Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Considerations of frequency resources for fast moving mobile backhaul]
Date Submitted: [7 JAN, 2015]
Source: [Minsoo KANG and Woojin Byun] Company [ETRI]
Address [218 Gajeong-ro, Yuseong-gu, Daejeon, 305-700, KOREA]
Voice:[+82-42-860-6425], FAX: [+82-42-860-5199], E-Mail:[mskang@etri.re.kr]

Abstract: [Considerations of frequency resources for fast moving mobile backhaul]

Purpose: [To consider frequency resources for mobile wireless backhaul system of fast moving cells]

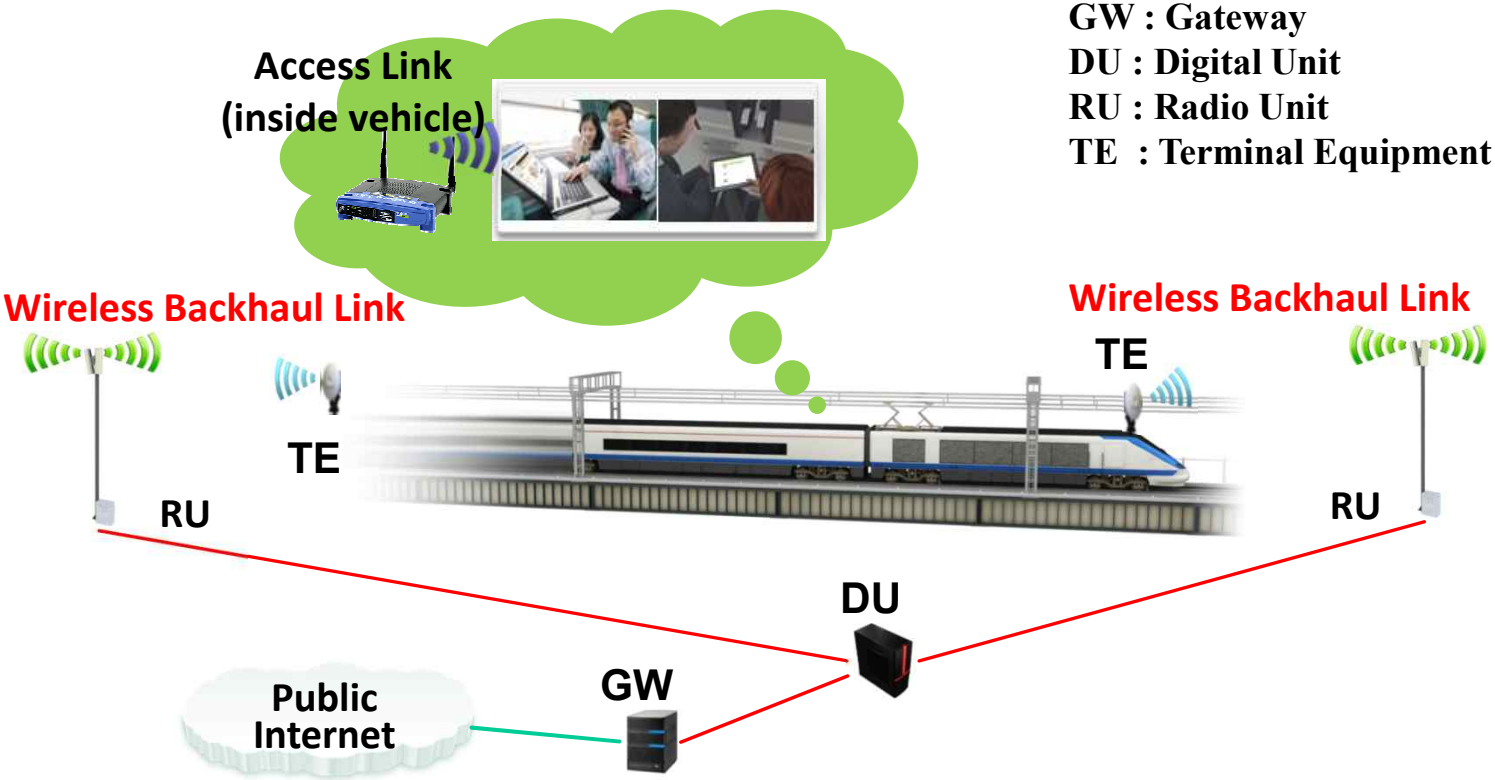
Considerations of frequency resources for fast moving mobile backhaul

Outline

- Mobile backhaul for fast moving cells
- Frequency allocations
- Path losses
- System Link-budget for candidate frequencies
- Propagation characteristics in KTX(Korea Train eXpress)

