



Carrier to Interference (C / I ratio) Calculations

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Section B3, Part B of the Rules of Procedure

- Outlines the C/I calculation methodology for interference assessment under No.11.32A w.r.t. coordination of networks under No. 9.7 (i.e. GSO vs GSO satellite networks)
- The ROP defines
 - how the different type of carriers are categorized according to the class of emission (item C.7 a Annex 2 in Appendix 4)
 - which criteria to apply for different combinations of carrier types
 - the interference adjustment factor to consider for different combinations of carrier types
 - when C/N objective (submitted in accordance with Appendix 4(Annex 2 item C.8.e.1) or Calculated C/N is used
 - assumptions to make when dealing with composite interference from a number of narrow band carriers

When No.11.32A is applied?

Each notice shall be examined:

11.32A c) with respect to the probability of harmful interference that may be caused to or by assignments recorded with a favourable finding under Nos. 11.36 and 11.37 or 11.38, or recorded in application of No. 11.41, or published under Nos. 9.38 or 9.58 but not yet notified, as appropriate, for those cases for which the notifying administration states that the procedure for coordination under Nos. 9.7, 9.7A, 9.7B, 9.11, 9.12, 9.12A, 9.13 or 9.14, could not be successfully completed (see also No. 9.65);

9.65 If, at the date of receipt of a notice under No. 9.64 above, the Bureau has been informed of a continuing disagreement, the Bureau shall examine the notice under Nos. 11.32A or 11.33 and shall act in accordance with No. 11.38.

C/I methodology

- More complex than delta T/T and more detailed
- Used by Bureau for No.11.32A examination*
- Widely accepted method for assessment of interference especially between geostationary satellite networks
- Widely used by Administrations for coordination of their satellite networks

*GSO vs GSO satellite networks

COORDINATION MEETING

- Occasion for information exchange
- Agreement of Assumptions
- Agreement of Criteria
- Agreement of Operating or Desired C/Ns
- Agreement of Calculation Method
- Agreement of set of parameters to be used
- More detailed information on service areas, type of carriers, antenna radiation patterns, implementation dates, transponder plan, etc.
- Radio Regulations and ITU Recommendations are often used as the main reference

WHAT'S IMPORTANT?

- Understanding the basics and concepts of C/I facilitates
 - C/I generation
 - Development of C/I calculation tool
 - Summarization and interpretation of results
 - Analysis and finding interference mitigation solutions

Examine Probability of Harmful Interference

Margin

Negative Margin

Potential for
Harmful Interference

Positive or Zero
Margin

No Harmful Interference

Calculating Margin

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

- C/I: Carrier to Interference (dB)
- Single-entry interference protection criteria

Finding C/I Required

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

1. C/N: Carrier to Noise (dB)
2. Type of Carrier

- Single-entry interference protection criteria
- §3.1 of Section B3 of Rules of Procedure

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*log(BW_w) (dB)	C/N + 12.2 (dB)	
	else if $BW_w > BW_{eqi}$ then C/N + 12.2 (dB)		
Analogue (Other than TV/FM)	11.4 + 2*log (BW_w) (dB)	C/N + 12.2 (dB)	
Other	11.4 + 2*log (BW_w) (dB)	C/N + 14 (dB)	

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

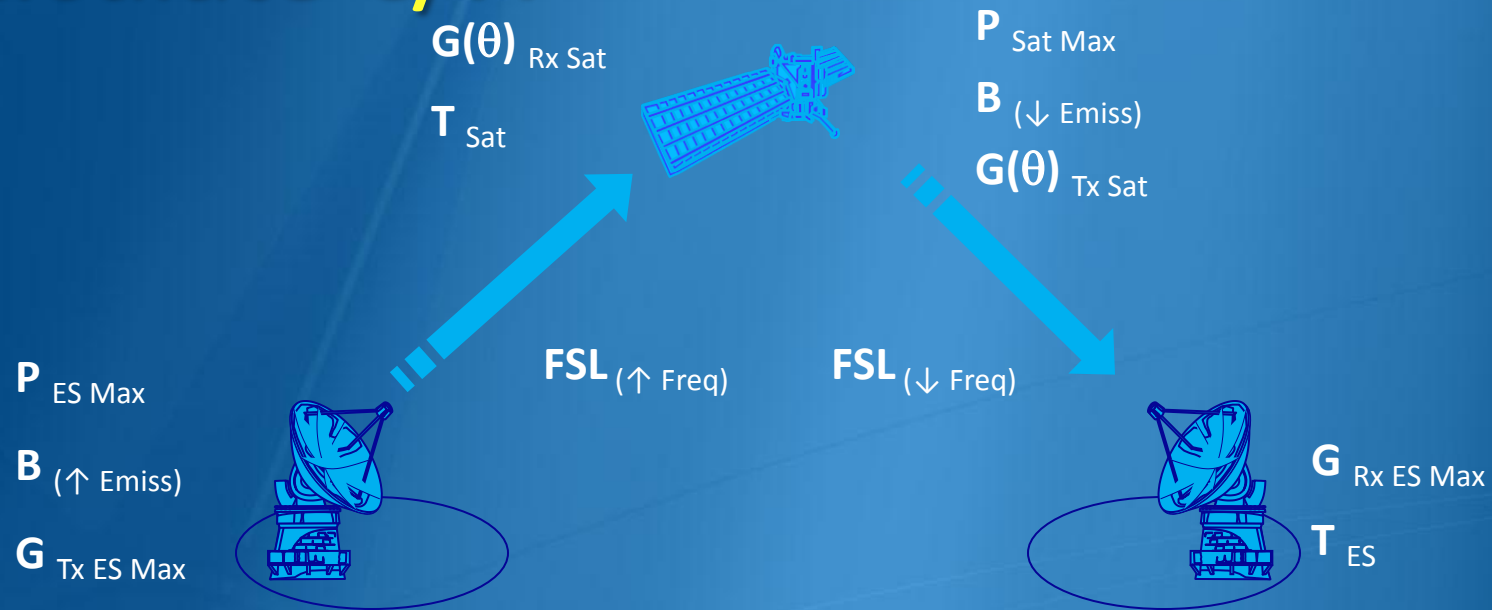
BW_w : Necessary bandwidth of wanted carrier (MHz)

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

C/N: Carrier to Noise ratio (dB)

Finding C/I 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

$G_{ES \text{ Max}}$

FSL

$G(\theta)_{Sat}$

T

Where to get these information?

SECTION SPECIALE / SPECIAL SECTION / SECCION ESPECIAL CR/C/45

A A1a Sat. Network MPRSAT-91-EP A1f1 Notifying adm. MLA A1f2 Inter. sat. org. BR1 Date of receipt 11.02.1999 BR20/BR21 IFIC no./part 2464/

BR6-BR6b Id. no. 9520006 BR3a/BR3b Provision reference RR1060 C BR2 Adm. serial no. C1UR R

Beam Level

A4a1 Orbital long. 11 E - 171 E A4a2 Long. tolerance 0.1 M - 0.1 E A4a3 Inclination precision 0.1

A4a3 Visibility arc 11 E - 171 E A4a4 Service arc 11 E - 171 E A4a5 Reason for arc diff.

B1a/B1b Beam designation C1UR B2 Emi-Rcp R B3a1/B3b1/B3b2a Max. ant. gain 30 B3d Pointing accuracy 0.05

B3a2/B3b2b Ant. gain cont. diag. B3f Ant. gain vs orbit long. diag. 2

B3e1 Ant. gain vs orbit long. diag. B3e2 Ref. pat. B3e3 Coef. A B3e4 Coef. B

Group Level

BR7a/BR7b Group id. 99880283 BR14 Special Section CR/C/45

C4a Class of station BC C3a Assigned freq. band 36000 C5a Noise temperature 500

C4b Nature of service CP C6a Polarization type L C6b Polarization angle 90 C8d/C8g Max. pwr

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

Sub-Group or Frequency Assignment Level

A5a Date of bringing into use 10.08.2003 A2b Period of valid. 50 A3a Op. agency 15 A3b Adm. resp. A BR16 Value of type C8b BR17 Reason for C8c/C8e absent

C2a Assigned frequency

5945	MHz	6065	MHz	6185	MHz	6305	MHz	6445	MHz	6565	MHz	6685	MHz	
5985	MHz	6105	MHz	6225	MHz	6345	MHz	6485	MHz	6605	MHz			
6025	MHz	6145	MHz	6265	MHz	6385	MHz	6525	MHz	6645	MHz			

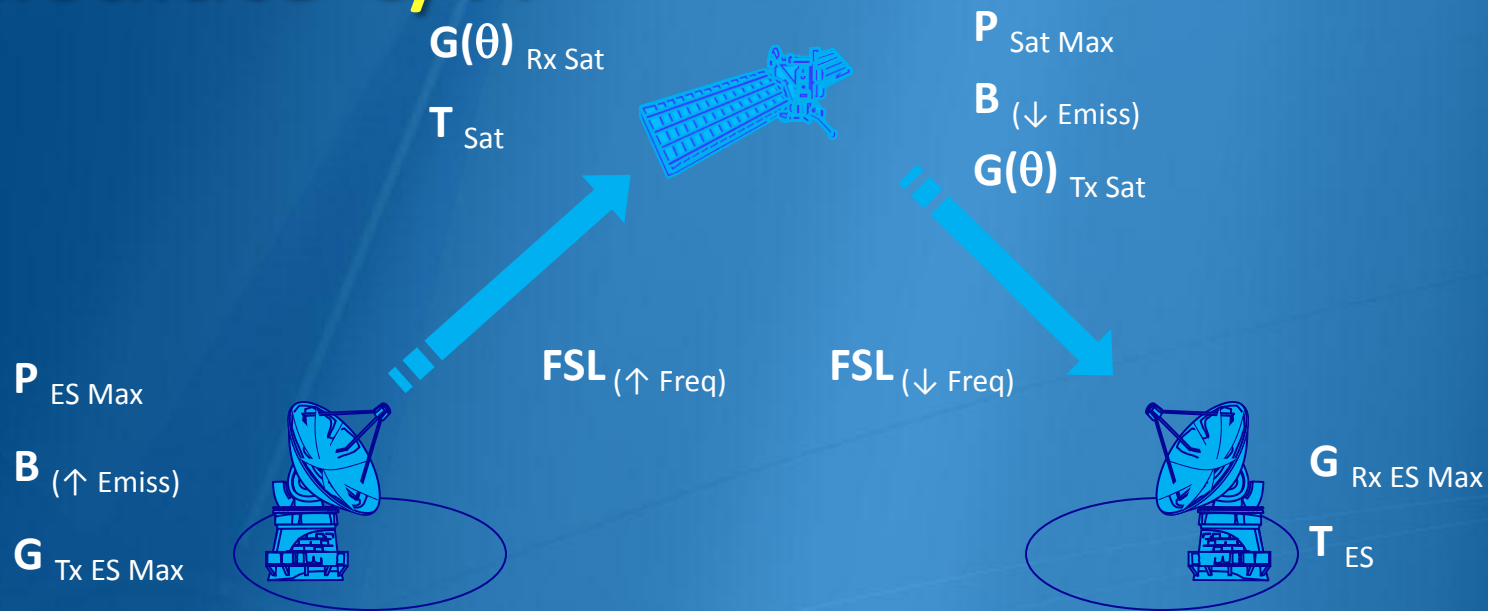
A13 Ref. to Special Sections		C7a Design. of emission		C8a1/C8b1 Max. peak pwr	C8a2/C8b2 Max. pwr dens.	C8c1 Min. peak pwr	C8c2 Min. pwr dens.	C8e C/N ratio	
1	AR11/A	393	1	38K4G7E--	9.1	-35.6	5.1	-39.6	9.4

