60-GHz Millimeter-Wave Pathloss Measurements in Boise Airport

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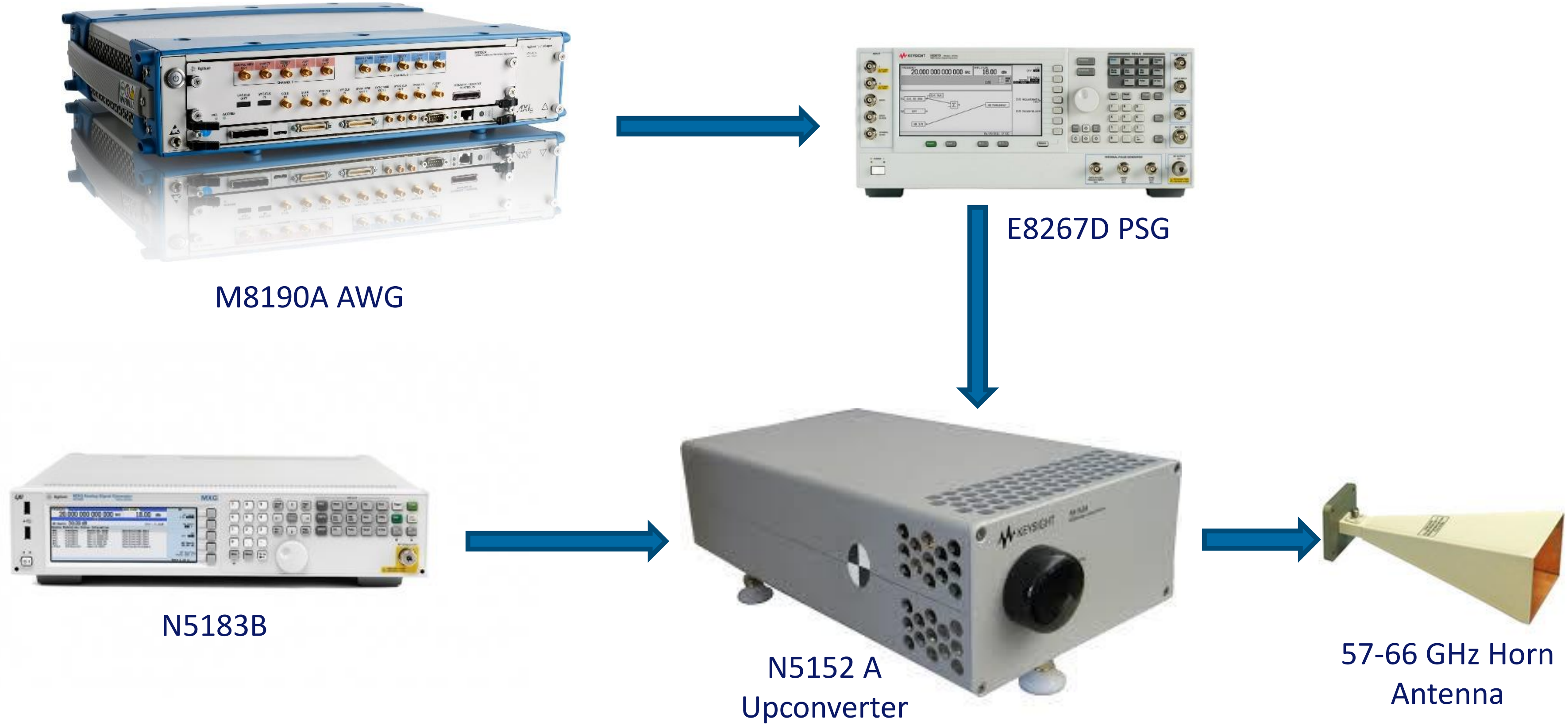
Contents

- ☐ 60 GHz channel measurement campaigns
    - ☐ Hardware setup
    - ☐ Specifications
- ☐ Measurements procedure and environment
    - ☐ Boise Airport
    - ☐ Boise State University
    - ☐ LOS scenarios
    - ☐ NLOS scenarios
- ☐ Large-scale path loss models at 60 GHz
    - ☐ Close-in reference path loss model (CIM)
    - ☐ Floating-intercept path loss model (FIM)
        - Least square regression fit
        - Gradient descent regression fit
- ☐ Path loss parameters
    - ☐ Path loss exponent and
    - ☐ Shadowing factor
- ☐ Scatter plot of the empirical data
- ☐ Conclusion and Future work

