UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,
Petitioner

v.

WILUS INSTITUTE OF STANDARDS AND TECHNOLOGY INC.,
Patent Owner

Case IPR2025-00934
U.S. Patent No. 11,159,210

REPLY DECLARATION OF CHRISTOPHER J. HANSEN

I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable under Section 1001 of Title 18 of the United States Code.

Date: June 21, 2026

Dr. Christopher J. Hansen, Ph.D.

SAMSUNG 1041
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IPR2025-00934

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I. INTRODUCTION

1. My name is Dr. Christopher Hansen. I have been retained on behalf of Samsung Electronics Co., Ltd. ("Samsung") to offer technical opinions related to 11,159,210 ("the '210 Patent") (SAMSUNG-1001) in IPR2025-00934.

2. I understand that the Patent Trial and Appeal Board ("PTAB" or "Board") institute Samsung's Petition for *inter partes* review ("IPR") in this proceeding and that Wilus Institute of Standards and Technology Inc. ("Patent Owner," "Wilus," or "PO") has submitted a Patent Owner Patent Owner's Response ("POR") addressing certain issues raised in Samsung's Petition and in my prior declarations in this proceeding. I understand that my prior declarations in this proceeding have been marked as exhibits SAMSUNG-1003, -1026, and -1038.

3. I have been asked to provide my independent assessment of Wilus's POR and the accompanying technical declaration from Wilus's witness, Dr. Todor Cooklev. I have closely reviewed the POR (Paper 25) and Dr. Cooklev's declaration (Ex. 2018). Based on my review, and for reasons that I address in detail herein, neither Wilus nor Dr. Cooklev have convincingly rebutted my analysis from my earlier declarations in SAMSUNG-1003, -1026, or -1038. Wilus and Dr. Cooklev instead erroneously characterize the prior art at issue in this proceeding while failing to address highly relevant portions of the prior art that are inconsistent with the positions advanced in the POR and Dr. Cooklev's declaration.

I maintain the opinions set forth in my earlier declarations, including my opinions that the claims of the ’210 Patent would have been obvious to a person of ordinary skill in the art (“POSITA”) over grounds based on 802.11ax/D1.0 (SAMSUNG-1004), Bharadwaj (SAMSUNG-1013), and Sun (SAMSUNG-1015).

4. I am not and never have been, an employee of Samsung. I received no compensation for this declaration beyond my normal hourly compensation based on my time actually spent analyzing the ’210 Patent, the prior art publications cited below, and issues related thereto, and I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the ’210 Patent.

5. My prior declaration submitted as exhibit SAMSUNG-1003 comprehensively analyzes the prior art and claims of the ’210 Patent. This Declaration incorporates my prior analysis by reference in its entirety. Although this Declaration responds to certain points raised by Wilus in the POR and raised by Dr. Cooklev in his declaration, I may not have responded to every such point raised by Wilus or Dr. Cooklev. The absence of a specific rebuttal to a particular point in either the POR or Dr. Cooklev’s declaration does not signify acquiescence or agreement with the point. On the contrary, the analysis provided in my earlier declarations and in this reply Declaration reflects my firm conviction that claims 1-9 of the ’210 Patent would have been obvious to a POSITA before the Critical

Date.

A. Summary of My Opinions

6. The Challenged Claims of the ’210 patent (claims 1-9) would have been obvious to a POSITA in view of 802.11ax Draft 1.0 (802.11ax/D1.0), Bharadwaj, and Sun, in accordance with the analysis I provided in my earlier declaration marked in this proceeding as SAMSUNG-1003. Specifically, claims 1-5 would have been obvious based on 802.11ax/D1.0 in view of Bharadwaj (Ground 1B); claims 6-9 would have been obvious based on 802.11ax/D1.0 alone (Ground 1A); and claims 1-9 would have been obvious based on Bharadwaj and Sun (Ground 2).

7. 802.11ax/D1.0 teaches single-user transmissions using a high-efficiency, multiple-user physical layer protocol data unit (HE-MU PPDU) when operating in full-bandwidth. 802.11ax/D1.0 provides multiple examples of an HE-MU PPDU being used in full-bandwidth for single-user transmissions, which I discuss in more detail below.

8. 802.11ax/D1.0 renders the challenged claims obvious for multiple reasons, including that it provides HE-SIG-B user field formats for both single-user transmissions and multiple-user transmissions, it distinguishes the resource unit (“RU”) signaling mechanisms when in full-bandwidth from non-full-bandwidth scenarios, it discloses no restrictions on single-user transmissions in

full-bandwidth, and, as mentioned above, it provides multiple examples of single user transmissions using full-bandwidth. It appears that Dr. Cooklev relies on one comment by Youhan Kim in supporting a conclusion that 802.11ax/D1.0 does not teach single-user transmissions in full-bandwidth. Kim's comment, however, was rejected by TGax, i.e., the 802.11ax task group charged with developing the ax amendment to the 802.11 standard. Here, I will discuss the comment and editing process further, and discuss other comments that show that the HE MU PPDU in 802.11ax/D1.0 was understood by others at that time to include single-user transmissions in full-bandwidth.

9. Bharadwaj teaches and renders obvious single-user transmissions in full-bandwidth, providing for the single user format in FIG. 5. Sun provides a specific encoding for the user field in HE-SIG-B for single-user transmissions. For example, Sun provides the NSTS bitfield encoding, which is unique to the single-user format.

10. Bharadwaj and Sun are distinct prior art references that stand on their own apart from 802.11ax/D1.0. Indeed, as I discuss in more detail below, Bharadwaj and Sun predate 802.11ax/D1.0, and yet, each reference includes teachings consistent with the 802.11 standards including the ax amendment at the times of their respective filings. Dr. Cooklev argues that Bharadwaj and Sun do not support single-user transmissions in full-bandwidth because their HE MU

PPDU does not omit the common block of the HE-SIG-B in the same manner as 802.11ax/D1.0. But the Challenged Claims do not require omission of the common block (they do not discuss the common block at all). The common block being omitted is simply an overhead-saving feature, and is not definitive of whether the system supports single-user transmissions in full-bandwidth. Also, at the time Bharadwaj and Sun were filed, the 802.11ax draft amendment had not yet evolved to omit the common block from HE-SIG-B when operating in full-bandwidth. So Bharadwaj and Sun were, at their time of filing, consistent with the state of the draft amendment.

B. Additional Materials Considered

11. In addition to the materials I considered for my other Declarations and the Patent Owner's Response (POR) (Paper 25 of this IPR), I have also considered the following:

SAMSUNG-1040	Deposition Transcript of Dr. Todor v. Cooklev, Ph.D.
SAMSUNG-1042	Comments on TGax 802.11-16-0535r10 November 2016
SAMSUNG-1043	Comment Resolutions on Clause 26.3.12 April 28, 2016
SAMSUNG-1044	Comment Resolutions on Clause 26.3.9.8 May 16, 2016

SAMSUNG-1045	IEEE P802.11ax/D2.0 Draft Standard for Information technology– Telecommunications and information exchange between systems Local and metropolitan area networks– Specific requirements. Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. Amendment 6: Enhancements for High Efficiency WLAN (November 2016) ("802.11ax_D2.0")
Ex. 2016	CIDs on Signaling for UL HE MU PPDU (dated January 16, 2017)
Ex. 2018	Declaration of Todor V. Cooklev, Ph.D.
Ex. 2021	CIDs on Signaling for UL HE MU PPDU (version of Ex. 2016, including redline)
Ex. 2022	LinkedIn Profile for Youhan Kim
Ex. 2023	LinkedIn Profile for John (Ju-Hyung) Son
Ex. 2024	Lochan Verma and Mohammad Fakharzadeh, *Wifi on Steroids: 802.11ac and 802.11ad*, IEEE Wireless Communications (December 2013)
Ex. 2025	Article Preview for *Collision-Aware Rate Adaptation in Multi-rate WLANs: Design and Implementation*

II. GROUNDS 1A-B – 802.11AX/D1.0 TEACHES TRANSMITTING HE-MU PPDU TO A SINGLE USER IN FULL-BANDWIDTH MU-MIMO – [1.5], [1.7], [6.3], [6.5]

12. Based on my review, Wilus's and Dr. Cooklev's assertion that 802.11ax/D1.0 does not support single-user transmissions using an HE-MU PPDU

in full-bandwidth mode is incorrect. Here, I discuss multiple examples in 802.11ax/D1.0 that show single-user transmissions using an HE-MU PPDU in full-bandwidth mode, where full-bandwidth is indicated by the SIGB Compression field in HE-SIG-A set to 1.

