Find the Gap: Multi-Band, Remote Measurement System to Quantify the Fit of Wearable Systems

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Garment fit is critical in wearable systems and functional garments, including masks and other PPE, and yet no methods exist that can reliably quantify the fit characteristics of non-translucent or non-form fitting garments. We propose a technique for remotely measuring the gap between an external wearable device or clothing surface and the underlying, visually-obstructed body surface – which we refer to as the garment-body "air gap" – that commonly occurs in positive ease garments (i.e., garments that are larger in dimension than the underlying body dimension). To do this, we developed a triple frequency band remote measurement system that is based on a 77-81GHz FMCW radar, 40kHz Ultrasound sensor, and an Infrared 344GHz distance sensor, which when used synergistically allows for remote measurement of the uniaxial distances to multiple layered surfaces simultaneously.

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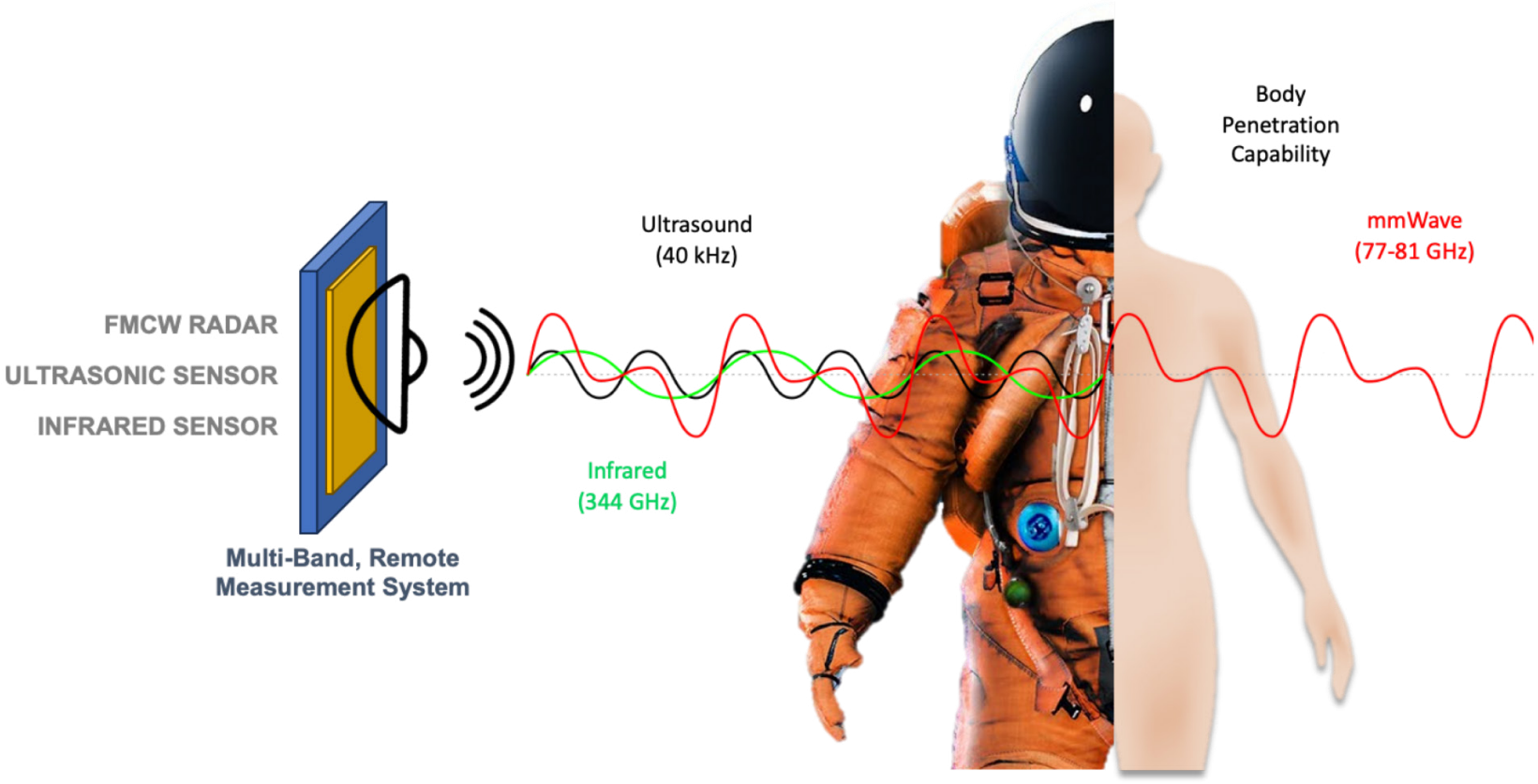

Image 1. A remote, multi-band sensor suite for measuring “air gaps”.