Mobile backhaul for fast moving cells(1/2)

- Backhaul Link between RU and TE



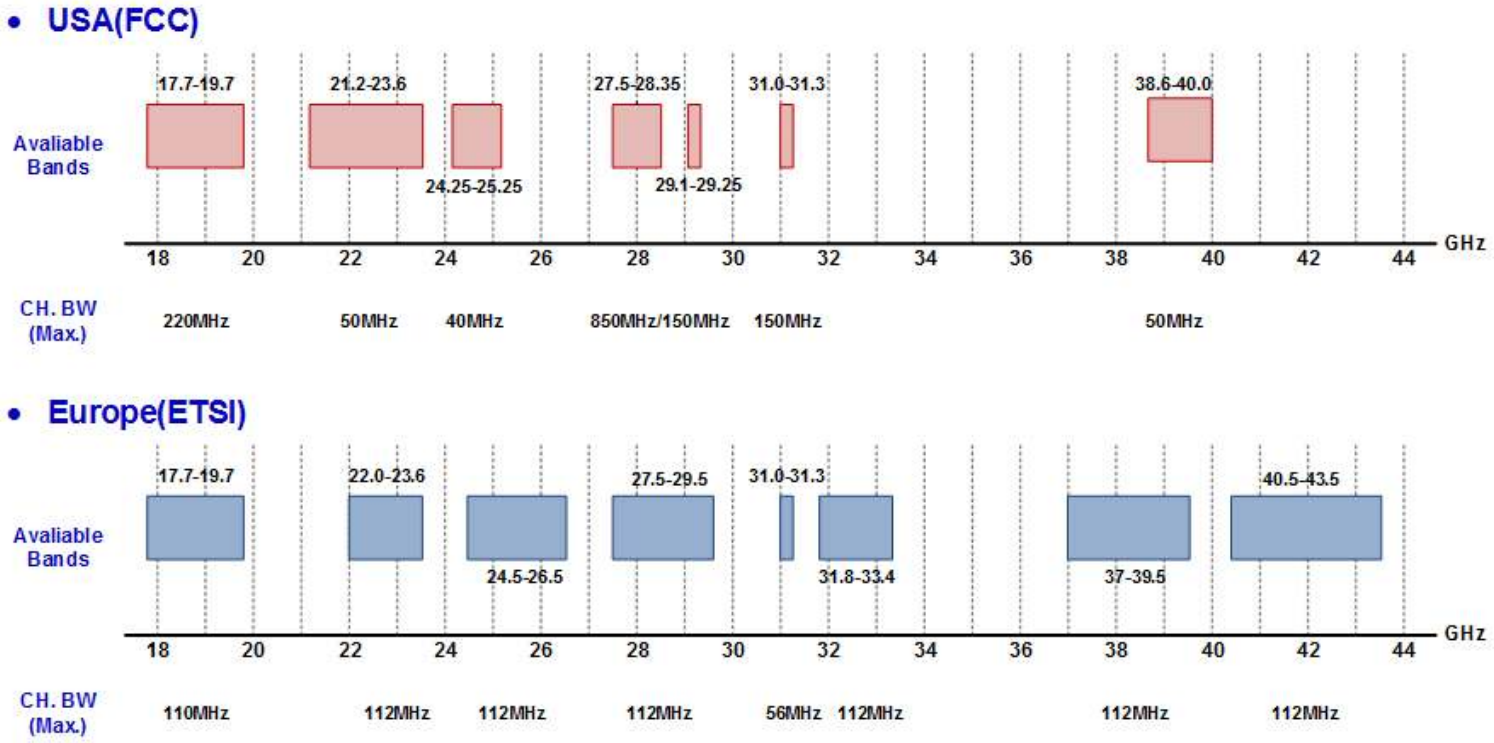
Mobile backhaul for fast moving cells(2/2)

- Features

New RAT for Mobile Wireless Backhaul	
Wireless Backhaul Link (Outside Vehicle)	OFDM based on mmWave
Data throughput (DL)	1 Gbps using 250-MHz bandwidth
Spectral efficiency	4 bps/Hz
Mobility	400 km/h
User Access Link (Inside Vehicle)	Small Cell (WiFi or Femto)

Frequency Allocations (1/2)

