

()
(2)

2001.

『

(; 2)』

.

2001.

: ()
:
()
()
()
()
()
()

1. : (2)
2. : 2000. 1. 1 - 12. 31
3. :
4. 가.

	1	2	3	4	5	6	7	8	9	10	11	12	
○													
- Single Entry (EPFD _{down} , EPFD _{up})	-----												
- Aggregate (EPFD _{down})	-----												
- WRC-2000 가 S/W					-----								
-		-----											
○ ITU-R													
- SG4 (WP4A, WP4-9S)		-----											
○													
- WRC-2000 (CEPT, CITELE)						-----							
- WP4A, WP4-9S	-----												
- APG, WRC	-----												
- APG e-mail correspondence group	-----												
	30			50			80			100			

1) ITU-R WRC-2000

o ITU-R Study Group 4 (Questions)

- ITU-R 3 (SG4) 1, 2

- (Recommendations)

o SG4 WP4A, WP4-9S WRC-2000

- WP4A (, 2)

- WP4-9S (, 9)

- WRC-2000 (3)

2) 가

o

가

- RR()

- (Single Entry

EPFD_{down}) 가

o (Aggregate

EPFD_{down})

3) WRC-2000

o S21 S22

가 /

o WRC-2000 RR(

) S9, S11

4) .

o . 가 ,

- APG-2000 4 (1) APG/WRC

- APG e-mail correspondence group

5.

1) ITU-R

- o SG 4
- 231 236 ,
- Doc 4A/210, 4A/254, 4A/422, 4A/465, 4A/515 (WP 4A)
- 135, 136 (WRC-2000) ITU-R Rec. S1323

2) ()

- o ITU BR
- , Ku carrier
- S22
- /
- S22
-

3) (non - GSO/FSS)

- (GSO/FSS)
- o EPFD
- o SG 4

4)

- o ITU-R WP 4A, APT WRC-2000
- WRC-2000 1.13.1
- (APG2000-4)
- 10.7 12.75GHz EPFD_{down}
- (WP 4A)
- WRC-2000 1.13.1 (WRC-2000)

o WRC-2000

-
- 130 538
- 10

5)

o 2000

- : non-GSO/FSS GSO/FSS
- : 2000. 11. 11,

o ()

- : WRC-2003
- : 2000. 10. 27,

6.

o 가

o

o

o 가

o 가

WRC (GSO) (non-GSO)
 Ku(14/11GHz) Ka(30/20GHz)

가 . , ,
 가 Ka Ku

Method Software) 가 DMS(Direct
 S.1323 가 ITU-R
 (non-GSO/FSS)

가 가가 10%

1 CPM-99 S22
 , CATV 가
 가가 10% ,
 , 2 EPFD
 , EPFD ,
 가 . 가 가가 10% ,

가 , Ku Ka
 , 가
 . , 가
 가

SUMMARY

The research is necessary about sharing between networks of the fixed-satellite service using non-geostationary satellites and other networks of the fixed-satellite service, interference criteria and calculation methods for the fixed-satellite service because WRC(World Radiocommunication Conference) in 1997 made a decision that the frequency bands 11/14GHz and 20/30GHz are also available to systems in the fixed-satellite service employing satellites in non-geostationary orbits. In this report, we have analyzed the interference effects from the non-geostationary satellite systems into our geostationary satellite networks.

The analysing tool DMS(Direct Method Software) developed by France was used for this analysis. This software followed the ITU-R Recommendation S.1323 and calculates the availability of geostationary orbit fixed satellite service network with/without non-geostationary fixed satellite services. The relative increase of unavailability of the geostationary systems due to the non-geostationary fixed satellite service is not allowed to exceed 10 percent.

We had analyzed the interference effect with limited values(EPFD limits) on the base of CPM-99 and article S.22 of Radio Regulation in the study of last year. More appropriate analysis is necessary because the increase of relative unavailability rate on CATV carrier was over the 10% criterion. In the study of this year, for the better analysis, we derived EPFD limits for the CATV carrier and assessed interference effects of Koreasat-1 with the derived limits. The result of relative increase of unavailability is to be near 10 percent, therefore, Koreasat-1 wouldn't have serious interference from non-geostationary orbit systems.

We have assessed interference effects with new limits derived in Ku band. Our study can be used to protect satellite communication networks of Korea in case that non-geostationary orbit systems' operation is begun afterward. Finally, we note that the derivation methodology of EPFD limits for the size of antenna to use should be studied more in various ways.

1	6
2	EPFD	7
1	A : EPFD	8
2	B : (Interpolation)	10
3	C : SCALING	11
4	D : CONSTANT I_o/N_o	15
5	E : 가	20
6	Ka	24
3	EPFD	30
1	CATV EPFDdown (3m)	30
2	CATV EPFDdown (3.7m)	33
4	36
	37

1

가
Bluetooth, IMT-2000
1990
가
(GSO/FSS) Ku Ka
SkyBridge (non-GSO) 가
non-GSO/FSS GSO/FSS
GSO/BSS 가
가 가 (WRC : World
Radiocommunication Conference)
WRC-2000 137 EPFD
(continuous curve) ITU-R
ITU-R WP 4A EPFD
ITU-R 5가 . 3 CATV
(single entry) EPFD(Equivalent Power Flux
Density) Ka
ITU-R(International Telecommunication Union-Radiocommunication) WP
(Working Party) 4A , 2 Ku
EPFD S22
(validation limits)
ITU-R WP4A
, 4

2 EPFD (Continuous Curves)

WRC-2000

10.7 12.75 GHz, 17.8 18.6 GHz, 19.7 20.2 GHz
가 (EPFD)

S22

(Guide)

EPFD (Continuous Curves)

EPFD

“

EPFD

”

5가

ITU-R WP 4A

- A : EPFD
(curves fitting procedure)
- B : (interpolation)
- C : Scaling
- D : Constant I_0/N_0
- E : 가

1 A : EPFD
(Curve Fitting Procedure)

1999 11 CPM(Conference Preparatory Meeting)

EPFD_{down} , S22

EPFD

EPFD_{down}

WP 4A

EPFD

1. 10.7 12.75GHz

$$EPFD_{down} = -179.77 - 19.16 \log D + \frac{15.114 + 4.794D}{1 + \exp \left[\frac{0.7042 + \log p + 0.159D}{1.948 - \frac{1}{0.5976 + (\log D - 0.263)^2}} \right]} \quad (2-1)$$

$$EPFD_{down} \leq EPFD_{0} = -160.0$$

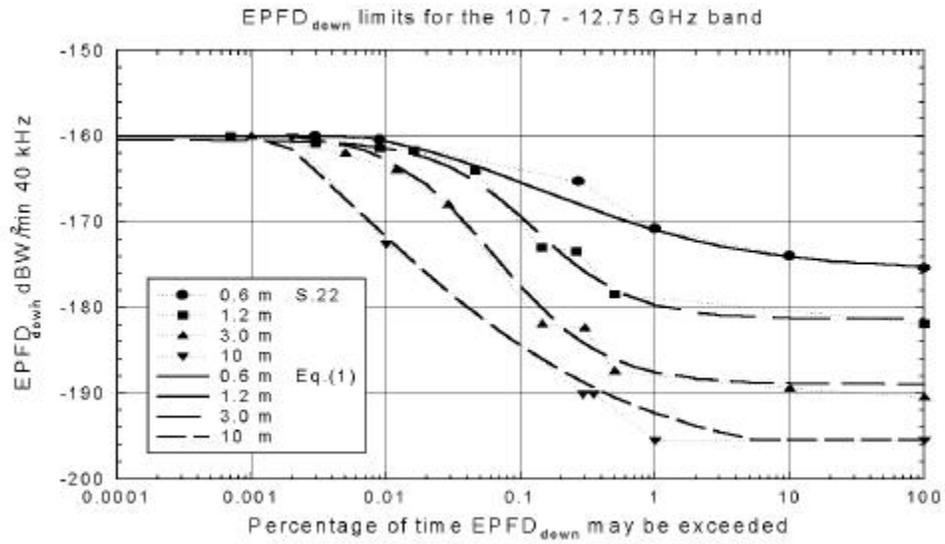
$$EPFD_{down} \geq EPFD_{100} = \begin{cases} -180.18 - 21.53 \log D & \text{for } D < 3.0 \text{ m} \\ -185.89 - 9.562 \log D & \text{for } D \geq 3.0 \text{ m} \end{cases}$$

p : EPFD_{down}

D : (m)

