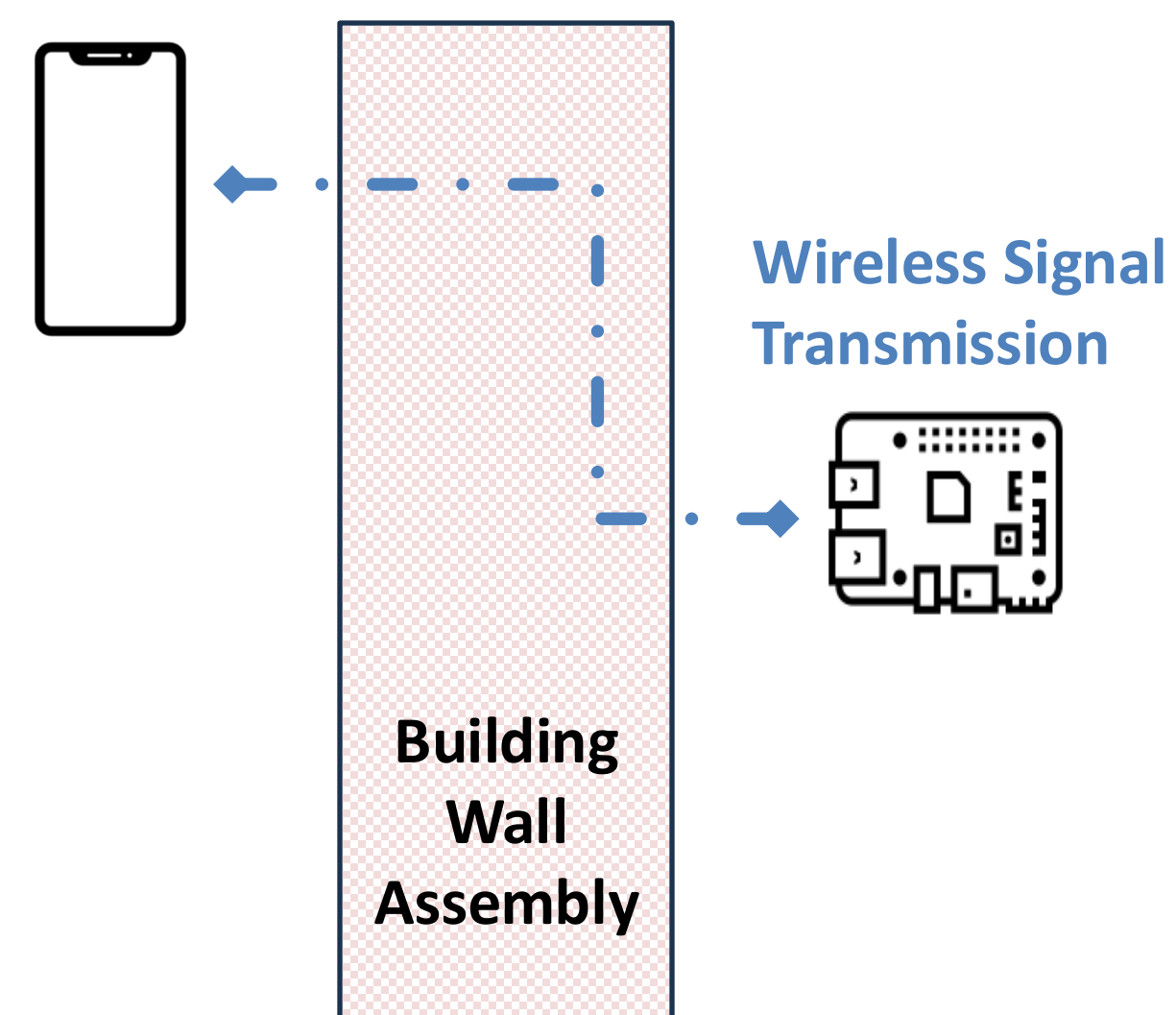


INTRODUCTION

- This project proposed the use of **wireless signal transmission** to estimate the **insulation properties** of building envelopes.
- This method provides a **low-cost alternative** to non-destructive evaluation techniques such as infrared thermal imaging and heat flow meters.
- Currently, techniques used to estimate insulation value require expensive equipment, skilled labor and are impacted heavily by environmental factors like wind and solar radiation.
- A low-cost alternative provides citizens with tools to evaluate their homes making building auditing more accessible.