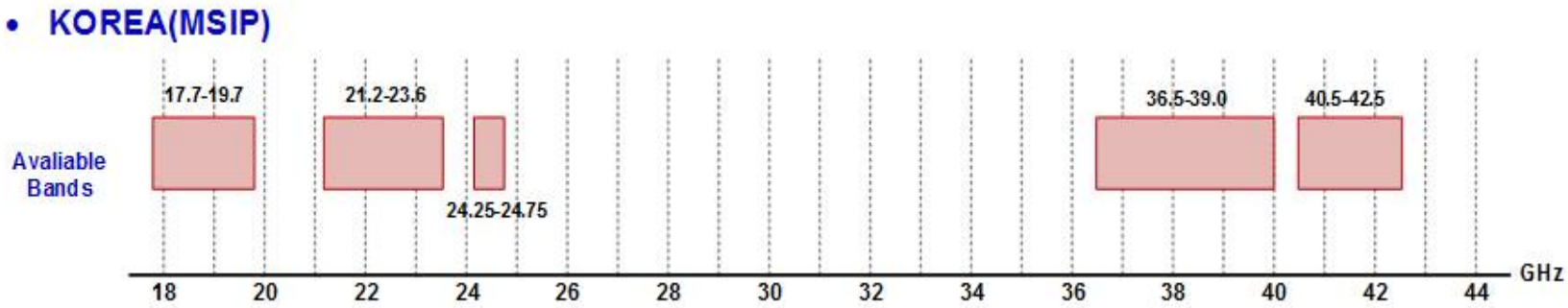
- Frequency allocations in USA and Europe
  - FWS/DFRS Mobile backhaul



. FWS : Fixed Wireless Services
. DFRS : Digital Fixed Radio Systems

Frequency Allocations (2/2)

- Frequency allocations in KOREA (Republic of)
  - Wireless Transmission Link



. MSIP : Ministry of Science, ICT and Future Planning

- Other bands

Frequency	Drawback
10.5-11.7GHz	Large Antenna
57-64GHz	Oxygen & Precipitation Attenuation
71-76/81-86GHz	Precipitation(Rain, Snow etc) Attenuation

Path Loss (1/4)

- Propagation Characteristics
  - Loss, Reflection, Refraction, Scattering
- Free-space Loss
  - ITU-R P.525.2, “Calculation of Free-space Attenuation”

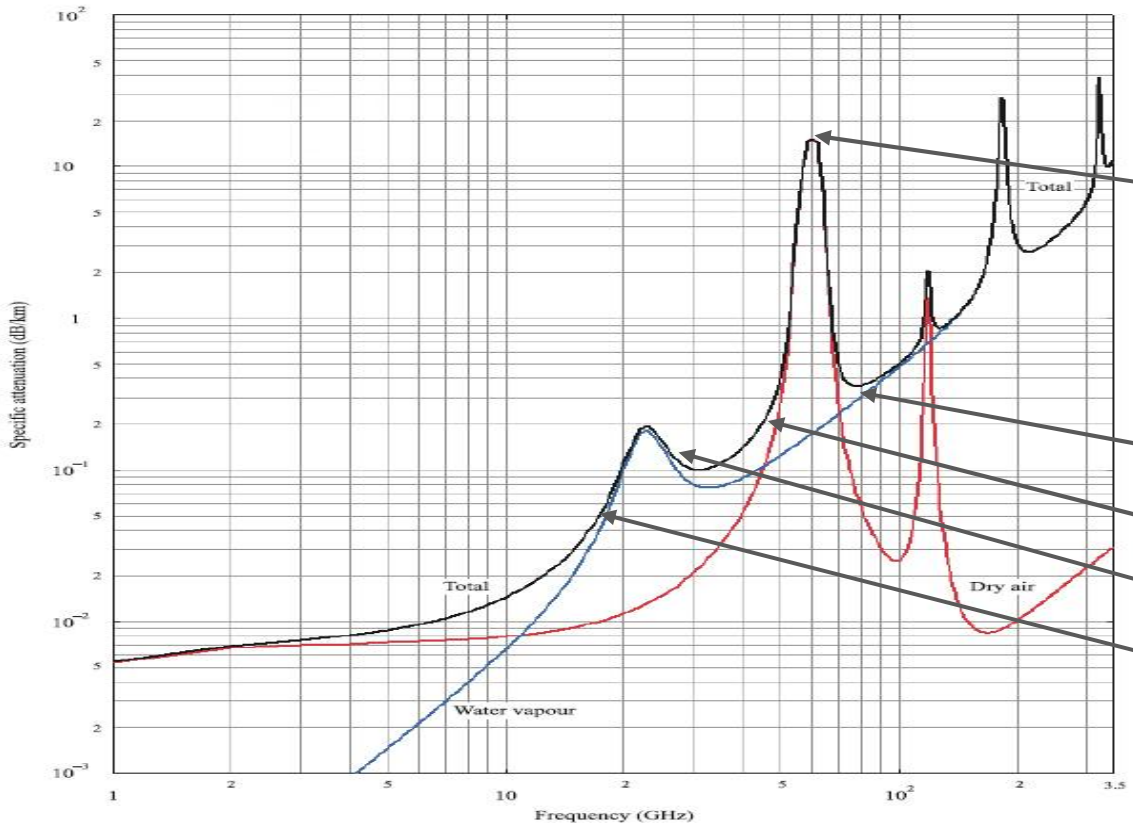
$$L_s = 20\log\left(\frac{4\pi d}{\lambda}\right) = 92.45 + 20\log f_{GHz} + 20\log d_{km}[dB]$$