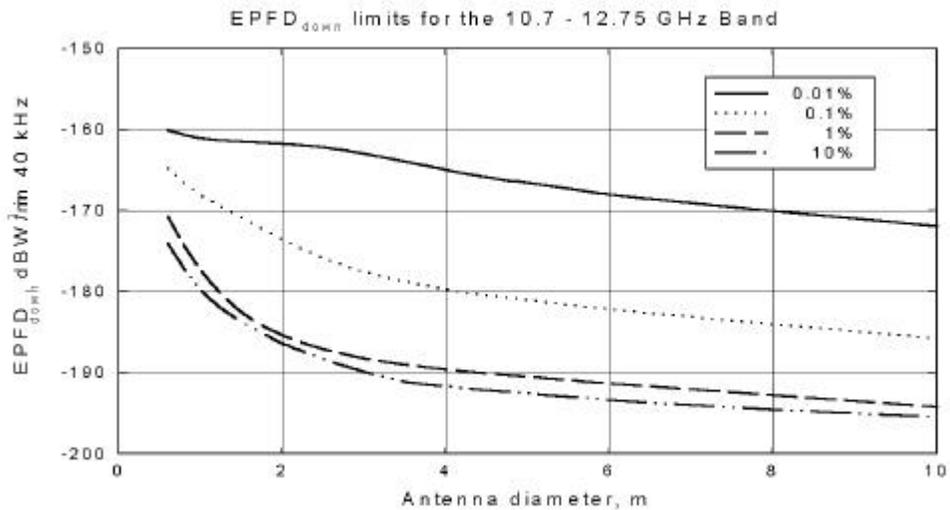
EPFD : EPFD_{down}

EPFD₀₀ : 100% EPFD_{down}



< 2-1> (2-1) .S22- 1A EPFDdown

< 2-1> S22- 1A (2-1)
 , S22- 1A (2-1) 1.2
 dB(W/m²) peak +3.2/-2.6 dB(W/m²) . < 2-2>
 0.6m 10m EPFDdown



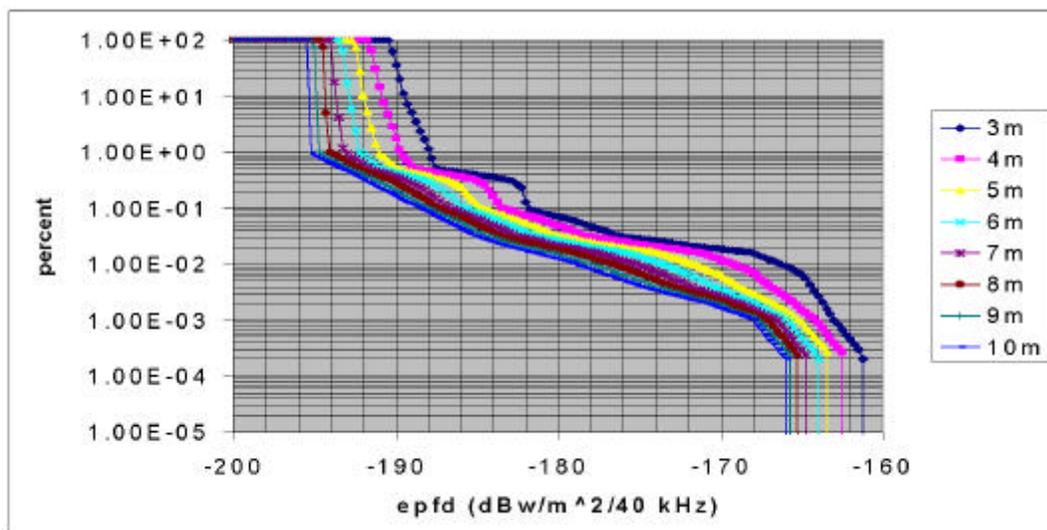
< 2-2> 0.01 10%
 EPFD [10.7 12.75GHz , (2-1)]

2 B : (Interpolation)

S22
 EPFD , EPFD
 , .
 , 1.0% 3m EPFD
 - 187.913dBW 10m - 189.714dBW 4m

$$\begin{aligned}
 \text{val} &= -187.913 + (\log 4 - \log 3) / (\log 10 - \log 3) * (-195.45 + 187.913) \\
 &= -187.913 + 0.2389 * (-7.537) \\
 &= -189.714
 \end{aligned}$$

Ku 3.7m
 network EPFD 3 2
 .(ITU-R WP 4A Doc.476).



3 C : SCALING

EPFD (power addition), (long-term)
 (time addition), (short-term)

- power addition : EPFD

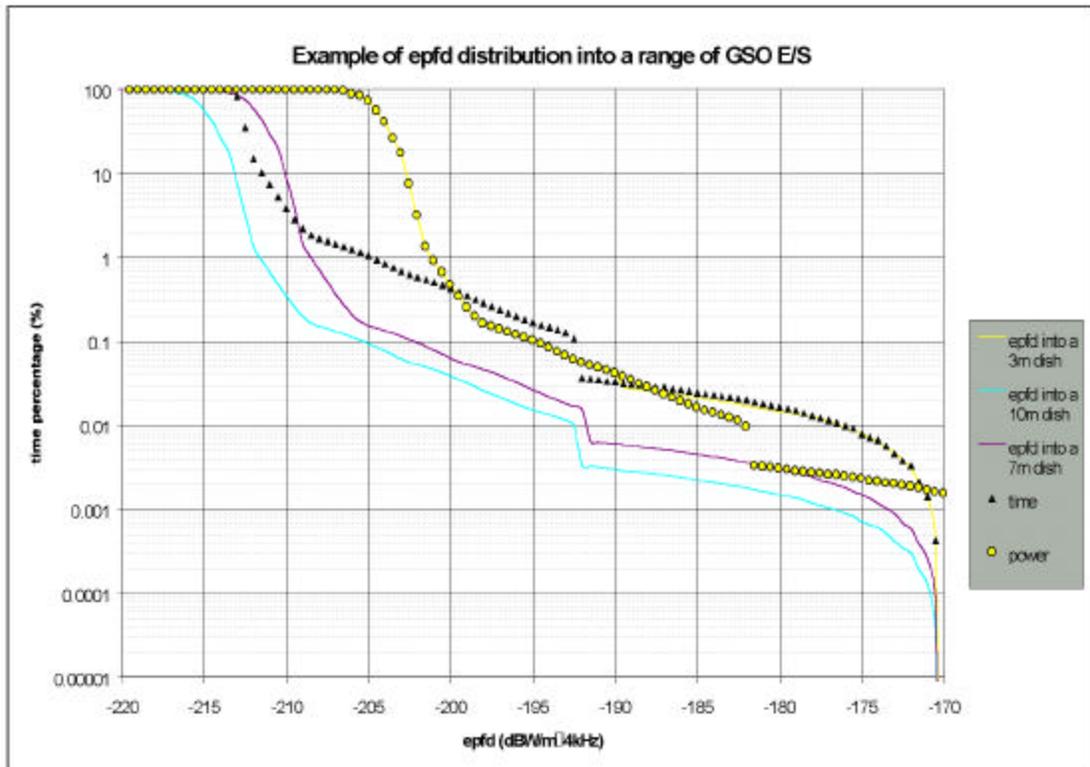
$$10 \cdot \log \left(\frac{D_{ref}}{D} \right)^2$$

- time addition : EPFD $(D_{ref}/D)^2$

scaling

EPFD

EPFD



< 2-4 >

(GSO)

