UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,

SAMSUNG ELECTRONICS AMERICA, INC.

Petitioners,

v.

MASSIVELY BROADBAND LLC,

Patent Owner.

IPR2025-01563 (Pat. 11,876,548)
IPR2025-01564 (Pat. 11,063,625)
IPR2025-01587 (Pat. 8,593,358)
IPR2025-01594 (Pat. 10,224,999)
IPR2025-01595 (Pat. 8,923,754)
IPR2025-01605 (Pat. 10,797,783)
IPR2026-00032 (Pat. 8,515,925)
IPR2026-00033 (Pat. 9,667,337)
IPR2026-00035 (Pat. 7,676,194)
IPR2026-00086 (Pat. 8,725,700)
IPR2026-00103 (Pat. 8,224,794)

DECLARATION OF PROF. THEODORE S. RAPPAPORT

I, Theodore S. Rappaport, Ph.D., declare as follows:

1. I make this declaration in connection with each of the aforementioned *inter partes* review proceedings. I am the sole listed inventor of each patent (the "Asserted Patents") challenged in the IPRs. I am the manager of MASSIVELY BROADBAND LLC, the entity that owns the Asserted Patents.

2. I understand that the petitioners for each of the aforementioned IPRs are Samsung Electronics America, Inc. and Samsung Electronics Co., Ltd., which I will collectively refer to as "Samsung" herein.

A. Background

3. I am presently the David Lee/Ernst Weber Professor at New York University (NYU) and I hold faculty appointments in the Electrical and Computer Engineering department of the NYU Tandon School of Engineering, the Courant Computer Science department, and the NYU Grossman School of Medicine.

4. I am the founder and founding director of NYU WIRELESS, a multidisciplinary research center focused on education and research related to wireless communications and applications.

5. I am a Hagler Fellow at Texas A&M University and a Neil Armstrong Distinguished Visiting Professor (NADVP) at Purdue University.

6. I have dedicated my academic and research career to the fields of wireless communications, radio propagation measurement, channel modeling,

antennas, and software. Some specific areas of my research include radio propagation measurements and prediction, statistical and site-specific wireless channel modeling, millimeter wave and THz wireless communications with beamforming, communications system design, and physical layer simulation.

7. I began my academic career at Purdue University, where I obtained my BS, MS, and PhD in electrical engineering, after which I began teaching as a professor at Virginia Tech in 1988. In 2002, I became the William and Bettye Nowlin Professor of Engineering at The University of Texas at Austin ("UT Austin"), where I taught for nearly a decade before transitioning to what is now referred to as the NYU Tandon School of Engineering to lead its wireless communications engineering and research initiatives as the David Lee/Ernst Weber Chair of Electrical Engineering.

8. I founded academic wireless research centers at each university where I taught, including:

(a) the Mobile and Portable Radio Research Group ("MPRG") at Virginia Tech, one of the world's first academic research centers for wireless communications, in 1990;

(b) the Wireless Networking and Communications Group ("WNCG") at UT Austin in 2002; and

(c) NYU WIRELESS, a multidisciplinary research center combining wireless engineering, computer science, and medicine in 2012.

Each research center focused on academic–industry collaboration in wireless communications, by conducting fundamental and applied research on radio

propagation, communication theory and simulation, antennas, circuits, and network architectures, with a focus on future developments for wireless communications. At each academic research center, I conducted work in the areas of millimeter-wave communications. Each academic research center operates through an industrial affiliates program in which companies and government agencies partner with faculty and students to define research projects, share testbeds and data, and accelerate technology transfer.

9. At Virginia Tech, I founded the Virginia Tech Symposium on Wireless Personal Communications in 1991 (now called Wireless@Virginia Tech Symposium and Summer School), a gathering on the campus of Virginia Tech for the benefit of the MPRG industrial affiliate companies, researchers, government officials, faculty and students. At UT Austin, I launched an annual wireless communications education conference (formerly known as the Texas Wireless Summit and now called the 6G@UT Forum, co-sponsored by Ericsson), bringing together students, business leaders, and technical innovators in the wireless industry. Subsequently, while at NYU, I founded the Brooklyn 5G Summit (now called the Brooklyn 6G Summit), a technical meeting of global leaders in technology, business, government, and academia, co-sponsored by Nokia/Bell Labs. This annual invitation-only event, known as "B6GS," brings together executives from global wireless companies, leading researchers, and government

officials to discuss the future of wireless technologies.