Free Space Path Loss (@1.0 Km)	
18 GHz	117.5 dB
27 GHz	121.0 dB
43 GHz	125.1 dB
80 GHz	130.5 dB

Path Loss (2/4)

- Atmospheric Loss

  - ITU-R REC.676-7, “Attenuation by Atmospheric Gases”



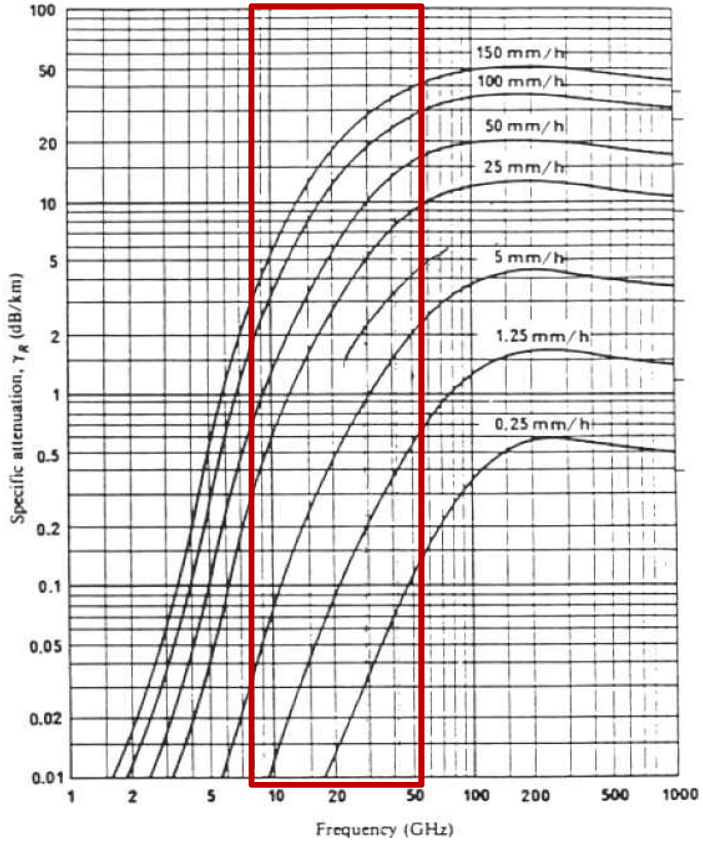
Path Loss (3/4)

- Precipitation(Rain, Snow) Loss
  - ITU-R P.837-5, “Characteristics of precipitation for propagation modeling”
    - Probability of rainfall in K-region (Units : mm/Hour)

Percentage of time (%)	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
1.0	<0.1	0.5	0.7	2.1	0.6	1.7	3	2	8	1.5	2	4	5	12	24
0.3	0.8	2	2.8	4.5	2.4	4.5	7	4	13	4.2	7	11	15	34	49
0.1	2	3	5	8	6	8	12	10	20	12	15	22	35	65	72
0.03	5	6	9	13	12	15	20	18	28	23	33	40	65	105	96
0.01	8	12	15	19	22	28	30	32	35	42	60	63	95	145	115
0.003	14	21	26	29	41	54	45	55	45	70	105	95	140	200	142
0.001	22	32	42	42	70	78	65	83	55	100	150	120	180	250	170

