Considerations on the Non-Synchronized Ranging Channels

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Venue:

Re: IEEE 80216m-09/0020, “Call for Contributions on Project 802.16m Amendment Working Document (AWD) Content”

“Comments on AWD 15.3.9 UL-CTRL”

Purpose: To be discussed and adopted by TGm for the IEEE 802.16m AWD.

Introduction

- **In this contribution, we need to determine the ranging formats and corresponding parameters for supporting various coverage, e.g., ranging subcarrier spacing, occupied bandwidth, lengths of RCP, RP, GT, etc.**
- **In addition, it is also essential to support enough reuse factors/opportunities using the ranging formats and their configurations in order not to restrict the system deployment.**
- **To Determine Required Basic Ranging Parameters and Formats**

  Provide the simulation results in various scenarios, i.e.,
  - ✓ Ranging subcarrier spacing: Different and Same with data subcarrier spacing
  - ✓ Resource size: 1 Subband vs. 2 Subbands
  - ✓ Link budget analysis for coverage comparison in data and ranging channels

  Ranging performance comparison in several ranging structures
  - ✓ Miss detection performance with 0.1% False alarm rate comparing with 16e ranging channels
  - ✓ Required SNR for ranging channels comparable to that of data channels
  - ✓ 16m ranging overhead comparison with 16e ranging and LTE RACH

  Reuse factors in terms of ranging opportunities
  - ✓ Supportable ranging codes: Ranging BW & Subcarrrier spacing
  - ✓ Increased opportunities for providing enough reuse factors (compared with LTE)

Basic Ranging Formats: Comparisons

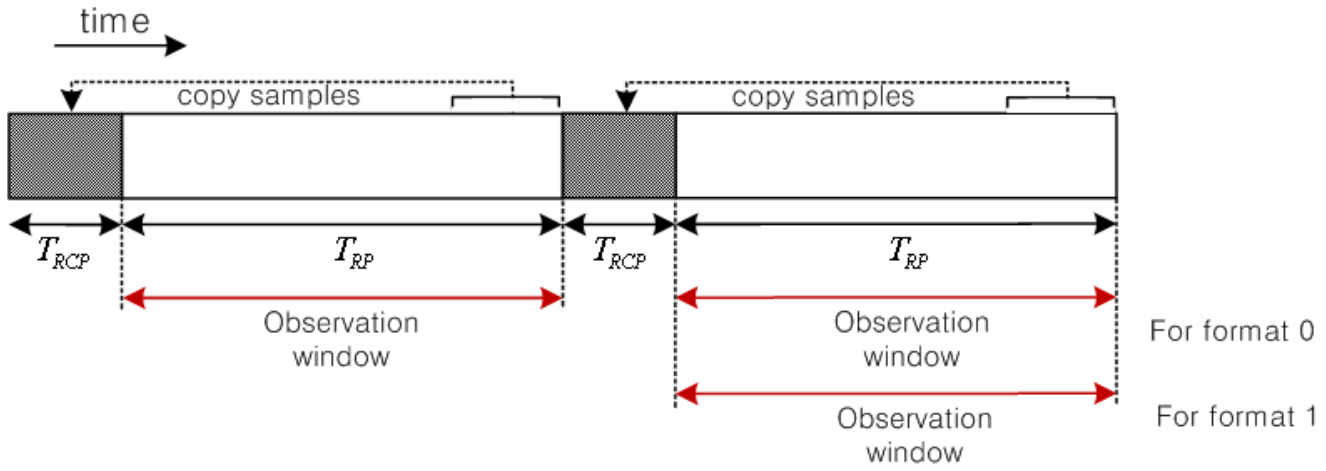
- **For different ranging subcarrier spacing : $\triangle f_{RA}=\triangle f/2.5$**

  Using the default ranging structure in the SDD (Structure 1 in the AWD), there exists a couple of its usage, i.e.,

  - ✓ Format 0: A single ranging opportunity with RP repetition
  - ✓ Format 1: 2 ranging opportunities in the TDM manner without RP repetition
    - Not necessary to consider GT between 2 ranging channels

  The length of ranging codes in 2 different ranging BWs

  - ✓ 349 length of ZC codes for 2 subbands
  - ✓ 173 length of ZC codes for 1 subband



