



EXERCISE 1

- Downlink
- Interference from Digital (narrow) to Digital(wide)
- Wanted
 - THAICOM-AK2 (78.5°E)
 - Group ID : 96604139
 - Emission : 27M0G1W
- Interfering
 - INTERSPUTNIK-75E-Q(75°E)
 - Group ID : 105625699
 - Emission : 45K0G1X



Exercise 1

Interference from Digital narrow to Digital wide

Wanted

C

THAICOM-AK2 (78.5E)

I

Longitudinal Tolerance

0.1

Interfering

INTERSPUTNIK-75E-Q (75E)

Longitudinal Tolerance

0.1

DOWNLINK

Beam	TK1
Group ID	96604139
Emission	27M0G1W
Wanted E/S long	106.86
Wanted E/S Lat	18.85
Topocentric angle	3.73
Wanted E/s sidelobe pattern	A-25log() A=29
Frequency (MHZ)	12585

Interfering	002
Group ID	105625699
Emission	45K0G1X

	Carrier
Ps	
Gs	
ES relative to wanted beam peak	-4
FSL	-205.82
Ges	
BW(Hz)	
Tes	

	Interference
Ps	
Gs	
ES relative to interfering beam peak	-1.58
FSL	-205.87
Wanted Ges()	
BW(Hz)	45000

Carrier	
Noise	
C/N	
C/I basic	
adj factor	
C/I adj	
C/I req'd	
Margin	
to add 1.87	

Interference

$N=kTB$

After taking into consideration adjustment factor or multiple carriers

$C/N+12.2$

Sect B3 ROP Attachment2 para5

DOWNLINK		Wanted	Interfering
Beam	TK1	Slide 6	002 Slide 7
Group ID	96604139	Slide 6	105625699 Slide 7
Emission	27M0G1W	Slide 6	45K0G1X Slide 7
Wanted E/S long	106.86	Slide 8	
Wanted E/S Lat	18.85	Slide 8	
Topocentric angle	3.73	Slide 5	
Wanted E/s sidelobe pattern	A-25log()	Slide 6	
Frequency (MHZ)	12585	Slide 6	
	Carrier		Interference
Ps	15.1	Slide 6	-16.6 Slide 7
Gs	38.9	Slide 6	37 Slide 7
ES relative to wanted beam peak	-4	Slide 10&11	ES relative to interfering beam peak -1.58 Slide 10&11
FSL	-205.82	Slide 13&14	FSL -205.82 Slide 13&14
Ges	40	Slide 6	Wanted Ges() 14.71 Slide 6
BW(Hz)	27000000	Slide 6	BW(Hz) 45000
Tes	200	Slide 6	

A=29

Emission	27M0G1W	Slide 17	Slide 18	45K0G1X	Slide 7
Wanted E/S long	106.86	Slide 8			
Wanted E/S Lat	18.85	Slide 8			
Topocentric angle	3.73	Slide 5			
Wanted E/s sidelobe pattern	A-25log()	Slide 6	A=29		
Frequency (MHZ)	12585	Slide 6			
	Carrier			Interference	
Ps	15.1	Slide 6	Ps	-16.6	Slide 7
Gs	38.9	Slide 6	Gs	37	Slide 7
ES relative to wanted beam peak	-4	Slide 10&11	ES relative to interfering beam peak	-1.58	Slide 10&11
FSL	-205.82	Slide 13&14	FSL	-205.87	Slide 13&14
Ges	40	Slide 6	Wanted Ges()	14.71	Slide 6
BW(Hz)	27000000	Slide 6	BW(Hz)	45000	
Tes	200	Slide 6			

Carrier	-115.82	Slide 15&16	Interference	-172.34	Slide 15&16
Noise	-131.28	Slide 15&16			
C/N	15.46	Slide 15&16			
C/I basic	56.52	Slide 19&20			
adj factor	27.78	Slide 21-24			
C/I adj	28.74				
C/I req'd	27.66	Slide 25	C/N+12.2		
Margin to add 1.87	2.96	Slide 26			Solution
		Slide 29	Sect B3 ROP Attachment2 para5		

N=kTB

After taking into consideration adjustment factor or multiple carriers



Topocentric Angular Separat Between Two Satellites

(Annex I of AP8)

$$\theta_t = \arccos \left[\frac{d_1^2 + d_2^2 - (84332 \sin(\theta_g/2))^2}{2d_1 \cdot d_2} \right]$$

Where

d1 and d2 are the distances (km),
from earth station to the two
satellites separately

θg is the geocentric angular
separation in degrees between
the two satellites, taking the
longitudinal station-keeping
tolerances into account

Wanted

THAICOM-AK2 (96500002)

B1a/BR17 Beam designation		TK1	B1b Steerable			B2 Emi-Rcp		E	B3a1 Max. co-polar gain		38.9	B3d Pointing accuracy		0.	
BR7a/BR7b Group id		96604139	BR1 Date of receipt		08.01.1996	C2c RR No. 4.4									
A2a Date of bringing into use		17.12.1993	A2b Period of valid.		35	A3a Op. agency		1	A3b Adm. resp.		A	BR16 Value of type C8b			
BR62 Expiry date for bringing into use		06.08.2000	BR63 Confirmed date of bringing into use		17.12.1993	BR64 Date of receipt of 1st Res49									
BR14 Special Section															
C4a Class of station		EC	C3a Assigned freq. band		54000										
C4b Nature of service		CP	C6a Polarization type			C6b Polarization angle									
C8d1 Max. tot. peak pwr.			C8d2 Contiguous bandwidth												
C11a1 Service area no.		1	C11a2 Service area			C11a3 Service area diagram									
A5/A6 Coordinations/Agreements		RR1060	O	G	TON	URS	USA	USA/IT							
C2a1 Assigned frequency															
12.5949	GHz	12.6575	GHz	12.7201	GHz										
A13 Ref. to Special Sections		C7a Design of emission		C8a1/C8b1 Max. peak pwr		C8a2/C8b2 Max. pwr dens.		C8c1 Min. peak pwr	C8c2 Atch.	C8c3 Min. pwr dens.	C8c4 Atch.	C8e1 C/N ratio	C8e2 Atch.		
AR11/A/727 AR11/C/2196 AP30/A/127		1 27M0G1W--		15.1		-59.2									
C10b1 Assoc. earth station id.		C10b2 Type	C10c1 Geographical coord.		C10c2 Ctry	C10d1/C10d2 Cls. / Nat.		C10d3 Max. iso. gain	C10d4 Bmwidth	C10d6 Noise temp.	C10d7 Ant. diameter	C10d9 Ant. dim. (DGSO)			
TYPICAL K3 (6/1)		T				1 TC CP		40	1.85	200					
C10d5a Co-polar antenna pattern															
C10b1 Assoc. earth station id.		Co-polar ref. pattern		Coef. A		Coef. B		Coef. C		Coef. D		Phi1	Co-polar rad. diag.		
TYPICAL K3 (6/1)		A-25*LOG(FI)		29											
Findings		2D Date of protection		08.01.1996	13A Conformity with RR		A-	A-	--	13B1 Provision		13B2 Remarks	13B3 Date of Review		
13C Remarks															