C10b1 Assoc. earth station id.	C10b4 Ctry	C10b3 Type	C10b5 Geographical coord.	C10c1a/C10c1b Cls. / Nat.	C10c2 Max. iso. gain	C10c3 Bmwidth	C10c4a Ref. pattern	C10c4b Rad. diag.	C10c4c				
									Coef A	Coef B	Coef C	Coef D	Phi1
TYPICAL-1.8M		T		1 TC CP	39.2	2.08	29-25LOG (PI)						

Findings 2D Date 11.02.1999 13A Conformity with RR A----- 13B1 Provision 13B2 Remarks 13B3 Date of Review

13C Remarks

Finding C/I Required Calculate C/N



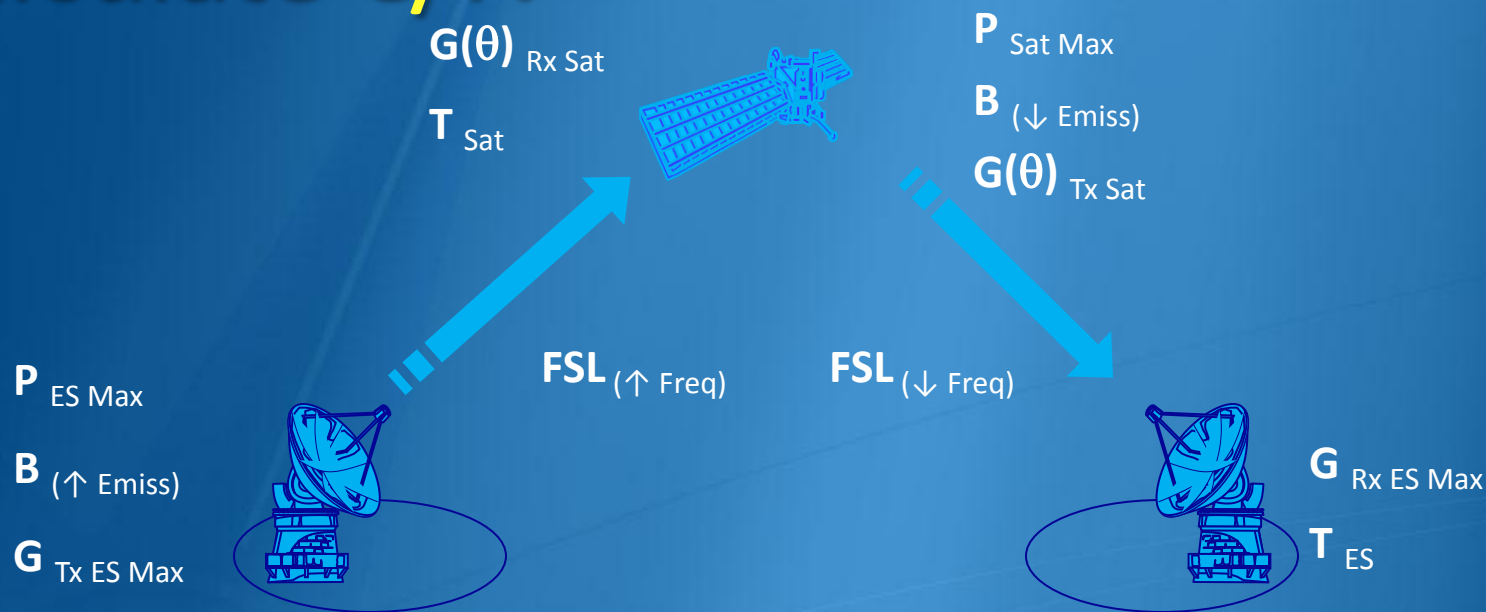
- Maximum Peak Power
- Necessary Bandwidth of Emission
- Maximum Earth Station Antenna Gain
- Free Space Loss (assigned frequency)
- Off-axis Satellite Antenna Gain
- Receiver System Noise Temperature
- Service Area

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

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

Appendix
4

Finding C/I Required Calculate C/N



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

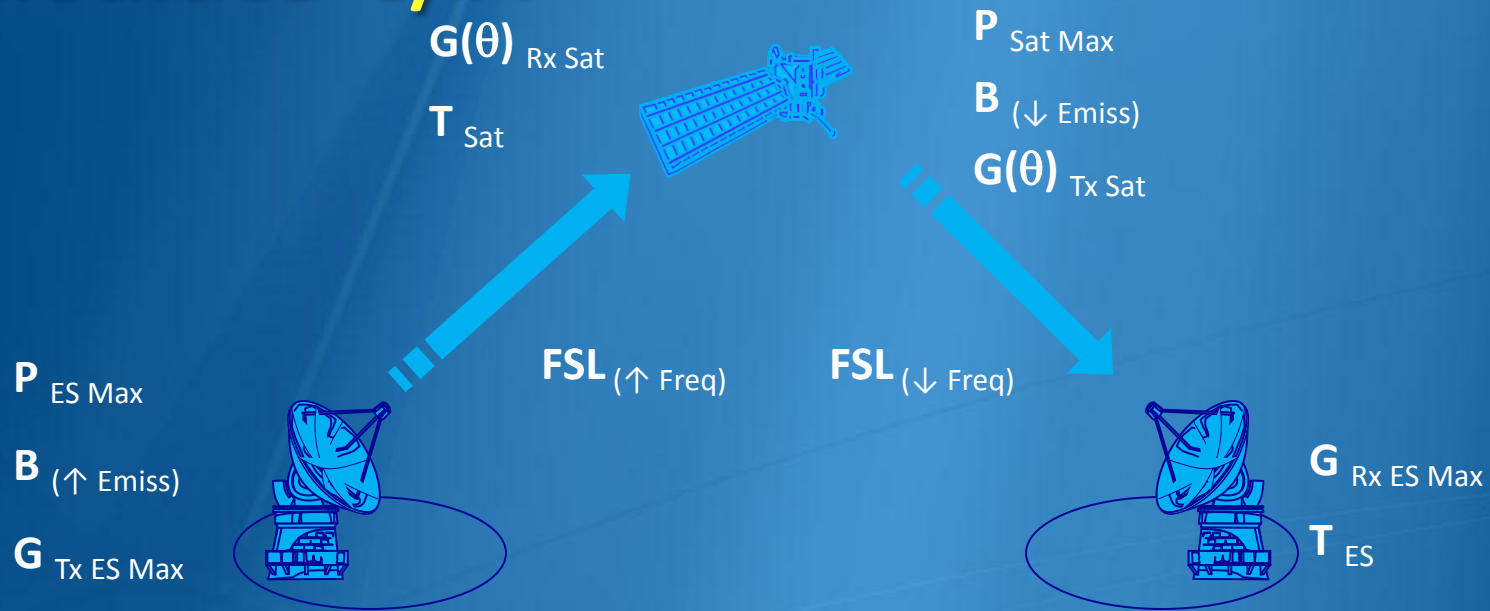
C, Carrier power

N, Noise power

$$FSL = 10 \log_{10} (4\pi df/c)^2$$

k, Boltzmann constant = -228.6 dBW/K/Hz

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

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

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:

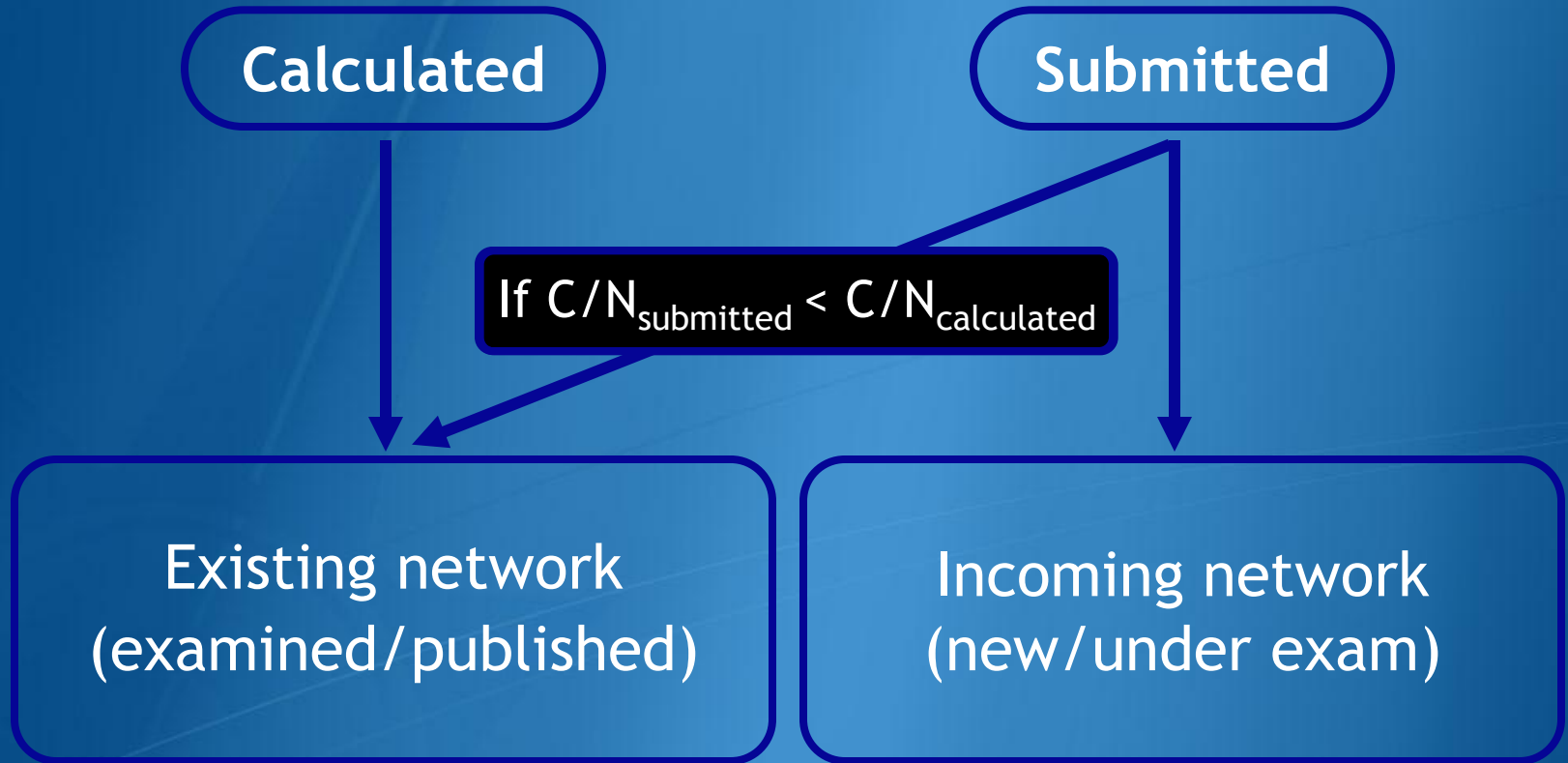
$$\cos \psi = \cos \zeta \times \cos \beta$$

where :

ζ = latitude of earth station

β = difference in longitude btw satellite and earth station

Finding C/I Required
Select C/N



Check Carrier Type

Example:

36M0G7W--

Necessary bandwidth

Class of Emission

1st Symbol: Type of modulation of the main carrier

2nd Symbol: Nature of signal(s) modulating the main carrier

3rd Symbol: Type of info to be transmitted

Finding C/I Required

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

To summarize:

- From Appendix 4 data, find C/N
- From emission, find carrier type
- From Table 2 in Section B3 of Rules of Procedure, find C/I Required

