

Exhibit 1

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

THL Holding Company, LLC,

Plaintiff,

v.

Apple, Inc.

Defendant.

Case No. 1:23-cv-548-OLG

JURY TRIAL DEMANDED

**EXPERT REPORT OF DR. MARTIN J. FEUERSTEIN REBUTTING
APPLE'S PROPOSED CONSTRUCTION OF "SIGNAL DELAY"**

I. Introduction

I have been retained by THL Holding Company, LLC to review U.S. Patent No. 11,350,246, and Apple's proposed claim construction for the term "signal delay" recited in claims 1 and 11 of the '246 patent.

For the reasons stated below, I believe that Apple's proposed construction improperly narrows the scope of that claim term and excludes an embodiment disclosed in the '246 patent for performing the claimed "direction" finding function recited in the relevant "signal delay" claim limitations.

II. Education, Relevant Experience and Disclosures

My academic education includes a Bachelors of Engineering degree with Magna Cum Laude honors from Vanderbilt University double majoring in Electrical Engineering and Mathematics in 1984. I also received a Masters of Science degree in Electrical Engineering from Northwestern University in 1987. My Masters thesis was in the area of electromagnetics and antennas. I then obtained a Doctorate degree from Virginia Tech in Electrical Engineering in 1990. The Dissertation for my Doctorate was in the area of spread spectrum wireless technologies for communications and position location, including Time Difference of Arrival (TDOA), Global Positioning System (GPS), Angle of Arrival (AoA) and other location methods. These wireless location technologies are relevant to the Asserted Patents and Accused Products at issue in this case.

Before joining industry, I worked as an Assistant Professor in the Electrical and Computer Engineering Department with the Mobile Radio Research Group at Virginia Tech between 1991-1992. I served as Principal Investigator on funded research projects in wireless technology, taught wireless communications courses, and developed wireless course curriculum. I supervised graduate students in research work on wireless systems and networks. I also taught industry short courses in wireless technologies for leading wireless companies.

I am currently the Principal of Jade Martin Consulting LLC, where my responsibilities include technology consulting with a focus on wireless systems, smart antennas, Internet of Things, location technology, data analytics, safety, and security systems. Past consulting clients include major wireless service providers T-Mobile and Verizon, as well as many wireless technology development companies. As a wireless consultant, my experience included network evolution strategy, standards, and planning for 5G, 4G and 3G technologies such as LTE, UMTS WCDMA and HSPA, which resulted in co-authoring a technical book titled "High Speed Packet Access (HSPA) Performance and Evolution: A practical perspective". As a consultant, I have served as an expert witness in domestic and international patent cases related to wireless technologies and products, including location services. I am also currently Chief Operating Officer of Ossia Inc., where my responsibilities include research and development of wireless technologies, including wireless power, sensors, and Internet of Things sensing and location tracking systems using GPS, mmWave radar and AoA. I have worked in various roles with Ossia Inc. since 2018.

Prior to my current positions, I was the Chief Executive Officer and Chief Technology Officer

at Recon Dynamics from 2011 to 2016, where my responsibilities included guiding all aspects of the company's operations in developing wireless asset location tracking and safety-of-life products, capitalizing on M2M, IoT, 4G/3G, cloud and analytics big data. Prior to that, I was the Chief Technology Officer at Polaris Wireless from 2003 to 2011, where my responsibilities included leading research and development of advanced wireless position location products for mission-critical and safety-of-life applications, such as E-911 emergency call systems; commercializing products for 4G, 3G and 2G networks to meet strict FCC location accuracy limits; and creating an LTE system and new products for network optimization and mass location in the security and surveillance location market. My research focus at Polaris was on wireless location approaches, such as Received Signal Strength Indicator (RSSI), RF Pattern Matching (RFPM), Network Measurement Reports (NMR), Time Difference of Arrival (TDOA), Time of Flight (ToF), Angle of Arrival (AoA), Direction of Arrival (DoA), Global Positioning System (GPS), Global Navigation Satellite Systems (GNSS), WiFi, Bluetooth and Hybrid location systems. These are wireless location technologies relevant to the Asserted Patents and Accused Products at issue in this case.