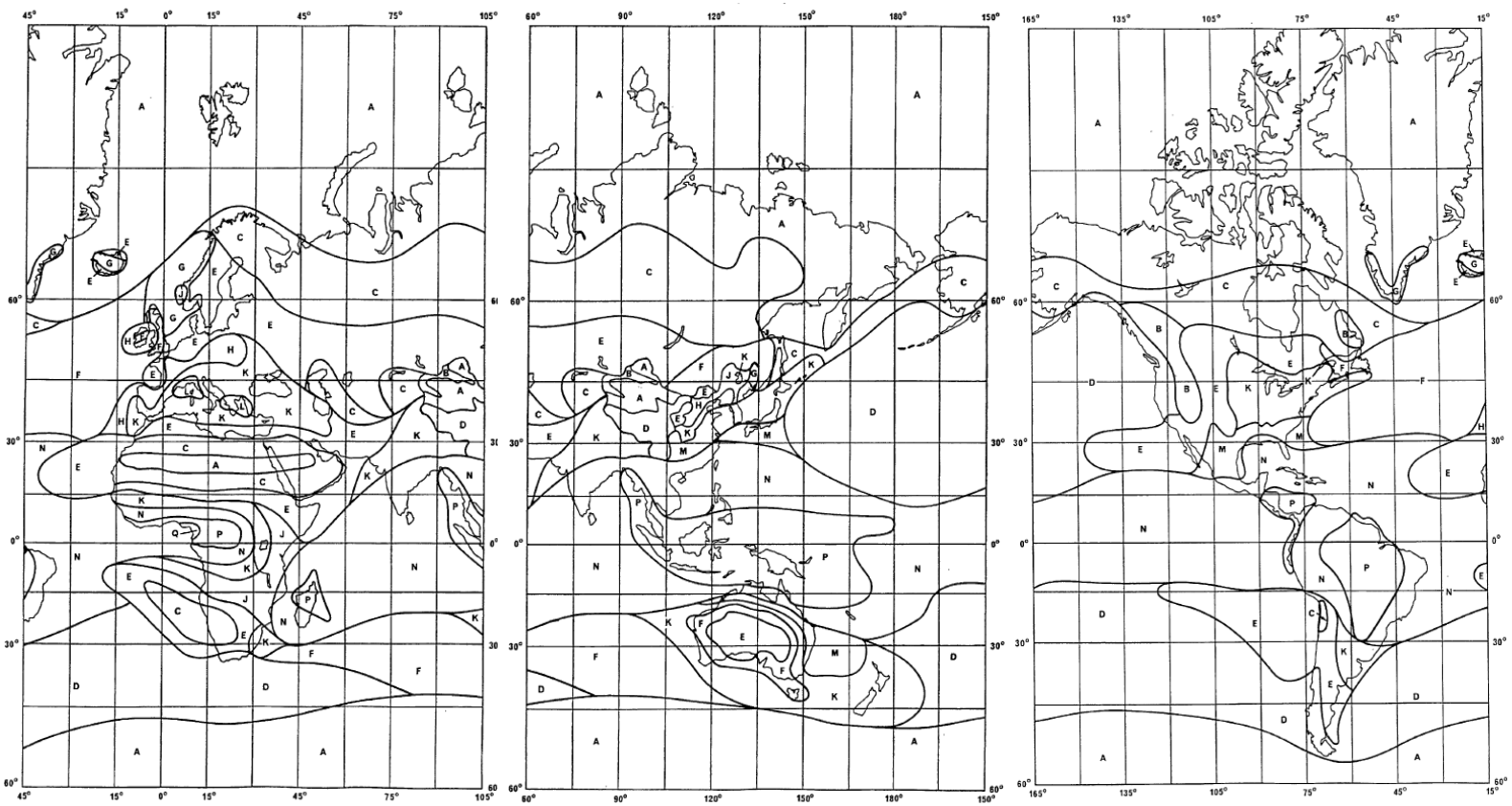
    - Precipitation Loss @12mm/hour condition

Frequency (GHz)	Precipitation Loss (dB/Km)
18	2.14
27	4.04
43	4.18
80	6.86



Path Loss (4/4)