Finding C/I

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

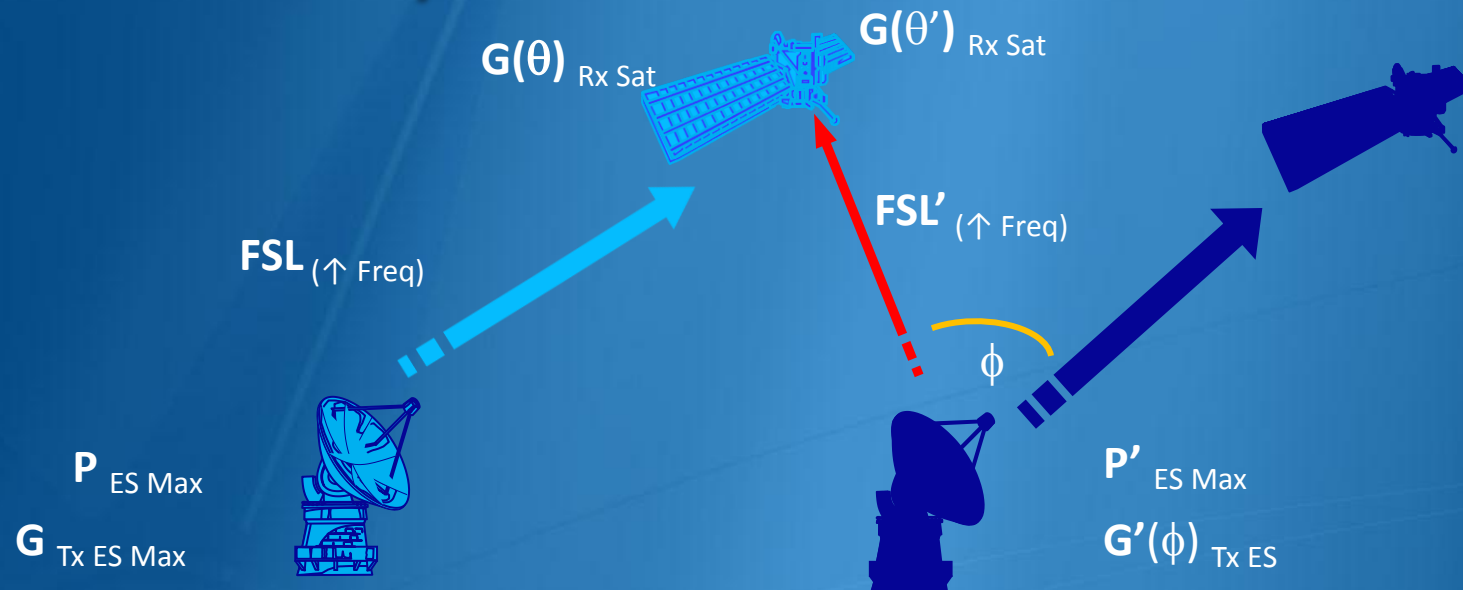
C/I: Carrier to Interference (dB)

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

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

Finding C/I

Calculate C/I basic



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

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

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

Topocentric Angular Separation 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

Antenna reference patterns

Annex 3 of Appendices 7 and 8 of the Radio Regulations

ITU-R S.580-6

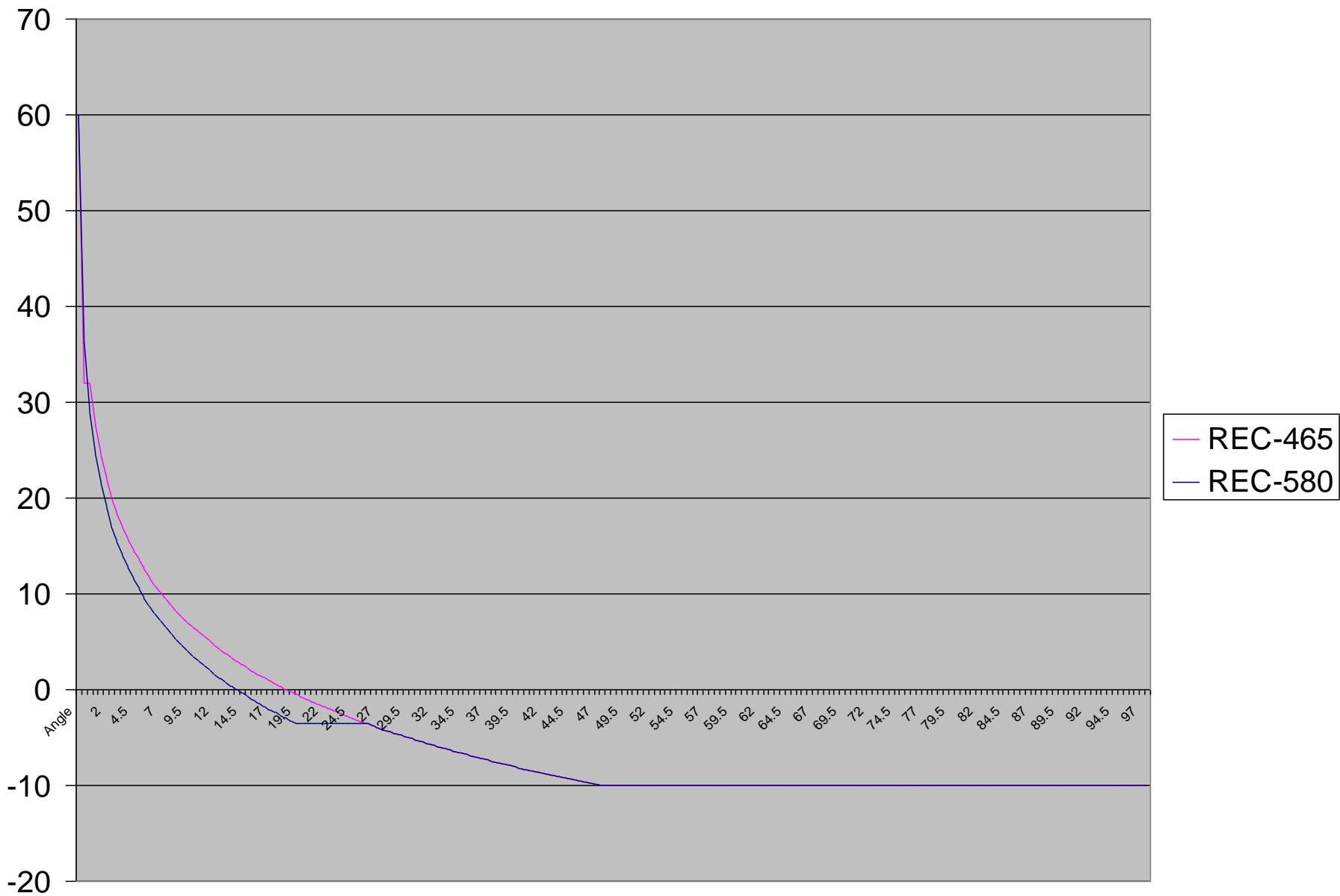
ITU-R S.465-6

ITU-R BO.1900

ITU-R M.694-1

ITU-R BO.1213-1

ITU-R Bo.1295

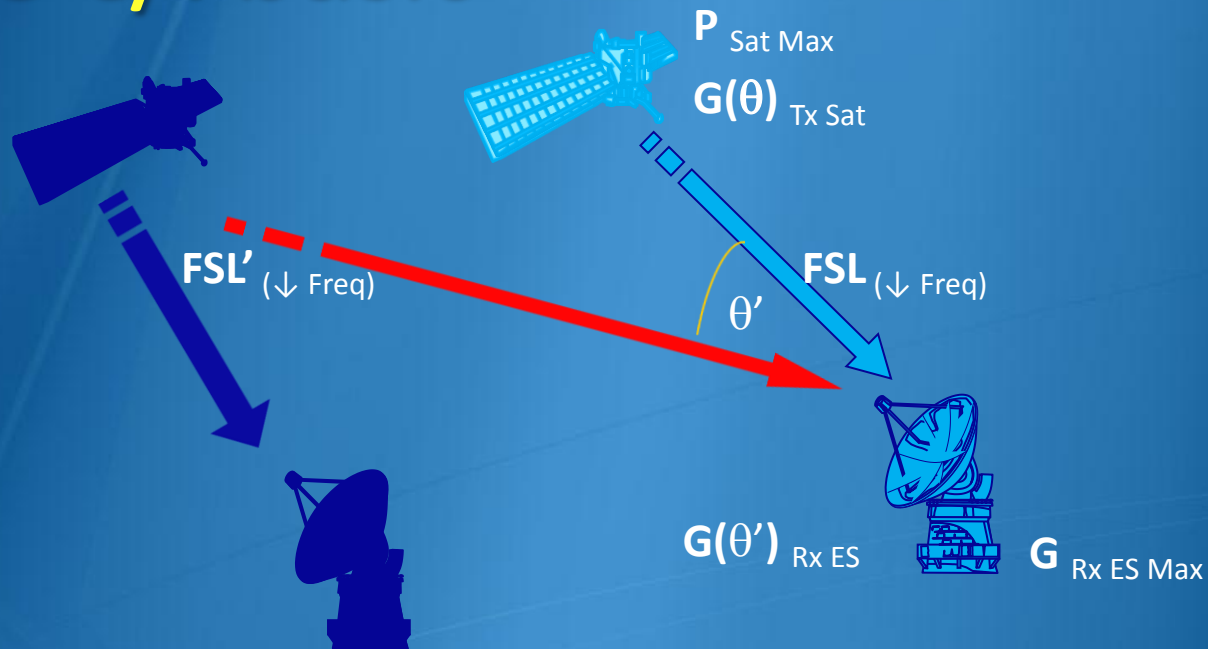


Pattern1	Pattern2	Freq (MHz)	Gmax (dBi)
REC-465	REC-580	7265	60

Finding C/I

Calculate C/I basic

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



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

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

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

Finding C/I

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

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)

