技　術　資　料

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A	See the cover	① Section.2 ② Section.4.2 ③ Appendix A	① Added all paragraphs. ② Revise the gain value of Table-3 and 4. ③ Change the diagram of Appendix A.

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1 Purpose

This document provides the information of the services which Misasa Deep Space Station (MDSS) can deliver to deep space mission projects.

In addition to the information, a comprehensive overview of the station and the parameters which the projects need for a link design is also described.

2 MDSS Overview

This section provides a description of the MDSS in the context of mission operations, a physical view of the MDSS, and the service concept of the MDSS.

2.1 Mission Operations Context

2.1.1 Functional View

Figure 2-1 shows a functional view of MDSS in the context of mission operations.

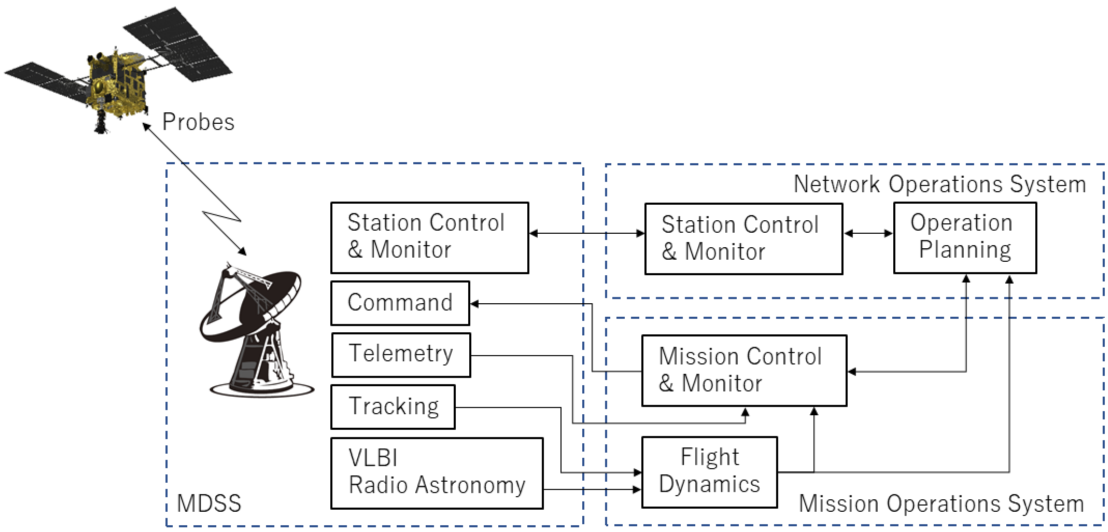


Figure 2-1 Mission Operations Context – Functional View

2.1.2 Physical View

Figure 2-2 shows the physical view of MDSS in the context of mission operations, identifying the key facilities used in supporting flight projects.

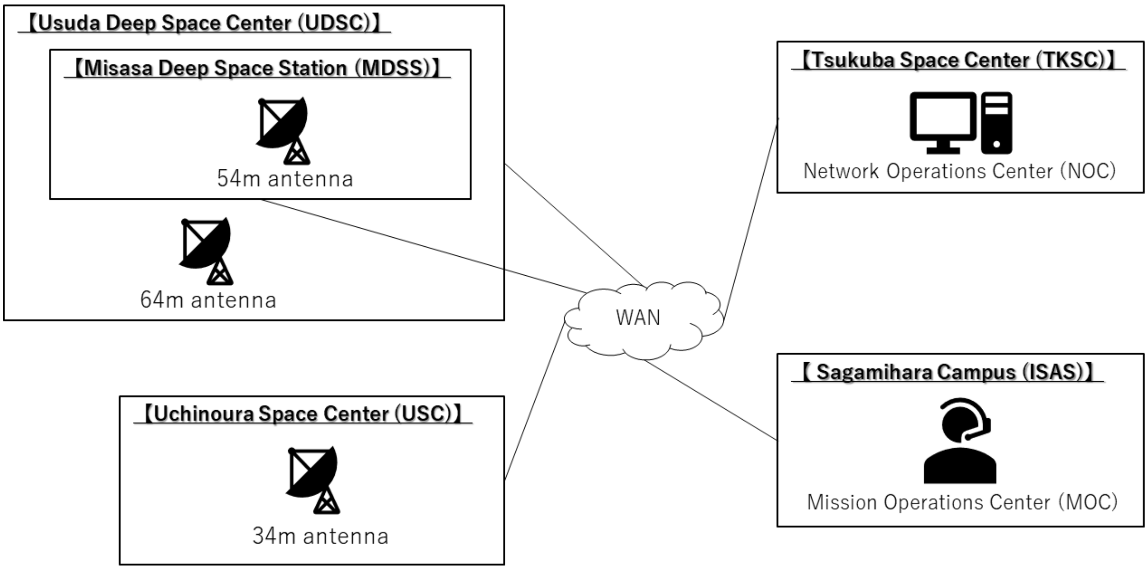


Figure 2-2 Mission Operations Context – Physical View

The facilities shown in the figure are described as follows:

- Three Stations – There are three stations in Usuda Deep Space Center (UDSC) and Misasa Deep Space Station which is located at another site of UDSC but managed as the part of the center, and Uchinoura Space Center (USC).

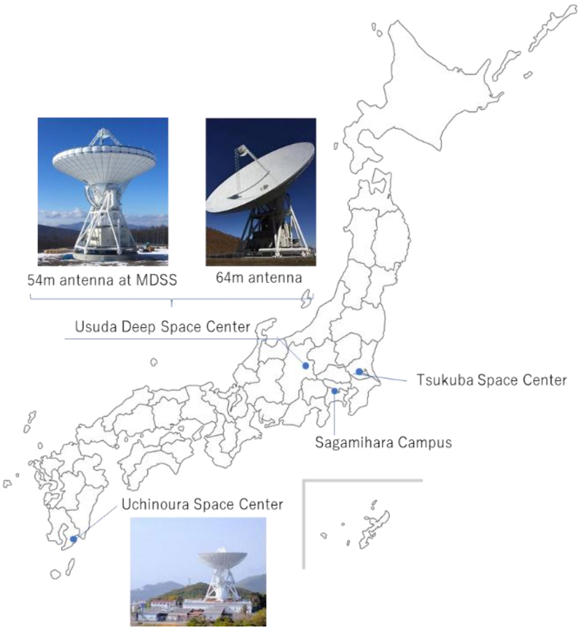
  UDSC and MDSS are located in Saku-city, Nagano prefecture, and USC is in Uchinoura in Kimotsuki-county, Kagoshima prefecture.
- Each station, UDSC, MDSS, and USC has, a 64m antenna, a 54m antenna and a 34m antenna respectively.

  It also has the support infrastructure and personnel needed to operate and maintain the antennas. These stations communicate with and track spacecraft at S-, X- or Ka-band.

  Figure 2-3 identifies the locations of each station. The 54m antenna is supposed to succeed to the 64m antenna and has started its routine operation since April 2021. The 64m antenna may be used as a backup for the 54m antenna in a while.
- Network Operations Center (NOC) – This is a facility located at Tsukuba Space Center (TKSC) in Tsukuba-city, Ibaraki prefecture.

  The NOC includes the computing and communications equipment and the personnel that provide central monitor and control through the wide area network (WAN), coordination between the distributed stations.

- Mission Operation Centers (MOCs) – This is a facility located at the Sagamihara Campus (ISAS) in Sagamihara-city, Kanagawa prefecture. They are typically assigned to a single flight project.



Drone view of the site. The site under development of the MDSS (Front), and UDSC antenna (64m antenna) is also seen behind the mountains.

Figure 2-3 Stations Location

2.2 Service Concepts

MDSS provides a variety of capabilities that support a broad range of mission functions. The capabilities provided by MDSS are classified as follows:

- Data Services
- Engineering Support

2.2.1 Data Services

Within this document, "Data Services" are mission operations services that relate directly to the transport of telemetry/command data, mission data and/or tracking data as well as observational data over space-ground communications links.

MDSS-provided data services are accessed via well-defined, standard data and control interfaces. The interface in this usage include those formally established by standards organizations (e.g., the Consultative Committee for Space Data Systems (CCSDS), the International Telecommunication Union (ITU)). This enables a high degree of interoperability with similar services from other providers.

2.2.2 Engineering Support

MDSS engineering personnel can provide customers who conduct their feasibility studies, mission definition, MOC development, integration and test, as well as mission operations with the technical assistance necessary for using the station.

These are most commonly conducted on a level-of-effort basis at first, but the scope of each engineering support activity must be assessed on a case-by-case basis in the end.

2.3 List of Services and Support

The following sections list the services offered by MDSS.

2.3.1 List of Standard Data Services

The list of standard data services are shown in Table 1. The related capabilities of MDSS are shown in Section.4.

2.3.2 List of Engineering Support

The supposed engineering supports are listed below. The engineering services depend on the requirements of each mission. Therefore, the detail contents of the services are based on coordination with each mission.

- ✓ System Engineering Support
- ✓ Advanced Mission Planning Support
- ✓ Emergency Limited Continuity of Operations
  - ☞ MDSS is operated in Misasa (local), TKSC and ISAS which realize the operational continuity.
- ✓ RF Compatibility Test Support
  - ☞ It is available with MDSS operation system, note that no equipment only for the RF compatibility test.
- ✓ Spacecraft Search / Emergency Support

2.3.3 List of Unsupported Capabilities

The following capabilities are not available to missions.

- ✓ Command Delivery Services（CFDP）
- ✓ Ka-band uplink
- ✓ Low Density Parity Code (LDPC)

2.4 Ground Communications Interface

The Ground Communications Interface is not in service. It must be performed by both MDSS, as the service provider, and the MOC, as the service user.

2.5 Service Management

Data services provided by MDSS are requested and controlled via a unified service management function. Service management by itself is not a service. It includes:

- ✓ Allocation and scheduling of space communication resources and assets during the scheduling phases.
- ✓ Configuring, monitoring and controlling MDSS assets during the service provision phase (i.e., before, during and after a pass).

Table 1 MDSS Services

No.	Service Class	Interfaces etc.
1.	Command Radiation Service	MDSS transmit the command data in the stream mode to the spacecrafts. In this mode, the command data is in the form of CLTUs which is defined in the below CCSDS document. · CCSDS TC Space Link Protocol (ref. CCSDS 232.0-B-1)
2.	Telemetry Frame Service Telemetry Packet Service	MDSS receives the telemetry data in the form of the frame and packet which follows the below CCSDS documents. · CCSDS TM Synchronization and Channel Coding (ref. CCSDS 131.0-B-1) · Transfer frame format conforming to CCSDS TM Space Data Link Protocol (ref. CCSDS 132.0-B-2) · VCDUs conforming to CCSDS AOS Space Data Link Protocol (ref. CCSDS 732.0-B-3)

3.	Validated Radio Metric Data Service	MDSS has the function of receiving the data needed for tracking the spacecrafts which shown below.
		➢ Ranging Data
		  · Sequential Ranging
		  · Regenerative/Non-regenerative Pseudo-noise Ranging
		➢ Coherent/Non-coherent Doppler Data
		The station can provide the Tracking Data Message (TDM) format which is based on CCSDS TRACKING DATA MESSAGE (ref. CCSDS 503.0-B-2) with the off-line interface such as e-mail.

