ETSI TS 102 744-2-2 V1.1.1 (2015-10)

TECHNICAL SPECIFICATION

Satellite Earth Stations and Systems (SES);
Family SL Satellite Radio Interface (Release 1);
Part 2: Physical Layer Specifications;
Sub-part 2: Radio Transmission and Reception

Reference

DTS/SES-00299-2-2

Keywords

3GPP, GPRS, GSM, GSO, interface, MSS, radio, satellite, TDM, TDMA, UMTS

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Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 2, sub-part 2 of a multi-part deliverable. Full details of the entire series can be found in ETSI TS 102 744-1-1 [i.1].

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).

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Introduction

This multi-part deliverable (Release 1) defines a satellite radio interface that provides UMTS services to users of mobile terminals via geostationary (GEO) satellites in the frequency range 1 518,000 MHz to 1 559,000 MHz (downlink) and 1 626,500 MHz to 1 660,500 MHz and 1 668,000 MHz to 1 675,000 MHz (uplink).

1 Scope

The present document defines the radio reception and transmission requirements for all classes of UE that comply with the Family SL physical layer specifications as defined in ETSI TS 102 744-2-1 [11]. The Family SL radio interface operates in spectrum allocated to mobile satellite services (see ETSI TS 102 744-2-1 [11], clauses 5.1.2 and 6.1.2).

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 reference document (including any amendments) applies.

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

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

[1] Recommendation ITU-R M.1480: "Essential technical requirements of mobile Earth stations of geostationary mobile-satellite systems that are implementing the Global mobile personal communications by Satellite (GMPCS) - Memorandum of understanding arrangements in parts of the frequency band 1-3 GHz".

[2] Recommendation ITU-R M.1091: "Reference off-axis radiation patterns for mobile earth station antennas operating in the land mobile-satellite service in the frequency range 1 to 3 GHz".

[3] Recommendation ITU-R M.694: "Reference radiation pattern for ship earth station antennas".

[4] ETSI EN 301 444: "Satellite Earth Stations and Systems (SES); Harmonized EN for Land Mobile Earth Stations (LMES) operating in the 1,5 GHz and 1,6 GHz bands providing voice and/or data communications covering essential requirements of article 3.2 of the R&TTE directive".

[5] ETSI EN 301 681: "Satellite Earth Stations and Systems (SES); Harmonized EN for Mobile Earth Stations (MESs) of Geostationary mobile satellite systems, including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) in the 1,5/1,6 GHz bands under the Mobile Satellite Service (MSS) covering the essential requirements of article 3.2 of the R&TTE Directive".

[6] ETSI EN 301 473: "Satellite Earth Stations and Systems (SES); Aircraft Earth Stations (AES) operating below 3 GHz under the Aeronautical Mobile Satellite Service (AMSS)/Mobile Satellite Service (MSS) and/or the Aeronautical Mobile Satellite on Route Service (AMS(R)S)/Mobile Satellite Service (MSS)".

[7] RTCA DO-210D: "Minimum Operational Performance Standards (MOPS) for Geosynchronous Orbit Aeronautical Mobile Satellite Services (AMSS) Avionics".

[8] International Civil Aviation Organisation, Global Navigation Satellite System, Standards and Recommended Practices (ICAO GNSS SARPs).

NOTE: This reference is contained in Volume 1 (Radio Navigation Aids) of Annex 10 (International Standards and Recommended Practices for Aeronautical Telecommunications) of the Chicago Convention on International Civil Aviation.

[9] ETSI TS 102 744-1-4: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 4: Applicable External Specifications, Symbols and Abbreviations".

[10] ETSI TS 102 744-1-2: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 2: System Operation Overview".

[11] ETSI TS 102 744-2-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 2: Physical Layer Specifications; Sub-part 1: Physical Layer Interface".

[12] ETSI TS 102 744-3-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 1: Bearer Control Layer Interface".

[13] ETSI TS 102 744-3-2: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 2: Bearer Control Layer Operation".

2.2 Informative references

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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 TS 102 744-1-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 1: Services and Architectures".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Block Error Rate (BLER): probability that a received FEC Block contains uncorrectable error(s)

NOTE: In the present document, the term Block Error Rate (BLER) always refers to FEC Blocks.

global beam: satellite beam that covers the full satellite coverage footprint

NOTE: A global beam is provided on each satellite to support (amongst other things) terminal access in spot beams that currently are not activated to support data services.

narrow spot beam: satellite beam that covers the smallest portion of the satellite coverage footprint

regional beam: satellite beam that covers a medium portion of the satellite coverage footprint

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TS 102 744-1-4 [9], clause 3 apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 102 744-1-4 [9], clause 3 apply.

4 General

4.1 UE classes

The requirements for the various UE classes are defined in groups as shown in Table 4.1.

Table 4.1: UE classes

Group	Subgroup	UE Class	Antenna Type	Clause
Land Class	N/A	Class 1	Land A3 size	Clause 5
		Class 2	Land A4 size	
		Class 3	Land A5 size	
Extension Class	Aeronautical	Class 4	Future Aeronautical Enhanced Low Gain (see note)	Clause 6
		Class 6	Aeronautical High Gain	
		Class 7	Aeronautical Intermediate Gain	
		Class 15	Aeronautical Low Gain	
	Maritime	Class 5	Future Maritime Low Gain (see note)	Clause 7
		Class 8	Maritime High Gain	
		Class 9	Maritime Low Gain	
	Land Mobile (e.g. vehicles)	Class 10	Land-Mobile High Gain	Clause 8
		Class 11	Land-Mobile Low Gain	
		Class 12	Future Land Low Gain (see note)	
NOTE: Class 4, Class 5 and Class 12 UEs are defined as future Low Gain Antenna (LGA) terminals that are designed to make use of the LGA bearers.				

The requirements for the Land Class are defined in full. The requirements for other classes are then defined relative to this baseline (i.e. differences from the Land Class requirements).

4.2 RF transceiver general capabilities

The requirements in the following clauses require a UE to provide the following general capabilities:

1) The transceiver shall be designed to operate as a full duplex transceiver supporting the channelisation defined in ETSI TS 102 744-2-1 [11].

2) The transceiver shall be able to tune to narrow signalling channels using nominal bandwidth sizes of 10,5 kHz, 21 kHz, 42 kHz, 84 kHz and 189 kHz wide band traffic channels as defined in ETSI TS 102 744-2-1 [11].

3) The transceiver shall receive a full 200 kHz multi-bearer subband and from this 200 kHz bandwidth pick out (one) "narrow" channel using nominal bandwidth sizes of 10,5 kHz, 42 kHz and 189 kHz width as defined in ETSI TS 102 744-2-1 [11].

4) The transceiver shall have a transmitter, which is capable of burst-by-burst re-tuning inside the assigned 200 kHz sub-band.

Some requirements in the present document are defined in terms of test conditions, which correspond to the worst case impairments. The UE shall meet the performance requirements under these test conditions with the expectation that equal or better performance will be achieved under less stringent impairments.

4.3 Antenna parameters

The terms medium elevation and low elevation shall be understood as follows in the present document:

- Low Elevation: $5° \leq$ Elevation $\leq 10°$
- Medium Elevation: $10° <$ Elevation $\leq 20°$

5 Land Class UE requirements

5.1 Antenna requirements

5.1.1 Radiation Pattern

Class 1 and 2 UE shall comply with the antenna radiation pattern restrictions as defined in Recommendation ITU-R M.1091 [2].

A Class 3 UE shall meet the following requirement:

- $G \leq -5$ dBi for $\theta > 90°$

  where θ and G are as defined as follows:

  - θ: angle (degrees) between the direction of maximum gain and the direction considered.
  - G: gain relative to an isotropic antenna.

5.1.2 Polarization

Right-hand circular polarization (RHCP) shall be used for receive and transmit directions.

5.1.3 Axial Ratio

The antenna circular polarization axial ratio shall be no greater than the requirements stated in Table 5.1 for a UE within the portion of the UE antenna main beam that could be directed towards the satellite position, taking into account beam pointing tolerances. For all UEs, this value is for antennas in 'free space' but with the antenna integrated in the final unit.

Table 5.1: UE Maximum Axial Ratio

UE Class	Axial Ratio Requirement
Class 1	3 dB
Class 2	5 dB
Class 3	5 dB

5.1.4 UE antenna pointing loss

Provision shall be made to aid the user in accurately pointing the antenna in the direction of the satellite.

The design target is that a user is expected to be able to point the UE to achieve pointing losses with respect to maximum gain in transmit and receive less than those stated in Table 5.2, in a short time with only a little practice.

Table 5.2: UE Maximum Antenna Pointing loss

UE Class	Maximum Antenna Pointing Loss
Class 1	0,5 dB
Class 2	0,3 dB
Class 3	0,3 dB

For antenna pointing adjustment, audio and/or visual feedbacks shall be provided during initial deployment to indicate C/No level or equivalent.

NOTE: For Class 3 UEs, a LED indication may be sufficient, whereas for Class 1 and Class 2 UEs a LCD bargraph or similar may be needed.

The UE shall ensure that the optimum pointing is found for both the uplink and downlink. Hence for low antenna gain UEs, a C/No measurement should be supplemented with estimates of carrier plus noise power changes due to changes in the antenna pointing.

5.2 Receiver requirements

5.2.1 Gain-to-Noise Temperature Ratio

The RF receiving system gain-to-noise-temperature ratio (G/T) shall be in accordance with Table 5.3 for the relevant UE type in the direction of the satellite and under the following simultaneous conditions:

1) clear sky climatic conditions;
2) including noise contribution of the full receiver from antenna to base band;
3) with the transmitter power amplifier at maximum specified output level;
4) if a dry radome is fitted then including the loss and noise temperature contributions;
5) including the loss and noise temperature contributions of the antenna feed system and associated cables and filters (such as a Diplexer);
6) the environmental conditions for which the UE is to be used;
7) including noise contribution of 290 K ground temperature with the satellite at 5° elevation.

The antenna gain G, measured over the appropriate frequency range and RHCP, is expressed in dB relative to an ideal (no ohmic loss) isotropic antenna, and the receiving system noise temperature T is expressed in dB relative to 1 K. G and T shall be referred to a suitable common point within the receiving system.

Table 5.3: Minimum G/T Requirements for Land Class UEs

UE Class	Minimum Receiver G/T (dB/K) (Forward Link) with sat ≥ 5° elevation
Class 1	-10,5
Class 2	-13,5
Class 3	-18,5

The above G/T requirements shall apply for integrated antenna and shall also apply when using a supported external antenna i.e. it includes the cable loss.

5.2.2 Received Signal Levels

The receiver design shall be such as to ensure full compliance with the performance requirements for the following range of received power flux densities (PFD) at the earth's surface given in Table 5.4.

Table 5.4: Power Flux Density per Single Forward Bearer

Satellite Beam	Minimum Single Carrier PFD (dBW/m^2)	Maximum Single Carrier PFD (dBW/m^2)
Global	-143	-131
Regional	-138	-126
Spot	-125	-113

The receiver design shall take into account existence and possible deployment of other mobile communications systems operating at or near L-band (see the examples below). The power flux densities (PFD) of such systems in the proximity of the UE operating bands, both composite and per-carrier, may be higher than the PFD of the wanted carriers. Particular attention needs to be paid to the dynamic range of possible UE LNA elements and the following mixer (to avoid saturation and consequent inter-modulation products in the UE operating bands), and to the provision of as much selectivity as possible, as early as possible in the receiver down-conversion process.

NOTE 1: Examples of potentially interfering systems are:

a) Mobile Satellite Service (MSS) networks operating in the 1 520 MHz to 1 560 MHz band, using geostationary earth orbit (GEO) satellites with orbital locations such that the UE antenna will provide little if any discrimination, and which it is estimated may result in a composite flux density as high as -95 dBW/m^2.

b) MSS networks operating in the 1 520 MHz to 1 560 MHz band, using low earth orbit (LEO) satellites with orbital locations such that the UE antenna will provide no discrimination, and which it is estimated may result in a composite flux density as high as -95 dBW/m^2.

c) Systems operating in the 1 500 MHz to 1 525 MHz band, using terrestrial base stations with omni-directional (in azimuth) antennas, which it is estimated may result in a flux density per carrier as high as -69 dBW/m^2 at a distance of 10 km. One such system currently in operation transmits 16 carriers from each base station, each of 80 Watts, at 750 kHz spacing, resulting in an estimated composite flux density at 10 km distance of -57 dBW/m^2.

d) Complementary Ground Component (CGC) or Ancillary Terrestrial Component (ATC) base-stations operating within the band 1 525 MHz to 1 559 MHz, in adjacent frequencies to that assigned for the system operation.

There shall be no degradation of the FEC Block Error Rate (BLER) performance in the presence of signals in the bands 100 kHz to 1 400 MHz and 1 626,5 MHz to 4 GHz, having a power flux density of -45 dBW/m^2 at the antenna.

There should be no degradation of the FEC Block Error Rate (BLER) performance in the presence of signals in the bands 100 kHz to 1 400 MHz and 1 626,5 MHz to 4 GHz, having a power flux density of up to -25 dBW/m^2 at the antenna.

NOTE 2: Some wireless LAN and phone standards (also personal mobile radio system) operating in close vicinity of the UE can easily exceed the -45 dBW/m^2 level for single entry interference. It is highly desirable that the UE be able to operate without degradation in these situations.

5.2.3 Received Phase Noise

The receiver design shall ensure full compliance with the FEC Block Error Rate (BLER) ≤ 1E-3 performance requirements for received signal phase noise impairment stated in Table 5.5. The phase noise is present at the UE antenna at L-band.

The phase noise present on a received carrier shall have a single sideband power density continuous spectrum not exceeding the limit mask defined in Table 5.5.

The "single sideband power density spectrum" is defined as the power spectrum due to phase noise on each sideband, above and below the carrier, individually.

Table 5.5: Limit mask for Received Phase Noise at L-band

Frequency Offset from actual received carrier frequency (Hz)	SSB Phase noise density limit in 1 Hz bandwidth (dBc)
10	-36,0
50	-54,0
100	-61,5
500	-74,0
1 000	-78,0
5 000	-79,5
10 000	-80,0
50 000	-89,0
100 000	-89,0

The above table applies to single carrier operation.

5.2.4 Receiver Channel Tuning

All land class UEs shall calculate the required receive bearer nominal frequency in accordance with ETSI TS 102 744-2-1 [11], clause 5.1.

1) The receiver operational tuning range shall be 1 518,0 - 1 559,0 MHz.

2) The receiver tuning shall be in steps of 1,25 kHz.

3) The UE shall retune to a new receive frequency anywhere within the receive range, within 70 ms from receipt of the last received symbol of the FEC block containing a Channel Number AVP. For bearers with 80 ms outer interleaver, the UE shall retune to a new receive frequency anywhere within the receive range, within 135 ms from receipt of the last received symbol of the FEC block containing a Channel Number AVP. The timing is referenced to the antenna input. Also refer to clause 5.2.9.

5.2.5 Received Signal Frequency Offsets

The frequency signal in space shall be within ±500 Hz of the nominal assigned frequency including residual satellite Doppler.

Short term frequency variation shall be ±25 Hz. This is based on the satellite Doppler acceleration and on the RAN and satellite short term frequency variation. For clarity, the relative frequency difference between the start of the two forward frames at the UE antenna shall not exceed the above ±25 Hz when the time separation between the frames is 128 frames or less.

5.2.6 Receiver Selectivity

The receiver shall employ sufficient pre-detection and post-detection filtering to operate in the presence of interferers adjacent to and within the 34 MHz receive band as outlined in clause 5.2.2.

The rejection of all signals in the 1 518 MHz to 1 559 MHz band, excluding a band within ±60 % of the L-band nominal bandwidth of the wanted signal from the centre frequency, shall be at least 30 dB relative to the wanted signal.

5.2.7 Receiver Demodulation Characteristics

All land portable class UEs, including Class 1 HDR shall demodulate and decode all the supported forward bearer types and coding rates listed in Table 5.6.

Note that Class 3 UE shall demodulate and decode up to code rate H3 for the F80T4.5X-8B bearer.

Table 5.6: Supported Bearer types for all Land Portal Class UEs including Class 1 HDR UE

Bearer Type	Code rates	UE Class
F80T0.25Q-1B	ALL	1, 2, 3 & 1 HDR
F80T1Q-4B	ALL	1, 2, 3 & 1 HDR
F80T1X-4B	ALL	1, 2, 3 & 1 HDR
F80T4.5X-8B	ALL	1, 2 & 1 HDR
	Up to code rate H3	3
FR80T2.5X16-5B	ALL	1 HDR
FR80T5X16-9B	ALL	1 HDR
FR80T2.5X32-6B	ALL	1 HDR
FR80T5X32-11B	ALL	1 HDR
FR80T2.5X64-7B	ALL	1 HDR
FR80T5X64-13B	ALL	1 HDR

5.2.8 Acquisition and Synchronisation Performances

The UE acquisition performance for initial, cold and warm cases shall meet the values stated in Table 5.7, for all channel impairment conditions defined in clause 5.2.9, and for the appropriate C/No related to the bearer and sub code rate as specified in clauses 5.2.11 and 5.2.11.1.

NOTE: The definition of initial, cold and warm are described in the notes in Table 5.7.

Assuming that the timing and frequency offsets are known (and the Forward Bearer type has not been modified according to ETSI TS 102 744-3-2 [13]), and that blockage occurs for 5 consecutive frames, the FEC Block Error Rate (BLER) for the first FEC block of the 6th frame after the 5 blocked frames shall be ≤ 1E-2; and ≤ 1E-3 for FEC blocks in subsequent frames. A frame is considered blocked if any FEC block of the frame is blocked.

For global beam operation (applicable only to F80T0.25Q-1B), the following shall also apply:

- Future Low Gain Antenna (LGA) terminals shall include capability for combining two adjacent FEC blocks prior to decoding. This mechanism shall be triggered by the UE for any two adjacent FEC blocks that are not successfully decoded. A BLER ≤ 1E-3 shall be achieved by employing combining two adjacent FEC blocks prior to decoding. This performance requirement shall be achieved with C/No of 36 dBHz under AWGN channel conditions with an ideal modem.

- For all other mobile terminals, if information is repeated in any two adjacent FEC blocks, then the repeated information should be ignored or discarded.

Table 5.7: Acquisition Performance

Acquisition mode (notes 1, 2, 3)	Fwd link / UE maximum frequency offset	FEC BLER after second possible UW	FEC BLER after fourth possible UW	Forward Bearer Types
Initial	±500 Hz (note 6)	< 10 sec to achieve BLER < 1E-3 and recognise system information broadcast header		F80T0.25Q-1B
Cold	±1 kHz	< 10 sec to achieve BLER < 1E-3		F80T1X-4B F80T1Q-4B F80T4.5X-8B
Warm	±100 Hz	N/A	< 1E-3	F80T1X-4B F80T1Q-4B
Warm	±100 Hz	< 1E-3	< 1E-3	F80T4.5X-8B
Cold	±1 kHz	< 10 sec to achieve BLER < 1E-3		F80T1Q-1B FR80T2.5X4/16-5B R80T2.5X16-5B FR80T2.5X32-6B FR80T2.5X64-7B FR80T5X4/16-9B FR80T5X16-9B FR80T5X32-11B FR80T5X64-13B
Warm	±100 Hz	N/A	< 1E-3	F80T1Q-1B FR80T2.5X4/16-5B R80T2.5X16-5B FR80T2.5X32-6B FR80T2.5X64-7B FR80T5X4/16-9B FR80T5X16-9B FR80T5X32-11B FR80T5X64-13B

NOTE 1: Initial is after UE start up with global beam acquisition. UE running on internal clock/frequency reference with no knowledge of forward bearer timing. Stored nominal value of forward bearer broadcast frequency is known.

NOTE 2: Cold is RAN to RAN handover.

NOTE 3: Warm is UE reference frequency referred to current forward bearer and applies anywhere within the receive range within the same RAN. Relative symbol and frame timings are not known.

NOTE 4: Assuming UW signals the coding rate of all the FEC blocks within the particular 80 ms frame. Hence no CodeRateAVP is present.

NOTE 5: First possible UW is defined as the first UW arriving at the UE antenna after the frequency retune maximum period as specified in clause 5.2.4.

NOTE 6: Under nominal operational conditions, the signal in space at the UE receive antenna will be within ±500 Hz of nominal L band downlink frequency (clause 5.2.12). This is due to frequency setting and control uncertainty within the forward link and satellite movement. At initial acquisition, the UE frequency search range shall also take into account the long term frequency stability in the UE free running reference oscillator. The long term stability should be no greater than ±5 ppm. UEs may implement designs with less accurate long term stability of the free running reference oscillator provided that the initial acquisition target, and all other performance requirements are met.

5.2.9 Channel Characteristics/Impairments

The UE Land Class channel characteristics and reference impairments are contained in Table 5.8.

Table 5.8: Channel Characteristics and Reference Impairments for UE Land Class

Test Parameters	Test Conditions
C/M	15 dB
Fading Bandwidth	20 Hz
Freq Offset	Refer to acquisition performance in clause 5.2.8
Continuous receive Phase Noise	Refer to Table 5.5
Discrete receive Phase Noise	1 discrete component at -30 dBc, 10 Hz to 200 Hz from the carrier
I/Q imbalance case #1: For soft modems and simulations (contribution due to RNC and UE hardware)	0,1 dB amplitude; 1 degree phase
I/Q imbalance case #2: Of the received 'signal in space'	0,05 dB amplitude; 0,5 degrees phase
Doppler	Sinusoidal model: 30 Hz/s, period 10 s
ACI	2 adjacent carriers at +6 dBc: • F80T0.25Q-1B: 10 kHz frequency spacing • F80T1X-4B, F80T1Q-4B: 45 kHz frequency spacing • F80T4.5X-8B: 200 kHz frequency spacing
ACI (New bearers)	2 adjacent carriers at 0 dBc: • F80T1Q-1B : 45 kHz frequency spacing • FR80T2.5X4/16-5B, FR80T2.5X16-5B, FR80T2.5X32-6B, FR80T2.5X64-7B: 95 kHz frequency spacing • FR80T5X4/16-9B, FR80T5X16-9B, FR80T5X32-11B, FR80T5X64-13B: 200 kHz frequency spacing

5.2.10 Received C/No Measurement Accuracy

In AWGN condition, on the forward link T1 and T4.5 rate bearers, 90 % of C/No estimates shall lie within ±0,5 dB of the C/No of the UE receive chain over the full range for the particular bearer (lowest code rate up to the highest code rate +6 dB). This shall be measured across an averaging of less than or equal to 10 seconds.

For UE Class 1 HDR, in AWGN condition, on the forward link T2.5 and T5 rate bearers, 90 % of C/No estimates shall lie within ±0,5 dB of the C/No of the UE receive chain over the full range for the particular bearer (lowest code rate up to the highest code rate). This shall be measured across an averaging of less than or equal to 10 seconds.

NOTE: The receive chain includes everything down to the soft decision input of the decoder.

5.2.11 Demodulator Performance

5.2.11.0 General

The UE shall acquire a single global bulletin board bearer (F80T0.25Q-1B) to the point of demodulating the global bulletin board bearer within 10 seconds.

The UE receiver performance (BLER and frame acquisition) shall be met in the presence of the following degradations:

1) Received Signal Phase Noise: Refer to Table 5.5.

NOTE: UE down conversion before the demodulator will add further a phase noise component.

2) The frequency offset for any frame at the receive input shall be within ±500 Hz.

3) UE initial acquisition accuracy of ±5 ppm or consistent with the initial acquisition performance of clause 5.2.9.

5.2.11.1 Demodulator C/No and BLER Performance

For all the forward bearer types and subtypes as defined in clause 5.2.7, the UE demodulator shall achieve an FEC Block Error Rate (BLER) ≤ 1E-3 with the required C/No as defined in ETSI TS 102 744-2-1 [11] of this multi-part deliverable, plus allowance for implementation loss for non fading case from Table 5.9. This allowance includes AWGN condition + Phase Noise + I/Q imbalance + Doppler + Frequency Offset (refer to Table 5.8) + ACI.

