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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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In the present document, certain modal verbs have the following meanings:

shall indicates a mandatory requirement to do something

shall not indicates an interdiction (prohibition) to do something

NOTE 1: The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

NOTE 2: The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

should indicates a recommendation to do something

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NOTE 3: The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

can indicates that something is possible

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NOTE 4: The constructions "can" and "cannot" shall not to be used as substitutes for "may" and "need not".

will indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

will not indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

NOTE 5: The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document provides an overview and overall description of the LTE-based 5G terrestrial broadcast comprising:

- a service delivering Free To Air content [2];
- a radio network comprising only MBMS-dedicated cells or FeMBMS/Unicast-mixed cells [3] as transmitters; and
- Receive Only Mode (ROM) devices and UEs supporting FeMBMS [4] as receivers.

Details of the radio interface protocols and procedures are specified in companion specifications of the 36 series.

This document is a 'living' document, i.e. it is permanently updated and presented to TSG-RAN meetings.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.101: "Service aspects; Service principles".

[3] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN)".

[4] 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description".

[5] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".

[6] 3GPP TS 36.331: "Radio Resource Control (RRC) Protocol".

[7] 3GPP TS 24.116: "Stage 3 aspects of system architecture enhancements for TV services".

[8] 3GPP TS 36.211: "E-UTRA; Physical Channels and Modulation".

[9] 3GPP TR 36.776: "Study on LTE-based 5G terrestrial broadcast".

[10] 3GPP TR 38.913: "Study on scenarios and requirements for next generation access technologies".

[11] 3GPP TR 36.440: "General aspects and principles for interfaces supporting Multimedia Broadcast Multicast Service (MBMS) within E-UTRAN".

[12] 3GPP TS 24.117: "TV service configuration Management Object (MO)".

[13] 3GPP TS 36.213: "E-UTRA; Physical layer procedures".

[14] 3GPP TS 36.304: "E-UTRA; Procedures in idle mode".

[15] 3GPP TS 36.133: "E-UTRA; Requirements for support of radio resource management".

[16] 3GPP TS 36.321: "E-UTRA; MAC protocol specification".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Symbols

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

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

CAS	Cell acquisition subframe
CFI	Control format indicator
DRX	Discontinuous reception
eMBMS	Evolved MBMS
FeMBMS	Further enhanced MBMS
HPHT	High power high tower
ISD	Inter-site distance
LPLT	Low power low tower
MBMS	Multimedia Broadcast/Multicast System
MBSFN	Multicast/Broadcast Single Frequency Network
MCCH	Multicast Control Channel
MPMT	Medium power medium tower
MTCH	Multicast Traffic Channel
NAS	Non-access stratum
PBCH	Physical Broadcast Channel
PCFICH	Physical Control Format Indicator Channel
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PMCH	Physical Multicast Channel
PSS	Primary synchronization signal
ROM	Receive only mode
RRC	Radio Resource Control
RRM	Radio resource management
SSS	Secondary synchronization signal
TV	Television

4 Introduction

4.1 General

The main aspects of the LTE-based 5G terrestrial broadcast described in this specification are:

- radio network comprising only MBMS-dedicated cells or FeMBMS/Unicast-mixed cells [3] as transmitters; and
- ROM devices and UEs supporting FeMBMS [4] as receivers.

NOTE: ROM devices support only ROM service [5]. ROM service uses one of the reserved TMGI values [7].

MBMS-dedicated cells support only MBMS transmission and do not support uplink transmission. MBSFN subframes of a MBMS-dedicated cell do not have a control region and can therefore be 100% allocated to MBMS. Non-MBSFN subframes, also called Cell Acquisition Subframes (CAS), which contain the control region, are used for transmission of the system acquisition signals (PSS/SSS), PDCCH, and system information on PBCH and PDSCH. CAS are transmitted with a periodicity of 40ms and use subframes with Δf = 15 kHz. PBCH of a MBMS-dedicated cell uses a different scrambling sequence initialization than PBCH of a non-MBMS-dedicated cell, which prevents UEs that do not support MBMS-dedicated cell from camping on it. For more information about MBMS-dedicated cell see TS 36.300 [3].

Multicast data is transmitted over PMCH. PMCH supports SFN transmission, where multiple eNBs synchronously transmit the same waveform. Multiple numerologies are supported for PMCH (see Clause 6.1), tailored for different scenarios (e.g. support of different mobility and ISD). A single cell can belong to multiple (up to 8) SFN areas, where different SFN areas may have different numerologies. The PMCH carries the MCCH and MTCH logical channels. The MCCH provides scheduling information for multicast data over the MTCH. The MTCH contains user plane data. MCCH scheduling information is provided in system information.