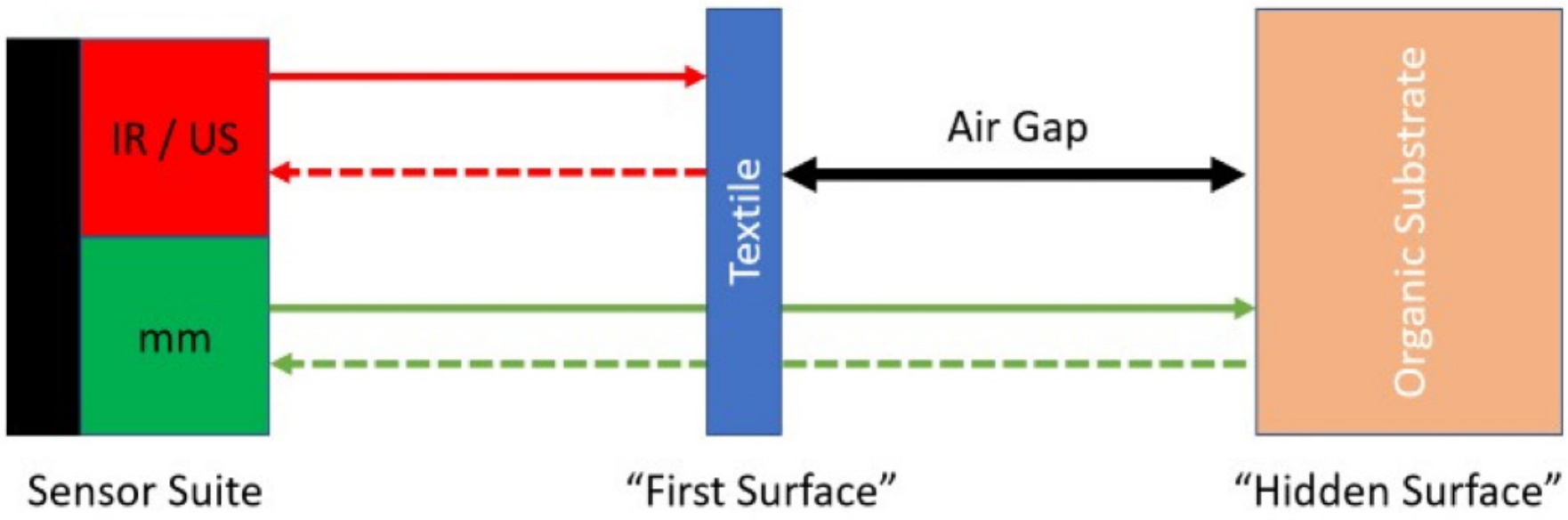

Image 2. An “air gap” is defined as the distance between the textile and the visually occluded body within it.

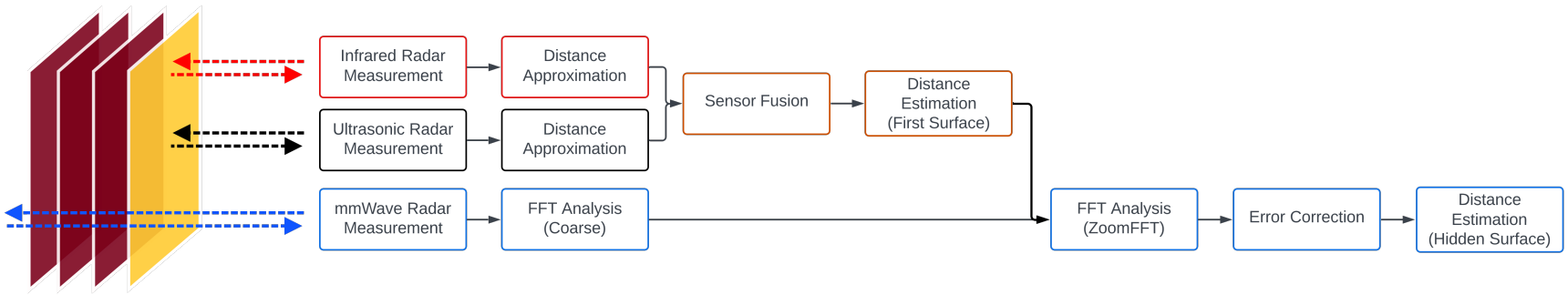

Image 3. Data processing and analysis resulting in “air gap” measurments. First surface measurements are leveraged for “focusing” the mmWave radar.