4.	Delta-DOR Service	MDSS acquire the Delta-DOR data with open-loop receiver. The data format is Delta-DOR Raw Data Exchange Format (RDEF) which based on CCSDS DELTA-DOR RAW DATA EXCHANGE FORMAT (ref. CCSDS 506.1 B-1)
5.	Experiment Access Service	Experiment Access Service provides the equipment of MDSS and technical assistance (including operatio n support, scientific collaboration) for the purpose of science and engineering research with various expe

No.	Service Class	Interfaces etc.
		riments planned by users with expertise of MDSS.
6.	Data Acquisition Service	Data Acquisition Service provides various measurements using all or sub-system of MDSS. raw measure ments and additional data from observations. MDSS support to develop experiment plan.
7.	Signal Capturing Service	The Signal Capture Service provides the analog signal output from the antenna. Users can receive RF s ignal or down-converted IF signal. Users are possible to install R&D equipment for data acquisition. Us ers need to negotiate with the management division of MDSS.
8.	VLBI Data Acquisition Service	VLBI terminal installed in MDSS is ADS-3000+ (Cosmo research), which can produce following VLBI Data format, Delta-DOR Raw Data Exchange Format (RDEF) which is same as No.4. VLBI Data Interchange Format (VDIF). We can convert file to K5 VLBI format developed by NICT, and other format using conversion tools.

3 MDSS System

MDSS has two building in the site as shown in Figure 3-1 and Figure 3-2.

The one is Operation/Test Building, which has the Hydrogen Maser (HM), making the reference signal and supply to MDSS system. It also has the station controllers for local operation and tests such as RF compatibility test.

The another is Power Supply Building. The power supply equipment is in the building, all the equipment receives the power from it.

Figure 3-3[*1] shows the system architecture of this station.

MDSS has the function of X-Band Transmission, X-Band Reception and Ka-Band Reception. It can also operate the Ranging and Range Rate with X-Band Uplink/X-Band Downlink and X-Band Uplink/Ka-Band Downlink.

In addition to these functions, the station has the capacity for the DDOR (Delta Differential One-way doppler Ranging) operation, this function is realized by openloop receiver.

The basic configuration is that the mirror #6 is set the FSR (Frequency Selection Refractor, also called Dichroic Mirror). The FSR reflect the X-Band frequency and is through the Ka-Band frequency, this feature realizes the X-Band Uplink with the Ka-Band Downlink.

If the more capability for X-Band Downlink is needed, the FSR can exchange the Solid Mirror (SM) as the mirror #6. In this configuration, X-Band G/T will be better than the FSR configuration, but Ka-Band Downlink cannot be received, because the SM has not the function to be thorough Ka-Band.

X and Ka-Band received signal streams through “X-Band downlink route” and “Ka-Band downlink route” and X-Band transmitted signal is at “X-Band uplink route”.

MDSS also has the automated track function only for Ka-Band reception. This function is realized by 5-point method, searching the highest power level direction and antenna is pointed to it, note that this function is not utilized for X-Band, it only has the function of programmatic tracking which antenna is oriented to the direction following an antenna prediction.

Other feature is that MDSS expandable space in antenna alidade building. This space is used for experimental use.

MDSS does not have redundant system and Space Link Extension (SLE) interface function which related to command, telemetry and RARR data interfaces. MDSS will be equipped with them by March 2024 (the end of JFY2023).

[*1] More detail diagram is in Appendix A

Figure 3-1 MDSS (From North)

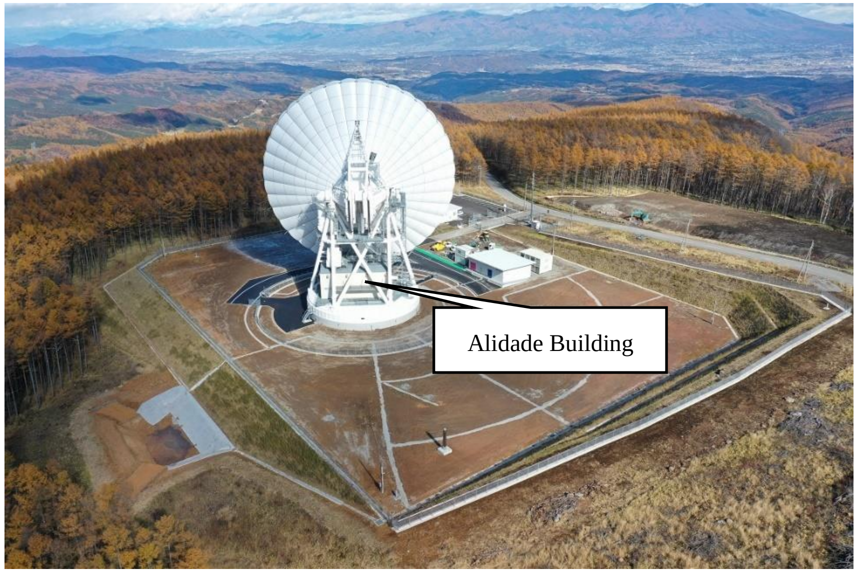


Figure 3-2 MDSS (From South)

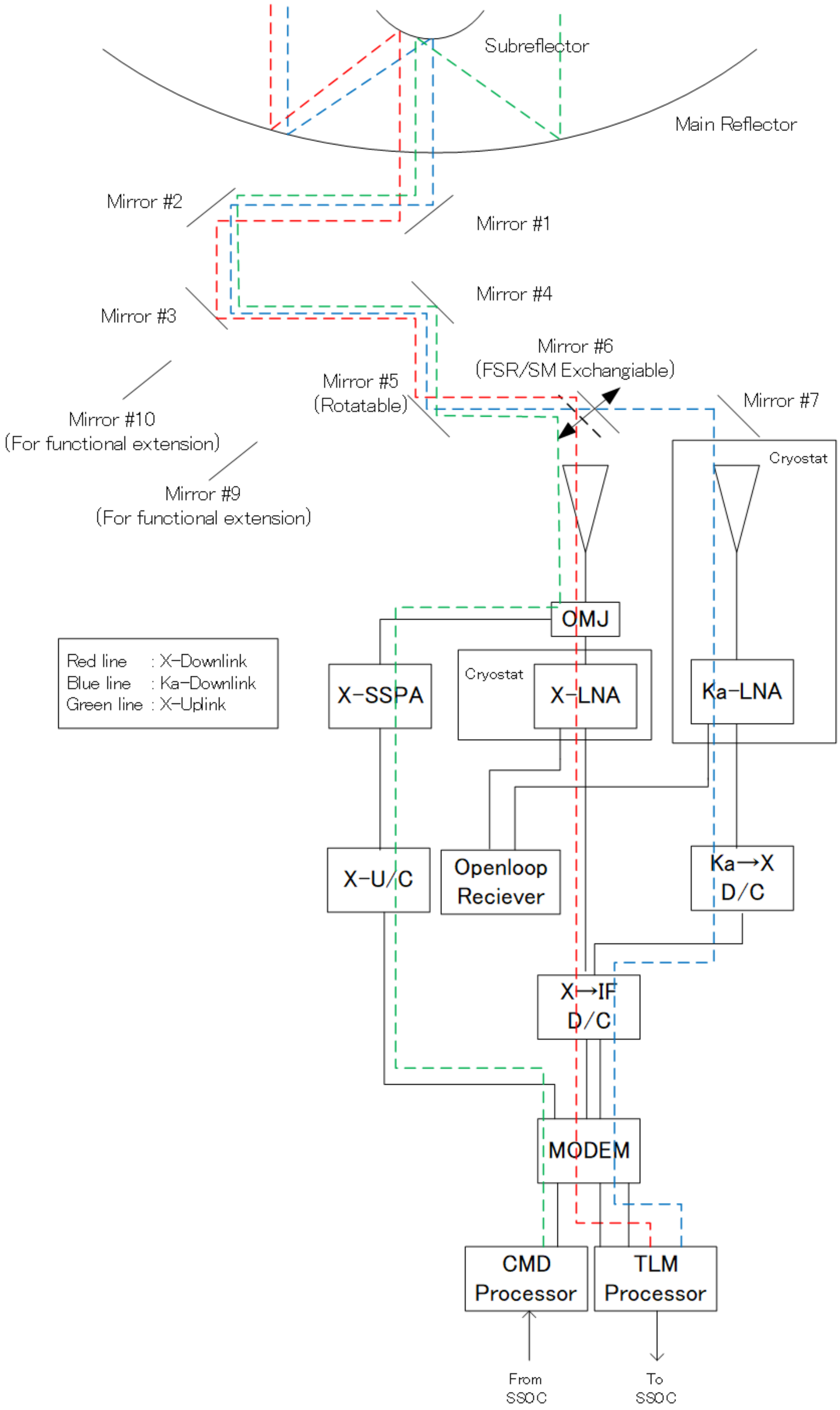


Figure 3-3 System Architecture

4 Main Capabilities

Table 2 shows the capabilities of MDSS for link design.

Table 2 MDSS capacities

No.	Item	Unit	Value	Remarks
1.	Latitude	deg	138.211	Address: 385-0046(Zip Code) 1905-43, Maeyama-U-Tateshina, Saku city, Nagano prefecture, Japan.
2.	Longitude	deg	36.083	
3.	Diameter	m	54	
4.	Uplink Frequency	MHz	7145-7235	
5.	Downlink Frequency	MHz	(title)	
6.	X-Band	GHz	8.400-8.500	
7.	Ka-Band	GHz	31.800-32.300	
8.	Other	GHz	8.350-8.550	For use of DDOR and Geometric VLBI
9.	Supported Polarization	-	RHCP LHCP	Not received RHCP/LHCP signal simultaneously
10.	Tx.EIRP	-	(title)	
11.	RHCP	dBm	142.5	
12.	LHCP	dBm	142.0	
13.	Rx Gain	-	(title)	
14.	X-Band	dBi	See Table 3	
15.	Ka-Band	dBi	See Table 4	
16.	System Noise Temperature	K	See Section 4.1	
17.	Pointing Loss	-	(title)	
18.	X-Band	dB	0.2	
19.	Ka-Band	dB	2.6	
20.	Modulation Type	-	PCM-PSK-PM PCM-PM	Ranging modulation is only PCM-PSK-PM

No.	Item	Unit	Value	Remarks
21.	Line Code Formats	-	NRZ-L/M/S Bi-phase-L/M/S	
22.	Error Correction Type for TLM	-	Reed-Solomon Convolutional Concatenated Turbo (r=1/2, 1/3, 1/4, 1/6)	
23.	Bitrate Settings for CMD	-	(title)	
24.	PCM-PSK-PM	bps	$4000/2^n$	n≧0 is integer
25.	PCM-PM	bps	100～600k	Max. symbol rate is 1.2Msps
26.	Bitrate Settings for TLM	-	(title)	
27.	PCM-PSK-PM	bps	4～300k	Max. symbol rate is 300ksps
28.	PCM-PM	bps	100～600k	Max. symbol rate is 1.2Msps

4.1 System Noise Temperature

The system noise temperature of MDSS is calculated by below equation, $T_{\text{AMW-CMB}}$, L_{ANT} and T_{rec} are constant parameter, given in Table 5.

$$\boldsymbol{T}_{\text{sys}}(\boldsymbol{\theta}) = \boldsymbol{T}_{\text{AMW-CMB}} + \boldsymbol{\alpha}\boldsymbol{T}_{\text{sky}}(\boldsymbol{\theta}, \boldsymbol{CD}) + \boldsymbol{T}_{\text{rec}}[\text{K}] \tag{1}$$

where

$T_{\text{sys}}(\theta)[\text{K}]$	System noise temperature.
θ[deg]	Elevation angel ≧ 7deg (mechanical limit of the antenna)
CD[%]	Cumulative distributions
$T_{\text{AMW-CMB}}[\text{K}]$	The contribution of the antenna and microwave hardware include cosmic noise.
α	A correction constant which is antenna losses of the specified point of the gain and the noise temperature
$T_{\text{sky}}(\theta)[\text{K}]$	Sky noise temperature, the definition is in Section.4.2
$T_{\text{rec}}[\text{K}]$	Receiver noise temperature.