METHODOLOGY — DATA COLLECTION

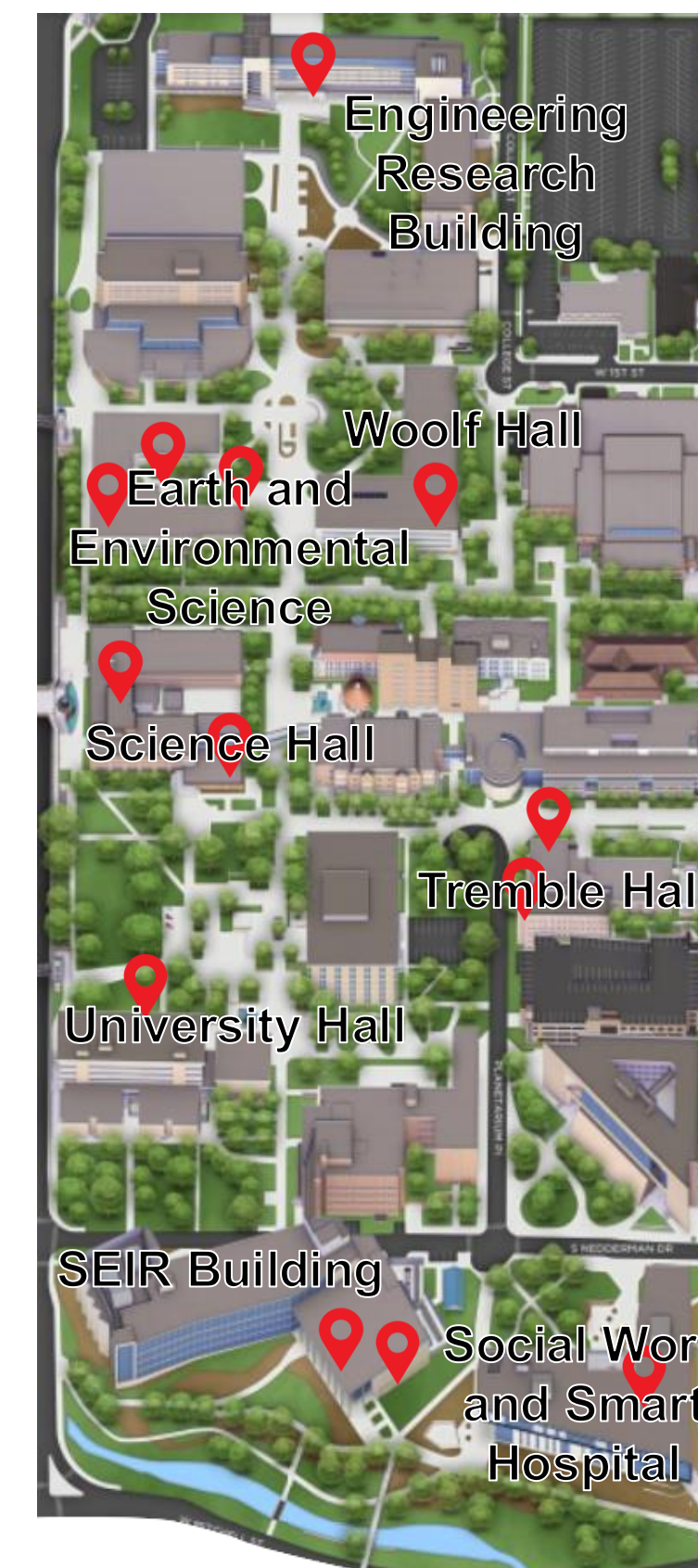
Figure 1: Experimental Set-Up Flowchart



- The experiment was set up using a **Raspberry Pi 4 module** as the network receiver and an iPhone as the network transmitter.
- The iPhone was used to transmit wi-fi frequencies at **2.4GHz and 5GHz**, while the Raspberry Pi 4 module ran a python script to measure, time-stamp and record the necessary data
- The script utilized configuration parameters to read the network strength from the iPhone at a **3-minute duration with 5 second intervals**.
- Enabled with function error checks the script was designed to run smoothly throughout the collection process.
- This process was repeated at varying wall assemblies across The University of Texas at Arlington's campus.