In addition, I have served as a Chief Technology Officer or other management roles working on mobile telecommunication systems, networks, and products at telecommunication companies such as Verizon/AirTouch/USWEST, Lucent/AT&T Bell Labs and Metawave Communications. While at Verizon (USWEST Advanced Technologies and AirTouch at that time) and Lucent/AT&T Bell Laboratories, I worked on the development, testing and deployment of the first spread spectrum CDMA cellular equipment and networks. At Verizon, I researched location technologies for zone-based billing systems and location-based services. I served as CTO of Metawave Communications, where I developed phased array antenna (smart antenna) technologies for use in increasing wireless network capacity and performance.

I have more than 30 years' experience with wireless location and communications engineering in industry, education, and consulting, including mobile telecommunication systems, networks, and devices, specifically. This includes extensive research and development work and publications in wireless technologies, such as those that underpin 2G, 3G, 4G and 5G wireless communications and location systems. I worked on development, deployment and performance improvement of common air interface technologies, location systems, smart antennas, spatial processing, interference management and MIMO.

I have authored or coauthored many publications concerning mobile wireless technologies, such as: "Wireless Personal Communications," with Prof. T. Rappaport, Kluwer Academic Publishers; "High Speed Packet Access (HSPA) Performance and Evolution: A Practical Perspective," John Wiley & Sons Ltd.; "Wireless Network Deployments," Chapter 3, Springer International; "Wireless Communications: Emerging Technologies for Enhanced Communications," Chapter 5, Springer International; "Performance Evaluation of a Base Station Multibeam Antenna," IEEE Transactions on Vehicular Technology; "Path Loss, Delay Spread and Outage Models for Microcellular System Design," IEEE Transactions on Vehicular Technology; "Design & Performance of Minimum Variance Hybrid Location Algorithms", Institute of Navigation and "Distribution of Phase Errors in Wireless Position Location Systems", IEE Electronics Letters.

I have been a member of, or representative to, a number of industry and professional organizations, including the Institute for Electrical and Electronics Engineers (IEEE), Third Generation Partnership Project (3GPP), Open Mobile Alliance (OMA), Telecommunications Industry Association (TIA), CDMA Development Group (CDG), and was appointed to the Federal Communications Commissions' Communications Security, Reliability and Interoperability Council (CSRIC), where I worked on next generation E-911 wireless location technology regulation matters. I also regularly attend and present at industry and educational conferences related to the wireless field, including the International Symposium on Advanced Radio Technologies, IEEE International Conference on Communications, Invitational Workshop on Opportunistic RF Localization for Next Generation Wireless Devices, and the Vehicle Navigation and Information Systems Conference, among others.

My Curriculum Vitae is attached as Exhibit A. A list of my prior litigation history is attached as Exhibit B. I am being compensated for my time working on this matter at a rate of \$590/hour.

III. Summary of My Opinions

Based on my review of the asserted claims and the written description of the '246 patent, I conclude that Apple's proposed construction for "signal delay," which is proposed as "the difference in time of flight calculations," is inconsistent with the claims as issued, and excludes an embodiment described in the application for the '246 patent for performing the claimed direction determination achieved by the "signal delay" limitation.

A Person of Ordinary Skill in the Art (POSITA) would interpret the claim term "signal delay" in accordance with its ordinary meaning as the difference in time between when a signal is received between the claimed "two or more antennas" for the purposes of determining direction.

IV. Analysis

a. Meaning of "signal delay" Based on the Claim Language

The relevant limitation of Claim 1 of '246 states: "determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device" (emphasis added).

Similarly, the relevant limitation of Claim 11 of '246 states: "determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device and on rotation of the mobile communication device detected by the orientation sensor" (emphasis added).