For all the forward bearer types and subtypes as defined in clause 5.2.7, and under all conditions as defined in Table 5.8 which includes a C/M = 15 dB + 20 Hz fading bandwidth, the UE demodulator shall achieve a BLER ≤ 1E-3 with the required C/No as defined in ETSI TS 102 744-2-1 [11] of this multi-part deliverable, plus fading case allowance for implementation loss from Table 5.9.

NOTE 1: The fading requirements are inserted so that "robust" demodulators will be implemented. This is intended to make sure that the demodulator has an amplitude and phase tracker, and it does not lose sync after a deep fast fade.

For the purpose of this multi-part deliverable, the implementation loss includes the effects of timing, frequency and phase estimation and correction within the demodulator, limited number of Turbo Decoder iterations and any arithmetic approximation. The implementation loss also includes other typical effects such as A/D converter quantisation noise at actual drive level, added Local Oscillator phase noise and spurs, and any contribution from operating the UE at maximum transmit power, etc.

The implementation loss excludes effects of co-channel interference and electromagnetic interference from any other system.

FEC Blocks that were transmitted which are corrupted or missed shall be included in the overall BLER calculation.

Table 5.9: Allowed implementation loss for UE Classes 1, 2, 3 and Class 1 HDR

Bearer Type	Code rates	Allowed Implementation loss (non fading case)	Allowed Implementation loss (fading case)
F80T0.25Q-1B	All	1,1 dB	5,6 dB
F80T1Q-4B	All	1,1 dB	5,6 dB
F80T1X-4B	L3 - H1	1,1 dB	5,6 dB
	H2 - H3	1,2 dB	5,7 dB
	H4 - H6	1,3 dB	5,8 dB
F80T4.5X-8B	L3 - RE	1,1 dB	5,6 dB
	H1 - H2	1,2 dB	5,7 dB
	H3	1,3 dB	5,8 dB
	H4 - H6	1,4 dB	5,9 dB
FR80T2.5X16-5B	All	0,4 dB	4,9 dB
FR80T2.5X32-6B	All	0,5 dB	5,0 dB
FR80T2.5X64-7B	RE - H1	0,3 dB	4,8 dB
	H2 - H5	0,9 dB	5,4 dB
	H6	1,5 dB	6,0 dB
FR80T5X16-9B	All	0,5 dB	5,0 dB
FR80T5X32-11B	All	0,6 dB	5,1 dB
FR80T5X64-11B	RE - H2	0,5 dB	5,0 dB
	H3 - H6	0,9 dB	5,4 dB

NOTE 2: The Allowed Implementation loss (non fading case) values for the new bearer types in Table 5.9 are preliminary results which were obtained by initial simulation and linear interpolation.

5.3 Transmitter requirements

5.3.1 EIRP

5.3.1.0 General

The UE nominal transmit EIRP shall meet the requirement as stated in Table 5.10 at any frequency in the transmit band. If applicable, this requirement shall also apply with an external antenna (i.e. cable loss is included).

Table 5.10: Nominal UE EIRP (RHCP)

UE Class	Nominal UE EIRP (dBW)
Class 1	20,0
Class 2	15,1
Class 3	10,0

5.3.1.1 Power Masks

5.3.1.1.0 General

The following clause applies to all bearers as specified in ETSI TS 102 744-2-1 [11].

For UE classes 1, 2, 3 and 1 HDR, the transmit EIRP shall meet the burst power mask for either π/4 QPSK or 4/16/32/64-QAM as defined in clauses 5.3.1.1.1 to 5.3.1.1.3.

The requirements in clause 5.3.8 shall be met while ramping the output power up and down.

During burst slots not assigned to the particular UE, the UE shall comply with the 'transmitter off' as described in clause 5.3.4.

NOTE: The QAM modulations stripped single sample per symbol values will need to be compensated to take into account the actual transmitted symbols before comparing with the burst power mask limits. For example, samples associated with the 'outer symbols' will ideally have optimal sample powers 2,55 dB average symbol power. Reducing measured outer symbol power by a (linear factor) of 9/5, increasing inner symbol powers by factor 5 and leaving the intermediate symbol powers unchanged will permit a fair comparison. This numerical example is for 16-QAM and the corrections factors will be different for X32 and X64-QAM.

5.3.1.1.1 Power Mask - R80T0.5Q-1B/R80T1Q-1B

The UE shall comply with the power masks for R80 bearers depicted in Figures 5.1 to 5.4.

If the Preamble is opted for transmission by the RNC (see ETSI TS 102 744-3-1 [12]), the signal level for the Preamble in Figures 5.1 and 5.2 shall be within Nominal EIRP level +1 dB within 24 to 34 symbol times for the R80T0.5Q-1B bearer, and within 48 to 68 symbol times for the R80T1Q-1B bearer, relative to the "0" time reference.

The ramp up for the burst in Figures 5.3 and 5.4 is only applicable when the 0,12 ms CW is present (see ETSI TS 102 744-2-1 [11]).

Only the last 80 ms frame on the same bearer shall ramp down as indicated in the burst mask.

Following ramp-down at the end of the last frame, the UE shall have at least one 80 ms slot of inactivity before the next transmission.

If the UE is transmitting more than one burst, and if during the transmission the UE Reference Level is modified through link adaptation, or the RNC elects to specify a different Power Level as specified in ETSI TS 102 744-3-2 [13], then the UE shall modify the transmit power level at the next available slot boundary.

NOTE: The "0" time reference in Figures 5.1 and 5.2 is 80 ms prior to the start of the first modulated symbol interval of the following 80 ms burst. The time scale in Figures 5.1 to 5.4 indicates the start of the corresponding symbol interval.

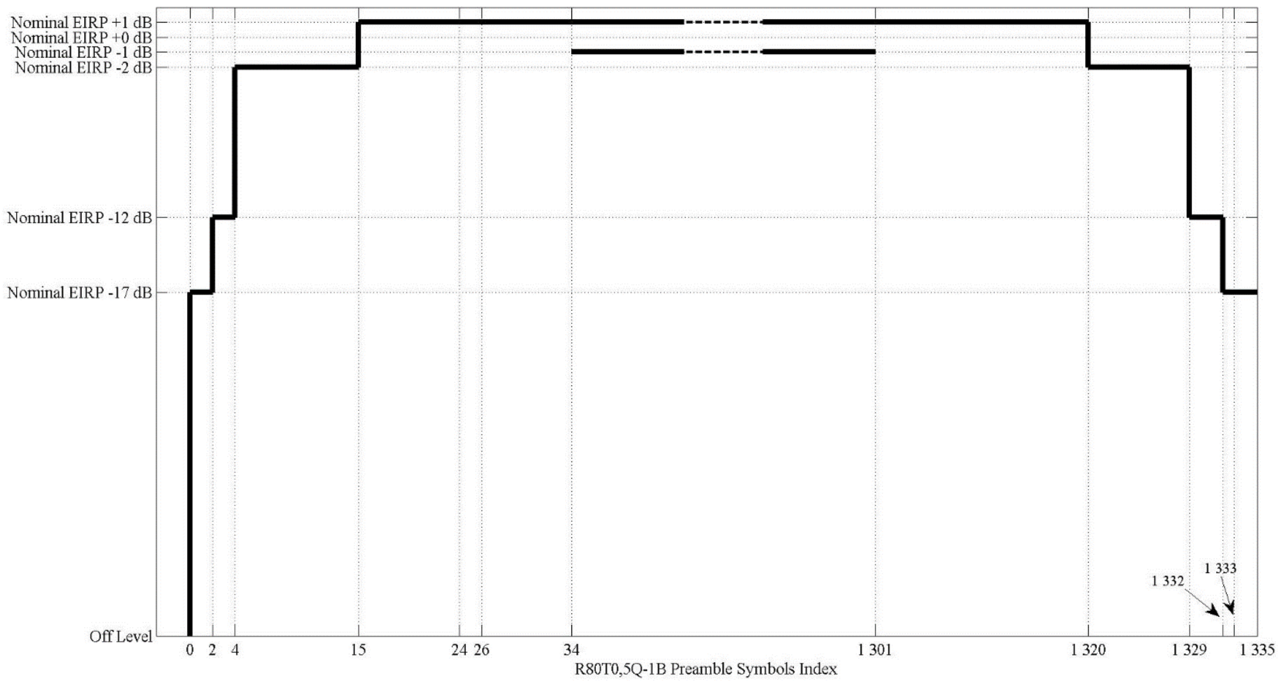


Figure 5.1: Power Mask - 79,52 ms Preamble of R80T0.5Q-1B

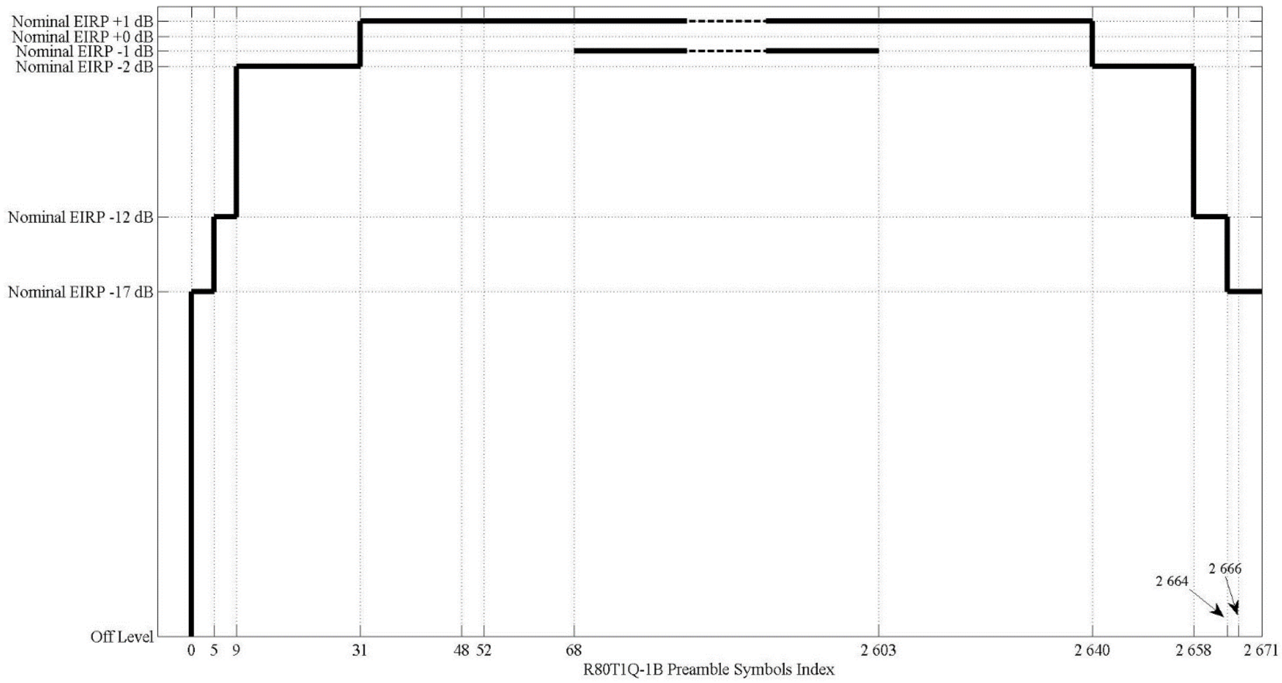


Figure 5.2: Power Mask - 79,52 ms Preamble of R80T1Q-1B

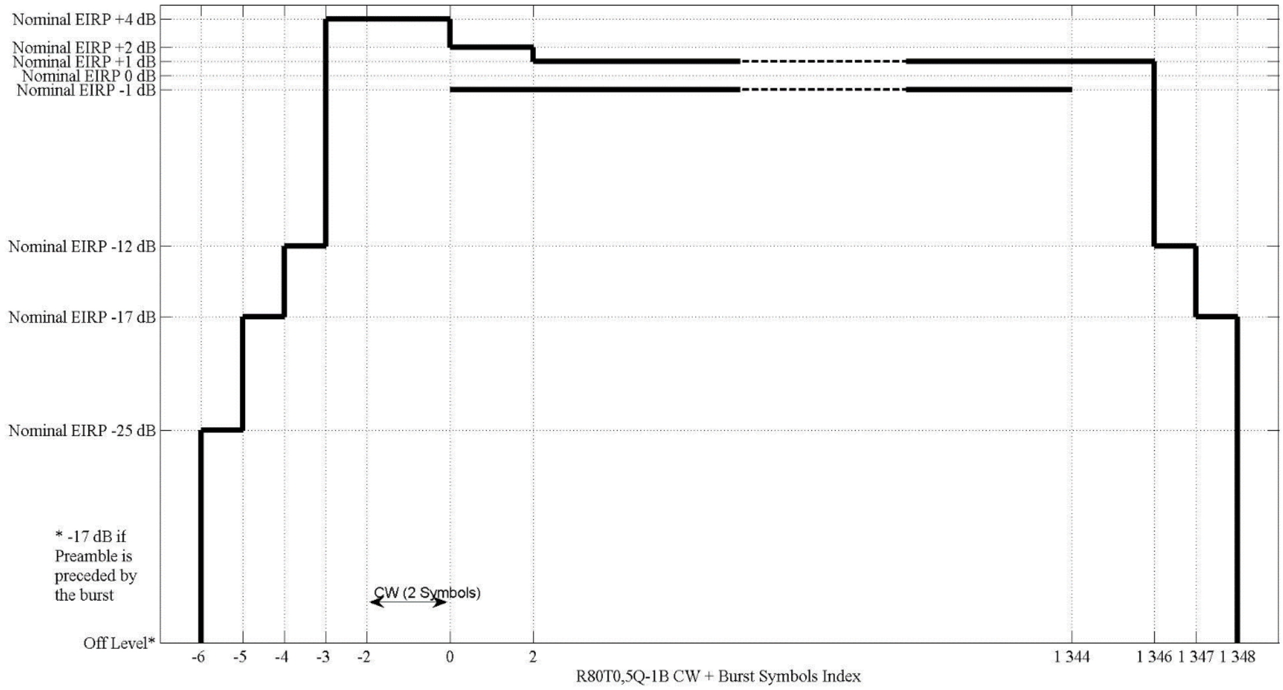


Figure 5.3: Power Mask - 0,12 ms CW + 80 ms Burst of R80T0.5Q-1B

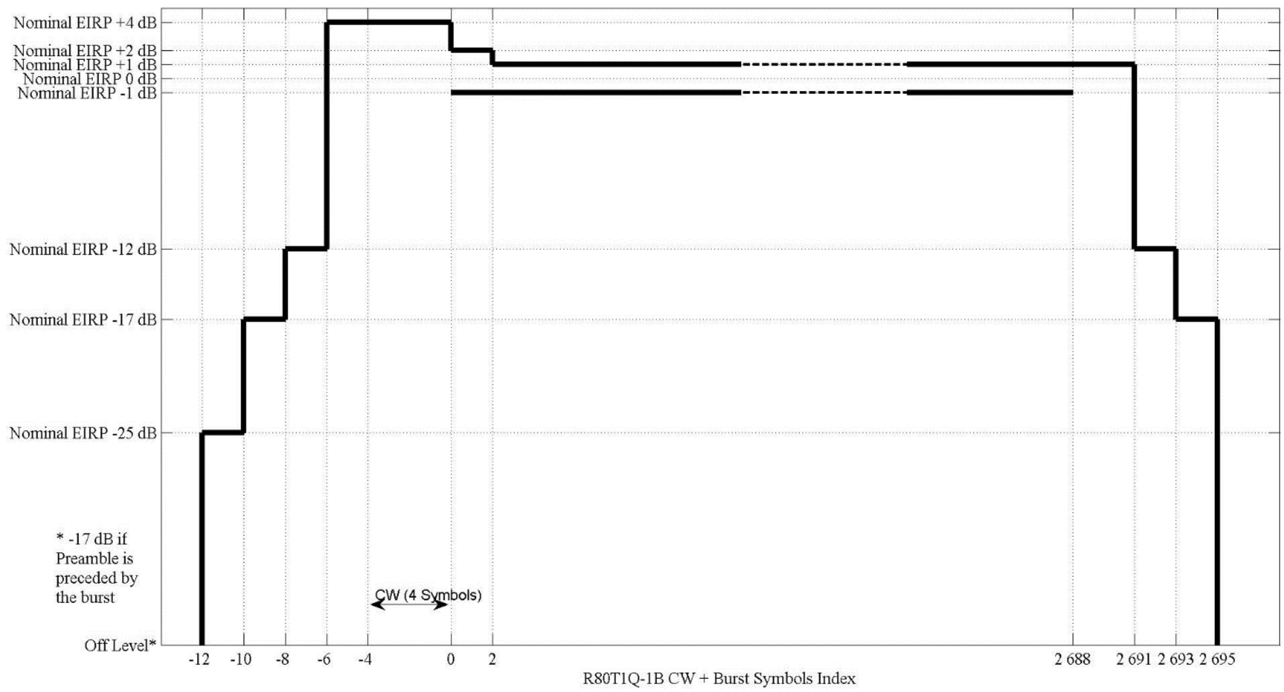


Figure 5.4: Power Mask - 0,12 ms CW + 80 ms Burst of R80T1Q-1B

5.3.1.1.2 Power Mask - FR80T2.5 and FR80T5

The UE shall comply with the power masks for FR80T2.5 and FR80T5 bearers as depicted in Figures 5.5 and 5.6 respectively.

The ramp up is only applicable when the CW is present.

Only the last 80 ms frame on the same bearer shall ramp down as indicated in the burst masks.

If the UE is instructed by the RNC to change its power level, the required change in power level may be accomplished in discrete steps or continuously such that each power level change shall be no greater than 1 dB per frame.

NOTE: The time scale in Figures 5.5 and 5.6 indicates the start of the corresponding symbol interval.

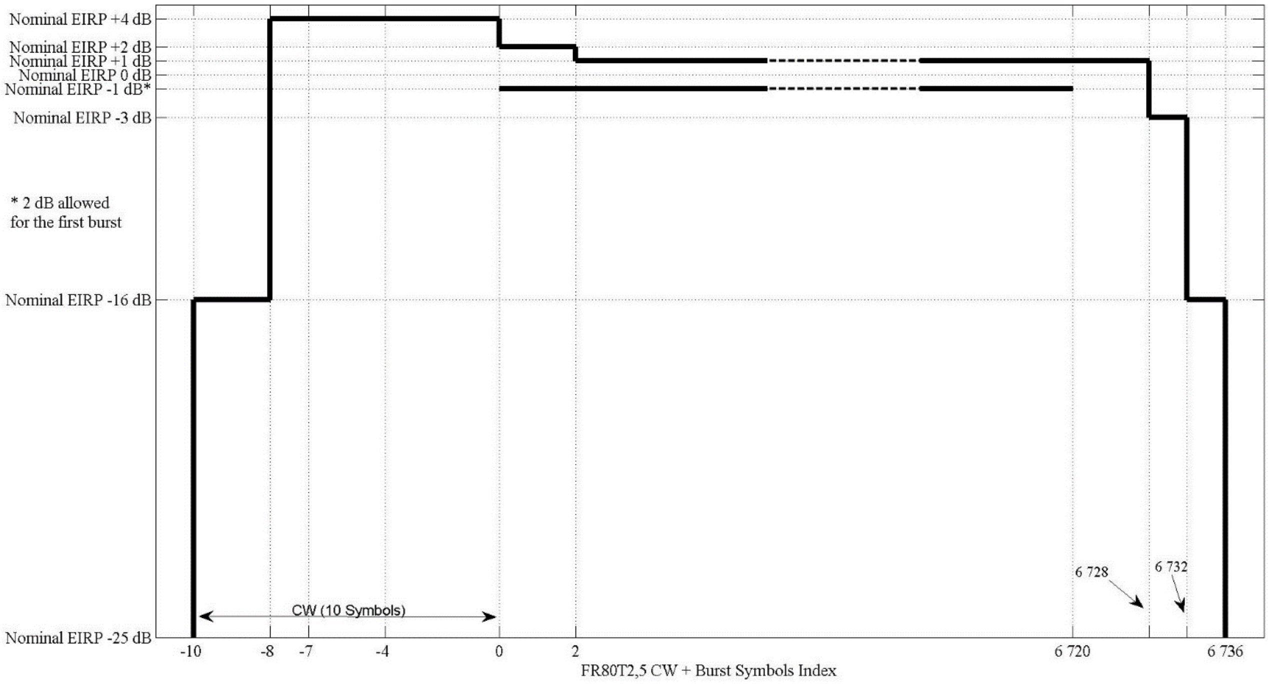


Figure 5.5: Power Mask - 0,12 ms CW + 80 ms FR80T2.5

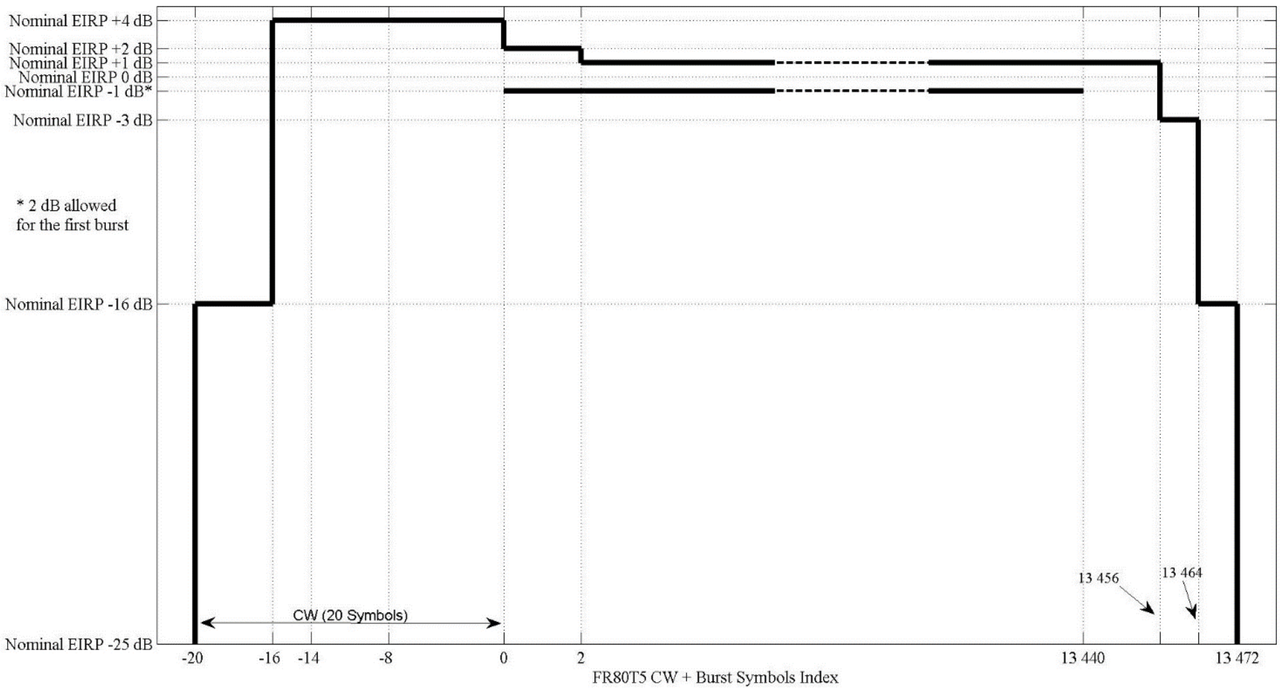


Figure 5.6: Power Mask - 0,12 ms CW + 80 ms FR80T5

5.3.1.1.3 Power Mask - All other bearers

Consecutive bursts on the same bearer still need to ramp down, as indicated in the burst mask shown in Figure 5.7 and defined in Table 5.11.