METHODOLOGY – BUILDING SELECTION

Figure 2: Experiment Locator Map



- Locations were selected based on their **unique building materials**, accessibility and **date of construction**
- Fenestration was taken into consideration when conducting the experiment. Presence of windows, doors and other opening lead to poorer data reliability.
- Buildings with readily available construction documentation and published insulation data were given priority.
- Construction dates raging from 1960 to 2024

R-Value Calculations:

- R-Values were either referenced directly from construction documents or calculated using element thickness (t) and element thermal conductivity (k) using the following equation
- $R = \frac{t}{k}$

RESULTS

Figure 3: 2.4 GHz Gaussian Distribution Curves Across All 15 Locations

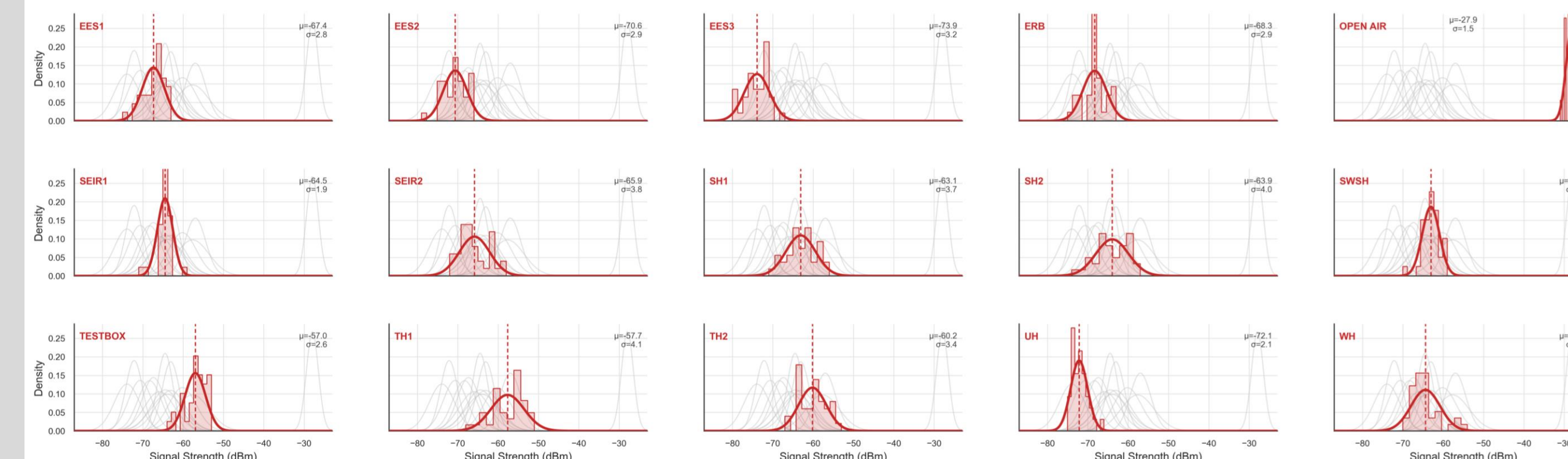
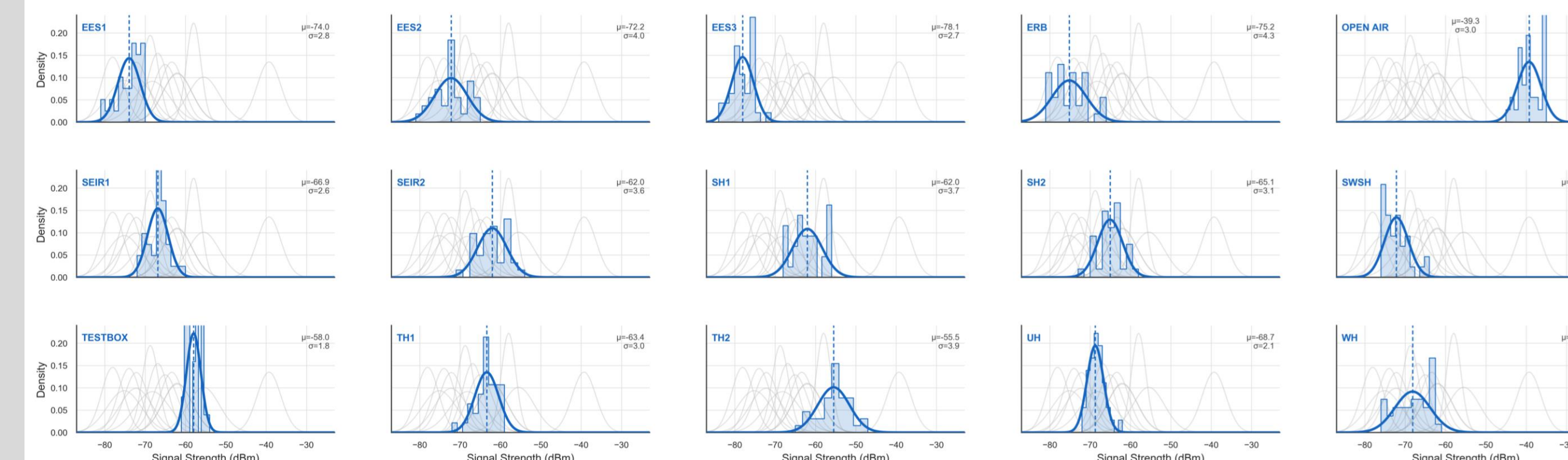