A. 802.11ax/D1.0 Teaches Single-User Transmissions using HE-MU PPDU in Full-Bandwidth

13. As I explained in my prior Declaration (SAMSUNG-1003), 802.11ax/D1.0 links the user field formats for single-user, non-MU-MIMO allocation to full-bandwidth transmissions when SIGB Compression is 1. *E.g.*, SAMSUNG-1003 ¶110. Specifically, 802.11ax/D1.0 describes that the format of the user fields (shown in Tables 28-22 and 28-23 above) are identified based on the number of MU-MIMO users indicated by a subfield of the HE-SIG-A when operating in full bandwidth. *See, e.g.*, SAMSUNG-1004, 264-265, 320-324. The cited portions of 802.11ax/D1.0 differentiate between allocation signaling mechanisms for full-bandwidth and for non-full-bandwidth transmissions. 802.11ax/D1.0 explains that when the value of SIGB Compression field in HE-SIG-A is 0 (indicating non-full-bandwidth mode (also referred to as partial bandwidth)), the number of users is indicated with the RU allocation as defined in Table 28-21 (RU allocation signaling: arrangement and number of MU-MIMO allocations).

28.3.3.8.3 Resource indication and STA self-identification in an HE MU PPDU

An AP that transmits an HE MU PPDU shall set the UL/DL field in the HE-SIG-A field to 0. A full bandwidth MU-MIMO transmission using HE MU PPDU format has a value of 1 for the SIGB Compression field in HE-SIG-A and the SIGB Common field is not present. If the value of SIGB Compression field in HE-SIG-A is 0, the RU allocation signaling in the HE-SIG-B common field indicates the combination of RUs in current PPDU bandwidth and the number of STAs on each RU for SU/MU-MIMO transmission. The number of users in RU r for MU-MIMO transmission, $N_{user,r}$ is indicated together with the RU allocation as defined in Table 28-21 (RU allocation signaling: arrangement and number of MU-MIMO allocations). If the

SAMSUNG-1004, 264 (annotated)

Thus, when SIGB Compression is 0 (non-full-bandwidth), 802.11ax/D1.0 uses the format in Table 28-21 for the RU allocation signaling. 802.11ax/D1.0 uses a different format for non-full-bandwidth because in non-full-bandwidth, in 802.11ax/D1.0, the HE-SIG-B includes a common block that includes the RU allocation. SAMSUNG-1004, 264.

14. By contrast, when the SIGB Compression field in HE-SIG-A is 1 (indicating full-bandwidth), the number of stations in the MU-MIMO group is indicated in the "Number Of HE-SIG-B Symbols Or MU-MIMO Users" field in HE-SIG-A, where "the number of spatial streams, $N_{SS,r,u}$, is indicated by the NSTS field in user specific block defined in Table 28-22 (Fields of the HE-SIG-B user field for a non-MU-MIMO allocation) and Table 28-23 (Fields of the HE-SIG-B user field for an MU-MIMO allocation)." *Id*., 265; *see also id*. (explaining that in $N_{SS,r,u}$, the number of users can include 1: "$u = 1, \ldots, N_{user,r}$"). Pertinent portions of 802.11ax/D1.0 are highlighted below:

defined in Table 28-21 (RU allocation signaling: arrangement and number of MU-MIMO allocations). If the value of the SIGB Compression field in HE-SIG-A is 1, there is no RU allocation signaling in HE-SIG-B Common field and HE-SIG-B contains only User specific fields. The number of STAs in the MU-MIMO group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in HE-SIG-A. For bandwidths larger than 20 MHz, the User block fields are split equitably between two SIG-B channels, i.e., for a k user MU-MIMO PPDU, 1, …., ceil(k/2) User block fields are carried in HE-SIG-B content channel 1 and ceil(k/2) + 1, …, k User block fields in HE-SIG-B content channel 2. The number of spatial streams, $N_{SS,r,u}$, is indicated by the NSTS field in user specific block as defined in Table 28-22 (Fields of the HE-SIG-B user field for an non-MU-MIMO allocation) and Table 28-23 (Fields of the HE-SIG-B user field for an MU-MIMO allocation). The allocated spatial streams for a designated MU-MIMO user and the total number of spatial streams on the RU are indicated in spatial configuration field of user specific block containing the STA ID of designated MU-MIMO STA as defined in Table 28-24 (Spatial Configuration subfield encoding).

When processing the HE-SIG-B, a STA will look at information of each RU to find out its membership status, i.e., if it belongs to a beamformee group in a certain RU. If $N_{user,r}$ STAs are scheduled in RU r, there are $N_{user,r}$ user specific blocks for RU r. Each user specific block has an 11-bit field indicating the STA ID. A STA identifies itself as a member in the beamformee group in the RU, if its STA ID matches one of the STA IDs. The user position is indicated by the block index. From a multiplexing information lookup table for $N_{user,r}$, the ordered number of spatial streams for all members in the beamformee group in RU r, $N_{SS,r,u}$, u = 1, …, $N_{user,r}$ is obtained. The spatial streams of different users are ordered in accordance to user position values, i.e., the spatial streams for the user in user position 0 come first, followed by the spatial streams for the user in position 1, followed by the spatial streams for the user in position 2, and followed by the spatial streams for the user in position 3, and so on.

SAMSUNG-1004, 264-265 (annotated)

Table 28-22 for non-MU-MIMO allocation includes a bitfield encoding for the number of spatial streams indicated by the NSTS field in the HE-SIG-B user block. SAMSUNG-1004, 264-265. But for MU-MIMO allocation, the spatial streams is embedded in Table 28-24, which provides for the spatial configuration subfield encoding of the user field defined by Table 28-23. SAMSUNG-1004, 264-265. This distinction between non-MU-MIMO format (does not include spatial configuration subfield) and MU-MIMO format (includes spatial configuration subfield) also provides important context to Youhan Kim's comment. As discussed further below, Kim's reference to the spatial configuration subfield is only relevant

to the MU-MIMO allocation, and has nothing to do with the non-MU-MIMO (single-user) allocation.

15. Therefore, 802.11ax/D1.0 differentiates the signaling mechanisms for non-full-bandwidth (in Table 28-21) from the signaling mechanisms for full-bandwidth (in Table 28-22 (non-MU-MIMO) and Tables 28-23–24 (MU-MIMO). Put simply, when SIGB Compression is 1 and indicates full-bandwidth and there is no common block field, 802.11ax/D1.0 provides a single-user format for HE-SIG-B user fields (in Table 28-22) and provides a multi-user format for HE-SIG-B user fields (in Tables 28-23 & 28-24). But in non-full-bandwidth, the allocation signaling is provided in the common block field by Table 28-21.