The burst power mask is divided into three main sections. The first section describes the raw over sampled burst power from the beginning of the burst slot to the beginning of the first UW symbol. The second section of the burst mask starting from the first UW symbol and ending at the last UW symbol, describes the bounds in which the modulation stripped single sample per symbol power level has to lie within. The single sample per symbol is obtained by receiving the burst through a linear matched filter receiver with perfect symbol timing recovery. The last section starting at the end of the last UW symbol and ending at the slot boundary describes, like the first section, the raw over sampled burst power.

For clarity, there is approximately 300 µs between the 0 and T4 reference points for all symbol rates. Care needs to be taken to ensure that measurements on the three main sections are referenced to the same transmit power reference and time frame (e.g. that differences in delay and gain in processing the raw oversampled burst power and in processing the single sample per symbol matched filtered output are accounted for).

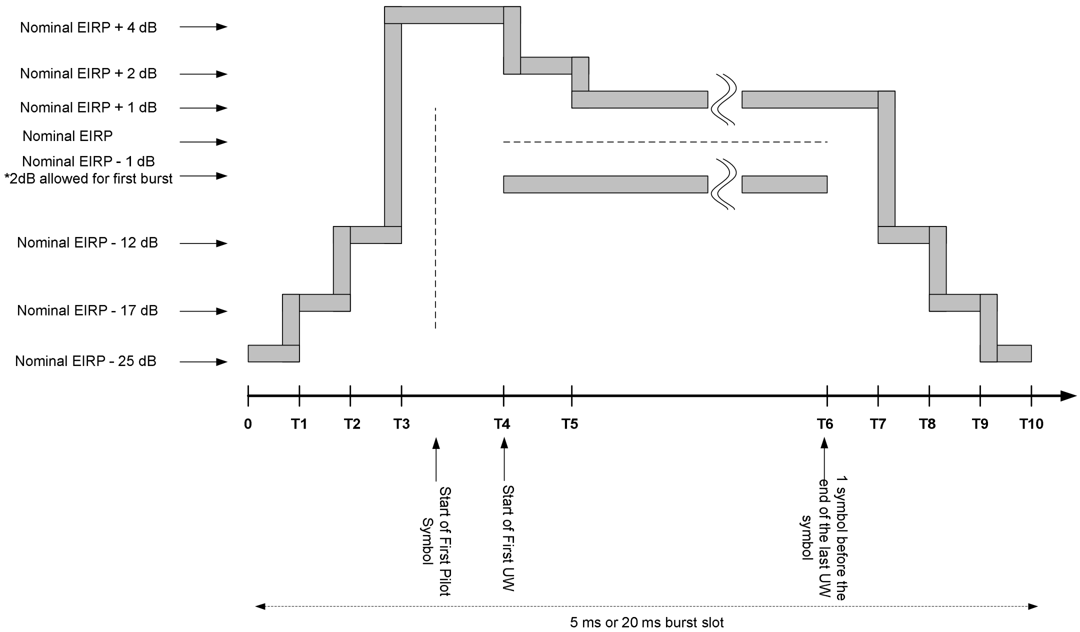


Figure 5.7: Power Mask - 5/20 ms Burst Format

Table 5.11: Timing offsets measured in symbols from the burst slot epoch

Symbol Rate	16,8	33,6		67,2		151,2	
Burst Duration	**20**	**5**	**20**	**5**	**20**	**5**	**20**
T1	0	3		9		24	
T2	1	4		10		25	
T3	2	5		11		26	
T4	5	10		20		45	
T5	7	12		22		47	
T6	332	161	665	323	1 331	728	2 996
T7	334	164	668	326	1 334	731	2 999
T8	335	164	668	326	1 334	731	2 999
T9	336	165	669	327	1 335	732	3 000
T10	336	168	672	336	1 344	756	3 024

5.3.1.2 EIRP Congruency with receive G/T

The direction of maximum EIRP shall be congruent with the receive maximum gain direction within 10 percent of the antenna 3 dB half cone angle.

NOTE: This will ensure that for any G/T reduction due to mispointing, the EIRP reduction will not be much different from the G/T reduction.

5.3.1.3 EIRP Stability

The EIRP stability for subsequent bursts (for the duration of time between EIRP setting changes) shall be ±0,5 dB from the median (half way between upper and lower measured EIRP) EIRP over 1 000 subsequent bursts.

The first burst transmitted by the UE after any period of non-transmission exceeding two seconds shall be considered to be a 'first burst'. The first burst after a retune outside the 200 kHz subband shall also be considered to be a 'first burst'. All other bursts shall be considered to be 'subsequent bursts'.

5.3.1.4 EIRP setting accuracy

The EIRP setting range, step size and setting accuracy shall meet the requirements stated in Table 5.12.

The upper value of the EIRP setting range corresponds to the nominal EIRP.

The UE shall support burst-to-burst power regulation within the limits and with the step size defined in Table 5.12.

Table 5.12: EIRP setting range, step size, accuracy

Terminal Class	EIRP Setting Range	EIRP step size (note 1)	EIRP setting accuracy (note 2)	EIRP setting accuracy for first burst or RACH (note 2)
Class 1	Nominal EIRP to nominal EIRP - 10 dB	1 dB	±1 dB	+1 dB -2 dB
Class 2	Nominal EIRP to nominal EIRP - 10 dB	1 dB	±1 dB	+1 dB -2 dB
Class 3	Nominal EIRP to nominal EIRP - 6 dB	1 dB	±1 dB	+1 dB -2 dB
NOTE 1: The meaning of the "EIRP step size" is the power regulation granularity only and not the maximum power change per-frame. NOTE 2: 100 % of time, total for antenna and HPA.				

5.3.2 Transmit Power Spectral Density Mask

In order to limit contributions from ACI, the mask shown in Figure 5.8 and defined in Table 5.13 shall be applicable for both pi/4 QPSK and 16 QAM modulated bearers transmitted by Class 1 or Class 2 UE at any output EIRP. The same mask shown in Figure 5.8 shall also be applicable for 4 QAM, 32 QAM and 64 QAM modulated bearers transmitted by Class 1 HDR UEs at any output EIRP.

This requirement shall be met simultaneously with the spurious emissions requirement defined in clause 5.3.8.

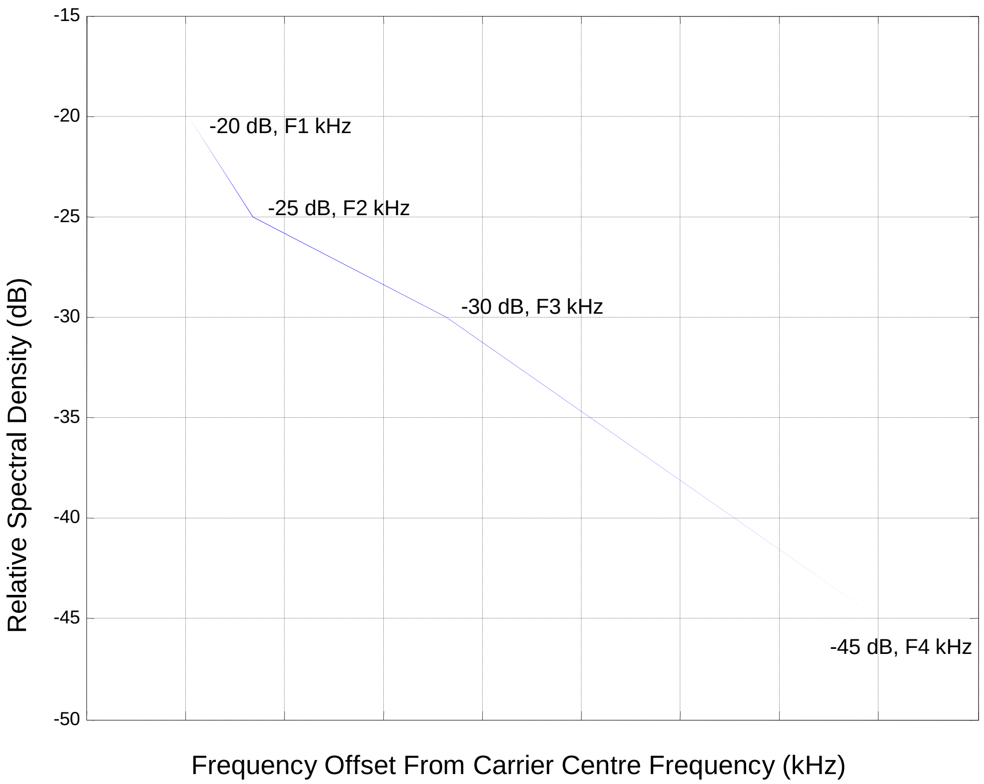


Figure 5.8: Transmit Power Spectral Density Mask for Class 1, 1 HDR and 2 UE (pi/4 QPSK and 4/16/32/64-QAM)

Table 5.13: Transmit Power Spectral Density Mask for pi/4 QPSK or 4/16/32/64-QAM Class 1, 1 HDR and 2 UE

Bearer Type	Amp (dB)	T0.5 (kHz)	T1 (kHz)	T2 (kHz)	T4.5 (kHz)	T2.5 (kHz)	T5 (kHz)
F1	-20	12,0	24,0	48,0	102,0	60	120
F2	-25	14,9	29,8	59,6	134,1	74,5	149
F3	-30	24,8	49,6	99,2	223,2	124	248
F4	-45	50,0	100,0	200,0	450,0	250	500

The above F1 to F4 are defined with respect to the bearer centre frequency. The relative PSD is defined with respect to the signal PSD at the bearer centre frequency.

In order to limit contributions from ACI, the mask shown in Table 5.14 shall be applicable for pi/4 QPSK modulated bearers transmitted by Class 3 UE at any output EIRP.

Table 5.14: Transmit Power Spectral Density Mask for pi/4 QPSK Class 3 UE

Bearer Type	Amp (dB)	T0.5 (kHz)	T1 (kHz)	T2 (kHz)	T4.5 (kHz)
F1	-20	15,7	31,4	62,9	133,6
F2	-25	32,7	65,5	131,0	256,0
F3	-30	34,7	69,4	138,8	282,6
F4	-45	65,5	131,0	262,0	450,0

This requirement shall be met simultaneously with the spurious emissions requirement defined in clause 5.3.8.

5.3.3 Transmitter Duty Cycle

The UE transmit system shall satisfy the performance requirements under all conditions, including continuous operation at the maximum power setting. Class 3 UE may have operational restrictions for time at the maximum power setting.

5.3.4 Transmitter Off level

The non-transmitting state includes the 'idle' state, covering periods when the UE is not engaged in traffic, and periods between bursts, both reserved and contention slots.

For this purpose only, idle is defined as when the UE has not transmitted for more than 2 seconds.

When class 1 or class 2 UE transmitter is in the non-transmitting state, the radiation from the UE antenna in the direction of maximum gain shall not exceed the "carrier-off" EIRP requirement defined in ETSI EN 301 444 [4].

When class 3 UE transmitter is in the non-transmitting state, the radiation from the UE antenna in the direction of maximum gain shall not exceed the "carrier-off" EIRP requirement defined in ETSI EN 301 681 [5].

5.3.5 Transmitter Modulation Characteristics

Class 1 (Briefcase), 2 (Notebook), 3 (Pocket) and Class 1 HDR UEs shall support all the applicable bearer types and subtypes specified in Tables 5.15 and 5.16.

Class 1 HDR UEs shall support wrap around of control index as defined in ETSI TS 102 77-3-1 [12].

Table 5.15: Summary of Return Bearer Types

Identifier	Burst Duration	Symbol Rate	Modulation	UE Class
R5T1X-1B	5 ms	1 x 33,6 kBd	16-QAM	1, 2, & 1 HDR
R5T2X-1B	5 ms	2 x 33,6 kBd	16-QAM	1, 2, & 1 HDR
R5T4.5X-1B	5 ms	4,5 x 33,6 kBd	16-QAM	1, 2, & 1 HDR
R20T1X-1B	20 ms	1 x 33,6 kBd	16-QAM	1, 2, & 1 HDR
R20T2X-1B	20 ms	2 x 33,6 kBd	16-QAM	1, 2, & 1 HDR
R20T4.5X-2B	20 ms	4,5 x 33,6 kBd	16-QAM	1, 2, & 1 HDR
R5T2Q-1B	5 ms	2 x 33,6 kBd	Pi/4 QPSK	1, 2, 3 & 1 HDR
R5T4.5Q-1B	5 ms	4,5 x 33,6 kBd	Pi/4 QPSK	1, 2, 3 & 1 HDR
R20T0.5Q-1B	20 ms	0,5 x 33,6 kBd	Pi/4 QPSK	1, 2, 3 & 1 HDR
R20T1Q-1B	20 ms	1 x 33,6 kBd	Pi/4 QPSK	1, 2, 3 & 1 HDR
R20T2Q-1B	20 ms	2 x 33,6 kBd	Pi/4 QPSK	1, 2, 3 & 1 HDR
R20T4.5Q-1B	20 ms	4,5 x 33,6 kBd	Pi/4 QPSK	1, 2, 3 & 1 HDR
R80T0.5Q-1B	80 ms	0,5 x 33,6 kBd	Pi/4 QPSK	n/a
R80T1Q-1B-1B	80 ms	1 x 33,6 kBd	Pi/4 QPSK	n/a
FR80T2.5X64-7B	80 ms	2,5 x 33,6 kBd	64-QAM	1 HDR
FR80T5X64-13B	80 ms	5 x 33,6 kBd	64-QAM	1 HDR
FR80T2.5X32-6B	80 ms	2,5 x 33,6 kBd	32-QAM	1 HDR
FR80T5X32-11B	80 ms	5 x 33,6 kBd	32-QAM	1 HDR
FR80T2.5X16-5B	80 ms	2,5 x 33,6 kBd	16-QAM	1 HDR
FR80T5X16-9B	80 ms	5 x 33,6 kBd	16-QAM	1 HDR
FR80T2.5X4-5B	80 ms	2,5 x 33,6 kBd	QPSK	1 HDR
FR80T5X4-5B	80 ms	5 x 33,6 kBd	QPSK	1 HDR

Table 5.16: Return bearer subtypes

Identifier	Bearer Subtypes	UE Class
R5T1X-1B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1, 2, & 1 HDR
R5T2X-1B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1, 2, & 1 HDR
R5T4.5X-1B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1, 2, & 1 HDR
R20T1X-1B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1, 2, & 1 HDR
R20T2X-1B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1, 2, & 1 HDR
R20T4.5X-2B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1, 2, & 1 HDR
R5T2Q-1B	All (i.e. L8, L7, L6, L5, L4, L3, L2, L1, RE)	1, 2, 3 & 1 HDR
R5T4.5Q-1B	All (i.e. L8, L7, L6, L5, L4, L3, L2, L1, RE)	1, 2, 3 & 1 HDR
R20T0.5Q-1B	All (i.e. L8, L7, L6, L5, L4, L3, L2, L1, RE)	1, 2, 3 & 1 HDR
R20T1Q-1B	All (i.e. L8, L7, L6, L5, L4, L3, L2, L1, RE, H1)	1, 2, 3 & 1 HDR
R20T2Q-1B	All (i.e. L8, L7, L6, L5, L4, L3, L2, L1, RE, H1)	1, 2, 3 & 1 HDR
R20T4.5Q-1B	All (i.e. L8, L7, L6, L5, L4, L3, L2, L1, RE)	1, 2, 3 & 1 HDR
R80T0.5Q-1B	All (i.e. L14, L13, L12, L11, L10, L9, L8, L7, L6, L5, L4, L3, L2, L1, R, H)	n/a
R80T1Q-1B	All (i.e. L14, L13, L12, L11, L10, L9, L8, L7, L6, L5, L4, L3, L2, L1, R, H)	n/a
FR80T2.5X64-7B	All (i.e. RE, H1, H2, H3, H4, H5, H6)	1 HDR
FR80T5X64-13B	All (i.e. RE, H1, H2, H3, H4, H5, H6)	1 HDR
FR80T2.5X32-6B	All (i.e. H1, H2, H3, H4, H5, H6)	1 HDR
FR80T5X32-11B	All (i.e. H1, H2, H3, H4, H5, H6)	1 HDR
FR80T2.5X16-5B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1 HDR
FR80T5X16-9B	All (i.e. L3, L2, L1, RE, H1, H2, H3, H4, H5, H6)	1 HDR
FR80T2.5X4/16-5B	QPSK (L8-L3), 16 QAM (L2-H6)	1 HDR
FR80T5X4/16-9B	QPSK (L8-L3), 16 QAM (L2-H6)	1 HDR

5.3.6 Transmitter Phase Noise

The phase noise induced on the transmitted L-band carrier (including that generated by the modulator) shall have a single sideband power density continuous spectrum not exceeding the limit mask defined in Table 5.17.

NOTE: The "single sideband power density spectrum" is defined as the power spectrum due to phase noise on each sideband, above and below the carrier, individually.

Table 5.17: Limit Mask for Transmitted Phase Noise at L-band

Offset from transmit carrier frequency (Hz)	SSB Phase noise limit in 1 Hz bandwidth (dBc)
10	-35
100	-55
1 000	-73
10 000	-75
100 000	-90
>100 000	-90

If discrete phase noise spectral components exceed the limit mask, then the integrated sum of all discrete and continuous spectral components (single sideband) between 10 Hz and 100 kHz from the carrier shall not exceed -24 dBc or 3,4° rms.

No discrete phase noise components shall exceed the limit mask defined in Table 5.18.

Table 5.18: Discrete Phase Noise Limit Mask

Offset from Carrier	Discrete Phase Noise Component Limit (dBc)
10 Hz to 100 Hz	-28
100 Hz to 3 kHz	-40
3 kHz to 10 kHz	-50
10 kHz to 100 kHz	-60
NOTE: The transmitter phase noise is to be measured on a CW carrier at or after the HPA output	

5.3.7 Modulator Performance

5.3.7.1 Transmit burst Error Vector Magnitude

The transmit burst mean squared Error Vector Magnitude after the HPA shall not exceed the values shown in Table 5.19.

Table 5.19: Mean squared EVM requirements

Modulation	Mean squared EVM
Pi/4 QPSK	0,03
16-QAM	0,01
4-QAM	0,03
32-QAM	0,004
64-QAM	0,004

5.3.7.2 Definition of mean squared EVM

The Error Vector Magnitude (EVM) is defined as the Euclidian distance between an actual demodulated soft-symbol and the expected demodulated signal, at the output of a noise-free linear channel of the same average delay and power gain as the test signal and with perfect estimation and matched filtering. This is measured in the I/Q plane for the two different modulation schemes. EVM measurements or estimations made through simulation shall determine the mean squared EVM over a stated number of symbols and normalised by dividing by the mean squared magnitude of expected symbols over the same period. If symbols are not equally probable over the course of the estimate (e.g. Uw versus data symbols) then the symbol probability shall also be accurately reflected in calculating both means. Only transmitted symbols are included in EVM estimates (i.e. ramp-up, ramp down and off periods are not included).

The mean squared estimate of the EVM is defined as:

$$EVM^2 = \frac{\frac{1}{N}\sum_{j=1}^{N}\left(\delta I_j^2 + \delta Q_j^2\right)}{S_{mean}^2}$$

Where δI and δQ are the errors in the received data points at the output of a linear matched receive filter. N is the number of data points in the measurement sample. S^2_{mean} is the mean squared magnitude of the expected symbols over the same period.

A description is provided below for the definition of the mean squared magnitude of the expected symbols for pi/4-QPSK and 16-QAM. A similar approach may be used for 32-QAM and 64-QAM.

For pi/4-QPSK these values are defined as follows:

$$\delta I_j = |rI_j| - \sqrt{1/2}$$
$$\delta Q_j = |rQ_j| - \sqrt{1/2}$$

Where:

- rIj and rQj are the scaled receive linear matched filter output with ideal timing and best possible phase estimate.

Pi/4 QPSK signals shall have the progressive pi/4 phase shift per symbol removed after the receive shaping filter and before calculating the EVM. The reference should be the ideal linear channel with the received signal level (rIi ,rQj) = ±√½ and the corresponding:

$$S_{mean}^{2} = 2(\sqrt{1/2})^{2} = 1$$

Accordingly the scaling should be such that mean(abs(I))^2 + mean(abs(Q))^2 = 1.

In this way the combination of non-linear amplifier and linear matched filter has unity gain so ±√½ is still the reference points when including the non-linearity.

For 16-QAM the signal can be modelled as two separate channels (I & Q) rIj and rQj can take values = ±1 and ±3 and with S^2(mean) = (12+32)=10. The δIj can be found after detection as:

$$\delta I_j = |rI_j| - 1 \quad if\ |rI_j| \leq 2$$
$$\delta I_j = |rI_j| - 3 \quad if\ |rI_j| > 2$$

and similarly for δQj.

The scale factor r is determined by separately finding the centre of mass of each cluster of sampled data points associated with each transmitted symbol and determining the scale factor required to move these mass centres into alignment with a reference linear 16 QAM constellation with average symbol energy = 10. The criterion for alignment is minimisation of the mean squared error between the scaled points and the reference constellation.

5.3.8 Spurious Radiated Emissions

5.3.8.0 General

Class 1 and Class 2 UEs shall comply with the ETSI EN 301 444 standard [4] and with the requirements of clause 5.3.8.1.

Class 3 UEs shall comply with the ETSI EN 301 681 standard [5] and with the requirements of clause 5.3.8.1.

These requirements shall include compliance with all in-band and out-of-band unwanted emissions (including harmonic) and carrier-off state.

5.3.8.1 Spurious emission requirements in the 1 559 MHz to 1 610 MHz band

All UEs shall ensure that in any operating mode and in any direction, the spurious EIRP shall not exceed the limits imposed for the protection of aeronautical navigation and automated approach systems using augmented/overlaid GNSS (e.g. GPS and Glonass systems) as follows:

Wideband limit:

a) A maximum EIRP density of -70 dBW/MHz averaged over any 2 millisecond active transmission interval in the band 1 559 MHz to 1 605 MHz.

b) The EIRP density of the emissions in the frequency band segment 1 605 MHz to 1 610 MHz shall be suppressed to an extent determined by linear interpolation from -70 dBW/MHz at 1 605 MHz to -46 dBW/MHz at 1 610 MHz, averaged over any 2 millisecond active transmission interval.

Narrowband limit:

a) The EIRP of discrete emissions of less than 700 Hz bandwidth shall not exceed -80 dBW, averaged over any 2 millisecond active transmission interval in the band 1 559 MHz to 1 605 MHz.

b) The EIRP of discrete emissions of less than 700 Hz bandwidth shall not exceed a level determined by linear interpolation from -80 dBW at 1 605 MHz to -56 dBW at 1 610 MHz, averaged over any 2 millisecond active transmission interval.

Carrier Off limit:

a) The peak EIRP density of carrier-off state emissions from mobile earth stations with assigned uplink frequencies between 1 and 3 GHz shall not exceed -80 dBW/MHz in the 1 559 MHz to 1 610 MHz band averaged over any 2 millisecond active transmission interval.

b) A root-mean-square detector shall be used for all power density measurements.

5.3.9 Transmit Channel Tuning

The UE shall determine the transmit channel frequency in accordance with ETSI TS 102 744-2-1 [11], clause 6.1.

1) The transmitter operational tuning range shall be 1 626,5 MHz to 1 660,5 MHz and 1 668,0 MHz to 1 675,0 MHz.

2) Transmitter tuning shall be in steps of 1,25 kHz.

3) For bearers without an 80 ms interleaver, the UE shall retune to a new transmit frequency anywhere within the transmit frequency range within 80 ms from the start of the frame, measured from the first received symbol of the UW of the frame containing a change bearer instruction. For bearers with 80 ms outer interleaver, the UE shall retune to a new transmit frequency anywhere within the transmit range, within 160 ms from the start of the frame.

4) When the UE has received the return schedule more than n × 80 ms in advance of the change in transmit frequency, as measured from the first received symbol of the UW of the frame containing a change bearer instruction:

    - For all transitions to and from outer interleaved bearers, the UE shall be able to change its transmit frequency within the same 200 kHz bandwidth within 5 ms, with n taking the value 2. Timing and frequency offset are assumed to be known.