Figure 4: 5 GHz Gaussian Distribution Curves Across All 15 Locations



RESULTS

Figure 5: Ranked Mean Signal Strength by Wall Location

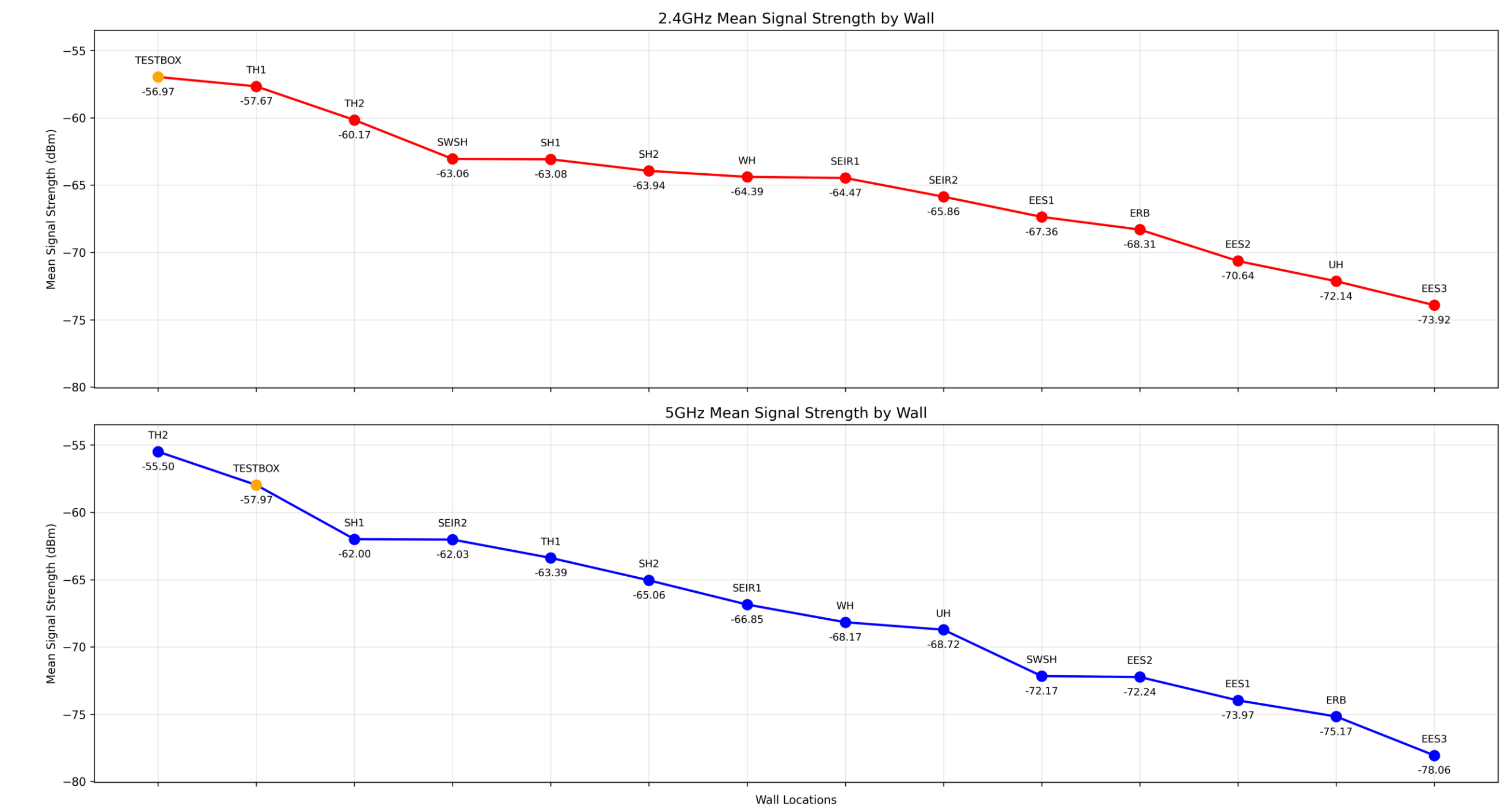
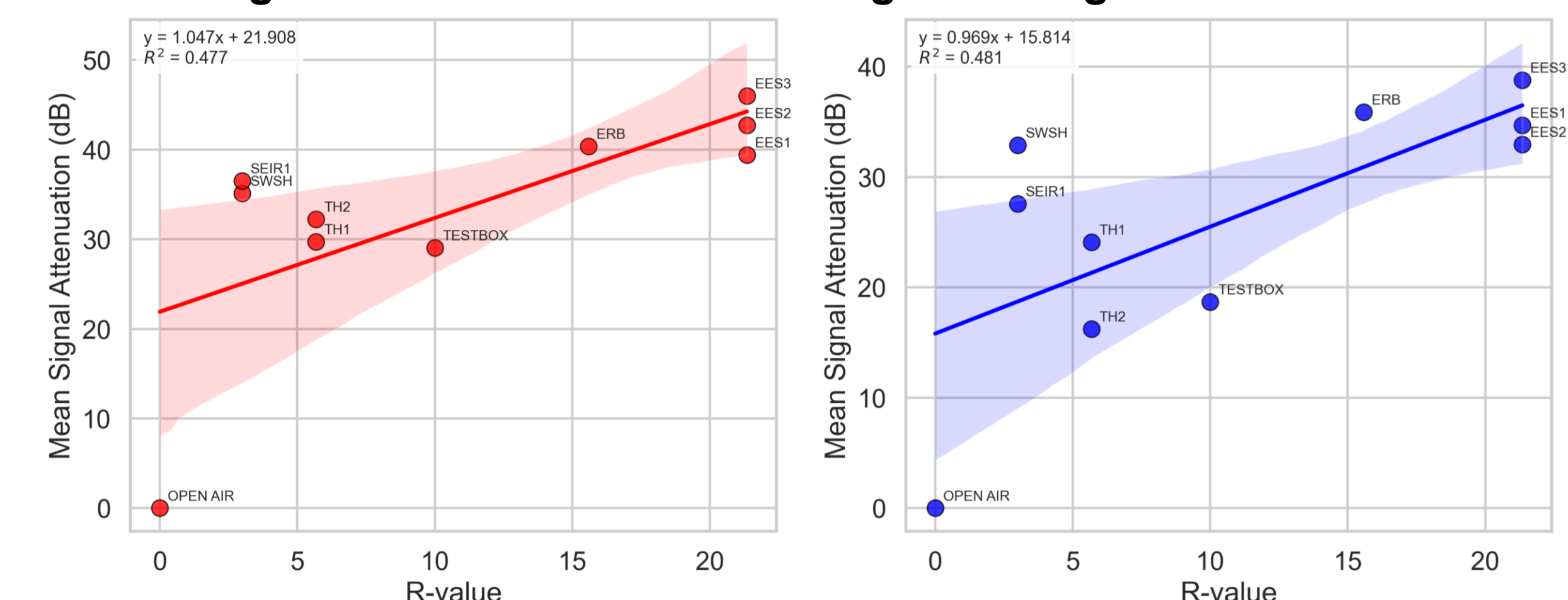