- Rain climatic zones



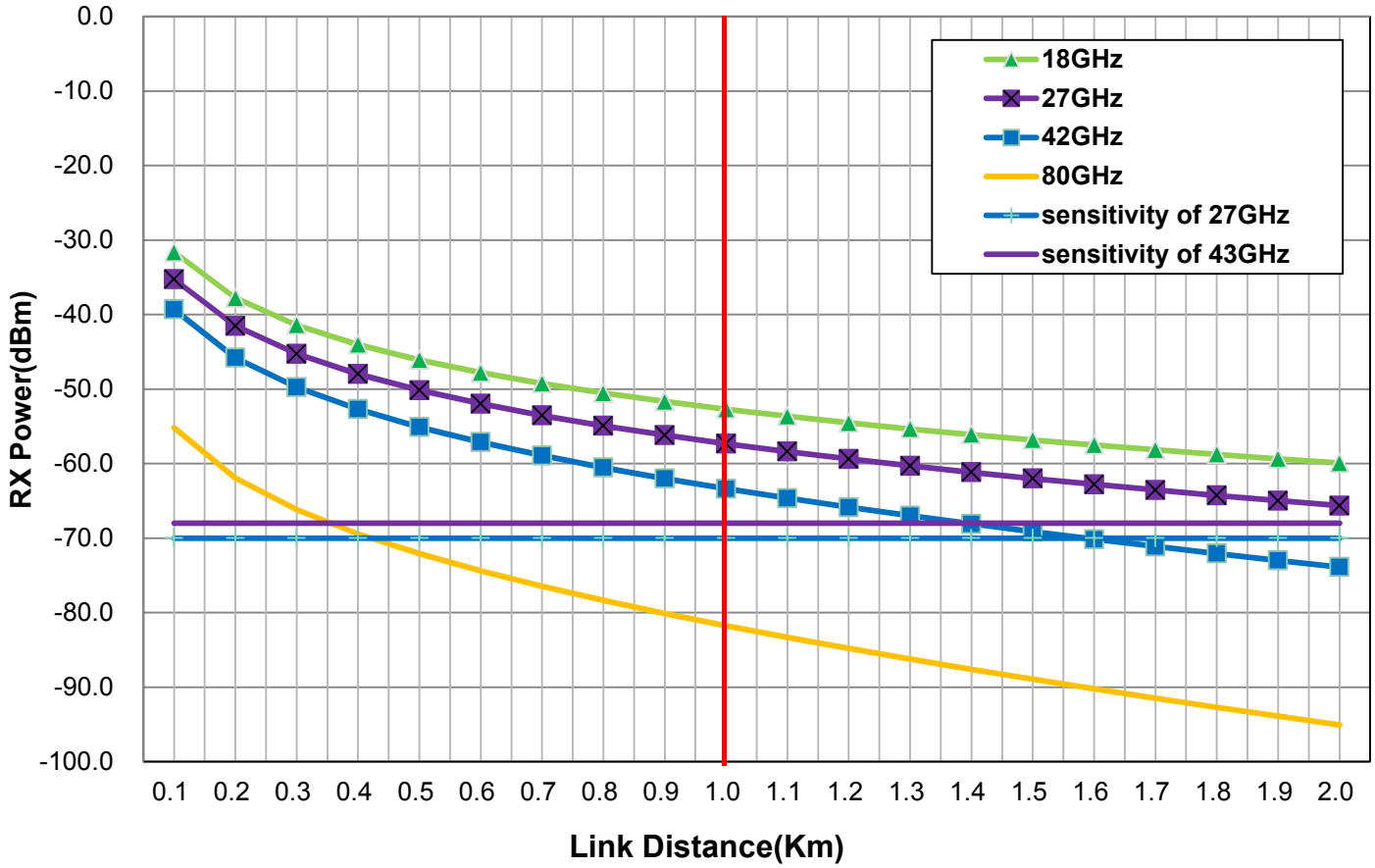
System Link Budget (1/2)

- Calculation of System link budget
  - 250MHz Bandwidth of noise power
  - Required C/N of 10.5dB for 16QAM
  - Link distance of over 1Km
  - Implementation margin of 3dB

Freq. (GHz)	Tx PWR (dBm)	Tx Antenna Gain(dBi)	Free-space Loss(dB)	Gas Loss (dB)	Rain Loss (dB)	Rx Antenna Gain(dBi)	Rx NF (dB)	RX PWR (dBm)	Sensi-tivity (dBm)	margin (dB)
18	20	23	117.5	0.1	1.1	23	5.0	-52.6	-71.5	18.9
27	20	23	121.0	0.2	2.1	23	6.5	-57.4	-70.0	12.6
43	20	23	125.1	0.3	4.2	23	8.5	-63.5	-68.0	4.5
80	10	23	130.5	0.4	6.9	23	13.0	-81.7	-63.5	-18.2

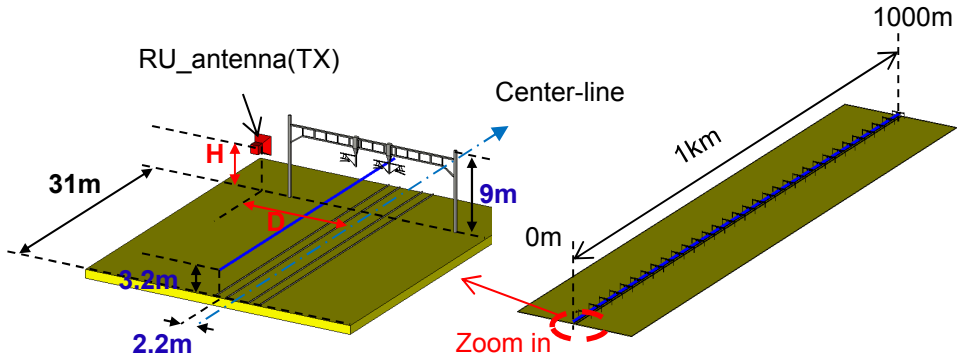
System Link Budget (2/2)