EPFD

10m

7m

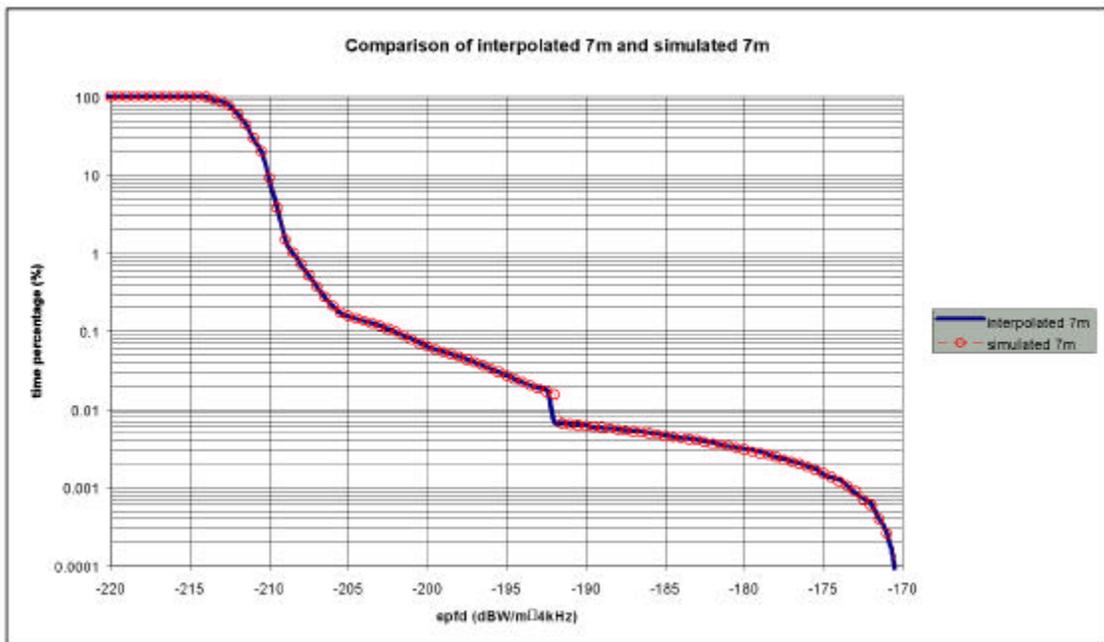
, < 2-4>

0.1%

7m

< 2-4>

3m



< 2-5> 7m

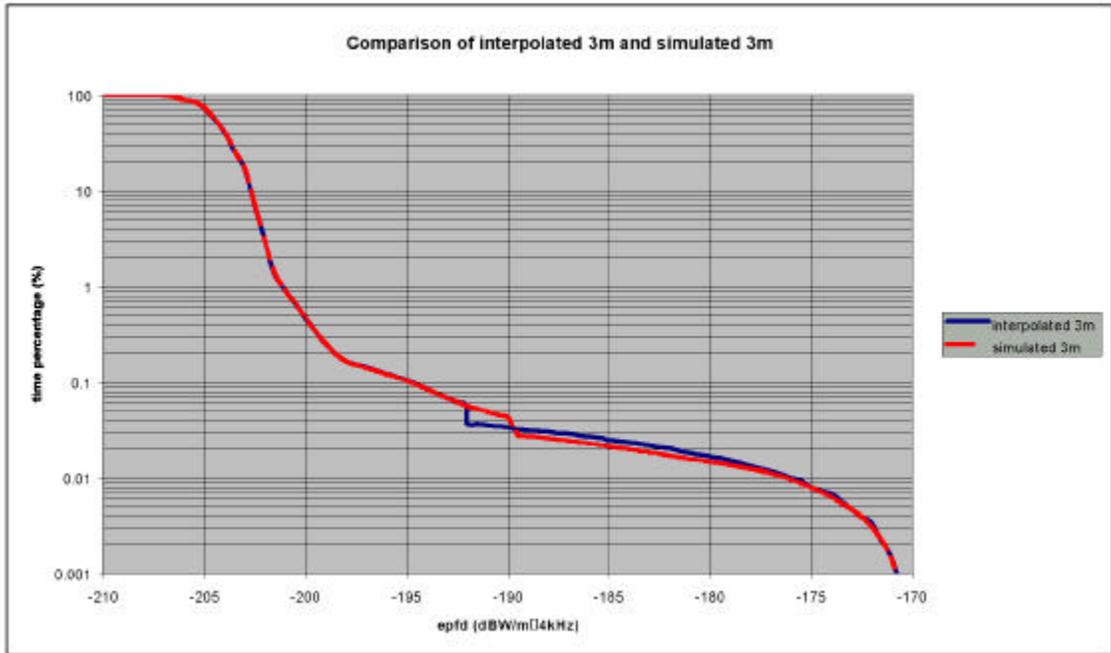
EPFD

< 2-5>, < 2-6>, < 2-7> < 2-4>

7m, 3m,

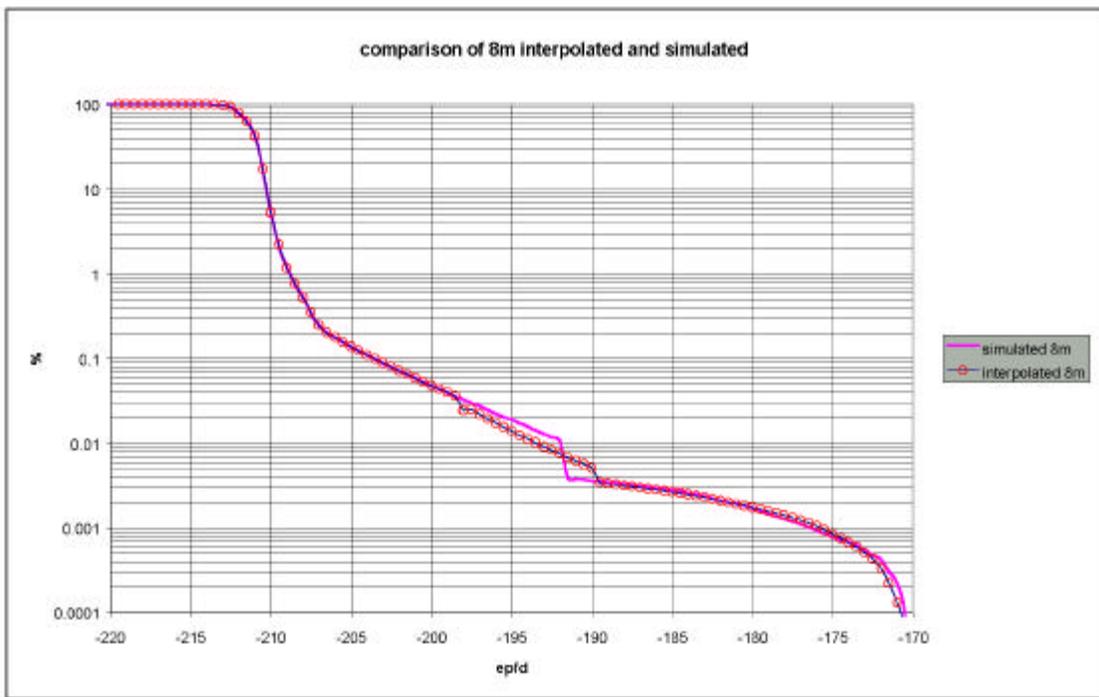
8m

EPFD



< 2-6 > 3m

EPFD



< 2-7 > 8m

EPFD

EPFD

CR-116 link budgets . , GSO
non-GSO EPFD GSO

가 EPFD .

EPFD 가 , EPFD 가
EPFD (envelope) ,
EPFD .

4 D : I_o/N_o (Constant I_o/N_o)

I_o/N_o () EPFD_{down}
 GSO EPFD_{down} I_o/N_o
 . non-GSO (main beam)
 GSO (side lobe) ,
 가 I_o/N_o
 GSO .

1. (Long - term) (mechanism)

4가 .
 - non-GSO GSO
 ()
 non-GSO
 ,
 . 4가 2가 .