INTERSPUTNIK-75E-Q (105500291)

B1a/BR17 Beam designation 002 B1b Steerable B2 Em. Rcp E B3a1 Max co-polar gain 37 B3d Pointing accuracy 0.1

BR7a/BR7b Group id. 105625699 BR1 Date of receipt 19.08.2005 C2c RR No. 4.4

A2a Date of bringing into use 01.09.2005 A2b Period of valid. 40 A3a Op. agency 2 A3b Adm. resp. A BR16 Value of type C8b

BR62 Expiry date for bringing into use 07.09.2005 BR63 Confirmed date of bringing into use 01.09.2005 BR64 Date of receipt of 1st Res49

BR14 Special Section

C4a Class of station EC C3a Assigned freq. band 36000

C4b Nature of service CP C6a Polarization type M C6b Polarization angle

C8d1 Max. tot. peak pwr. 18 C8d2 Contiguous bandwidth 36000

C11a1 Service area no. 1 C11a2 Service area C11a3 Service area diagram 2

A5/A6 Coordinations/Agreements	9.7	<input type="checkbox"/>	BRU	CHN	F/EUT	G	INS	LAO	RUS	SNG	THA	TUR	UAE	USA	VTN
	AP30#7.1	<input type="checkbox"/>													
	N/9.7	<input type="checkbox"/>	TON												

C2a1 Assigned frequency											
12.525	GHz	12.565	GHz	12.605	GHz	12.645	GHz	12.685	GHz		
12.545	GHz	12.585	GHz	12.625	GHz	12.665	GHz	12.705	GHz		

A13 Ref. to Special Sections	C7a Design. of emission	C8a1/C8b1 Max. peak pwr	C8a2/C8b2 Max. pwr dens.	C8c1 Min. peak pwr	C8c2 Atch.	C8c3 Min. pwr dens.	C8c4 Atch.	C8e1 C/N ratio	C8e2 Atch.
API/A/428	1 36M0F8W--	5.9	-60.1	0.9		-65.1		16.6	
CR/C/144	2 32M2C7W--	14.9	-60.1	7.9		-67.1		23.1	
	3 45K0G1X--	-16.6	-63.1	-23.6		-70.1		20.2	

C10b1 Assoc. earth station id.	C10b2 Type	C10c1 Geographical coord.	C10c2 Ctry	C10d1/C10d2 Cls. / Nat.	C10d3 Max. iso. gain	C10d4 Bmwidth	C10d6 Noise temp.	C10d7 Ant. diameter	C10d9 Ant. dim. (DGSO)
TYPICAL-4, 5	T			1 TC CP	53.3	0.36	200		

C10b1 Assoc. earth station id.	C10d5a Co-polar antenna pattern					Phi1	Co-polar rad. diag.
Co-polar ref. pattern	Coef. A	Coef. B	Coef. C	Coef. D			
TYPICAL-4, 5	REC-580						

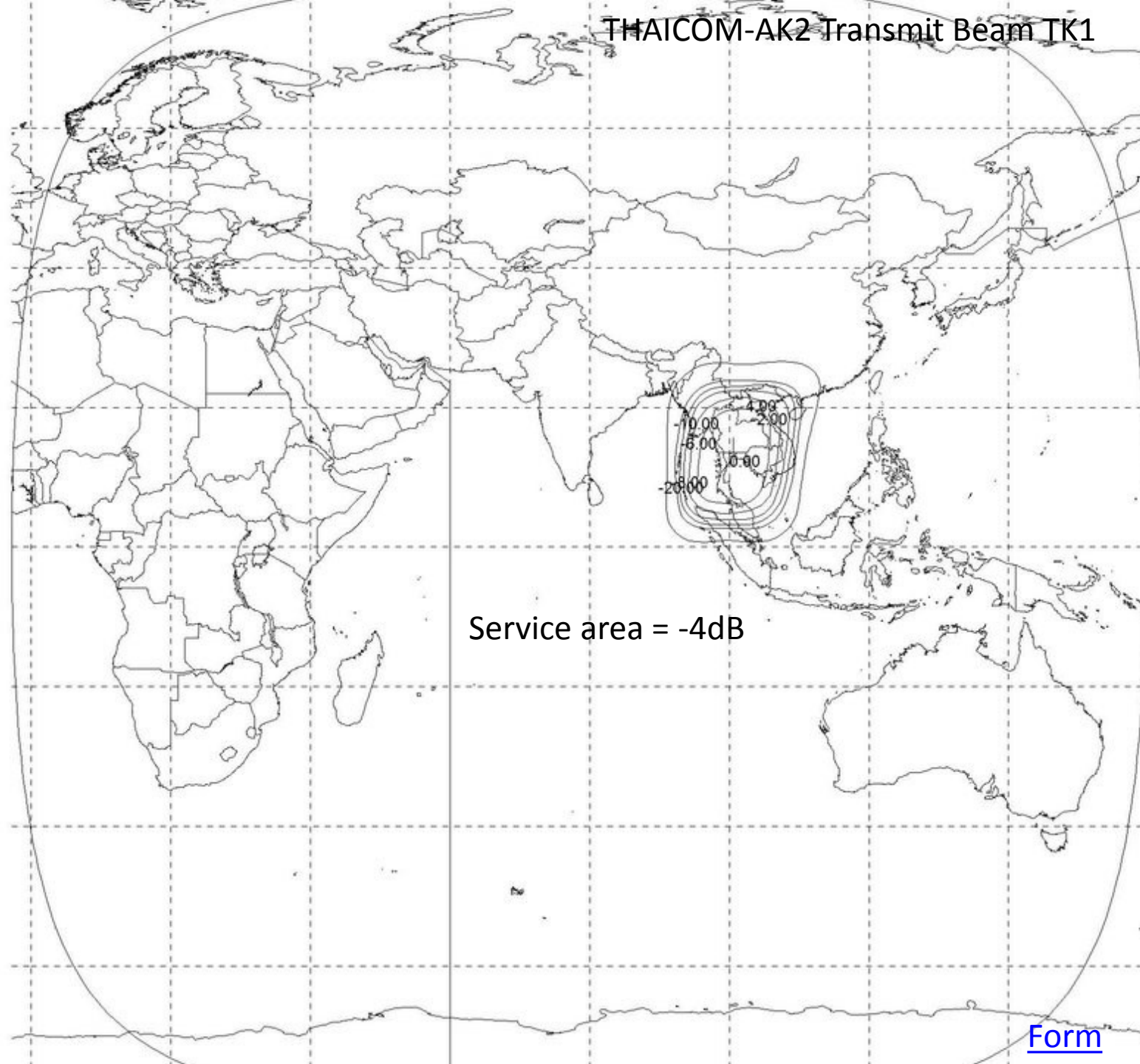
Findings 2D Date of protection 19.08.2005 13A Conformity with RR A- A- -- 13B1 Provision 13B2 Remarks 13B3 Date of Review

