ITU WORKSHOP

Activities of ITU-R Study Group 3 on radiowave propagation

Working Party 3K – Point-to-Area Propagation

EuCAP 2024, Glasgow

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Outline

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Recommendations of WP 3K

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Working Party 3K Recommendations

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Correspondence Groups

- CG 3K-6: ITU-R P.1238-11 and ITU-R P. 1411-11 Model harmonization of path loss models
- CG-3K-5: Measurements procedures for P. 1238 and P. 1411
- CG 3J-3K-3M-8: ITU-R P. 2109-1 Building entry loss model
- CG 3K-3M-12: ITU-R P. 2108-1 Clutter loss prediction

Working Group 3K-1 Recommendation(s)

Chairman: Dr. I. Stevanovic

Recommendations P.1812

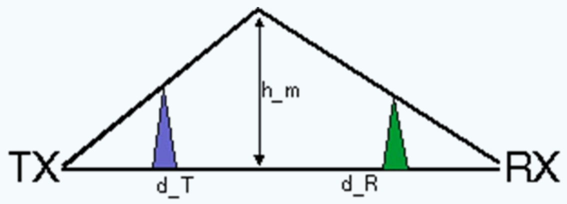
- The model in this recommendation is appropriate for predictions of basic transmission loss on terrestrial paths where both terminals are less than (approximately) 3 km height above ground
- The model includes prediction methods for the
  - Line-of-sight
  - Diffraction
  - Troposcatter/Ducting

P.1812

- Line-of-sight propagation (principally free space loss, with two-ray multipath enhancements at low time percentages)

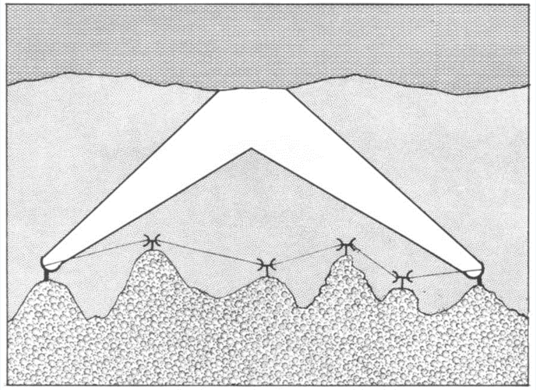
- Propagation by diffraction (a combination of both knife-edge and smooth sphere/earth diffraction – “delta” Bullington method)

  - **Knife-edge diffraction**: constructs the Bullington equivalent single knife-edge, (adjusted for atmospheric refraction/earth bulge)
  - Smooth sphere diffraction accounts for both land and sea paths



P.1812

- Propagation by tropospheric forward scatter (troposcatter) Time variability (i.e., atmospheric super-refraction and ducting/layering) are mostly accounted for through the lower quantiles of the predicted cumulative distribution function (i.e., enhancement side of the distribution)



  - Dependence on radiometeorological parameters, such as coastal land and sea contributions to the total path length, proximity of terminals to large bodies of water and point-incidence of ducting percentage (from map/digital database)

P.1812

- The **method is site-specific** in that a terrain profile must be provided as input data (usually equally spaced horizontal increments, less than or equal to 90 m if available, but equal spacing is not inherently required);

- To achieve a point-to-area prediction, the user should apply the method to suitably small pixels covering the area where the prediction is sought – that is a point-to-multipoint approach;
  - For predictions involving mobile and/or portable systems where a terminal is not fixed, location variability is provided.

Working Group 3K-2 Recommendation(s)

Chairman: Dr F. Lewicki

Recommendations P.1546

- Provides a site-general terrestrial propagation model/method
- The “model” is empirical, i.e., measurements of signal strengths, suitably normalized, were used to derive families of field strength curves vs. distance at fixed frequencies, time percentages and environments

P.1546

- Curve families represent different values of the base/transmitter height, h_1, while the receiver/mobile height, h_2, is fixed.

- Each curve of field strength vs. distance (or its tabulated values) serves as a basis for either the lower or upper values of interpolating formulae (except for limited cases of extrapolations)

  - A different method is devised for mixed land-sea paths.

P.1546

- The curves represent the mean/median of the measured results (suitably adjusted) at the desired time percentage and are thus expected to exemplify the dominant propagation mechanisms as these vary with the “input” parameters and thus show
  - Line-of-sight (inclusive of some two-ray interference and first Fresnel zone intrusions);
  - Diffraction by both irregular terrain (land) and a smooth spherical earth (land and sea);
  - Troposcatter (into ducting/super-refraction at low time percentages.

P.1546

Further work to extend the model/method to higher frequencies and the full range of time variability is on-going.