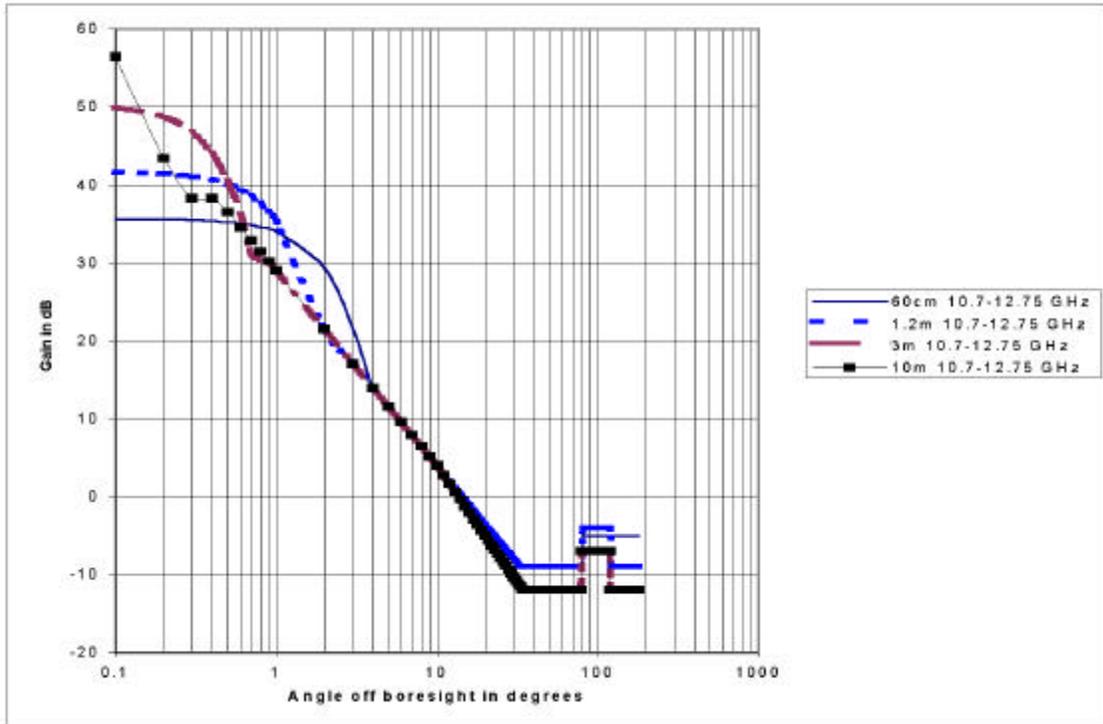
2. GSO

EPFD 10.7GHz 30GHz FSS
 DNR ITU-R S.1428 , <
 2-9> Off bore-sight angle
 . 4° 10°
 . 10° (side lobe)
 가 . D/λ가 100 , .(
 60cm D/λ 100 , 3, 10m D/λ 100
 .) non-GSO 4° ,
 (, Io) GSO

Io/No

가

$$\frac{C}{N+I} = \frac{C}{N(1 + \frac{I_o}{N_o})}$$



< 2-9> ITU-R S.1428 FSS

Ku non-GSO GSO arc avoidance

4° . < 2-1> Ku non-GSO

. USAKU-M1 USAKU-H2 ,

< 2-1> non-GSO

F-SAT-MULTI1B	10°
USAKU-M1	15°
USAKU-M3	10°
USAKU-H2	40°
USAKU-H1	44.8°

3. (Long-term) EPFD_{down}

$$EPFD_{down} = \frac{I_o \cdot BW_{ref}}{A_e} \quad (2-2)$$

I_o :

BW_{ref} :

A_e : GSO

$$A_e = \frac{G \cdot \lambda^2}{4 \pi} \quad (2-3)$$

G : peak

:

$$G_{max} = 5.89 \cdot \left(\frac{D}{\lambda}\right)^2, \frac{D}{\lambda} < 100 \quad (2-4)$$

$$G_{max} = 6.92 \cdot \left(\frac{D}{\lambda}\right)^2, \frac{D}{\lambda} > 100 \quad (2-5)$$

$$\frac{C}{N+I} = \frac{C}{N \cdot \left(1 + \frac{I_o}{N_o}\right)} \quad (2-6)$$

C :

I :

N_o :

$$N_o = k \cdot T_{sys} \quad (2-7)$$

T_{sys} : GSO

k :

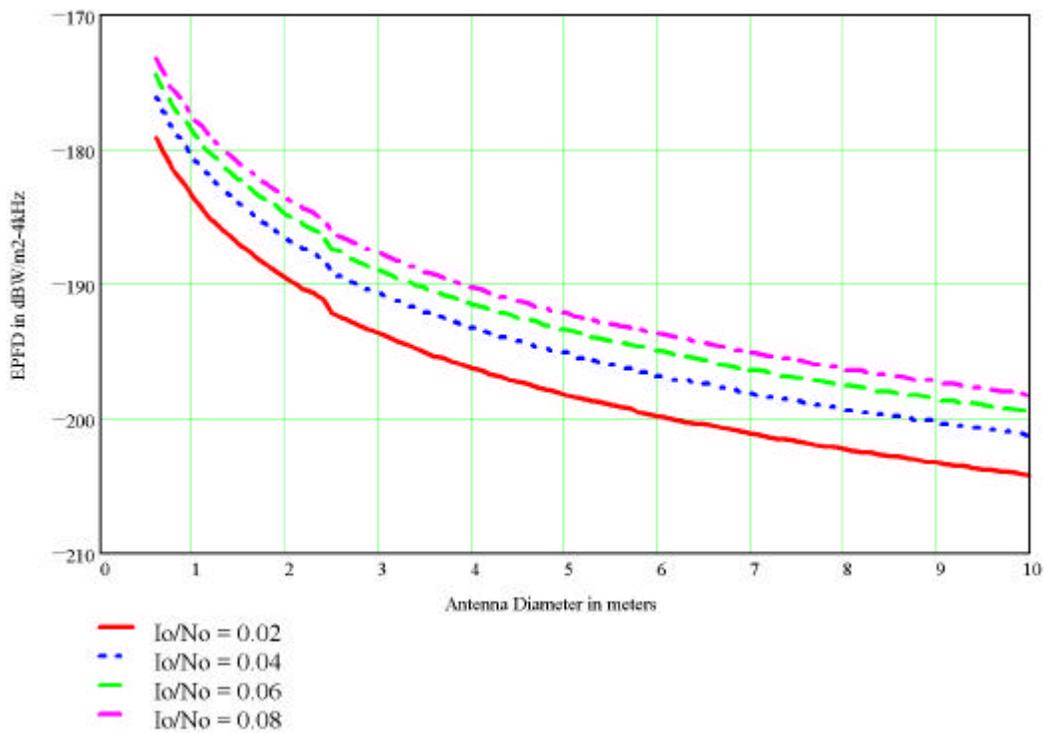
$$I_o = \frac{I_o}{N_o} \cdot k \cdot T_{sys} \quad (2-8)$$

$$EPFD_{down} = 4\pi \cdot \frac{I_o}{N_o} \cdot kT_{sys} \cdot \frac{BW_{ref}}{5.89 \cdot D^2} \cdot \frac{D}{\lambda} < 100 \quad (2-9)$$

$$EPFD_{down} = 4\pi \cdot \frac{I_o}{N_o} \cdot kT_{sys} \cdot \frac{BW_{ref}}{6.92 \cdot D^2} \cdot \frac{D}{\lambda} > 100 \quad (2-10)$$

$$\frac{I_o}{N_o} = \frac{EPFD_{down} \cdot 5.89 \cdot D^2}{4\pi kT_{sys} \cdot BW_{ref}} \text{ for } \frac{D}{\lambda} < 100 \quad (2-11)$$

$$\frac{I_o}{N_o} = \frac{EPFD_{down} \cdot 6.92 \cdot D^2}{4\pi kT_{sys} \cdot BW_{ref}} \text{ for } \frac{D}{\lambda} > 100 \quad (2-12)$$



< 2-10>

EPFD_{down}

< 2-10> I_o/N_o

EPFD

$\cdot I_o/N_o \cdot \lambda$

EPFD_{down}

, I_o/N_o

5 E : 가

10 12GHz S22 가 2.5 °

1.