13C Remarks





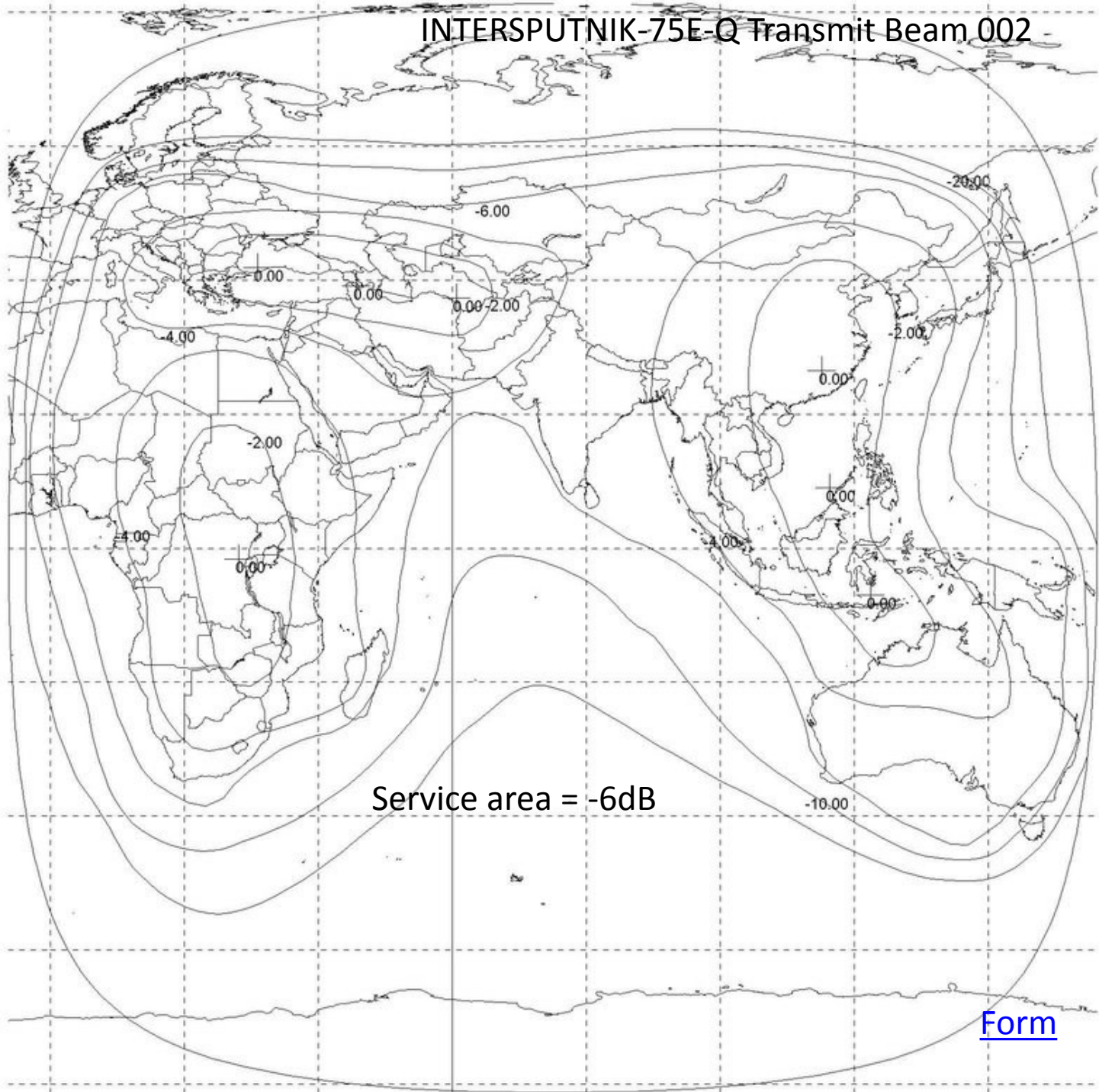
THAICOM-AK2 Transmit Beam TK1



Service area = -4dB



INTERSPUTNIK-75E-Q Transmit Beam 002



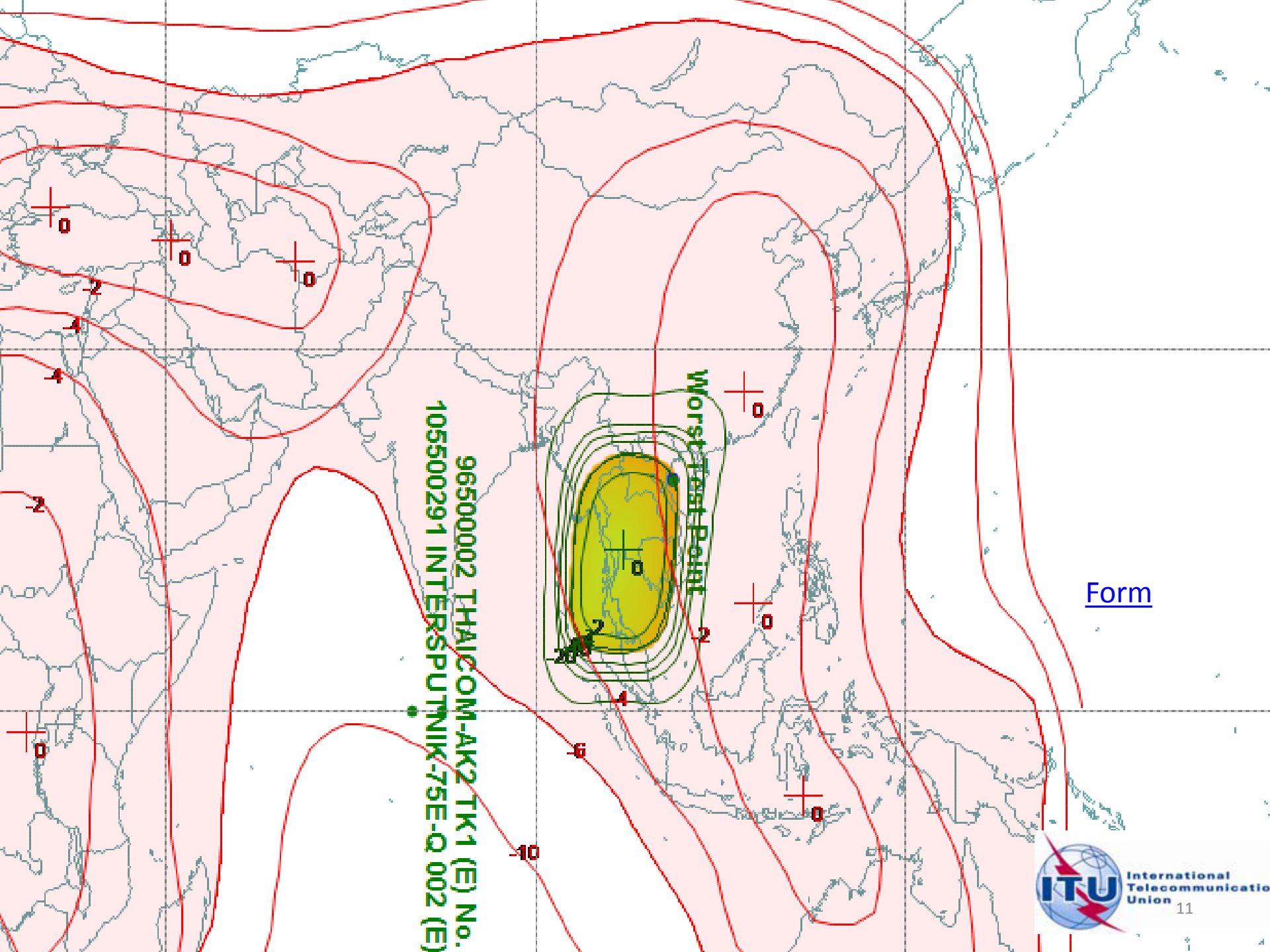
Service area = -6dB

[Form](#)

[Form](#)

96500002 THAIKOM-AK2 TK1 (E) No. 1
105500291 INTERSPUTNIK-75E-Q 002 (E) No. 1

Worst Case Point



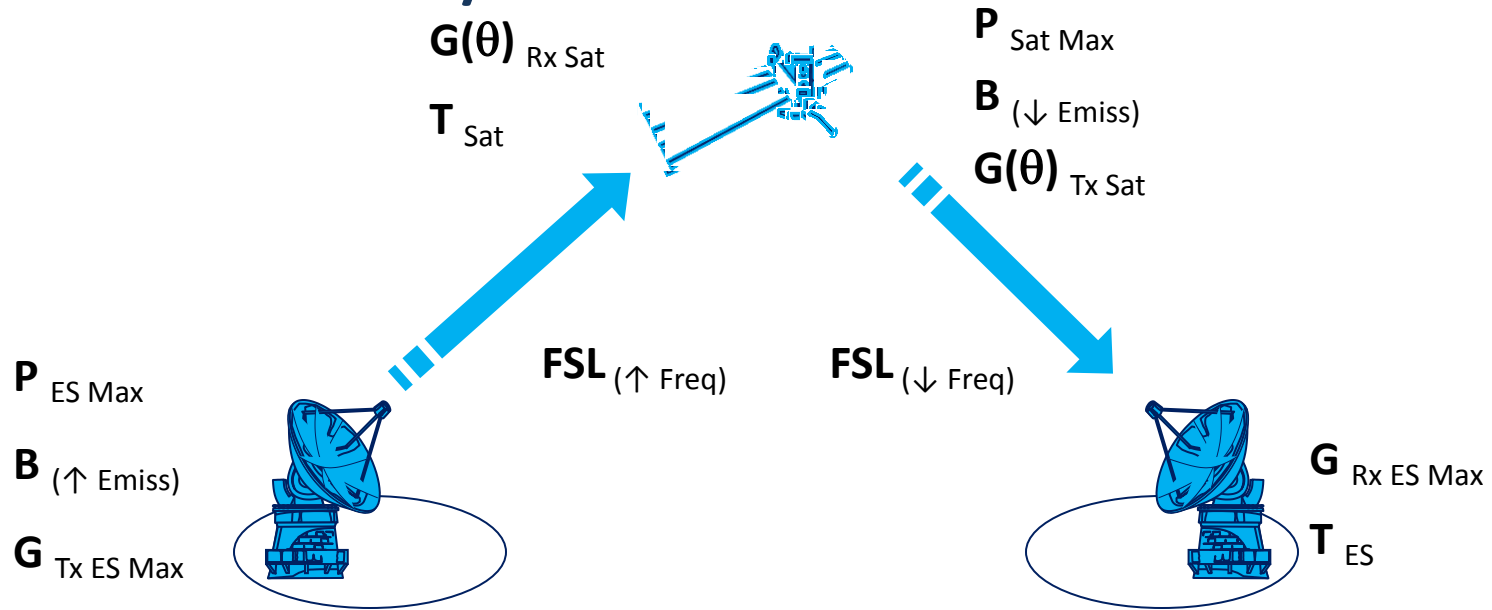
96500002 THAICOM-AK2 TK1 (E) No.
105500291 INTERSPUTNIK-7SE-Q 002 (E)

Worst-Case Point

[Form](#)



Finding C/I Required Calculate C/N



- Maximum Peak Power
- Necessary Bandwidth of Emission
- Maximum Earth Station Antenna Gain
- Free Space Loss (assigned frequency)
- Off-axis Satellite Antenna Gain
- Receiver System Noise Temperature
- Service Area