10. My contributions to my fields of study have been recognized by: (i) induction into the IEEE Vehicular Technology Society Hall of Fame in 2024; (ii) receipt of the NYU Research Catalyst Prize in 2022; (iii) election as a member of the National Academy of Engineering in 2021 for contributions to the characterization of radio frequency propagation in millimeter wave bands for cellular communication networks; (iv) receipt of the 2021 IEEE Global Communications Conference (GLOBECOM) Best Paper Award for the Wireless Communications Symposium, (as well as about ten other best paper awards in international conferences or major research journals); (v) receipt of the 2020 IEEE Eric E. Sumner Award for pioneering contributions to radio channel modeling and characterization, and millimeter wave communication systems; (vi) induction into the Wireless History Foundation Hall of Fame in 2019 (the first career academic ever to be chosen); and (vii) receipt of the 2018 Armstrong Medal from the Radio Club of America, the world's oldest radio society.

11. I am the lead author of a seminal paper and book about 5G millimeter wave (mmWave) wireless communications. *See* T.S. Rappaport et al, "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!," IEEE Access, vol. 1, May 10, 2013, pp. 335-349; T.S. Rappaport et al., Millimeter Wave Wireless Communications, Pearson Educ., Inc., 2015.

12. Tom Wheeler, the former Chairman of the Federal Communications Commission (en.wikipedia.org/wiki/Tom_Wheeler), described me as being the "father" of 5G mmWave. *See* 2022 Brooklyn 6G Wireless Summit (ieeetv.ieee.org/channels/communications/pioneer-award-tom-wheeler-2022-b6gs-virtual); *see also* Hagler Institute for Advanced Study (hias.tamu.edu/fellow/dr-theodore-ted-s-rappaport/); "Remarks of FCC Chairman Ajit Pai at the National Spectrum Consortium 5G Collaboration Event," Arlington, VA, April 30, 2019 (former Chairman of the Federal Communications Commission, Ajit Pai, stating that Rappaport is "the man who did a lot of the foundational research beneath the use of millimeter wave spectrum for 5G") (docs.fcc.gov/public/attachments/DOC-357245A1.pdf).

13. Print and broadcast media have interviewed me on newsworthy topics related to my research, such as:

(a) NBC News, "Ringing in 40 years of cell phones," April 3, 2013 (www.nbcnews.com/video/ringing-in-40-years-of-cell-phones-24601155609);

(b) Fierce Network, "NYU Wireless' Rappaport envisions a 5G, millimeter-wave future," Jan. 13, 2014 (www.fierce-network.com/special-report/nyu-wireless-rappaport-envisions-a-5g-millimeter-wave-future);

(c) Fox Business, "Nokia president on 5G: 'Take it seriously what China is about to do,'" Apr. 25, 2019 (www.foxbusiness.com/technology/nokia-president-china-5g);

(d) Light Reading, "It's Officially Time to Start Talking About 6G," Mar. 15, 2019 (www.lightreading.com/5g/it-s-officially-time-to-start-talking-about-6g);

(e) Microwave Journal, "Interview with Prof. Theodore (Ted) Rappaport of NYU WIRELESS," Feb. 22, 2019 (www.microwavejournal.com/blogs/9-pat-hindle-mwj-editor/post/31837-interview-with-prof-theodore-ted-rappaport-of-nyu-wireless);

(f) Wired Magazine, "Trump Shouldn't Plan to Tweet From a 6G Phone Anytime Soon," Feb. 21, 2019 (www.wired.com/story/trump-shouldnt-plan-tweet-from-6g-phone-soon/);

(g) CNN Business, "Think 5G is exciting? Just wait for 6G," Feb. 11, 2020 (www.cnn.com/2020/02/10/perspectives/6g-future-communications);

(h) USA Today, "Fact check: 5G technology is not linked to coronavirus," Apr. 23, 2020 (www.usatoday.com/story/news/factcheck/2020/04/23/fact-check-5-g-technology-not-linked-coronavirus/3006152001/);

(i) Marketplace, Trump administration moves to adapt military airwaves for 5G networks," Aug. 11, 2020 (www.marketplace.org/story/2020/08/11/trump-administration-white-house-5g-network-plan-military-radio-frequencies);

