Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Proposed Text for the Draft P802.16m Amendment on the PHY Structure for Ranging channel**
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Re:	In reply to UL Control Drafting Group comments IEEE 80216m-09/0386, “Proposed Text for the Draft P802.16m Amendment on the PHY Structure for UL Control”
Abstract	This contribution proposes the text of ranging channel section to be included in the IEEE 802.16m AWD.
Purpose	To be discussed and adopted by TGm for the IEEE 802.16m AWD
Notice	
Release	
Patent Policy	

Proposed Text for the Draft P802.16m Amendment on the PHY Structure for Ranging channel

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1. Introduction

This contribution proposes the text of ranging channel section to be included in the proposed text of UL control drafting group [1] and IEEE 802.16m amendment [2]. The proposed text is developed in order to be readily combined with IEEE P802.16 Rev2/D9 [3]. It is also compliant to the 802.16m SRD [4] and the 802.16m SDD [5] based on the proposed text in [6].

2. Considerations

In [6], we proposed the ranging channel formats and its parameters as Table 1.

Table 1. Ranging channel formats supporting up to 100 km cell radius [6]

Format No.	Ranging channel format	T_{RP}	Δf_{RP}	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	228.571429 μs ($4096\times T_{rtu}$)	4.375 kHz	57.14286 μs ($1280\times T_{rtu}$)	6.852 km	43.79464 μs ($981\times T_{rtu}$)	5.708 km	76.16071 μs ($1706\times T_{rtu}$)	10.560 km
1	RCP+RP								
2	RCP+RP+ RP	228.571429 μs ($5120\times T_{rtu}$)	4.375 kHz	11.42857 μs ($256\times T_{rtu}$)	22.270 km	5.71429 μs ($128\times T_{rtu}$)	17.988 Km	5.71429 μs ($128\times T_{rtu}$)	32.549 km
3	RCP+RP	731.428571 μs ($6144\times T_{rtu}$)	1.3671875 kHz	678.57143 μs ($15200\times T_{rtu}$)	66.168 / 100 km	672.85714 μs ($15072\times T_{rtu}$)	51.607 / 100 km	672.85714 μs ($15072\times T_{rtu}$)	95.291 / 100 km

In this contribution, we shortly review the design criteria/considerations which are highly compliant to the 802.16m SDD [5].

2.1. Required length of RP

For the system to operate correctly, the ranging channel for non-synchronized MSs shall be able to operate at the same received SNR as data and any associated UL control signaling. In other words, when the minimum uplink data rate from a certain AMS can support under worst situation, e.g., cell edge, the corresponding AMS shall be able to basically access at the serving ABS through the ranging channel for non-synchronized AMSs.

This implies that the required SNR for UL transmission with minimum data rate and initial/handover ranging coverage are strongly coupled. To support comparable coverage between data and ranging channel, the required total length of repeated RP can be calculated as shown in [7]. The power balancing between data and ranging channel is given by

$$\frac{E_p}{N_0}\cdot\frac{1}{T_p}=\frac{E_b}{N_0}\cdot R$$

where T_p is the preamble duration, R is data rate. Since the SNR for data channel is a function of the transmission data rate, we therefore need to establish a reasonable minimum data rate for data channel. As a simple example, it is assumed that target E_p/E_b is 16.0~16.5 dB roughly (e.g., E_b/N_0=3 dB, E_p/N_0=19.5 dB [8]) and the minimum data rate is 96 kbps. Then, the required preamble length becomes longer than 414.6950~465.2954 μs. It should be noted that, in order to maintain the coverage balance between data and ranging channels, the required length of RP increases as the minimum data rate decreases.

2.2. Ranging cyclic prefix and ranging subcarrier spacing

From 802.16m SDD [5], it is described that '*The physical ranging channel for non-synchronized mobile stations consists of three parts: 1) ranging cyclic prefix (RCP), 2) ranging preamble (RP) and 3) guard time (GT). The length of RCP is not shorter than the sum of the maximum channel delay spread and round trip delay (RTD) of supported cell size. The length of GT is not also shorter than the RTD of supported cell size. The length of ranging preamble is equal to or longer than RCP length of ranging channel.*' Here, the long length of RP is needed to increase the received energy of ranging channel as shown in section 2.1. To achieve this goal, one method is a simple repetition of a code with data subcarrier spacing [11] and the other method is to use the different ranging subcarrier spacing [6]. However, using the same subcarrier spacing of data is not providing any benefits due to the following reasons:

1. If the length of RP is not multiple of T_b, the remaining parts in time domain after the consecutive FFT windows can not use efficiently. Moreover, even if data subcarrier spacing is re-used, the ABS shall operate at the different FFT windows from data OFDMA symbols as shown in Figure 1. This implies that the different detection windows still are necessary for ranging channel.
2. It is hard to optimize the resource within a given subframe. As shown in Figure 1, if the available T_{RP} is not a multiple of T_b, some part of RP can be a time-waste due to the restriction of data useful duration. If T_{RP} is a multiple of T_b, the ranging coverage will be reduced because it decreases the received energy or the length of RCP and GT without overhead optimization.

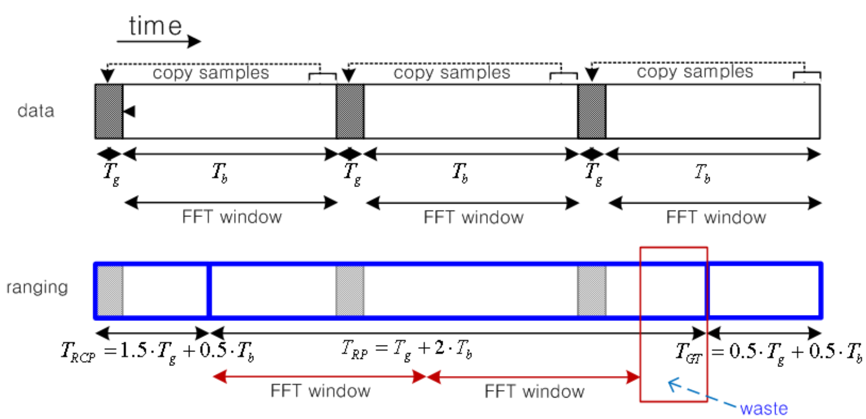

Figure 1. Example of different FFT window position

3. A simple repetition of T_b can not support longer propagation delay than T_b because the larger delay than T_b causes timing ambiguity as shown in Figure 2. If the delay is longer than T_b, the detector of the ABS can not distinguish between longer delay than T_b and shorter delay than one. In other words, the maximum supportable cell size is restricted by the duration of a code (e.g., T_b). Therefore, in order to support large cell size, which is not covered by the RP length of T_b, it is necessary to consider another ranging channel and its preamble codes.

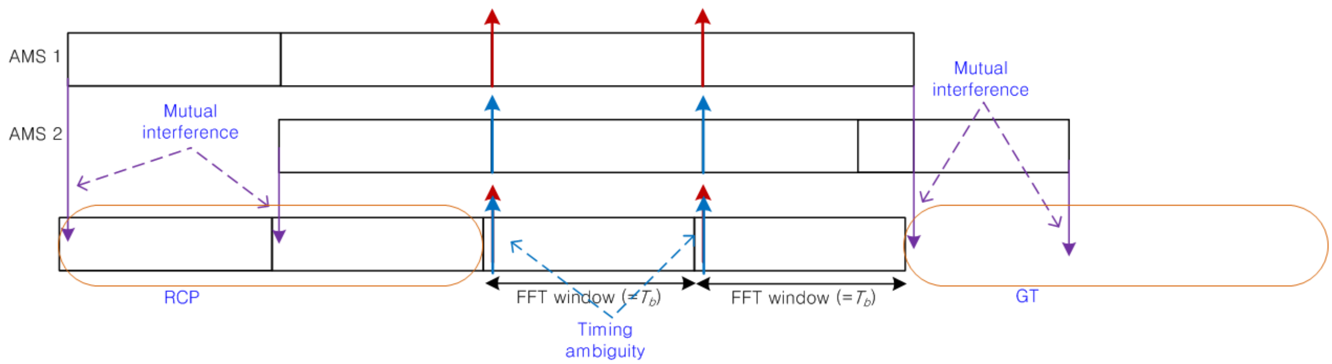

Figure 2. Timing ambiguity when the round trip delay is longer than T_b.