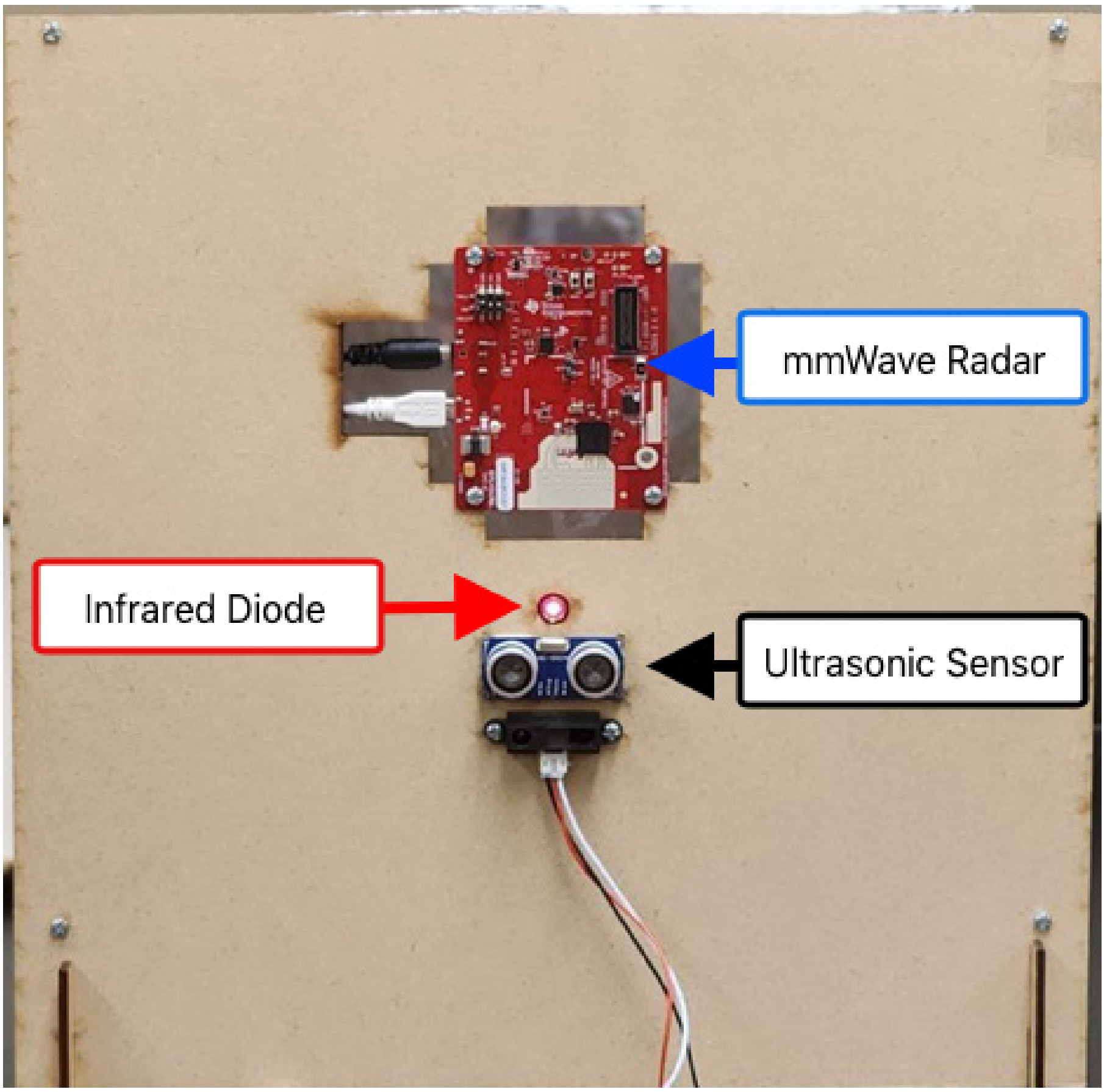

Image 4. Multiple scanning methods (Infrared, Ultrasound, and mmWave) are used synergistically to create measurements of garment fit.