Finding C/I Get Adjustment Factor

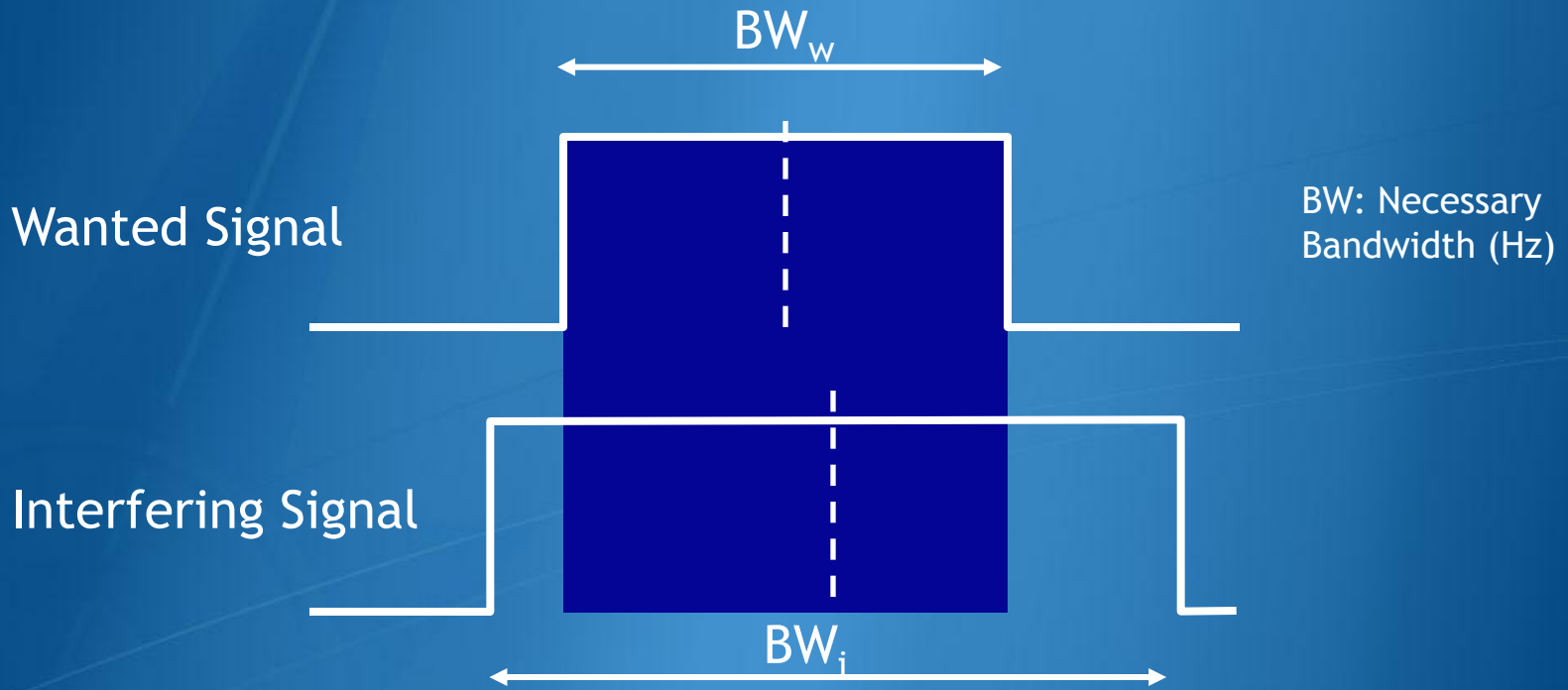
Wanted Interfering	Digital	Analogue (Other than TV/FM)	Other	TV/FM
Digital	METHOD 1: Wanted Bandwidth (BW) to Interfering BW Overlapping Ratio Adjustment			
TV/FM	METHOD 2: Wanted BW to Interfering Equivalent BW Overlapping Ratio Adjustment		METHOD 1: Co-freq.	
Analogue (Other than TV/FM)			METHOD 3: 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:

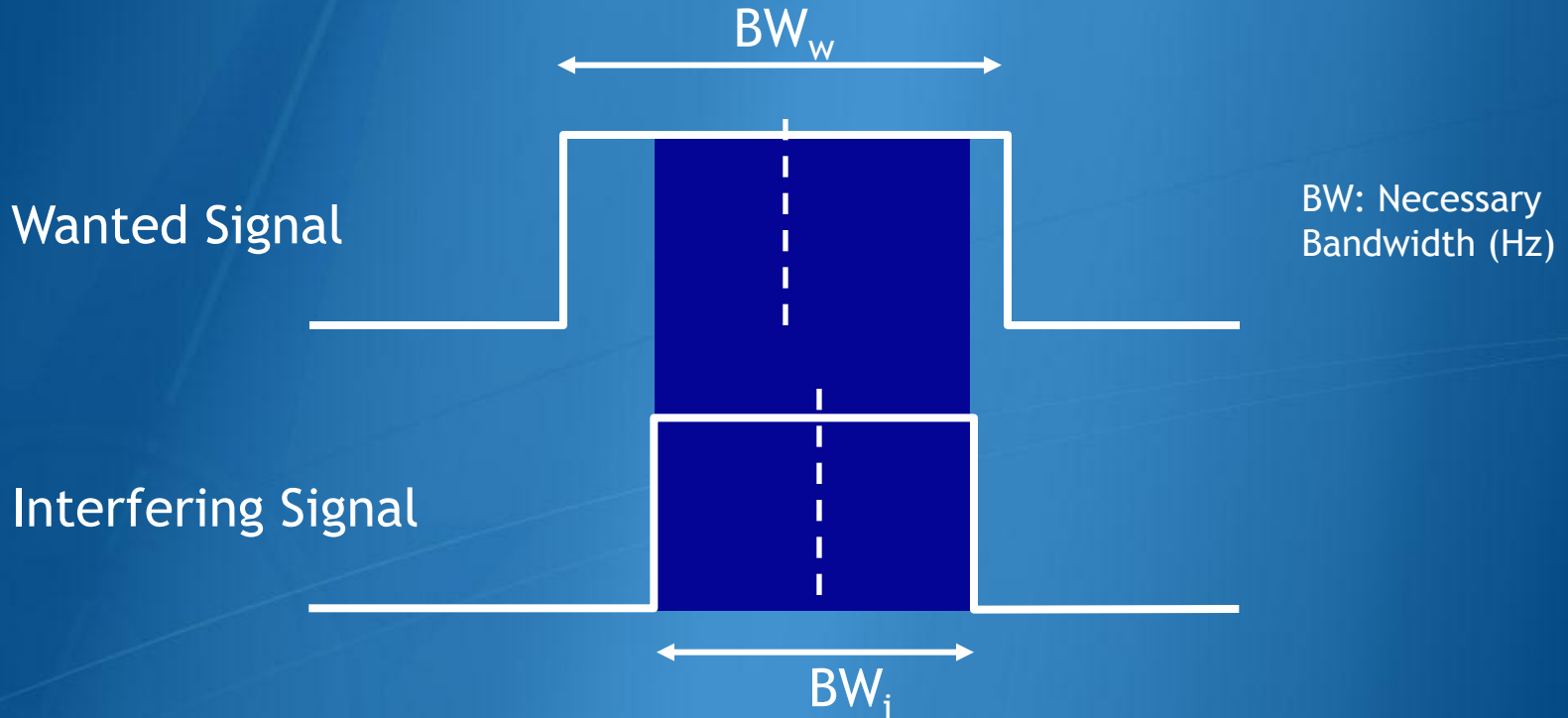


$$\begin{aligned} I_a &= 10\log_{10} (BW_{\text{overlap}} / BW_i) \\ &= 10\log_{10} (BW_w / BW_i) \\ &< 0 = \text{Improvement!} \end{aligned}$$

Finding C/I

Get Adjustment Factor

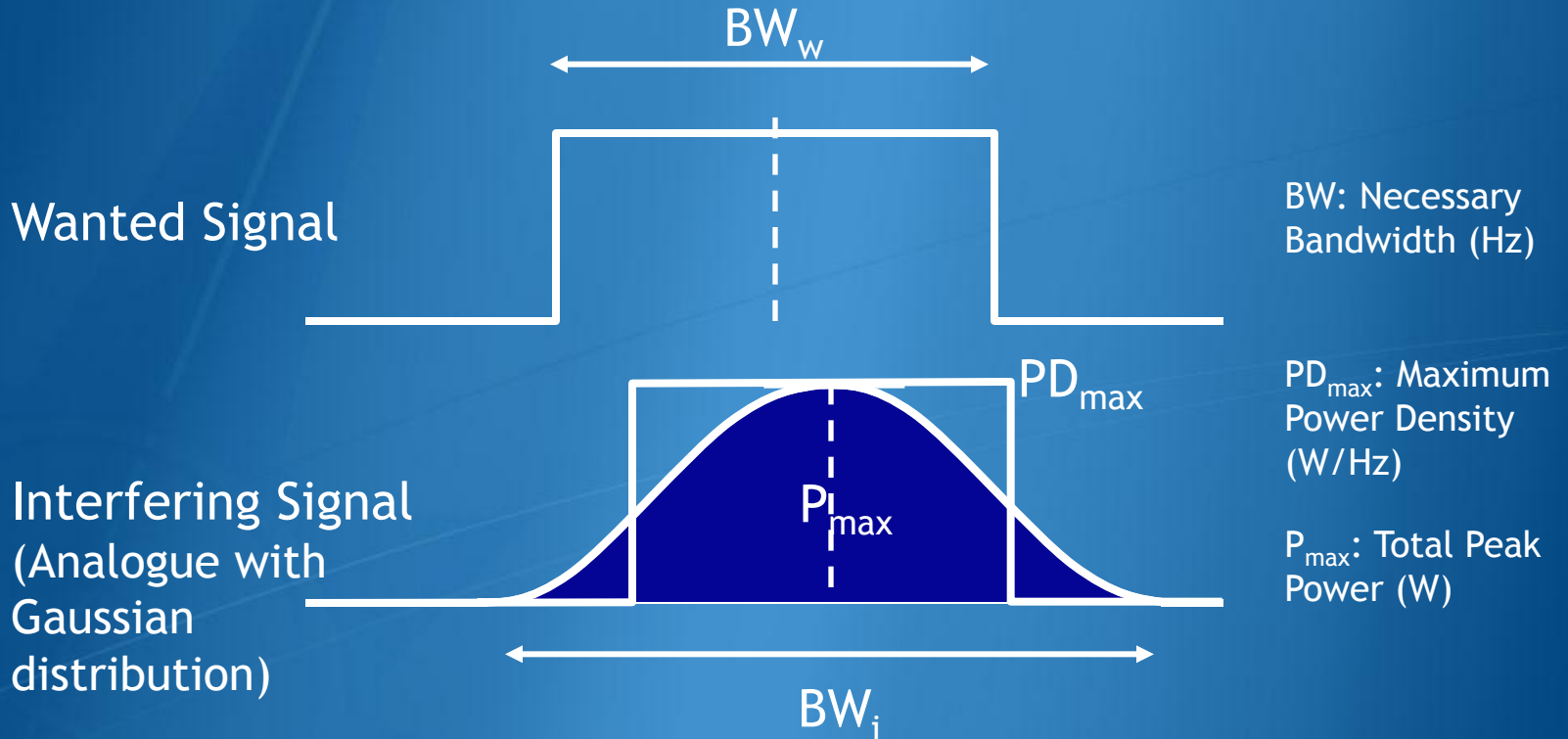
Method 1:



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

Finding C/I Get Adjustment Factor

Method 2:

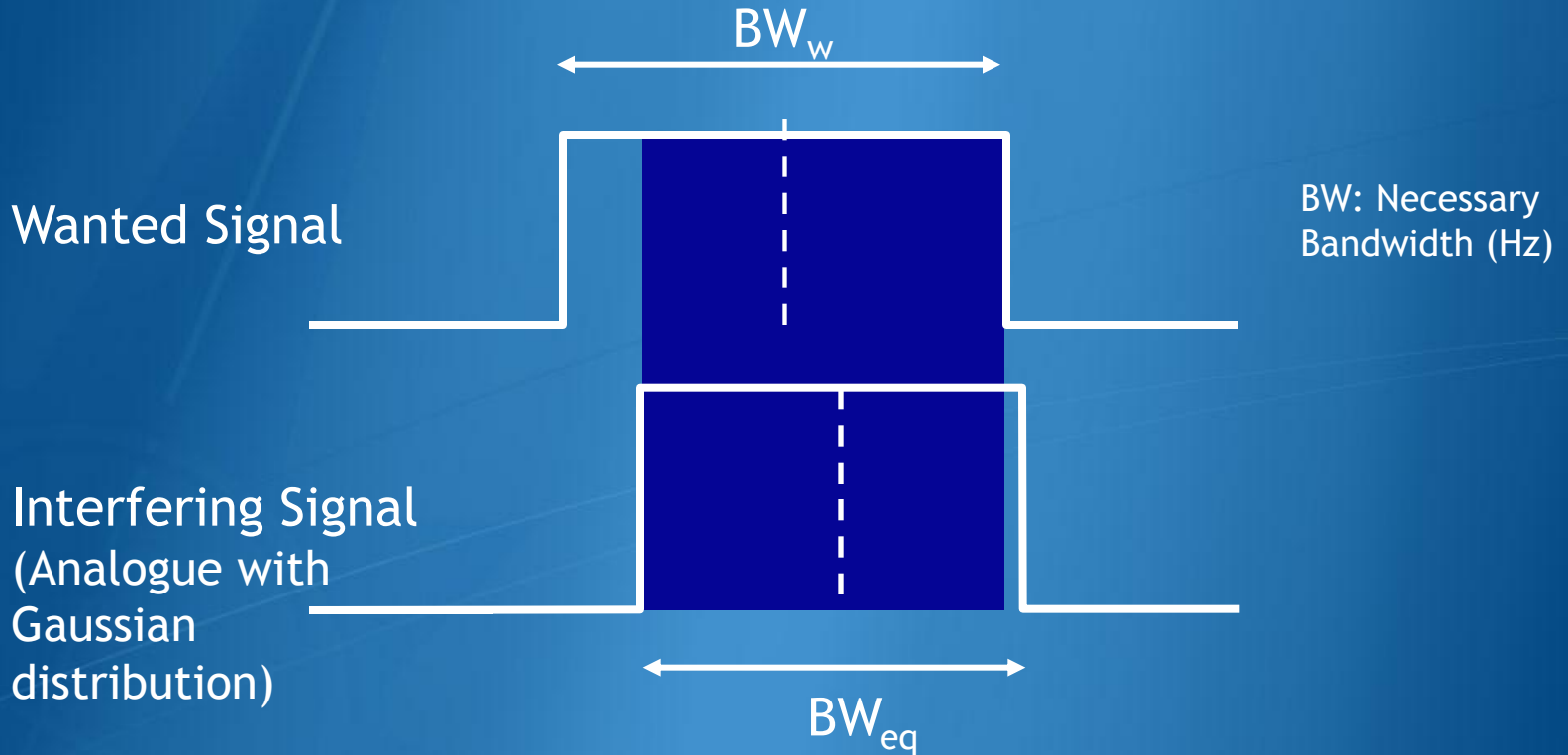


$$BW_{eq} = P_{max} / PD_{max}$$

Finding C/I

Get Adjustment Factor

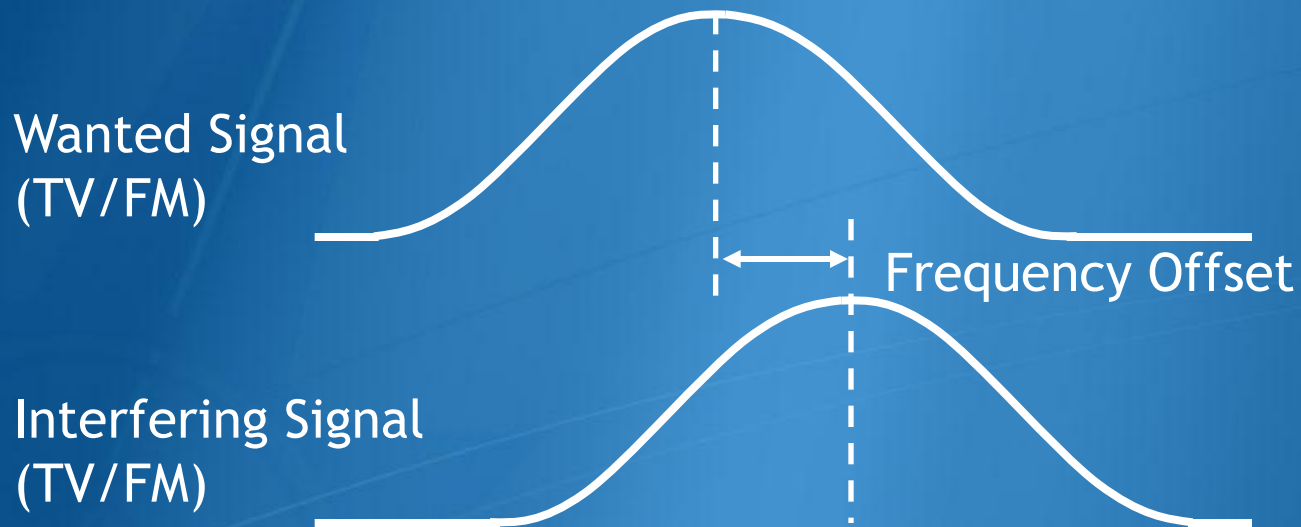
Method 2:



$$I_a = 10 \log_{10} (BW_{\text{overlap}} / BW_{eq})$$

Finding C/I Get Adjustment Factor

Method 3:



Relative Protection Ratio adjustment factor is

- derived from protection masks using frequency offset
- a function of overlapping bandwidths of wanted and interfering signals

Finding C/I

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

To summarize:

- From Appendix 4 data, find basic calculated C/I_b
- From Table 1 in Section B3 of Rules of Procedure, find Interference Adjustment Factor I_a
- $C/I = C/I_b - I_a$

Finding C/I Multiple interfering narrowband carriers

Wanted Signal



Interfering Signal



- Interfering transponder fully loaded with N narrowband carriers
- N is maximized by transponder bandwidth (item C.3.a of Appendix 4) and maximum total peak power (item C.8.d.1) or the maximum aggregate power supplied to the E/S transmit antenna (item C.8.g.1)

Calculating Margin

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

- Positive or Zero Margin:
No harmful interference
- Negative Margin:
Potential for harmful interference

Results

C/I Access Tool - v6042

28.04.2006

List of Existing Networks already Selected

Incoming Network

ADM / ORG: **RUS / IK** Date of Receipt: **27.05.2008**
 Network name: **INTERSPUTNIK-75E-Q** Orbital Position: **75.00°East**
 Notice (tgt) Id.No.: **105500291** () Notice reason: **N**

Date on and before which existing assignments are taken into account: 27.05.2008
 (except for incoming network group Ids with a 2D-date older than this date, if so the 2D-date is used instead)

Existing Network(s)

No	ADM / ORG	Network name	Notice Id.No. (reason)	(target Id.No.)	Orb. Pos.	See Notes
1	THA /	THAICOM-AK2	96500002	(N) ()	78.50°E	

Up-link findings for all networks - Group level

Incoming Network: **INTERSPUTNIK-75E-Q** Notice Id.No.: **105500291** (N) ADM/ORG: **RUS IK**
 Orbital Position: **75.00°East** Beam: **AKS** Em / Rx: **R** S.A.: **1** Date of Receipt: **27.05.2008**

Date on or before which existing assignments were taken into account 27.05.2008
 (except for incoming network group Ids with a 2D-date older than this date, if so the 2D-date is used instead)

Group Id./FR	Findings	Min Margin Of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
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Beam: **AKS** Emission / Reception: **R** Service Area No: **1**

Group Id./FR	Findings	Min Margin of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
108643477	ChkFdgAssgmtLeve	-5.55 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-4.15 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643478	ChkFdgAssgmtLeve	-9.10 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-1.81 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643479	ChkFdgAssgmtLeve	-3.60 dB	THAICOM-AK2 (No.1: NctId. 96500002)	4.46 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643480	ChkFdgAssgmtLeve	-2.24 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-7.81 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643481	ChkFdgAssgmtLeve	-6.10 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-1.81 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643482	ChkFdgAssgmtLeve	-3.60 dB	THAICOM-AK2 (No.1: NctId. 96500002)	6.01 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643483	Unfavourable	-6.24 dB	THAICOM-AK2 (No.1: NctId. 96500002)	3.79 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA

Beam: **BKS** Emission / Reception: **R** Service Area No: **1**

Group Id./FR	Findings	Min Margin of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
108643484	ChkFdgAssgmtLeve	30.55 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-3.95 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643485	ChkFdgAssgmtLeve	23.81 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-1.61 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643486	Favourable	29.31 dB		6.21 dB		THA
108643487	Favourable	26.67 dB		3.99 dB		THA

Beam: **CKS** Emission / Reception: **R** Service Area No: **1**

Group Id./FR	Findings	Min Margin of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
108643488	ChkFdgAssgmtLeve	27.84 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-3.85 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643489	ChkFdgAssgmtLeve	21.10 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-1.51 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
108643490	Favourable	26.60 dB		6.31 dB		THA
108643491	Favourable	23.96 dB		4.09 dB		THA

Beam: **DKS** Emission / Reception: **R** Service Area No: **1**

Group Id./FR	Findings	Min Margin of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
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C/I Access Tool - v6042

28.04.2006

Downlink findings for all networks - Group level

Incoming Network: **INTERSPUTNIK-75E-Q** Notice Id.No.: **105500291** (N) ADM/ORG: **RUS IK**
 Orbital Position: **75.00°East** Beam: **001** Em / Rx: **E** S.A.: **1** Date of Receipt: **27.05.2008**

Date on or before which existing assignments were taken into account 27.05.2008
 (except for incoming network group Ids with a 2D-date older than this date, if so the 2D-date is used instead)

Group Id./FR	Findings	Min Margin Of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
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Beam: **001** Emission / Reception: **E** Service Area No: **1**

Group Id./FR	Findings	Min Margin of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
108643462	This Beam is Favour	999.99 dB		999.99 dB		
108643463	This Beam is Favour	999.99 dB		999.99 dB		
108643506	This Beam is Favour	999.99 dB		999.99 dB		
108643507	This Beam is Favour	999.99 dB		999.99 dB		

Beam: **002** Emission / Reception: **E** Service Area No: **1**

Group Id./FR	Findings	Min Margin of Incoming	Most Interfering Existing Network	Min Margin of Existing	Most interfered Existing Network	Existing * ADM / ORG
105625655	Unfavourable	-5.33 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-3.11 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
105625699	ChkFdgAssgmtLeve	-7.33 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-3.19 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
105625720	ChkFdgAssgmtLeve	-1.82 dB	THAICOM-AK2 (No.1: NctId. 96500002)	-2.81 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
105625722	ChkFdgAssgmtLeve	-1.12 dB	THAICOM-AK2 (No.1: NctId. 96500002)	0.19 dB	THAICOM-AK2 (No.1: NctId. 96500002)	THA
105625728	Unfavourable	-1.82 dB	THAICOM-A (No.1: NctId. 96500002)			
105625729	Unfavourable	-1.12 dB	THAICOM-A (No.1: NctId. 96500002)			

Beam: **AKS** Emission / Reception: **E**

Group Id./FR	Findings	Min Margin of Incoming	Most Interf	Existing Network	Existing Network	ADM / ORG
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EXAMPLE 1