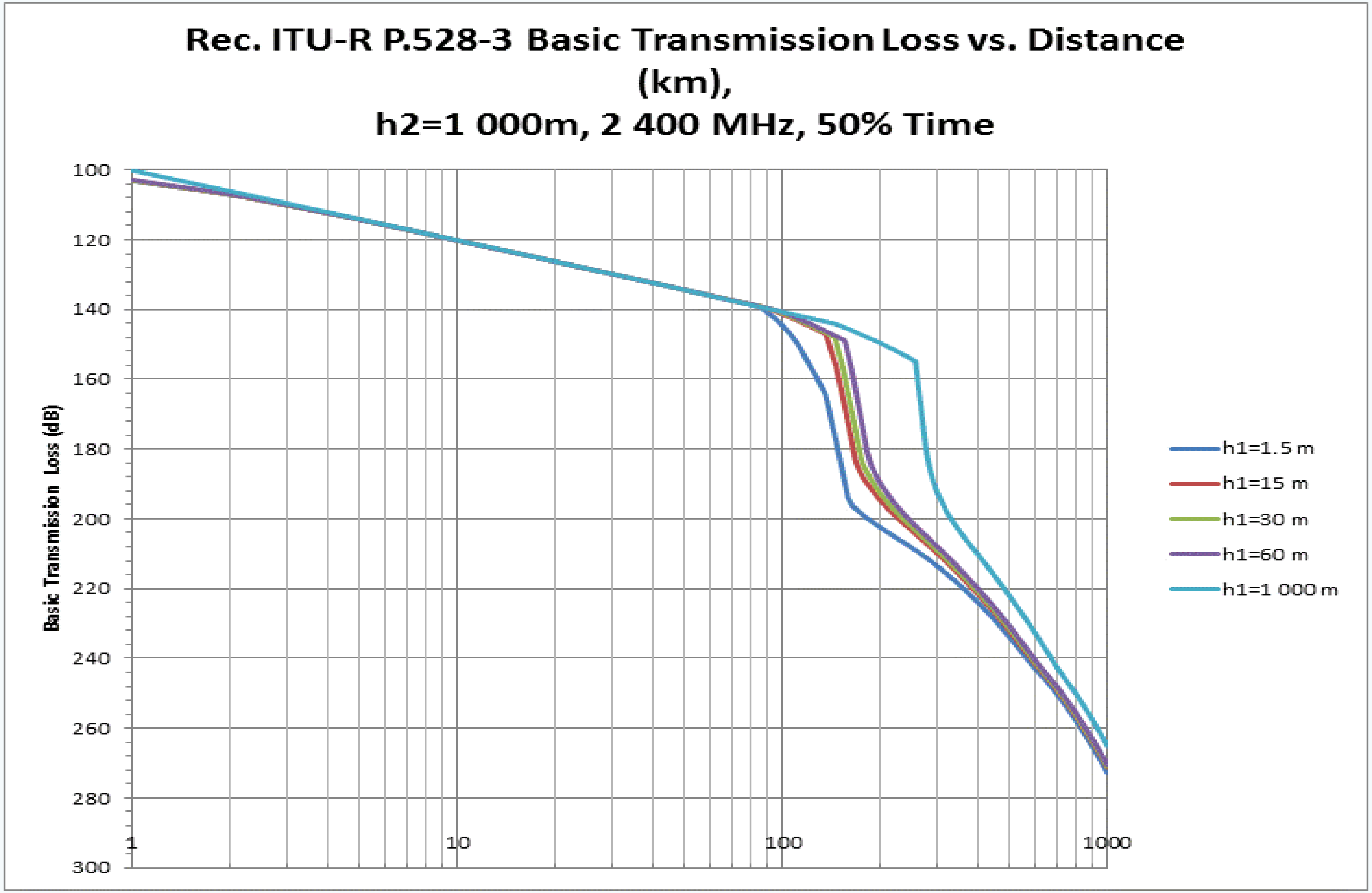
Recommendation ITU-R P.528

- A site-general air – (air/ground) propagation prediction method
- The important additional feature that this model includes is the refraction of the radio rays as they pass through the vertically stratified earth's atmosphere.

P.528

- Ray trajectories are dictated by Snell's Law for radial (vertical) stratification;

- The propagation model accounts for the major propagation mechanisms:
  - ➢ Line-of-sight;
  - ➢ Diffraction (smooth earth only);
  - ➢ Troposcatter;
  - ➢ Time variability (including ducting and super-refraction).


Rec. ITU-R P.528-3 Basic Transmission Loss vs. Distance (km),
h2=1 000m, 2 400 MHz, 50% Time
Basic Transmission Loss (dB)
100
120
140
160
180
200
220
240
260
280
300
1
10
100
1000
h1=1.5 m
h1=15 m
h1=30 m
h1=60 m
h1=1 000 m

Working Group 3K-3 Recommendation(s)

Chairman: Dr W. Yamada

- Rec. ITU-R P.1411: propagation models for outdoor, short-range paths (urban, suburban, residential environments) from 300 MHz- 100 GHz

- Path categories;

➢ Basic transmission loss models;

➢ Multipath models;

➢ Polarization characteristics;

➢ Cross-correlation model (multi-link channel);

➢ High doppler environments.