    - For all other bearers, the UE shall be able to change its transmit frequency within the same 200 kHz bandwidth, on a burst by burst basis within the inter-burst guard time, with n taking the value 1. Timing and frequency offset are assumed to be known.

5.3.10 Transmitter Frequency Accuracy and Stability

The UE shall derive its carrier and clock frequency from the received forward bearer to meet the frequency accuracy requirements.

- The UE frequency stability, as measured from the transmitted signal from the UE, when receiving a stable and continuous data channel, shall be less than ±150 Hz for > 99,7 % of bursts. For UEs supporting the FR80 bearers and in continuous transmission mode, the frequency stability shall be less than ±150 Hz for >99,7 % of frames.

- The performance requirement shall be met taking into account the combined effects of the Frequency Control System and the transmitter frequency synthesizer settling time and slew.

- If the UE frequency reference is at either end of its tuning range, or for any reason fails to lock onto the forward carrier, the UE shall cease all transmissions until the problem is known to have been corrected

5.3.11 Timing

The overall transmit timing accuracy (for burst and continuous transmissions), for all timed access shall be ≤ 10 microseconds within a 3 sigma (99,8 %) value (this includes timing uncertainty in both receive and transmit chain).

The timing offset levels are determined by the timing reference information provided by the BCtManager. For the purposes of R80T0.5Q-1B and R80T1Q-1B bearers, the transmit timing for Controlled Random Access bursts may be adjusted for each sequence of initial followed by continuation bursts on the return bearer (continuation bursts will have the same timing offset as for initial bursts). For Shared Reservation Access bursts, the timing offset will be specified by the RNC and fixed for the duration of the Shared Reservation allocation.

For all FR80 and R80 bearers transmitting continuously, the UE shall correct the timing offset (as described in V4C4). As an illustration the following methods can be adopted:

- cease transmission for one slot duration and adjust the timing offset accordingly;
- correct the timing offset smoothly (while transmitting) with a maximum rate of change of ±5ppm.

5.4 Positioning requirements

5.4.1 UE Positioning Requirements

Each UE shall support positioning reporting via GPS or equivalent method.

When GPS supplied UE position estimate is available, network initiated position shall result in longitude and latitude being reported by the UE to an accuracy of ±100 m.

It shall be possible to present GPS co-ordinate information on the UE MMI.

It shall be possible to deactivate presentation of GPS co-ordinate information on the UE MMI when instructed by the network.

Suitable security provisions shall be taken to ensure the user cannot falsify GPS co-ordinate information. This means that it shall not be possible to enter GPS co-ordinates via the TE or UE without the system being informed that the source is not from the GPS module.

From UE power up or reset, the UE shall not display the GPS information on the UE MMI unless instructed by the network.

NOTE: In certain countries, it is against the law to possess a device which can display GPS position information near to sensitive areas such as airports.

The GPS signal should be used to determine the correct elevation and azimuth to support pointing the antenna to the satellite.

5.4.2 GPS Receiver Unit

The UE shall contain an omni-directional (or near hemispherical) GPS antenna (or any other antenna providing equivalent performance over the UE field of view) to support location-based services, terminal mobility management and spot beam selection/reselection, etc.

The GPS receiver shall allow accurate (i.e. within ±100 m) position determination using the GPS in 2 lateral dimensions with 2-sigma variation and within the limits of the GPS system (non-differential).

The UE should allow for fast but low accuracy 2D lock.

NOTE: UE rough 2D position lock helps in quickly assigning a bearer in a narrow spot Beam. without having to wait for a 3D lock if 4 satellites are not visible to the UE, especially if the UE is operating indoors.

Special filtering shall be employed to avoid GPS interference with the satellite receiver.

It shall be possible to "program" the UE ephemeris and almanac data. This requirement helps to reduce the GPS cold start time.

All position reporting in terms of latitude and longitude as well as any conversions of position to other coordinate systems (such as ECEF for return channel timing control) shall be in accordance with the WGS-84 reference ellipsoid. The UE shall not use any other geodetic reference system nor shall it use the WGS-84 geodetic height model.

6 Aeronautical Class UE Requirements

6.0 General

An aeronautical user terminal may be logically thought of as composed of three main subsystems: the antenna system which consists of the radome, the antenna radiating elements, the tracking/pointing mechanism (if applicable) and associated feeder networks and power supply; a combined Diplexer/Low Noise Amplifier Unit (DLNA); and a main control unit commonly referred to as Satellite Data Unit (SDU) which functions as the central communications console. The High Power Amplifier (HPA) function is typically housed within the SDU. However, this is not always the case; it could be designed as a separate external unit or embedded within the antenna subsystem.

The avionics for an aircraft can contain one or more Aeronautical Class UEs where each UE contains one transmit and one receive RF channel and is associated with a unique IMSI.

6.1 Antenna requirements

6.1.1 Radiation pattern

The gain at both the receive and transmit frequencies shall be such that the G/T requirements specified in clause 6.2.1 and the EIRP requirements specified in clause 6.3.1 are satisfied.

For all antenna steering angles, the Class 6 UE shall discriminate in antenna gain against satellites spaced 45º or more in longitude from the wanted satellite by at least 13 dB relative to the gain toward the wanted satellite, for all frequencies of operation and for all normal aircraft orientations.

For all antenna steering angles, the Class 7 UE and Class 15 (steerable antenna only) shall discriminate in antenna gain against 85 % of all visible geostationary arc locations spaced 80º or more in longitude from the wanted satellite in either direction by at least 7 dB relative to the gain toward the wanted satellite, for all frequencies of operation and for all normal aircraft orientations.

A non-steerable antenna operating with a Class 15 UE shall not exceed the envelope specified below:

$90° < \theta \leq 110°$ (or $-20° \leq$ elevation < 0): $G0dBr - G(\theta) \geq 4$ dB

$110° < \theta \leq 180°$ (or $-90° \leq$ elevation $< -20°$) : $G0dBr - G(\theta) \geq 12$ dB

where $G(\theta)$ is the Tx gain averaged at $\theta°$ from zenith. The corresponding elevation angle is $90° - \theta°$ and the gain is averaged over the range of azimuth from 0° to 360°.

The 0 dBr gain level is defined as: $G0dBr = G(\theta = 70°)$, which is at 20° elevation.

6.1.2 Polarization

The requirements of clause 5.1.2 shall apply.

6.1.3 Axial Ratio

The antenna circular polarization axial ratio shall be no greater than the requirements stated in Table 6.1 for UE within the portion of the UE antenna main beam that could be directed towards the satellite position (referenced as on-axis).

Table 6.1: UE Maximum Axial Ratio

UE Class	Axial Ratio Requirement
Class 6 (Aeronautical High Gain)	Less than 6 dB over the declared coverage volume (see note 1)
Class 7 (Aeronautical Intermediate Gain)	Less than 6 dB over the declared coverage volume (see note 1)
Class 15 (Aeronautical Low Gain)	Less than 6 dB over the declared coverage volume (see note 1)
Class 4 (Aeronautical Enhanced Low Gain)	Less than 6 dB over the declared coverage volume (see notes 1 and 2)
NOTE 1: The declared coverage volume is defined in Annex A. NOTE 2: For Class 4, localised degradations in axial ratio beyond the specified requirements may be acceptable if there is sufficient gain margin in the antenna over that region. A satellite antenna axial ratio of 2,5 dB should be assumed with the polarization ellipse axis orthogonal.	

6.1.4 UE antenna pointing loss

The UE shall automatically keep the antenna pointed towards the appropriate satellite with sufficient accuracy to ensure the relevant G/T and EIRP requirements are satisfied continuously under all appropriate aircraft operations.

6.1.5 Carrier-to-Multipath Discrimination

For all Aeronautical Class UEs, the antenna shall attenuate the reflected signal from the sea surface relative to the main signal in the direction of the satellite, so as to achieve a minimum C/M of 10 dB at 5° elevation and 12 dB at 20° elevation. The compliance shall be estimated with the aircraft in horizontal flight over a sea in median sea condition and under conditions of the following note.

The C/M over median (C/Mmed) sea is defined on the basis of a combination of the C/M for rough sea (C/Mrgh corresponding to sea states with Beaufort Number 3 or higher) and on the C/M for smooth sea (C/Msmth, corresponding to sea state with Beaufort Number 0) - by C/Mmed = 0,3 × C/Msmth + 0,7 × C/Mrgh.

NOTE: A suitable method to determine C/M is shown in section 2.4.3.3.10 of the AMSS MOPS - RTCA DO210D [7].

6.1.6 Antenna Control

The Aeronautical Class 6 and Class 7 UEs shall control the antenna pointing direction based on GNSS or IRS position information and the aircraft attitude information provided by the aircraft navigation systems.

NOTE: The position information may be provided by an internal GNSS unit.

The pointing function shall operate with adequate latency and periodicity to ensure that the antenna tracks the satellites during changes in aircraft attitude and position. However for the Class 4 UE, the aircraft attitude is not required for the antenna pointing.

6.1.7 High-Gain and Intermediate-Gain Antenna Reported Gain Accuracy

For Aeronautical Class UE implementations using power control mechanisms based on antenna reported gain, the antenna reported gain sent from the antenna to the SDU shall be based on the minimum gain value of the antenna measured at ambient for the highest, lowest and central frequencies in the transmit band for that pointing angle. This value shall be rounded to the nearest 0,5 dB and have an accuracy (before rounding) of -0,5 dB to +0,5 dB (including gain variation with frequency and measurement accuracy). This accuracy is required over 80 % of the declared coverage volume (see Annex A).

6.1.8 Operating Frequency

The antenna shall operate over the frequency ranges 1 518,0 to 1 559,0 MHz (receive) and 1 626,5 to 1 660,5 MHz and 1 668,0 - 1 675,0 MHz (transmit).

6.1.9 Antenna-switching performance

Aeronautical Class UE installations that require more than one antenna in order to satisfy the G/T and EIRP requirements over the declared coverage volume (see Annex A) shall switch between antennas automatically as necessary. During switchover, the time in which the antenna subsystem fails to meet its performance requirements shall not exceed 40 ms.

NOTE: 'Antenna' here refers to each distinct array of one or more elements.

6.1.10 Beam-steering performance

For a Aeronautical Class UE antenna where the beam steering is performed in discrete steps (typically using a phased array), the signal shall not be interrupted by more than 50 microseconds when switching between any adjacent UE antenna beam positions. For a non Class 4 UE, beam-steering transitions between adjacent beam positions shall not cause a peak-to-peak RF phase discontinuity introduced into transmitted or received signals greater than:

- 8° for a minimum of 90 % of all combinations of transitions between adjacent beam positions;
- 12° for a minimum of 99 % of all combinations of transitions between adjacent beam positions.

For a Class 4 UE, phase jumps shall be minimised by usage of hysteresis to prevent multiple transitions at steering breakpoints.

6.2 Receiver requirements

6.2.1 Gain-to-Noise Temperature Ratio

The RF receiving system gain to noise-temperature ratio (G/T) shall be in accordance with Table 6.2 for the relevant UE type in the direction of the satellite and under the simultaneous conditions specified in clause 5.2.1 together with the following additional requirements:

1) With residual antenna pointing errors, including those due to imperfect stabilization system performance.

2) The G/T requirement shall apply over the declared coverage volume (see Annex A).

3) With the transmitter power amplifier under all possible operating conditions and taking into account of any associated active and passive intermodulation effects and spurious signals caused by interaction of carriers from any other services on the aircraft.

Table 6.2: Minimum G/T Requirements for Aeronautical Class UEs

UE Class	Minimum Receiver G/T (dB/K) (Forward Link) per satellite elevation at antenna
Class 6 (Aeronautical High Gain)	≥ -13 for Elevation > 5°
Class 7 (Aeronautical Intermediate Gain)	≥ -19 for Elevation > 5°
Class 15 (Aeronautical Low Gain)	≥ -20 for Elevation > 5°
Class 4 (Aeronautical Enhanced Low Gain) (see note)	≥-22 for Elevation = 70°- 90° ≥-21 for Elevation = 60°- 70° ≥-20 for Elevation = 20° -60° ≥-21 for Elevation = 15°- 20° ≥-22 for Elevation = 5°- 15°
NOTE: At the elevation angles that border the five ranges, i.e. 70°, 60°, 20° and 15°, the minimum receiver G/T to be met is the higher of the two values.	

Definitions of G, T, and suitable measurement point are given in clause 5.2.1.

For a non-steerable antenna operating as a Class 15 UE, the following requirements shall apply:

90° < $\theta \leq$ 110° (or -20° ≤ elevation < 0): $G_{0dBr} - GT(\theta) \geq 4$ dB

110° < $\theta \leq$ 180° (or -90° ≤ elevation < -20°): $G_{0dBr} - GT(\theta) \geq 12$ dB

where GT(θ) is the G/T function averaged at θ° from zenith. The corresponding elevation angle is 90° - θ° and the G/T is averaged over the range of azimuth from 0° to 360°.

The 0 dBr gain level is defined as: $GT_{0dBr} = GT(\theta = 70°)$, which is at 20° elevation.

6.2.2 Received Signal Levels

The requirements of clause 5.2.2 shall apply.

6.2.3 Received Phase Noise

The requirements of clause 5.2.3 shall apply.

6.2.4 Receiver Channel Tuning

The requirements of clause 5.2.4 shall apply.

6.2.5 Received Signal Frequency Offsets

6.2.5.0 General

The frequency signal in the air will be within ±500 Hz of the nominal assigned frequency including residual satellite Doppler, but excluding any Doppler frequency induced due to UE movement.

Short term frequency variation will be ±25 Hz. This is based on the satellite Doppler acceleration and short-term frequency variation at the RAN, but does not take into consideration the Doppler frequency variation due to UE movement. For clarity, the relative frequency difference between the start of the two forward frames at the UE antenna will not exceed the above ±25 Hz figure when the time separation between the frames is 128 frames or less (resulting from sleep mode considerations).

6.2.5.1 Compensation for Doppler Frequency Offset.

Since Aeronautical Class UEs when in flight move at considerable speed, frequency changes due to Doppler effects of the aircraft motion shall be compensated for by the UE. The compensation shall be adequate for the declared operating conditions of the UE.

A recommended method of Doppler frequency compensation is that each Aeronautical Class UE should calculate the expected Doppler shift according to satellite nominal position data provided in the satellite bulletin-board broadcast information, and the aircraft position and velocity data obtained from the on-board positioning system.

For Aeronautical Class UEs, the Doppler frequency compensation implementation shall cope with a Doppler shift of up to ±2,5 kHz and peak rate of change of up to ±30 Hz/s, which represents a worst case shift induced by the aircraft velocity in the direction of the satellite nominal position.

The receive frequencies shall be offset by the calculated Doppler Frequency compensation. The uncertainty of the frequency compensation resulting from Doppler compensation process (i.e. the residual frequency error) shall not exceed ±150 Hz at any time. The UE mechanism shall also meet the transmit frequency requirement of clause 6.3.10.1.

NOTE: It is allowed for the UE receiver to have a larger Doppler offset error, however the transmit frequency error requirement in clause 6.3.10.1 is still applicable. Hence any additional Doppler error on receive beyond the ±150 Hz limit will make the transmit frequency error requirement more difficult to meet.

6.2.6 Receiver Selectivity

The requirements of clause 5.2.6 shall apply.

6.2.7 Receiver Demodulation Characteristics

All Aeronautical Class UEs, including Class 6 HDR and 7 HDR UEs, shall demodulate and decode all the supported forward bearer types and coding rates listed in Table 6.3.

Table 6.3: Supported Bearer types and subtypes for Aeronautical Class UEs

Bearer Type	Code rates	UE Class
F80T0.25Q-1B	All	4, 6, 7, 15, 6 HDR & 7 HDR
F80T1Q-4B	All	4, 6, 7, 15, 6 HDR & 7 HDR
F80T1X-4B	All	4, 6, 7, 15, 6 HDR & 7 HDR
F80T4.5X-8B	All	4, 6, 7, 15, 6 HDR & 7 HDR
F80T1Q-1B	All	4
FR80T2.5X4/16-5B	QPSK (L8-L3), 16 QAM (L2-H6)	4
FR80T2.5X16-5B	All	4, 6 HDR & 7 HDR
FR80T5X4/16-9B	QPSK (L8-L3), 16 QAM (L2-H6)	4
FR80T5X16-9B	All	4, 6 HDR & 7 HDR
FR80T2.5X32-6B	All	6 HDR & 7 HDR
FR80T5X32-11B	All	6 HDR & 7 HDR
FR80T2.5X64-7B	All	6 HDR & 7 HDR
FR80T5X64-13B	All	6 HDR & 7 HDR

6.2.8 Acquisition and Synchronisation Performances

6.2.8.1 All Aeronautical Class UEs

The requirements of clause 5.2.9 shall apply, except that the blocking requirement defined second paragraph of clause 5.2.9 is modified by the paragraphs below.

Assuming that timing and frequency offsets are known (and the Forward Bearer type hasn't been modified according to ETSI TS 102 744-3-2 [13]), and that blockage occurs for 5 consecutive frames, the FEC Block Error Rate (BLER) for the first FEC block of the 8th frame after the 5 blocked frames shall be ≤ 1E-2; and ≤ 1E-3 for FEC blocks in subsequent frames. A frame is considered blocked if any FEC block of the frame is blocked.

The values of C/No (relating to the bearer and sub-bearer rates) over which UE acquisition requirement shall be met are specified in clauses 6.2.11 and 6.2.11.1.

NOTE: The BLER compliance (as defined in clause 5.2.8) for "initial" and "cold" acquisition performance requirements are based on an assumed received C/No that has been adjusted to take into consideration mobile channel conditions.

The indicated maximum frequency offsets do not taken into consideration the result of any Doppler frequency effects. Consequently, for any Aeronautical Class UE an additional residual frequency error of up to ±150 Hz shall be considered to exist arising from inaccurate Doppler receive frequency compensation at the UE.

6.2.8.2 Tolerance to Signal Blocking

In order to prevent premature call clearing, the UE receiver design should tolerate deep fading which can cause lower C/No conditions than those specified in clause 6.2.11.1 for short periods (e.g. of the order of seconds).

6.2.8.3 Aeronautical Receiver Damage Level

Aeronautical class UEs shall withstand, without permanent degradation, a 1 second out-of-band RF pulse with the flux density in Table 6.4.

Table 6.4: Aeronautical Receiver Radar Pulse Protection Levels

Frequency (MHz)	Input Flux Density (dBW/m^2)
0 to 1 459	30
1 675 to 18 000	38

The aeronautical class UE receiver design should also take into account the existence and/or probable deployment of other mobile communications systems operating at L-band.

NOTE: Because the power flux densities (both composite and per-carrier) of such systems in the proximity of the Aeronautical class UE may be very much higher than the power flux density of the wanted carriers, particular attention needs to be paid to the dynamic range of the UE LNA and the subsequent mixer stage (to avoid saturation and consequent intermodulation product generation). Furthermore provision should be made of as much selectivity as possible, as early as possible, in the receiver down-conversion process. See also clause 6.2.2.

6.2.9 Channel Characteristics/Impairments

6.2.9.1 Fading Channel Model

A wide-band multi-path fading channel model is defined for the Aeronautical channels. This model is shown in Figure 6.1 and is used to evaluate the receiver performance requirements. It is based on signal interference between a direct line-of-sight (LOS) path and 5 reflected paths (multi-path). Also, the multi-path component has significant delay with respect to the LOS component and hence the resultant fading is frequency selective.

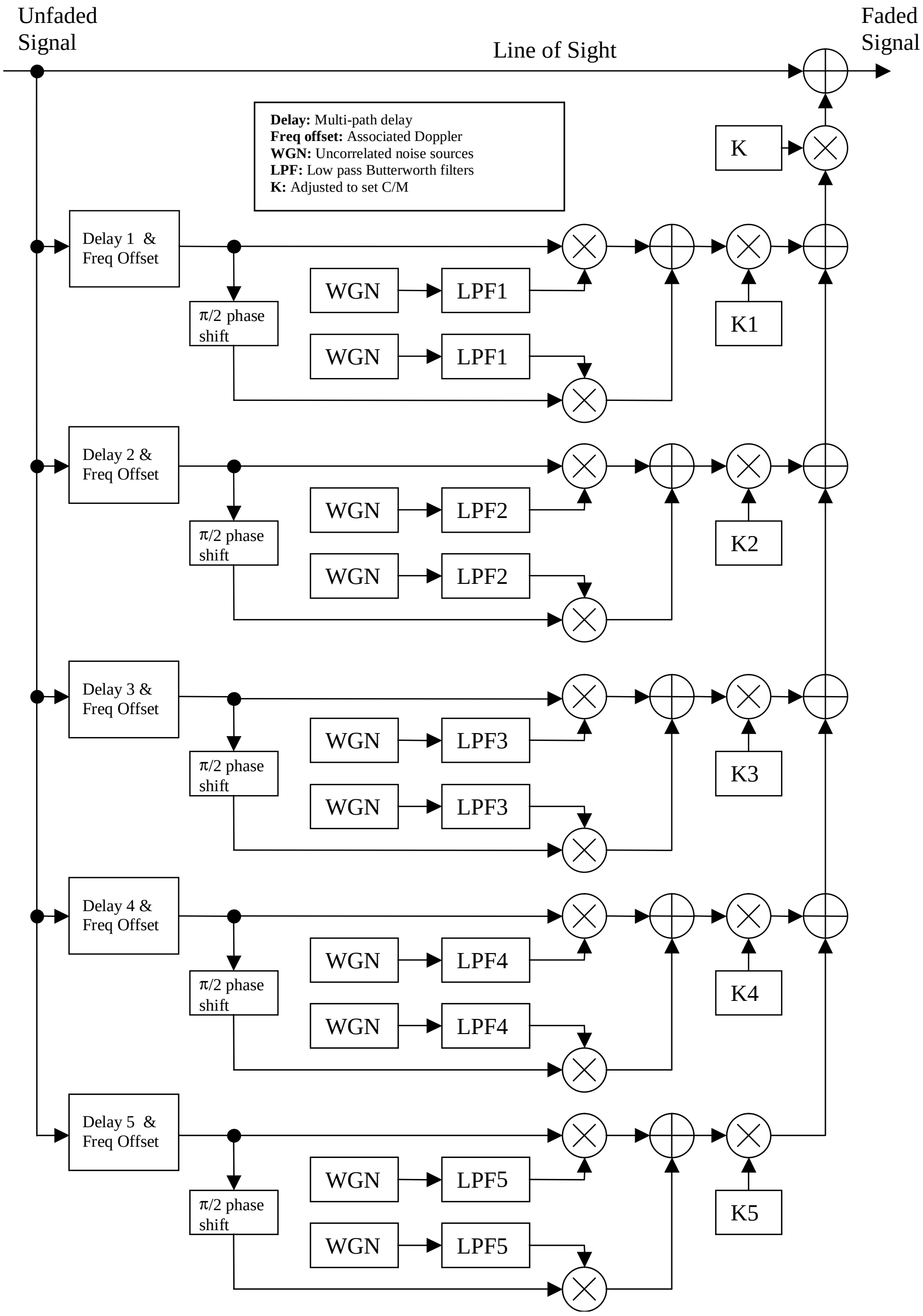


Figure 6.1: Aeronautical "multiple tap" fading model

Each multi-path component is modulated by a complex valued zero mean independent Gaussian random process. The power spectrum of each modulating vector is the fading Doppler spectrum and the one sided nonzero range is called the 3 dB fading bandwidth (FBw (-3 dB)). For the aeronautical channel, the fading power spectrum is modelled by a second order Butterworth filter with its -3 dB point representing a specified fading bandwidth in Hz. The resultant multi-path carrier envelope has a Rayleigh probability distribution and its phase is uniformly distributed between 0 and 2π radians.

Each multi-path component undergoes a Doppler shift dependent on its angle of arrival at the antenna.

A representative set of parameters of the multiple delay tap used within the aeronautical channel fading model for all classes of aeronautical UEs is listed in Table 6.5. Each multi-path component is specified in terms of a differential delay T (μS), a differential Doppler shift F (Hz) and relative power difference between the direct and reflected path K (dB). C/M is the ratio between the average power in the direct path signal and the average power in the sum of all reflected paths.