가. EPFD

ITU-R EPFD single entry

S22 S22- 1A 3m

(Guide) 2006

3m

[- 160dB (W/m²)per 40kHz] , < 2-2> < 2- 11>

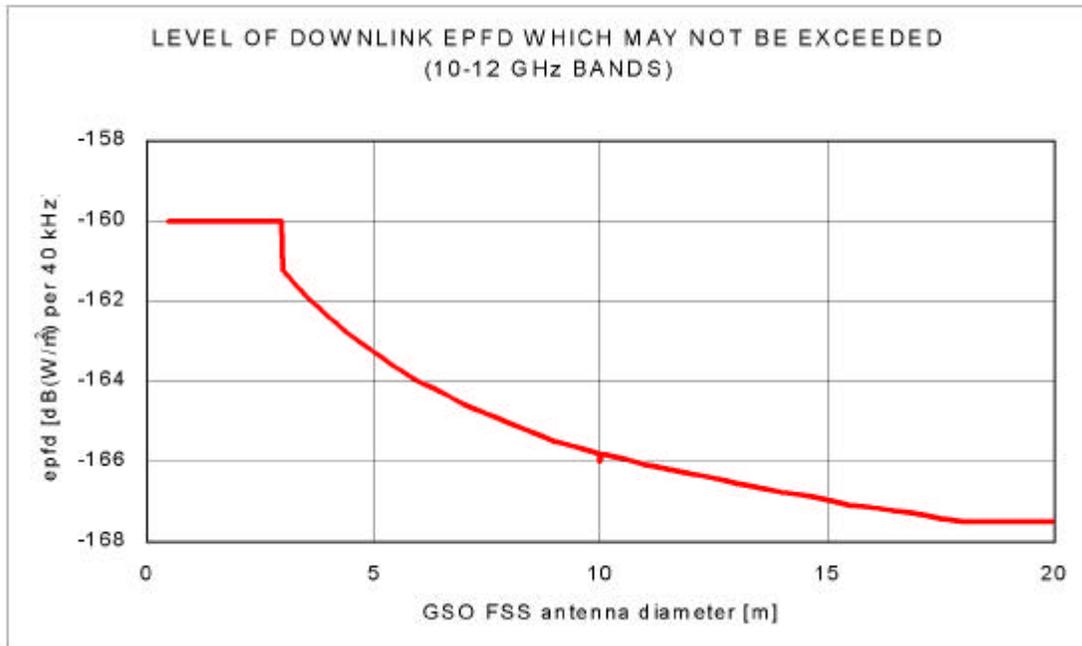
< 2-2> EPFDdown

(m)	EPFDmax (dB (W/m ²)per 40kHz)
<3m	- 160
3m	- 161.25
6m	- 164
9m	- 165.5

< 2-2>

EPFDdown (decibels) scale

(meters) scale
 10m EPFDmax S22-4A 1
 [- 166dB (W/m²) per 40kHz]



< 2- 11> 10 12GHz EPFDdown

EPFD

ITU-R

GSO/FSS

EPFD

. 10 12GHz

GSO/FSS

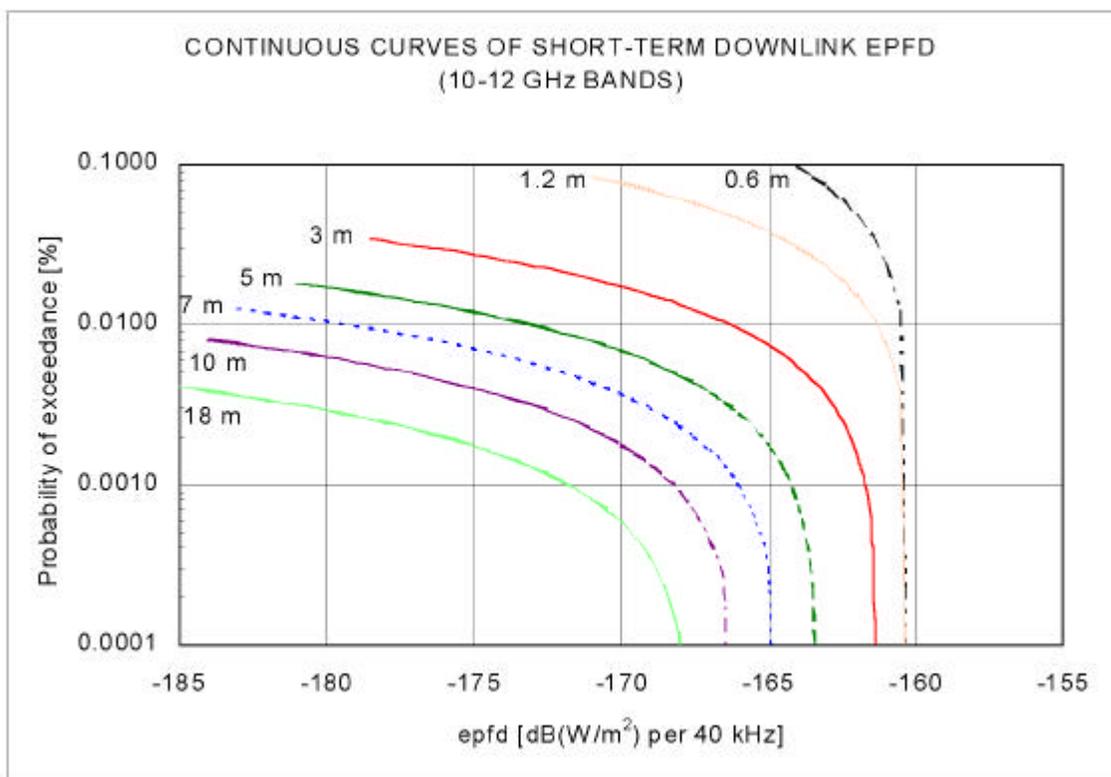
$$P=(0.045+0.027*D)*(EPFD_{max} - EPFD)/(7*D^2)$$

P = EPFD

EPFD_{max} = EPFD

D = GSO/FSS

S22 EPFD 가 < 2-12> . < 2-3>
(Spot Value) (Set)



< 2-12> EPFD (10 12GHz)

< 2-3>

S22

epfd[dB(W/m ²) per40kHz]	(%) (epfd가)	(%)	GSO (m)
- 175.40	0.0000	-	0.6
- 174.00	90.0000	-	
- 170.80	99.0000	-	
- 165.30	99.7300	99.871	Note 1
- 160.40	99.9910	99.990	
- 160.00	99.9970	-	
- 160.00	100.000	-	
- 181.90	0.0000	-	1.2
- 178.40	99.5000	-	
- 173.40	99.7400	-	
- 173.00	99.8570	-	
- 164.00	99.9540	99.969	
- 161.60	99.9840	99.988	Note 1
- 161.40	99.9910	99.989	
- 160.80	99.9970	99.994	
- 160.50	99.9970	99.996	
- 160.00	99.9993	-	
- 160.00	100.0000	-	
- 182.00	99.9000	-	3
- 179.00	99.9400	-	
- 176.00	99.9700	99.971	
- 171.00	99.9800	99.981	
- 168.00	99.9840	99.987	Note 2
- 165.00	99.9930	99.993	
- 163.00	99.9990	99.997	
- 161.25	99.9998	-	
- 161.25	100.0000	-	
- 185.00	99.9700	-	10
- 183.00	99.9800	99.992	
- 179.00	99.9900	99.994	
- 175.00	99.9960	99.996	Note 2
- 171.00	99.9980	99.998	
- 168.00	99.9990	99.999	
- 166.00	99.9998	-	
- 166.00	100.0000	-	

Note 1 : S22- 1A

Note 2 : S22- 4A1 가

2.