P.1411

- The models are both site-general and site-specific and cover a distance range out to approximately 1 km.
- Many models have a big empirical component;
  - Gaseous attenuation is inherently included;
  - Paths are in inherently cluttered environments.

Path loss model

- Single frequency vs multiple frequency

- $PL_{logDist}(d) = 10\alpha \log_{10}(d) + \beta \ dB$

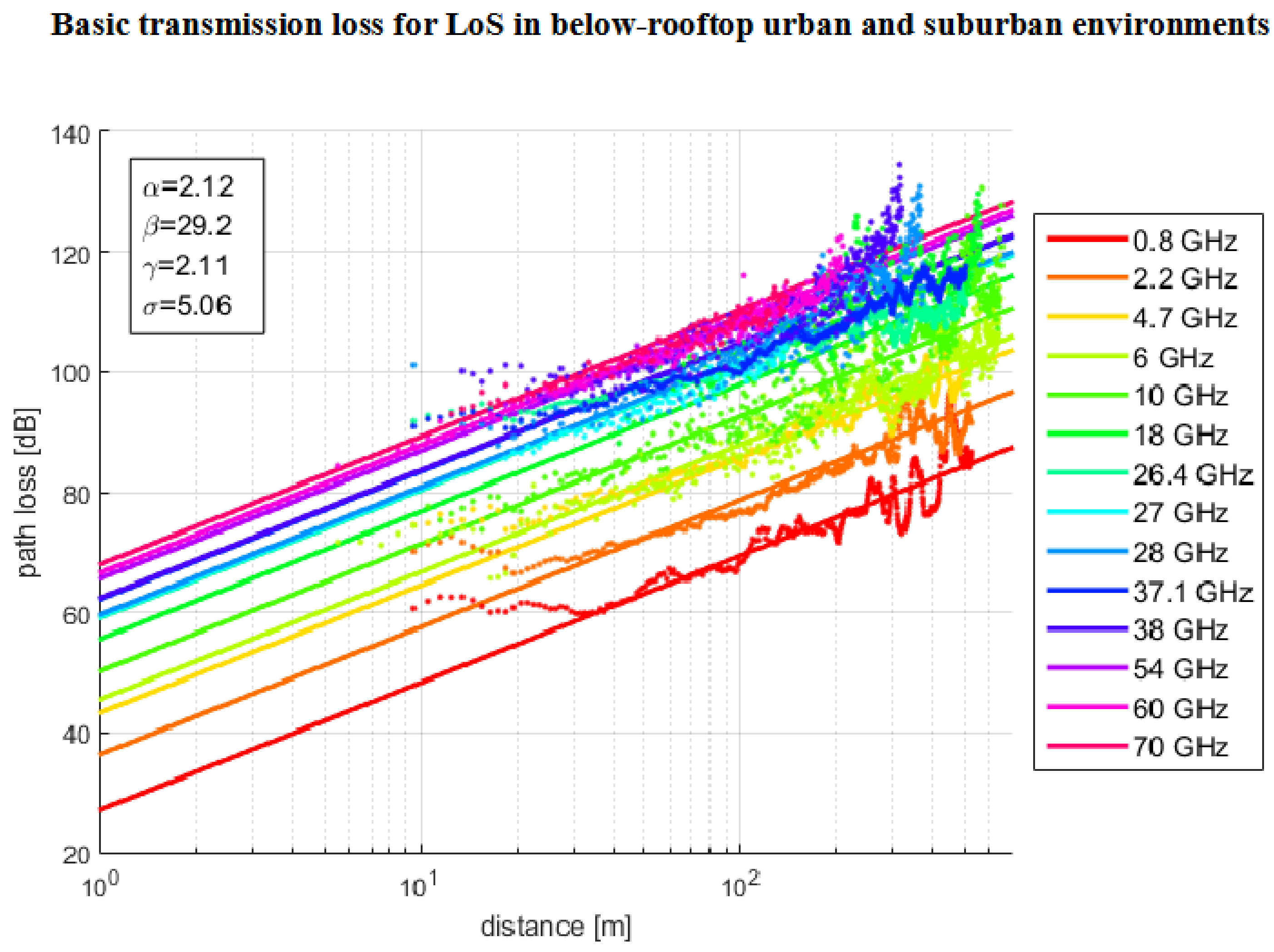
- $PL(d, f) = 10\alpha \log_{10}(d) + \beta + 10\gamma \log_{10}(f) \ dB$