16. Note that in 802.11ax/D.10, the HE-SIG-B is only in the HE-MU PPDU, and is not in the HE-SU PPDU:

HE-SIG-B only present in HE-MU PPDU

The format of the HE SU PPDU is defined as in Figure 28-5 (HE SU PPDU format). This PPDU format is used for SU transmission and, in this format, the HE-SIG-A field is not repeated.



Figure 28-5—HE SU PPDU format

The format of the HE MU PPDU is defined as in Figure 28-6 (HE MU PPDU format). This format is used for transmission to one or more users that is not a response of a Trigger frame. The HE-SIG-B field is present in this format.



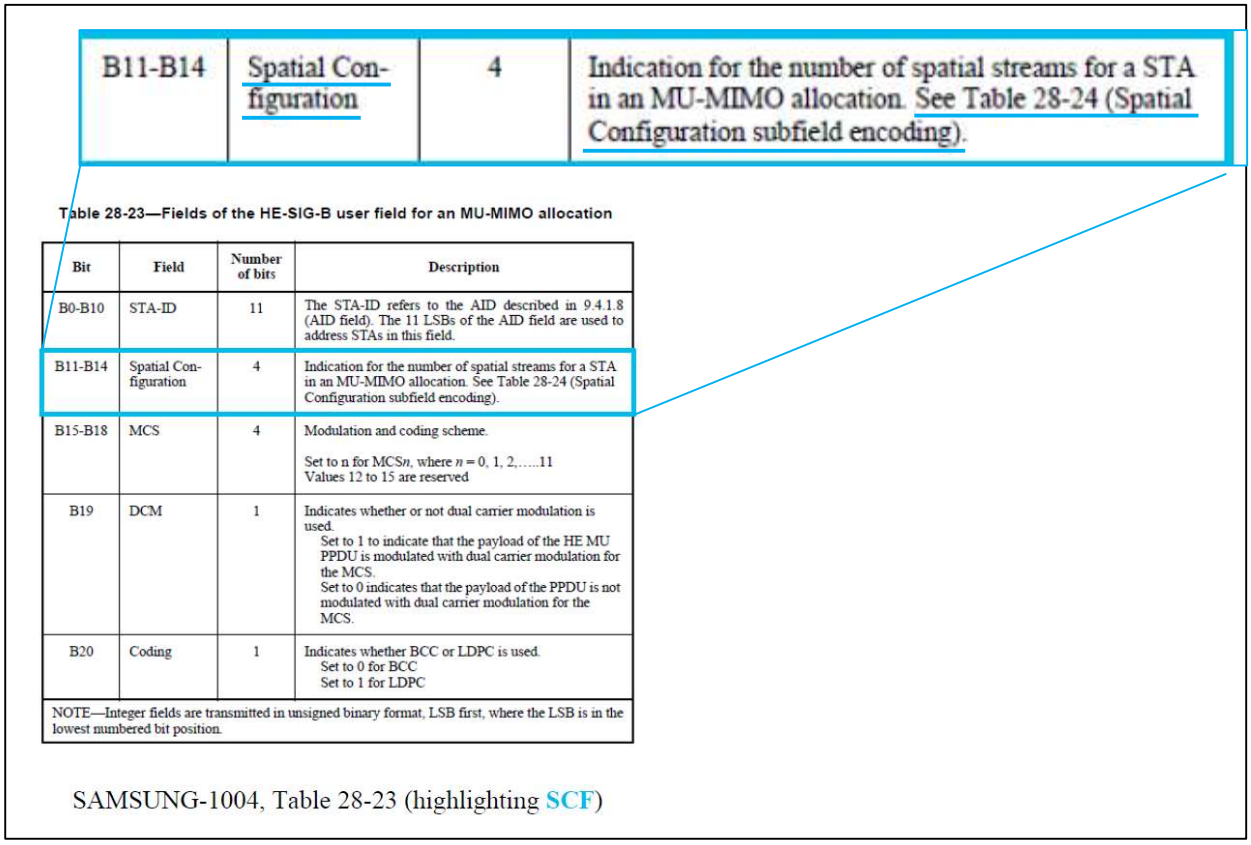
Figure 28-6—HE MU PPDU format

SAMSUNG-1004, Figures 28-5–5 (annotated)

SAMSUNG-1004, 267; SAMSUNG-1003 ¶61. Comparing Figures 28-5 (HE-SU PPDU Format) with 28-6 (HE-MU PPDU format), both contain the HE-SIG-A, but only the HE-MU PPDU includes the HE-SIG-B. SAMSUNG-1004, 267. Thus, when 802.11ax/D1.0 refers to the fields of the HE-SIG-B, it is referring to an HE-MU PPDU and not an HE-SU PPDU. Note also that the HE extended range SU PPDU format and the HE trigger-based PPDU format do not have HE-SIG-B fields either. SAMSUNG-1004, 267. Therefore, 802.11ax/D1.0 provides an HE-MU PPDU HE-SIG-B user-field format for single user, non-MU-MIMO allocation.

17. Dr. Cooklev seems to acknowledge that Table 28-24 is used for MU-MIMO allocation in full-bandwidth. Ex. 2018 ¶50. Table 28-24 provides the

spatial configuration subfield encoding for Table 28-23, which is also for full-bandwidth transmissions. 802.11ax/D1.0, 265, 320-324:



B11-B14	Spatial Con-figuration	4	Indication for the number of spatial streams for a STA in an MU-MIMO allocation. See Table 28-24 (Spatial Configuration subfield encoding).

Table 28-23—Fields of the HE-SIG-B user field for an MU-MIMO allocation

Bit	Field	Number of bits	Description
B0-B10	STA-ID	11	The STA-ID refers to the AID described in 9.4.1.8 (AID field). The 11 LSBs of the AID field are used to address STAs in this field.
B11-B14	Spatial Con-figuration	4	Indication for the number of spatial streams for a STA in an MU-MIMO allocation. See Table 28-24 (Spatial Configuration subfield encoding).
B15-B18	MCS	4	Modulation and coding scheme. Set to n for MCSn, where n = 0, 1, 2,.....11 Values 12 to 15 are reserved
B19	DCM	1	Indicates whether or not dual carrier modulation is used. Set to 1 to indicate that the payload of the HE MU PPDU is modulated with dual carrier modulation for the MCS. Set to 0 indicates that the payload of the PPDU is not modulated with dual carrier modulation for the MCS.
B20	Coding	1	Indicates whether BCC or LDPC is used. Set to 0 for BCC Set to 1 for LDPC
NOTE—Integer fields are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.			

SAMSUNG-1004, Table 28-23 (highlighting SCF)

Petition, 37-38 (citing SAMSUNG-1004, Tablet 28-23)

SAMSUNG-1003, ¶¶107-115. And as shown in 802.11ax/D1.0 (highlighted above), single-user, non-MU-MIMO allocation in Table 28-22 is mentioned in the same sentence as Table 28-23, and is likewise for full-bandwidth transmissions.

18. As I explained in my prior Declaration (SAMSUNG-1003), Table 28-22 supports single-user (non-MU-MIMO) full-bandwidth transmissions, whereas Tables 28-23–28-24 support MU-MIMO transmissions. SAMSUNG-1003 ¶¶108-115. In 802.11ax/D1.0 (and in the '210 patent), Table 28-22 for single-user (non-

MU-MIMO) full-bandwidth transmissions does not include a spatial configuration subfield; whereas Table 28-24 is the bitfield encoding for the spatial configuration subfield for the MU-MIMO format of Table 28-23. SAMSUNG-1001, 20:33-21:54, FIGS. 13(d)-1–2; SAMSUNG-1004, 264-265, 321-324; SAMSUNG-1003 ¶¶91, 108-115. Table 28-24 is not relevant to the single-user format of Table 28-22 because Table 28-22 does not include a spatial configuration subfield. SAMSUNG-1004, 264-265, 321-324. As discussed below, Youhan Kim's comment only applied to the multi-user scenario of Table 28-24 and was rejected because it failed to recognize the single-user, full-bandwidth scenario, supported by Table 28-22 in 802.11ax/D1.0.