Hardware Setup for Channel Measurement (Tx Side)



M8190A AWG

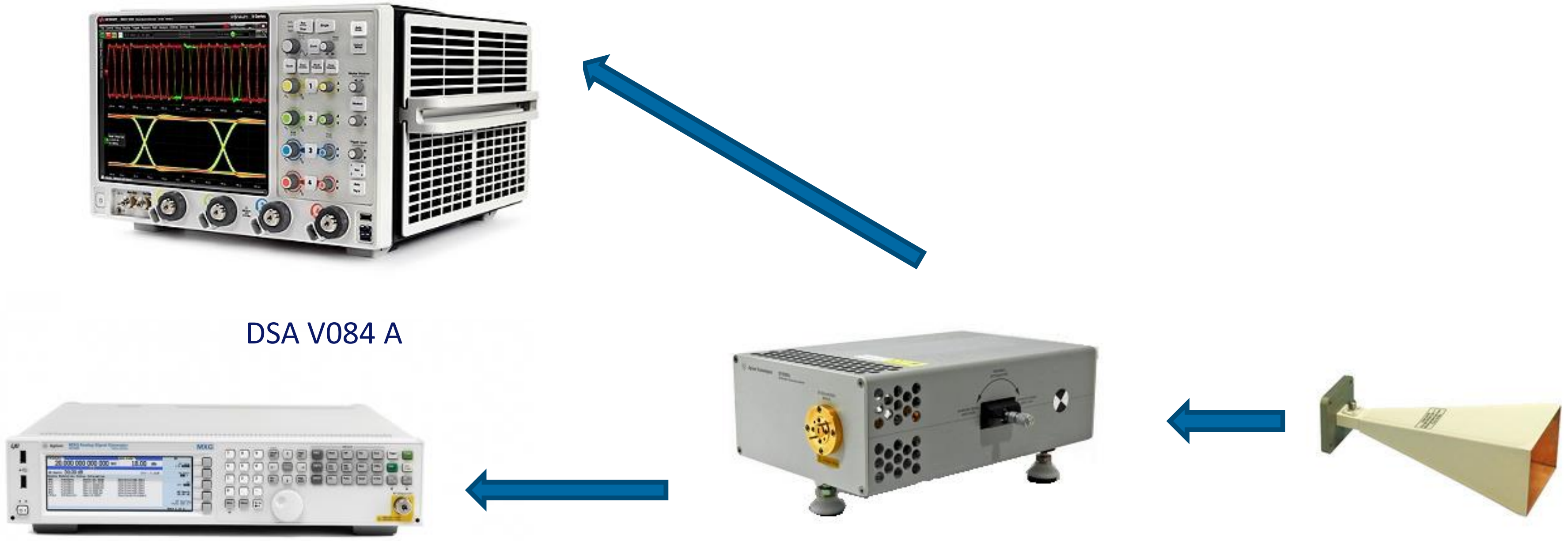
E8267D PSG

N5183B

N5152 A Upconverter

57-66 GHz Horn Antenna

Hardware Setup for Channel Measurement (Rx Side)



DSA V084 A

N5183B

N1999 A
Downconverter

57-66 GHz Horn
Antenna

Hardware Specifications

Table I: CHANNEL MEASUREMENTS HARDWARE SPECIFICATION AT 60 GHZ CAMPAIGN

60 GHz campaign	
Carrier frequency	60 GHz
Modulation scheme	BPSK
Bandwidth	1.3 GHz
Tx and Rx antenna gain	25 dB
Tx and Rx antenna 3dB beamwidth in E-plane	7.92°
Tx and Rx antenna 3dB beamwidth in H-plane	9.65°
Max. Tx power	-5 dBm