The term "signal delay" is not limited in these claims to "the difference in time of flight" or "time of flight calculations", in contrast to what Apple asserts in its proposed claim construction. One reason this is clear to a POSITA is because "time of flight" is separately recited in *other* limitations for each of these two claims, with respect to the "distance" determination. Claim 1 states: "estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband

communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations” (emphasis added). Similarly, Claim 11 states: “estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations” (emphasis added).

The language of both Claims 1 and 11 makes clear that the term “signal delay” is not limited to time of flight calculations as Apple proposes. This distinction is important because the claimed signal delay need not be determined from time of flight calculations. Estimation of direction in the claims uses “signal delay between two or more antennas” (emphasis added), which means the signal delay applies to an array antenna (i.e., two or more antennas used together). Array antennas are also called phased arrays, because their directional characteristics can make use of the phases of signals received from (or applied to) the individual array antenna elements (i.e., each one of the claims’ two or more antennas). “An array antenna whose main beam maximum direction or pattern shape is controlled primarily by the relative phase of the [antenna] element excitation currents is referred to as a phased array.” (see Antenna Theory and Design, Warren L. Stutzman and Gary A. Thiele, John Wiley & Sons, 1981, p. 160) Controlling the main beam maximal direction or pattern shape is also called pointing, steering, sweeping or scanning the antenna.

With phased arrays, it is common to denote the difference in signal phases between antenna elements as the “phase delay” or “phase shift”. This phase delay is a signal delay, which can be measured as a vector phase angle representing the difference in phase between different array antenna elements. For a given signal frequency, the phase delay or phase shift can be converted to an equivalent time delay, because the phase delay is directly proportional to the product of the frequency and the time delay. Therefore signal delay, as denoted in Claims 1 and 11, can be measured as phase delay or time delay.

Estimation of phase angle for determination of signal delay in an array antenna need not make use of time of flight calculations. For example, phase angle can be estimated using a phase detector to directly estimate phase differences between antenna elements in the antenna array. Such a phase detector would not typically use time of flight in its determination of phase angles. Similarly, time delay can be used to estimate the signal delay differences between antenna elements in an array. Approaches for detecting time delay may not use time of flight in determination of delay estimates.

Signal delay can be measured in terms of phase, often called for example phase angle, phase delay, phase shift or phase offset. By its nature, phase is always a relative measurement. The phase delay of a signal (e.g., a sinusoid or waveform) is measured relative to another signal. That other signal could be a reference signal, such as a master clock, or it could be another signal. In the context of the ‘246 patent, with array antennas having two or more antenna elements, the signal’s phase delay can be measured relative to one another. For example, with a two-element array consisting of two antennas, the phase can be measured differentially (i.e., relatively) between antenna number 1 and antenna number 2. There is no absolute measurement of phase delay, thus there is no inherent meaning of saying the phase of the signal from antenna number 1. This contrasts with time of flight, which can be an absolute measurement of time delay.

Therefore, Apple’s proposed claim construction limiting signal delay to “the difference in time of flight calculations” is counter to the longstanding use of phase angles for signal delay estimation in the types of array antennas denoted in Claims 1 and 11 for determination of direction. In separate limitations, the claims describe time of flight for estimating a distance, which is not the same as

determining a direction, and thereby does not necessitate the same type of calculation.

b. Meaning of “signal delay” Based on the Written Description

The specification for the ‘246 patent discloses at least two embodiments for determining direction based on “signal delay”: (i) beam or null steering, or (ii) time of flight calculations. I address each embodiment below.

The field of direction-finding using two or more antennas (i.e., array antennas or phased arrays) incorporates different methods for determining direction, such as direction of arrival (DoA) or angle of arrival (AoA) of signals. These can yield different embodiments for estimating direction. One such embodiment is beam steering or null steering, which determines direction based on adjusting (i.e., steering or pointing) the antenna pattern in azimuth, elevation or both. Beam/null steering is typically a one-way method (also called simplex), because it relies on measuring the characteristics (e.g., received power, received signal strength) of a signal to determine direction. It does not necessarily rely on measuring a signal transmitted from source to destination, and then a reply transmission from destination back to the source. In other words, beam/null steering is not inherently a two-way round-trip approach.