ROM devices support MBMS reception but do not support uplink transmission. ROM devices may not have USIM. As such, ROM devices do not support two-way signalling procedures with the network, including connection establishment procedures and security procedures. ROM devices only support the idle mode. Not all idle mode procedures are supported, as described in clause 7.3. For more details on ROM devices see clause 7, TS 36.300 [3] clause 15.11, TS 23.246 [4] Annex D and TS 24.116 [7] clause 4.

NOTE 1: As a matter of implementation, a cellular device can host a ROM device and a traditional UE capable of unicast. Such device is further described in TS 36.246 [4] Annex E and called *ROM device with independent unicast*. The co-hosted UE is connected to a different cell from the MBMS-dedicated cell serving the co-hosted ROM device. If the co-hosted UE and ROM device share baseband resources, the co-hosted UE can use *MBMSInterestIndication* signalling procedure, specified in TS 36.331 [6], to inform the serving RAN about the baseband resources occupied by the co-hosted ROM device and therefore not available for unicast.

NOTE 2: There may be awareness at the application layer of the ROM device with independent unicast. How this awareness is created is outside of the scope of specifications.

4.2 Use cases and requirements

In Release 14, the use cases and scenarios for eMBMS services based on LTE have been expanded to include terrestrial broadcasting (the feature also referred to as "EnTV"). This included new requirements:

- network dedicated to TV broadcast via eMBMS;
- SFN deployments with ISD significantly larger than a typical ISD associated with typical cellular deployments;
- support for ROM device.

NOTE: At the upper layers, the requirements included the support for Free to Air service [2] and for eMBMS network sharing [4].

In Release 16, a gap analysis documented in TR 36.776 [9] compared the Release 14 LTE terrestrial broadcasting capabilities with the requirements for 5G dedicated broadcast networks in TR 38.913 [10]. As a result of this analysis, the following two requirements were deemed unfulfilled by Release 14 LTE eMBMS:

1. Support for service over large geographic area, including SFN with ISD > 100km;
2. Support for mobility scenarios including speeds of up to 250 km/h.

In relation to the first requirement, the new ISD of 125 km, referred to as HPHT network, with omni-directional transmitters was defined. The following two ISD were also included in the evaluation:

- 15 km, referred to as LPLT network with sectorized cells;
- 50 km, referred to as MPMT network with omni-directional transmitters.

The first requirement is associated with receivers with high-gain rooftop directional antennas, low mobility and a predominantly line-of-sight channel.

The second requirement is associated with receivers in cars, with external omni-directional antennas.

In addition to the above two requirements, a third requirement was added related to improving the CAS reception for both large ISD and high mobility scenarios.

4.3 Enhancements targeting LTE terrestrial broadcast

In Release 14, the following key RAN enhancements were made to the specifications to enable LTE terrestrial broadcast:

- MBMS-dedicated cell [3];
- MBSFN subframes using Δf = 1.25 kHz [8], with a cyclic prefix duration of 200μs and a symbol duration of 1ms;
- New information blocks on PBCH and PDSCH of CAS [3], [6]:
  - *MIB-MBMS* is transmitted with a 40ms periodicity and updated every 160 ms; and
  - *SIB1-MBMS* is transmitted with an 80ms periodicity and updated every 160 ms, containing information relevant for receiving MBMS service and, optionally, the scheduling of other system information blocks;
- *MBMSInterestIndication* RRC signalling procedure (see clause 4.1).

NOTE: For upper layer enhancements, see TS 23.246 [4] Annex D and E, TS 24.116 [7], TS 24.117 [12] and TS 26.346 [5] (ROM service aspects).

In Release 16, the following RAN enhancements were made to address the use cases described in clause 4.2:

- MBSFN subframes using Δf = 0.37 kHz, with a cyclic prefix duration of 300μs and a symbol duration of 3ms, for the support of large ISD;
- MBSFN subframes using Δf = 2.5 kHz, with a cyclic prefix duration of 100μs and a symbol duration of 0.5ms, for the support of high mobility;
- The following enhancements on the CAS:
  - PDCCH enhancements:
    - CFI indication in MIB [6] to avoid the need to decode PCFICH; and
    - New aggregation level 16;
  - Repetition of PBCH to increase its robustness.

In Release 17, the following RAN enhancement was introduced to enable deployment of LTE-based 5G terrestrial broadcast in broadcast UHF spectrum, where the channelization is 6/7/8MHz (depending on the geography):

- PMCH bandwidth of 30, 35 and 40 PRBs (corresponding to 6/7/8MHz), applicable for CAS bandwidth of 15 or 25 PRBs (corresponding to 3 and 5MHz).