Measurement Environment

- The measurement campaigns were conducted at Boise Airport & Boise State University
  - Airport gate areas
  - Airport baggage claim areas
  - Hallway of Engineering building
  - Outdoor of the Engineering building

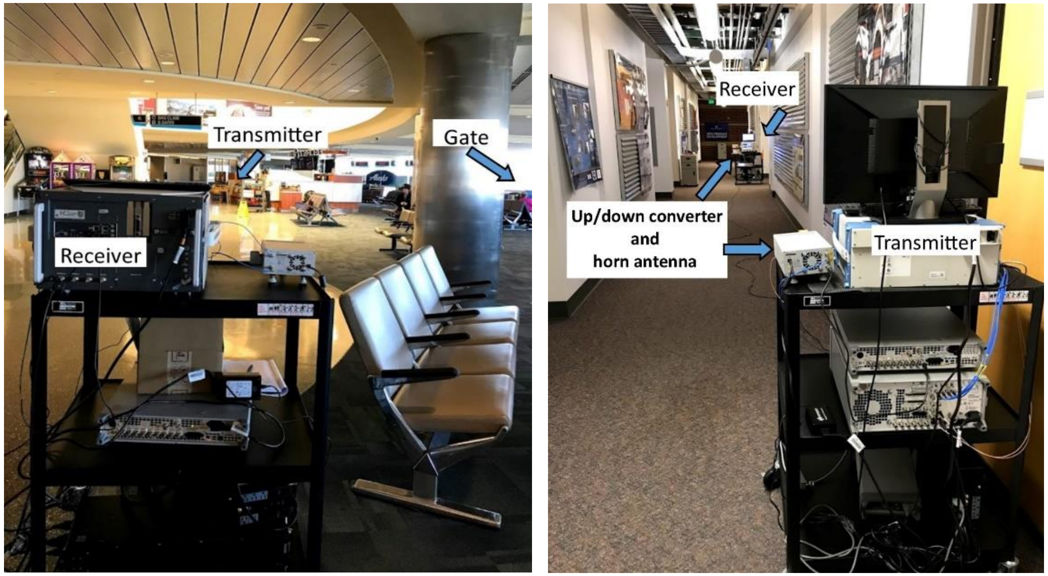


Fig. 2: 60 GHz channel measurement conducted in airport gate (left) and hallway (right)

Large-scale Fading Model

Close-in reference path loss model

$$PL(d) = PL(d_o) + 10\, n\, log_{10}\left(\frac{d}{d_o}\right) + \chi_\sigma$$

$PL(d_o)$ = free space path loss at 60 GHz

n = path loss exponent, how fast the path loss increases with the separation

χ_σ = log-normal random variable with 0 mean and standard variation σ

Floating- Intercept path loss model

$$PL(d) = \alpha + 10\beta log_{10}\,(d) + \chi_\sigma$$

$\alpha =$ floating intercept in dB

β = linear slope

χ_σ = log-normal random variable with 0 mean and standard variation σ

Two Approaches

- ☐ Gradient- descent fit (GDM)
- ☐ Least-square fit (FIM)

Path Loss Results

- ☐ The blue triangle represents the LOS measurement data
- ☐ The path loss exponent and shadow factor are determined using three models: CIM, FIM and GDM