Table 6.5: Aeronautical Multiple Tap Model Parameters - Delay (τ in µS), relative power (K in dB) and mean differential Doppler (F in Hz) for Aeronautical Class UEs

UE Class	Approx Elevation Angle	C/M (dB)	Fading BW (Hz)	Delay (τ1…τ5)	Relative power (K1…K5)	Mean Diff Doppler (F1…F5) (Hz)
6	Low	15	35	10,2; 11,2; 12,2; 13,2; 14,2	-24; -17; -19; -25; -31	15; 42; 70; 100; 129
6	Medium	21	45	20; 21; 22; 23; 24	-18; -21; -23; -24; -25	15; 42; 70; 100; 129
7	Low	12	35	10,2; 11,2; 12,2; 13,2; 14,2	-32; -22; -19; -21; -27	15; 29; 42; 57; 71
7	Medium	18	45	20; 20,5; 21; 21,5; 22	-13; -17; -22; -24; -25	15; 29; 42; 57; 71
15	Medium	18	45	20; 20,5; 21; 21,5; 22	-13; -17; -22; -24; -25	15; 29; 42; 57; 71
4	Low	10	35	10,2; 11,2; 12,2; 13,2; 14,2	-31; -24; -17; -19; -29	15; 29; 42; 57; 71
4	Medium	14,3	45	20; 20,5; 21; 21,5; 22	-16; -18; -21; -23; -26	15; 29; 42; 57; 71

A set of parameters representative of the narrow-band fading model for each Aeronautical Class UE is listed in Table 6.6. The faded signal is a composite consisting of the sum of the LOS component and the multi-path components. The LOS component is assumed to be always present and with fixed power C (dBW); while the total multi-path power is the sum of the multi-path power components with a fixed long term average power M (dBW). The resultant faded signal is characterised by the C/M (dB) parameter, which is adjusted by the overall "K" value shown in Figure 6.1.

The parameters of Tables 6.5 and 6.6 have been chosen to represent typical aeronautical operational scenarios relating to an assumed elevation angle, sea state, aircraft speed, altitude and UE antenna radiation characteristics. These relate to the following operational conditions: 5 and 20 degree elevation, calm sea, aircraft altitude = 8 534 m, velocity = 224 m/s and frequency = 1 542 MHz.

Table 6.6: Aeronautical Channel Parameters

		Channel Model - Low Elevation		Channel Model - Medium Elevation	
UE Class	**Antenna.**	**C/M (dB)**	**FBw (-3 dB) (Hz)**	**C/M (dB)**	**FBw (-3 dB) (Hz)**
Class 6	Aeronautical High Gain	15	35	21	45
Class 7	Aeronautical Intermediate Gain	12	35	18	45
Class 15	Steerable Antenna	-	-	18	45
Class 4	Aeronautical Enhanced Low Gain	10	35	14,3	45

6.2.9.2 Channel Characteristics/Impairments

The UE Aeronautical Class channel characteristics and reference impairments are contained in Table 6.7.

Table 6.7: Channel Characteristics and Reference Impairments for UE Aeronautical Class

Test Parameter	Test Conditions	
C/M	See Table 6.6	
Fading BW	See Table 6.6	
Multipath Delay	See Table 6.5	
Discrete Phase Jumps	Piece-wise uniform distribution with: (75 % < 8°); (93 % < 12°); (99 % < 18°); (100 % < 20°) and 0,5 Hz jump rate	
Freq Offset	Refer to acquisition clause 6.2.8	
Continuous receive Phase Noise	Refer to Table 5.5 (applies to forward bearers received by the UE)	
Discrete receive Phase Noise	1 discrete component at -30 dBc, 10 Hz to 200 Hz from the carrier	
I/Q imbalance	For soft modems and simulations (contribution due to RNC and UE hardware)	0,1 dB amplitude, 1 degrees phase
	Of the received 'signal in the air'	0,05 dB amplitude, 0,5 degrees phase
Doppler	See Table 6.5	
ACI	2 adjacent carriers at +6 dBc (also faded along with the wanted channel) F80T0.25Q-1B: 11,25 kHz frequency spacing F80T1Q-4B: 45 kHz frequency spacing F80T1X-4B: 45 kHz frequency spacing F80T4.5X-8B: 200 kHz frequency spacing	
ACI (HDR)	2 adjacent carriers at 0 dBc (also faded along with the wanted channel) F80T1Q-1B: 45 kHz frequency spacing FR80T2.5X4/16-5B: 95 kHz frequency spacing FR80T2.5X16-5B: 95 kHz frequency spacing FR80T2.5X32-6B: 95 kHz frequency spacing FR80T2.5X64-7B: 95 kHz frequency spacing FR80T5X4/16-9B: 200 kHz frequency spacing FR80T5X16-9B: 200 kHz frequency spacing FR80T5X32-11B: 200 kHz frequency spacing FR80T5X64-13B: 200 kHz frequency spacing	

6.2.10 Received C/No Measurement Accuracy

The requirements of clause 5.2.10 shall apply for the measurement accuracy requirements in 'Additive Gaussian White Noise' (AGWN) conditions.

The UE shall not report higher C/No (+1 dB) than the AWGN channel C/No.

Additionally, in fading conditions of clause 6.2.9, the C/No of the received forward channel shall be measured or estimated in accordance with the following requirements for all forward bearers except F80T0.25Q-1B:

a) 90 % of the C/No measurements should have an accuracy of ±1 dB for the low degrees elevation angle fading models and +1 dB/-0,5 dB for the medium degrees elevation angle fading models;

b) the C/No measurement shall be an average value measured during a maximum of 10 s period. The measurement time shall exclude any time when frame synchronization is lost; and

c) the C/No measurement should meet the accuracy requirement of requirement (a) above over the full C/No range (encompassing all coding rates) of the particular carrier.

6.2.11 Demodulator Performance

6.2.11.0 General

The requirements of clause 5.2.11 shall apply except that, for Aeronautical Class UEs, the UE receiver performance shall additionally be met in the presence of any residual frequency error (of up to ±150 Hz) resulting from inaccurate Doppler receive frequency compensation at the UE.

NOTE: The actual magnitude of the residual frequency error to be considered for Aeronautical Class UEs will relate to the performance of the implemented Doppler compensation mechanism.

6.2.11.1 Demodulator C/No and BLER Performance

For all the forward bearer types and subtypes as defined in clause 6.2.7, the UE demodulator shall achieve an FEC Block Error Rate (BLER) ≤ 1E-3 with the required C/No indicated in Table 6.8 for both the non-fading and the two fading scenarios contained within Tables 6.5 and 6.6.

The C/No requirement incorporates an allowance for implementation loss to AWGN condition to include the effects of Phase Noise, I/Q imbalance, Doppler, and Frequency Offset impairments as indicated within Table 6.7. The C/No requirements also incorporates an allowance for modem implementation loss to include the effects of timing, frequency and phase estimation and correction within the demodulator, limited number of Turbo Decoder iterations and any arithmetic approximation. The implementation loss also includes other typical impairment effects such as A/D converter quantisation noise, added Local Oscillator phase noise and spurs, and any contribution from operating the UE at maximum transmit power, etc. However, the C/No requirement does not include an allowance for co-channel interference (CCI).

NOTE: The fading requirements are included so that "robust" demodulators will be implemented; hence ensuring that the demodulator has an adequate amplitude and phase tracker and it does not lose carrier synchronisation after a deep fast fade. This will also mean for aeronautical UE Classes (Classes 4, 6 and 7) a channel equaliser will be needed to improve the multi-path fading performance and meet the required BLER performance (see clause 6.2.12).

The implementation loss excludes the effects of CCI, and electromagnetic interference from other external systems (both inter and intra-system interference).

FEC Blocks that were transmitted which are corrupted or missed shall be included in the overall BLER calculation.

Table 6.8: BLER vs C/No Performance Requirements for Aeronautical Class UEs

		C/No (dBHz) required to achieve BLER of 10^{-3} (see note 1)							
		UE Classes 6 & 7	UE Class 6		UE Class 7		UE Class 15	UE Class 4	
Bearer Type	Code rates	Non-faded (note 3)	Faded (note 5)						
		Practical receiver in AGWN + non-fading channel impairments	Channel Model, Low elevation	Channel Model, Medium elevation	Channel Model, Low elevation	Channel Model, Medium elevation	Channel Model, Medium elevation (Steerable antenna)	Channel Model, Low elevation	Channel Model, Medium elevation
F80T0.25Q-1B	L8	40,1	40,4	40,4	40,9	40,4	40,4	41,3	40,7
	L7	41,4	41,7	41,7	42,2	41,7	41,7	42,7	42,1
	L6	42,4	42,8	42,7	43,4	42,7	42,7	44,2	43,1
	L5	43,4	43,8	43,7	44,5	43,7	43,7	45,4	44,2
	L4	44,3	45,2	44,8	46,4	44,9	44,9	47,6	45,4
	L3	45,3	46,5	45,8	47,4	46,0	46,0	49,1	46,6
	L2	46,3	47,3	46,6	48,3	46,6	46,6	50,7	47,2
	L1	47,4	48,0	47,7	50,2	47,7	47,7	N/A	48,4
	RE	48,3	49,3	48,6	51,5	48,6	48,6	N/A	49,2
F80T1Q-4B	L8	46,1	46,5	46,4	47,4	46,4	46,4	48,3	46,7
	L7	46,9	47,5	47,2	48,5	47,2	47,2	49,5	47,6
	L6	47,9	48,8	48,2	50,1	48,4	48,4	51,3	48,8
	L5	48,8	50,0	49,2	51,6	49,4	49,4	52,9	49,9
	L4	49,7	51,0	50,1	53,2	50,4	50,4	54,8	51,1
	L3	50,6	52,3	51,2	55,3	51,4	51,4	57,9	52,2
	L2	51,6	53,5	52,1	58,6	52,5	52,5	N/A	53,3
	L1	52,6	55,0	53,2	N/A	53,7	53,7	N/A	54,5
	RE	53,6	56,0	53,9	N/A	54,6	54,6	N/A	55,5
F80T1X-4B	L3	50,6	51,9	51,1	53,3	51,2	51,2	55,3	51,9
	L2	51,6	53,0	52,1	54,5	52,3	52,3	56,9	53
	L1	52,5	54,0	53,0	55,6	53,4	53,4	59	54,3
	RE	53,5	55,5	54,3	57,4	54,7	54,7	64,9	55,7
	H1	54,5	56,8	55,4	59,4	55,9	55,9	N/A	56,9
	H2	55,6	58,2	56,6	61,4	57,2	57,2	N/A	58,4
	H3	56,5	59,4	57,5	N/A	58,0	58,0	N/A	59,3
	H4	57,6	61,2	58,7	N/A	59,3	59,3	N/A	61
	H5	58,7	63,1	59,5	N/A	60,5	60,5	N/A	62,5
	H6	59,5	65,1	59,8	N/A	61,3	61,3	N/A	64
F80T4.5X-8B	L3	56,8	58,0	57,1	59,9	57,3	57,3	62,9	58,1
	L2	57,7	59,3	58,1	61,1	58,3	58,3	65,8	59,4
	L1	58,7	60,6	59,1	63,0	59,7	59,7	N/A	61
	RE	59,6	62,0	60,3	64,9	60,8	60,8	N/A	62,3
	H1	60,8	63,8	61,7	68,3	62,3	62,3	N/A	63,9
	H2	61,9	65,6	63,0	N/A	64,9	64,9	N/A	66,6
	H3	63,0	67,8	64,3	N/A	66,1	66,1	N/A	67,8
	H4	64,2	N/A	65,8	N/A	68,2	68,2	N/A	70,1
	H5	65,1	N/A	66,6	N/A	69,7	69,7	N/A	N/A
	H6	66,2	N/A	67,6	N/A	N/A	N/A	N/A	N/A

NOTE 1: Includes modem implementation losses and any equaliser losses.
NOTE 2: Practical receiver in AGWN + non-fading channel impairments.
NOTE 3: An additional 0,3 dB on the non-faded requirement is acceptable.
NOTE 4: N/A indicates "Not Applicable".
NOTE 5: Requirements are based on use of an equaliser to help mitigate the effect of multi-path fading.

Table 6.9: BLER vs C/No Performance Requirements for Aeronautical Class UEs Supporting the New Bearer Types

		C/No (dBHz) required to achieve BLER of 10^{-3} (see note 1)						
		UE Classes 6 & 7	UE Class 6		UE Class 7		UE Class 4	
Bearer Type	**Code rates**	**Practical receiver in AGWN + non-fading channel impairments**	**Channel Model, Low elevation**	**Channel Model, Medium elevation**	**Channel Model, Low elevation**	**Channel Model, Medium elevation**	**Channel Model, Low elevation**	**Channel Model, Medium elevation**
F80T1Q-1B	L8	45,3	45,6	45,6	46,1	45,6	46,5	45,9
	L7	46,1	46,6	46,5	47,2	46,5	47,7	46,8
	L6	47,2	47,9	47,6	48,8	47,7	49,3	48
	L5	48,2	49,1	48,6	50,2	48,7	50,8	49,1
	L4	49,1	50,1	49,6	51,6	49,8	52,4	50,2
	L3	50	51,4	50,7	53,7	50,8	54,5	51,2
	L2	51	52,5	51,6	56,9	51,8	57,7	52,4
	L1	51,9	53,9	52,5	57,8	53	58,8	53,5
	RE	53,1	54,8	53,3	58,8	53,8	N/A	54,5
FR80T2.5X4/16-5B L8 to L3 (QPSK) (see note 2) L2 to H6 (16QAM)	L8	49,5	49,6	49,8	50	49,8	50,6	49,9
	L7	50,4	50,7	50,8	51,4	50,8	52	51,1
	L6	51,4	52	51,7	52,8	51,8	53,5	52,1
	L5	52,3	53,3	52,7	54,3	52,8	55,2	53
	L4	53,3	54,2	53,7	55,7	53,9	56,8	54,3
	L3	54,2	55,5	54,8	57,9	54,8	59,2	55,2
	L2	55,3	56,4	55,7	57,6	55,7	60,2	56,1
	L1	56,6	57,6	56,9	58,9	57,3	63,9	57,9
	RE	57,8	60,1	58,5	64,4	58,7	N/A	59,3
	H1	58,9	60,5	59,7	64,1	59,8	N/A	60,5
	H2	59,9	63,7	61	N/A	62	N/A	63,2
	H3	61	66,2	62,2	N/A	63,3	N/A	64,8
	H4	62	N/A	63,2	N/A	65	N/A	66,8
	H5	62,8	N/A	63,8	N/A	66,4	N/A	72,3
	H6	64,2	N/A	65	N/A	N/A	N/A	N/A
FR80T2.5X4/16-9B L8 to L3 (QPSK) L2 to H6 (16QAM)	L8	52,6	52,8	52,9	53,4	52,9	53,8	52,9
	L7	53,6	54	54	54,6	53,9	55,4	54
	L6	54,7	55,4	55	56,2	55,1	57,3	55,3
	L5	55,8	56,6	56,2	57,6	56,2	58,5	56,4
	L4	56,8	57,6	57,1	59,2	57,3	60,6	57,6
	L3	57,8	59	58,4	61,5	58,4	62,7	58,9
	L2	58,5	59,2	58,8	60,2	58,8	61,3	59,4
	L1	59,5	60,6	59,8	61,7	60,1	63	60,9
	RE	60,7	62,2	61,4	64	61,6	66,1	62,8
	H1	61,6	63,3	62,3	65,3	62,5	67	63,6
	H2	62,6	65,4	63,6	N/A	64,8	N/A	65,9
	H3	63,7	66,9	64,7	N/A	66,2	N/A	67,2
	H4	64,8	N/A	66	N/A	68,1	N/A	68,7
	H5	65,6	N/A	66,6	N/A	69,3	N/A	69,9
	H6	66,3	N/A	67,1	N/A	N/A	N/A	N/A
FR80T2.5X16-5B	L3	53,9	54,7	54,2	55,8	54,2	57,8	54,5
	L2	55,3	56,2	55,6	57,6	55,6	60,3	56
	L1	56,5	57,5	56,9	58,9	57,2	64,6	57,8
	RE	57,7	60	58,4	65,1	58,5	N/A	59,1
	H1	58,8	60,7	59,6	64,5	59,6	N/A	60,5
	H2	59,8	64,3	60,9	N/A	62	N/A	63,2
	H3	60,9	66,9	62	N/A	63,1	N/A	65,1
	H4	61,9	74,8	63,1	N/A	64,9	N/A	67,6
	H5	62,8	N/A	63,7	N/A	66,5	N/A	74,1
	H6	64,2	N/A	65	N/A	67,8	N/A	N/A

		C/No (dBHz) required to achieve BLER of 10^{-3} (see note 1)						
		UE Classes 6 & 7	UE Class 6		UE Class 7		UE Class 4	
Bearer Type	**Code rates**	**Practical receiver in AGWN + non-fading channel impairments**	**Channel Model, Low elevation**	**Channel Model, Medium elevation**	**Channel Model, Low elevation**	**Channel Model, Medium elevation**	**Channel Model, Low elevation**	**Channel Model, Medium elevation**
FR80T5X16-9B	L3	56,9	57,5	57,2	58,4	57,2	59,4	57,6
	L2	58,2	59	58,5	59,9	58,6	60,7	59,1
	L1	59,3	60,3	59,6	61,2	59,9	62,3	60,7
	RE	60,4	61,8	61,1	63,4	61,3	65,2	62,4
	H1	61,4	62,9	62,1	64,8	62,3	66,2	63,2
	H2	62,3	64,7	63,3	69,2	64,6	N/A	65,4
	H3	63,4	66,1	64,4	70,4	65,8	N/A	66,6
	H4	64,4	67	65,7	72,5	67,6	N/A	68,2
	H5	65,4	68,6	66,4	N/A	68,9	N/A	69,4
	H6	66,1	68,7	66,8	N/A	69,4	N/A	69,9
FR80T2.5X32-6B	H1	61,8	N/A	63	N/A	64,2		
	H2	62,8	N/A	64,6	N/A	67,8		
	H3	64,2	N/A	66,6	N/A	N/A	Not supported	
	H4	65,1	N/A	68,1	N/A	N/A		
	H5	66,3	N/A	70,6	N/A	N/A		
	H6	67,4	N/A	74,8	N/A	N/A		
FR80T5X32-11B	H1	64	70,1	64,9	N/A	65,8		
	H2	64,8	N/A	66,2	N/A	68,4		
	H3	66	N/A	67,7	N/A	71,1	Not supported	
	H4	67,2	N/A	69,3	N/A	76,4		
	H5	68,2	N/A	70,5	N/A	N/A		
	H6	69,7	N/A	72,9	N/A	N/A		
FR80T2.5X64-7B	RE	RE	61,2	N/A	62,3	N/A		
	H1	H1	62,4	N/A	63,7	N/A		
	H2	H2	63,9	N/A	66,1	N/A		
	H3	H3	65,1	N/A	67,9	N/A	Not supported	
	H4	H4	66,2	N/A	70,3	N/A		
	H5	H5	67,3	N/A	74,1	N/A		
	H6	H6	69,3	N/A	N/A	N/A		
FR80T5X64-13B	RE	64,6	74,9	65,7	N/A	67		
	H1	66	N/A	67,4	N/A	69,4		
	H2	67,6	N/A	70	N/A	76,9		
	H3	69,2	N/A	72,7	N/A	N/A	Not supported	
	H4	70,4	N/A	76,1	N/A	N/A		
	H5	71,5	N/A	N/A	N/A	N/A		
	H6	73,2	N/A	N/A	N/A	N/A		

NOTE 1: Includes modem implementation losses and any equaliser losses.
NOTE 2: Practical receiver in AGWN + non-fading channel impairments.
NOTE 3: An additional 0,3 dB on the non-faded requirement is acceptable.
NOTE 4: N/A indicates "Not Applicable".
NOTE 5: Requirements are based on use of an equaliser to help mitigate the effect of multi-path fading.
NOTE 6: The C/No values for all the new bearer types and coding rates, under all channel conditions are preliminary results which were obtained by initial simulation and linear interpolation.

6.2.12 Equaliser performance

Aeronautical Class UEs (Classes 4, 6 and 7) should use an equaliser to improve performance under frequency selective fading conditions. Any type of equaliser which meets or exceeds the performance criteria (as specified in clause 6.2.11) and under the aeronautical channel model specified in clause 6.2.9.1, may be used.

The UE should only employ the equalizer if there are errors encountered on the channel. Therefore in benign fading channel conditions, the equaliser can be effectively switched off, thus avoiding any equaliser loss being introduced and also avoiding any delay arising from use of the equalizer. The decision on whether to equalise or not should be made on a FEC-by-FEC (block) basis.

6.3 Transmitter requirements

6.3.1 EIRP

6.3.1.0 General

The Aeronautical class UE nominal transmit EIRP shall meet the requirement stated in Table 6.10 over the UEs declared coverage volume (see Annex A) at any frequency in the transmit band. This requirement shall include cable and any other losses, and be satisfied continuously under all appropriate environmental conditions.

Table 6.10: Nominal UE EIRP (RHCP) for Aeronautical Class UEs

UE Class	Nominal UE EIRP (dBW)
Class 6	20,0
Class 7	15,1
Class 15	11,4
Class 4	10,0 (Elevation = 5-70°) 8,0 (Elevation = 70-90°)

6.3.1.1 Power Masks

The requirements of clause 5.3.1.1 shall apply.

6.3.1.2 EIRP Congruency with received G/T

The requirements of clause 5.3.1.2 shall apply.

6.3.1.3 EIRP Stability

The requirements of clause 5.3.1.3 shall apply.

6.3.1.4 EIRP setting accuracy

The EIRP setting range, step size and setting accuracy shall meet the requirements stated in Table 6.11.

The upper values of the EIRP setting range correspond to the nominal EIRP.

The UE shall support burst-to-burst power regulation within the limits and with the step size defined in Table 6.11.

Table 6.11: EIRP setting range, step size, accuracy for Aeronautical Class UEs

Terminal Class	EIRP Setting Range relative to Nominal EIRP	EIRP step size (note 1)	EIRP setting accuracy (note 2)	EIRP setting accuracy for first burst or RACH (note 2)
Class 6	0 dB to -10 dB	1 dB	+2,0 dB -3,5 dB	+2,0 dB -3,5 dB
Class 7	0 dB to -10 dB	1 dB	+3,5 dB -2,0 dB	+3,5 dB -2,0 dB
Class 15	0 dB to -10 dB	1 dB	+3,5/-1,5 dB	+3,5/-1,5 dB
Class 4	0 dB to -10 dB	1 dB	+3,5/-1,5 dB (5-70° elevation)	+3,5/-1,5 dB (5-70° elevation)
			+5,5/-1,5 dB (70-90° elevation)	+5,5/-1,5 dB (70-90° elevation)
NOTE 1: The meaning of the "EIRP step size" is the power regulation granularity only and not the maximum power change per-frame. NOTE 2: 100 % of time, total for antenna and HPA.				

6.3.2 Transmit Power Spectral Density Mask

Class 6 UEs shall meet the transmit power spectral density mask requirements shown in Figure 6.2 (which is referenced to parameters contained in Table 6.12). This shall be applicable for both pi/4 QPSK and 16 QAM modulated bearers transmitted by Class 6 UEs at any output EIRP. The same mask as shown in Figure 6.2 shall be also applicable for 4 QAM, 16 QAM, 32 QAM and 64 QAM modulated bearers transmitted by Class 6 HDR UEs at any output EIRP.

Class 7 and 15 UEs, and Class 4 and 7 HDR UEs transmitting the new bearer types, shall meet the transmit power spectral density mask requirements contained in clause 5.3.2 for Class 1 and 2 UEs.

This requirement shall be met simultaneously with the emissions requirement defined in clause 6.3.8.