4.2 Sky Noise Temperature

MDSS follows ITU-Recommendations for the atmospheric attenuation calculation method.

The definition of the sky noise temperature in MDSS which is based on chapter 3 of [1] is below,

$$\boldsymbol{T_{sky}}(\boldsymbol{\theta}) = \mathbf{275}\left(\mathbf{1} - \mathbf{10}^{-\frac{\boldsymbol{A}}{\mathbf{10}}}\right)[\text{K}] \tag{2}$$

$$\mathbf{A} = \frac{\boldsymbol{A}_{\text{gas}}(\boldsymbol{CD})}{\sin\boldsymbol{\theta}} + \boldsymbol{A_{rain}}(\boldsymbol{\theta}, \boldsymbol{CD}) + \frac{\boldsymbol{A}_{\text{cloud}}(\boldsymbol{CD})}{\sin\boldsymbol{\theta}} \tag{3}$$

Where

$A_{\text{gas}}(\text{CD})[\text{dB}]$	Attenuation by atmospheric gases
$A_{\text{rain}}(\theta,\text{CD})[\text{dB}]$	Attenuation by rain
$A_{\text{cluod}}(\text{CD})[\text{dB}]$	Attenuation by clouds

Each attenuation is calculated with the methods of [2][3][4]

Note that the definition of CDs is different from it of [5]. This document follows the ITU-R documents

For atmospheric gases attenuation, it is estimated using meteorological data in MDSS for temperature (℃), humidity (%) and pressure (hPa) with cumulative distributions. The data covers the period January 2016 through 2020.

The rain also used the local meteorological data, the calculation parameter $R_{0.01}$ which is the rainfall rate exceeded for 0.01% of an average year (with an integration time of 1min.), the data covers same as the period of the data for atmospheric gases loss.

The clouds attenuations, which is available only for Ka-Band, are calculated with given parameters in [4].

The estimated values of each attenuations are shown in Table 6 to Table 24, these values depends on the frequency which mission project use, therefore the tables shows the attenuations of the representative frequencies which is the upper, middle and lower frequencies of X and Ka-band shown in Chapter 3

Table 3 X-Band Rx Gain

EL [deg]	Rx Gain [dBi]	
	RHCP	LHCP
15.0≦EL<17.5	72.63 dBi ± 0.13 dB	72.58 dBi ± 0.13 dB
17.5≦EL<22.5	72.61 dBi ± 0.14 dB	72.65 dBi ± 0.13 dB
22.5≦EL<27.5	72.60 dBi ± 0.14 dB	72.65 dBi ± 0.13 dB
27.5≦EL<32.5	72.59 dBi ± 0.13 dB	72.64 dBi ± 0.13 dB
32.5≦EL<37.5	72.59 dBi ± 0.14 dB	72.64 dBi ± 0.14 dB
37.5≦EL<42.5	72.58 dBi ± 0.15 dB	72.57 dBi ± 0.16 dB
42.5≦EL<47.5	72.58 dBi ± 0.14 dB	72.65 dBi ± 0.16 dB
47.5≦EL<52.5	72.57 dBi ± 0.15 dB	72.60 dBi ± 0.15 dB
52.5≦EL<57.5	72.58 dBi ± 0.14 dB	72.58 dBi ± 0.17 dB
57.5≦EL<62.5	72.58 dBi ± 0.15 dB	72.62 dBi ± 0.17 dB
62.5≦EL<67.5	72.58 dBi ± 0.15 dB	72.60 dBi ± 0.19 dB
67.5≦EL<72.5	72.58 dBi ± 0.15 dB	72.63 dBi ± 0.19 dB
72.5≦EL<77.5	72.58 dBi ± 0.16 dB	72.64 dBi ± 0.19 dB
77.5≦EL<80.0	72.56 dBi ± 0.13 dB	72.63 dBi ± 0.13 dB

Table 4 Ka-Band Rx Gain

EL [deg]	Rx Gain [dBi]	
	RHCP	LHCP
15.0≦EL<17.5	83.67 dBi ± 0.14 dB	82.83 dBi ± 0.14 dB
17.5≦EL<22.5	83.39 dBi ± 0.13 dB	83.24 dBi ± 0.13 dB
22.5≦EL<27.5	83.37 dBi ± 0.13 dB	83.00 dBi ± 0.13 dB
27.5≦EL<32.5	83.28 dBi ± 0.13 dB	82.73 dBi ± 0.13 dB
32.5≦EL<37.5	83.30 dBi ± 0.15 dB	82.81 dBi ± 0.15 dB
37.5≦EL<42.5	83.00 dBi ± 0.15 dB	82.55 dBi ± 0.15 dB
42.5≦EL<47.5	83.22 dBi ± 0.14 dB	82.56 dBi ± 0.15 dB
47.5≦EL<52.5	82.89 dBi ± 0.14 dB	82.33 dBi ± 0.15 dB
52.5≦EL<57.5	82.85 dBi ± 0.14 dB	82.29 dBi ± 0.15 dB
57.5≦EL<62.5	83.24 dBi ± 0.16 dB	82.36 dBi ± 0.15 dB
62.5≦EL<67.5	83.09 dBi ± 0.17 dB	82.36 dBi ± 0.16 dB
67.5≦EL<72.5	83.06 dBi ± 0.18 dB	82.38 dBi ± 0.17 dB
72.5≦EL<77.5	82.75 dBi ± 0.19 dB	82.11 dBi ± 0.19 dB
77.5≦EL<80.0	82.56 dBi ± 0.13 dB	81.88 dBi ± 0.13 dB

Table 5 Constant Parameters

Item	Unit	X-Band	Ka-Band
$T_{\text{AMW-CMB}}$	K	17.51	22.67
$\boldsymbol{\alpha}$	-	0.96	0.94
T_{rec}	K	14.02	15.00

Table 6 Atmospheric gases attenuation, 7.145GHz, dB

Frequency[GHz]	7.145											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.025	0.026	0.026	0.026	0.026	0.027	0.031	0.030	0.029	0.027	0.026	0.026
5	0.026	0.026	0.026	0.026	0.027	0.029	0.032	0.032	0.030	0.028	0.027	0.026
10	0.026	0.026	0.026	0.027	0.027	0.029	0.033	0.033	0.031	0.029	0.027	0.027
20	0.027	0.027	0.027	0.027	0.028	0.030	0.033	0.034	0.031	0.030	0.028	0.027
30	0.027	0.027	0.027	0.027	0.029	0.031	0.033	0.034	0.032	0.030	0.028	0.027
50	0.027	0.027	0.028	0.028	0.029	0.031	0.034	0.035	0.033	0.031	0.029	0.028
70	0.028	0.028	0.028	0.029	0.030	0.032	0.035	0.035	0.034	0.032	0.029	0.028
80	0.028	0.028	0.028	0.029	0.030	0.033	0.035	0.036	0.034	0.032	0.029	0.028
90	0.028	0.028	0.029	0.030	0.031	0.033	0.036	0.036	0.035	0.033	0.030	0.029
95	0.028	0.029	0.029	0.030	0.031	0.034	0.036	0.037	0.035	0.034	0.031	0.029
99	0.030	0.031	0.030	0.031	0.032	0.034	0.037	0.037	0.037	0.034	0.032	0.031

Table 7 Atmospheric gases attenuation, 7.190GHz, dB

Frequency[GHz]	7.190											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.025	0.026	0.026	0.026	0.026	0.027	0.031	0.030	0.029	0.027	0.026	0.026
5	0.026	0.026	0.026	0.026	0.027	0.029	0.032	0.032	0.030	0.028	0.027	0.026
10	0.026	0.026	0.027	0.027	0.027	0.030	0.033	0.033	0.031	0.029	0.027	0.027
20	0.027	0.027	0.027	0.027	0.028	0.030	0.033	0.034	0.031	0.030	0.028	0.027
30	0.027	0.027	0.027	0.027	0.029	0.031	0.034	0.034	0.032	0.030	0.028	0.027
50	0.027	0.027	0.028	0.028	0.030	0.031	0.034	0.035	0.033	0.031	0.029	0.028
70	0.028	0.028	0.028	0.029	0.030	0.032	0.035	0.036	0.034	0.032	0.029	0.028
80	0.028	0.028	0.028	0.029	0.030	0.033	0.035	0.036	0.035	0.032	0.030	0.028
90	0.028	0.028	0.029	0.030	0.031	0.033	0.036	0.037	0.035	0.033	0.030	0.029
95	0.029	0.029	0.029	0.030	0.031	0.034	0.036	0.037	0.036	0.034	0.031	0.030
99	0.030	0.031	0.031	0.031	0.032	0.035	0.038	0.038	0.037	0.034	0.032	0.031

Table 8 Atmospheric gases attenuation, 7.235GHz, dB

Frequency[GHz]	7.235											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.025	0.026	0.026	0.026	0.027	0.028	0.032	0.030	0.029	0.027	0.026	0.026
5	0.026	0.026	0.026	0.027	0.027	0.029	0.032	0.032	0.030	0.028	0.027	0.026
10	0.026	0.026	0.027	0.027	0.027	0.030	0.033	0.033	0.031	0.029	0.027	0.027
20	0.027	0.027	0.027	0.027	0.028	0.030	0.033	0.034	0.032	0.030	0.028	0.027
30	0.027	0.027	0.027	0.027	0.029	0.031	0.034	0.034	0.032	0.030	0.028	0.027
50	0.027	0.027	0.028	0.028	0.030	0.032	0.034	0.035	0.033	0.031	0.029	0.028
70	0.028	0.028	0.028	0.029	0.030	0.032	0.035	0.036	0.034	0.032	0.029	0.028
80	0.028	0.028	0.028	0.029	0.031	0.033	0.036	0.036	0.035	0.032	0.030	0.028
90	0.028	0.028	0.029	0.030	0.031	0.034	0.036	0.037	0.036	0.033	0.030	0.029
95	0.029	0.029	0.029	0.030	0.031	0.034	0.037	0.037	0.036	0.034	0.031	0.030
99	0.030	0.031	0.031	0.031	0.032	0.035	0.038	0.038	0.037	0.035	0.032	0.031

Table 9 Atmospheric gases attenuation, 8.400GHz, dB

Frequency[GHz]	8.400											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.026	0.027	0.027	0.027	0.028	0.029	0.035	0.033	0.031	0.029	0.027	0.027
5	0.027	0.027	0.027	0.028	0.029	0.031	0.036	0.036	0.033	0.030	0.029	0.028
10	0.027	0.028	0.028	0.028	0.029	0.032	0.037	0.037	0.034	0.031	0.029	0.028
20	0.028	0.028	0.028	0.029	0.030	0.033	0.037	0.038	0.035	0.032	0.029	0.028
30	0.028	0.028	0.029	0.029	0.031	0.034	0.038	0.039	0.036	0.033	0.030	0.029
50	0.029	0.029	0.029	0.030	0.032	0.035	0.039	0.040	0.037	0.034	0.031	0.029
70	0.029	0.029	0.030	0.031	0.033	0.036	0.040	0.041	0.038	0.035	0.031	0.030
80	0.029	0.030	0.030	0.032	0.033	0.037	0.040	0.041	0.039	0.036	0.032	0.030
90	0.030	0.030	0.031	0.032	0.034	0.038	0.041	0.042	0.040	0.037	0.033	0.031
95	0.030	0.031	0.031	0.033	0.035	0.038	0.042	0.043	0.041	0.038	0.033	0.032
99	0.032	0.033	0.033	0.034	0.035	0.039	0.044	0.044	0.043	0.039	0.035	0.034