- with an additive zero mean Gaussian random variable $N(0, \sigma)$ with a standard deviation σ (dB)

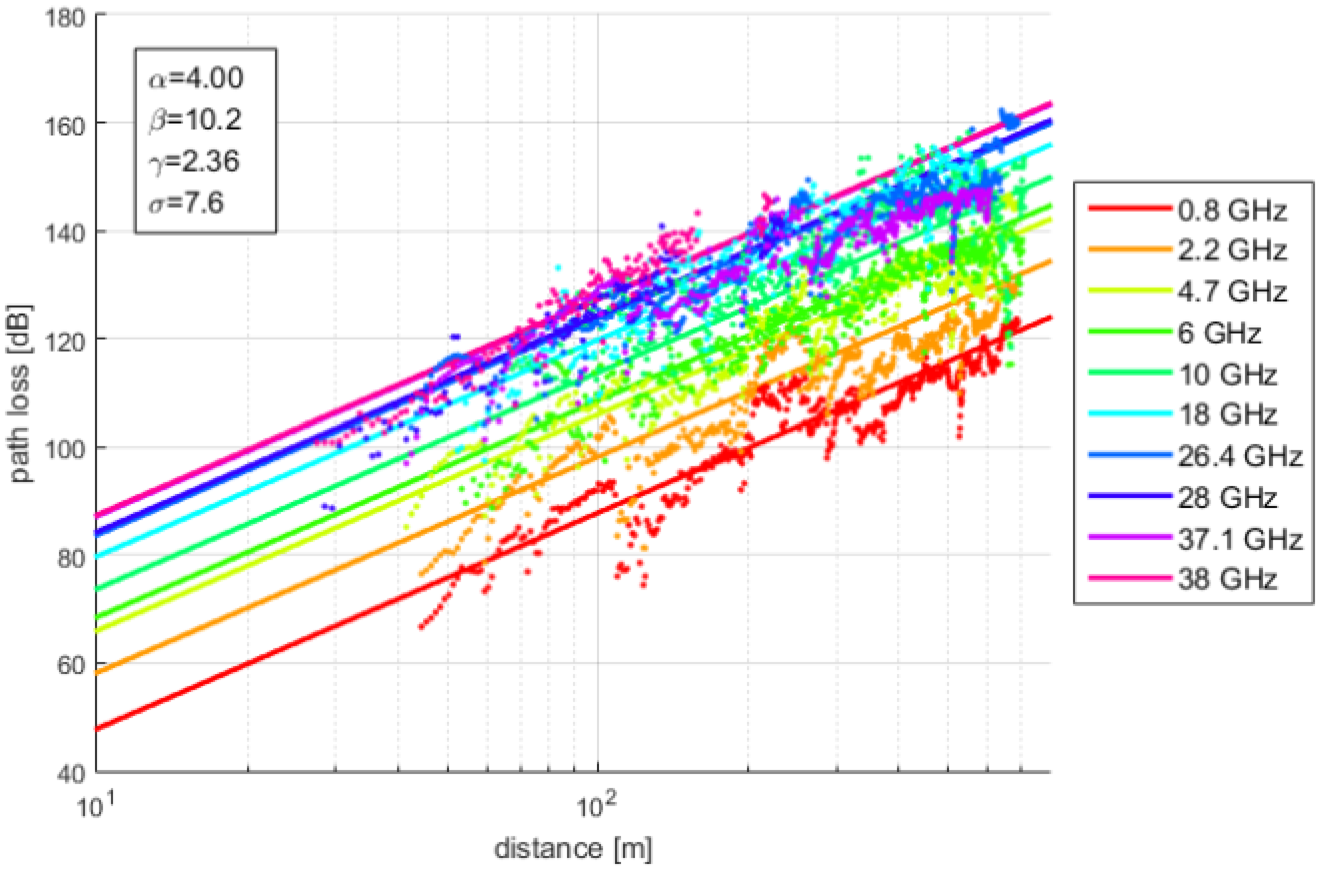
WRC15/WRC19 frequency bands

WRC15/19 Band (GHz)	Bandwidth (GHz)
24.25-27.5	3.25
31.8-33.4	1.6
37-43.5	6.5
45.5-50.2 45.5-47, 47.2-48.2	4.7 1.5, 1
50.4-52.6	2.4
66-76 66-71	10 5
81-86	5

With 14.75 GHz harmonized worldwide, ~ 85% of global harmonization


Basic transmission loss for LoS in below-rooftop urban and suburban environments
α=2.12
β=29.2
γ=2.11
σ=5.06
path loss [dB]
distance [m]
140
120
100
80
60
40
20
10^0
10^1
10^2
0.8 GHz
2.2 GHz
4.7 GHz
6 GHz
10 GHz
18 GHz
26.4 GHz
27 GHz
28 GHz
37.1 GHz
38 GHz
54 GHz
60 GHz
70 GHz