Wanted

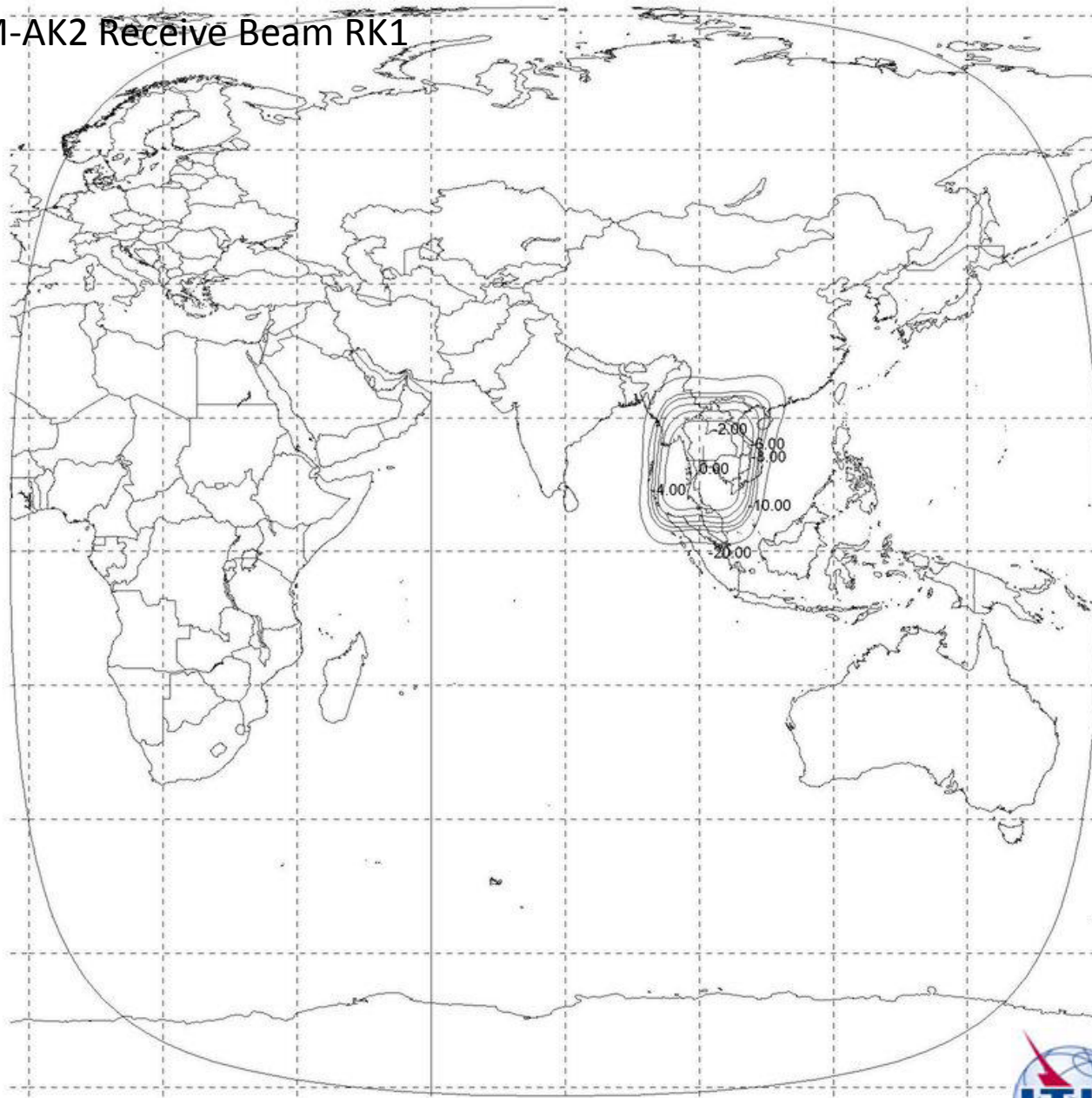
B1a/BR17 Beam designation		RR1	B1b Steerable			B2 Em-Rcp		R	B3a1 Max. co-polar gain		38.8	B3d Pointing accuracy		0.08									
BR7a/BR7b Group id.		96604123	BR1 Date of receipt		08.01.1996	C2c RR No. 4.4																	
A2a Date of bringing into use		17.12.1993	A2b Period of valid.		35	A3a Op. agency		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	C5a Noise temperature		603															
C4b Nature of service		CP	C6a Polarization type			C6b Polarization angle																	
C11a1 Service area no.		1	C11a2 Service area			C11a3 Service area diagram		1															
A5/A6 Coordinations/Agreements		RR1060	0	G		TON		URS	USA	USA/IT													
C2a1 Assigned frequency																							
14.3429	GHz	14.4055	GHz	14.4681	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 Attn.		C8c3 Min. pwr dens.		C8c4 Attn.		C8e1 C/N ratio		C8e2 Attn.					
AR11/A/727		1 22K0G7W--		-15		-58.4																	
AR11/C/2196																							
C10b1 Assoc. earth station id.		C10b2 Type		C10c1 Geographical coord.		C10c2 Ctry		C10d1/C10d2 Cls. / Nat.		C10d3 Max. iso. gain		C10d4 Bmwdth		C10d7 Ant. diameter		C10d9 Ant. dim. (DGSO)		C8g1 Max. aggr. pwr.		C8g2 Aggr. bandwidth		C8g3 Transp. bandwidth = Aggr. bandwidth	
TYPICAL K2 (6/1.2)		T				1 TC CP		57		0.25													
C10b1 Assoc. earth station id.		Co-polar ref. pattern		Coef. A		Coef. B		Coef. C		Coef. D		Phi1		Co-polar rad. diag.									
TYPICAL K2 (6/1.2)		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																							

Interfering

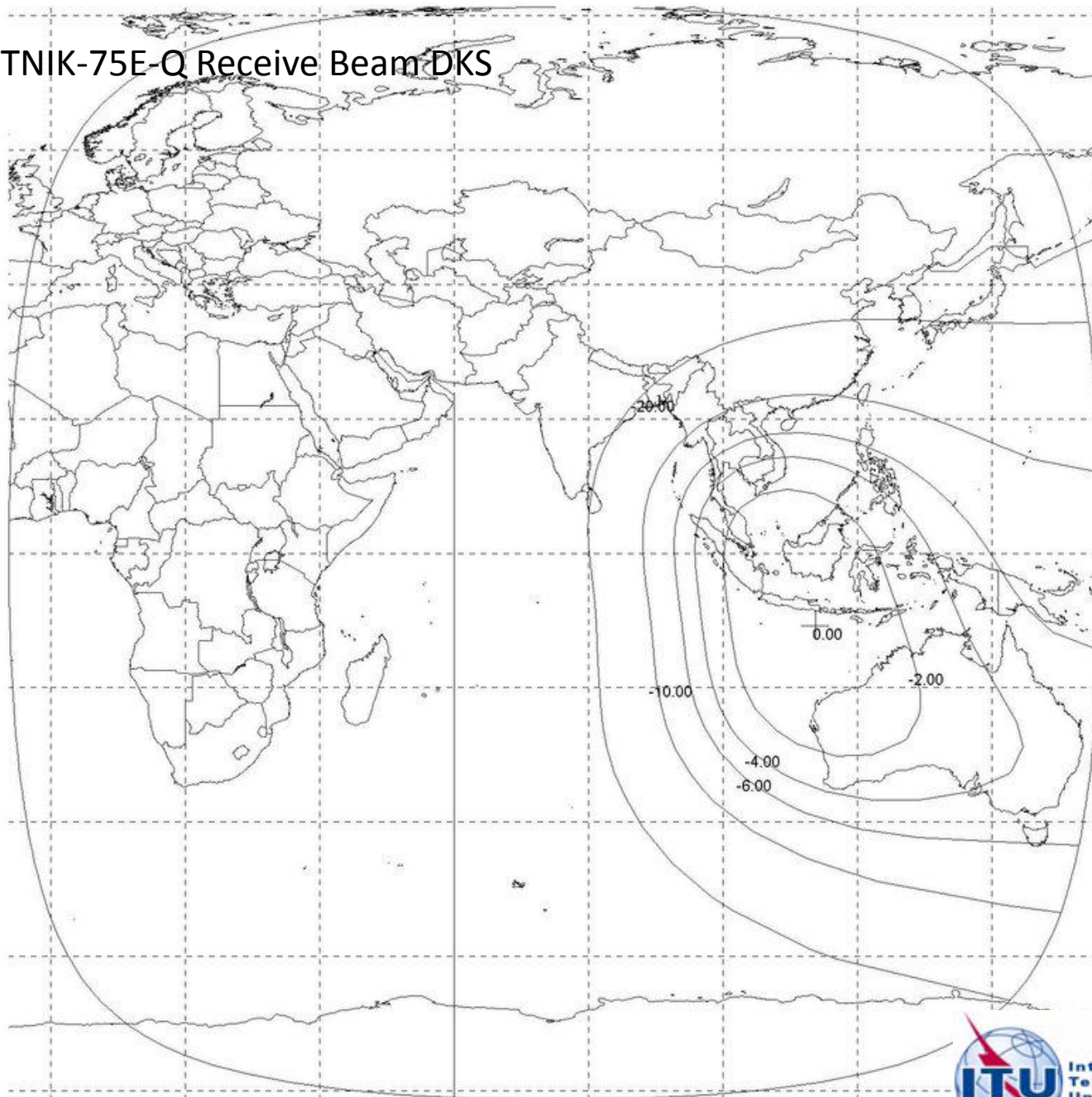
INTERSPUTNIK-75E-Q (105500291)