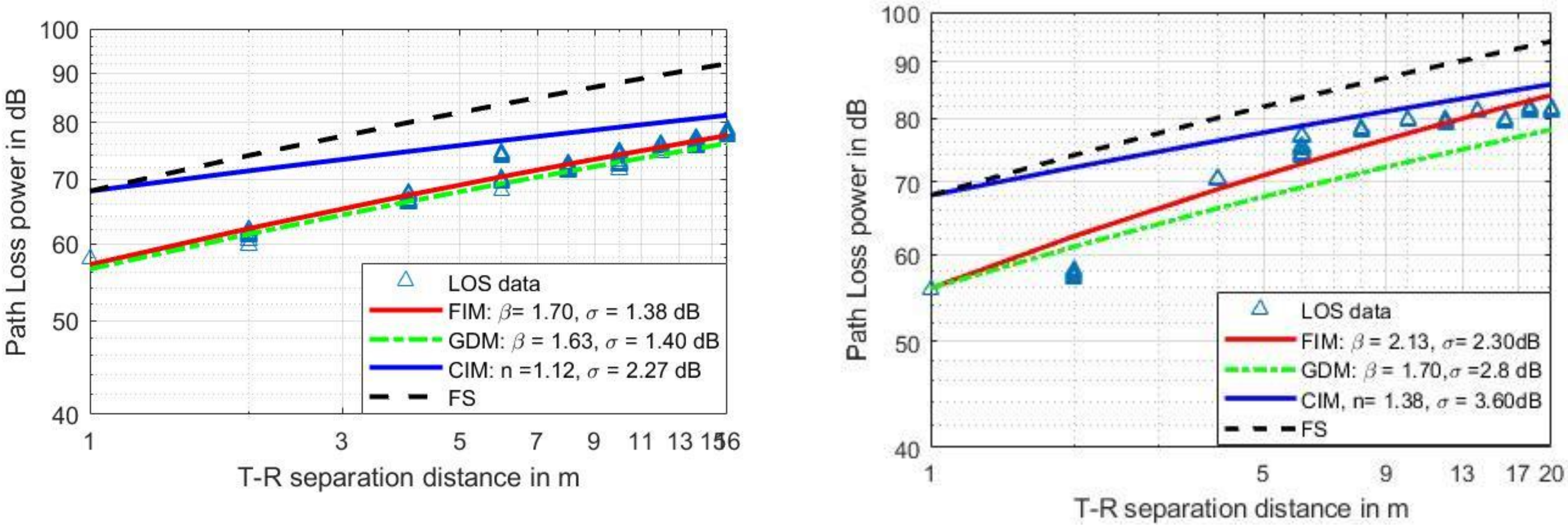


Fig. 3: FIM, GDM and CIM along with the measurement data taken from the airport baggage (left) and gate (right) area at 60 GHz

Result and Analysis

- Measurement campaign at 60 GHz at Boise State University
- Two Indoor measurements
- One outdoor campaign measurement

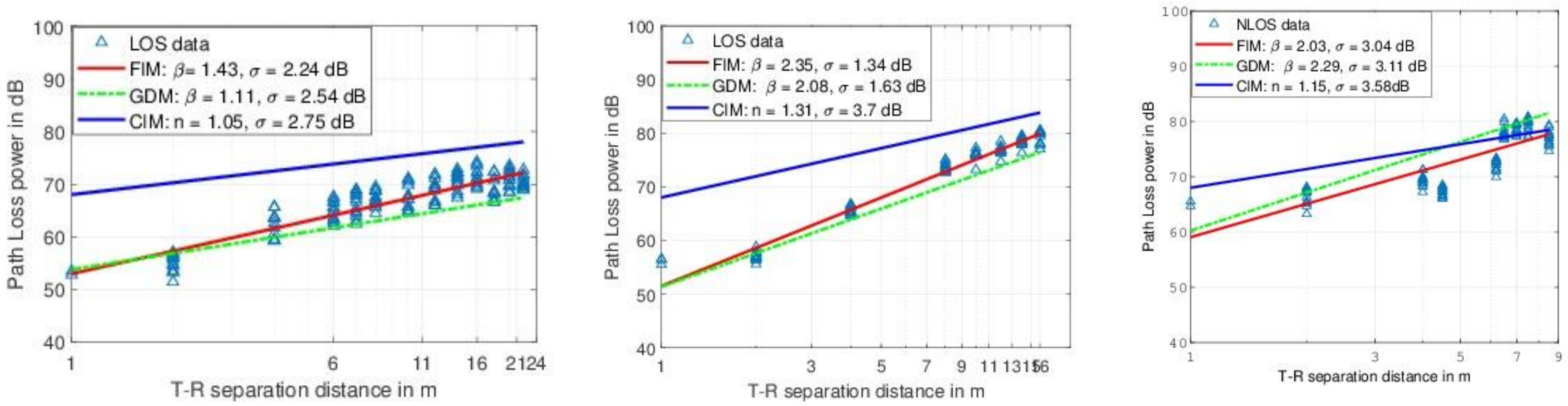


Fig. 3: FIM, GDM and CIM along with the measurement data taken from the indoor of LOS link (left), outdoor of LOS link (middle) and indoor NLOS link (right) at 60 GHz