Table 10 Atmospheric gases attenuation, 8.450GHz, dB

Frequency[GHz]	8.450											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.026	0.027	0.027	0.027	0.028	0.029	0.035	0.033	0.031	0.029	0.027	0.027
5	0.027	0.027	0.027	0.028	0.029	0.031	0.036	0.036	0.033	0.030	0.029	0.028
10	0.027	0.028	0.028	0.028	0.029	0.032	0.037	0.038	0.034	0.031	0.029	0.028
20	0.028	0.028	0.029	0.029	0.030	0.034	0.038	0.039	0.035	0.032	0.030	0.028
30	0.028	0.028	0.029	0.029	0.031	0.034	0.038	0.039	0.036	0.033	0.030	0.029
50	0.029	0.029	0.029	0.030	0.032	0.035	0.039	0.040	0.037	0.034	0.031	0.029
70	0.029	0.029	0.030	0.031	0.033	0.036	0.040	0.041	0.039	0.035	0.031	0.030
80	0.030	0.030	0.030	0.032	0.033	0.037	0.041	0.042	0.039	0.036	0.032	0.030
90	0.030	0.030	0.031	0.033	0.034	0.038	0.041	0.042	0.041	0.037	0.033	0.031
95	0.031	0.031	0.031	0.033	0.035	0.039	0.042	0.043	0.041	0.038	0.034	0.032
99	0.032	0.033	0.033	0.034	0.035	0.039	0.044	0.044	0.043	0.039	0.035	0.034

Table 11 Atmospheric gases attenuation, 8.500GHz, dB

Frequency[GHz]	8.500											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.026	0.027	0.027	0.027	0.028	0.030	0.035	0.033	0.031	0.029	0.027	0.027
5	0.027	0.027	0.028	0.028	0.029	0.032	0.037	0.036	0.034	0.031	0.029	0.028
10	0.027	0.028	0.028	0.028	0.029	0.033	0.037	0.038	0.034	0.031	0.029	0.028
20	0.028	0.028	0.029	0.029	0.030	0.034	0.038	0.039	0.035	0.032	0.030	0.029
30	0.028	0.028	0.029	0.029	0.031	0.034	0.038	0.039	0.036	0.033	0.030	0.029
50	0.029	0.029	0.029	0.030	0.032	0.035	0.039	0.040	0.037	0.034	0.031	0.029
70	0.029	0.029	0.030	0.031	0.033	0.036	0.040	0.041	0.039	0.035	0.032	0.030
80	0.030	0.030	0.030	0.032	0.034	0.037	0.041	0.042	0.040	0.036	0.032	0.030
90	0.030	0.030	0.031	0.033	0.034	0.038	0.042	0.043	0.041	0.037	0.033	0.031
95	0.031	0.032	0.032	0.033	0.035	0.039	0.042	0.043	0.041	0.038	0.034	0.032
99	0.032	0.034	0.034	0.034	0.036	0.040	0.044	0.044	0.043	0.039	0.035	0.034

Table 12 Atmospheric gases attenuation, 31.800GHz, dB

Frequency[GHz]	31.800											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.097	0.105	0.105	0.110	0.123	0.157	0.254	0.223	0.185	0.140	0.109	0.106
5	0.106	0.110	0.115	0.122	0.135	0.187	0.273	0.270	0.219	0.163	0.130	0.118
10	0.111	0.115	0.121	0.129	0.145	0.204	0.282	0.296	0.231	0.172	0.135	0.121
20	0.119	0.120	0.129	0.136	0.161	0.223	0.294	0.311	0.244	0.191	0.143	0.126
30	0.124	0.124	0.132	0.141	0.176	0.234	0.302	0.321	0.257	0.200	0.150	0.130
50	0.130	0.128	0.139	0.155	0.196	0.248	0.317	0.335	0.282	0.218	0.161	0.137
70	0.136	0.135	0.146	0.172	0.210	0.268	0.332	0.350	0.306	0.241	0.175	0.146
80	0.140	0.142	0.151	0.182	0.217	0.280	0.343	0.361	0.317	0.256	0.183	0.153
90	0.145	0.155	0.163	0.197	0.227	0.296	0.358	0.375	0.337	0.274	0.197	0.166
95	0.156	0.172	0.177	0.210	0.239	0.308	0.370	0.386	0.345	0.289	0.209	0.182
99	0.189	0.206	0.208	0.229	0.252	0.321	0.400	0.401	0.375	0.309	0.234	0.213

Table 13 Atmospheric gases attenuation, 32.050GHz, dB

Frequency[GHz]	32.050											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.099	0.106	0.107	0.111	0.125	0.158	0.255	0.224	0.186	0.141	0.110	0.107
5	0.107	0.112	0.117	0.124	0.136	0.189	0.274	0.271	0.220	0.164	0.132	0.119
10	0.112	0.117	0.123	0.130	0.147	0.205	0.283	0.297	0.232	0.173	0.136	0.122
20	0.121	0.121	0.130	0.137	0.162	0.224	0.295	0.312	0.245	0.193	0.144	0.128
30	0.125	0.126	0.133	0.143	0.177	0.235	0.303	0.322	0.258	0.201	0.151	0.131
50	0.131	0.129	0.141	0.156	0.197	0.249	0.318	0.336	0.283	0.219	0.162	0.139
70	0.137	0.137	0.148	0.173	0.211	0.269	0.333	0.351	0.307	0.243	0.176	0.147
80	0.142	0.143	0.152	0.183	0.218	0.281	0.344	0.362	0.318	0.257	0.184	0.154
90	0.146	0.156	0.164	0.199	0.228	0.297	0.359	0.376	0.338	0.275	0.198	0.167
95	0.157	0.174	0.178	0.211	0.240	0.309	0.371	0.387	0.346	0.290	0.210	0.183
99	0.190	0.207	0.210	0.230	0.252	0.322	0.400	0.401	0.376	0.310	0.235	0.214

Table 14 Atmospheric gases attenuation, 32.300GHz, dB

Frequency[GHz]	32.300											
CDs[%]/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.100	0.107	0.108	0.113	0.126	0.159	0.257	0.225	0.187	0.143	0.112	0.109
5	0.109	0.113	0.118	0.125	0.138	0.190	0.275	0.272	0.221	0.165	0.133	0.121
10	0.114	0.118	0.124	0.132	0.148	0.206	0.285	0.298	0.233	0.175	0.137	0.124
20	0.122	0.123	0.132	0.138	0.163	0.225	0.296	0.313	0.246	0.194	0.146	0.129
30	0.126	0.127	0.135	0.144	0.179	0.236	0.304	0.323	0.259	0.203	0.153	0.133
50	0.133	0.131	0.142	0.157	0.199	0.250	0.319	0.337	0.284	0.220	0.163	0.140
70	0.139	0.138	0.149	0.174	0.212	0.270	0.334	0.352	0.308	0.244	0.177	0.149
80	0.143	0.145	0.153	0.185	0.219	0.282	0.345	0.363	0.320	0.258	0.185	0.156
90	0.147	0.158	0.165	0.200	0.229	0.298	0.360	0.377	0.339	0.276	0.199	0.169
95	0.159	0.175	0.179	0.212	0.241	0.310	0.372	0.388	0.347	0.291	0.211	0.184
99	0.192	0.208	0.211	0.231	0.254	0.323	0.401	0.402	0.377	0.311	0.236	0.216

Table 15 Rain attenuation, 7.145GHz, dB

Frequency[GHz]	7.145									
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.005	0.005	0.005	0.006	0.007	0.009	0.015	0.022	0.042	0.077	0.277
8	0.004	0.004	0.004	0.005	0.006	0.008	0.013	0.020	0.037	0.068	0.247
9	0.004	0.004	0.004	0.004	0.005	0.007	0.012	0.018	0.033	0.061	0.224
10	0.003	0.003	0.004	0.004	0.005	0.006	0.011	0.016	0.030	0.056	0.205
11	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.028	0.051	0.189
12	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.026	0.047	0.175
13	0.002	0.003	0.003	0.003	0.004	0.005	0.008	0.012	0.024	0.044	0.164
14	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.022	0.041	0.154
15	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.145
16	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.137
17	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.010	0.019	0.035	0.131
18	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.125
19	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.009	0.017	0.031	0.119
20	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.114
21	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.110
22	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
23	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.027	0.102
24	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.099
25	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.096
26	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.093
27	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.006	0.012	0.023	0.090
28	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.023	0.088
29	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.085
30	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.083
31	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
32	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
33	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.010	0.020	0.076
34	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.019	0.074
35	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.019	0.072
36	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.018	0.070
37	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.018	0.069
38	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.017	0.067
39	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.009	0.017	0.066
40	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.009	0.016	0.064
41	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.016	0.063
42	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.016	0.062
43	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.060
44	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.059
45	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.058
46	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.014	0.057
47	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.007	0.014	0.056
48	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.055
49	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.054
50	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.054
51	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.013	0.053
52	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.052
53	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.051
54	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.051
55	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.050
56	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.050
57	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.049
58	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.048
59	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.048
60	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.047
61	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.047
62	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.046
63	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.046
64	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.046
65	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
66	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
67	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
68	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
69	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
70	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
71	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
72	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
73	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
74	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
75	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
76	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.011	0.042
77	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
78	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
79	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
80	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
81	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
82	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
83	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
84	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
85	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
86	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
87	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
88	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
89	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
90	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041

Table 16 Rain attenuation, 7.190GHz, dB

Frequency[GHz]	7.190									
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.005	0.005	0.005	0.006	0.007	0.009	0.015	0.022	0.042	0.078	0.279
8	0.004	0.004	0.004	0.005	0.006	0.008	0.013	0.020	0.038	0.069	0.249
9	0.004	0.004	0.004	0.004	0.005	0.007	0.012	0.018	0.034	0.062	0.225
10	0.003	0.003	0.004	0.004	0.005	0.007	0.011	0.016	0.031	0.056	0.206
11	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.028	0.052	0.190
12	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.014	0.026	0.048	0.177
13	0.002	0.003	0.003	0.003	0.004	0.005	0.008	0.013	0.024	0.044	0.165
14	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.022	0.042	0.155
15	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.146
16	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.139
17	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.035	0.132
18	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.126
19	0.002	0.002	0.002	0.002	0.002	0.004	0.006	0.009	0.017	0.032	0.120
20	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.115
21	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.029	0.111
22	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
23	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.027	0.103
24	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.099
25	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.096
26	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.093
27	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.006	0.013	0.024	0.091
28	0.001	0.001	0.001	0.002	0.002	0.002	0.004	0.006	0.012	0.023	0.088
29	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.086
30	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.022	0.084
31	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
32	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
33	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.010	0.020	0.077
34	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.019	0.075
35	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.019	0.073
36	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.018	0.071
37	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.018	0.069
38	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.017	0.068
39	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.017	0.066
40	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.009	0.016	0.065
41	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.016	0.063
42	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.016	0.062
43	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.061
44	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.060
45	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.059
46	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.058
47	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.008	0.014	0.057
48	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.056
49	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.055
50	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.054
51	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.013	0.053
52	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.013	0.052
53	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.052
54	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.051
55	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.050
56	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.050
57	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.049
58	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.049
59	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.048
60	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.048
61	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.047
62	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.047
63	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.046
64	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.046
65	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.046
66	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
67	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
68	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
69	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
70	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
71	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
72	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
73	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
74	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
75	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
76	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
77	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
78	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.011	0.042
79	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
80	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
81	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
82	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
83	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
84	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
85	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
86	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
87	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
88	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
89	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041
90	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.041