Basic Ranging Formats: Comparisons

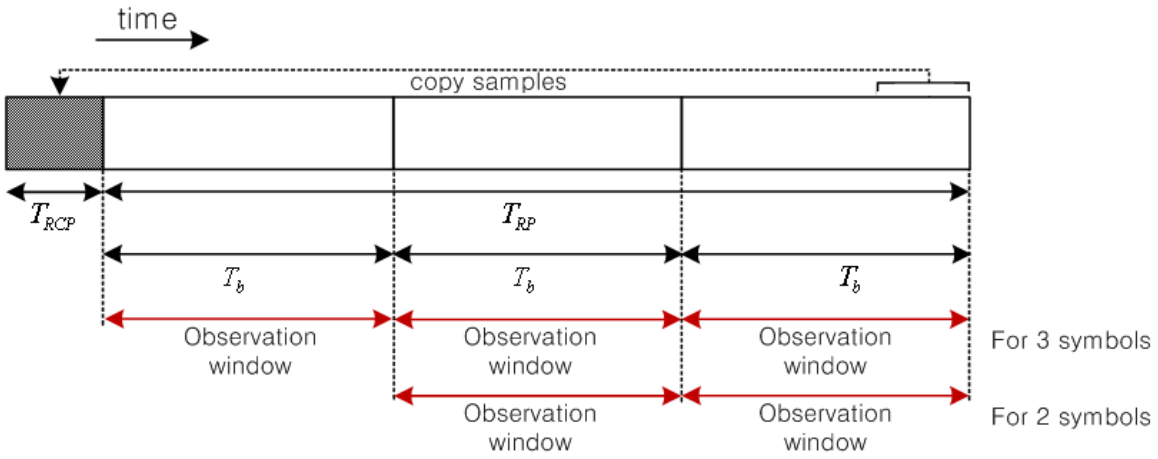
- **For same ranging subcarrier spacing with data : $\triangle f_{RA}=\triangle f$**

  Using the structure 2 or its modification, the ranging formats using the data subcarrier spacing can be considered with different repetition factors, i.e.,