(j) Tech Crunch, "Trump administration announces major midband spectrum auction for 5G," Aug. 10, 2020 (techcrunch.com/2020/08/10/trump-administration-announces-major-midband-spectrum-auction-for-5g/);

(k) NPR, "Airlines are concerned 5G wireless service may affect the ability to land planes," Jan. 7, 2022 (www.npr.org/2022/01/07/1071409710/airlines-are-concerned-5g-wireless-service-may-affect-the-ability-to-land-planes); and

(l) Time Magazine, "Will the Solar Eclipse Affect Cell Service?" Apr. 10, 2024 (time.com/6962788/solar-eclipse-cell-wireless-service-2024/).

14. On March 15, 2019, then-FCC Chairman Ajit Pai invited me to address the FCC Commissioners to explain the technology behind terahertz spectrum wireless communications (100 GHz and above) at an FCC Open Commission Meeting about opening such radio bands for the first time. *See* (i) www.fcc.gov/news-events/events/2019/03/march-2019-open-commission-meeting, (ii) docs.fcc.gov/public/attachments/DOC-356643A1.pdf, and (iii) docs.fcc.gov/public/attachments/FCC-19-19A2.pdf.

15. I authored a popular textbook on wireless communications, called "Wireless Communications: Principles and Practices." The original version was published in 1996. It has been adopted by hundreds of universities and published in several foreign languages, including Korean, Chinese, Spanish, and Greek. Numerous versions of the textbook have been published over the years, and according to Google Scholar, my textbook has been cited over 35,000 times. *See* scholar.google.com/citations?user=aLOSzWwAAAAJ&hl=en.

B. Interactions with Samsung

16. Samsung has interacted with me in many ways over my career.

17. For example, at various times Samsung was a member of the three university research centers that I founded. Samsung joined the MPRG at Virginia Tech in around 1999. Then it became a member of the WNCG at UT Austin. Finally, Samsung was a founding member of the NYU WIRELESS center.

18. When renewing Samsung's industrial affiliate membership in NYU WIRELESS in 2019, Charlie Zhang, a Samsung senior vice president and head of Samsung's Standards and Mobility Innovation Team, stated "we believe close collaborations between academia and industry leaders are the key to sustained innovation for the future of 5G and beyond." *See* NYU WIRELESS, Momentum Continues at NYU WIRELESS with New Industrial Affiliates, NYU WIRELESS Pulse, Spring 2019, vol. 6, no. 1 at 2, available at wireless.engineering.nyu.edu/newsletter/pulse-final-spring-2019.pdf.

19. Samsung employees have presented at the Brooklyn 5G/6G Summit that I founded. For example, Thomas Novlan, a former Samsung engineer, spoke at the 2016 Brooklyn 5G Summit. *See* ieeetv.ieee.org/ieeetv-specials/brooklyn-5g-2016-panel-on-ran-for-5g-lt-6ghz-cmwave-and-mmwave. Also, Emad Farag, another Samsung engineer, spoke at the 2024 Brooklyn 6G Summit. *See* ieeetv.ieee.org/channels/communications/session-5-6g-midband-technology-and-spectrum-b6gs-2024.

20. As part of my involvement with NYU WIRELESS, I developed channel measurement systems to test and measure the path loss, multipath time delay, and multipath angle of arrival and departure of mmWave bands in indoor and outdoor environments in order to assess the feasibility of millimeter wave frequency bands for mobile broadband access. Samsung worked with NYU

WIRELESS to replicate a similar channel measurement system at its Samsung Complex in Suwon, Korea. *See* T.S. Rappaport, NYU WIRELESS, New York University School of Engineering, Keynote Presentation at the 2014 International Conference on Communications: Millimeter Wave Wireless Communications: The Renaissance of Computing and Communications (June 13, 2014), wireless.engineering.nyu.edu/presentations/keynote.pdf; T.S. Rappaport, NYU WIRELESS, Polytechnic Institute of New York University (NYU-Poly), Presentation at the IEEE ICC 2013: Millimeter Wave Cellular (June 11, 2013), wireless.engineering.nyu.edu/presentations/icc2013.pdf.