- P_{Max}
- B
- $G_{ES Max}$
- FSL
- $G(\theta)_{Sat}$
- T

- C8a1/C8b1
- C7a
- C10d3
- C2a1
- B3a + B3b
- C5a/C10d6
- C11a

Appendix
4

Form



Free Space Loss (Annex II of AP8)

$$\text{FSL} = 20 (\log f + \log d) + 32.45 \text{ dB}$$

where :

f : frequency (MHz)

d : distance (km)

where:

$$d = 42644(1 - 0.2954 \cdot \cos \psi)^{0.5}$$

where:

$$\cos \psi = \cos \zeta \times \cos \beta$$

where :

ζ = latitude of earth station

β = difference in longitude btw satellite and earth station



Free Space Loss (Annex II of AP8)

$$\text{FSL} = 20 (\log f + \log d) + 32.45 \text{ dB}$$

where : example

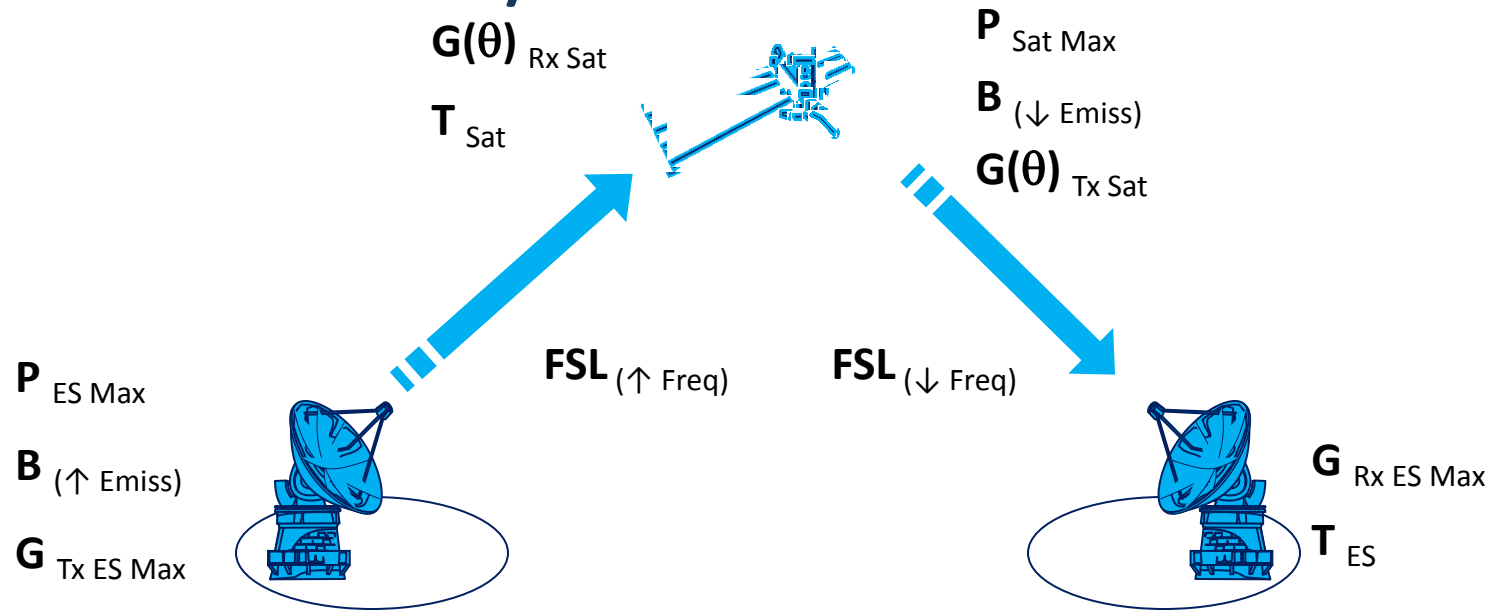
f : 12585 (MHz)

d : 36000 (km)

$$\text{FSL} = 205.6 \text{ dB}$$



Finding C/I Required Calculate C/N



Uplink C/N

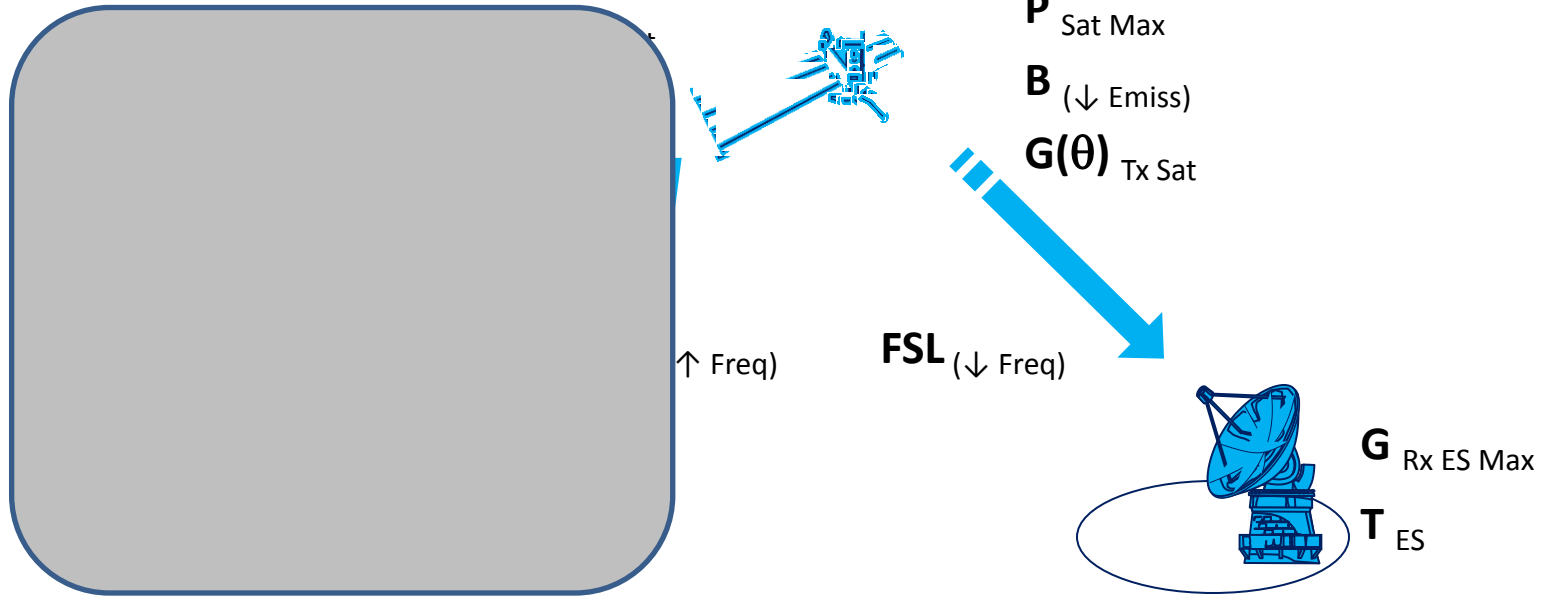
$$C/N \uparrow = P_{ES \text{ Max}} + G_{Tx \text{ ES Max}} + G(\theta)_{Rx \text{ Sat}} - FSL_{(\uparrow \text{ Freq})} - (k + T_{Sat} + B_{(\uparrow \text{ Emiss})}) \text{ (dB)}$$

