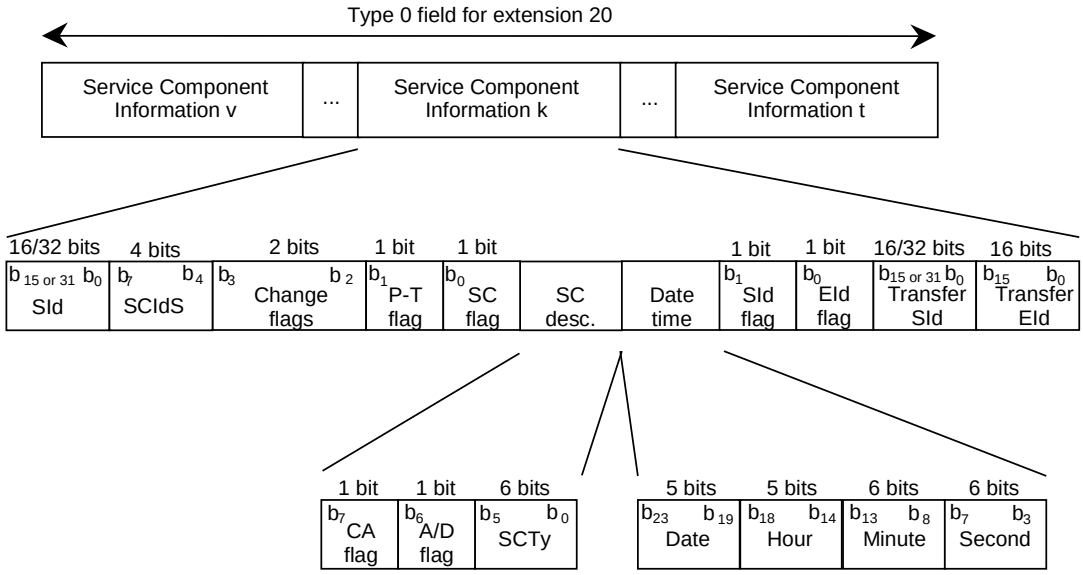

Figure F.1: Structure of Service Component Information field

The following definitions apply:

SId (Service Identifier): this 16-bit or 32-bit field shall identify the service (see ETSI EN 300 401 [1], clause 6.3.1). The length of the SId shall be signalled by the P/D flag, see ETSI EN 300 401 [1], clause 5.2.2.1.

SCIdS (Service Components Identifier within the Service): this 4-bit field shall identify the service component within the service. The combination of the SId and the SCIdS provides a service component identifier which is valid globally.

NOTE: The primary component has its SCIdS set to 0.

Change flags: this 2-bit field shall indicate future changes to a service element, as follows:

0 0 : the service will remain in the ensemble with a new SId or will be moved to or from another ensemble;

0 1 : the service element will be added to the ensemble;

1 0 : the service element will be removed from the ensemble;

1 1 : the service element will be removed from all ensembles.

P-T (Part-time) flag: this 1-bit flag shall indicate whether the service element is on-air or off-air continuously or cycles through on-air and off-air periods, as follows:

0 : the service element is on-air or off-air continuously (i.e. 24 hours/day);

1 : the service element cycles on-air and off-air (i.e. part-time).

SC (Service Component) flag: this 1-bit flag shall indicate the presence of the SC description field, as follows:

0 : SC description field is absent;

1 : SC description field is present.

SC (Service Component) description: the presence of this field is indicated by the SC flag. When present it contains the following:

- **CA flag:** this 1-bit field flag shall indicate whether access control applies to the service component, as follows:

  0 : no access control or access control applies only to a part of the service component;

  1 : access control applies to the whole of the service component.

- **A/D flag:** this 1-bit flag shall indicate whether the SCTy field carries the ASCTy or DSCTy, as follows:

  0 : ASCTy;

  1 : DSCTy.

- **SCTy (Service Component Type):** this 6-bit field shall carry either the ASCTy or DSCTy of the service component in accordance with the A/D flag.

Date-time: this 22-bit field contains the following sub-fields:

- **Date:** this 5-bit field shall carry the lower 5 bits of the MJD for the day on which the service component change occurs and which shall be no more than 28 days ahead of the current date.

NOTE 1: The Date field refers to the earliest future event - there may be an implied carry bit in the MJD - unless the Hour, Minute and Second fields carry the special value.

- **Hour:** this 5-bit field shall define the hour in UTC at which the service component change occurs in the range 0 to 23, or the special value 31.

- **Minute:** this 6-bit field shall define the minute in UTC at which the service component change occurs in the range 0 to 59, or the special value 63.

- **Second**: this 6-bit field shall define the second in UTC at which the service component change occurs in the range 0 to 59, or the special value 63.

NOTE 2: When the Hour, Minute and Second fields carry the special value, the Date field has no meaning.

NOTE 3: The precise instant of any change is signalled by the reconfiguration instant in FIG 0/0 (see ETSI EN 300 401 [1] clause 6.3.5).

SId flag: this 1-bit field shall indicate the presence of the Transfer SId field as follows:

0 : Transfer SId field is absent;

1 : Transfer SId field is present.

EId flag: this 1-bit field shall indicate the presence of the Transfer EId field as follows:

0 : Transfer EId field is absent;

1 : Transfer EId field is present.

Transfer SId: this 16-bit or 32-bit field, when present, shall contain the SId of the re-directed service. The length of the SId shall be signalled by the P/D flag, see ETSI EN 300 401 [1], clause 5.2.2.1.

NOTE: The ECC of the Transfer SId is identical to the ECC of the SId.

Transfer EId: this 16-bit field, when present, shall contain the EId of the ensemble that contains the re-directed service.

NOTE: The ECC of the Transfer EId is identical to the ECC of the tuned ensemble.

History

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