21. Samsung has invited me to Korea to speak about my research on several occasions.

(a) One such instance was in the early to mid-2000s (circa 2004 to 2006) for an annual Samsung 4G Forum. For this forum, Samsung convened a group of approximately 100 global wireless experts to discuss 4th generation mobile communication standards.

(b) Another instance was in November 2011, when Samsung invited me to its Korean campus to discuss my research and development in mmWave. My presentation was titled "Millimeter wave cellular communications channel."

(c) I also presented to Samsung again in November 2012 on my research. My 2012 presentation was titled "28 GHz Cellular Radio Propagation Measurements with Steerable Beams in New York City."

Hundreds of Samsung employees, including Samsung executives, attended my 2011 and 2012 presentations.

22. Wonil Roh, Samsung's Director of Advanced Communications, has

stated that my research "provides strong evidence of the feasibility of high-frequency bands for outdoor cellular applications" and that such research on "millimeter-wave bands can be the most effective answer to the problem of ever-increasing mobile data traffic." *See* Gary Anthes, NSF Grant to Help Point Way to 5g Wireless, Communications of the ACM (Nov. 7, 2013), cacm.acm.org/news/nsf-grant-to-help-point-way-to-5g-wireless/.

23. I have provided at least the following keynote addresses and plenary talks at industry and government conferences:

(a) 2012 IEEE International Conference on Communications in China (ICCC), Beijing China, Aug. 2012 (iccc2012.ieee-iccc.org/patrons.html);

(b) Fall 2012 Fall IEEE Vehicular Technology Conference Plenary talk in Quebec City, Canada (www.ieeevtc.org/vtc2012fall/final-programme.pdf, *see* p. 11);

(c) 2013 IEEE International Conference on Communications (ICC), Budapest, Hungary, June 2013, invited speaker (icc2013.ieee-icc.org/program/ICC2013_FP.pdf). Wonil Roh, then Director & Head of Samsung's Advanced Communications Lab, was also an invited speaker at this conference;

(d) 2014 IEEE International Conference on Communications (ICC), Sydney, Australia (icc2014.ieee-icc.org/speakers.html);

(e) 2014 IEEE International Symposium on Personal, Indoor, and Mobile Radio Communication (PIMRC), Washington, DC, Sept. 2014 (pimrc2014.ieee-pimrc.org/program.html);

(f) 2016 Federal Communications Commission, Spectrum Frontiers Workshop, Washington, DC, March 2016 (www.fcc.gov/news-events/events/2016/03/spectrum-frontiers-workshop);

(g) Brooklyn 5G Summit, April 2016, NYU WIRELESS and Nokia Networks (bgarchive.com/wp-content/uploads/2022/04/Brooklyn-5G-Summit-2016.pdf);

(h) 2016 IEEE GLOBECOM, Washington, DC, Dec. 2016, Plenary Panel (globecom2016.ieee-globecom.org/plenary-panel.html);

(i) 2018 IEEE International Conf. on Computer Communications (INFOCOM), Keynote for Workshop on mmSys: Millimeter-Wave Networked Systems, Hawaii (infocom2018.ieee-infocom.org/content/workshop-mmsys-millimeter-wave-networked-systems.html); and

(j) 2024 IEEE Wireless Communications and Networking Conference (WCNC), keynote speaker, April 22, 2024, Dubai (wcnc2024.ieee-wcnc.org/keynotes).

24. Samsung employees regularly attend those same conferences, and sometimes they have presented and referenced my work in their own presentations, such as:

(a) Wonil Roh, Vice President & Head of Advanced Communications Lab, Samsung Electronics Corp., at WCNC 2014, April 2014, Istanbul, "5G Mobile Communications for 2020 and Beyond," (wcnc2014.ieee-wcnc.org/sites/wcnc2014.ieee-wcnc.org/files/u21/WCNC2014_Keynote_Samsung.pdf), slide 43, references [7] and [8];

(b) Wonil Roh, EUCNC, June 2014, Bologna (eucnc.eu/files/keynotes/Roh.pdf) (similar);

(c) Dr. Maziar Nekovee, Samsung Electronics R&D, UK, IEEE ICUWB, Paris, Sept. 2014 (https://5g-ppp.eu/wp-content/uploads/2015/07/Nekovee-2Sept2014.pdf , *see* slides 17-18)