Basic transmission loss for NLoS in below-rooftop urban environments



Adopted model for below rooftop

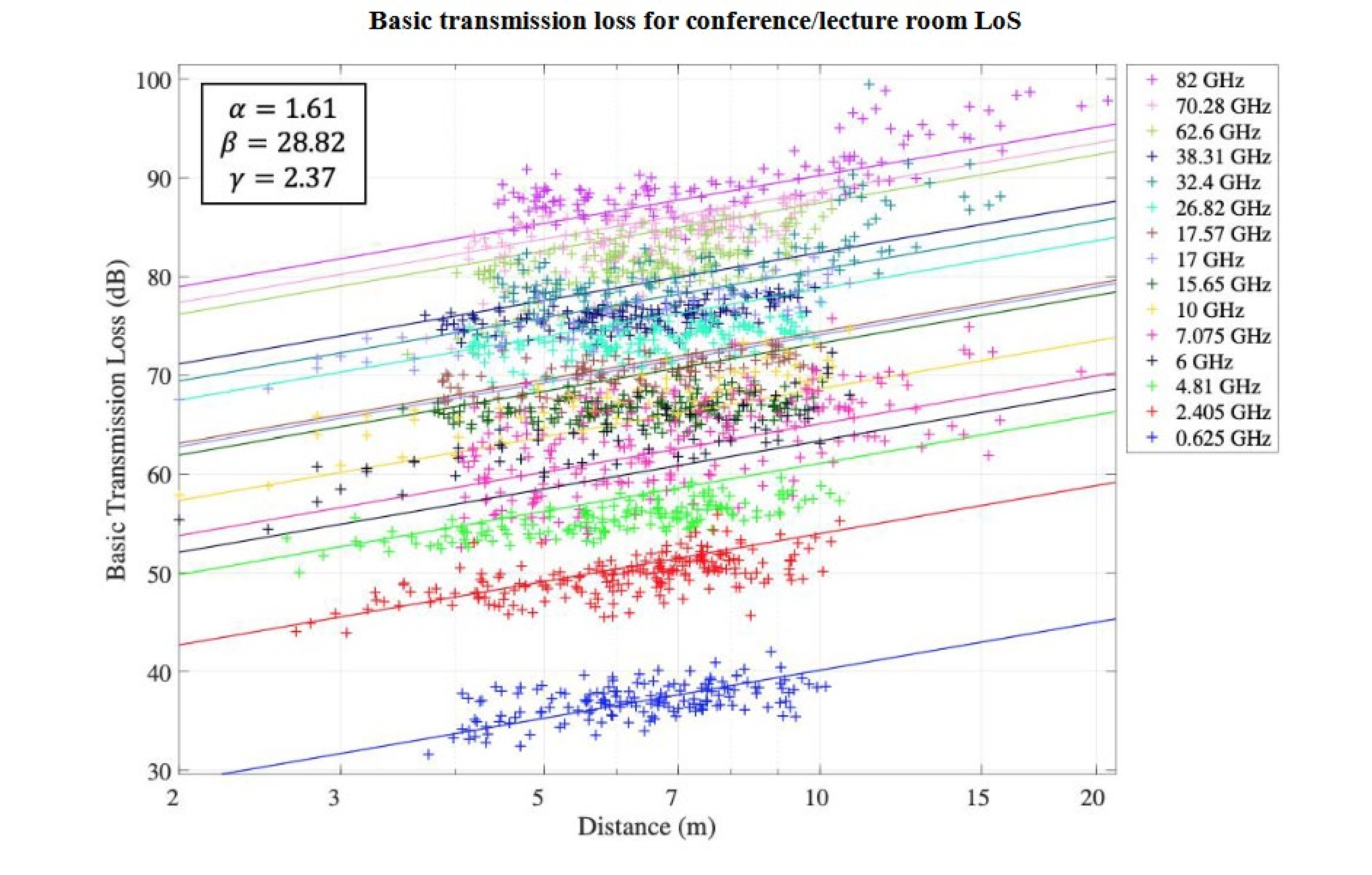
Frequency range (GHz)	Distance range (m)	Type of environment	LoS/ NLoS	α	β	γ	σ
0.8-73	5-660	Urban high-rise, Urban low-rise/ Suburban	LoS	2.12	29.2	2.11	5.06
0.8-38	30-715	Urban high-rise	NLoS	4.00	10.2	2.36	7.60
10-73	30-250	Urban low-rise/ Suburban	NLoS	5.06	-4.68	2.02	9.33
0.8-73	30-170	Residential	NLoS	3.01	18.8	2.07	3.07