  - ✓ 2- or 3-symbol duration for ranging observation window

  The length of ranging codes in 2-subband ranging BW

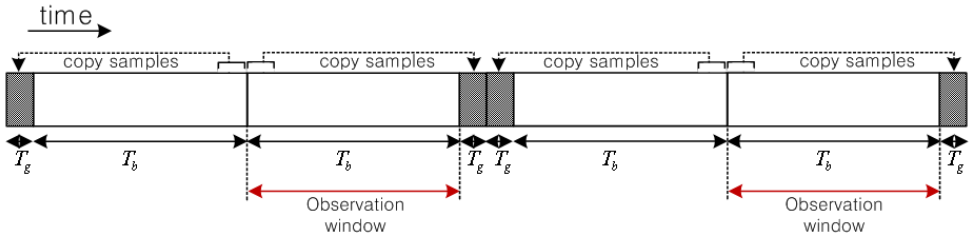
  - ✓ 139 length of ZC codes



- **16e ranging channel**

  2/4 symbol-structure

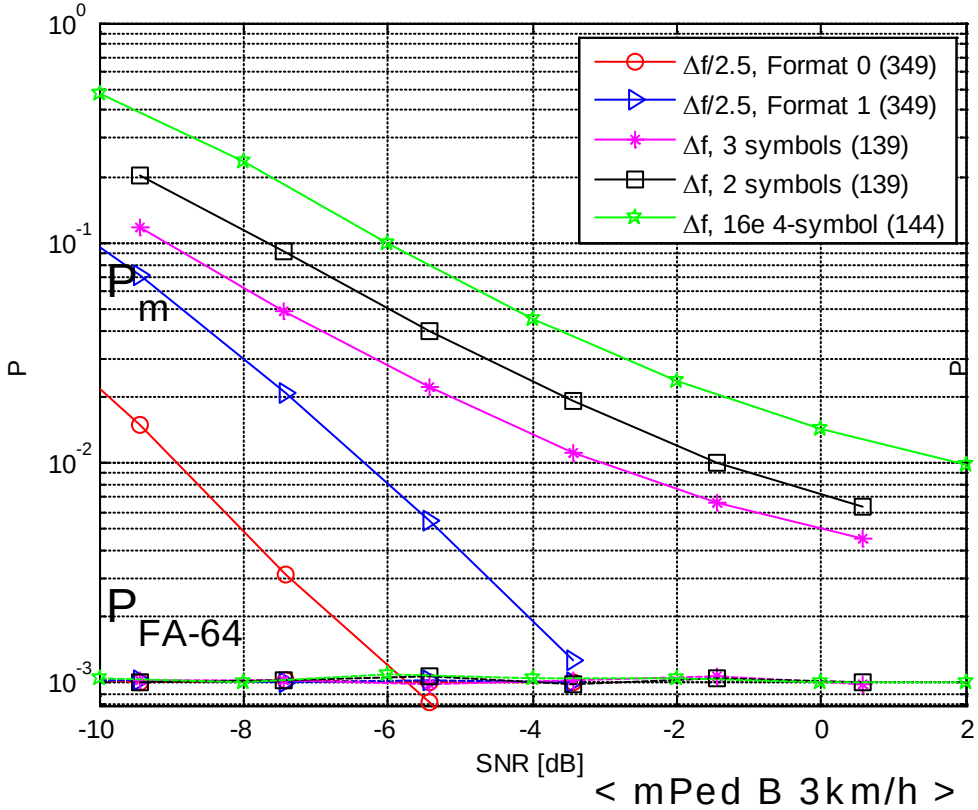
  144 length of 16e codes

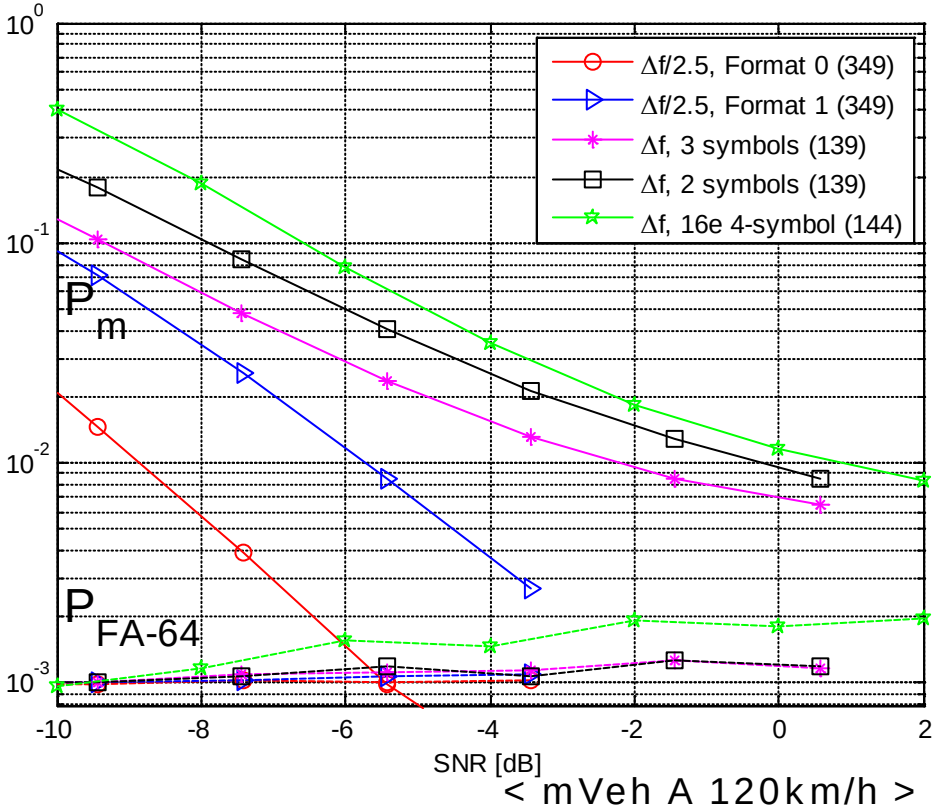


Simulation Environments

	Parameters	Assumptions
System	Carrier Frequency (f_C)	2.5 GHz
	Total Bandwidth (BW)	5 MHz
	Number of Points in FFT (N_{FFT})	512
	Sampling Frequency (F_s)	5.6 MHz
	Subcarrier Spacing (Δf)	10.9375 kHz
	OFDMA Symbol Duration without Cyclic Prefix ($T_0 = 1/\Delta f$)	91.43 μs
	Cyclic Prefix Length (faction of T_0)	1/8
	OFDMA Symbol Duration with Cyclic Prefix (T_s)	102.86 μs for CP=1/8
	Residual Frequency Offset	Random < 218.75 Hz (< 2% of Δf)
Channel	Multi-antenna Transmission Format	1 Tx
	Receiver Structure	2 Rx
	Fading Channel Model	Modified Pedestrian B 3km or Modified Vehicular A 350 km/h
Ranging	Ranging Resource	2 subbands or 1 subband
	Ranging Subcarrier Spacing	4.3750 kHz or 10.9375 kHz
	Ranging Detector	Frequency domain energy detector
	Number of Ranging Codes per Channel	64
	Number of Ranging Channel per Sector	1
	Codes Set per Sector	Random within all codes
	Code Selection per AMS	Random within code set of sector
	Round Trip Delay	Random within 5km RTD
	Target Miss-Detection Probability	1 %
	Target Overall False Alarm Rate	0.1 %

Ranging Subcarrier Spacing (2 subbands)