25. Several Samsung employees in the field of wireless communications have co-authored papers with me, including:

(a) T. S. Rappaport, W. Roh and K. Cheun, "Mobile's millimeter-wave

makeover," IEEE Spectrum, vol. 51, no. 9, Sept. 2014 at 34-58;

(b) S. Hur et al., "Proposal on Millimeter-Wave Channel Modeling for 5G Cellular System," IEEE Journal of Selected Topics in Signal Processing, vol. 10, no. 3, April 2016 at 454-69;

(c) K. Haneda et al., "Indoor 5G 3GPP-like channel models for office and shopping mall environments," 2016 IEEE International Conference on Communications Workshops (ICC), Kuala Lumpur, Malaysia, 2016, at 694-99;

(d) K. Haneda et al., "5G 3GPP-Like Channel Models for Outdoor Urban Microcellular and Macrocellular Environments," 2016 IEEE 83rd Vehicular Technology Conference (VTC Spring), Nanjing, China, 2016, at 1-7.

26. According to Google Scholar, my paper titled "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!," IEEE Access, vol. 1, May 10, 2013, pp. 335-349, has been cited by over nine thousand other papers. *See* scholar.google.com/citations?user=aLOSzWwAAAAJ&hl=en&oi=ao. Several authors from Samsung have cited this paper in their scientific papers, including the following:

(a) W. Roh et al., "Millimeter-Wave Beamforming as an Enabling Technology for 5G Cellular Communications: Theoretical Feasibility and Prototype Results," IEEE Communications Magazine, Feb. 2014 (see reference [7]);

(b) S. Hur et al., "Proposal on Millimeter-Wave Channel Modeling for 5G Cellular System," IEEE J. Selected Topics in Signal Processing, vol. 10, No. 3, April 2016 (see reference [5]);

(c) K. Haneda et al., "5G 3GPP-like Channel Models for Outdoor Urban Microcellular and Macrocellular Environments," 2016 IEEE 83rd Vehicular Technology Conf., Spring 2016 (see reference [10]);

(d) W. Hong et al., "Millimeter-Wave 5G Antennas for Smartphones: Overview and Experimental Demonstration," IEEE Trans. on Antennas and Propagation, vol. 65, no. 12, Dec. 2017 (see reference [3]); and

(e) S.K. Vankayala et al., "Deep-Learning Based Proactive Handover for 5G/6G Mobile Networks using Wireless Information," 2022 IEEE Globecom Workshops, 2022 (see reference [2]).

27. Samsung has also cited this paper – "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!," IEEE Access, vol. 1, May 10, 2013, pp. 335-349 – in some of its own patents, including:

(a) Pub. No. 2018/0310137 A1, published Oct. 25, 2018, by Mouhouche et al.; and

(b) Pat. No. 12,119,914 B2, issued Oct. 15, 2024, by Chavva et al.

28. Samsung employees, in their scientific papers, have also cited many other papers of mine, including the following:

(a) S. Kadambar et al., "Millimeter Wave Multi-Beam Combining Algorithm for Efficient 5G Cell Search," 2020 IEEE 17th Annual Consumer Communications & Networking Conference (see references [8] and [13]);

(b) S. Baek et al., "Impact Analysis of Receiver Sensitivity and Censored Data to NLoS Channel Models in Millimeter Wave Frequency Bands," 2021 IEEE 18th Annual Consumer Communications & Networking Conference (see references [2], [3], [4], [7] and [18]);

(c) D. Singh et al., "Modeling Time-Varying and Frequency-Selective Channels with Generative Adversarial Networks," IEEE Int'l Conf. on Communications (ICC) 2022, (see references [4], [7] and [14]); and

(d) X. Zhou et al., "Deep Reinforcement Learning Coordinated Receiver Beamforming for Millimeter-Wave Train-Ground Communications," IEEE Trans. on Vehicular Tech., vol. 71, No. 5, May 2022 (see references [11] and [13]).

C. Concluding Remarks

29. I am not being compensated for making this declaration, although I have an economic interest in any recovery by MASSIVELY BROADBAND LLC related to the Asserted Patents.

30. I am over the age of twenty-one and mentally competent to make this declaration.

31. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on December 5th, 2025 in Raleigh, North Carolina.

Theodore S. Rappaport