B. Other Portions of 802.11ax/D1.0 Support Single User HE-MU PPDU in Full BW

19. In response to Dr. Cooklev's statement that 802.11ax/D1.0 does not support single-user transmissions of HE-MU PPDU in full-bandwidth MU-MIMO, I offer the following by way of counterpoints:

20. 802.11ax/D1.0 taken as a whole discloses and renders obvious single-user transmissions in full-bandwidth. To begin with, 802.11ax/D1.0 supports transmitting an HE-MU PPDU to a single user. For example, 802.11ax/D1.0 defines the HE-MU PPDU format as carrying "one or more PSDUs to **one or more users**." SAMSUNG-1004, 239. Dr. Cooklev confirmed that a PSDU is a PHY service data unit that carries data for a single user. SAMSUNG-1040, 35:12-36:17,

49:6-20. The HE-MU PPDU is defined as the format for transmitting to one or more users throughout 802.11ax/D1.0. SAMSUNG-1004, 188 ("HE-MU downlink "allows the AP to transmit simultaneously to **one or more non-AP STAs"** using DL MU-MIMO), 253 ("During transmission, a PSDU (in the SU case) or one or more PSDUs (in the MU case) are processed (i.e., scrambled and coded) and appended to the PHY preamble to create the PPDU."), 267 (HE-MU PPDU format used "for transmission to **one or more users**"), 312 (User Specific field of an HE-SIG-B (only in HE-MU PPDU) consists of one or more User Block Fields, where last block is for 1 or 2 users).

21. 802.11ax/D1.0 explains that in full bandwidth mode, the HE-MU PPDU is configured with a single resource unit (RU) that spans the entire bandwidth of the channel. Given that the HE-MU PPDU carries data in some instances to just one user (as discussed above), and that a user can be assigned to at most one RU, a POSITA would have understood that an HE-MU PPDU directed to "one" user employs a full bandwidth transmission consisting of a single RU. *E.g.*, 802.11ax/D.10, 189 ("Two STA-ID fields in HE-SIG-B shall not have the same value, unless the value is 2046, which is used to indicate an unallocated RU. If an AP sets one of the STA-ID field in the HE-SIG-B field to match the AID of a non-AP STA, then the non-AP STA may disregard any broadcast RU in the same HE MU PPDU."). In 802.11ax/D1.0, the STA-ID is the association identifier given to

each STA by the AP when it associates with the AP. These are unique. The HE-SIG-B common field is used to allocate each RU individually or as a broadcast RU. Each STA only has to receive and decode one RU.

22. Next, 802.11ax/D1.0 supports single-user transmissions utilizing the full bandwidth of the channel using a single resource unit. 802.11ax/D1.0 defines a full-bandwidth HE transmission as using a single, 242-tone resource unit (RU) allocated for the 20 MHz channel:

> **non-orthogonal frequency division multiple access (non-OFDMA):** A full bandwidth HE transmission with 242-tone RU, 484-tone RU, 996-tone RU, 2×996-tone RU, or 2×996-tone RU allocated for 20 MHz, 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz transmission, respectively.

SAMSUNG-1004, 39 (annotated)

23. As Dr. Cooklev confirmed during deposition, a full bandwidth transmission, in the case of 20 MHz, indicates a single, 242-tone RU. SAMSUNG-1040, 54:17-56:7, 44:21-455 ("Whatever the format for single user, that transmission or that PPDU will use one resource unit."). I agree. 802.11ax/D1.0 characterizes the maximum number of RUs for a 20 MHz channel width (CHW20) as equal to 1 for a 242-tone RU:

The maximum number of RUs in the 20 MHz, 40 MHz, 80 MHz, 160 MHZ and 80+80 MHz HE PPDU formats are defined in Table 28-2 (Maximum number of RUs for each channel width)..

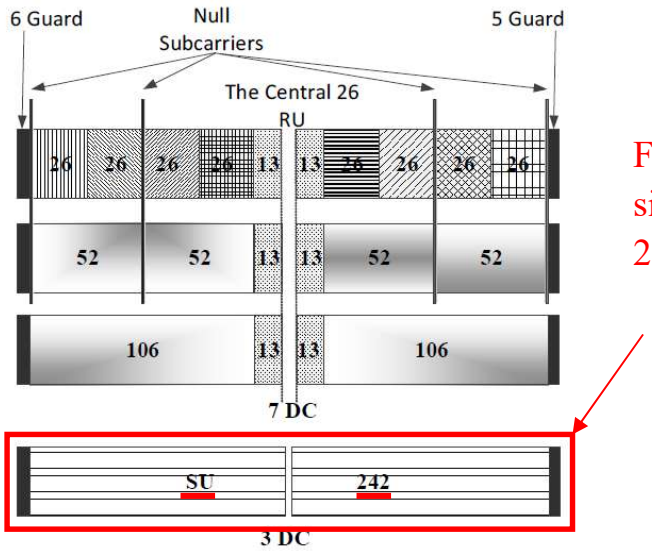
Table 28-2—Maximum number of RUs for each channel width

RU type	CBW20	CBW40	CBW80	CBW80+80 and CBW160
26-tone RU	9	18	37	74
52-tone RU	4	8	16	32
106-tone RU	2	4	8	16
242-tone RU	1	2	4	8
484-tone RU	N/A	1	2	4
996-tone RU	N/A	N/A	1	2
2×996 tone RU	N/A	N/A	N/A	1

SAMSUNG-1004, 255, Table 28-2, (annotated)

24. Likewise, I understand Dr. Cooklev agreed in deposition that full-bandwidth refers to a transmission using a single resource unit ("RU") over the entire channel (e.g., a 20 MHz channel). SAMSUNG-1040, 50:23-51:8. This is correct. For example, 802.11ax/D1.0 uses the HE-MU PPDU format using a single, 242-tone RU in 20 MHz full-bandwidth transmissions. SAMSUNG-1004, 255.

25. 802.11ax/D1.0 discloses full-bandwidth, single 242-tone RU for single user transmissions using an HE-MU PPDU, as shown in Figure 28-2:



Full bandwidth, 242-tone RU for single user (SU) transmissions in a 20 MHz HE-MU PPDU

Figure 28-2—RU locations in a 20 MHz HE PPDU

SAMSUNG-1004, FIG. 28-2 (annotated)

26. Dr. Cooklev confirmed that Figure 28-2 shows RU locations for a 20 MHz HE-MU PPDU. SAMSUNG-1040, 58:6-59:9; SAMSUNG-1004, 257. Likewise, Dr. Cooklev confirmed that Figure 28-2 shows that the HE-MU PPDU uses the full-bandwidth, single 242-tone RU for single user (SU) transmissions. SAMSUNG-1040, 59:6-60:5.

27. Other portions of 802.11ax/D1.0 likewise indicate support for full-bandwidth, single user transmissions using HE-MU PPDU. For example, 802.11ax/D1.0 teaches the following:

- 802.11ax/D1.0 teaches that a non-AP station can indicate support for "the reception of an HE MU PPDU payload **over full bandwidth**" in Table 9-262a–Subfields of the HE PHY Capabilities Information field. SAMSUNG-

1004, 110.