Recommendation P.1238

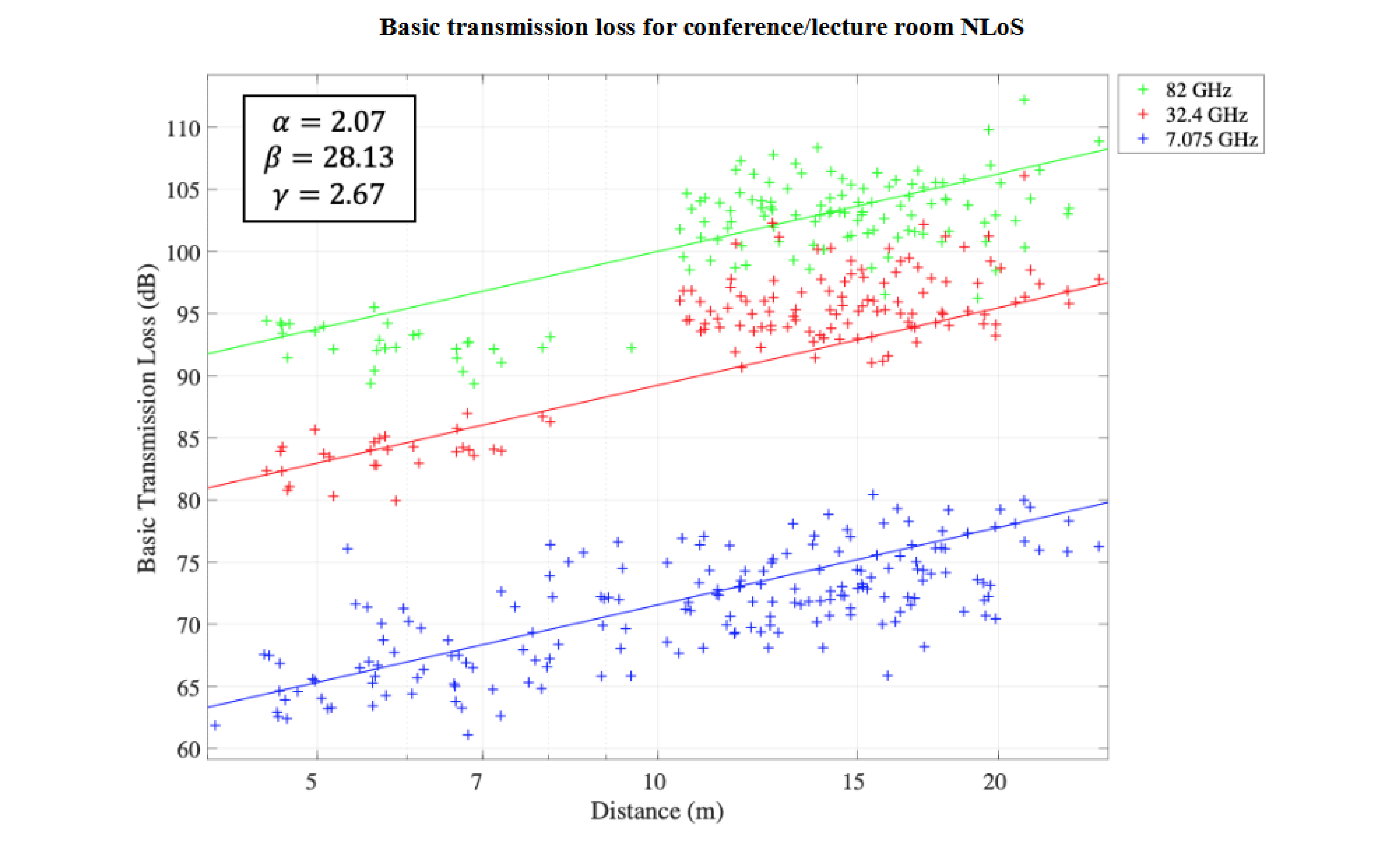
Rec. ITU-R P.1238: Propagation models for indoor environments (including multi-storey buildings), in the frequency range from approximately 300 MHz - 450 GHz.

Recommendation P.1238

- Basic transmission loss models;
- Delay spread models;
- Effects of polarization;
- Effects of antenna radiation patterns;
- Effects of transmitter and receiver siting;
- Effects of building materials, furnishings and furniture; Effects of movement of objects in the room;
- Angular spread models;
- Statistical model in static usage.