In the proposed ranging channel format in Table 1 [6], there are only two lengths of RP to support up to 100 km cell radius. Specifically, ONLY one length of RP and related codes with 4.375 kHz ranging subcarrier spacing can support up to 30 km cell radius. The performance results with proposed parameters up to 350 km/h have been shown in [8]. Note that the smaller subcarrier spacing of ranging channel than that of data channel does not make any problem, e.g., 1/12 subcarrier spacing of data (1.25 kHz) is already used in LTE [13].

2.3. Increase of ranging time opportunity and GT overlapping

From the 802.16m SDD [5], '*Figure 3 shows the default ranging channel structure spanning one subframe. The ranging preamble is repeated as a single opportunity.*' This implies that the default ranging channel structure with repeated RPs is used as a single opportunity to increase received ranging energy.

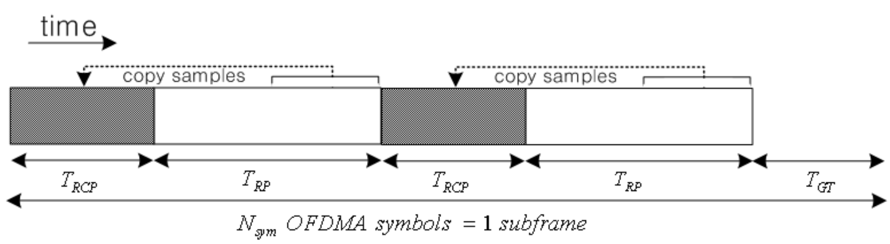

Figure 3. The default ranging structure for non-synchronized AMSs (Figure 47 in [5])

In the cases where UL power limited situation is not serious, e.g., hot spot/relay operations, or the increased ranging opportunities are necessary for supporting the large amount of ranging channels, e.g., the multi-carrier supports, a single RP can be separately used for different non-synchronized AMSs in order to increase the ranging opportunities. It also described in 802.16m SDD [5] as '*Only one instance of the ranging preamble with an RCP can be used by different non-synchronized AMS for increasing ranging opportunities.*' This implies a couple of important considerations: 1) GT overlapping [8] and 2) using the same ranging numerology without inter-cell interference [9].

Figure 4 shows the GT overlapping when a single RP is used by a AMS within a cell. The delay of first time opportunity always exists only within a RCP of second time opportunity. Therefore, ONLY one GT within a subframe is needed and the expansion of the length of RP is possible to increase received preamble energy for power-limited AMS.

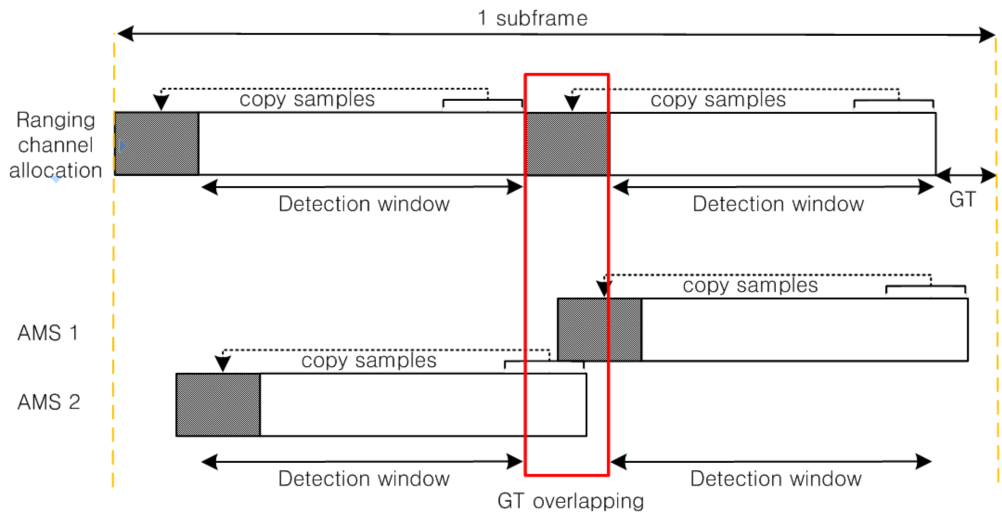

Figure 4. GT overlapping with increased time-opportunity

Figure 5 shows the use of the same ranging numerology without inter-cell interference when the increased ranging opportunities are used. Let’s assume there are two adjacent cells which are use different ranging Formats. Cell 1 is the general macro cell and use Format 0. Cell 2 is the hot-spot which is located in the near of Cell 1 and used the Format 1. Then, each AMS transmits the ranging signal in two synchronized cells. There is no mutual interference between the cells because it is always located in RCP and GT of other cell.