- "An HE AP shall support … [t]ransmission of an HE MU PPDU where none of the RUs utilize MU-MIMO (DL OFDMA)." SAMSUNG-1004, 237.
- "An HE AP shall support … [t]ransmission of an HE MU PPDU consisting of a single RU spanning the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO)." SAMSUNG-1004, 237.
- "An HE non-AP station shall support … [r]eception of an HE MU PPDU consisting of a single RU spanning the entire PPDU bandwidth and utilizing MU-MIMO (DL MU-MIMO)." SAMSUNG-1004, 237.
- "An HE non-AP station may support … [t]ransmission of an HE MU PPDU over partial PPDU bandwidth and full PPDU bandwidth." SAMSUNG-1004, 238.
- Figure 28-13 depicts a "[t]ransmitter block diagram for the Data field of an **HE SU transmission** in a … **242-tone RU** with BCC encoding," and in particular "the transmitter blocks used to generate the Data field of a **single user HE transmission within a … 242-tone RU** with BCC encoding for a single frequency segment when the number of spatial stream is less than or

equal to 4."[1] SAMSUNG-1004, 271-272.

28. Dr. Cooklev's declaration turns to Table 28-24 as evidence of why 802.11ax/D1.0 prohibits full-bandwidth single-user transmission, relying on Kim's comments regarding the spatial configuration subfield. *E.g.*, SAMSUNG-1040, 63:9-13. But Table 28-24 is not relevant to the single-user (non-MU-MIMO) scenario. As explained before, Tables 28-23 and 28-24 are specifically for MU-MIMO allocation, where Table 28-23 includes a spatial configuration field and 28-24 provides the spatial configuration subfield encoding. *E.g.*, SAMSUNG-1004, 322-324; Petition, 25-26 (citing SAMSUNG-1001, FIGS. 13(d)1-(d)2); *see also* SAMSUNG-1001, 20:33-54, cls. 2, 7. Thus, Kim's comments about the number of users being greater than or equal to 2 make sense in that context—Table 28-24 is ONLY for MU-MIMO, so the number of users is greater than 2. But 802.11ax/D1.0 provides for ANOTHER user field format to support single-user, non-MU-MIMO transmissions, including transmissions in full-bandwidth.

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[1] The disclosure in Figure 28-13 is not limited to HE SU PPDUs, but likewise applies to HE MU PPDUs that support OFDMA transmissions. SAMSUNG-1004, 271 ("This also includes the SU transmission in an RU that is part of a downlink or uplink OFDMA PPDU"). Other transmitter diagrams in 802.11ax/D1.0 apply specifically to HE SU PPDUs. *See e.g.*, SAMSUNG-1004, 274, FIG. 28-16.

Specifically, Table 28-22 (Fields of the HE-SIG-B user field for an non-MU-MIMO allocation) provides the subfields for the "HE-SIG-B user field for an SU allocation." SAMSUNG-1004, 321. In contrast to Tables 28-23–24, Table 28-22 does not include a spatial configuration subfield; instead, Table 28-22 indicates the number of spatial streams $N_{SS,r,u}$ by the NSTS field, where in $N_{SS,r,u}$, the number of users can include 1: "u = 1, …, $N_{user,r.}$" SAMSUNG-1004, 264-266, 320-324; Petition, 26-27, 35-41, 47; SAMSUNG-1001, 20:33-54, cls. 2 & 7.

29. As I explained in my prior Declaration (SAMSUNG-1003), and consistent with 802.11ax/D1.0 and the '210 patent, the user field format for single user, non-MU-MIMO allocation includes the NSTS field without a spatial configuration field, whereas the format for the MU-MIMO allocation includes a spatial configuration subfield. SAMSUNG-1004, 264-266, 320-324; Petition, 26-27, 35-41, 47; SAMSUNG-1001, 20:33-54, cls. 2 & 7; SAMSUNG-1003 ¶¶88-91, 108-115. Thus, Dr. Cooklev's reliance on Kim's comment that "the Spatial Config subfield in HE-SIG-B has Nuser >= 2" is not probative to single-user transmissions because the spatial configuration subfield only applies to the user field format for MU-MIMO allocations in Tables 28-23–28-24.

30. Based on my extensive involvement with the 802.11 Working Group, including the ax Task Group (TGax), the notion that a significant change to D1.0 would be made based on comments during the letter ballot process is very unlikely.

Overwhelmingly, comments produced during the letter ballot process, including the comment from John Son et al., *Discussions on Signaling for UL HE MU PPDU*, SAMSUNG-1115, prompt clarifications to features already understood to be part of or suggested by the draft amendment, as opposed to introducing new technical features that were not already supported or clearly suggested. As I mentioned above, 802.11ax/D1.0 already taught that an "HE non-AP station may support … [t]ransmission of an HE MU PPDU over partial PPDU bandwidth and full PPDU bandwidth." SAMSUNG-1004, 238. The disclosures noted above provided the basis, already in 802.11ax/D1.0, for the task group's rejection of Kim's comment. The edits made to 802.11ax/D1.0 were clarifications to concepts already enshrined within the draft.

III. 802.11AX/D1.0 RENDERS THE CHALLENGED CLAIMS OBVIOUS

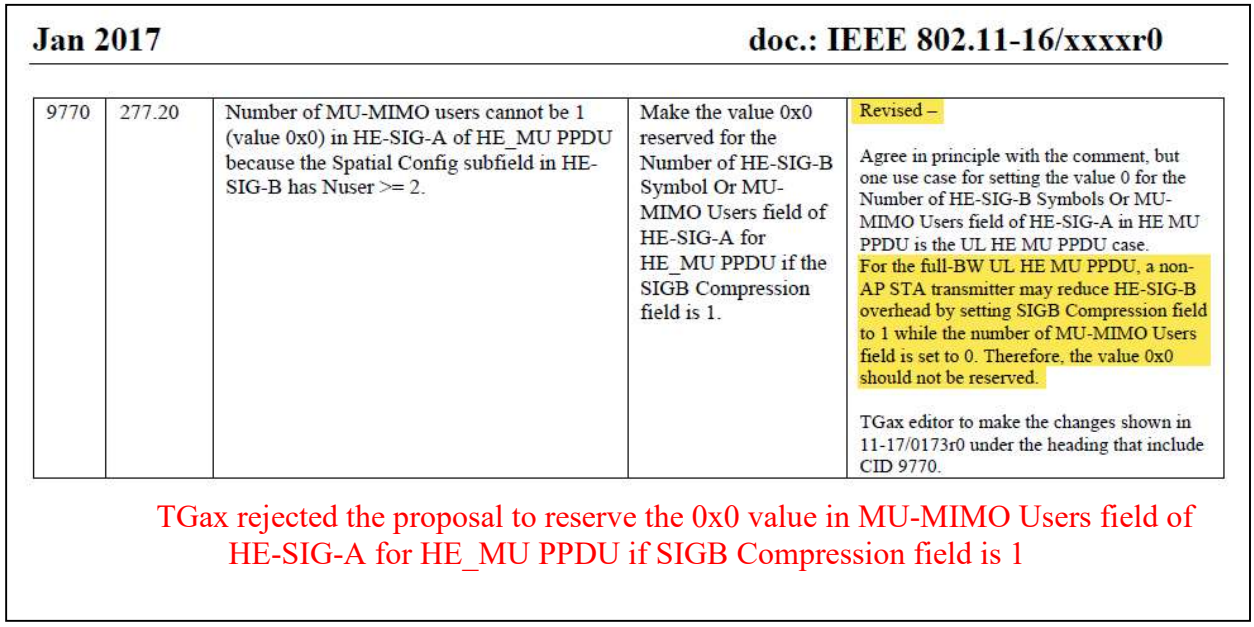
31. 802.11ax/D1.0 expressly teaches single-user transmissions of HE-MU PPDU in full-bandwidth, where the number of users is indicated by HE-SIG-A when SIGB Compression is set to 1. But 802.11ax/D1.0 also renders the challenged claims obvious. As I discussed above, the totality of the 802.11ax/D1.0 draft provides ample evidence that single-user transmissions of HE-MU PPDU using full-bandwidth were explicitly disclosed by 802.11ax/D1.0. At a minimum, a holistic assessment of D1.0 and contemporaneous comments on the draft demonstrate that single-user transmissions of HE-MU PPDU using full-bandwidth

was at least plainly suggested in D1.0 and therefore would have been obvious and understood by a POSITA before the Critical Date of the '210 Patent.