5 Architecture

The network architecture for LTE-based 5G terrestrial broadcast is described in TS 36.300 [3] clause 15.1.1, with the exception that only:

- ROM reception via MBMS-dedicated cell; or
- MBMS reception via FeMBMS/Unicast-mixed cell

is supported.

RAN interfaces for LTE-based 5G terrestrial broadcast are described in TS 36.300 [3] clause 15.1.1 and in TS 36.440 [11]. In case of a MBMS-dedicated cell, the counting procedure is not supported by the eNB.

User plane and control plane protocol stack for LTE-based 5G terrestrial broadcast is described in TS 36.300 [3] clause 15.1.2 and clause 15.1.3, respectively.

NOTE: For upper layer architecture, see TS 23.246 [4].

6 Protocol aspects

6.1 Frame structure and numerologies

Only frame structure type 1 is supported. All numerologies specified in TS 36.211 [8] are supported. For subframes using Δf other than 0.370 kHz, the frame structure is according to Figure 6.1-1. For transmissions using Δf = 0.370 kHz, the frame structure is shown in Figure 6.1-2.

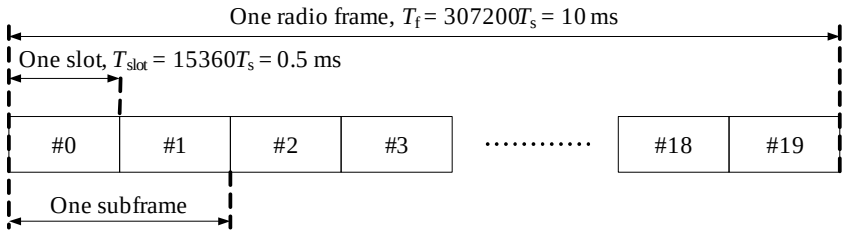

Figure 6.1-1: Frame structure type 1 for subframes not using Δf = 0.370 kHz For Δf = 1.25 kHz, one subframe contains a single slot with a duration of 1ms.

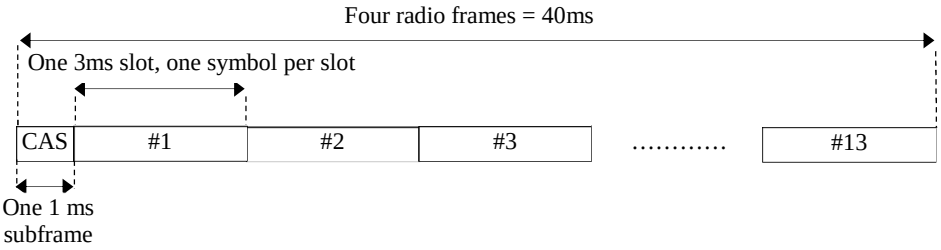

Figure 6.1-2: Frame structure type 1 for transmissions using Δf = 0.370 kHz. The CAS is a non-MBSFN subframe, and is configured with 15 kHz subcarrier spacing

Table 6.1 summarizes the supported numerologies for MBMS transmission over PMCH. The theoretical equalization interval is obtained as the maximum channel delay spread that can be estimated from the pilot pattern, and is equal to the Symbol duration (excluding CP) divided by the frequency separation (in number of subcarriers) between two consecutive pilot tones.

Table 6.1: Summary of supported numerologies for MBMS transmission over PMCH

Subcarrier spacing	Symbol duration (excluding CP)	Cyclic prefix length	Time separation between pilots in the same subcarrier, in number of OFDM symbols	Frequency separation between pilots, in number of subcarriers (after de-stagger)	Theoretical equalization interval
15 kHz	66.6 μs	16.6 μs	8 (NOTE)	1	66.6 μs
7.5 kHz	133.3 μs	33.3 μs	4 (NOTE)	2	66.6 μs
2.5 kHz	400 μs	100 μs	2	2	200 μs
1.25 kHz	800 μs	200 μs	2	3	266.67 μs
0.370 kHz	2700 μs	300 μs	2 or 4	3	900 μs
NOTE: For 15 and 7.5kHz, this denotes the separation within one subframe of one of the staggers. See TS 36.211 [8] Figures 6.10.2.2-1 and 6.10.2.2-3.					

6.2 MBMS Transmission

MBMS transmission is performed according to TS 36.300 [3] clause 15.3.3.