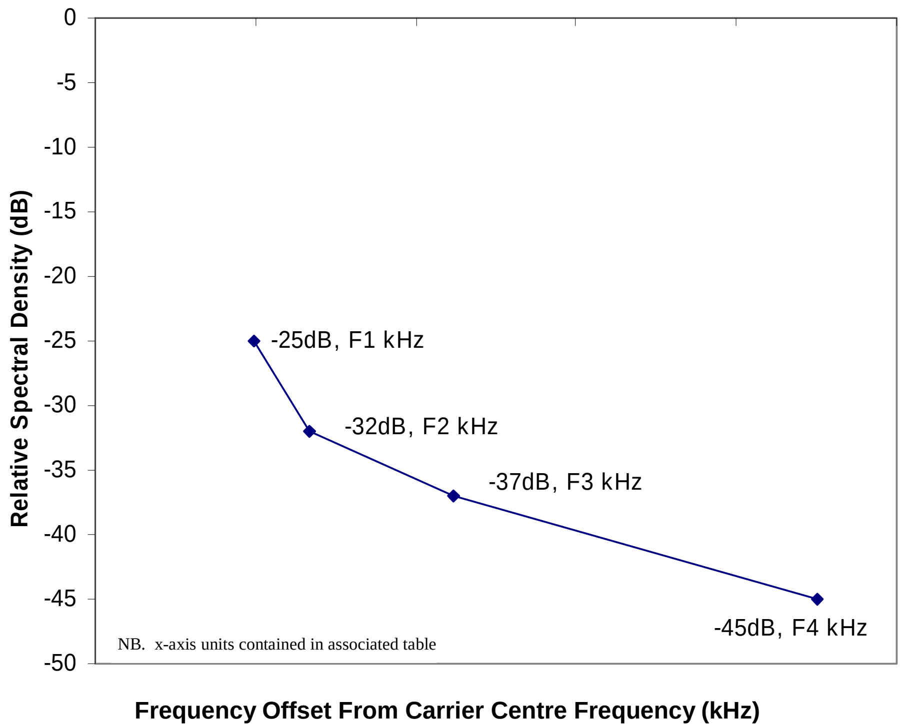


Figure 6.2: Transmit Power Spectral Density Mask for Aeronautical Class UEs (Class 6) (pi/4 QPSK and 16-QAM) and (Class 6 HDR) (4-QAM, 16-QAM, 32-QAM and 64-QAM)

Table 6.12: Transmit Power Spectral Density Mask for Aeronautical Class UEs (Class 6) (pi/4 QPSK and 16-QAM) and (Class 6 HDR) (4-QAM, 16-QAM, 32-QAM and 64-QAM)

Frequency	Amp (dB)	T0.5 (kHz)	T1 (kHz)	T2 (kHz)	T4.5 (kHz)	Class 6 HDR	
						T2.5 (kHz)	T5 (kHz)
F1	-25	11,0	22,0	44,0	99,0	55	110
F2	-32	14,9	29,8	59,6	134,1	74,5	149
F3	-37	24,8	49,6	99,2	223,2	124	248
F4	-45	50,0	100,0	200,0	450,0	250	500

The above F1 to F4 parameters are defined with respect to the bearer centre frequency. The relative PSD is defined with respect to the signal PSD at the bearer centre frequency.

6.3.3 Transmitter Duty Cycle

The UE transmit system shall satisfy the performance requirements under all conditions, including continuous operation at the maximum power setting.

6.3.4 Transmitter Off level

The non-transmitting state includes the 'idle' state, covering periods when the UE is not engaged in traffic, and periods between bursts, both reserved and contention slots.

The 'idle' state is defined as the period after the UE has not transmitted for more than 2 seconds.

When an Aeronautical UE transmitter is in the non-transmitting state, the radiation from the UE antenna in the direction of maximum gain shall not exceed the carrier-off EIRP requirements contained in ETSI EN 301 473 [6].

6.3.5 Transmitter Modulation Characteristics

All aeronautical Class UEs, including Class 6 HDR and 7 HDR shall support all the applicable bearer types and coding rates specified in Table 6.13. Class 6 and 7 HDR UEs shall support wrap-around of control index as defined in ETSI TS 102 744-3-2 [13].

Table 6.13: Summary of Return Bearer Types and Subtypes

Identifier	Burst Duration (ms)	Symbol Rate (kBd)	Modulation	Code Rates	Class
R5T1XD-1B	5	33,6	16-QAM	All	4, 6, 7, 15 & 6 HDR
R5T2XD-1B	5	2 x 33,6	16-QAM	All	4, 6, 7, 15 & 6 HDR
R5T4.5XD-1B	5	4,5 x 33,6	16-QAM	All	4, 6, 7, 15 & 6 HDR
R20T1XD-1B	20	33,6	16-QAM	All	4, 6, 7, 15 & 6 HDR
R20T2XD-1B	20	2 x 33,6	16-QAM	All	4, 6, 7, 15 & 6 HDR
R20T4.5XD-2B	20	4,5 x 33,6	16-QAM	All	4, 6, 7, 15 & 6 HDR
R5T2QD-1B	5	2 x 33,6	Pi/4 QPSK	All	4, 6, 7, 15 & 6 HDR
R5T4.5QD-1B	5	4,5 x 33,6	Pi/4 QPSK	All	4, 6, 7, 15 & 6 HDR
R20T0.5QD-1B	20	0,5 x 33,6	Pi/4 QPSK	All	4, 6, 7, 15 & 6 HDR
R20T1QD-1B	20	33,6	Pi/4 QPSK	All	4, 6, 7, 15 & 6 HDR
R20T2QD-1B	20	2 x 33,6	Pi/4 QPSK	All	4, 6, 7, 15 & 6 HDR
R20T4.5QD-1B	20	4,5 x 33,6	Pi/4 QPSK	All	4, 6, 7, 15 & 6 HDR
R80T0.5Q-1B	80	0,5 x 33,6	Pi/4 QPSK	All	4
R80T1Q-1B	80	1 x 33,6	Pi/4 QPSK	All	4
FR80T2.5X4-5B	80	2,5 x 33,6	QPSK	All	4
FR80T2.5X16-5B	80	2,5 x 33,6	16-QAM	All	4, 6 HDR & 7 HDR
FR80T5X16-9B	80	5 x 33,6	16-QAM	All	4, 6 HDR & 7 HDR
FR80T2.5X32-6B	80	2,5 x 33,6	32-QAM	All	6 HDR & 7 HDR
FR80T2.5X64-7B	80	2,5 x 33,6	64-QAM	All	6 HDR & 7 HDR
FR80T5X32-11B	80	5 x 33,6	32-QAM	All	6 HDR & 7 HDR
FR80T5X64-13B	80	5 x 33,6	64-QAM	All	6 HDR & 7 HDR

6.3.6 Transmitter Phase Noise

The requirements of clause 5.3.6 shall apply.

6.3.7 Modulator Performance

6.3.7.1 Transmit burst Error Vector Magnitude

The requirements of clause 5.3.7.1 shall apply.

6.3.7.2 Definition of mean squared EVM

The requirements of clause 5.3.7.2 shall apply.

6.3.8 Spurious Radiated Emissions and Intermodulation Products

6.3.8.0 General

All Aeronautical Class UEs shall comply with ETSI EN 301 473 [6] for requirements pertaining to AES transmitting in the band 1 626,5 MHz to 1 660,5 MHz and 1 668 MHz to 1 675 MHz, and also the requirements contained in the RTCA DO-210D [7] standard.

This above requirement shall include compliance with all in-band and out-of-band unwanted emissions (including harmonic and intermodulation products) and carrier-off state indicated within the respective standard or recommendation.

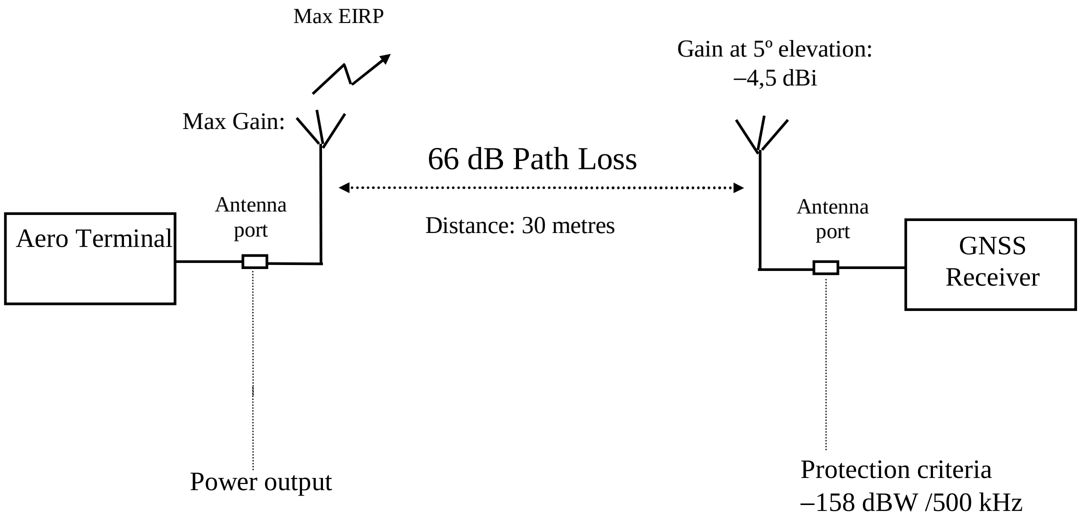
In consideration of the need to change the symbol rate in RTCA DO-210D [7] from 10,5 kBd to the maximum satellite interface symbol rate of 151,2 kBd, the in-band unwanted emission measurement exclusion shall be ±504 kHz from the wanted carrier centre frequency.

6.3.8.1 Special spurious emission requirements in the 1 559 MHz to 1 610 MHz band

The requirements of clause 5.3.8.1 shall apply. Aeronautical Class UEs shall comply with the following additional requirements:

To ensure the protection of Global Navigation Satellite System (GNSS) equipment installed on adjacent aircraft, the EIRP level in the band 1 559 MHz to 1 605 MHz shall not exceed -84,5 dBW/MHz at the UE's antenna port.

NOTE: The EIRP level derives from the scenario shown in Figure 6.3.



GNSS protection criteria (antenna port):	–158 dBW/500 kHz
Conversion to 1 MHz:	+3 dB
GNSS antenna gain at 5 degrees elevation:	–(–4,5)dBi
Path loss:	+66 dB
Max EIRP radiated from an Aero terminal:	–84,5 dBW/MHz

Figure 6.3: Derivation of maximum EIRP values from Aeronautical UEs (Class 4, 6, 7 & 15) within the band 1 559 MHz to 1 605 MHz for the protection of GNSS receivers

To ensure protection to GPS equipment which may be installed onboard the same aircraft as Aeronautical Class UEs, the level of interference at the GPS antenna port shall not exceed -152,5 dBW/MHz, as specified in the International Civil Aviation Organisation, Global Navigation Satellite System Standards and Recommended practises (ICAO GNSS SARPs) [8], Figures B-15 and B-17.

To ensure protection to GLONASS equipment which may be installed onboard the same aircraft as Aeronautical Class UE, the level of interference at the GLONASS antenna port is strongly recommended not to exceed -158 dBW/500 kHz, as specified in the International Civil Aviation Organisation, Global Navigation Satellite System Standards and Recommended practises (ICAO GNSS SARPs) [8], Figures B-16 and B-18.

6.3.8.2 Maximum Transmitted Intermodulation Products

For any Class 6 or 7 UEs (aeronautical terminals) having the potential of multi-carrier operation through a shared transmit power amplifier, the linearity of the transmitting system shall be such that the third order intermodulation product shall be at least either: 29,5 dB below the EIRP of each of two unmodulated test carriers or 29,5 dB below the maximum power spectral density (per 3 kHz or less) of two modulated test carriers. The requirement shall be met when the two test carriers are assigned frequencies anywhere within the transmit portion of the L-band and are placed at least 200 kHz apart. The requirement shall be met under all combinations of bearer types and coding rates applicable for the terminal under consideration.

In the above specifications, the power of each of the test carriers from the output of the HPA shall be set to provide the nominal EIRP per carrier as indicated in clause 6.3.1 (i.e. accounting for the minimum antenna gain of the intended installation and maximum cabling and other insertion losses between the HPA and antenna). The measurement bandwidth used in the compliance testing shall be 3 kHz or less.

Also, for any multi-carrier aeronautical terminals that are designed to support one or more non-Family SL aeronautical services (carriers), while simultaneously having the potential of supporting one or more aeronautical Family SL services (carriers), then the following additional intermodulation product requirement shall be met. For such terminals, when the HPA is transmitting two equal two unmodulated carriers each at 3 dB below the maximum rated power, the EIRP of the intermodulation product (third and higher order) shall be at least 24 dB below the EIRP of each carrier. This requirement shall be met when the two test carriers are assigned frequencies anywhere within the transmit portion of the L-band and are placed at least 200 kHz apart.

6.3.8.3 Intermodulation Products in 1 616 MHz to 1 625,5 MHz Band

Multicarrier aeronautical terminals shall not put intermodulation emissions into the 1 616 MHz to 1 625,5 MHz band above a level of -38,7 dBc. This level can be measured with either modulated or unmodulated carriers as described in the first paragraph of clause 6.3.8.2, and shall be referenced to the higher of the two carrier powers (if different). The level of each of the test carriers shall be set to provide the nominal EIRP per carrier for the channel type and account for minimum antenna gain of the intended installation and maximum cabling and other insertion losses between the HPA and antenna. Terminals may meet this requirement either by the use of adequate RF components (e.g. HPAs/DLNAs), or alternatively the terminal will require a software algorithm to determine the intermodulation emissions, and, if it is above threshold, then not transmit on an old or a new carrier.

6.3.8.4 Intermodulation Products in Receive Band (1 518 MHz to 1 559 MHz)

Intermodulation requirements in the receive band (1 518 MHz to 1 559 MHz) are taken into account in the UE G/T requirement (see clause 6.2.1).

6.3.9 Transmit Channel Tuning

The requirements of clause 5.3.9 shall apply.

6.3.10 Transmitter Frequency Accuracy and Stability

6.3.10.0 General

The requirements of clause 5.3.10 shall apply.

All commanded changes of transmit frequency including Doppler-tracking for Aeronautical Class UEs should take place in the guard-time between transmitted bursts.

NOTE: If any frequency changes are commanded while transmitting a burst it will likely impact the transmitter modulation accuracy and hence the UE will fail to meet the EVM requirement, which is unacceptable (see clause 6.3.7).

When Aeronautical Class UEs operate in continuous mode, the Doppler compensation cannot take place in the guard time between transmitted bursts, and in that case, the Doppler compensation should be made continuously, while at the same time the frequency accuracy and stability (clause 5.3.10), as well as EVM requirements, shall be met. The Doppler compensation shall be made without introducing any significant phase discontinuities, and the frequency shall step with less than 0,5 Hz.

6.3.10.1 Aeronautical Class UEs (Classes 4, 6, 7 and 15)

Additionally, for Aeronautical Class UEs (Classes 4, 6, 7 and 15) the transmit frequency shall be corrected for Doppler frequency generation due to aircraft and satellite motion as described in ETSI TS 102 744-3-2 [13]. The transmit frequency (pre-transmit Doppler compensation) shall be frequency-locked to the receive frequency (post-receive Doppler compensation) with appropriate scaling for the L-band frequency.

The total error of the transmitted frequency attributable to the UE shall not exceed 427 Hz from the nominal channel frequency. This error requirement includes allowances for incorrect Doppler correction due to aircraft manoeuvres, Rx frequency estimator error, oscillator error and any other relevant contributions from the UE. However, it does not include any allowance for Doppler introduced by satellite movement (which will be compensated for by the RAN transmitters) nor errors caused by the difference between the actual and the nominal frequency of the received forward bearer (assuming the aircraft is stationary). The Doppler adjustment resolution shall not exceed 10 Hz and any associated frequency changes should be made without introducing phase discontinuity into the transmitted signal.

NOTE: If any phase discontinuities are introduced it will likely impact the transmitter modulation accuracy and hence the UE will fail to meet the EVM requirement, which is unacceptable (see clause 6.3.7).

For a typical aeronautical system these contributions are broken down in Table 6.14.

Table 6.14: Transmit Frequency Error Apportionment

Frequency error component	Error contribution (Hz)
Forward Link Residual Doppler (see note)	160
Return Link Residual Doppler (see note)	163
UE Rx Frequency Estimator Error	20
UE Tx System Frequency Granularity	50
Frequency scaling error	34
Worst Case transmit frequency error attributable to the UE	427
NOTE: Estimated on the basis of imperfect position and velocity information with respect to the satellite; assumes the UE transmit frequency is derived from the received forward link frequency and that the gross Rx and Tx Doppler is corrected based on position and velocity estimates.	

6.3.11 Timing

The requirements of clause 5.3.11 shall apply.

6.4 Positioning requirements

6.4.0 General

The requirements of clause 5.4 shall apply.

During the transition from the current spot beam to an adjacent spot beam, Class 6 and 7 UEs are expected to perform a spot beam handover (see ETSI TS 102 744-1-2 [10]) which attempts to preserve the call session. Positioning information is required by the UE to initiate a request for spot beam handover to the RNC.

The spot beam handover procedure may only be used for transitions between spot beams in the same satellite. If the spot-beam handover cannot be supported on the current satellite, the RNC will trigger deregistration and the implicit release of all connections by the UE. At this point the UE will return to an initial state and attempt to re-establish communications via the most appropriate satellite, based upon its locally referenced positioning information.

6.4.1 GPS Receiver Unit

Aeronautical Class UEs shall be equipped with a mechanism that can provide the UE with precise position, speed, attitude and acceleration, based on the data derived from the aircraft navigation system, an integrated GPS receiver, or a similar device/system. The derived position, attitude, speed and (acceleration if used) data shall be used for satellite selection, the Doppler Frequency Offset compensation (see clauses 6.2.5.1 and 6.3.10), spot-beam hand-over selection, antenna pointing and transmit timing. The aeronautical positioning system shall have sufficient performance (in terms of accuracy, availability, position lock, update rate, latency, etc.) such that the UE meets the requirements for the above functions as defined in the present document.

NOTE: For terminals without access to GPS position data, transmit timing is controlled by a closed loop control system involving the RAN. Hence relative 3-dimensional position accuracy is important whilst absolute accuracy is less so. This control system requires that the underlying navigation data (1) has an error characteristic similar to that of an Inertial Reference System (error of no more than 2 nautical miles per hour and is slowly varying), (2) is updated frequently e.g. at least once per second (3) has adequate relative accuracy and resolution and (4) is compatible with WGS-84.

7 Maritime Class UE Requirements

7.1 Antenna requirements

7.1.1 Radiation Pattern

The radiation pattern of the UE antenna (including side-lobes) at both the transmit and receive L-band frequencies shall not exceed an envelope described by the following expressions of Table 7.1.

Table 7.1: Reference radiation patterns for Maritime UEs

UE Class	Reference radiation pattern	
Class 8	$G \leq G_{max}$ (dBi) $G \leq (41 - 25\times\log(\theta))$ (dBi) $G \leq -4$ (dBi)	for $0° \leq \theta < 30°$ for $30° \leq \theta < 63°$ for $63° \leq \theta$
Class 9	$G \leq G_{max}$ (dBi) $G \leq (47 - 25\times\log(\theta))$ (dBi) $G \leq -2$ (dBi)	for $0° \leq \theta < 40°$ for $40° \leq \theta < 90°$ for $90° \leq \theta$
NOTE 1: G is the gain of the antenna in a specific direction (relative to an isotropic antenna), Gmax is the maximum gain of the particular antenna, and θ is the absolute angle in degrees between the direction of maximum gain (Gmax) and the direction under consideration in any possible plane of operation of the antenna (i.e. covering both azimuth and elevation angles). NOTE 2: For Maritime High Gain Class UEs (Class 8) having transmit and receive antenna gain of 19 dBi or greater (e.g. approximately 70cm diameter antenna or greater), the radiation pattern within 30 degrees off-axis angle shall be compliant to Recommendation ITU-R M.694 (06/90) [3].		

7.1.2 Polarization

Same as clause 5.1.2.

7.1.3 Axial Ratio

The antenna circular polarization axial ratio shall be no greater than the requirements stated in Table 7.2 for UE within the portion of the UE antenna main beam that could be directed towards the satellite position (referenced as on-axis).

Table 7.2: UE Maximum Axial Ratio

UE Class	Maximum Axial Ratio Requirement
Class 8	2 dB on axis
Class 9	4 dB on axis

The maximum axial ratio requirement is for antennas in 'free space' and with the antenna connected to the final unit.

7.1.4 UE antenna pointing loss

The antenna subsystem shall be capable of being steered in the direction of any appropriate geostationary satellite whose orbital inclination does not exceed ±5º and whose longitude excursions does not exceed ±1º.

The directional UE shall automatically keep the antenna pointed towards the appropriate satellite with sufficient accuracy to ensure the relevant G/T and eirp requirements are satisfied continuously under all appropriate environmental conditions. Furthermore, the implementer shall characterise the antenna pointing characteristics, such as the time to acquire lock, any slew-rate limitations, and possible jumps with positive and negative impacts on received C/No or satellite acquisition and tracking behaviour.

The pointing and polarization loss experienced by the UE shall not be greater than 0,6 dB for 95 % of the time under all appropriate environmental conditions.

For antennas with "cable-unwrap" the antenna shall unwrap and reacquire the satellite within 10 s.

7.1.5 Antenna Control

The Maritime Class UE shall control the antenna pointing direction based on 3D GPS position information.

NOTE 1: The position information may be provided by an internal GPS unit.

The response to the GPS position shall be sufficiently up-to-date to be accurate to within 1 500 metres.

The calculation of the correct antenna pointing direction compensating for the effect of the vessel orientation (pitch, tilt and roll) in relation to the satellite may be performed internally within the UE or internally by the antenna unit.

NOTE 2: Commonly, such control is performed within the antenna unit itself. However, if control is to be performed by the UE, then the orientation information provided to the antenna control unit should be sufficiently up-to-date to allow correct antenna pointing.

7.2 Receiver requirements

7.2.1 Gain-to-Noise Temperature Ratio

The RF receiving system gain-to-noise-temperature ratio (G/T) shall be in accordance with Table 7.3 for the relevant UE type in the direction of the satellite and under the simultaneous conditions specified in clause 5.2.1 together with the following additional requirements:

1) With an assumed sea brightness temperature of 190 K instead of the 290 K ground temperature contribution as stated in clause 5.2.1.

Table 7.3: Minimum G/T Requirements for Maritime Class UEs

UE Class	Minimum Receiver G/T (dB/K) (Forward Link) with sat ≥ 5° elevation
Class 8	-7,0
Class 9	-15,5

Definitions of G, T, and suitable measurement point are as stated in clause 5.2.1.

7.2.2 Received Signal Levels

The requirements of clause 5.2.2 shall apply.

7.2.3 Received Phase Noise

The requirements of clause 5.2.3 shall apply.

7.2.4 Receiver Channel Tuning

The requirements of clause 5.2.4 shall apply.

7.2.5 Received Signal Frequency Offsets

The requirements of clause 5.2.5 shall apply.

7.2.6 Receiver Selectivity

The requirements of clause 5.2.6 shall apply, except the additional consideration of the potential interfering system indicated in clause 7.2.2.

7.2.7 Receiver Demodulation Characteristics

Maritime Class UEs shall demodulate and decode QPSK and 16-QAM modulated forward bearers described in ETSI TS 102 744-2-1 [11], clause 5.3. The complete list of supported bearer types for these UE Classes is listed in Table 7.4.

Table 7.4: Supported Bearer types for Maritime Class UEs

Bearer Type	Code rates
F80T0.25Q	All
F80T1Q	All
F80T1X	All
F80T4.5X	All

7.2.8 Acquisition and Synchronisation Performances

7.2.8.1 General

No changes from clause 5.2.8, except for the blocking requirement. The blocking requirement is defined in the paragraph below.