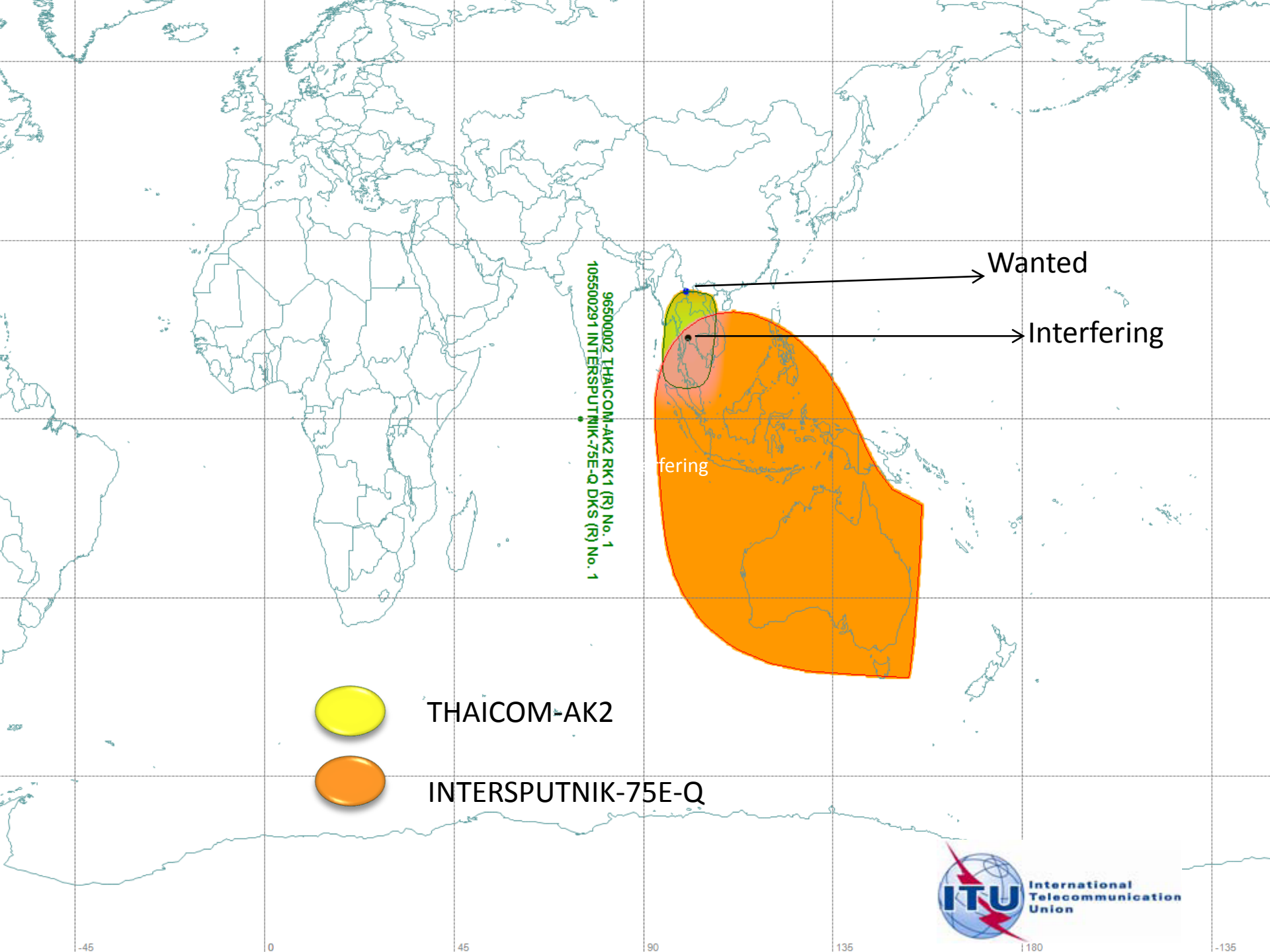
B1a/BR17 Beam designation <input type="text" value="DKS"/>		B1b Steerable <input type="text"/>		B2 Emi-Rcp <input type="text" value="R"/>		B3a1 Max. co-polar gain <input type="text" value="37"/>		B3d Pointing accuracy <input type="text" value="0.1"/>	
BR7a/BR7b Group id. <input type="text" value="108643494"/>		BR1 Date of receipt <input type="text" value="27.05.2008"/>		C2c RR No. 4.4 <input type="text"/>					
A2a Date of bringing into use <input type="text" value="01.09.2005"/>		A2b Period of valid. <input type="text" value="40"/>		A3a Op. agency <input type="text" value="2"/>		A3b Adm. resp. <input type="text" value="A"/>		BR16 Value of type C8b <input type="text"/>	
BR62 Expiry date for bringing into use <input type="text" value="07.09.2005"/>		BR63 Confirmed date of bringing into use <input type="text" value="01.09.2005"/>				BR64 Date of receipt of 1st Res49 <input type="text"/>			
BR14 Special Section <input type="text"/>									
C4a Class of station <input type="text" value="EC"/>		C3a Assigned freq. band <input type="text" value="40000"/>				C5a Noise temperature <input type="text" value="1400"/>			
C4b Nature of service <input type="text" value="CP"/>		C6a Polarization type <input type="text" value="M"/>				C6b Polarization angle <input type="text"/>			
C11a1 Service area no. <input type="text" value="1"/>		C11a2 Service area <input type="text"/>				C11a3 Service area diagram <input type="text" value="8"/>			
A5/A6 Coordinations/Agreements		<input type="text" value="11.41"/> <input type="text" value="9.7"/> <input type="text" value="N/9.7"/>		<input type="text" value="X"/> <input type="text" value="O"/> <input type="text" value="O"/>		IND BRU CHN F/EUT G INS LAO MLA RUS SNG THA TUR UAE USA VTN TON			
C2a1 Assigned frequency									
<input type="text" value="14.02"/> GHz		<input type="text" value="14.1"/> GHz		<input type="text" value="14.18"/> GHz		<input type="text" value="14.26"/> GHz		<input type="text" value="14.34"/> GHz	
<input type="text" value="14.06"/> GHz		<input type="text" value="14.14"/> GHz		<input type="text" value="14.22"/> GHz		<input type="text" value="14.3"/> GHz		<input type="text" value="14.38"/> GHz	
<input type="text" value="14.42"/> GHz		<input type="text" value="14.46"/> GHz							
A13 Ref. to Special Sections		C7a Design. of emission		C8a1/C8b1 Max. peak pwr		C8a2/C8b2 Max. pwr dens.		C8c1 Min. peak pwr	
<input type="text" value="API/A/428"/> <input type="text" value="CR/C/144"/>		<input type="text" value="1"/> <input type="text" value="2"/> <input type="text" value="3"/>		<input type="text" value="36M0F8W--"/> <input type="text" value="6M60G7W--"/> <input type="text" value="45K0G1X--"/>		<input type="text" value="27"/> <input type="text" value="16.5"/> <input type="text" value="-1.5"/>		<input type="text" value="-39"/> <input type="text" value="-50.5"/> <input type="text" value="-48"/>	
						<input type="text" value="5.5"/> <input type="text" value="-12.5"/>		<input type="text" value="Min. pwr dens."/> <input type="text" value="-50.5"/> <input type="text" value="-61.5"/> <input type="text" value="-59"/>	
								<input type="text" value="C8c4"/> <input type="text" value="C8e1"/> <input type="text" value="C8e2"/>	
								<input type="text" value="11"/> <input type="text" value="8.6"/> <input type="text" value="9.5"/>	
C10b1 Assoc. earth station id.		C10b2 Type		C10c1 Geographical coord.		C10c2 Ctry		C10d1/C10d2 Cls. / Nat.	
<input type="text" value="TYPICAL-4.5"/>		<input type="text" value="T"/>						<input type="text" value="1"/> TC CP	
								<input type="text" value="54.5"/> <input type="text" value="0.32"/>	
								<input type="text" value="C10d7"/> <input type="text" value="C10d9"/> <input type="text" value="C8g1"/> <input type="text" value="C8g2"/> <input type="text" value="C8g3"/>	
								<input type="text" value="Ant. diameter"/> <input type="text" value="Ant. dim. (DGSO)"/> <input type="text" value="Max. aggr. pwr."/> <input type="text" value="Aggr. bandwidth"/> <input type="text" value="Transp. bandwidth = Aggr. bandwidth"/>	
C10d5a Co-polar antenna pattern									
C10b1 Assoc. earth station id.		Co-polar ref. pattern		Coef. A		Coef. B		Coef. C	
<input type="text" value="TYPICAL-4.5"/>		<input type="text" value="REC-580"/>						<input type="text" value="Phi1"/> <input type="text" value="Co-polar rad. diag."/>	
Findings		2D Date of protection <input type="text" value="19.08.2005"/>		13A Conformity with RR <input type="text" value="A-"/> <input type="text" value="N-"/> <input type="text" value="N-"/>		13B1 Provision <input type="text" value="11.41"/>		13B2 Remarks <input type="text"/>	
13C Remarks <input type="text" value="E/270508"/>									

THAICOM-AK2 Receive Beam RK1



INTERSPUTNIK-75E-Q Receive Beam DKS





96500002 THAICOM-AK2 RK1 (R) No. 1
105500291 INTERSPUTNIK-75E-Q DKS (R) No. 1

Wanted

Interfering

Interfering



THAICOM-AK2



INTERSPUTNIK-75E-Q



EXAMPLE 1

interference from TVFM to Digital (narrow)

Wanted	THAICOM-AK2 (78.5 deg E)	Longitudinal Tolerance	0.1
Interfering	INTERSPUTNIK-75E-Q (75 deg E)	Longitudinal Tolerance	0.1

UPLINK

	Wanted		Interfering
Beam	RK1		DKS
Group ID	96604123		108643494
Emission	22K0G7W		36M0F8W
Sidelobe			REC-580
Wanted E/S Long	100.02	Interfering E/S Long	100.53
Wanted E/S Lat	21.41	Interfering E/S Lat	13.57
Topocentric Angle			3.79
Frequency	14340		
	Wanted		Interfering
Pes	-15	Pes	27
Ges	57	Ges(ϕ)	14.53
FSL	-206.89	FSL	-206.83
Gs	38.8		
ES relative to beam peak	-4.87	ES relative to beam peak	0
Ts	603		
BW (kHz)	22000		
Carrier	-130.96	Interference	-126.50
Noise	-157.37		
C/N	26.41		
C/I basic	-4.46		
adj factor	22.58	Equivalent BW (MHz)	3.98
C/I adj	18.11		
C/I required	26.11	C/N+5.5+3.5log(Wanted Carrier BW)	
Margin	-8.00		
to add 1.87	-6.13	Wanted Carrier is Digital	



EXAMPLE 2

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 0.08

BR7a/BR7b Group id. 96604135 **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 1

A5/A6 Coordinations/Agreements RR1060 0 G TON URS USA USA/IT

C2a1 Assigned frequency

12.5949 GHz 12.6575 GHz 12.7201 GHz

A13 Ref. to Special Sections	C7a	C8a1/C8b1	C8a2/C8b2	C8c1	C8c2	C8c3	C8c4	C8e1	C8e2
	Design. of emission	Max. peak pwr	Max. pwr dens.	Min. peak pwr	Attch.	Min. pwr dens.	Attch.	C/N ratio	Attch.
AR11/A/727 AR11/C/2196 AP30/A/127	1 22K0G7W--	-14.9	-58.3						

C10b1	C10b2	C10c1	C10c2	C10d1/C10d2	C10d3	C10d4	C10d6	C10d7	C10d9
Assoc. earth station id.	Type	Geographical coord.	Ctry	Cls. / Nat.	Max. iso. gain	Bmwdth	Noise temp.	Ant. diameter	Ant. dim. (DGSO)
TYPICAL K2 (6/1.2)	T			1 TC CP	41.5	1.45	200		

C10d5a Co-polar antenna pattern

C10b1	Co-polar ref. pattern	Coef. A	Coef. B	Coef. C	Coef. D	Phi1	Co-polar rad. diag.
TYPICAL K2 (6/1.2)	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



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 0.08

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 1

A5/A6 Coordinations/Agreements RR1060 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 Attch.	C8c3 Min. pwr dens.	C8c4 Attch.	C8e1 C/N ratio	C8e2 Attch.
	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 Bmwdth	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



Interfering

INTERSPUTNIK-75E-Q (105500291)

B1a/BR17 Beam designation **B1b** Steerable **B2** Emi-Rcp **B3a1** Max. co-polar gain **B3d** Pointing accuracy

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

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

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

BR14 Special Section

C4a Class of station **C3a** Assigned freq. band

C4b Nature of service **C6a** Polarization type **C6b** Polarization angle

C8d1 Max. tot. peak pwr. **C8d2** Contiguous bandwidth

C11a1 Service area no. **C11a2** Service area **C11a3** Service area diagram

A5/A6 Coordinations/Agreements BRU CHN F/EUT G INS LAO RUS SNG THA TUR UAE USA VTN
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 Attch.	C8c3 Min. pwr dens.	C8c4 Attch.	C8e1 C/N ratio	C8e2 Attch.
	API/A/428	1	36M0F8W--	5.9	-60.1	0.9		-65.1		16.6
CR/C/144	2	32M2G7W--	14.9	-60.1	7.9		-67.1		23.1	
	3	45K0G1X--	-16.6	-63.1	-23.6		-70.1		20.2	