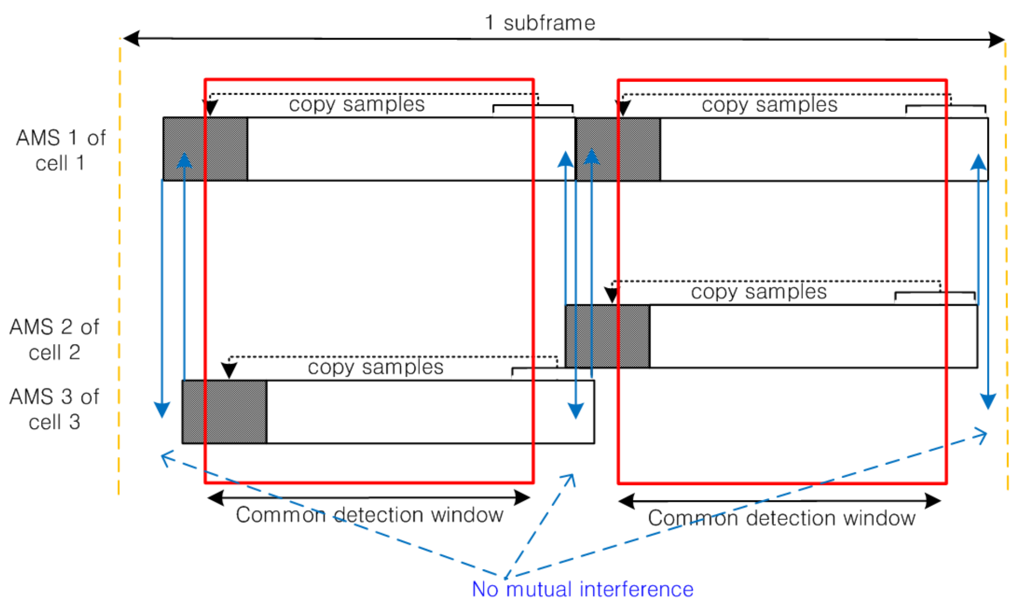

Figure 5. Using same ranging numerology with increased time-opportunity

2.4. Use of TTG for TDD duplex mode

It is proposed that using TTG as a part of ranging channel [10] as addressed in the SDD, '*In the TDD mode, the GT can be omitted for extending the length of RCP.*' This implies that the type/length of ranging code is the same to that of FDD mode for maximizing commonality, however, the length of RCP in TDD mode can be longer than that in FDD mode to increase the ranging coverage.

Figure 6 shows an example of the TTG usage. The ABS transmits DL signals up to *t*=0. The AMS can receive the last DL signal from *t*=0 to *t*=RTD/2 depending on its propagation delay. Then, AMS can transmit its uplink signal after SSRTG from the last DL arrival. The ABS can receive it from SSRTG to SSRTG+TTG. Therefore, we can use 'TTG-SSRTG' as a part of ranging channel.