Basic transmission loss for conference/lecture room LoS
α = 1.61
β = 28.82
γ = 2.37
Basic Transmission Loss (dB)
Distance (m)
100
90
80
70
60
50
40
30
2
3
5
7
10
15
20
82 GHz
70.28 GHz
62.6 GHz
38.31 GHz
32.4 GHz
26.82 GHz
17.57 GHz
17 GHz
15.65 GHz
10 GHz
7.075 GHz
6 GHz
4.81 GHz
2.405 GHz
0.625 GHz


Basic transmission loss for conference/lecture room NLoS
α = 2.07
β = 28.13
γ = 2.67
82 GHz
32.4 GHz
7.075 GHz
Basic Transmission Loss (dB)
Distance (m)
60
65
70
75
80
85
90
95
100
105
110
5
7
10
15
20

Adopted model ITU-R 1238-12

Environment	LoS/NLoS	Frequency range (GHz)	Distance range (m)	α	β	γ	σ
Office	LoS	0.3–83.5	2–27	1.46	34.62	2.03	3.76
	NLoS	0.3–82.0	4–30	2.46	29.53	2.38	5.04
Corridor	LoS	0.3–83.5	2–160	1.63	28.12	2.25	4.07
	NLoS	0.625–83.5	4–94	2.77	29.27	2.48	7.63
Industrial	LoS	0.625–70.28	2–102	2.34	24.26	2.06	2.67
	NLoS	0.625–70.28	5–110	3.66	22.42	1.34	9.00
Conference/lecture room	LoS	0.625–82.0	2–21	1.61	28.82	2.37	3.28
	NLoS	7.075–82.0	4–25	2.07	28.13	2.67	3.67

Bothe 1411 and 1238 Recommendations

Are being studied for sub-THz frequencies

Joint Working Group Recommendation(s)

JWG Clutter: Ms. C. Allen and Dr. R. Arefi and JWG BEL: Dr. R. Rudd

Recommendations P.2109 (BEL)

- Prediction of Building Entry Loss (80 MHz – 100 GHz) for ‘traditional’ and ‘thermally efficient’ building types and various elevation angles of the path relative to the normal to building façade.