Table 17 Rain attenuation, 7.235GHz, dB

Frequency[GHz]	7.235									
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.005	0.005	0.005	0.006	0.007	0.009	0.015	0.023	0.043	0.078	0.281
8	0.004	0.004	0.004	0.005	0.006	0.008	0.014	0.020	0.038	0.069	0.251
9	0.004	0.004	0.004	0.005	0.005	0.007	0.012	0.018	0.034	0.062	0.227
10	0.003	0.003	0.004	0.004	0.005	0.007	0.011	0.016	0.031	0.057	0.208
11	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.028	0.052	0.192
12	0.003	0.003	0.003	0.003	0.004	0.006	0.009	0.014	0.026	0.048	0.178
13	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.024	0.045	0.166
14	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.023	0.042	0.156
15	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.147
16	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.140
17	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.035	0.133
18	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.034	0.127
19	0.002	0.002	0.002	0.002	0.002	0.004	0.006	0.009	0.017	0.032	0.121
20	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.031	0.116
21	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.029	0.112
22	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
23	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.027	0.104
24	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.100
25	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.097
26	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.025	0.094
27	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.091
28	0.001	0.001	0.001	0.002	0.002	0.002	0.004	0.006	0.012	0.023	0.089
29	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.087
30	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.084
31	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.082
32	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
33	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.077
34	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.019	0.075
35	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.019	0.073
36	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.018	0.071
37	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.018	0.070
38	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.017	0.068
39	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.017	0.067
40	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.009	0.017	0.065
41	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.009	0.016	0.064
42	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.016	0.062
43	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.016	0.061
44	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.060
45	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.059
46	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.008	0.015	0.058
47	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.008	0.014	0.057
48	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.007	0.014	0.056
49	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.055
50	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.054
51	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.014	0.054
52	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.013	0.053
53	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.052
54	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.052
55	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.051
56	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.013	0.050
57	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.012	0.050
58	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.049
59	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.049
60	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.048
61	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.048
62	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.047
63	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.047
64	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.012	0.046
65	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.046
66	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.046
67	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
68	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
69	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.045
70	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
71	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
72	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
73	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.044
74	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
75	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
76	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
77	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
78	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
79	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.006	0.011	0.043
80	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.011	0.042
81	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.011	0.042
82	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
83	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
84	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
85	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
86	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
87	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
88	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
89	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042
90	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.005	0.010	0.042

Table 18 Rain attenuation, 8.400GHz, dB

Frequency[GHz]	8.400

EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.008	0.009	0.009	0.010	0.012	0.017	0.027	0.040	0.074	0.134	0.467
8	0.007	0.008	0.008	0.009	0.011	0.015	0.024	0.035	0.066	0.119	0.418
9	0.007	0.007	0.007	0.008	0.009	0.013	0.022	0.032	0.059	0.108	0.380
10	0.006	0.006	0.007	0.007	0.008	0.012	0.020	0.029	0.054	0.098	0.348
11	0.005	0.006	0.006	0.007	0.008	0.011	0.018	0.026	0.050	0.090	0.322
12	0.005	0.005	0.006	0.006	0.007	0.010	0.017	0.024	0.046	0.084	0.300
13	0.005	0.005	0.005	0.006	0.007	0.009	0.015	0.023	0.043	0.078	0.281
14	0.004	0.005	0.005	0.005	0.006	0.009	0.014	0.021	0.040	0.073	0.264
15	0.004	0.004	0.004	0.005	0.006	0.008	0.013	0.020	0.038	0.069	0.250
16	0.004	0.004	0.004	0.005	0.005	0.008	0.013	0.019	0.036	0.065	0.237
17	0.004	0.004	0.004	0.004	0.005	0.007	0.012	0.018	0.034	0.062	0.226
18	0.003	0.004	0.004	0.004	0.005	0.007	0.011	0.017	0.032	0.059	0.216
19	0.003	0.003	0.004	0.004	0.005	0.007	0.011	0.016	0.031	0.057	0.207
20	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.029	0.054	0.199
21	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.028	0.052	0.191
22	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.014	0.027	0.050	0.184
23	0.003	0.003	0.003	0.003	0.004	0.006	0.009	0.014	0.026	0.048	0.178
24	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.025	0.047	0.172
25	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.024	0.045	0.167
26	0.002	0.003	0.003	0.003	0.004	0.005	0.008	0.012	0.024	0.044	0.162
27	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.023	0.042	0.158
28	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.022	0.041	0.154
29	0.002	0.002	0.002	0.003	0.003	0.005	0.008	0.011	0.022	0.040	0.150
30	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.146
31	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.038	0.143
32	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.140
33	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.036	0.137
34	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.036	0.134
35	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.035	0.132
36	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.010	0.018	0.034	0.129
37	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.034	0.127
38	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.125
39	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.017	0.032	0.123
40	0.002	0.002	0.002	0.002	0.002	0.004	0.006	0.009	0.017	0.032	0.120
41	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.009	0.017	0.031	0.118
42	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.115
43	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.113
44	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.029	0.111
45	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.109
46	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
47	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.105
48	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.027	0.104
49	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.027	0.102
50	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.101
51	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.099
52	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.098
53	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.096
54	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.095
55	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.094
56	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.093
57	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.092
58	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.006	0.013	0.024	0.091
59	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.006	0.012	0.023	0.090
60	0.001	0.001	0.001	0.002	0.002	0.002	0.004	0.006	0.012	0.023	0.089
61	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.023	0.088
62	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.023	0.087
63	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.087
64	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.086
65	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.085
66	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.084
67	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.022	0.084
68	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.022	0.083
69	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.083
70	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.082
71	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.082
72	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
73	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
74	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
75	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
76	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
77	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
78	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
79	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
80	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.079
81	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
82	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
83	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.078
84	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.078
85	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.078
86	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.078
87	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.077
88	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.077
89	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.010	0.020	0.077
90	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.077

Table 19 Rain attenuation, 8.450GHz, dB

Frequency[GHz]	8.450										
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.008	0.009	0.009	0.011	0.012	0.017	0.027	0.040	0.075	0.135	0.470
8	0.007	0.008	0.008	0.009	0.011	0.015	0.024	0.036	0.066	0.120	0.421
9	0.007	0.007	0.007	0.008	0.009	0.013	0.022	0.032	0.060	0.108	0.382
10	0.006	0.006	0.007	0.007	0.009	0.012	0.020	0.029	0.054	0.099	0.351
11	0.005	0.006	0.006	0.007	0.008	0.011	0.018	0.027	0.050	0.091	0.324
12	0.005	0.005	0.006	0.006	0.007	0.010	0.017	0.025	0.046	0.084	0.302
13	0.005	0.005	0.005	0.006	0.007	0.009	0.016	0.023	0.043	0.079	0.283
14	0.004	0.005	0.005	0.005	0.006	0.009	0.014	0.021	0.040	0.074	0.266
15	0.004	0.004	0.005	0.005	0.006	0.008	0.014	0.020	0.038	0.070	0.252
16	0.004	0.004	0.004	0.005	0.005	0.008	0.013	0.019	0.036	0.066	0.239
17	0.004	0.004	0.004	0.005	0.005	0.007	0.012	0.018	0.034	0.063	0.228
18	0.003	0.004	0.004	0.004	0.005	0.007	0.012	0.017	0.032	0.060	0.218
19	0.003	0.003	0.004	0.004	0.005	0.007	0.011	0.016	0.031	0.057	0.208
20	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.016	0.030	0.055	0.200
21	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.028	0.052	0.193
22	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.014	0.027	0.050	0.186
23	0.003	0.003	0.003	0.003	0.004	0.006	0.009	0.014	0.026	0.049	0.180
24	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.025	0.047	0.174
25	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.025	0.045	0.168
26	0.002	0.003	0.003	0.003	0.004	0.005	0.008	0.012	0.024	0.044	0.164
27	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.023	0.043	0.159
28	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.022	0.042	0.155
29	0.002	0.002	0.002	0.003	0.003	0.005	0.008	0.011	0.022	0.040	0.151
30	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.147
31	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.038	0.144
32	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.020	0.038	0.141
33	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.138
34	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.036	0.135
35	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.035	0.133
36	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.010	0.019	0.035	0.130
37	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.034	0.128
38	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.126
39	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.124
40	0.002	0.002	0.002	0.002	0.002	0.004	0.006	0.009	0.017	0.032	0.121
41	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.009	0.017	0.031	0.118
42	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.031	0.116
43	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.114
44	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.029	0.112
45	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.110
46	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.108
47	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
48	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.027	0.104
49	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.027	0.103
50	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.101
51	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.100
52	0.001	0.001	0.002	0.002	0.002	0.003	0.005	0.007	0.014	0.026	0.098
53	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.097
54	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.096
55	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.007	0.013	0.025	0.095
56	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.094
57	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.092
58	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.013	0.024	0.091
59	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.006	0.012	0.024	0.091
60	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.006	0.012	0.023	0.090
61	0.001	0.001	0.001	0.002	0.002	0.002	0.004	0.006	0.012	0.023	0.089
62	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.023	0.088
63	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.023	0.087
64	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.086
65	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.086
66	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.085
67	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.012	0.022	0.084
68	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.022	0.084
69	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.022	0.083
70	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.083
71	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.082
72	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.082
73	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
74	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
75	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.081
76	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
77	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
78	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.021	0.080
79	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
80	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
81	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006	0.011	0.020	0.079
82	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.079
83	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
84	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
85	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
86	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
87	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
88	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.005	0.011	0.020	0.078
89	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.077
90	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.011	0.020	0.078