ITU-R non-GSO Power
 Addition . GSO/FSS
 non-GSO/FSS

6%

6 Ka

1. A Ka

가. 17.8 18.6GHz

$$EPFD_{down} = -175.44 - 7.763 \log D - 8.681(\log D)^2 + \frac{6.727 + 4.956D - 0.404D^2}{1 + \exp \left[-\frac{\log p + 0.2773 + 3.242 \log D - 2.49(\log D)^2}{0.028 \log D - 0.00737(\log D)^2 - 0.2944} \right]} \quad (2-13)$$

$$EPFD_{down} \leq EPFD_0 = -164.0$$

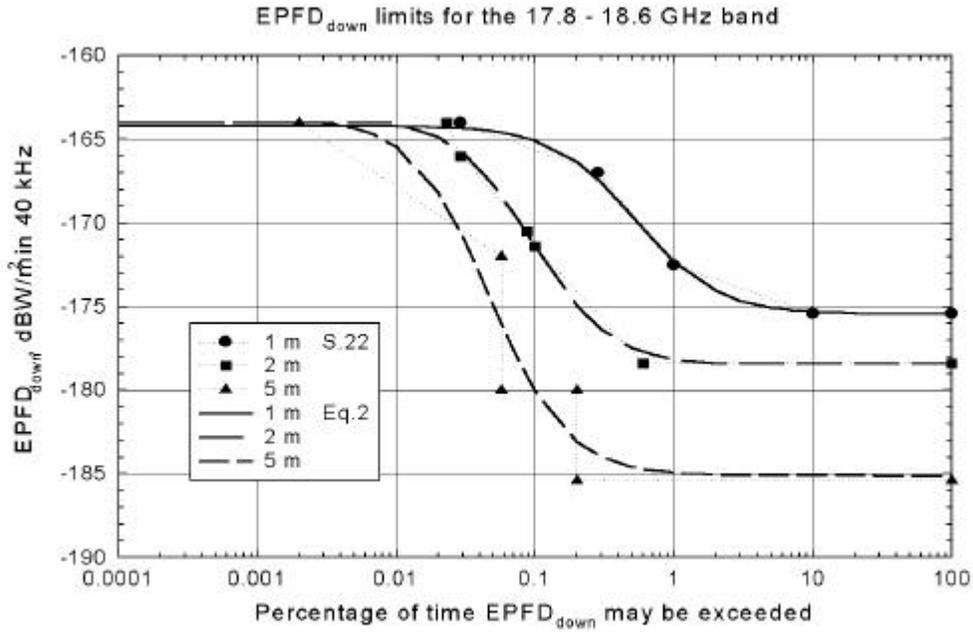
$$EPFD_{down} \geq EPFD_{100} = -175.4 - 6.682 \log D - 10.91(\log D)^2$$

p : EPFD_{down}

D : (m)

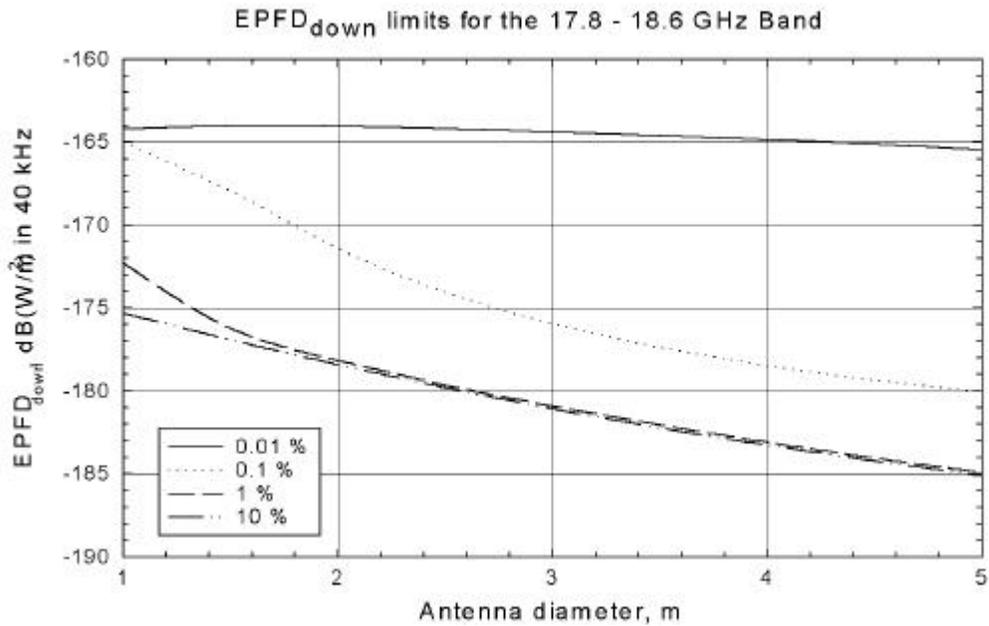
EPFD : EPFD_{down}

EPFD₀₀ : 100% EPFD_{down}



< 2- 13> 17.8 18.6GHz EPFD

(2- 13) < 2- 14> , < 2- 13>
 S22- 1B (2- 13) ,
 S22- 1B (2- 13) 1.3 dB(W/m²) peak
 4dB(W/m²) .



< 2- 14> 17.8 18.6GHz EPFD

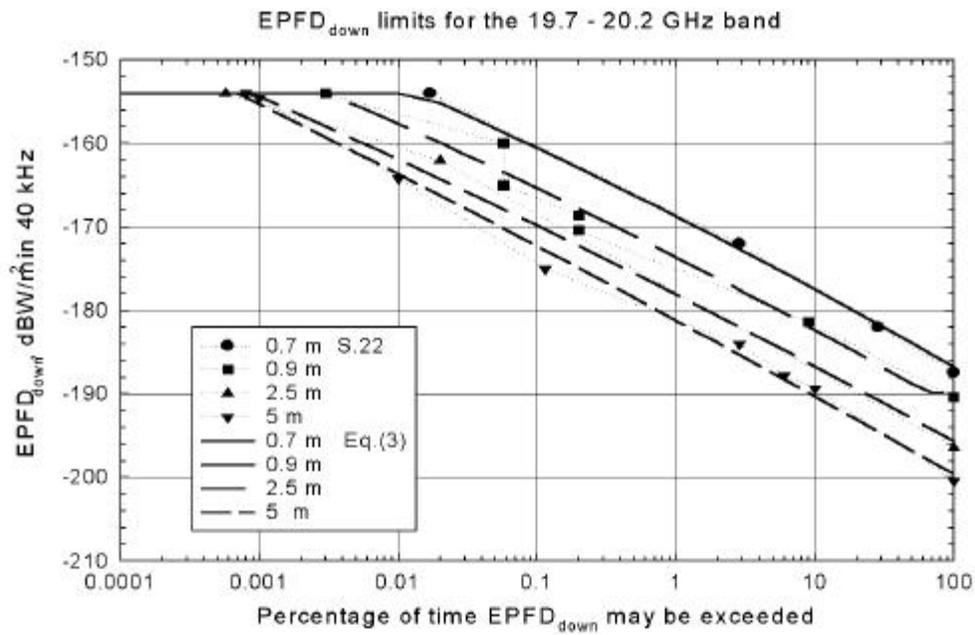
. 19.7 - 20.2GHz

$$EPFD_{down} = -777.7 + 27.19D + \frac{69665 - 7.48D}{1 + \exp\left[\frac{\log p - 17.639 - 0.8684D + 0.3603D^2}{11.2 + 6.0473 \log D}\right]} \quad (2-14)$$

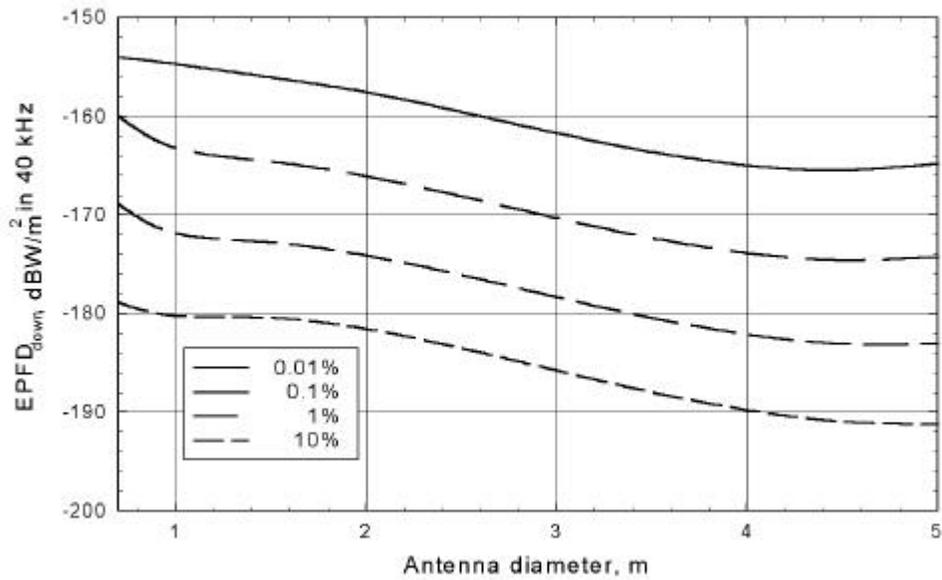
$$EPFD_{down} \leq EPFD_0 = -154.0$$

$$EPFD_{down} \geq EPFD_{100} = -190.6 - 17.22 \log D + 4.809(\log D)^2$$

p : $EPFD_{down}$
 D : (m)
 $EPFD$: $EPFD_{down}$
 $EPFD_{00}$: 100% $EPFD_{down}$



EPFD_{down} limits in the 19.7 - 20.2 GHz band



< 2- 16> 19.7 20.2GHz

EPFD

(2- 14)

< 2- 16> , < 2- 15>

S22- 1B (2- 14)

,

S22- 1B (2- 14)

1.1 dB(W/m²) peak

+2.6/- 3.4dB(W/m²) .