Table 1: Cross-Frequency Mean Differential by R-Value

Location	R-Value	2.4 GHz Mean (dBm)	5 GHz Mean (dBm)	Δ (dBm)
EES1	21.35	-67.36	-73.97	-6.61
EES2	21.35	-70.64	-72.24	-1.60
EES3	21.35	-73.92	-78.06	-4.14
ERB	15.59	-68.31	-75.17	-6.86
Test-box	10.00	-56.97	-57.97	-1.00
TH1	5.68	-57.67	-63.39	-5.72
TH2	5.68	-60.17	-55.50	+4.67
SEIR1	3.00	-64.47	-66.85	-2.38
SWSH	3.00	-63.06	-72.17	-9.11
Open-Air	0.00	-27.94	-39.28	-11.34

Figure 6: 2.4 and 5 GHz Mean Signal Strength vs. R-Value



REFERENCES

- Liu, S., and Bobrow, J. E., "An Analysis of a Pneumatic Servo System and Its Application to a Computer-Controlled Robot," *ASME Journal of Dynamic Systems, Measurement, and Control*, 1988, Vol 110 pp 228-235.
- El Masri, Y., & Rakha, T. (2020). A scoping review of non-destructive testing (NDT) techniques in building performance diagnostic inspections. *Construction and Building Materials*, 265, 120542.