Table 20 Rain attenuation, 8.500GHz, dB

Frequency[GHz]	8.500										
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.011	0.012	0.012	0.014	0.016	0.022	0.036	0.052	0.096	0.173	0.593
8	0.010	0.010	0.011	0.012	0.014	0.019	0.032	0.046	0.086	0.154	0.532
9	0.009	0.009	0.010	0.011	0.012	0.017	0.028	0.041	0.077	0.139	0.484
10	0.008	0.008	0.009	0.010	0.011	0.016	0.026	0.038	0.070	0.127	0.444
11	0.007	0.008	0.008	0.009	0.010	0.014	0.024	0.035	0.065	0.117	0.411
12	0.007	0.007	0.007	0.008	0.010	0.013	0.022	0.032	0.060	0.109	0.384
13	0.006	0.006	0.007	0.008	0.009	0.012	0.020	0.030	0.056	0.102	0.360
14	0.006	0.006	0.006	0.007	0.008	0.012	0.019	0.028	0.052	0.095	0.339
15	0.005	0.006	0.006	0.007	0.008	0.011	0.018	0.026	0.049	0.090	0.321
16	0.005	0.005	0.006	0.006	0.007	0.010	0.017	0.025	0.047	0.085	0.305
17	0.005	0.005	0.005	0.006	0.007	0.010	0.016	0.023	0.044	0.081	0.290
18	0.005	0.005	0.005	0.006	0.007	0.009	0.015	0.022	0.042	0.077	0.278
19	0.004	0.005	0.005	0.005	0.006	0.009	0.014	0.021	0.040	0.074	0.266
20	0.004	0.004	0.005	0.005	0.006	0.008	0.014	0.020	0.039	0.071	0.256
21	0.004	0.004	0.004	0.005	0.006	0.008	0.013	0.020	0.037	0.068	0.246
22	0.004	0.004	0.004	0.005	0.005	0.008	0.013	0.019	0.036	0.065	0.238
23	0.004	0.004	0.004	0.005	0.005	0.007	0.012	0.018	0.034	0.063	0.230
24	0.004	0.004	0.004	0.004	0.005	0.007	0.012	0.017	0.033	0.061	0.222
25	0.003	0.004	0.004	0.004	0.005	0.007	0.011	0.017	0.032	0.059	0.216
26	0.003	0.003	0.004	0.004	0.005	0.007	0.011	0.016	0.031	0.057	0.210
27	0.003	0.003	0.004	0.004	0.005	0.006	0.011	0.016	0.030	0.056	0.204
28	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.029	0.054	0.199
29	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.029	0.053	0.194
30	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.015	0.028	0.051	0.189
31	0.003	0.003	0.003	0.004	0.004	0.006	0.010	0.014	0.027	0.050	0.185
32	0.003	0.003	0.003	0.003	0.004	0.006	0.009	0.014	0.026	0.049	0.181
33	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.014	0.026	0.048	0.177
34	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.025	0.047	0.174
35	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.025	0.046	0.170
36	0.003	0.003	0.003	0.003	0.004	0.005	0.009	0.013	0.024	0.045	0.167
37	0.002	0.003	0.003	0.003	0.004	0.005	0.008	0.012	0.024	0.044	0.164
38	0.002	0.003	0.003	0.003	0.003	0.005	0.008	0.012	0.023	0.043	0.162
39	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.023	0.043	0.159
40	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.023	0.042	0.157
41	0.002	0.002	0.003	0.003	0.003	0.005	0.008	0.012	0.022	0.041	0.154
42	0.002	0.002	0.002	0.003	0.003	0.005	0.008	0.011	0.022	0.041	0.152
43	0.002	0.002	0.002	0.003	0.003	0.005	0.008	0.011	0.022	0.040	0.150
44	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.040	0.148
45	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.146
46	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.039	0.145
47	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.021	0.038	0.143
48	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.011	0.020	0.038	0.142
49	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.140
50	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.010	0.020	0.037	0.138
51	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.036	0.136
52	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.036	0.134
53	0.002	0.002	0.002	0.002	0.003	0.004	0.007	0.010	0.019	0.035	0.132
54	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.010	0.019	0.035	0.130
55	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.010	0.018	0.034	0.129
56	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.034	0.127
57	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.126
58	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.018	0.033	0.124
59	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.017	0.033	0.123
60	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.009	0.017	0.032	0.122
61	0.002	0.002	0.002	0.002	0.002	0.004	0.006	0.009	0.017	0.032	0.121
62	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.009	0.017	0.032	0.119
63	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.009	0.017	0.031	0.118
64	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.009	0.017	0.031	0.117
65	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.031	0.116
66	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.115
67	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.115
68	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.114
69	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.008	0.016	0.030	0.113
70	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.030	0.112
71	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.029	0.112
72	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.016	0.029	0.111
73	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.110
74	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.110
75	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.109
76	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.029	0.109
77	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.108
78	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.108
79	0.002	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
80	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
81	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
82	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.107
83	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
84	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
85	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
86	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
87	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106
88	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.027	0.105
89	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.007	0.015	0.027	0.104
90	0.001	0.002	0.002	0.002	0.002	0.003	0.005	0.008	0.015	0.028	0.106

Table 21 Rain attenuation, 31.800GHz, dB

Frequency[GHz]	31.800										
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.272	0.282	0.296	0.330	0.372	0.500	0.774	1.080	1.864	3.116	9.091
8	0.245	0.254	0.267	0.297	0.335	0.452	0.700	0.978	1.692	2.835	8.316
9	0.223	0.232	0.244	0.271	0.306	0.413	0.641	0.897	1.554	2.609	7.690
10	0.206	0.214	0.225	0.250	0.283	0.381	0.592	0.830	1.441	2.424	7.173
11	0.191	0.199	0.209	0.233	0.263	0.355	0.552	0.774	1.346	2.268	6.738
12	0.179	0.186	0.196	0.218	0.246	0.333	0.518	0.727	1.266	2.136	6.367
13	0.169	0.175	0.184	0.205	0.232	0.313	0.488	0.686	1.197	2.022	6.046
14	0.159	0.166	0.174	0.194	0.219	0.297	0.463	0.651	1.137	1.923	5.766
15	0.151	0.157	0.166	0.185	0.209	0.282	0.441	0.620	1.084	1.836	5.519
16	0.144	0.150	0.158	0.176	0.199	0.270	0.421	0.593	1.037	1.758	5.300
17	0.138	0.144	0.151	0.169	0.190	0.258	0.404	0.569	0.996	1.690	5.104
18	0.133	0.138	0.145	0.162	0.183	0.248	0.388	0.547	0.959	1.628	4.929
19	0.128	0.133	0.140	0.156	0.176	0.239	0.374	0.527	0.925	1.573	4.770
20	0.123	0.128	0.135	0.150	0.170	0.231	0.361	0.510	0.895	1.523	4.626
21	0.119	0.124	0.130	0.145	0.164	0.223	0.350	0.494	0.868	1.477	4.496
22	0.115	0.120	0.126	0.141	0.159	0.216	0.339	0.479	0.843	1.435	4.376
23	0.112	0.116	0.123	0.137	0.155	0.210	0.330	0.466	0.820	1.397	4.267
24	0.109	0.113	0.119	0.133	0.151	0.205	0.321	0.454	0.799	1.363	4.166
25	0.106	0.110	0.116	0.130	0.147	0.199	0.313	0.442	0.780	1.330	4.074
26	0.104	0.108	0.113	0.126	0.143	0.195	0.306	0.432	0.762	1.301	3.988
27	0.101	0.105	0.111	0.124	0.140	0.190	0.299	0.423	0.745	1.274	3.910
28	0.099	0.103	0.108	0.121	0.137	0.186	0.293	0.414	0.730	1.249	3.837
29	0.097	0.101	0.106	0.118	0.134	0.182	0.287	0.406	0.716	1.225	3.769
30	0.095	0.099	0.104	0.116	0.131	0.179	0.281	0.398	0.703	1.204	3.706
31	0.093	0.097	0.102	0.114	0.129	0.176	0.276	0.391	0.691	1.184	3.648
32	0.092	0.095	0.100	0.112	0.127	0.173	0.272	0.385	0.680	1.165	3.594
33	0.090	0.094	0.099	0.110	0.125	0.170	0.268	0.379	0.670	1.148	3.544
34	0.089	0.092	0.097	0.109	0.123	0.167	0.264	0.373	0.660	1.132	3.497
35	0.087	0.091	0.096	0.107	0.121	0.165	0.260	0.368	0.651	1.117	3.453
36	0.086	0.090	0.094	0.105	0.119	0.163	0.256	0.363	0.643	1.103	3.413
37	0.085	0.089	0.093	0.104	0.118	0.161	0.253	0.359	0.635	1.090	3.375
38	0.084	0.087	0.092	0.103	0.117	0.159	0.250	0.355	0.628	1.078	3.340
39	0.083	0.086	0.091	0.102	0.115	0.157	0.248	0.351	0.622	1.067	3.307
40	0.082	0.086	0.090	0.101	0.114	0.155	0.245	0.347	0.615	1.056	3.277
41	0.081	0.085	0.089	0.100	0.113	0.154	0.243	0.344	0.610	1.047	3.249
42	0.081	0.084	0.088	0.099	0.112	0.152	0.240	0.341	0.604	1.038	3.222
43	0.080	0.083	0.088	0.098	0.111	0.151	0.238	0.338	0.599	1.030	3.198
44	0.079	0.082	0.087	0.097	0.110	0.150	0.236	0.336	0.595	1.022	3.176
45	0.079	0.082	0.086	0.096	0.109	0.149	0.235	0.333	0.591	1.015	3.155
46	0.078	0.081	0.086	0.096	0.108	0.148	0.233	0.331	0.587	1.008	3.136
47	0.078	0.081	0.085	0.095	0.108	0.147	0.232	0.329	0.583	1.002	3.119
48	0.077	0.080	0.084	0.094	0.107	0.146	0.230	0.327	0.580	0.997	3.103
49	0.077	0.080	0.084	0.094	0.106	0.145	0.229	0.325	0.577	0.992	3.088
50	0.076	0.079	0.084	0.093	0.106	0.144	0.228	0.324	0.574	0.988	3.075
51	0.076	0.079	0.083	0.093	0.105	0.144	0.227	0.322	0.572	0.983	3.063
52	0.076	0.079	0.083	0.093	0.105	0.143	0.226	0.321	0.570	0.980	3.052
53	0.075	0.078	0.083	0.092	0.105	0.143	0.225	0.320	0.568	0.976	3.043
54	0.075	0.078	0.082	0.092	0.104	0.142	0.225	0.319	0.566	0.974	3.034
55	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.564	0.971	3.026
56	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.563	0.969	3.019
57	0.075	0.078	0.082	0.091	0.103	0.141	0.223	0.316	0.562	0.967	3.014
58	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.316	0.561	0.965	3.009
59	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.315	0.560	0.963	3.004
60	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.962	3.001
61	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.961	2.997
62	0.074	0.077	0.081	0.091	0.103	0.140	0.221	0.314	0.558	0.960	2.995
63	0.074	0.077	0.081	0.091	0.103	0.140	0.221	0.314	0.558	0.960	2.993
64	0.074	0.077	0.081	0.090	0.103	0.140	0.221	0.314	0.557	0.959	2.991
65	0.074	0.077	0.081	0.090	0.103	0.140	0.221	0.314	0.557	0.959	2.990
66	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.314	0.557	0.958	2.989
67	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.314	0.557	0.958	2.988
68	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.313	0.557	0.958	2.987
69	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.313	0.556	0.957	2.986
70	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.313	0.556	0.957	2.985
71	0.074	0.077	0.081	0.090	0.102	0.140	0.220	0.313	0.556	0.957	2.984
72	0.074	0.077	0.081	0.090	0.102	0.139	0.220	0.313	0.556	0.956	2.983
73	0.074	0.077	0.081	0.090	0.102	0.139	0.220	0.313	0.555	0.955	2.981
74	0.074	0.076	0.081	0.090	0.102	0.139	0.220	0.312	0.555	0.954	2.978
75	0.073	0.076	0.080	0.090	0.102	0.139	0.220	0.312	0.554	0.953	2.974
76	0.073	0.076	0.080	0.090	0.102	0.139	0.219	0.311	0.553	0.952	2.970
77	0.073	0.076	0.080	0.090	0.102	0.139	0.219	0.311	0.552	0.950	2.965
78	0.073	0.076	0.080	0.089	0.101	0.138	0.218	0.310	0.551	0.948	2.959
79	0.073	0.076	0.080	0.089	0.101	0.138	0.218	0.309	0.549	0.945	2.951
80	0.072	0.075	0.079	0.089	0.101	0.137	0.217	0.308	0.547	0.942	2.942
81	0.072	0.075	0.079	0.088	0.100	0.137	0.216	0.307	0.545	0.939	2.932
82	0.072	0.075	0.079	0.088	0.100	0.136	0.215	0.306	0.543	0.935	2.920
83	0.071	0.074	0.078	0.088	0.099	0.135	0.214	0.304	0.540	0.930	2.907
84	0.071	0.074	0.078	0.087	0.099	0.135	0.213	0.302	0.537	0.925	2.892
85	0.071	0.073	0.077	0.086	0.098	0.134	0.212	0.301	0.534	0.920	2.877
86	0.070	0.073	0.077	0.086	0.097	0.133	0.210	0.299	0.531	0.915	2.862
87	0.070	0.073	0.076	0.085	0.097	0.132	0.209	0.297	0.529	0.911	2.849
88	0.070	0.072	0.076	0.085	0.097	0.132	0.209	0.296	0.527	0.908	2.841
89	0.070	0.073	0.076	0.085	0.097	0.132	0.209	0.297	0.529	0.911	2.849
90	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.962	3.000

