UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GEOTAB INC. AND GEOTAB USA, INC.,
Petitioners,

v.

FRACTUS, S.A.,
Patent Owner.

Case No. IPR2025-01026
Patent No. 11,031,677

EXPERT DECLARATION OF HOSSEIN HASHEMI, Ph.D.

I, Hossein Hashemi, Ph.D., do hereby declare as follows:

1. This is my second declaration in the above-captioned proceeding. I hereby incorporate by reference the entirety of my previous opinions as set forth in the EXPERT DECLARATION OF HOSSEIN HASHEMI, Exhibit 2010 in the above-captioned proceeding. As noted in paragraph 5 of Exhibit 2010, I reserved the right to supplement my previous opinions.

2. I have been asked to provide technical background regarding antenna diversity techniques, which I provide below.

3. Spatial diversity is a technique in wireless communications that uses multiple antennas to improve signal reliability and performance by mitigating the effects of multipath fading and other interference. Multipath fading occurs when a wireless signal propagates along multiple different paths of differing lengths because of interactions with obstacles, resulting in portions of the signal energy arriving at a receiver with different phases slightly offset in time, which causes constructive and destructive interference. Such interference is spatially dependent – it varies from one spot to another based on the relative phases of the different-path-length versions of the same signal at different locations. Locations separated by a small fraction of the wavelength of the wireless signal tend to experience similar fading and interference

characteristics. By providing sufficient spacing between two or more antennas transmitting and/or receiving the same signal at a given wavelength, the likelihood increases that at least one receiving antenna will be positioned at a location where the multipath or other interference is relatively low, thereby improving overall signal quality and reliability.

4. As I noted in my previous declaration, in general, having at least a quarter-wavelength spacing between antennas is considered acceptable to provide adequate spatial diversity between antennas. This is a common rule of thumb that I teach my students. In some contexts, a larger distance such as a half-wavelength spacing or mor may be preferable.

5. Unlike spatial diversity, polarization diversity involves the relative orientation of two or more antennas rather than their spacing. Electromagnetic waves, such as wireless communication signals, may propagate with the electric field vector oscillating in the vertical direction (vertical polarization), or with the electric field vector oscillating in the horizontal direction (horizontal polarization), or with a combination of both vertical and horizontal polarization. Scattering caused, for example, by obstacles in a signal path, may result in vertically and horizontally polarized wireless signals experiencing different signal attenuation over the signal

path. Polarization diversity mitigates the impact of either vertically or horizontally polarized signals being highly attenuated by using two antennas with different polarizations so that at least one polarization of a signal can be received with an acceptable amplitude. Because the orientation of an antenna impacts the polarization of the signals it transmits and receives, one way to achieve polarization diversity is to orient two similar antennas at 90° relative to each other. On the other hand, two identically shaped antennas oriented in parallel would exhibit similar polarization, and therefore, would not provide polarization diversity. Polarization techniques were described in references in proceedings related to this one, such as the Gaucher references in *Inter Partes* Review IPR2025-00929.[1]

6. Antenna pattern diversity is a technique used in wireless communication systems to improve signal reliability by exploiting differences in radiation patterns. Every antenna has a specific radiation pattern, meaning each antenna transmits and receives electromagnetic energy more strongly in certain

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[1] The Gaucher references refer to U.S. Pre-Grant Publication 2006/0082503 and U.S. Pre-Grant Publication No. 2004/0113848, designated Exhibits 1012 and 1013 in *Inter Partes* Review IPR2025-00929.

directions. As the receiving device moves (rotational and/or translational movement), a transmitting device may be located at an angle relative to the antenna that corresponds to a null in the antenna's radiating pattern, causing signal loss. By having two or more antennas whose radiation patterns are different or differently oriented, the nulls of the antennas lie in different directions/orientations, and the likelihood of a receiving a signal from the transmitter at at least one of the antennas is improved. When using two (or more) different patterns with nulls oriented in different directions, it is unlikely that all patterns experience signal loss at the same time, improving overall link robustness.

7. Pattern diversity may be implemented by integrating multiple antennas into the device, each shaped differently to produce distinct radiation patterns. The system then uses a switching or combining algorithm to select the antenna with the strongest signal (selection diversity) or combine signals from multiple antennas (maximal-ratio combining). On the other hand, two identical similarly oriented antennas will exhibit the same radiation pattern, and therefore, will not provide pattern diversity.

I declare under penalty of perjury that the foregoing is true and correct.

Date: 02/25/2026 By: ______________________
Hossein Hashemi, Ph.D.