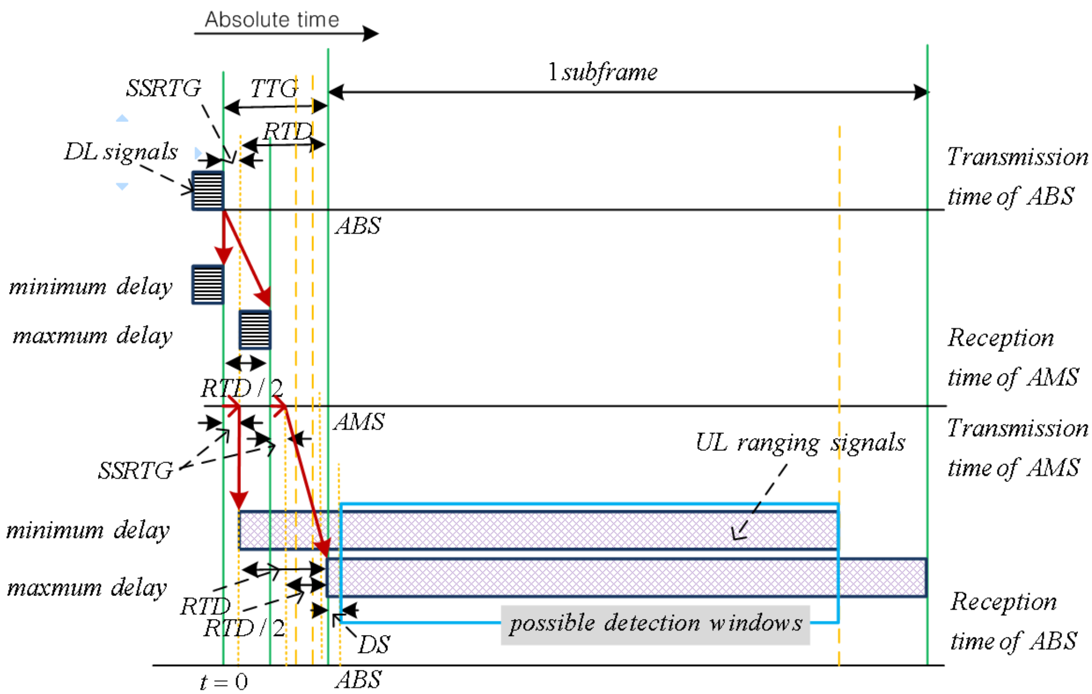

Figure 6. Using of TTG for TDD duplex mode

The fixed transmission start time can be defined as the SSRTG value in the WiMAX profile, i.e., the SSRTG as performance/fidelity requirements is 50 µs [12]. For examples, if there is 102.857 µs idle time (TTG) before UL subframe, we can use 52.857 µs as a part of ranging channel.

3. References

[1] IEEE 802.16m-09/386, "Proposed Text for the Draft P802.16m Amendment on the PHY Structure for UL Control," March 2009

[2] IEEE 802.16m-08/0010, "IEEE 802.16m Amendment Working Document," January 2009.

[3] IEEE P802.16Rev2/D9, "DRAFT Standard for Local and metropolitan area networks / Part 16: Air Interface for Broadband Wireless Access Systems," January 2009.

[4] IEEE 802.16m-07/002r8, "IEEE 802.16m System Requirements," January 2009.

[5] IEEE 802.16m-08/003r7, "IEEE 802.16m System Description Document," February 2009.

[6] IEEE C802.16m-08/0335r1, "Proposed Text of Ranging Section for the IEEE 802.16m Amendment,"

January 2009.

[7] IEEE C802.16m-08/853r2, “Ranging Channel Structure for the 802.16m SDD,” July 2008.

[8] IEEE C802.16m-08/1030r1, “PHY Structure Design of Non-synchronized Ranging Sequence for IEEE 802.16m,” September 2008.

[9] IEEE C80216m-UL_PHY-Ctrl-08/066, “Ranging Channel Structure for Non-Synchronized MSs,” November 2008.

[10] IEEE C80216m-UL_PHY_Ctrl-08/054r1, “Proposed Ranging Channel Structure in IEEE 802.16m TDD mode,” November 2008.

[11] IEEE C80216m-09/0253r1, “Ranging Section for the IEEE 802.16m Amendment,” January 2009.

[12] WiMAX Forum Mobile System Profile Release 1.0 (Revision 1.4.0), May 2007.

[13] 3GPP TS 36.211 v.8.5.0, “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation,” December 2008.

Text proposal for inclusion in the 802.16m amendment

Black text: current text in [1]
~~Red Strike through Text~~: Deleted
Blue text: new text
[Bracketed Italic text]: Informative

[---------------------------------- Text Proposal #1 ----------------------------------]

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15.3.9.1.4. Ranging Channel

The UL ranging channel is used for UL synchronization. The UL ranging channel can be further classified into ranging channel for non-synchronized mobile stations and synchronized mobiles stations. The ranging channel for synchronized AMSs is used for periodic ranging. The ranging channel for non-synchronized AMSs is used for initial access and handover.