Table 22 Rain attenuation, 32.050GHz, dB

Frequency[GHz]	32.050										
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.273	0.284	0.298	0.332	0.374	0.503	0.778	1.086	1.874	3.133	9.138
8	0.246	0.256	0.269	0.299	0.337	0.454	0.704	0.984	1.701	2.850	8.359
9	0.225	0.233	0.245	0.273	0.308	0.415	0.644	0.902	1.563	2.623	7.730
10	0.207	0.215	0.226	0.252	0.284	0.383	0.596	0.835	1.449	2.437	7.210
11	0.192	0.200	0.210	0.234	0.264	0.357	0.555	0.779	1.354	2.281	6.773
12	0.180	0.187	0.197	0.219	0.248	0.334	0.521	0.731	1.273	2.148	6.400
13	0.170	0.176	0.185	0.206	0.233	0.315	0.491	0.690	1.203	2.033	6.077
14	0.160	0.167	0.175	0.195	0.221	0.299	0.466	0.655	1.143	1.933	5.796
15	0.152	0.158	0.167	0.186	0.210	0.284	0.443	0.624	1.090	1.846	5.547
16	0.145	0.151	0.159	0.177	0.200	0.271	0.424	0.596	1.043	1.768	5.327
17	0.139	0.145	0.152	0.170	0.192	0.260	0.406	0.572	1.001	1.699	5.131
18	0.133	0.139	0.146	0.163	0.184	0.249	0.390	0.550	0.964	1.637	4.954
19	0.128	0.134	0.140	0.157	0.177	0.240	0.376	0.530	0.930	1.581	4.795
20	0.124	0.129	0.136	0.151	0.171	0.232	0.363	0.513	0.900	1.531	4.650
21	0.120	0.125	0.131	0.146	0.165	0.225	0.352	0.497	0.872	1.485	4.519
22	0.116	0.121	0.127	0.142	0.160	0.218	0.341	0.482	0.847	1.443	4.399
23	0.113	0.117	0.123	0.138	0.156	0.211	0.332	0.469	0.824	1.405	4.289
24	0.110	0.114	0.120	0.134	0.151	0.206	0.323	0.456	0.803	1.370	4.188
25	0.107	0.111	0.117	0.130	0.148	0.201	0.315	0.445	0.784	1.338	4.095
26	0.104	0.108	0.114	0.127	0.144	0.196	0.307	0.435	0.766	1.308	4.009
27	0.102	0.106	0.111	0.124	0.141	0.191	0.301	0.425	0.750	1.281	3.930
28	0.100	0.103	0.109	0.122	0.138	0.187	0.294	0.416	0.735	1.255	3.857
29	0.097	0.101	0.107	0.119	0.135	0.183	0.289	0.408	0.721	1.232	3.789
30	0.096	0.099	0.105	0.117	0.132	0.180	0.283	0.401	0.708	1.210	3.726
31	0.094	0.098	0.103	0.115	0.130	0.177	0.278	0.394	0.695	1.190	3.667
32	0.092	0.096	0.101	0.113	0.128	0.174	0.273	0.387	0.684	1.171	3.613
33	0.091	0.094	0.099	0.111	0.126	0.171	0.269	0.381	0.674	1.154	3.562
34	0.089	0.093	0.098	0.109	0.124	0.168	0.265	0.376	0.664	1.138	3.515
35	0.088	0.092	0.096	0.108	0.122	0.166	0.261	0.370	0.655	1.123	3.471
36	0.087	0.090	0.095	0.106	0.120	0.164	0.258	0.366	0.647	1.109	3.431
37	0.086	0.089	0.094	0.105	0.119	0.162	0.255	0.361	0.639	1.096	3.393
38	0.085	0.088	0.093	0.104	0.117	0.160	0.252	0.357	0.632	1.084	3.357
39	0.084	0.087	0.092	0.102	0.116	0.158	0.249	0.353	0.625	1.073	3.325
40	0.083	0.086	0.091	0.101	0.115	0.156	0.246	0.349	0.619	1.062	3.294
41	0.082	0.085	0.090	0.100	0.114	0.155	0.244	0.346	0.613	1.053	3.266
42	0.081	0.084	0.089	0.099	0.113	0.153	0.242	0.343	0.608	1.044	3.240
43	0.080	0.084	0.088	0.098	0.112	0.152	0.240	0.340	0.603	1.035	3.215
44	0.080	0.083	0.087	0.098	0.111	0.151	0.238	0.337	0.598	1.028	3.193
45	0.079	0.082	0.087	0.097	0.110	0.150	0.236	0.335	0.594	1.021	3.172
46	0.079	0.082	0.086	0.096	0.109	0.149	0.235	0.333	0.590	1.014	3.153
47	0.078	0.081	0.086	0.096	0.108	0.148	0.233	0.331	0.587	1.008	3.136
48	0.078	0.081	0.085	0.095	0.108	0.147	0.232	0.329	0.583	1.003	3.120
49	0.077	0.080	0.085	0.095	0.107	0.146	0.231	0.327	0.580	0.998	3.105
50	0.077	0.080	0.084	0.094	0.107	0.145	0.229	0.326	0.578	0.993	3.092
51	0.076	0.080	0.084	0.094	0.106	0.145	0.228	0.324	0.575	0.989	3.080
52	0.076	0.079	0.083	0.093	0.106	0.144	0.228	0.323	0.573	0.985	3.069
53	0.076	0.079	0.083	0.093	0.105	0.144	0.227	0.322	0.571	0.982	3.059
54	0.076	0.079	0.083	0.093	0.105	0.143	0.226	0.321	0.569	0.979	3.050
55	0.075	0.078	0.083	0.092	0.105	0.143	0.225	0.320	0.568	0.976	3.042
56	0.075	0.078	0.082	0.092	0.104	0.142	0.225	0.319	0.566	0.974	3.036
57	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.565	0.972	3.030
58	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.564	0.970	3.025
59	0.075	0.078	0.082	0.092	0.104	0.141	0.223	0.317	0.563	0.969	3.020
60	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.563	0.968	3.017
61	0.075	0.078	0.082	0.091	0.103	0.141	0.223	0.316	0.562	0.967	3.013
62	0.074	0.077	0.082	0.091	0.103	0.141	0.223	0.316	0.561	0.966	3.011
63	0.074	0.077	0.082	0.091	0.103	0.141	0.223	0.316	0.561	0.965	3.009
64	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.316	0.561	0.964	3.007
65	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.316	0.560	0.964	3.006
66	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.315	0.560	0.964	3.005
67	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.315	0.560	0.963	3.004
68	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.315	0.560	0.963	3.003
69	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.315	0.560	0.963	3.002
70	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.962	3.001
71	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.962	3.000
72	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.961	2.998
73	0.074	0.077	0.081	0.091	0.103	0.140	0.221	0.314	0.558	0.961	2.996
74	0.074	0.077	0.081	0.091	0.103	0.140	0.221	0.314	0.558	0.960	2.993
75	0.074	0.077	0.081	0.090	0.103	0.140	0.221	0.314	0.557	0.958	2.990
76	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.313	0.556	0.957	2.985
77	0.074	0.077	0.081	0.090	0.102	0.139	0.220	0.313	0.555	0.955	2.980
78	0.073	0.076	0.080	0.090	0.102	0.139	0.220	0.312	0.554	0.953	2.973
79	0.073	0.076	0.080	0.090	0.102	0.139	0.219	0.311	0.552	0.950	2.965
80	0.073	0.076	0.080	0.089	0.101	0.138	0.218	0.310	0.550	0.947	2.956
81	0.073	0.076	0.080	0.089	0.101	0.137	0.217	0.309	0.548	0.944	2.946
82	0.072	0.075	0.079	0.088	0.100	0.137	0.216	0.307	0.546	0.939	2.934
83	0.072	0.075	0.079	0.088	0.100	0.136	0.215	0.306	0.543	0.935	2.920
84	0.071	0.074	0.078	0.087	0.099	0.135	0.214	0.304	0.540	0.930	2.906
85	0.071	0.074	0.078	0.087	0.099	0.135	0.213	0.302	0.537	0.925	2.890
86	0.071	0.073	0.077	0.086	0.098	0.134	0.211	0.300	0.534	0.919	2.875
87	0.070	0.073	0.077	0.086	0.097	0.133	0.210	0.299	0.531	0.915	2.861
88	0.070	0.073	0.077	0.086	0.097	0.133	0.210	0.298	0.529	0.912	2.853
89	0.070	0.073	0.077	0.086	0.097	0.133	0.210	0.299	0.531	0.915	2.860
90	0.074	0.077	0.082	0.091	0.103	0.141	0.223	0.316	0.561	0.966	3.011