2.

	S22- 1B	S22- 1C	EPFDdown
40kHz	1000kHz	.	(2- 1), (2- 13), (2- 14)
	40kHz	.	1000kHz
	14dB	.	

$$10\log (1000/40)=14\text{ dB}$$

3. Ka

Ka 가 . E . 19.7
20.2GHz Peak EPFD Ka

(probabilities) , EPFD e.i.r.p.
(Traffic pattern) .
EPFD (shift) ,

Ka .

$$P = K(EPFD_{max} - EPFD) / D^2$$

17.8 18.6 GHz

$$K=0.0490$$

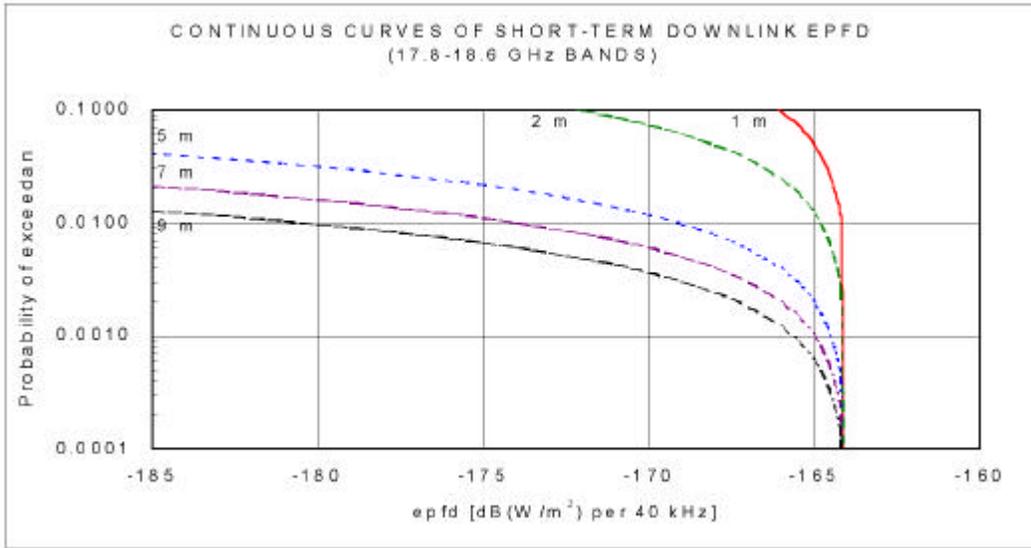
19.7 20.2 GHz

$$K=0.0045$$

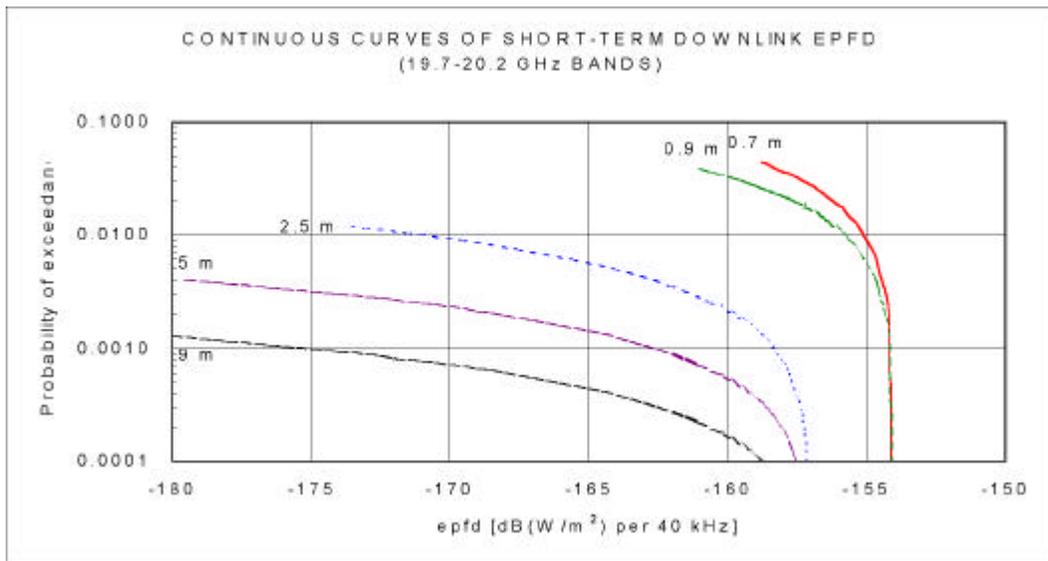
EPFD_{max} = -154dB (W/m² per 40kHz) 1.6m

EPFD_{max} = -157dB (W/m² per 40kHz) 1.6m

Ka EPFD .



< 2- 17> Ka EPFD



< 2- 18> Ka EPFD

WP 4A EPFD

가

EPFDup

, 2.5°

가 6

0°

가

가

가

Scaling , Ka

3

EPFD

Ku (KOREASAT - 1)
 가 KOREASAT - 1
 (carriers) , (70cm), TVRO(1.8m, #256), CATV(3.7m, #257), VSAT (3.7m, #258) E- 1(6.1m, #259)
 ITU-R S.1323 procedure D DMS
 . 가 EPFDdown
 (validation limits) S22 (WRC-2000) 60cm, 1.2m
 3m , 가
 (70cm 60cm, 1.8m 1.2m, 3.7/6m 3m)
 . CATV (3.7m)
 ITU-R S.1323 10% (가 가)
 . S22 3.7m
 CATV .

1 CATV EPFDdown (3m)

CATV 가 10% EPFDdown
 (Validation limits) EPFDdown (operational
 limits) 4가 .
 1) S22
 2) 100% 2005.12.31
 3) 100% 2005.12.31
 4) 2005. 12. 31 가 (additional operational limits)

< 3- 1> 10.7 12.75GHz 3m EPFDdown

+2005.12.31. [2]		+2005.12.31. 가 [4]	
EPFDdown (dB(W/m ² /40kHz))	(EPFD _{down})	EPFDdown (dB(W/m ² /40kHz))	(EPFD _{down})
- 190.45	0	- 190.45	0
- 189.45	90	- 189.45	90
- 187.45	99.5	- 187.45	99.5
- 182.4	99.7	- 182.4	99.7
- 182	99.855	- 182	99.855
- 168	99.971	- 182	99.9
- 164	99.988	- 179	99.94
- 162	99.995	- 176	99.97
- 161.25	99.999	- 171	99.98
- 161.25	100	- 168	99.984
		- 165	99.993
		- 163	99.999
		- 161.25	99.99975
		- 161.25	100

< 3- 2> 3m 4가 EPFDdown
 가 , CATV (3.7m) DMS
 가 가(relative increase of unavailability)가 17.56^{*1}, 14.50,
 17.56, 9.29% 4) 10%
 . 1) 2) 3% 가
 , 1) 3) 가 , 가
 4) 10% .