The specification of ‘246 teaches “steering the null of the antenna [pattern] in an implementation of a programmable antenna”, such that “direction to the wireless device 120 can be determined based on the direction θ_1 , where the antenna null is pointed at the wireless device 120.” (see ‘246 at 14:34-38) This null in the antenna pattern can be accomplished in one embodiment by “antenna configurations that are aligned in position and phase to have a directional pattern that includes a single null” (see ‘246 at 11:16-17). As explained earlier, for an array antenna using phase is a method of “controlling” the “main beam maximum direction or pattern shape”. (see Antenna Theory and Design, Warren L. Stutzman and Gary A. Thiele, John Wiley & Sons, 1981, p. 160) The programmable antenna in an embodiment in ‘246 can be commanded “to sweep the null direction by 360 degrees and to collect corresponding signal strength data.” (see ‘246 at 11:61-63) Further, ‘246 describes “steering the beam of the antenna in an implementation of a programmable antenna, such as antenna 148” (see ‘246 at 13:45-47). A POSITA would understand that sweeping the null direction in the programmable antenna would be done using relative phase delay (or equivalently relative time delay), which is signal delay. “Analysis of the signal strength data can be used to determine the direction of the wireless device 120 based on the direction corresponding to the null”, based on the sweeping of the antenna pattern using phase or time delay. (see ‘246 at 11:62-64). For example, the phase or time delay associated with the null would result in lower signal strength; therefore, the direction can be determined from the resulting phase or time delay. In other words, for the programmable antenna, phase or time delay can be mapped to direction of arrival of a signal.

The steering, sweeping or pointing of the programmable antenna’s pattern (i.e., beam or null) is also called scanning. As noted, this can be accomplished through adjustment of the phase delay (i.e., time delay or signal delay) between the antenna elements. “If the phase [or equivalently time delay] of each element is changed with time ... the [antenna] pattern is scanned and thus the main beam pointing direction θ_0 changes with time.” (see Antenna Theory and Design, Warren L. Stutzman and Gary A. Thiele, John Wiley & Sons, 1981, p. 161)

An approach, different than beam/null steering, for determining direction using two or more antennas could be based on the difference in time of flight calculations. In such an approach, the time of flight could be estimated to each of the two or more antennas. Because from ‘246 the time of flight is

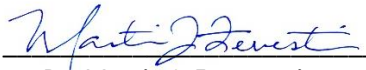
the difference between when a signal is transmitted and when a reply signal is received, it relies on two-way (also called duplex) communications. This two-way aspect is explained in '246, "...time [of flight] can be measured from the transmission of the paging signal to the reception of the location signal. This time delay (round trip time) can indicate the distance to the remote device." (see '246 at 34:34-40) Note that time of flight is an absolute measurement, in this case of the time between transmission of a paging signal and the reception a location signal response. This is in contrast to signal delay measured as relative phase or time delay, for example as described above for beam/null steering, which is always a relative measurement.

By subtracting the times of flight, the differences in times of arrival (ToA) can be calculated. These ToA values can then be used to estimate an angle of arrival of the signal, resulting in determination of the direction. Time of flight is inherently a two-way round trip approach with absolute measurements, in contrast to the beam/null steering embodiment of '246 which can be a one-way method with relative measurements. Time of flight calculations for direction determination do not make use of the beam/null steering embodiment as taught in the '246 specification.

V. Conclusion

As explained, limiting the claim term "signal delay" to Apple's proposed claim construction of "the difference in time of flight calculations" would be counter to the structure and meaning of the limitations of both Claims 1 and 11. Such a construction would also exclude the beam/null steering embodiment of '246 for determining direction; this is because time of flight uses two-way, absolute measurement whereas beam/null steering typically uses one-way, relative measurement. In contrast, THL's proposed construction of the "difference in time between when a signal is received at two or more antennas" is consistent with '246 Claims 1 and 11 and captures two of the embodiments disclosed in the '246 specification for performing the claimed location function.

Date: August 17, 2023


Dr. Martin J. Feuerstein