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| C:\Program Files\Default Company Name\ICAOMainMenuSetup\Icons\icaologo.jpg | International Civil Aviation Organization  **WORKING PAPER** | |  | | --- | | ACP-WG S/Web Meeting 5 WP-04  6/5/14 | |  | |

**AERONAUTICAL COMMUNICATIONS PANEL (ACP)**

**15Th APRIL WEBMEETING OF THE WORKING GROUP S (SURFACE)**

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| **Agenda Item 3:** |  |

BER estimation through Packet Error Rate Measurement

(Proposed by Shoichi Hanatani / Toshiaki Akita / Ichiro Murata)

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| **SUMMARY** |
| This document provides information about how Packet Error Rate (PER) has been evaluated as the primary index for radio link quality instead of Bit Error Rate (BER). |
| **ACTION** |
| For SARPs validation work on AeroMACS , a PER based evaluation method should be considered and introduced. |

1. INTRODUCTION

In order to validate a receiver sensitivity, BER has been adopted and used as a basis for evaluation; however, with data-oriented radio communications having been globally deployed with error correction schemes embedded, PER is now practically used a receiver sensitivity evaluation, which is equivalent to BER.

1. discussion

2-1 Definition PER

Propose to add the following PER definition to Chapter 1 DEFINITIONS of the SARPs:

***Packet error rate (PER)***. The number of error packets after Forward Error Correction (FEC) divided by the total number of received packets. A packet is the unit of data for radio transmission subject to FEC.

2-2 BER Estimation through PER measurement

IEEE Std 802.16-2009 also is mandating usage of BER to evaluate a receiver sensitivity as follows:

Section 8.3.11.1 Receiver sensitivity

*The BER measured after FEC shall be less than 10–6 …*

As explained in the section.1, PER instead of BER should be adopted as a the basis for measurement. The reason is that BER should be measured after Forward Error Correction (FEC); however since errors s are corrected in the unit of FEC block, which is also termed as a Packet, it is more practical to measure PER as an indicator, based on which BER could be extrapolated, to determine a receiver sensitivity.

The relationship between PER and BER can be simply expressed as follows:

*PER =1− (1− BER)n*

Packet size *n* is defined as the size of one unit of FEC block, the PER value corresponding to the required BER 10 -6 can be calculated based on *n* varying with different testing items.

Propose to add the following technical note

*Note: For evaluating receiver sensitivity, PER can be used as the basis to extrapolate BER.*

to both

“3.4.1 The sensitivity level is defined as the power level measured at the receiver input when the bit error rate (BER) is equal to 1\*10-6”

and

“4.4.4 The maximum bit error rate shall not exceed 10-6 after FEC assuming a minimum received signal equal to the corresponding sensitivity level”

2-3 Testing Evaluation Procedure

This method for packet error rate evaluation has been specified in WiMAX Forum document Mobile Radio Conformance Tests (MRCT) WMF-T25-002-R010v06.

Packet size n is defined as one unit size of FEC block, which is different for various testing items. This PER is measured during a period long enough to maintain the relation to average BER. The number of frames to be measured for each test item is determined for each test item.

An error packet threshold counter is also determined for each testing items, with level of confidence also taken into consideration.

Detailed expected packet size, a number of measured frames and the maximum number of error packets for each test are shown in APPENDIX.

1. ACTION BY THE MEETING

ACP WG-S is invited to consider

1. Adopting PER as the basis to extrapolate BER to evaluate receiver sensitivity in AeroMACS SARPs validation.
2. Modifying SARPs draft adding the definition of PER as well as the technical notes proposed in section.2

**APPENDIX**

**1 .Reference**

WiMAX MRCT WMF-T25-002-R010v06 .

**2. Relation between PER and BER**

The following description is excerpted from WMF-T25-002-R010v06

*APPENDIX1*

This section provides generic test packets, receiver sensitivity requirements, Bit Error Rate (BER) to Packet Error Rate (PER) conversion.