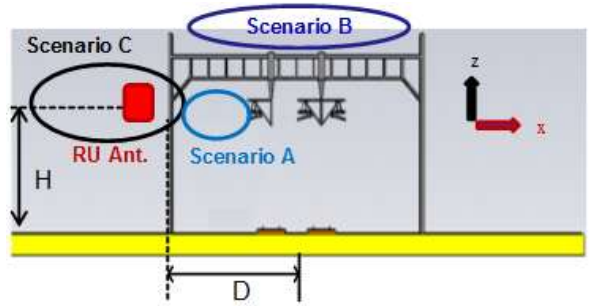
- RX power vs. link distance



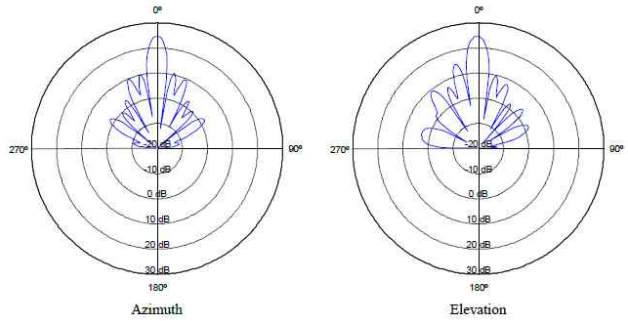
Propagation characteristics in KTX(1/4)

- Simulation for Railroad with steel-frame structure in KTX
  - Ray tracing method
  - TX PWR of 20dBm, Antenna : 27GHz, 24dBi, 8x8 patch array type
  - RX Antenna is located center-line with 3.2m height





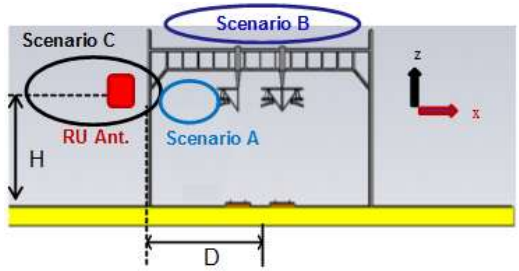
scenario	RU antenna location	
A	Inside	H : 5m, D :15m
B	Upside	H : 10m , D : 0/15m
C	Beside	H : 5/10m, D : 30/50/100m