Assuming that timing and frequency offsets are known, and that the blockage occurs for 5 consecutive frames, the FEC Block Error Rate (BLER) for the first FEC block of the 8th frame after the 5 blocked frames shall be ≤ 1E-2; and ≤ 1E-3 for FEC blocks in subsequent frames. A frame is considered blocked if any FEC block of the frame is blocked.

The values of C/No (relating to the bearer and sub-bearer rates) over which UE acquisition requirement shall be met are specified in clause 7.2.11.

It should be noted the BLER compliance (contained within the referenced Land Class requirements) for "initial" and "cold" acquisition performance requirements shall be based on an assumed received C/No that has been adjusted to take into consideration mobile channel conditions.

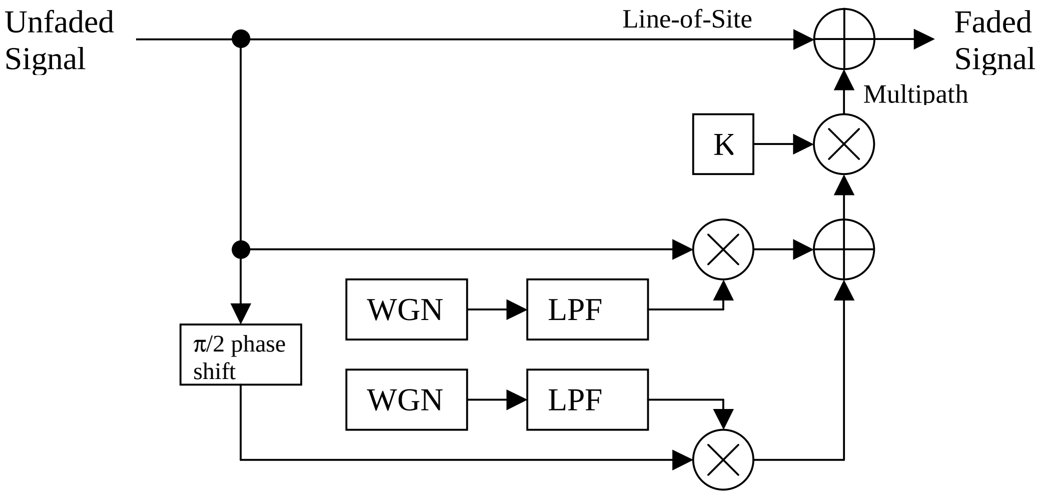
7.2.8.2 Tolerance to Signal Blocking.

In order to prevent premature call clearing, the receiver design should tolerate deep fading which can cause lower C/No conditions than those specified in clause 7.2.11.1 for short periods (e.g. of the order of seconds).

7.2.9 Channel Characteristics/Impairments

7.2.9.1 Fading Channel Model

For Maritime Class UEs (Classes 8 and 9), the multi-path fading shall be modelled with a Rician distribution caused by the interference between the direct line-of-sight (LOS) path and one reflected path (multi-path). Figure 7.1 illustrates the Rician fading model.



WGN: Uncorrelated noise sources
LPF: Low pass Butterworth filters
K: adjusted to set C/M

Figure 7.1: Rician fading model for Maritime Class UEs

The parameters to be used for maritime UE classes are shown in Table 7.5. C/M represents the carrier-to-multipath factor, and FBw (-3 dB) the fading spectral characteristics corresponding to a second-order Butterworth filter with 3 dB fading bandwidth.

NOTE: The values of C/M and fading bandwidth have been aligned for both maritime classes of UEs. However, in practice, these values will be better than assumed for Class 8 UEs and worse than assumed for Class 9 UEs; the actual magnitude of C/M experienced in practice will be influenced by the state of sea in the vicinity of the receiver, radiation pattern of the installed antenna and the elevation angle to the satellite.

Table 7.5: Maritime Channel Parameters

		Channel Model Low Elevation		Channel Model Medium Elevation	
Terminal Class	**Antenna.**	**C/M (dB)**	**FBw (−3 dB) (Hz)**	**C/M (dB)**	**FBw (−3 dB) (Hz)**
Class 8 and 9	Maritime High and Low Gain	10,2	2,0	14,7	2,0

7.2.9.2 Channel Characteristics/Impairments

The UE Maritime Class channel characteristics and reference impairments are contained in Table 7.6.

Table 7.6: Channel Characteristics and Reference Impairments for UE Maritime Class

<table>
<tr><th>Test Parameter</th><th colspan="2">Test Conditions</th></tr>
<tr><td>C/M</td><td colspan="2">See Table 7.5</td></tr>
<tr><td>Fading BW</td><td colspan="2">See Table 7.5</td></tr>
<tr><td>Multipath Delay</td><td colspan="2">0 μs delay spread and no differential Doppler for Maritime.</td></tr>
<tr><td>Freq Offset</td><td colspan="2">Refer to acquisition clause 7.2.9.</td></tr>
<tr><td>Continuous receive Phase Noise</td><td colspan="2">Refer to Table 5.5.
(applies to forward bearers received by the UE)</td></tr>
<tr><td>Discrete receive Phase Noise</td><td colspan="2">1 discrete component at -30 dBc, 10 Hz to 200 Hz from the carrier.</td></tr>
<tr><td rowspan="2">I/Q imbalance</td><td>For soft modems and simulations (contribution due to RNC and UE hardware)</td><td>0,3 dB amplitude, 4 degrees phase</td></tr>
<tr><td>Of the received 'signal in the air'</td><td>0,15 dB amplitude, 1,5 degrees phase</td></tr>
<tr><td>Doppler</td><td colspan="2">Sinusoidal model: 30 Hz/s, period 10 s.</td></tr>
<tr><td>ACI</td><td colspan="2">2 adjacent carriers at +6 dBc (also faded along with the wanted channel),
F80T0.25Q : 11,25 kHz frequency spacing
F80T1Q : 45 kHz frequency spacing
F80T1X : 45 kHz frequency spacing
F80T4.5X : 200 kHz frequency spacing</td></tr>
</table>

7.2.10 Received C/No Measurement Accuracy

The requirements of clause 5.2.10 shall apply, for measurement accuracy requirements in 'Added Gaussian White Noise' (AGWN) conditions.

Additionally, in fading conditions of clause 7.2.9, the C/No of the received channel shall be measured or estimated in accordance with the following requirements (only applicable for F80T1X, F80T1Q and F80T4.5X):

a) 90 % of the C/No measurements shall have an accuracy of +1 dB/-0,5 dB of the UE receive chain;

b) the C/No measurement shall be an average value measured during a maximum of 10 s period. The measurement time shall exclude any time when frame synchronization is lost; and

c) the C/No measurement shall meet the accuracy requirement of requirement (a) above over the full C/No range (encompassing all coding rates) of the particular carrier.

7.2.11 Demodulator Performance

7.2.11.0 General

The requirements of clause 5.2.11 shall apply.

7.2.11.1 Demodulator C/No and BLER Performance

For all the forward bearer types and subtypes as defined in clause 7.2.7, the UE demodulator shall achieve an FEC Block Error Rate (BLER) ≤ 1E-3 with the required C/No indicated in Table 7.7 for both the non-fading and the two fading scenarios contained within Table 7.6.

The C/No requirement incorporates an allowance for implementation loss in AWGN conditions to include the effects of Phase Noise, I/Q imbalance, Doppler, and Frequency Offset impairments as indicated within Table 7.6. The C/No requirements also incorporates an allowance for modem implementation loss to include the effects of timing, frequency and phase estimation and correction within the demodulator, limited number of Turbo Decoder iterations and any arithmetic approximation. The implementation loss also includes other typical impairment effects such as A/D converter quantisation noise, added Local Oscillator phase noise and spurs, and any contribution from operating the UE at maximum transmit power, etc. However, the C/No requirement does not include an allowance for co-channel interference (CCI).

The frequency offset of the adjacent band carriers shall be either 11,25 kHz away from a desired F80T0.25Q carrier, 45 kHz away from a desired F80T1Q/X carrier, or 200 kHz away from a desired F80T4.5X carrier. Both interfering signals shall be regarded as similar in modulation and +6 dB higher eirp level to the desired signal.

NOTE: The fading requirements are included so that "robust" demodulators will be implemented; hence ensuring that the demodulator has an adequate amplitude and phase tracker and it does not lose carrier synchronisation after a deep fast fade.

The implementation loss excludes the effects of CCI and electromagnetic interference from other external systems (both inter and intra-system interference).

FEC Blocks that were transmitted which are corrupted or missed shall be included in the overall BLER calculation.

Table 7.7: Maritime UE FEC Block Error Rate (BLER) Performance Requirements

Bearer Type	Code rates	C/No (dBHz) required to achieve BLER non-fading (see note)	C/No (dBHz) required to achieve BLER for Forward Bearer in fading	
		Non fading. BLER ≤ 10^{-3}	Low elevation. BLER ≤ 10^{-3}	Med. elevation. BLER ≤ 10^{-3}
F80T0.25Q	L8	40,1	47,4	43,4
	L7	41,4	49,1	44,8
	L6	42,4	50,1	45,8
	L5	43,4	51,0	46,7
	L4	44,3	52,5	47,9
	L3	45,3	53,4	49,0
	L2	46,3	53,9	49,4
	L1	47,4	54,9	50,4
	RE	48,3	55,6	50,9
F80T1Q	L8	46,1	53,1	49,1
	L7	46,9	54,4	49,8
	L6	47,9	55,7	51,3
	L5	48,8	56,6	52,1
	L4	49,7	57,4	53,1
	L3	50,6	58,4	54,1
	L2	51,6	59,7	55,0
	L1	52,6	60,5	56,0
	RE	53,6	60,7	56,4
F80T1X	L3	50,6	58,5	54,2
	L2	51,6	59,6	55,1
	L1	52,5	60,1	56,6
	RE	53,5	61,8	57,1
	H1	54,5	62,6	58,3
	H2	55,6	63,9	59,4
	H3	56,5	64,6	60,3
	H4	57,6	65,9	61,4
	H5	58,7	66,5	62,0
	H6	59,5	67,2	62,2
F80T4.5X	L3	56,8	64,8	60,4
	L2	57,7	65,8	61,4
	L1	58,7	67,1	62,6
	RE	59,6	67,8	63,4
	H1	60,8	69,5	64,7
	H2	61,9	N/A	65,8
	H3	63,0	N/A	67,0
	H4	64,2	N/A	68,2
	H5	65,1	N/A	68,6
	H6	66,2	N/A	69,2
NOTE: Includes Modem Implementation loss.				

7.3 Transmitter requirements

7.3.1 EIRP

7.3.1.0 General

The UE nominal transmit EIRP shall meet the requirement stated in Table 7.8 at any frequency in the transmit band.

This requirement shall include cable and any other losses.

Table 7.8: Nominal UE EIRP for Maritime Class UEs

UE Class	Nominal UE EIRP (dBW)
Class 8	22,0
Class 9	15,1

7.3.1.1 Power Masks

The requirements of clause 5.3.1.1 shall apply.

7.3.1.2 EIRP Congruency with received G/T

The requirements of clause 5.3.1.2 shall apply.

7.3.1.3 EIRP Stability

The requirements of clause 5.3.1.3 shall apply.

7.3.1.4 EIRP setting accuracy

The EIRP setting range, step size and setting accuracy shall meet the requirements stated in Table 7.9.

The upper values of the EIRP setting range corresponds to the nominal EIRP.

The UE shall support burst-to-burst power regulation within the limits and with the step size defined in Table 7.9.

Table 7.9: EIRP setting range, step size, accuracy for Maritime Class UEs

Terminal Class	EIRP Setting Range relative to Nominal EIRP	EIRP step size	EIRP setting accuracy (see note)	EIRP setting accuracy for first burst or RACH (see note)
Class 8	0 dB to -10 dB	1 dB	+1 dB -2 dB	+2 dB -2 dB
Class 9	0 dB to -10 dB	1 dB	+1 dB -2 dB	+2 dB -2 dB
NOTE: 100 % of time, total for antenna and HPA.				

7.3.2 Transmit Power Spectral Density Mask

Class 8 UEs shall meet the transmit power spectral density mask requirements shown in Figure 7.2 (which is referenced to parameters contained in Table 7.10).This shall be applicable for both pi/4 QPSK and 16 QAM modulated bearers transmitted by Class 8 UEs at any output EIRP.

Class 9 UEs shall meet the maximum transmit limit mask requirements contained in Table 5.12 for Class 1 and 2 UEs.

This requirement shall be met simultaneously with the Spurious Radiated Emissions requirements as defined in clause 7.3.8.

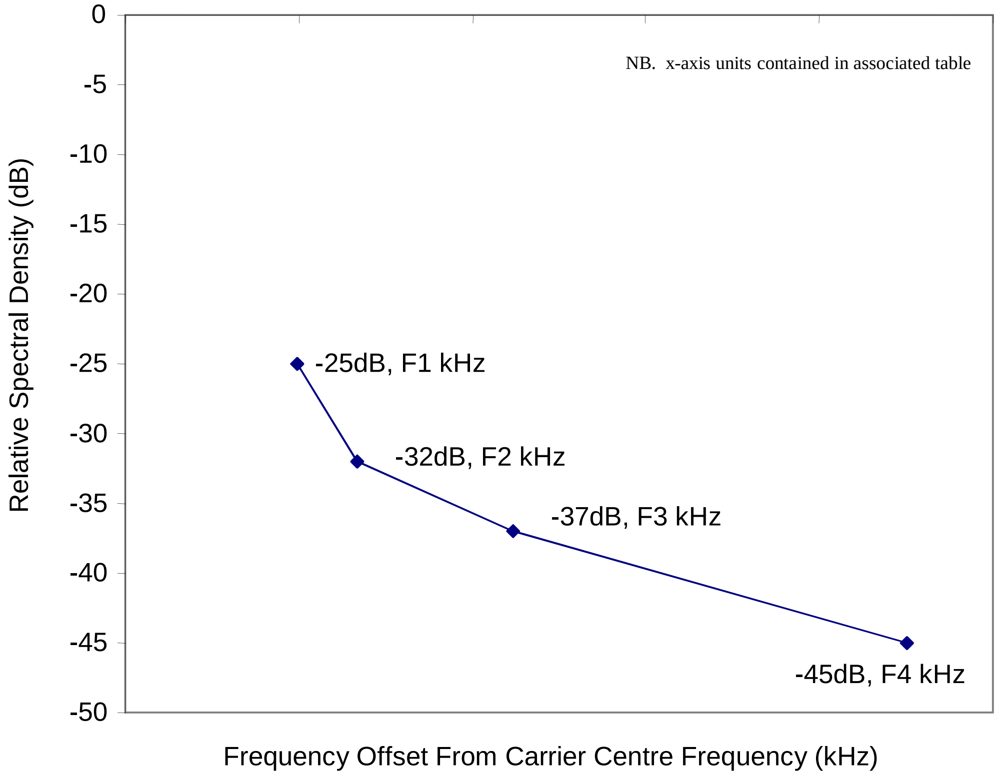


Figure 7.2: Transmit Power Spectral Density Mask for Class 8 UEs (pi/4 QPSK and 16-QAM)

Table 7.10: Transmit Power Spectral Density Mask for Class 8 UEs (pi/4 QPSK and 16-QAM)

Frequency Offset	Amp (dB)	T0.5 (kHz)	T1 (kHz)	T2 (kHz)	T4.5 (kHz)
F1	-25	11,0	22,0	44,0	99,0
F2	-32	14,9	29,8	59,6	134,1
F3	-37	24,8	49,6	99,2	223,2
F4	-45	50,0	100,0	200,0	450,0

The above F1 to F4 parameters are defined with respect to the bearer centre frequency. The relative PSD is defined with respect to the signal PSD at the bearer centre frequency.

7.3.3 Transmitter Duty Cycle

The UE transmit system shall satisfy the performance requirements under all conditions, including continuous operation at the maximum power setting.

7.3.4 Transmitter Off level

The non-transmitting state includes the 'idle' state, covering periods when the UE is not engaged in traffic, and periods between bursts, both reserved and contention slots.

When a Class 8 or 9 UE transmitter is in the non-transmitting state, the radiation from the UE antenna in the direction of maximum gain shall not exceed the carrier-off EIRP requirement in Recommendation ITU-R M.1480 [1].

For above compliance purposes only, idle is defined as the period after the UE has not transmitted for more than 2 seconds.

7.3.5 Transmitter Modulation Characteristics

UE Class 8 and Class 9 shall support all the bearer types/subtypes, data and coding rates specified in clause 5.3.5 for Class 1 and Class 2 UEs.

7.3.6 Transmitter Phase Noise

The requirements of clause 5.3.6 shall apply.

7.3.7 Modulator Performance

7.3.7.1 Transmit burst Error Vector Magnitude

The transmit burst mean squared Error Vector Magnitude (EVM) measured at the output of the HPA shall not exceed the values specified in Table 7.11. for Class 8 and Class 9 UEs.

NOTE: A description of mean squared EVM is contained in clause 5.3.7.

Table 7.11: Mean squared EVM requirements for Class 8 and Class 9 UEs

Modulation	Mean squared EVM
Pi/4 QPSK	0,01
16-QAM	0,01

7.3.7.2 Definition of mean squared EVM

The requirements of clause 5.3.7.2 shall apply.

7.3.8 Spurious Radiated Emissions

7.3.8.0 General

Class 8 and Class 9 UEs shall comply with Recommendation ITU-R M.1480 [1]. The unwanted emissions limits above 1 000 MHz contained within Recommendation ITU-R M.1480 [1] are categorised into Table 2a and Table 2b (see [1]) requirements. Maritime Class UEs (Classes 8 and 9) shall comply with the Table 2b (see [1]) requirements.

This requirement shall include compliance with all in-band and out-of-band unwanted emissions (including harmonic) and carrier-off state.

NOTE: Recommendation ITU-R M.1480 [1] is only strictly applicable for earth stations implementing Memorandum-of-Understanding arrangements to facilitate the circulation of GMPCS terminals, and as such, the requirements contained in the Recommendation M.1480 [1] are not directly applicable for Maritime Class UEs. However, the present document requires compliance with Recommendation ITU-R M.1480 [1] regardless of the stated scope of the Recommendation.

In determining compliance to the requirements of the Recommendation ITU-R M.1480 [1], the nominated bandwidth shall be stated by UE manufacturer. The nominated bandwidth is centred on the transmit frequency and shall be wide enough to take account transmit carrier frequency stability; It shall not exceed 180 % of the 3 dB bandwidth of the signal.

7.3.8.1 Special spurious emission requirements in the 1 559 MHz to 1 610 MHz band

The requirements of clause 5.3.8.1 shall apply.

7.3.9 Transmit Channel Tuning

The requirements of clause 5.3.9 shall apply.

7.3.10 Transmitter Frequency Accuracy and Stability

7.3.10.0 General

The requirements of clause 5.3.10 shall apply.

All commanded changes of transmit frequency including Doppler-tracking should take place in the guard-time between transmitted bursts. If any frequency changes are commanded while transmitting a burst it will likely impact the transmitter modulation accuracy and hence the UE will fail to meet the EVM requirement, which is unacceptable (see clause 7.3.7).

7.3.10.1 Maritime-Class UEs (Classes 8 and 9)

For UE Classes 8 and 9, the return frequency compensation shall be as defined in ETSI TS 102 744-3-2 [13]. The transmit frequency shall be frequency-locked to the receive frequency, with appropriate scaling for the L-band frequency.

7.3.11 Timing

The requirements of clause 5.3.11 shall apply.

7.4 Positioning requirements

7.4.1 UE Positioning Requirements

The requirements of clause 5.4.1 shall apply.

During the transition from the current spot beam to an adjacent spot beam, Class 8 and 9 UEs are expected to perform a spot beam handover (see ETSI TS 102 744-1-2 [10]) which attempts to preserve the call session. Positioning information is required by the UE to initiate a request for spot beam handover to the RNC.

The spot beam handover procedure may only be used for transitions between spot beams in the same satellite. If the spot-beam handover cannot be supported on the current satellite, the RNC will trigger deregistration and the implicit release of all connections by the UE. At this point the UE will return to an initial state and attempt to re-establish communications via the most appropriate satellite, based upon it's locally referenced positioning information.

7.4.2 GPS Receiver Unit

7.4.2.1 Class 8 and 9 UEs

The requirements of clause 5.4.2.1 shall apply, except that for Class 8 UEs the following optional requirement applies:

Class 8 UEs shall employ an internal positioning receiver as the source of positioning information. However, in cases when the positioning information from the internal receiver is unavailable due to, for example, limitation on the visibility of the positioning satellites as a result of blockage by the ship's structure or by other obstacles, the UE may obtain the positioning information data from an external source. In such circumstances, it is recommended the user be informed when the internal positioning is unavailable and the external source is being used. The selection may be automatic or set manually by the user. The internal positioning receiver shall be the preferred mode of obtaining the positioning information and the external source shall be used as backup only.

The UE shall have the ability to detect a fault with the external position information resulting from cable disconnect, or through external equipment failure. In such circumstances the provisions of ETSI TS 102 744-3-2 [13] shall apply.

8 Land Mobile Class UE Requirements

8.1 Antenna requirements

8.1.1 Radiation Pattern

The radiation pattern of the mobile UE antenna (including side-lobes) at both the transmit and receive L-band frequencies shall not exceed an envelope as defined in Annex 3 of Recommendation ITU-R M.1091 [2].

NOTE: The full range of requirements contained in Recommendation ITU-R M.1091 [2] may not be achievable for a low profile linear array antenna (e.g. having 1x4 or 1x2 elements in horizontal plane), since the radiation pattern will be highly asymmetrical pattern (wide in elevation plane and narrow in azimuth plane).
When the antenna is pointing to high elevation angles (only encountered for certain locations on the earths' surface assuming a flat plane operation), the sidelobe gain requirement of 4 dBi measured at 60 degrees to the ground plane (as stated within Recommendation ITU-R M.1091 [2]) may not be achievable for a low relative gain class antenna. This problem is recognised in Note 1, Annex 3 of the Recommendation ITU-R M.1091 [2], where it is stated that further work is required to develop appropriate values for low-gain fan-beam antennas.

Class-10 UEs shall be treated as a "high" relative gain class and the Class-11 UEs shall be treated as a "medium" relative gain class for the purposes of the Recommendation ITU-R M.1091 [2]. Also, the measurement principle given in Annex 5 of the recommendation [2] shall be used to determine compliance.

The following additional requirements apply:

a) G is the gain of the antenna in a specific direction (relative to an isotropic antenna), Gmax is the maximum gain of the particular antenna at a given AZMAX and ELMAX angle, angle (AZ, EL) is the azimuth and elevation angle of the point under consideration, A is the azimuth offset angle = AZ - AZMAX, and k is the with constant = 0,33.

b) If the antenna is designed around low profile linear array architecture, then for the purposes of complying with the reference radiation pattern contained within the table, ELMAX can be assumed to vary only between 0 to 60 degrees elevation range. However, the antenna shall comply with the G/T and eirp requirements over a 5 (min) to 90 degree elevation range.

c) An appropriate ground plane should be used in conducting the antenna pattern measurements (as in Annex 5 of the Recommendation ITU-R M.1091 [2]).

8.1.2 Polarization

Same as clause 5.1.2.

8.1.3 Axial Ratio

The antenna circular polarization axial ratio shall be no greater than the requirements stated in Table 8.1 for UE within the portion of the UE antenna main beam that could be directed towards the satellite position (referenced as on-axis).

Table 8.1: UE Maximum Axial Ratio

UE Class	Maximum Axial Ratio Requirement
Class 10	8 dB on axis
Class 11	8 dB on axis

The maximum axial ratio requirement is with the antenna installed on the body of a vehicle. For the purposes of compliance testing, such installation can be simulated with the antenna unit placed on, or at the recommended installation height off, a 1 m^2 metallic ground plane.

8.1.4 UE antenna pointing loss

For any Land-Mobile (Class 10 and 11) UEs under normal use, the antenna subsystem shall be capable of being steered in the direction of any geostationary satellite whose orbital inclination does not exceed ±5º and whose longitude excursions does not exceed ±1º.