A. Youhan Kim's Comments Were Rejected

32. Because Dr. Cooklev's analysis in his declaration relies heavily on Youhan Kim's comments, I will start there to address how contemporaneous comments from TGax participants do not support Dr. Cooklev's theories. First, Youhan Kim's comment was one of thousands submitted as part of votes on the 802.11ax/D1.0 draft, and, importantly, Kim's comment was rejected by the task group. SAMSUNG-1035. EX2021, 3.

33. The comment and task group's response is reproduced below:



Jan 2017 **doc.: IEEE 802.11-16/xxxxr0**

9770	277.20	Number of MU-MIMO users cannot be 1 (value 0x0) in HE-SIG-A of HE_MU PPDU because the Spatial Config subfield in HE-SIG-B has Nuser >= 2.	Make the value 0x0 reserved for the Number of HE-SIG-B Symbol Or MU-MIMO Users field of HE-SIG-A for HE_MU PPDU if the SIGB Compression field is 1.	Revised – Agree in principle with the comment, but one use case for setting the value 0 for the Number of HE-SIG-B Symbols Or MU-MIMO Users field of HE-SIG-A in HE MU PPDU is the UL HE MU PPDU case. For the full-BW UL HE MU PPDU, a non-AP STA transmitter may reduce HE-SIG-B overhead by setting SIGB Compression field to 1 while the number of MU-MIMO Users field is set to 0. Therefore, the value 0x0 should not be reserved. TGax editor to make the changes shown in 11-17/0173r0 under the heading that include CID 9770.

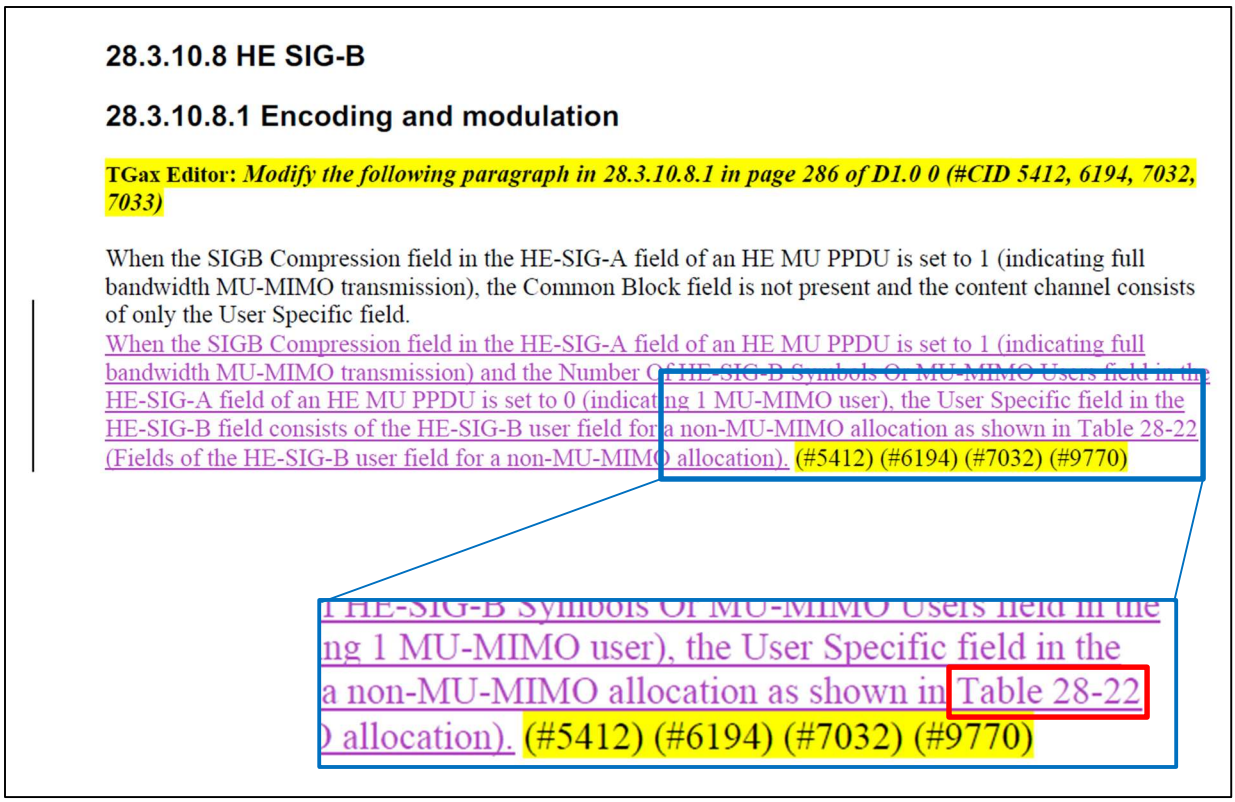
TGax rejected the proposal to reserve the 0x0 value in MU-MIMO Users field of HE-SIG-A for HE_MU PPDU if SIGB Compression field is 1

EX2021, 3 (annotated)

34. Parsing Kim's comment first, he is suggesting to reserve the 0x0 value of HE-SIG-A because the number of users in the Spatial Config subfield is greater

than or equal to 2. Note that as I discussed above, Kim is correct that in Table 28-24, the number of users starts at 2, but that is because Table 28-24 (and Table 28-23) are only used to support the MU-MIMO in a resource unit (RU). The task group rejected Kim's comment, noting that there are use-cases that would require setting the value of the number of users to 1. We know that that the task group rejected the comment because they did not reserve the 0x0 value as Kim suggested. Instead, the task group pointed out that in 802.11ax/D1.0, the number of MU-MIMO users field can be set to 0 while in full bandwidth. EX2021, 3 (see highlighting above).

35. The edits that the task group emphasize, consistent with other portions of the draft amendment, that 802.11ax/D1.0 does support single-user transmissions using HE-MU PPDU in full-bandwidth in the downlink, pointing expressly to Table 28-22 for the non-MU-MIMO allocation. Ex. 2021, 3:



Ex. 2021 at 3 (annotated)

As discussed above at length, Table 28-22 was in 802.11ax/D1.0 and was the user field format in HE-SIG-B for single user, non-MU-MIMO allocation in full-bandwidth. Thus, the edits reflect what was already understood from 802.11ax/D1.0.

36. In this same document, to reject yet another Wilus comment, the task group pointed out that 802.11ax/D1.0 required the use of the non-MU-MIMO user field format for full-bandwidth single-user transmissions:

5412	285.55	An HE MU PPDU with the UL/DL field set to 1 is intended to one STA and the HE-SIG-B design is not efficient.	Please refine the HE-SIG-B design for the UL case to reduce the length of the HE-SIG-B field.	Revised – Agree in principle with the comment as discussed in 11-17/0110r0. For the full-BW UL HE MU PPDU, the Common Block field of HE-SIG-B is redundant. A transmitter may omit the field by setting SIGB Compression field in HE-SIG-A to 1. However, when SIGB Compression field is 1, MU-MIMO user field is sent where its Spatial Configuration subfield can only support NSTS indication for N_user >= 2. Therefore, it is required that the User field in HE-SIG-B contains the non-MU-MIMO user field when the Num of MU-MIMO Users field in HE-SIG-A is set to 0. TGax editor to make the changes shown in 11-17/0173r0 under the heading that include CID 5412.