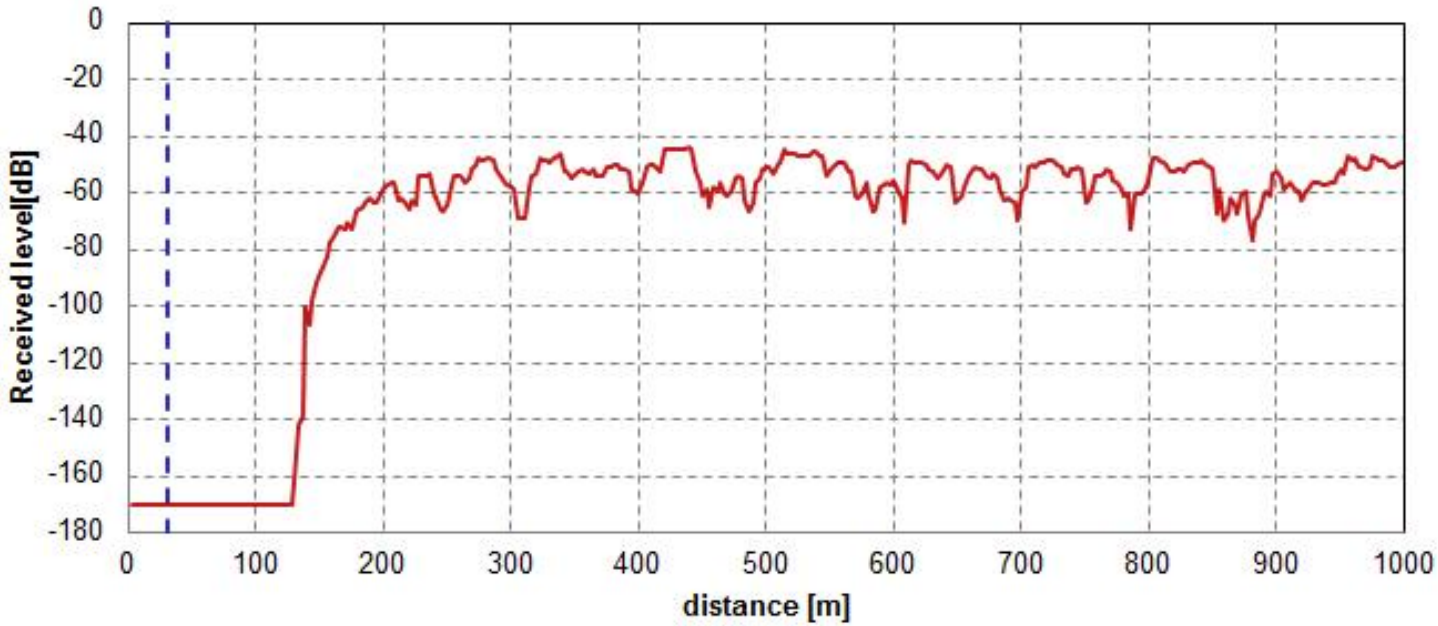


- TX/RX Antenna pattern

Propagation characteristics in KTX(2/4)

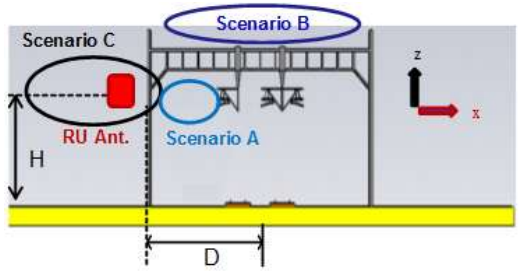
- Scenario A (H=5m, D=15m)

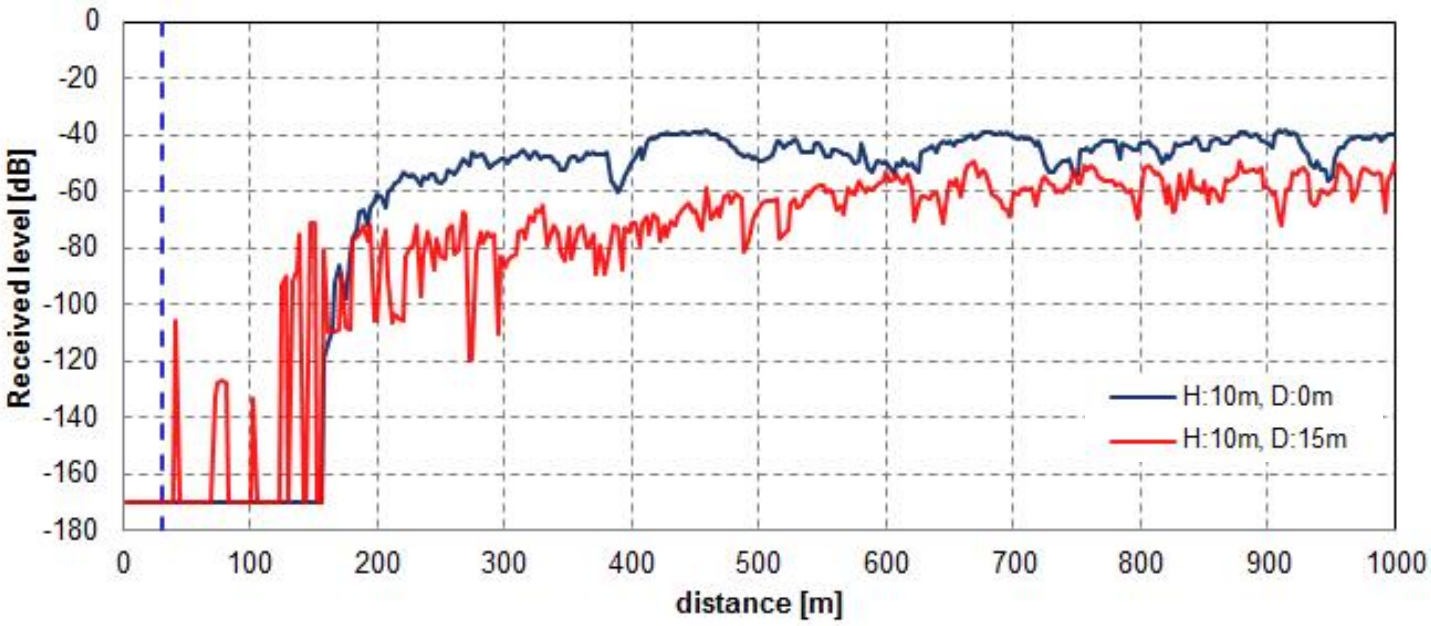




Propagation characteristics in KTX(3/4)

- Scenario B
  - Case 1 : H=10m, D=0m
  - Case 2 : H=10m, D=15m





Propagation characteristics in KTX(4/4)

- Scenario C
  - Case 1 : H=5m, D=30m
  - Case 2 : H=5m, D=50m
  - Case 3 : H=5m, D=100m