15.3.9.1.4.1. Ranging Channel Structure for Non-synchronized AMSs

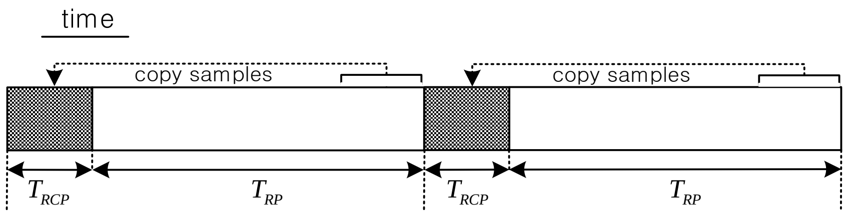
The ranging channel for non-synchronized AMSs is used for initial network entry and association and for ranging against a target BS during handover.

A physical ranging channel for non-synchronized AMSs consists of the ranging preamble (RP) with length of T_{RP} depending on the ranging subcarrier spacing $\Delta f_{RP,}$ and the ranging cyclic prefix (RCP) with length of T_{RCP} in the time domain.

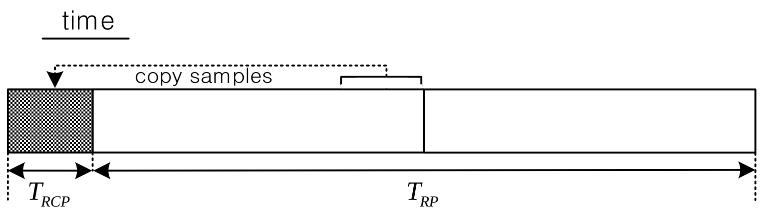
A ranging channel occupies a localized bandwidth corresponding to the [1 or 2] subbands.

Power control operation described in subclause [TBD] applies to ranging signal transmission.

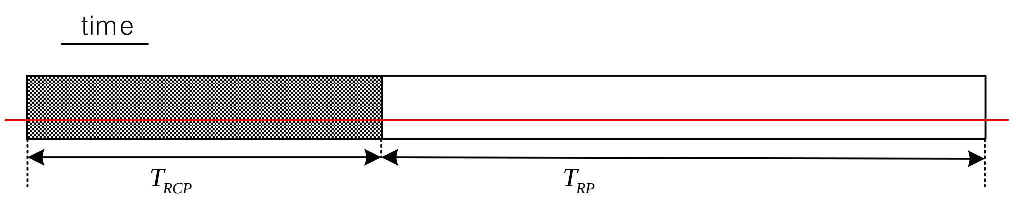
Figure UL- 2 illustrates the ranging channel structures in the time domain.

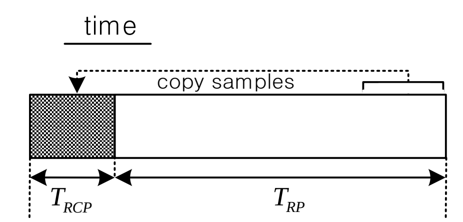


(a) Structure 1



(b) Structure 2





(c) Structure 3

Figure UL- 1, The ranging channel structures in the time domain.

Table UL- 1 shows ~~[~~4~~]~~ ranging channel formats and parameters.

Table UL- 1, Ranging Channel Formats and Parameters.

Format No.	Ranging Channel ~~Format~~Structure	T_{RCP}	T_{RP}	Δf_{RP}
0	Structure 1	$T_g+k\times T_b$ (a)	$2.5\times T_b$	$\Delta f / 2.5$
1	Structure ~~2~~3			

2	Structure 32	$\alpha+T_g$ (b)	$2\times2.5\times T_b$ (c)	
…3	…Structure 3	$T_g+7.296875\times T_b$	$8\times T_b$	Δf / 8

where T_s, T_b, T_g and Δf are defined in *Section 15.3.2.4 Derived parameters.*

(a): The T_{RCP} for Formats 0 and 1 depends on OFDMA parameters, subframe types and duplex mode as follows:

$$k = \left\lceil \left\{ \left[N_{sym} \cdot T_s + \alpha - 2 \cdot \left(T_{RP} + T_g \right) \right] / 3 \right\} \cdot F_s \right\rceil / N_{FFT}$$

where α is 0 and T_{TTG} -50µs for FDD and TDD mode, respectively. N_{sym} is the number of OFDMA symbols in a subframe as defined in *Section 15.3.6.1 Physical and logical resource unit*. F_s and N_{FFT} are defined in *Section 15.3.2.4 Derived parameters*.