Table 23 Rain attenuation, 32.300GHz, dB

Frequency[GHz]	32.300									
EL[deg]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
7	0.275	0.286	0.300	0.334	0.376	0.506	0.782	1.092	1.885	3.150	9.185
8	0.248	0.257	0.270	0.301	0.339	0.457	0.708	0.989	1.711	2.866	8.402
9	0.226	0.235	0.247	0.275	0.310	0.418	0.648	0.907	1.571	2.638	7.769
10	0.208	0.216	0.227	0.253	0.286	0.386	0.599	0.839	1.457	2.450	7.247
11	0.194	0.201	0.211	0.236	0.266	0.359	0.558	0.783	1.361	2.293	6.807
12	0.181	0.188	0.198	0.221	0.249	0.336	0.524	0.735	1.280	2.159	6.432
13	0.171	0.177	0.186	0.208	0.235	0.317	0.494	0.694	1.210	2.044	6.108
14	0.161	0.168	0.176	0.196	0.222	0.300	0.468	0.658	1.149	1.944	5.825
15	0.153	0.159	0.167	0.187	0.211	0.286	0.446	0.627	1.096	1.856	5.576
16	0.146	0.152	0.160	0.178	0.201	0.273	0.426	0.600	1.049	1.778	5.355
17	0.140	0.145	0.153	0.171	0.193	0.261	0.408	0.575	1.007	1.708	5.157
18	0.134	0.140	0.147	0.164	0.185	0.251	0.393	0.553	0.969	1.646	4.980
19	0.129	0.134	0.141	0.158	0.178	0.242	0.378	0.533	0.936	1.590	4.819
20	0.125	0.130	0.136	0.152	0.172	0.233	0.366	0.516	0.905	1.539	4.674
21	0.121	0.125	0.132	0.147	0.166	0.226	0.354	0.499	0.877	1.493	4.542
22	0.117	0.121	0.128	0.143	0.161	0.219	0.343	0.485	0.852	1.451	4.422
23	0.113	0.118	0.124	0.138	0.157	0.213	0.334	0.471	0.829	1.413	4.311
24	0.110	0.115	0.121	0.135	0.152	0.207	0.325	0.459	0.808	1.378	4.210
25	0.107	0.112	0.118	0.131	0.148	0.202	0.317	0.448	0.788	1.345	4.116
26	0.105	0.109	0.115	0.128	0.145	0.197	0.309	0.437	0.770	1.315	4.030
27	0.102	0.106	0.112	0.125	0.142	0.192	0.302	0.428	0.754	1.288	3.950
28	0.100	0.104	0.110	0.122	0.139	0.188	0.296	0.419	0.739	1.262	3.877
29	0.098	0.102	0.107	0.120	0.136	0.185	0.290	0.411	0.725	1.239	3.808
30	0.096	0.100	0.105	0.118	0.133	0.181	0.285	0.403	0.711	1.217	3.745
31	0.094	0.098	0.103	0.115	0.131	0.178	0.280	0.396	0.699	1.197	3.686
32	0.093	0.096	0.102	0.113	0.128	0.175	0.275	0.389	0.688	1.178	3.632
33	0.091	0.095	0.100	0.112	0.126	0.172	0.271	0.383	0.678	1.160	3.581
34	0.090	0.093	0.098	0.110	0.124	0.169	0.267	0.378	0.668	1.144	3.533
35	0.089	0.092	0.097	0.108	0.123	0.167	0.263	0.373	0.659	1.129	3.489
36	0.087	0.091	0.096	0.107	0.121	0.165	0.259	0.368	0.651	1.115	3.449
37	0.086	0.090	0.094	0.105	0.119	0.163	0.256	0.363	0.643	1.102	3.410
38	0.085	0.089	0.093	0.104	0.118	0.161	0.253	0.359	0.635	1.090	3.375
39	0.084	0.088	0.092	0.103	0.117	0.159	0.250	0.355	0.629	1.079	3.342
40	0.083	0.087	0.091	0.102	0.115	0.157	0.248	0.351	0.622	1.068	3.311
41	0.082	0.086	0.090	0.101	0.114	0.156	0.245	0.348	0.617	1.058	3.283
42	0.082	0.085	0.089	0.100	0.113	0.154	0.243	0.345	0.611	1.049	3.257
43	0.081	0.084	0.089	0.099	0.112	0.153	0.241	0.342	0.606	1.041	3.232
44	0.080	0.083	0.088	0.098	0.111	0.152	0.239	0.339	0.602	1.033	3.210
45	0.080	0.083	0.087	0.097	0.110	0.151	0.238	0.337	0.598	1.026	3.189
46	0.079	0.082	0.087	0.097	0.110	0.150	0.236	0.335	0.594	1.020	3.170
47	0.079	0.082	0.086	0.096	0.109	0.149	0.234	0.333	0.590	1.014	3.152
48	0.078	0.081	0.086	0.096	0.108	0.148	0.233	0.331	0.587	1.008	3.136
49	0.078	0.081	0.085	0.095	0.108	0.147	0.232	0.329	0.584	1.003	3.121
50	0.077	0.080	0.085	0.095	0.107	0.146	0.231	0.328	0.581	0.999	3.108
51	0.077	0.080	0.084	0.094	0.107	0.146	0.230	0.326	0.579	0.995	3.096
52	0.077	0.080	0.084	0.094	0.106	0.145	0.229	0.325	0.576	0.991	3.085
53	0.076	0.079	0.084	0.093	0.106	0.144	0.228	0.324	0.574	0.988	3.075
54	0.076	0.079	0.083	0.093	0.106	0.144	0.227	0.323	0.573	0.985	3.066
55	0.076	0.079	0.083	0.093	0.105	0.144	0.227	0.322	0.571	0.982	3.059
56	0.076	0.079	0.083	0.093	0.105	0.143	0.226	0.321	0.570	0.980	3.052
57	0.075	0.079	0.083	0.092	0.105	0.143	0.226	0.320	0.568	0.978	3.046
58	0.075	0.078	0.083	0.092	0.105	0.143	0.225	0.320	0.567	0.976	3.041
59	0.075	0.078	0.082	0.092	0.104	0.142	0.225	0.319	0.567	0.974	3.036
60	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.319	0.566	0.973	3.032
61	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.565	0.972	3.029
62	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.565	0.971	3.027
63	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.564	0.970	3.025
64	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.318	0.564	0.970	3.023
65	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.317	0.564	0.969	3.022
66	0.075	0.078	0.082	0.092	0.104	0.141	0.223	0.317	0.563	0.969	3.020
67	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.563	0.969	3.019
68	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.563	0.968	3.019
69	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.563	0.968	3.018
70	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.563	0.968	3.016
71	0.075	0.078	0.082	0.091	0.104	0.141	0.223	0.317	0.562	0.967	3.015
72	0.075	0.078	0.082	0.091	0.103	0.141	0.223	0.316	0.562	0.966	3.013
73	0.074	0.077	0.082	0.091	0.103	0.141	0.223	0.316	0.561	0.966	3.011
74	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.316	0.561	0.965	3.008
75	0.074	0.077	0.081	0.091	0.103	0.141	0.222	0.315	0.560	0.964	3.005
76	0.074	0.077	0.081	0.091	0.103	0.140	0.222	0.315	0.559	0.962	3.000
77	0.074	0.077	0.081	0.091	0.103	0.140	0.221	0.314	0.558	0.960	2.994
78	0.074	0.077	0.081	0.090	0.102	0.140	0.221	0.313	0.557	0.958	2.988
79	0.074	0.077	0.081	0.090	0.102	0.139	0.220	0.313	0.555	0.955	2.980
80	0.073	0.076	0.080	0.090	0.102	0.139	0.219	0.311	0.553	0.952	2.970
81	0.073	0.076	0.080	0.089	0.101	0.138	0.218	0.310	0.551	0.948	2.960
82	0.073	0.076	0.080	0.089	0.101	0.138	0.217	0.309	0.549	0.944	2.947
83	0.072	0.075	0.079	0.088	0.100	0.137	0.216	0.307	0.546	0.939	2.934
84	0.072	0.075	0.079	0.088	0.100	0.136	0.215	0.305	0.543	0.934	2.919
85	0.071	0.074	0.078	0.087	0.099	0.135	0.214	0.304	0.540	0.929	2.903
86	0.071	0.074	0.078	0.087	0.098	0.134	0.212	0.302	0.536	0.924	2.887
87	0.071	0.073	0.077	0.086	0.098	0.134	0.211	0.300	0.534	0.919	2.873
88	0.070	0.073	0.077	0.086	0.098	0.133	0.211	0.299	0.532	0.916	2.865
89	0.070	0.073	0.077	0.086	0.098	0.134	0.211	0.300	0.533	0.918	2.872
90	0.075	0.078	0.082	0.092	0.104	0.142	0.224	0.317	0.564	0.970	3.022

Table 24 Cloud attenuation, dB

Frequency[GHz]/CDs[%]	1	5	10	20	30	50	70	80	90	95	99
31.800	0.000	0.000	0.000	0.000	0.000	0.004	0.079	0.241	0.762	1.401	2.451
32.050	0.000	0.000	0.000	0.000	0.000	0.004	0.080	0.244	0.773	1.421	2.486
32.300	0.000	0.000	0.000	0.000	0.000	0.004	0.081	0.247	0.784	1.441	2.521

5 Reference

[1] Deep Space Network Services Catalog, DSN No. 820-100, Rev, F

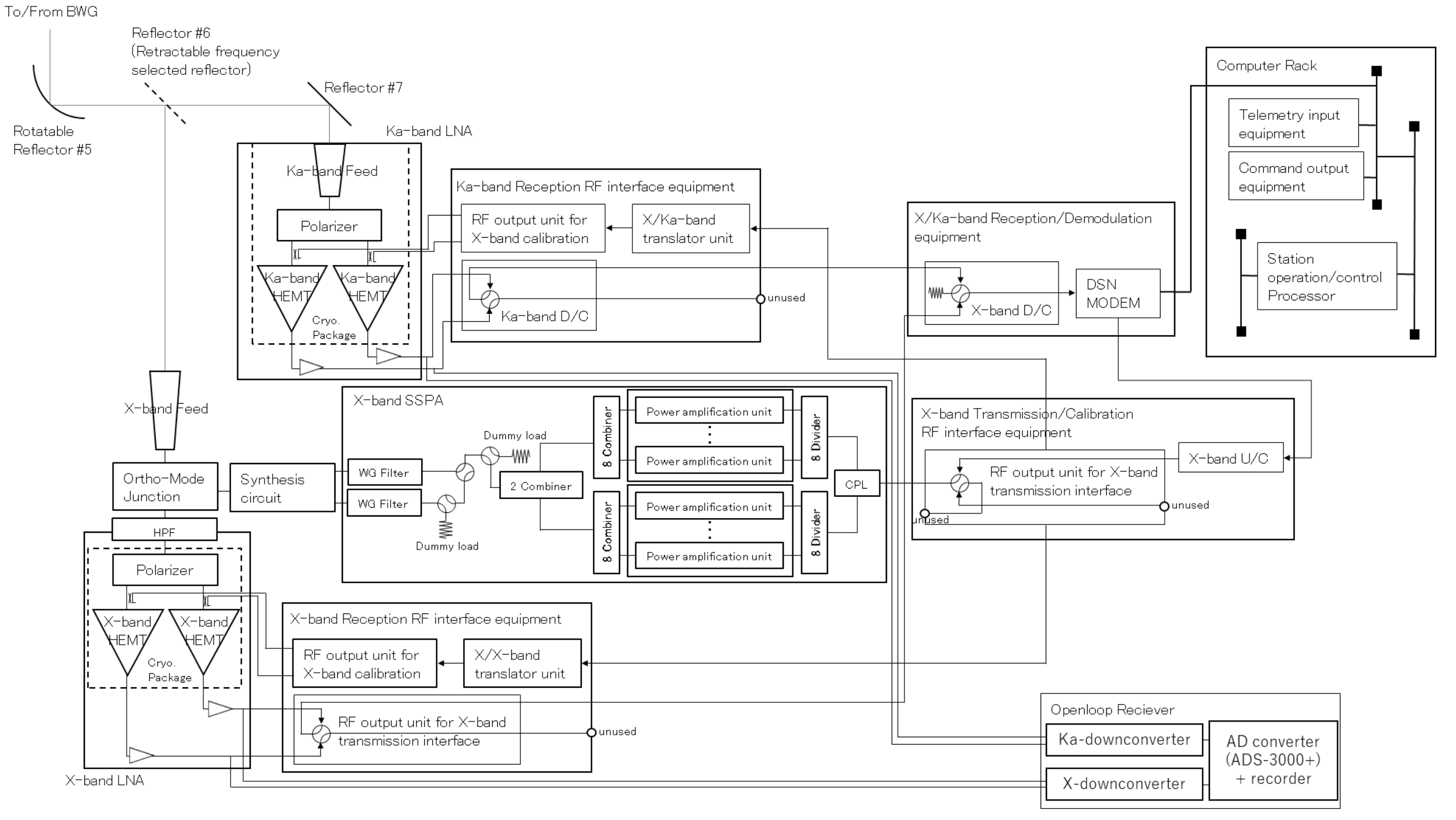
[2] Recommendation ITU-R P.618-13, Propagation data and prediction methods required for the design of Earth-space telecommunication systems, Sub-subsection 2.2.1.1.

[3] Recommendation ITU-R P.676-12, Attenuation by atmospheric gases and related effect, Section 2.2, Annex 2.

[4] Recommendation ITU-R P.840-8, Attenuation due to clouds and fog, Chapter 2 and 3

[5] Atmospheric and Environmental Effects, DSN No. 810-005, 105, Rev. E

6 Appendix A



To/From BWG
Reflector #6
(Retractable frequency
selected reflector)
Reflector #7
Rotatable
Reflector #5
Ka-band LNA
Ka-band Feed
Polarizer
Ka-band HEMT
Ka-band HEMT
Cryo. Package
Ka-band Reception RF interface equipment
RF output unit for X-band calibration
X/Ka-band translator unit
Ka-band D/C
unused
X/Ka-band Reception/Demodulation equipment
X-band D/C
DSN MODEM
Computer Rack
Telemetry input equipment
Command output equipment
Station operation/control Processor
X-band Feed
X-band SSPA
Dummy load
WG Filter
WG Filter
Dummy load
2 Combiner
8 Combiner
8 Combiner
Power amplification unit
Power amplification unit
Power amplification unit
Power amplification unit
8 Divider
8 Divider
CPL
X-band Transmission/Calibration RF interface equipment
X-band U/C
RF output unit for X-band transmission interface
unused
unused
Ortho-Mode Junction
Synthesis circuit
HPF
Polarizer
X-band HEMT
X-band HEMT
Cryo. Package
X-band LNA
X-band Reception RF interface equipment
RF output unit for X-band calibration
X/X-band translator unit
RF output unit for X-band transmission interface
unused
Openloop Reciever
Ka-downconverter
X-downconverter
AD converter (ADS-3000+) + recorder