Downlink C/N

$$C/N \downarrow = P_{Sat \text{ Max}} + G(\theta)_{Tx \text{ Sat}} + G_{Rx \text{ ES Max}} - FSL_{(\downarrow \text{ Freq})} - (k + T_{ES} + B_{(\downarrow \text{ Emiss})}) \text{ (dB)}$$



Finding C/I Required Calculate C/N



Uplink C/N

$$C/N \uparrow = P_{ES Max} + G_{Tx ES Max} + G(\theta)_{Rx Sat} - FSL_{(\uparrow Freq)} - (k + T_{Sat} + B_{(\uparrow Emiss)}) \text{ (dB)}$$

Downlink C/N

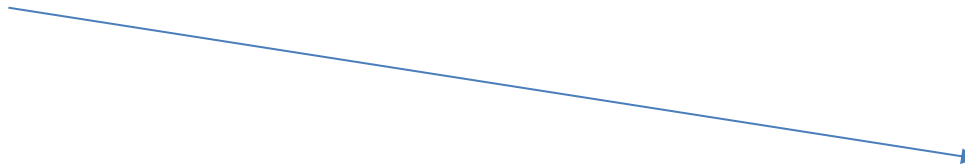
$$\begin{aligned} C/N \downarrow &= 15.1 + (38.9 - 4) + 40 - 205.82 - (-228.6 + 10 \log(200) + 10 \log(27000000)) \\ &= -115.82 - (-131.28) \\ &= 15.46 \text{ dB} \end{aligned}$$



27M0G1W



Bandwith of wanted
Carrier 27.0 MHz



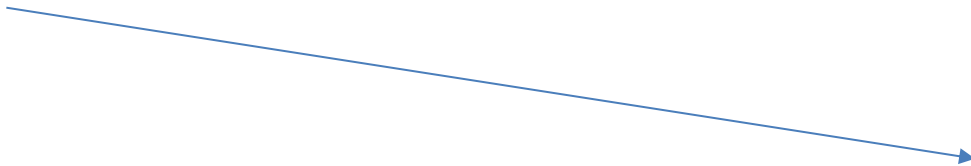
Carrier=Digital



45K0G1W



Bandwith of wanted
Carrier 45.0 kHz



Carrier=Digital

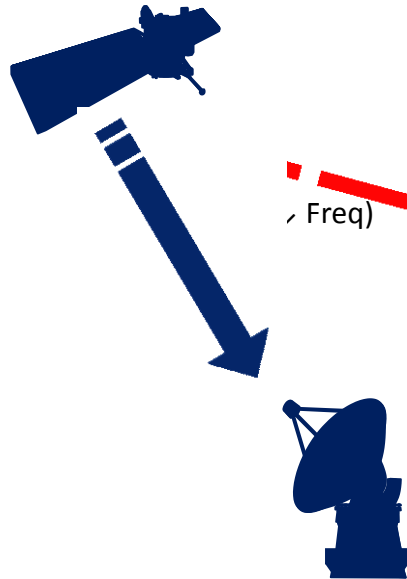


Finding C/I

Calculate C/I basic

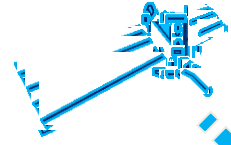
$P'_{\text{Sat Max}}$

$G'(\phi)_{\text{Tx Sat}}$



$P_{\text{Sat Max}}$

$G(\theta)_{\text{Tx Sat}}$



$G(\theta')_{\text{Rx ES}}$

$G_{\text{Rx ES Max}}$

$$C \downarrow = P_{\text{Sat Max}} + G(\theta)_{\text{Tx Sat}} + G_{\text{Rx ES Max}} - FSL_{(\downarrow \text{Freq})} \text{ (dBW)}$$

$$I \downarrow = P'_{\text{Sat Max}} + G'(\phi)_{\text{Tx Sat}} + G(\theta')_{\text{Rx ES}} - FSL'_{(\downarrow \text{Freq})} \text{ (dBW)}$$

$$C/I \downarrow = C \downarrow - I \downarrow \text{ (dB)}$$



Finding C/I

Calculate C/I basic

$P'_{\text{Sat Max}}$

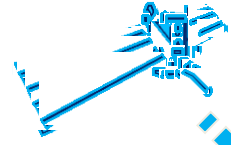
$G'(\phi)_{\text{Tx Sat}}$



\downarrow Freq)

$P_{\text{Sat Max}}$

$G(\theta)_{\text{Tx Sat}}$



FSL (\downarrow Freq)

θ'



$G(\theta')_{\text{Rx ES}}$



$G_{\text{Rx ES Max}}$

$$C \downarrow = 15.1 + (38.9-4) + 40 - 205.82 \text{ (dBW)}$$

$$I \downarrow = -16.6 + (37-1.58) + 14.71 - 205.87 \text{ (dBW)}$$

$$\begin{aligned} C/I \downarrow &= -115.82 - (-172.34) \\ &= 56.52 \end{aligned}$$