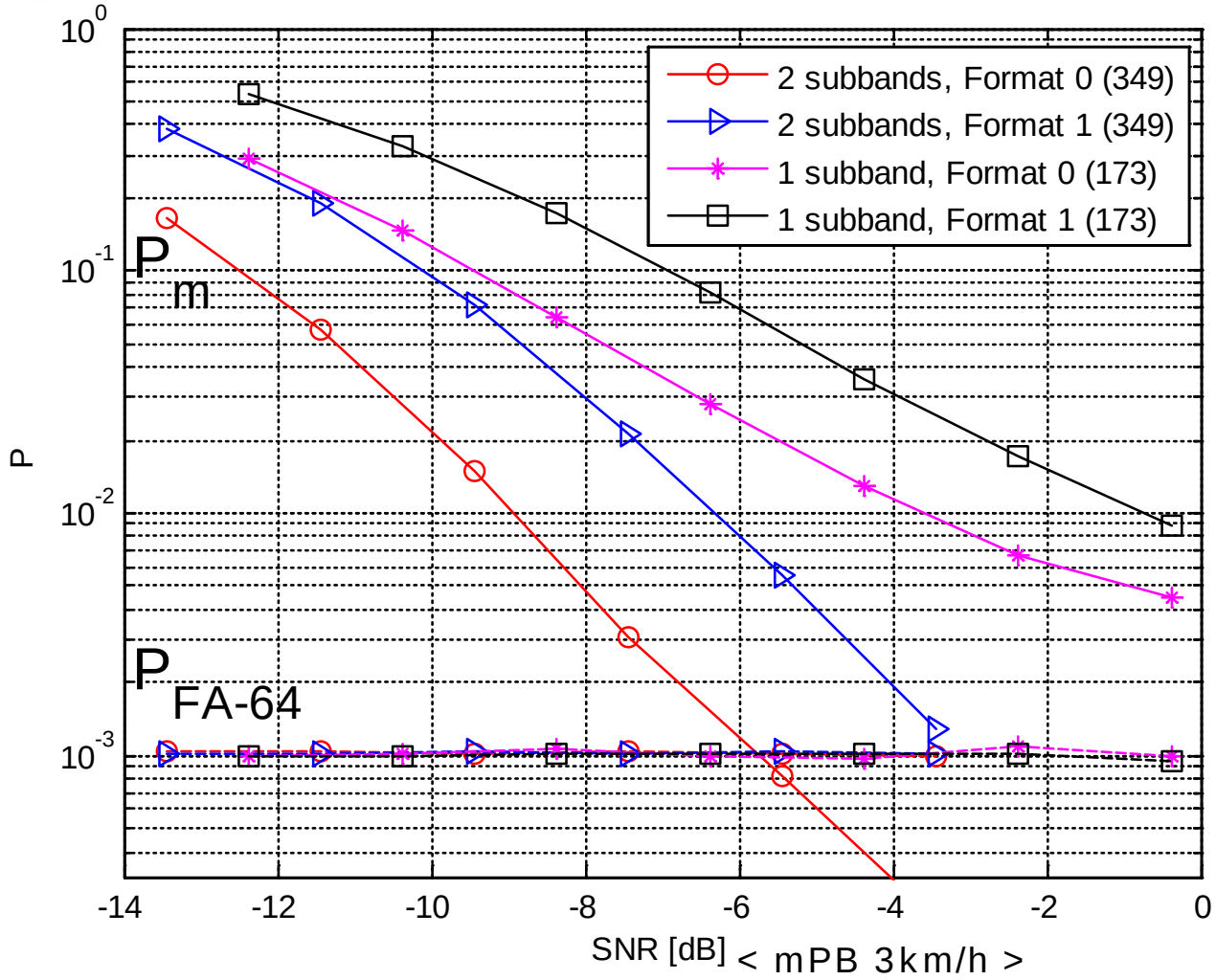




- **The performance of △*f*/2.5 subcarrier spacing has 5~6 dB gain compare with that of data subcarrier spacing.**

  △*f*/2.5 subcarrier spacing can obtain higher time diversity gain for high mobility

Ranging Bandwidth ($\triangle f$/2.5 subcarrier spacing)



- The performance of 2 subbands has 5~6 dB gain compare with that of 1 subband.

Data Coverage vs. Ranging Coverage

- **Consider 12.2 kbps VoIP**
  - Total VoIP packet size : 44 bytes for active ☞ 352 bits
  - CTC coding rate 101/256, 71/256, 48/256, 31/256 ☞ 893, 1270, 1878, 2907 bits
  - QPSK modulation ☞ 447, 635, 939, 1435 subcarriers
  - Required PRUs ☞ 5, 7, 10, 15 PRUs
  - Required CINR (20%) ☞ -2.5, -3.5, -4.5, -6.0 dB

< The Receiver Sensitivity [dBm] >

Coding rate		101/256 CTC		71/256 CTC		48/256 CTC		31/256 CTC	
HARQ ReTx		No	1	No	1	No	1	No	1
Used PRUs in Freq.	1	-118.56	-121.56	-119.56	-122.56	-120.56	-123.56	-122.06	-125.06
	2	-115.56	-118.55	**-116.55**	-119.55	**-117.55**	-120.55	-119.05	-122.05
	3	-113.79	**-116.79**	-114.79	**-117.79**	**-115.79**	-118.79	**-117.29**	-120.29
	4	-112.54	-115.54	-113.54	**-116.54**	-114.54	**-117.54**	**-116.04**	-119.04
Ranging		**-115.64 (1 subband)/-117.93 (2 subbands)**							

Thermal noise : -174 dBm/Hz, Noise figure: 5 dB, -2dB margin for ranging [-5.6 dB (1 subband), -10.9 dB (2 subbands)]

☞ **To support data and ranging coverage balancing, 2 subbands for ranging BW should be supported.**

Number of codes: Opportunities

- **Ranging opportunities are directly coupled with the reuse factor:**
  - $\triangle f/2.5$ subcarrier spacing (vs. $\triangle f$ subcarrier spacing)
    - Approx. 2.5 times increased cross-correlation
  - 2 subbands (vs. 1 subband)
    - Approx. 2 times increased reuse factors
- **Sufficient reuse factor is needed for at least 1-tier support:**
  - Exploiting time-domain opportunity in a subframe is beneficial to increase the reuse factors.

< The reuse factor in 5km cell radius >

Subcarrier spacing	Ranging bandwidth	# of root seq.	# of used root seq. per cell for 64 opp.	Reuse factor	
				Single Format	Including Format 1
$\triangle f/2.5$	2 subbands	348	16	**21.75**	**43.50**
	1 subband	172	16	10.69	**21.38**
$\triangle f$	2 subbands	138	64	2.14	4.28
	1 subband	66	64	1.02	2.03
LTE	6 RBs	838	16	**52.38**	

Support 1 tier

Support 2 tiers

Not support even 1 tier!