^{*1} 가 가가 15.01% 가
 e.i.r.p 1 43.08dBW , 2 39.2dBW

S.22

3.7m

3m

EPFDdown

< 3-2*2 > 3m

EPFDdown

CATV

EPFDdown %	1) (Validation on limits)	2) + Validation limits with the operational limit (2005.12.31)	3) + Validation limits with the operational limit (2005.12.31)	4) (Validation limits)+ 가 (Additional operational limit)*3
가 (Calculated availability without non-GSO)	99.90805	99.90805	99.90805	99.90805
가 (Calculated availability with non-GSO using the limits in Radio Regulation)	99.8919	99.89472	99.8919	99.89951
가 가 (Calculated relative increase of unavailability)	17.56	14.50	17.56	9.29

*2

51.8 dBi

*3

EPFDdown 가

2 CATV EPFD_{down} (3.7m)

가 , 3.7m

EPFD_{down} S.22 3m

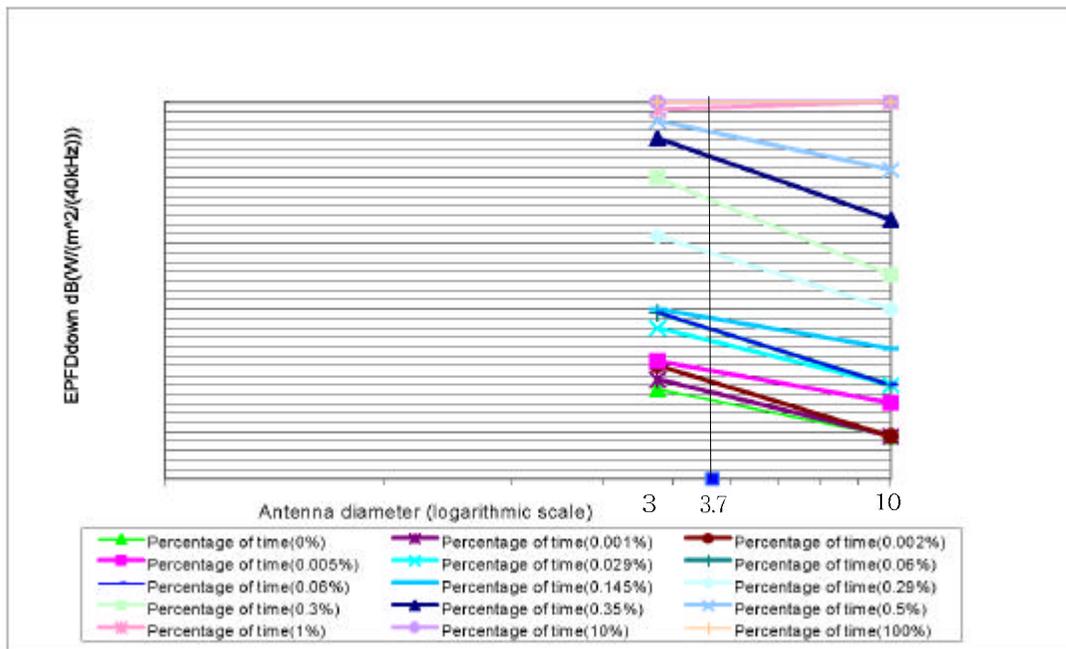
10m < 3- 1>

EPFD_{down} (dB) (linear) , (m)

(logarithmic) 3m 10m (linear

interpolation) 3.7m EPFD_{down} <

3- 3>

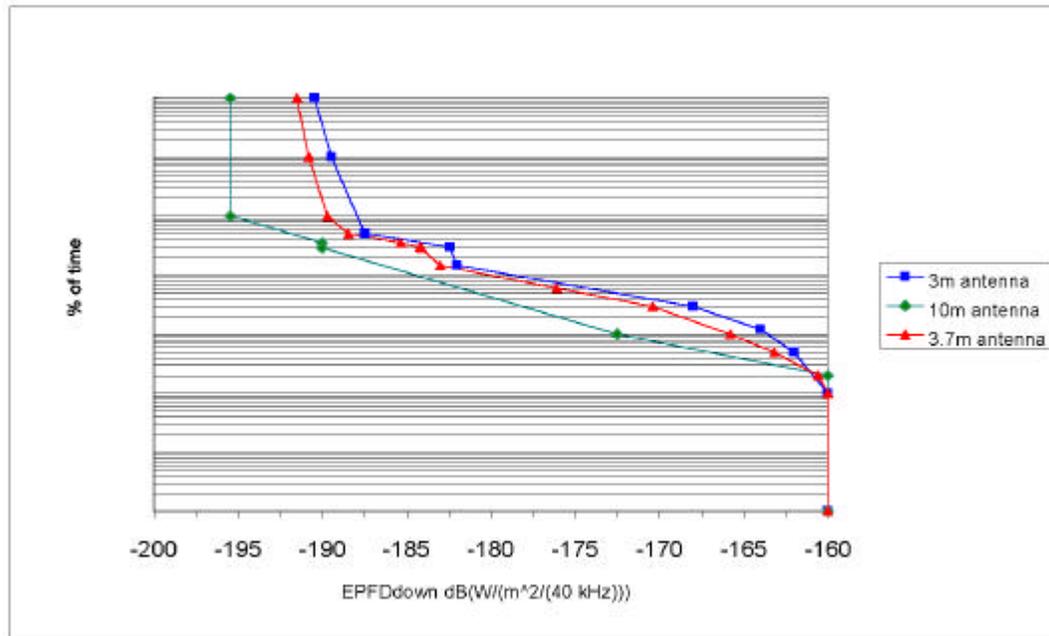


< 3- 1> 3m 10m EPFD_{down} 3.7m EPFD_{down}

< 3-3> 3.7m

EPFD_{down}

	3m	10m	3.7m
	EPFD _{down} (dB(W/m ² /40kHz))	EPFD _{down} (dB(W/m ² /40kHz))	EPFD _{down} (dB(W/m ² /40kHz))
0	- 190.45	- 195.45	- 191.5
90	- 189.45	- 195.45	- 190.8
99	- 188	- 195.45	- 189.7
99.5	- 187.45	- 191.95	- 188.45
99.65	- 184	- 190	- 185.35
99.7	- 182.4	- 190	- 184.2
99.71	- 182.3	- 190	- 184.1
99.855	- 182	- 186.2	- 183
99.94	- 174.25	- 181.95	- 176.1
99.971	- 168	- 178.35	- 170.4
99.99	- 163.8	- 172.5	- 165.8
99.995	- 162	- 167.15	- 163.2
99.998	- 160.8	- 160	- 160.6
99.999	- 160	- 160	- 160
100	- 160	- 160	- 160



< 3-2> 3.7m

Single entry

< 3-2> < 3-3>

< 3-4>

3.7m

EPFD

CATV

EPFDdown %	1)	2) + (2005.12.31)	3) + (2005.12.31)
가	99.90805	99.90805	99.90805
가	99.89609	99.90104	99.89618
가 가	13.00	7.62	12.91

< 3-4>

3.7m

EPFDdown

가

가

가

3m

EPFDdown

ITU-R S.1323 (10%)

GSO FSS

non-GSO

(WRC-97

130, 131 538)

non-GSO

GSO

가

non-GSO

GSO

, GSO

EPFDdown

가

EPFDdown

4

가

Ku

(KOREASAT - 1)

가

S22

EPFD

ITU

EPFD

ITU-R

가

5가

EPFDdown

ITU-R WP 4A

/

Ka

EPFD

non-GSO

가

;

- [1] , " [. " (P.219 257)],1999
- [2] , "2000 (WRC- 2000)
", 1999.12
- [3] , "ITU-R "(2000, 4)
- [4] , "2000 "
- [5] , "2000 (上)(P.665 668)", 2000.11
- [6] Recommendation ITU-R S.1323, Maximum permissible levels of interferece in a satellite network(GSO/FSS; non-GSO/FSS; non-GSO/MSS feeder links) for a hypothetical reference digital path in the fixed satellite service caused by other codirectional networks below 30 GHz
- [7] Contribution ITU-R WP 4A/254, Methodology to derive continuous curves of long-term epfd limits as a fuction of antenna size
- [8] Contribution ITU-R WP 4A/465, Continuous curves of EPFD_{down} versus GSO FSS earth station antenna diameter
- [9] Contribution ITU-R WP 4A/476, Review of EPFD_{down} limits in the bands 10.7- 12.75 GHz
- [10] Contribution ITU-R WP 4A/494, A method for accessing iterference levels from non-GSO FSS systems into GSO FSS antenna sizes between 3 and 10 meters
- [11] Contribution ITU-R WP 4A/515, Interpolation of epfd limits to other antenna diameters
- [12] Contribution ITU-R WP 4A/63, Methodology to derive continuous curves of EPFD versus GSO FSS antenna diameter