EX2021 at 2 (annotated).[2]

The text in the task group comment says that when SIGB compression field is 1, "it is required that the User field in HE-SIG-B contains the non-MU-MIMO user field when the Num of MU-MIMO Users field in HE-SIG-A is set to 0." Ex. 2021 at 2. This statement confirms that 802.11ax/D1.0 supported single-user transmissions of HE-MU PPDU in full-bandwidth. The 802.11ax task group understood that it was "required" to use the non-MU-MIMO user field (shown in Table 28-22) when the number of users in HE-SIG-A was set to 0 (indicating 1 user). Ex. 2021 at 2; *see also* Petition, 34-42 (discussing the user field format for

[2] Note that in 802.11ax/D0.2, the common block is not used for full-bandwidth operation. SAMSUNG-1008, 177; SAMSUNG-1042 (comment 2126 by Sriram Venkatsewaran); SAMSUNG-1043, 2 (entering edits).

single-user, non-MU-MIMO allocation in Table 28-22 for full-bandwidth transmissions of HE-MU PPDU).

37. In this context, it would have been understood to a POSITA that 802.11ax/D1.0 supported single-user transmissions in full-bandwidth. Even if Wilus's argument were accepted that a POSITA would have questioned whether 802.11ax/D1.0 supported the use of HE MU PPDUs for single-user transmissions in full-bandwidth (which, as I have explained, a POSITA would not have questioned), the question itself speaks to the obviousness of the claimed solution because the question presents a simple choice between two recognized options. The '210 Patent at best claims one of these two recognized options.

38. Also, consistent with the Petition's mappings, the edits made to §28.3.10.8 emphasize that the user field for a non-MU-MIMO allocation is shown in Table 28-22, a concept already disclosed by 802.11ax/D1.0. EX2021, 3; SAMSUNG-1004, 320-324 ("The HE-SIG-B user field for an SU allocation contain the subfields shown in Table 28-22 (Fields of the HE-SIG-B user field for an non-MU-MIMO allocation)."), 277-278 (HE-SIG-B only for HE-MU PPDU); Petition, 26-27, 35-41, 47.

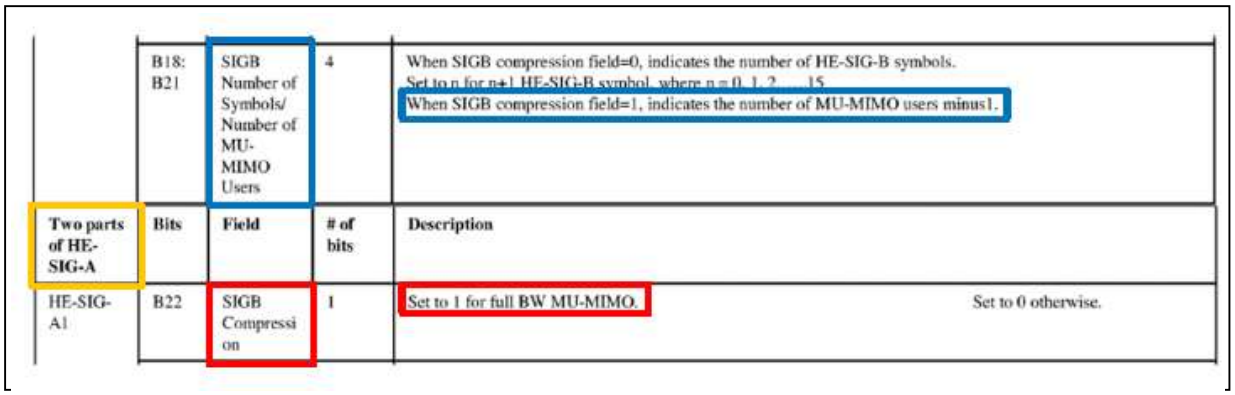
B. Dorothy Stanley's Comments Show Obviousness

39. Wilus attempts to couch Dorothy Stanley's comments as evidence that a POSITA would not have understood 802.11ax/D1.0 as permitting use of an HE-

MU PPDU for a single user. POR, n.3. I disagree. Stanley stated "Regarding 'Each User Block field is made up of two user fields,' is it allowed to use the HE MU PPDU for a single user? If so, this statement is incorrect. Please clarify." SAMSUNG-1036, 3. In response, the task group agreed with Stanley, commenting that the text described that "the User Block field consists of 2 User field except the last user block field" and that "the HE-MU PPDU can be used for single user." SAMSUNG-1036, 3. Stanley's comment assumed that using HE-MU PPDU for a single-user was permitted, and was requesting that the draft expressly reflect that fact. SAMSUNG-1035, 142; SAMSUNG-1041, 3. The task group agreed with her. SAMSUNG-1041, 3. Stanley's comment also confirms that single-user transmissions were not prohibited by the standard, as PO suggests. Instead, Stanley's comments are evidence that single-user transmissions were contemplated by the standard, evidence borne-out by the task group's acceptance of her request.

IV. GROUND 2 – BHARADWAJ CONTEMPLATES SINGLE USER MU-MIMO TRANSMISSIONS IN FULL-BANDWIDTH – CLAIMS [1.7], [6.5]

40. Bharadwaj contemplates full-bandwidth MU-PPDU transmissions to a single user. First, as discussed in the Petition, Bharadwaj teaches that in full-bandwidth, the number of MU-MIMO users is indicated by the "SIGB Number of Symbols/Number of MU-MIMO Users" field:



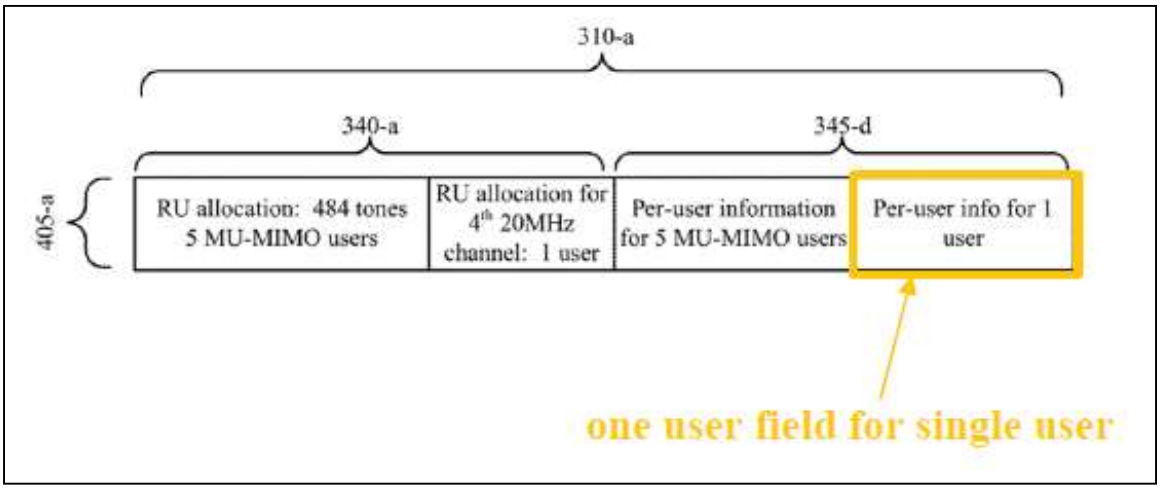
	B18: B21	SIGB Number of Symbols/ Number of MU-MIMO Users	4	When SIGB compression field=0, indicates the number of HE-SIG-B symbols. Set to n for n+1 HE-SIG-B symbol, where n = 0, 1, 2 ..... 15 When SIGB compression field=1, indicates the number of MU-MIMO users minus1.
Two parts of HE-SIG-A	**Bits**	**Field**	**# of bits**	**Description**
HE-SIG-A1	B22	SIGB Compression	1	Set to 1 for full BW MU-MIMO. Set to 0 otherwise.