The relationship between the BER and PER is valid for an ideal communication system that transmits data over binary symmetric channel with uncorrelated noise. This relationship is not valid for correlated noise channels and is dependent on the specific receiver implementation. The length of the packet in bits is *n* and the bit error probability for the channel is *pb*. Any packet that has one bit or more in error is discarded and the probability *p* of getting a packet in error is given by:

*Pn = 1 - (1- pb)n* Equation 1

*pn* is the packet error rate (PER) and *pb* is the bit error rate (BER).

A real communications system is considered equivalent to the ideal system if they have the same PER. The equivalency means that the real system has the same packet throughput as the reference ideal system having the known BER=10-6.

The PER is determined exclusively by the BER and the number of bits in the packet’s data payload and is not dependent by how the data is encoded or what happens during the transmit-receive process. Therefore the relationship between PER and BER is given by:

*PER =1− (1− BER)n* Equation 2

**3. Packet size**

The following description is excerpted from following section of WMF-T25-002-R010v06

*10.1.6 BS-06.1: BS receiver sensitivity*

In order to be compliant to the minimum receiver sensitivity requirement, the receiver is required to achieve a Packet Error Rate (PER) equal to or better than a certain target level when the received signal is set at the maximum sensitivity level.

The packet length is chosen to be, after encoding, a single FEC block with a maximum data size allowed by the CTC sub-channel concatenation rule, i.e., 60/54 bytes depending on the particular MCS level. Each data packet consists of a 6-byte generic MAC header at the beginning and a 4-byte CRC- 32 at the end, leaving the remaining as payload bits. Random payload bits are used. The CRC is calculated based on MAC header and the payload.

The BS receiver sensitivity, measured PDU is defined as FEC unit as follows.

PER correspondent BER 10-6 are shown in Table 1.

**Table 1 PDU packet size and PER(BER=1e-6)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channel BW (MHz) | MCS | Packet size  (PDU Size) (bytes) | Packet size  (PDU size) (bits) | PER (BER=1e-6) |
| 5 | QPSK rate-1/2 | 60 | 480 | 0.048% |
| QPSK rate-3/4 | 54 | 432 | 0.0432% |
| 16QAM rate-1/2 | 60 | 480 | 0.048% |
| 16QAM rate-3/4 | 54 | 432 | 0.0432% |

Source: Tabel.202

**4. Packet number to be tested and error count threshold**

The following description is excerpted from the following section of *WMF*-T25-002-R010v06

*APPENDIX1*

The PER is defined as the limit of the ratio between the number of the packets in error (*Npe*) to the number of the packets transmitted (*Npt*) when *Npt* goes to infinity. Therefore PER cannot be measured in a finite time measurement. Instead we define experiments that, once validated, will give a defined level of confidence that the PER is less than the requirement.

An experiment is defined by the level of confidence α, the value of the PER, the total number of *N* packets transmitted and the maximum number *M* of packets that can be in error for the experiment to be considered valid. *M* is determined from N, PER and α that the probability for a system that has a PER higher than the nominal one to pass the test is less than 1*-* α. The number *M* is the highest one that verifies the inequality:



Equation 3

*10.1.6 BS-06.1: BS receiver sensitivity*

For each modulation and coding, the test is performed for the different packet according to Table 2 and run until the number of frames specified in the table 2 has been transmitted. The number of packets in error should be less than the limit indicated in the last column of the table.

The column # of error packets shows the M, derived from Equation 4 . For each MCS below the test is evaluated at 95% confidence level.

**Table 2. Parameters for Single-antenna Receiver Sensitivity (PUSC)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Channel BW (MHz) | MCS | PDU Size (bytes) | # of frames | PER (BER=1e-6) | # of error packets |
| 5 | QPSK rate-1/2 | 60 | 60000 | 0.048% | 20 |
| QPSK rate-3/4 | 54 | 68000 | 0.0432% | 21(Note1) |
| 16QAM rate-1/2 | 60 | 60000 | 0.048% | 20 |
| 16QAM rate-3/4 | 54 | 68000 | 0.0432% | 21 (Note1) |

Source: Tabel.202

In the case of QPSK 1/2, at least 60000 frames are measured, and the number of the error packets should be equal or under 20, for proving its receiver sensitivity.

(Note1): The original value defined in WMF-T25-002-R010v06 is 20, however we conclude the correct value shall be 21 after careful review and verification.