The directional UE shall automatically keep the antenna pointed towards the appropriate satellite with sufficient accuracy to ensure the relevant G/T and eirp requirements are satisfied continuously under all appropriate environmental conditions. Furthermore, the implementer shall characterise the antenna pointing characteristics (such as the time to acquire lock, any slew-rate limitations, and possible jumps) with positive and negative impacts on received C/No or satellite acquisition and tracking behaviour.

The pointing and polarization loss experienced by the UE shall not be greater than 0,6 dB for 95 % of the time under all appropriate environmental conditions.

For antennas with 'cable-unwrap' the antenna shall unwrap and reacquire the satellite within 10 seconds.

8.1.5 Antenna Control

The Land Mobile Class UE shall control the antenna pointing direction based on 3D GPS position information.

NOTE: The position information may be provided by an internal GPS unit.

The response to the GPS position shall be sufficiently up-to-date to be accurate to within 1 500 metres.

The calculation of the correct antenna pointing direction compensating for the effect of the vehicle orientation (pitch, tilt and roll) in relation to the satellite may be performed internally within the UE or internally by the antenna unit.

8.2 Receiver requirements

8.2.1 Gain-to-Noise Temperature Ratio

The RF receiving system gain to noise-temperature ratio (G/T) shall be in accordance with Table 8.2 for the relevant UE type in the direction of the satellite and under the simultaneous conditions specified in clause 5.2.1.

Table 8.2: Minimum G/T Requirements for Land Mobile Class UEs

UE Class	Minimum Receiver G/T (dB/K) (Forward Link) with sat ≥ 5° elevation
Class 10	-12,5
Class 11	-15,5

NOTE: Definitions of G, T, and suitable measurement point are provided in clause 5.2.1.

8.2.2 Received Signal Levels

The requirements of clause 5.2.2 shall apply.

8.2.3 Received Phase Noise

The requirements of clause 5.2.3 shall apply.

8.2.4 Receiver Channel Tuning

The requirements of clause 5.2.4 shall apply.

8.2.5 Received Signal Frequency Offsets

The requirements of clause 5.2.5 shall apply.

It should be noted that Land-mobile terminals can introduce a Doppler shift of up to around ±300 Hz induced by a vehicle/train velocity of around 200 km/Hr in the direction of the satellite nominal position, and a rate of change of up to around 40-50 Hz. Any Land-Mobile Class terminal (Classes 10 or 11) that is installed on a vehicle/train that will travel faster than 200 km/Hr when the terminal is in use shall include a Doppler compensation mechanism similar to the requirement for aeronautical class UEs (refer to clause 6). Furthermore, the received signal frequency offsets contained in the referenced clause 5.2.5 for the Land Class UE requirements (i.e. received offset of ±500 Hz and short term variation of ±25 Hz) does take into consideration any additional frequencies offsets induced by UE movement. These additional frequency offsets shall be taken into account by UE manufacturers in the design of the receivers and modems. It should also be noted that the UE may receive fine frequency-corrections commanded by the RNC as specified in ETSI TS 102 744-3-1 [12].

8.2.6 Receiver Selectivity

The requirements of clause 5.2.6 shall apply, except for the additional consideration of the potential interfering system indicated in clause 8.2.2.

8.2.7 Receiver Demodulation Characteristics

Land-Mobile Class UEs (Classes 10 and 11) UEs shall demodulate and decode QPSK and 16-QAM modulated forward bearers described in ETSI TS 102 744-2-1 [11] of this multi-part deliverable. The complete list of supported bearer types for these UE Classes is listed in Table 8.3.

Table 8.3: Supported Bearer types for Land Mobile Class UEs

Bearer Type	Code rates
F80T0.25Q	All
F80T1Q	All
F80T1X	All
F80T4.5X	All

8.2.8 Acquisition and Synchronisation Performances

8.2.8.1 Land-Mobile Class UEs (Classes 10 and 11)

No changes from clause 5.2.8, except for the blocking requirement. The blocking requirement is defined in the paragraph below.

Assuming that timing and frequency offsets are known, and that blockage occurs for 5 consecutive frames, the FEC Block Error Rate (BLER) for the first FEC block of the 8th frame after the 5 blocked frames shall be ≤ 1E-2; and ≤ 1E-3 for FEC blocks in subsequent frames. A frame is considered blocked if any FEC block of the frame is blocked.

The values of C/No (relating to the bearer and sub-bearer rates) over which UE acquisition requirement shall be met are specified in clauses 8.2.11 and 8.2.11.1.

NOTE: The BLER compliance (contained within the referenced Land Class requirements) for "initial" and "cold" acquisition performance requirements will be based on an assumed received C/No that has been adjusted to take into consideration mobile channel conditions.

The indicated maximum frequency offsets do not taken into consideration the result of any Doppler frequency effects. Consequently, for Class 10 and 11 UEs, the UE acquisition and performance should additionally be met in the presence of an uncorrected Doppler shifts due to UE movement of up to ±300 Hz.

8.2.8.2 Tolerance to Signal Blocking

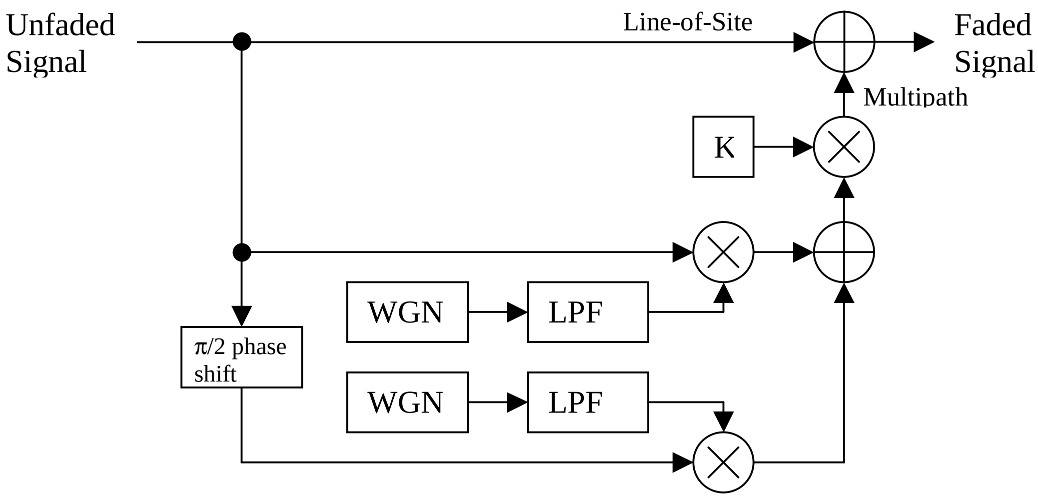
In order to prevent premature call clearing, it is recommended that provision be made in the receiver design to tolerate deep fading which can cause lower C/No conditions than those specified in clause 8.2.11.1 for short periods (e.g. of the order of seconds).

Additionally, for Class 10 and 11 UEs, provision should also be made in the receiver design to cater for significant periods of signal blocking (e.g. of the order of tens of seconds).

8.2.9 Channel Characteristics/Impairments

8.2.9.1 Fading Channel Model

For Class 10 and 11 UEs, multi-path fading shall be modelled with a Rician distribution caused by the interference between the direct line-of-sight (LOS) path and one reflected path (multi-path). Figure 8.1 illustrates the Rician fading model.



WGN: Uncorrelated noise sources
LPF: Low pass Butterworth filters
K: adjusted to set C/M

Figure 8.1: Rician fading model for Land-Mobile UEs (Classes 10 and 11)

The parameters to be used for land mobile classes are shown in Table 8.4. C/M represents the carrier-to-multipath factor, and FBw (-3 dB) the fading spectral characteristics corresponding to a second-order Butterworth filter with 3 dB fading bandwidth.

NOTE: The actual magnitude of C/M experienced in practice will be influenced by the magnitude of reflections in the vicinity of the receiver, radiation pattern of the installed antenna and the elevation angle to the satellite.

Table 8.4: Land-Mobile Channel Parameters

		Channel Model - Low Elevation		**Channel Model - Medium Elevation**	
Terminal Class	**Antenna.**	**C/M (dB)**	**FBw (-3 dB) (Hz)**	**C/M (dB)**	**FBw (-3 dB) (Hz)**
Class 10 and 11	Land-Mobile Directional	10,0	31,0	20,6	31,0

8.2.9.2 Channel Characteristics/Impairments

The UE Land-Mobile Class channel characteristics and reference impairments are contained in Table 8.5.

Table 8.5: Channel Characteristics and Reference Impairments for UE Land Mobile Class

<table>
<tr><th>Test Parameters</th><th colspan="2">Test Conditions</th></tr>
<tr><td>C/M</td><td colspan="2">See Table 8.4</td></tr>
<tr><td>Fading BW</td><td colspan="2">See Table 8.4</td></tr>
<tr><td>Multipath Delay</td><td colspan="2">0 μs delay spread and no differential Doppler for Land Mobile</td></tr>
<tr><td>Freq Offset</td><td colspan="2">Refer to acquisition clause 8.2.8</td></tr>
<tr><td>Continuous receive Phase Noise</td><td colspan="2">Refer to Table 5.5
(applies to forward bearers received by the UE)</td></tr>
<tr><td>Discrete receive Phase Noise</td><td colspan="2">1 discrete component at -30 dBc, 10 Hz to 200 Hz from the carrier</td></tr>
<tr><td rowspan="2">I/Q imbalance</td><td>For soft modems and simulations (contribution due to RNC and UE hardware)</td><td>0,3 dB amplitude, 4 degrees phase</td></tr>
<tr><td>Of the received 'signal in the air'</td><td>0,15 dB amplitude, 1,5 degrees phase</td></tr>
<tr><td>Doppler</td><td colspan="2">Sinusoidal model: 30 Hz/s, period 10 s</td></tr>
<tr><td>ACI</td><td colspan="2">2 adjacent carriers at +6 dBc (also faded along with the wanted channel),
F80T0.25Q : 11,25 kHz frequency spacing
F80T1Q : 45 kHz frequency spacing
F80T1X : 45 kHz frequency spacing
F80T4.5X : 200 kHz frequency spacing</td></tr>
</table>

8.2.10 Received C/No Measurement Accuracy

The requirements of clause 5.2.10 shall apply for the measurement accuracy requirements in 'Added Gaussian White Noise' (AGWN) conditions.

Additionally, in the fading conditions of clause 8.2.9, the C/No of the received channel shall be measured or estimated in accordance with the following requirements (only applicable for F80T1X, F80T1Q and F80T4.5X):

a) 90 % of the C/No measurements shall have an accuracy of ±1,0 dB of the UE receive chain, when using the low elevation fading model. When using the medium elevation fading model, the UE shall have an accuracy of +1 dB/-0,5 dB;

b) the C/No measurement shall be an average value measured during a 10 seconds period. The measurement time shall exclude any time when frame synchronization is lost; and

c) the C/No measurement shall meet the accuracy requirement of requirement (a) above over the full C/No range (encompassing all coding rates) of the particular carrier.

8.2.11 Demodulator Performance

8.2.11.0 General

The requirements of clause 5.2.11 shall apply, except that for Class 10 and Class 11 (Land-Mobile) UEs, the UE receiver performance should be met in the presence of an uncorrected Doppler shifts due to UE movement of up to ±300 Hz (in addition to the 500 Hz frequency offset requirement indicated in clause 5.2.11), and a peak rate of change of 30 Hz/s (due to velocity changes of the vehicle).

8.2.11.1 Demodulator C/No and BLER Performance

For all the forward bearer types and subtypes as defined in clause 8.2.7, the UE demodulator shall achieve an FEC Block Error Rate (BLER) ≤ 1E-3 with the required C/No indicated in Table 8.6, as appropriate, for both the non-fading and the two fading scenarios contained within Tables 8.5 and Table 8.4.

NOTE 1: The BLER verses C/No requirements contained in Table 8.6 are based on results of simulation studies and interpolation of results for some intermediate sub-bearer types.

The C/No requirement incorporates an allowance for implementation loss to AWGN condition to include the effects of Phase Noise, I/Q imbalance, Doppler, and Frequency Offset impairments as indicated within Table 8.5. The C/No requirements also incorporates an allowance for modem implementation loss to include the effects of timing, frequency and phase estimation and correction within the demodulator, limited number of Turbo Decoder iterations and any arithmetic approximation. The implementation loss also includes other typical impairment effects such as A/D converter quantisation noise, added Local Oscillator phase noise and spurs, and any contribution from operating the UE at maximum transmit power, etc. However, the C/No requirement does not include an allowance for co-channel interference (CCI). The frequency offset of the adjacent band carriers shall be either 11,25 kHz away from a desired F80T0.25Q carrier, 45 kHz away from a desired F80T1Q/X carrier, or 200 kHz away from a desired F80T4.5X carrier. Both interfering signals shall be regarded as similar in modulation and +6 dB higher eirp level to the desired signal.

NOTE 2: The fading requirements are included so that "robust" demodulators will be implemented; hence ensuring that the demodulator has an adequate amplitude and phase tracker and it does not lose carrier synchronisation after a deep fast fade.

The implementation loss excludes the effects of CCI, and electromagnetic interference from other external systems (both inter and intra-system interference).

FEC blocks that were transmitted which are corrupted or missed shall be included in the overall BLER calculation.

Table 8.6: Land Mobile UE FEC Block Error Rate (BLER) Performance Requirements

Bearer Type	Code rates	C/No (dBHz) required to achieve BLER non-fading (see note)	C/No (dBHz) required to achieve BLER for Forward Bearer in fading	
		Non fading. BLER ≤ 10^{-3}	Low elevation. BLER ≤ 10^{-3}	Med. elevation. BLER ≤ 10^{-3}
F80T0.25Q	L8	40,1	42,4	40,4
	L7	41,4	43,8	41,7
	L6	42,4	45,0	42,7
	L5	43,4	46,2	43,7
	L4	44,3	47,6	44,9
	L3	45,3	49,4	46,1
	L2	46,3	50,6	46,5
	L1	47,4	52,7	47,6
	RE	48,3	54,9	48,5
F80T1Q	L8	46,1	51,3	46,6
	L7	46,9	52,3	47,4
	L6	47,9	54,0	48,7
	L5	48,8	55,6	49,7
	L4	49,7	56,8	50,5
	L3	50,6	58,5	51,6
	L2	51,6	60,6	52,5
	L1	52,6	62,8	53,5
	RE	53,6	63,6	53,9
F80T1X	L3	50,6	57,2	51,5
	L2	51,6	58,4	52,6
	L1	52,5	59,4	53,4
	RE	53,5	61,0	54,6
	H1	54,5	62,5	55,7
	H2	55,6	64,3	56,8
	H3	56,5	66,8	57,8
	H4	57,6	69,1	58,8
	H5	58,7	N/A	59,6
	H6	59,5	N/A	59,9

Bearer Type	Code rates	C/No (dBHz) required to achieve BLER non-fading (see note)	C/No (dBHz) required to achieve BLER for Forward Bearer in fading	
		Non fading. BLER ≤ 10^{-3}	Low elevation. BLER ≤ 10^{-3}	Med. elevation. BLER ≤ 10^{-3}
F80T4.5X	L3	56,8	65,8	57,9
	L2	57,7	66,8	58,9
	L1	58,7	67,9	60,0
	RE	59,6	68,8	60,9
	H1	60,8	N/A	62,3
	H2	61,9	N/A	63,3
	H3	63,0	N/A	64,4
	H4	64,2	N/A	65,8
	H5	65,1	N/A	66,2
	H6	66,2	N/A	67,1
NOTE: Includes Modem Implementation loss.				

8.3 Transmitter requirements

8.3.1 EIRP

8.3.1.0 General

The UE nominal transmit EIRP shall meet the requirement stated in Table 8.7 at any frequency in the transmit band. This requirement shall include cable and any other losses.

Table 8.7: Nominal UE EIRP for Land Mobile Class UEs

UE Class	Nominal UE EIRP (dBW)
Class 10	18,0
Class 11	15,1

8.3.1.1 Power Masks

The requirements of clause 5.3.1.1 shall apply.

8.3.1.2 EIRP Congruency with received G/T

The requirements of clause 5.3.1.2 shall apply.

8.3.1.3 EIRP Stability

The requirements of clause 5.3.1.3 shall apply.

8.3.1.4 EIRP setting accuracy

The EIRP setting range, step size and setting accuracy shall meet the requirements stated in Table 8.8.

The upper values of the EIRP setting range corresponds to the nominal EIRP.

The UE shall support burst-to-burst power regulation within the limits and with the step size defined in Table 8.8.

Table 8.8: EIRP setting range, step size, accuracy for Land Mobile Class UEs

Terminal Class	EIRP Setting Range relative to Nominal EIRP	EIRP step size	EIRP setting accuracy (see note)	EIRP setting accuracy for first burst or RACH (see note)
Class 10 and 11	0 dB to -10 dB	1 dB	+1 dB -2 dB	+2 dB -2 dB
NOTE: 100 % of time, total for antenna and HPA.				

8.3.2 Transmit Power Spectral Density Mask

Class 10 and 11 UEs shall meet the maximum transmit limit mask requirements contained in clause 5.3.2 and Table 5.12 specified for Class 1 and 2 UEs.

This requirement shall be met simultaneously with the spurious emissions requirement (refer to clause 8.3.8).

8.3.3 Transmitter Duty Cycle

The UE transmit system shall satisfy the performance requirements under all conditions, including continuous operation at the maximum power setting.

8.3.4 Transmitter Off level

The non-transmitting state includes the 'idle' state, covering periods when the UE is not engaged in traffic, and periods between bursts, both reserved and contention slots.

For above compliance purposes only, idle is defined as the period after the UE has not transmitted for more than 2 seconds.

When a Class 10 and 11 UE transmitter is in the non-transmitting state, the radiation from the UE antenna in the direction of maximum gain shall not exceed the carrier-off EIRP requirement in Recommendation ITU-R M.1480 [1].

8.3.5 Transmitter Modulation Characteristics

Class 10 and 11 UEs shall support all the bearer types/subtypes, data and coding rates specified in Table 8.9.

Table 8.9: Summary of Return Bearer Types for Class 10 and 11 (Land-Mobile Directional) UEs

Identifier	Burst Duration (ms)	Symbol Rate (kBd)	Modulation	FEC Blocks per Burst	Code rates
R5T1XD	5	33,6	16-QAM	1	All
R5T2XD	5	2 x 33,6	16-QAM	1	All
R5T4.5XD	5	4,5 x 33,6	16-QAM	1	All
R20T1XD	20	33,6	16-QAM	1	All
R20T2XD	20	2 x 33,6	16-QAM	1	All
R20T4.5XD	20	4,5 x 33,6	16-QAM	2	All
R5T2QD	5	2 x 33,6	Pi/4 QPSK	1	All
R5T4.5QD	5	4,5 x 33,6	Pi/4 QPSK	1	All
R20T0.5QD	20	0,5 x 33,6	Pi/4 QPSK	1	All
R20T1QD	20	33,6	Pi/4 QPSK	1	All
R20T2QD	20	2 x 33,6	Pi/4 QPSK	1	All
R20T4.5QD	20	4,5 x 33,6	Pi/4 QPSK	1	All

8.3.6 Transmitter Phase Noise

The requirements of clause 5.3.6 shall apply.

8.3.7 Modulator Performance

8.3.7.1 Transmit burst Error Vector Magnitude

The transmit burst mean squared Error Vector Magnitude (EVM) measured at the output of the HPA shall not exceed the values specified in Table 8.10 for Class 10 and Class 11 UEs.

NOTE: A description of mean squared EVM is contained in clause 5.3.7.

Table 8.10: Mean squared EVM requirements for Class 10 and Class 11 UEs

Modulation	Mean squared EVM
Pi/4 QPSK	0,01
16-QAM	0,01

8.3.7.2 Definition of mean squared EVM

The requirements of clause 5.3.7.2 shall apply.

8.3.8 Spurious Radiated Emissions

8.3.8.0 General

Class 10 and 11 UEs shall comply with Recommendation ITU-R M.1480 [1]. The unwanted emissions limits above 1 000 MHz contained within Recommendation ITU-R M.1480 [1] are categorised into Table 2a and Table 2b (see [1]) requirements. Land-Mobile Class UEs (Classes 10 and 11) shall comply with the Table 2b (see [1]) requirements.

This requirement shall include compliance with all in-band and out-of-band unwanted emissions (including harmonic) and carrier-off state.

NOTE: Recommendation ITU-R M.1480 [1] is only strictly applicable for earth stations implementing Memorandum-of-Understanding arrangements to facilitate the circulation of GMPCS terminals, and as such, the requirements contained in Recommendation M.1480 [1] are not directly applicable for Land-Mobile UEs. However, the present specification requires compliance with the Recommendation ITU-R M.1480 [1] regardless of the stated scope of the Recommendation.

In determining compliance to the requirements of the recommendation, the nominated bandwidth shall be stated by UE manufacturer. The nominated bandwidth is centred on the transmit frequency and shall be wide enough to take account transmit carrier frequency stability; It shall not exceed 180 % of the 3 dB bandwidth of the signal.

8.3.8.1 Special spurious emission requirements in the 1 559 to 1 610 MHz band

The requirements of clause 5.3.8.1 shall apply.

8.3.9 Transmit Channel Tuning

The requirements of clause 5.3.9 shall apply.

8.3.10 Transmitter Frequency Accuracy and Stability

8.3.10.0 General

The requirements of clause 5.3.10 shall apply.

All commanded changes of transmit frequency including Doppler-tracking for the Land mobile UE Class should take place in the guard-time between transmitted bursts. If any frequency changes are commanded while transmitting a burst it will likely impact the transmitter modulation accuracy and hence the UE will fail to meet the EVM requirement, which is unacceptable. See clause 8.3.7.

8.3.10.1 Land-Mobile UEs (Class 10 and 11)

Return frequency compensation shall be as per ETSI TS 102 744-3-2 [13] requirements. The transmit frequency shall be frequency-locked to the receive frequency, with appropriate scaling for the L-band frequency.

8.3.11 UE Timing

The requirements of clause 5.3.11 shall apply.

8.4 Positioning requirements

8.4.1 UE Positioning Requirements

The requirements of clause 5.4.1 shall apply.

During the transition from the current spot beam to an adjacent spot beam, Class 10 and 11 UEs are expected to perform a spot beam handover (see ETSI TS 102 744-1-2 [10]) which attempts to preserve the call session. Positioning information is required by the UE to initiate a request for spot beam handover to the RNC.

The spot beam handover procedure may only be used for transitions between spot beams in the same satellite. If the spot-beam handover cannot be supported on the current satellite, the RNC will trigger deregistration and the implicit release of all connections by the UE. At this point the UE will return to an initial state and attempt to re-establish communications via the most appropriate satellite, based upon it's locally referenced positioning information.

8.4.2 GPS Receiver Unit

The requirements of clause 5.4.2 shall apply.

Annex A (informative): Coverage volume for Aeronautical installations

A.1 Declared coverage volume

The declared coverage volume is the coverage volume over which the Aeronautical UE installation achieves the following performance requirements:

- A Class 6 UE simultaneously achieves G/T (clause 6.2.1), EIRP (clause 6.3.1), Axial Ratio (clause 6.1.3) and Discrimination (clause 6.1.1).
- A Class 7 UE simultaneously achieves G/T (clause 6.2.1), EIRP (clause 6.3.1) and Axial Ratio (clause 6.1.3).

NOTE: The declared coverage volume will depend on the installation as well as the antenna design.

A.2 Typical coverage requirements

The typical coverage requirements for Aeronautical UE installations are defined by the minimum fractions specified below. These fractions should be calculated on the basis of the hemisphere above the aircraft (excluding the lowest 5° above the horizon) and with the aircraft in horizontal flight.

- For Class 6 (Aeronautical High Gain) UEs: minimum of 75 % declared coverage volume.
- For Class 7 (Aeronautical Intermediate Gain) UEs: minimum of 85 % declared coverage volume.

History

Document history		
V1.1.1	October 2015	Publication