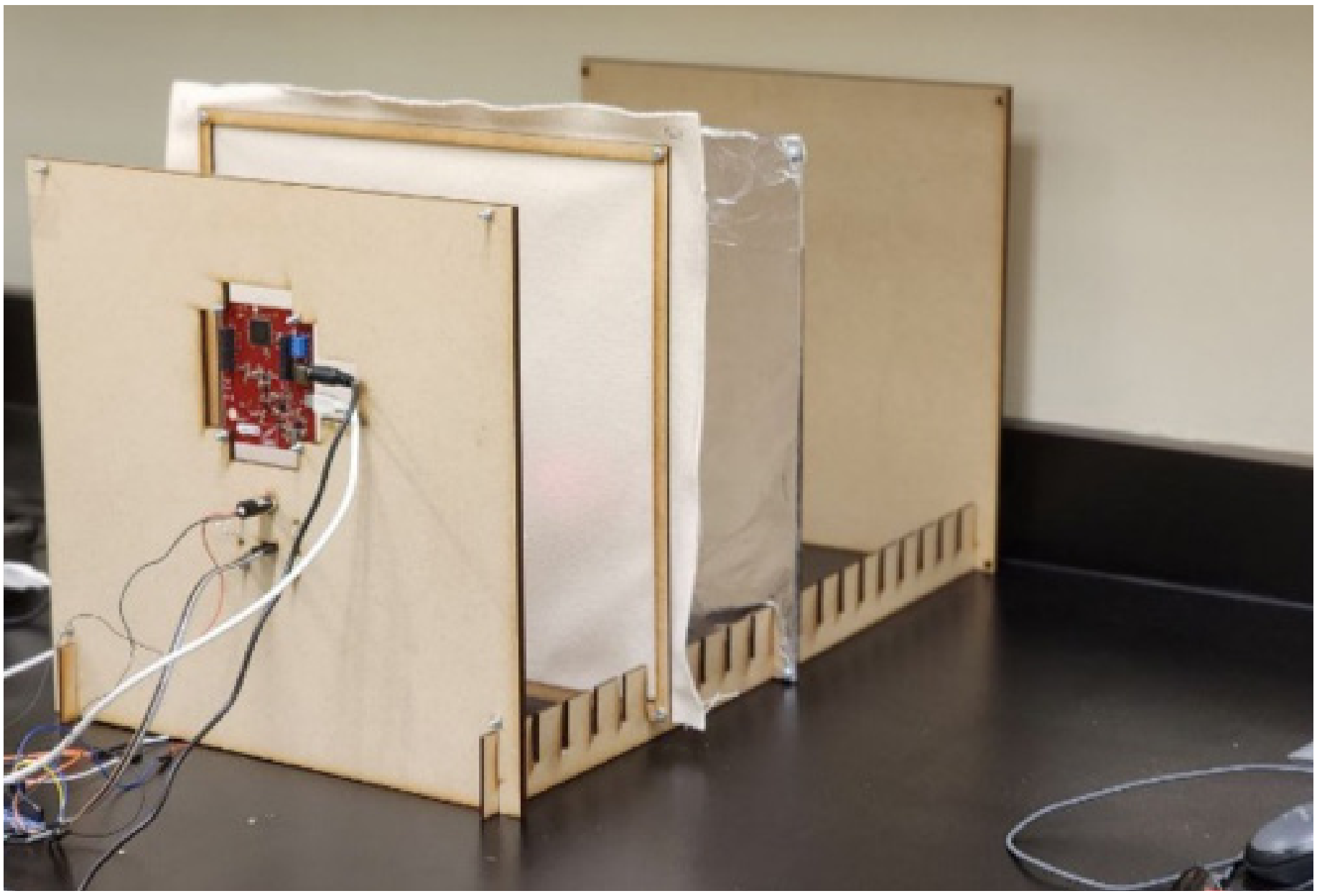

Image 5. Photo of the testing rig featuring a textile surface detected by Infrared/Ultrasonic and hidden surface detectable by the mmWave radar.