Occupied Resource: Overhead

- **16m for 10 MHz**
  - FDD : 48 PRUs by 8 subframe
  - 4:4 TDD : 48 PRUs by 4 subframe
- **LTE for 10 MHz**
  - FDD : 50 RBs by 10 subframe
  - UD configuration 1 TDD (D S U U D D S U U D) : 50 RBs by 4 subframe

Subcarrier spacing	Ranging channel	Duplex mode	No. of ranging channels per super-frame (20 ms)				
			1 ch.	2 ch.	4 ch.	8 ch.	16 ch.
16m	2 subbands × 6 symbols	FDD	0.5208	1.0417	2.0833	4.1667	8.3333
		TDD	1.0417	2.0833	4.1667	8.3333	16.6667
	1 subband × 6 symbols	FDD	0.2604	0.5208	1.0417	2.0833	4.1667
		TDD	0.5208	1.0417	2.0833	4.1667	8.3333
LTE	6 RBs × 7 symbols	FDD	0.6000	1.2000	2.4000	4.8000	9.6000
		TDD	1.5000	3.0000	6.0000	12.0000	24.0000
	6 RBs × 14 symbols	FDD	1.2000	2.4000	4.8000	9.6000	19.2000
		TDD	3.0000	6.0000	12.0000	24.0000	48.0000

☞ **2-subband ranging bandwidth can provide lower overhead than that of LTE.**

Ranging Formats and Parameters: Coverage

Format No.	Format	T_{RP}	Δf_{RP}	Duplex mode (2)	Within subframe for data CP=1/8 $\cdot T_b$		Within type-1 subframe for data CP=1/16 $\cdot T_b$		Within type-2 subframe for data CP=1/16 $\cdot T_b$	
					T_{RCP}	C_{max}	T_{RCP}	C_{max}	T_{RCP}	C_{max}
0	RCP+RP+RCP+RP	228.5714 μs ($4096\times T_{st}$)	$\Delta f/2.5$	FDD	57.1429 μs ($1280\times T_{st}$)(1)	6.852 km	43.8393 μs ($982\times T_{st}$)	5.708 km	76.2054 μs ($1707\times T_{st}$)	10.560 km
				TDD	75.7143 μs ($1696\times T_{st}$)(1)	9.636 km	54.8214 μs ($1227\times T_{st}$)	7.354 km	87.1429 μs ($1952\times T_{st}$)	12.206 km
1	RCP+RP									
2	RCP+RP+RP	228.5714 μs ($5120\times T_{st}$)		FDD	11.4286 μs ($256\times T_{st}$)	22.270 km(3)	5.7143 μs ($128\times T_{st}$)	17.988 km	5.7143 μs ($128\times T_{st}$)	32.549 km
				TDD	113.5714 μs ($2544\times T_{st}$)	15.311 km	82.1429 μs ($1840\times T_{st}$)	11.456 km	130.7143 μs ($2928\times T_{st}$)	18.737 km
3	RCP+RP	731.4286 μs ($6144\times T_{st}$)	$\Delta f/8$	Both	678.57143 μs ($15200\times T_{st}$)	70.237 / 95.934 km	672.85714 μs ($15072\times T_{st}$)	55.676 / 95.934 km	672.85714 μs ($15072\times T_{st}$)	99.340 / 95.934 km

(1) : The number of samples with sampling time for 20 MHz.
(2) : It is assume that the TTG is 105.714 μs and 82.853 μs, and maximum SSRTG is 50 μs for TDD duplex mode.
(3) : It is assume that first RP is used as RCP for Format 2 of FDD duplex mode.

Conclusion

- **From the Simulation Results,**

  Ranging performance

  - ✓ $\triangle f/2.5$ subcarrier spacing has 5~6 dB gain compare with $\triangle f$ subcarrier spacing
  - ✓ 2 subbands bandwidth has 5~6 dB gain compare with 1 subband bandwidth
  - ✓ We can assume $\triangle f$ subcarrier spacing with 1 subband may have 10~12 dB performance degradation.

  Power balancing with data channel

  - ✓ To support comparable coverage with data channel, the ranging channel shall operate lower SNR, properly.

  No. of code and reuse factor

  - ✓ The reuse factor of codes shall be supported to cover at least 1 tier in the 5km cell coverage.
  - ✓ It is desirable that the reuse factor of codes with frequency reuse could be close to the number of cell ID.

- **Proposed AWD Text**

  Adopted the proposed AWD text in C802.16m-09/1092 or its latest version.