Type of properties measured

Traditional

Victorian House

80s build

Modern

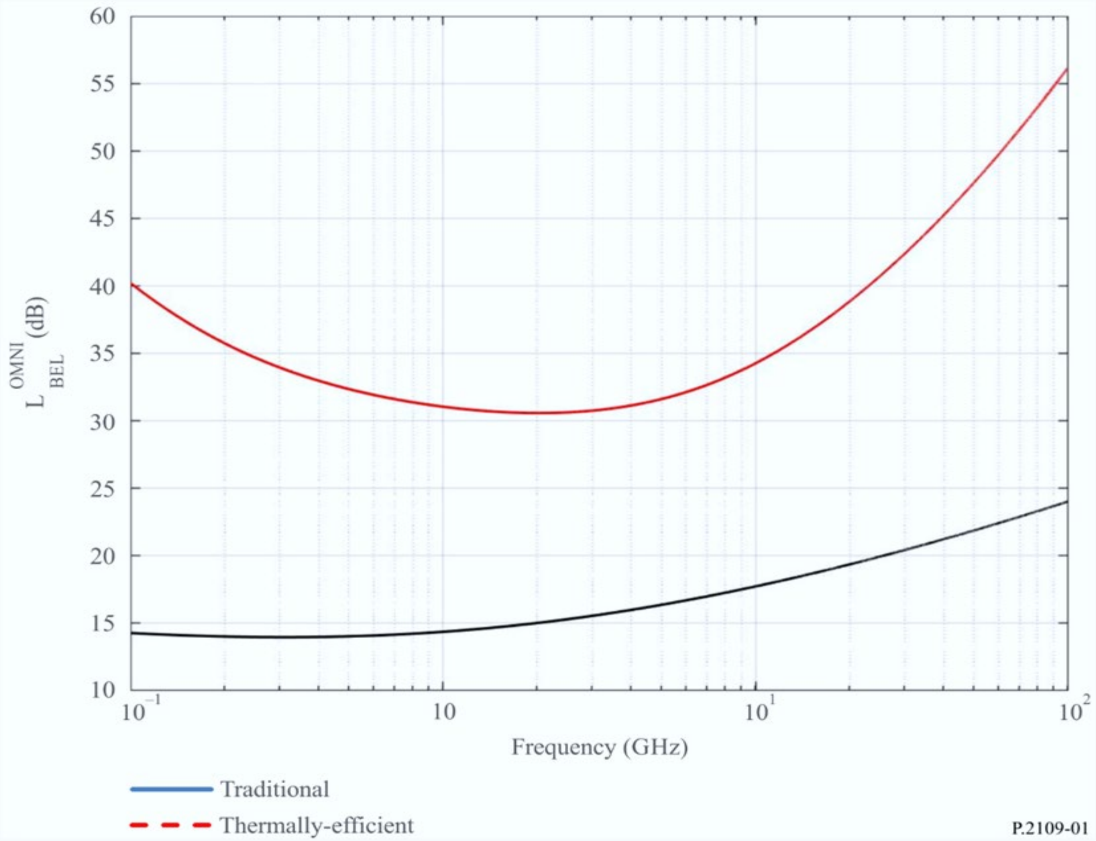
Üserhuus

Weinerberger-E4

Building Research Establishment (BRE) in Watford, UK

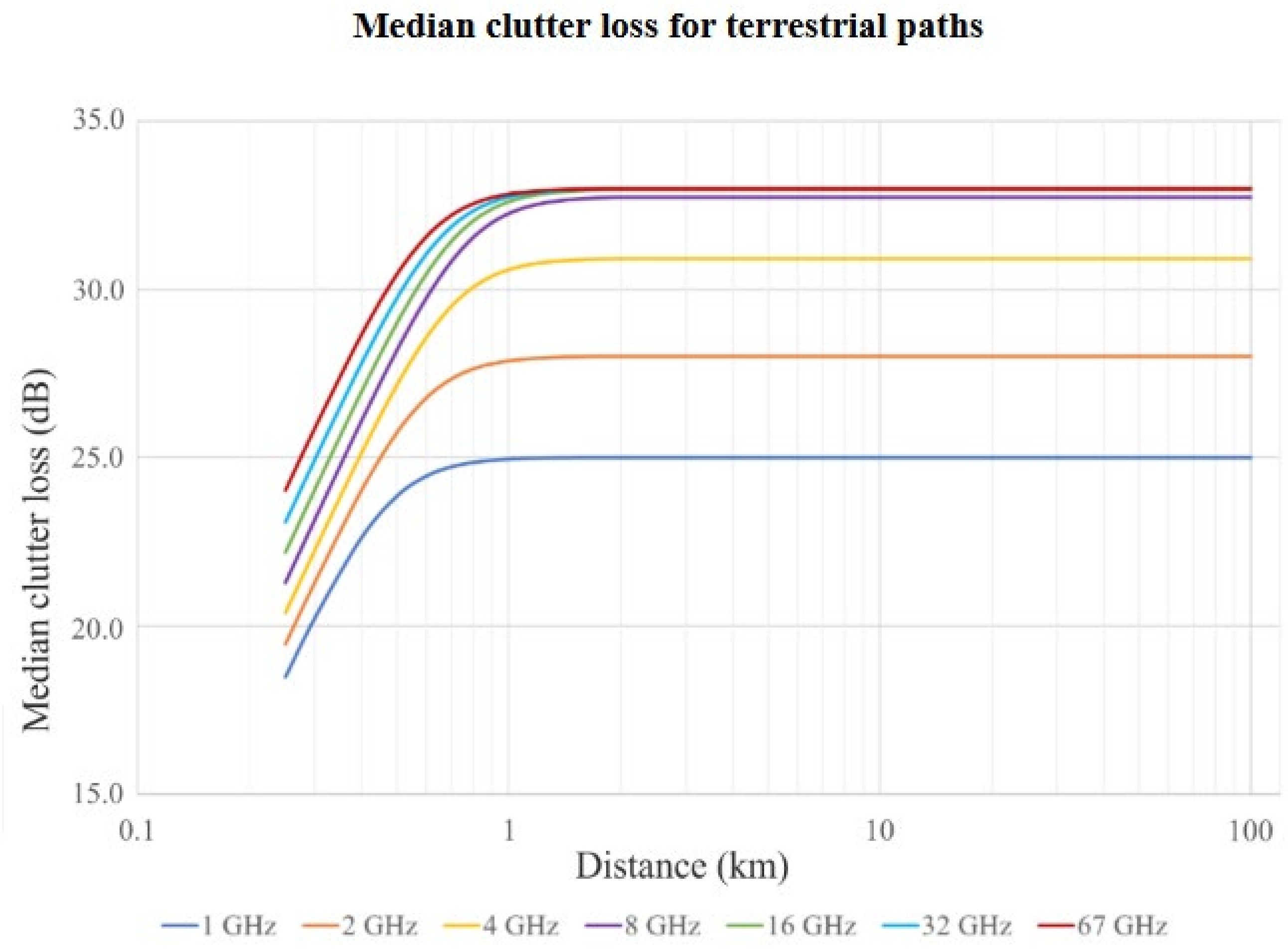
CG 3J-3K-3M-8: Building entry loss model

- ITU-R P. 2109 based on measurements (Report ITU-R P.2346) from 80 MHz - 73 GHz building entry loss for probabilities of 0.0 < P < 1.0.



CG 3K-3M-12: Clutter loss prediction ITU-R P. 2108

- Clutter refers to objects, such as buildings or vegetation, which are on the surface of the Earth but not actually terrain



Median clutter loss for terrestrial paths
35.0
30.0
25.0
20.0
15.0
Median clutter loss (dB)
0.1
1
10
100
Distance (km)
1 GHz
2 GHz
4 GHz
8 GHz
16 GHz
32 GHz
67 GHz

Cumulative distribution of clutter loss not exceeded for 30 GHz