Get Adjustment Factor

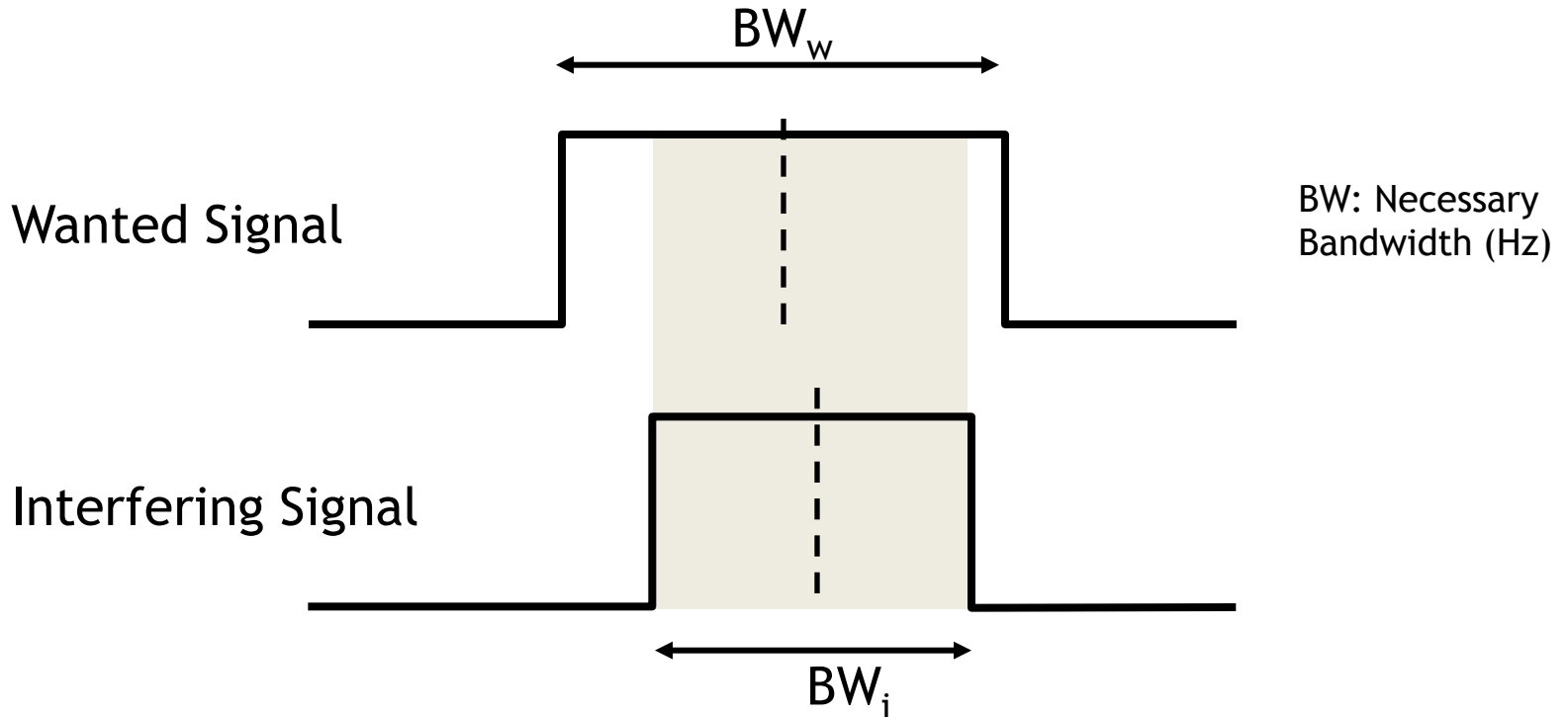
Wanted Interfering	<u>Digital</u>	Analogue (Other than TV/FM)	Other	TV/FM
<u>Digital</u>	METHOD 1: Wanted Bandwidth (BW) to Interfering BW Overlapping Ratio Adjustment			
TV/FM	METHOD 2: Wanted BW to Interfering Equivalent BW Overlapping Ratio Adjustment		METHOD 1: Co-freq.	
Analogue (Other than TV/FM)			METHOD 3: Non co-freq. (Relative Protection Ratio)	
Other			METHOD 2	

Source: Table 1 in Section B3 of Rules of Procedures, ITU-R S.741-2



Finding C/I Get Adjustment Factor

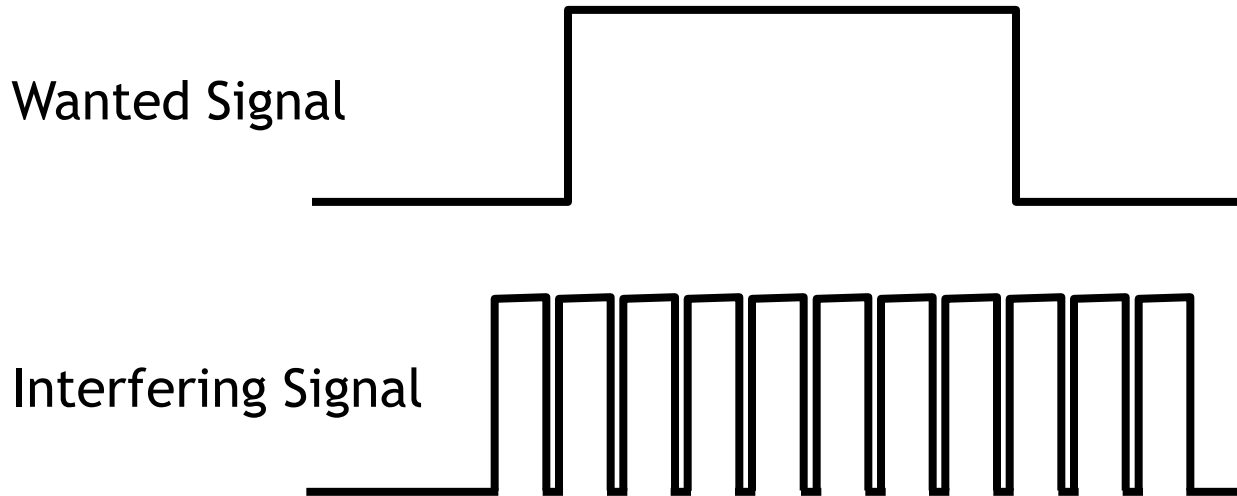
Method 1:



$$\begin{aligned} I_a &= 10\log_{10} (BW_{\text{overlap}} / BW_i) \\ &= 10\log_{10} (BW_i / BW_i) \\ &= 0 = \text{No Improvement!} \end{aligned}$$



Multiple interfering narrowband carriers



- Interfering transponder fully loaded with N narrowband carriers
- N is maximized by transponder bandwidth (item C.3.a of Appendix 4) = 36000 MHz and maximum total peak power (item C.8.d.1)