Petition, 70-71; SAMSUNG-1013, FIGS. 21A-B

41. Note that Bharadwaj does not restrict the number of MU-MIMO users indicated in the HE-SIG-A to be greater than 1. Also in FIG. 21B, Bharadwaj provides a bitmap for encoding a cyclic prefix and long training field for a full bandwidth MU PPDU targeted to a single user. SAMSUNG-1013, FIG. 21B. Thus, a POSITA would have understood that Bharadwaj, when read as a whole, discloses or renders obvious that the number of MU-MIMO users indicates a single user in full-bandwidth..

42. The Petition links the single user transmissions to full-bandwidth operation. Specifically, the Petition explains that, in Bharadwaj, 1) **when SIGB compression is set to 1**, the "SIGB Number of Symbols/Number of MU-MIMO Users" field indicates **the number of MU-MIMO users**; and 2) when **the number of MU-MIMO users** indicates a single user, the HE-SIG-B field includes a user-specific field for non-MU-MIMO (SU) allocation for one user. Petition, 70-71, 73; SAMSUNG-1013, FIGS. 21A-B, ¶[0097]. The Petition explained that Bharadwaj

discloses a user block in an HE-SIG-B for a single user:



Petition, 73; SAMSUNG-1013 ¶[0085]-[0087], FIG. 5

43. The POR points to Bharadwaj, FIG. 7, which is a table showing the spatial configuration encoding. Bharadwaj ¶[0093]. And as Bharadwaj explains, a "**user field for an MU-MIMO allocation**, e.g. in a HE-SIG-B field, may include a spatial configuration subfield." *Id*. Thus, in Bharadwaj, like in 802.11ax/D1.0, the spatial configuration subfield is encoded only in user fields for MU-MIMO allocation, and FIG. 7 is not relevant to the non-MU-MIMO allocation. In the combination, Sun teaches a user block field for a single-user transmission encoded into the HE-SIG-B (which is only for HE-MU PPDU). Petition, 74; SAMSUNG-1015 ¶¶[0072]-[0073], FIGS. 13A-B; SAMSUNG-1003, ¶¶171-172. Sun teaches that for single user transmission, the HE-SIG-B user field includes an NSTS encoding. *E.g.*, Petition, 75-76; SAMSUNG-1015 ¶[0084]; SAMSUNG-1003, ¶174. Thus, in the combination, Bharadwaj teaches a user field format for MU-

MIMO allocation that includes spatial configuration subfield encoding, while Sun teaches a user field format for non-MU-MIMO allocation that includes an NSTS subfield encoding. Therefore, the Bharadwaj/Sun combination meets the limitations of the challenged claims.

44. While 802.11ax/D1.0 omitted the common block from HE-SIG-B in full-bandwidth, Bharadwaj is consistent with earlier versions of 802.11, evidenced by 802.11ax/D0.1 (March 2016):

801.11ax/D0.1, 173 (SAMSUNG-1009)	**Bharadwaj ¶[0097] (SAMSUNG-1013)**
If the value of SIGB Compression field in HE-SIG-A is 1, there is no RU allocation signaling in HE-SIG-B common field. The number of STAs in the MU MIMO group is indicated in the TBD field in HE-SIG-A.	The compressed mode may be used for MU-MIMO utilizing a full bandwidth. In such case, no RU signal information is transmitted in a HE_SIG-B [field]. … In the compressed mode, a number of MU-MIMO users need to be indicated. To accomplish this, a field in the SIG-A field corresponding to the number of SIG-B symbols may be re-interpreted or repurposed, and the

	number of SIG-B symbols derived from the number of MU-MIMO users.

45. Additionally, contrary to the POR, Bharadwaj recognized that omitting the common block would reduce overhead. SAMSUNG-1013 ¶[0097] (describing that while the number of MU-MIMO users may be "indicated in a common portion of a HE-SIG-B field," doing so "increases overhead"). Note that the omission of the common field during full-bandwidth was introduced into 802.11ax in D0.2. SAMSUNG-1008, 177. Also note that the PO is asserting the Challenged Claims against a non-AP station, meaning that they are applying the claims to the downlink. *E.g.*, SAMSUNG-1025, 19-20 (mapping the receiving and decoding steps being performed at a mobile phone). Thus, the POR's discussion of uplink signaling is irrelevant..

46. Significantly, none of the challenged claims require the omission of the common block while in full-bandwidth. Indeed, none of the claims mention the common block at all. Thus, the POR is placing a requirement onto Bharadwaj/Sun that is absent from the claims. By contrast, the Bharadwaj-Sun combination teaches each and every aspect of the challenged claims, and in combination, renders them obvious.

V. GROUND 2 – BHARADWAJ AND SUN STAND ON THEIR OWN

47. The POR argues that "a POSITA would have interpreted Bharadwaj the same as D1.0." POR, 24-25. As discussed above, PO's conclusion that 801.11ax/D1.0 did not support single user HE-MU PPDU transmissions in full-bandwidth is incorrect. Therefore, PO's attempt to color Bharadwaj-Sun as being likewise restricted does not make sense. Additionally, PO's attempt to link Bharadwaj/Sun to 802.11ax/D1.0 is a distraction . POR, 20, 26. PO's attempt to tie Bharadwaj/Sun to 802.11ax/D1.0 fails for a number of reasons. First, Bharadwaj and Sun are prior art printed publications (patent publication) that render the Challenged Claims obvious in view of their own teachings and the knowledge of a POSITA at that time.

48. Second, the POR mischaracterizes Bharadwaj's discussion of 802.11. POR, 20. Bharadwaj is broadly applicable to wireless local area networks (WLAN) and never limits itself to compliance to 802.11ax. SAMSUNG-1013, [0005] (802.11 Wi-Fi is one example of a WLAN protocol), [0063]-[0064] (describing that stations and APs communicate according to direct wireless links, as well as 802.11 versions "including, but not limited to, 802.11b, 802.11g, 802.11a, 802.11n, 802.11ac, 802.11ad, 802.11ah, 802.11z, 802.11ax, etc."), [0143] (describing compatibility with different versions of 802.11). Additionally, to link Bharadwaj to 802.11ax/D1.0, the POR relies on Bharadwaj's December 21, 2016

filing date. But the POR ignores how Bharadwaj claims priority to a set of provisional applications filed as early as December 21, 2015. POR, 20; SAMSUNG-1013, face.

49. Given that Bharadwaj expressly intended broad applicability to Wi-Fi protocols and that Bharadwaj's priority predates 802.11ax/D1.0, PO's conclusion that a POSITA would have interpreted Bharadwaj the same as 802.11ax/D1.0 is incorrect.

VI. 802.11AX/D1.0 WAS PUBLICLY ACCESSIBLE PRIOR TO THE CRITICAL DATE

50. I understand that Wilus is no longer challenging the public accessibility of 802.11ax/D1.0 in this proceeding. I have provided two declarations pertaining to public accessibility of 802.11ax/D1.0 (SAMSUNG-1026 ("First Declaration on Public Accessibility") and SAMSUNG-1038 ("Second Declaration on Public Accessibility"). I have been deposed already on those Declarations. While my opinions about the public accessibility of 802.11ax/D1.0 has not changed, this declaration pertains solely to unpatentability and obviousness of the Challenged Claims in view of 802.11ax/D1.0, Bharadwaj, and Sun.

VII. CONCLUSION

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.