MCCH configuration and scheduling is performed according to TS 36.300 [3] clause 15.3.5 and TS 36.331 [6] clause 5.8.1. In case of a MBMS-dedicated cell, the MBMS counting configuration is not supported.

MCCH information acquisition is performed according to TS 36.300 [3] clause 15.3.5 and TS 36.331 [6] clause 5.8.2. In case of a MBMS-dedicated cell, only RRC_IDLE is supported.

6.3 MAC Layer

MAC layer supports only:

- BCH reception for BCCH;
- DL-SCH reception for BCCH; and
- MCH reception for MCCH/MTCH.

BCH reception and DL-SCH reception in the MAC layer use transparent MAC [16], i.e. single MAC PDU per TTI with no headers. HARQ entity uses the dedicated broadcast HARQ process, defined in [16].

MCH reception in the MAC layer is specified in TS 36.321 [16] clause 5.12 and in TS 36.300 [3] clause 15.3.3.

6.4 RLC layer

BCCH uses the RLC-TM mode.

MTCH and MCCH use the RLC-UM mode. RLC operation for MTCH and MCCH is described in TS 36.300 [3] clause 15.3.3.

6.5 RRC layer

RRC layer supports only:

- System information reception (see TS 36.331 [6] clause 5.2) in MBMS-dedicated cell; and
- MBMS reception (see TS 36.331 [6] clause 5.8) in MBMS-dedicated cell and in FeMBMS/Unicast-mixed cell.

For system information reception, the following applies:

- only *BCCH-BCH-Message-MBMS* and *BCCH-DL-SCH-Message-MBMS* message class is supported;
- acquisition of system information messages is performed according to TS 36.331 [6] clause 5.2.3b.

For MBMS reception, the following applies:

- MBMS counting procedure and MBMS interest indication procedure are not supported.

7 ROM aspects

7.1 General

Since a ROM device does not support uplink transmission or two-way signalling procedures, and does not comprise USIM, it cannot support all the physical layer procedures of the conventional UE. By the same token, only a subset of idle mode procedures and RRM requirements applicable to a conventional UE will be supported. The following clauses provide an overview of the physical layer and idle mode procedures and the RRM requirements applicable to a ROM device.

7.2 Physical layer procedures

ROM device only supports the following physical layer procedures specified in TS 36.213 [13]:

- Cell search;
- Timing synchronization;
- PDSCH procedures;
- PDCCH assignment procedure;
- PMCH procedures; and
- Assumptions independent on physical channels (clause 12) related to MBMS-dedicated cell.

7.3 Idle mode procedures

ROM device only supports the following idle mode procedures specified in TS 36.304 [14]:

- Cell selection; and
- Cell reselection.

PLMN prioritization for cell reselection is specified in TS 36.304 [14] clause 5.2.4.1.

NOTE: NAS layer PLMN selection does not apply to ROM device. PLMN selection for ROM device is specified in TS 24.116 [7].

ROM device does not support DRX.

7.4 RRM requirements

ROM device only supports the following requirements specified in TS 36.133 [15]:

- Cell selection; and
- Cell reselection, except for:
  - IRAT reselection;
  - paging-related requirements; and
  - CSG cell-related requirements.

Appendix Upper layer aspects

LTE-based 5G terrestrial broadcast supports *transparent delivery*, which allows for broadcasting of IP-based services for which the media codecs and application protocols are defined outside 3GPP (see clause 8B, TS 26.346 [5]).

Broadcast service announcement and session management are defined in clause 4.4.3, TS 23.246 [4].

ROM devices are defined in clause 7, TS 36.300 [3] clause 15.11, TS 23.246 [4] Annex D and TS 24.116 [7] clause 4.

Annex A:
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2019-08	RAN1#97	R1- 1908844				Skeleton TR	0.0.1
2019-11	RAN1#99	R1-1913483				Added technical content to all clauses. Incorporated technical and editorial the comments received in the meeting	0.1.0
2019-11	RAN1#99	R1-1913542				Endorsed with minor changes agreed in RAN1#99	0.2.0
2019-12	RAN#86	RP-192688				Clean version as v1.0.0 for presentation to plenary	1.0.0
2020-02	RAN1#100-e	R1-2000713				Incorporated additional technical and editorial changes	1.1.0
2020-02	RAN1#100-e	R1-2001230				Incorporated comments during email discussion	2.0.0
2020-03	RAN#87e	RP-200167				Clean version based on 2.0.0 for RAN approval.	2.1.0
2020-03	RAN#87e					TR under change control – MCC clean-up	16.0.0
2022-03	RAN#95-e	RP-220259	0001	-	B	Introduction of Rel-17 enhancements	17.0.0

History

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