Multiple interfering narrowband carriers

- Interfering transponder fully loaded with N narrowband carriers
- N is maximized by transponder bandwidth (item C.3.a of Appendix 4) = 36000 MHz and maximum total peak power (item C.8.d.1) = 18 dBW
- Total power = $-16.6 + 27.78 = 11.18$ dBW

$$\bullet \quad 10 \cdot \log(27000000 / 45000) = 27.78$$



Finding C/I Required

Interfering \ Wanted	TV/FM or Other	Digital	Analogue (Other than TV/FM)
TV/FM	$C/N + 14$ (dB)		
Digital	If $BW_w \leq BW_{eqi}$ then $C/N + 5.5 + 3.5 \cdot \log(BW_w)$ (dB) else if $BW_w > BW_{eqi}$ then $C/N + 12.2$ (dB)	$C/N + 12.2$ (dB) $= 15.46 + 12.2$ $= 27.66$	
Analogue (Other than TV/FM)	$11.4 + 2 \cdot \log(BW_w)$ (dB)	$C/N + 12.2$ (dB)	
Other	$11.4 + 2 \cdot \log(BW_w)$ (dB)	$C/N + 14$ (dB)	

Source: Table 2 in Section B3 of Rules of Procedures, ITU-R S.741-2

BW_w : Necessary bandwidth of wanted carrier (MHz)

BW_{eqi} : Equivalent bandwidth of interfering carrier (MHz)

C/N: Carrier to Noise ratio (dB)



Finding C/I

$$\text{Margin} = 56.39 - C/I_{\text{required}} \quad (\text{dB})$$

$$\text{Margin} = \boxed{C/I} - C/I_{\text{required}} \quad (\text{dB})$$

C/I: Carrier to Interference (dB)

$$C/I = C/I_b - I_a$$

1. C/I_b : Basic calculated C/I (dB)
2. I_a : Interference adjustment factor (dB)

DOWNLINK

Beam	TK1	Interfering	002
Group ID	966604139		105625699
Emission	27M0G1W		45K0G1X
Wanted E/S Long	106.86		
Wante E/S Lat	18.85		
Topocentric Angle	3.73		
Wanted E/S Sidelobe			
Pattern	A-25log(θ)		

Frequency 12585

	Wanted		Interfering
Ps	15.1	Ps	-16.6
Gs	38.9	Gs	37

ES relative to wanted beam

peak	-4
FSL	-205.82
Ges	40
BW (Hz)	27000000
Tes	200

ES relative to interfering beam

peak	-1.58
FSL	-205.87
Ges(θ)	14.71
	45000

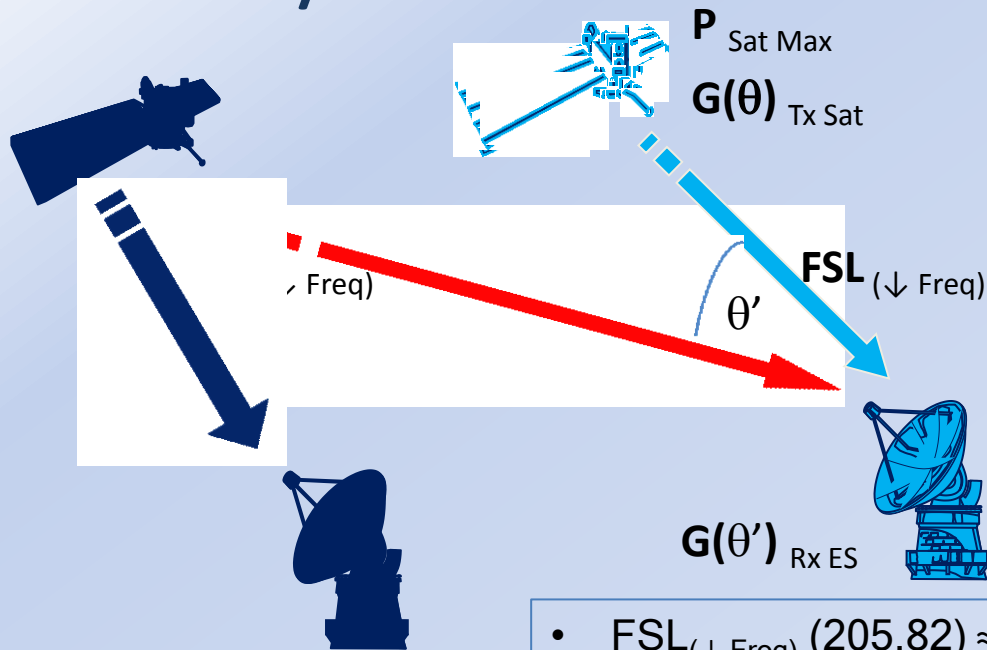
Carrier	-115.82	Interference	-172.34
Noise	-131.28		
C/N	15.46		
C/I basic	56.52		
adj factor	27.78		
C/I adj	28.74		
C/I required	27.66	C/N+12.2	
Margin	1.09		
to add 1.87	2.96	Wanted Carrier is Digital	



Finding C/I

Calculate C/I basic

$P'_{\text{Sat Max}}$
 $G'(\phi)_{\text{Tx Sat}}$



• $FSL_{(\downarrow \text{Freq})} (205.82) \approx -FSL'_{(\downarrow \text{Freq})} (205.82)$

$$C \downarrow = P_{\text{Sat Max}} + G(\theta)_{\text{Tx Sat}} + G_{\text{Rx ES Max}} - FSL_{(\downarrow \text{Freq})} \text{ (dBW)}$$

$$I \downarrow = P'_{\text{Sat Max}} + G'(\phi)_{\text{Tx Sat}} + G(\theta')_{\text{Rx ES}} - FSL'_{(\downarrow \text{Freq})} \text{ (dBW)}$$

$$C/I \downarrow = C \downarrow - I \downarrow \text{ (dB)}$$

• topocentric \approx geocentric plus agreed factor of improvement

[Form2](#)

Section B3, Part B of the Rules of Procedure

- C/N defined as “ratio (dB) of carrier to total noise power which includes all internal system noise and interference from other systems in REC ITU-R S.741-2
- No. 1.174 noise temperature excludes “the noise due to interference coming from satellite links using other satellites and from terrestrial system”
- To comply with definition, an additional margin will be added to the margins calculated on the basis of the internal system noise temperature (Attachment 2 of ROP)
- Wanted Analog TV emissions – 0.46 dB
- Other Wanted emissions – 1.87 dB