Result and Analysis

Table I : PARAMETERS OF THE CLOSE-IN REFERENCE MODEL (CIM), FLOATING INTERCEPT MODEL (FIM) AND GRADIENT DESCENT FIT MODEL (GDM) FOR AIRPORT AND UNIVERSITY ENVIRONMENTS

Directional Path Loss Models									
Environments	Scenarios	CIM		FIM			GDM		
		n	σ, dB	α, dB	β	σ,dB	α	β	σ,dB
Airport gate area	LOS	1.38	3.6	56	2.13	2.30	56	1.7	2.8
Airport baggage area	LOS	1.12	2.27	57	1.70	1.38	56.78	1.63	1.4
indoor	LOS	1.05	2.75	53	1.43	2.24	53.78	1.11	2.54
outdoor	LOS	1.31	3.7	51.5	2.35	1.34	51.37	2.08	1.63
indoor	NLOS	1.15	3.58	59.086	2.03	3.04	60.25	2.29	3.11

Recent Work (Path Loss Values at 60 GHz)

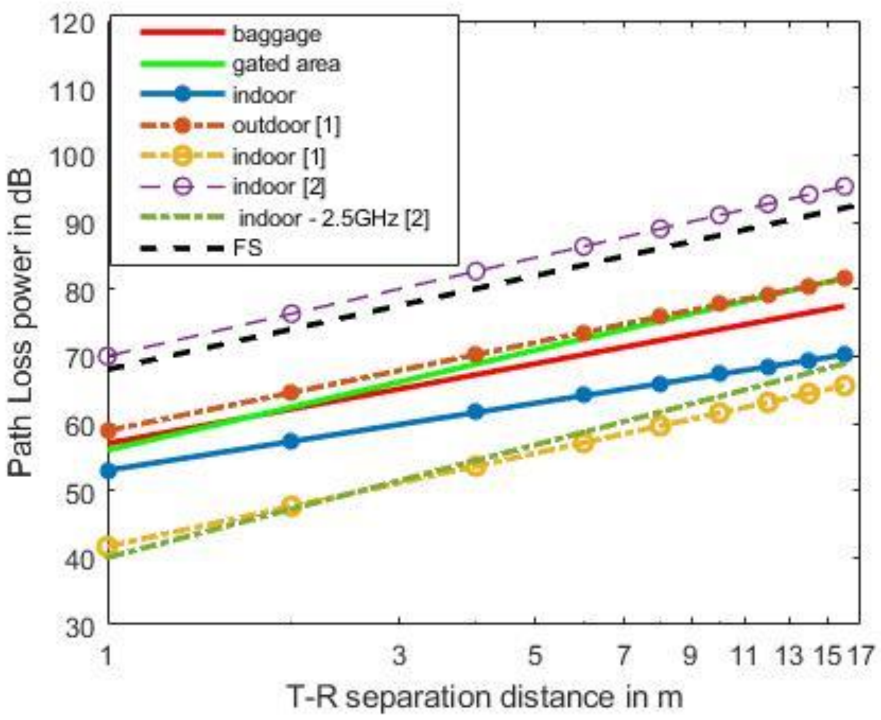


Fig. 4: Plots of the path loss values from recent work

- ❑ Similarities
  - ❑ Similar results to indoor hallway [1] PL value. These are $\alpha = 58.9 \quad \beta = 1.88$
  - ❑ Our result deviates from the free-space values which similar to indoor [1], outdoor [1] PL values at 60 GHz.
- ❑ Differences
  - ❑ Far from indoor single [2], and indoor hallway [1] value.
  - ❑ All results far from free-space values except indoor[2] value.

Conclusion & Future Work

- Gradient-Descent regression fit is used, and comparable results are found with the least-square fit line
- CIM provides more waveguiding effects than the FI model
  - Single parameter model
  - Physical basis model
- Multipath propagation effects can be experimented in the airport environments.
- Wideband MIMO (Multiple-input Multiple-Output) channel measurements

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Thank You