(b): The T_{RCP} for Formats 2 depends on duplex mode. α is 0 and T_{TTG} -50µs for FDD and TDD mode, respectively,

(c): T_{RP} for Format 2 denotes the total length of repeated ranging preamble.

In the ranging channel Format 0, the repeated RCPs and RPs are used as a single time ranging opportunity within a subframe in Figure UL- 2 (a). Format 12 consists of a single RCP and repeated RPs within a subframe. Format 21 consists of a single RCP and RP which is a part of the Format 0. When Format 1 is used, there are two time opportunities within a subframe. Format 3 has same structure with Forma 1 but its lengths are different

For the ranging code-opportunity of the non-synchronized AMS, each AMS randomly chooses one of ranging preamble sequences from the available ranging sequence set in a cell defined in *Subclause 15.3.9.2.4.1.1* TBD Ranging preamble codes. When the ranging channel Format 1 is used, a AMS additionally chooses one of a couple of time-opportunities within a subframe.

When the ranging channel format is configured as Format 0, 2, 3, or Format 1 with the first time-opportunity in the time domain, the transmission start time of the ranging channel is aligned with the UL subframe start time at the AMS for FDD mode and the transmission of ranging channel starts at T_{TTG} -50µs before the UL subframe start time at the AMS for TDD mode. For the Format 1 in the second time-opportunity, the transmission of the ranging channel starts at $T_{RCP}+T_{RP}$ after the start time of first time-opportunity in the FDD and TDD mode.

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15.3.9.2.4.1.1. Ranging channel configurations

The information for ranging time/frequency resource allocation is conveyed by the corresponding S-SFH. There are different types of ranging opportunities among ranging channel formats. First, each AMS randomly chooses a subframe-opportunity in the ranging assigned frames within a superframe, which is indicated by S-SFH. When ranging channel Format 1 is used, each AMS randomly chooses a time-opportunity within a selected ranging subframe. Finally, each AMS randomly chooses a code-opportunity from the available ranging sequence set in a cell defined in *Subclause 15.3.9.2.4.1.1 Ranging preamble codes.*

The ranging channel within a frame shall be allocated as the unit of subframe(s) by the unit of subband(s). The ranging subframe-opportunity size is the number of subframe and subband required to allocate the Format of Table UL-1, which are denoted by N_1 and N_2, respectively. For Format 0, 1, and 2, N_1 = 1, and for Format 3, N_1 = 3. The unit of N_2 is [1 or 2] subband(s) for all Formats.

15.3.9.2.4.1.2. Ranging signal transmission

Eqn. UL- 7 specifies the transmitted signal voltage to the antenna, as a function of time, during ranging channel format.

$$s(t) = f_{ranging}()$$

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_C t} \sum_{k=0}^{N_{RP}-1} x_p(k) \cdot e^{j2\pi\left[-\{(N_{used}-1)/2 - k_0 \cdot P_{sc}\}\cdot K + k\right]\Delta f_{RP}(t-\alpha)} \right\} \quad \text{Eqn. UL- 7}$$

where

$f_{ranging}()$ is TBD function

t is the elapsed time since the beginning of the subject ranging channel,

k_0 is a logical ranging channel parameter in the frequency domain as units of N_l, where N_l is the number of the adjacent PRUs within a subband as defined 15.3.6.2.1 *Subband partitioning*.

P_{sc} is the number of the consecutive subcarriers within a PRU in frequency domain as defined 15.3.6.1 *Physical and logical resource unit.*

K is a scaling factor representing subcarrier frequency spacing ratio between the RP and uplink data transmission and is defined by $K = \triangle f / \triangle f_{RP}$

α is the parameter related to the length of ranging cyclic prefix and is defined by

$$\alpha = \begin{cases} T_{RCP}, & 0 \le t < T_{RCP} + R_{RP} \text{ for all formats} \\ T_{RP} + 2 \cdot T_{RCP}, & T_{RCP} + R_{RP} \le t < 2 \cdot (T_{RCP} + R_{RP}) \text{ for format 0} \end{cases}$$

$x_p(n)$ is the *p*-th ranging preamble code with length N_{RP}.

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