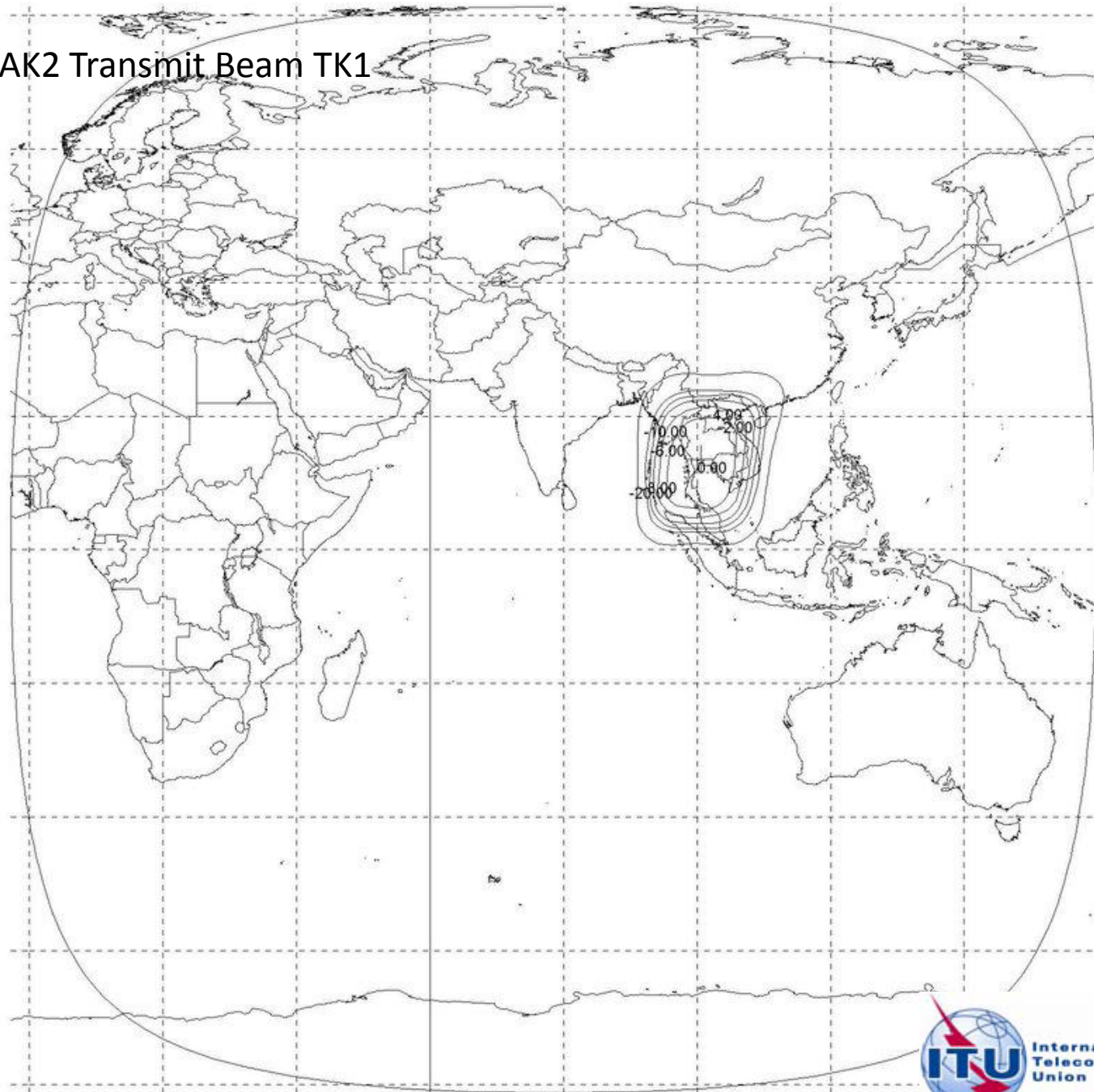
C10b1 Assoc. earth station id.	C10b2 Type	C10c1 Geographical coord.	C10c2 Ctry	C10d1/C10d2 Cls. / Nat.	C10d3 Max. iso. gain	C10d4 Brmwdth	C10d6 Noise temp.	C10d7 Ant. diameter	C10d9 Ant. dim. (DGSO)
TYPICAL-4, 5	T			1 TC CP	53.3	0.36	200		

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-4, 5	REC-580						

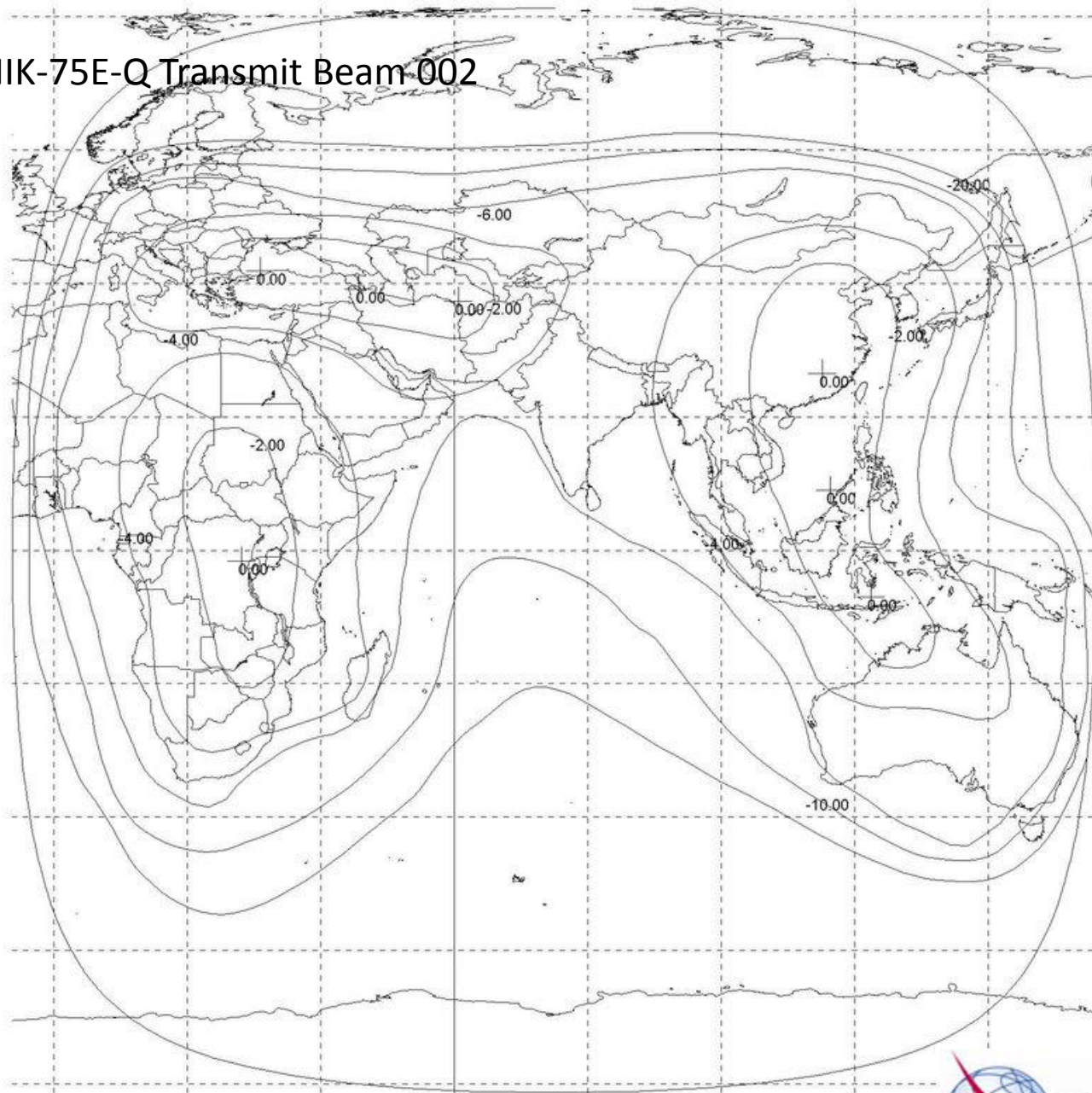
Findings **2D** Date of protection **13A** Conformity with RR **13B1** Provision **13B2** Remarks **13B3** Date of Review

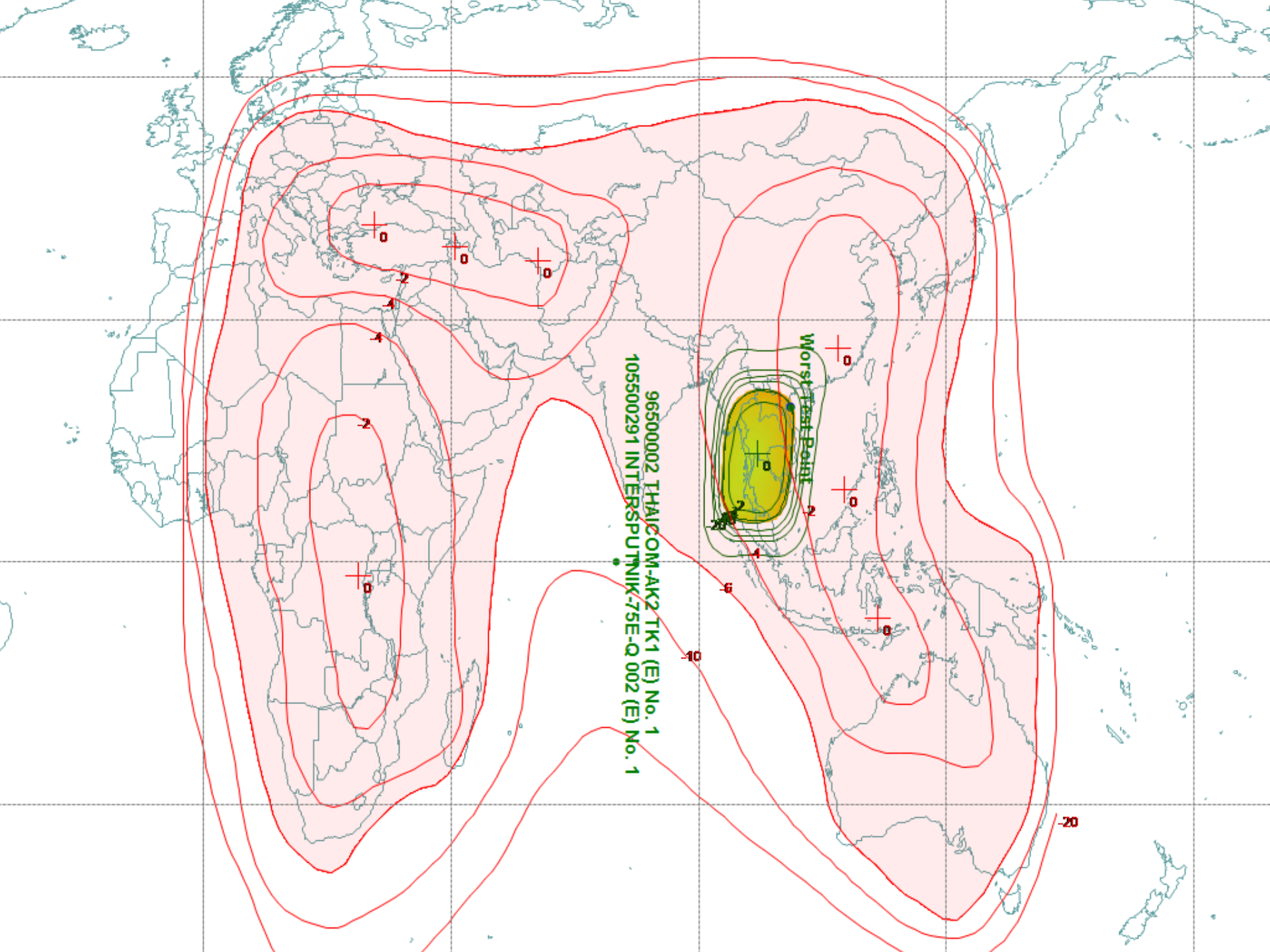
13C Remarks

THAICOM-AK2 Transmit Beam TK1



INTERSPUTNIK-75E-Q Transmit Beam 002





96500002 THAI COM-AK2 TK1 (E) No. 1
105500291 INTERSPUTNIK-7SE-Q 002 (E) No. 1

Worst Case Point

20

Example 2

Interference from Digital(narrow) to Digital(wide)

Wanted	THAICOM-AK2 (78.5 deg E)	Longitudinal Tolerance	0.1
Interfering	INTERSPUTNIK-75E-Q (75 deg E)	Longitudinal Tolerance	0.1

DOWNLINK

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

Frequency 12585

	Wanted	Interfering
Ps	15.1	-16.6
Gs	38.9	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



Example 3

Interference from Digital(wide) to Digital(narrow)

Wanted	THAICOM-AK2 (78.5 deg E)	Longitudinal Tolerance	0.1
Interfering	INTERSPUTNIK-75E-Q (75 deg E)	Longitudinal Tolerance	0.1

DOWNLINK

	Wanted	Interfering
Beam	TK1	002
Group ID	966604135	105625699
Emission	22K0G7W	32M2G7W
Wanted E/S Long	106.86	
Wanted E/S Lat	18.85	
Topocentric Angle	3.73	
Wanted E/S Sidelobe Pattern	A-25log(θ)	

Frequency 12585

	Wanted		Interfering
Ps	-14.9	Ps	14.9
Gs	38.9	Gs	37
ES relative to wanted beam		ES relative to interfering beam	
peak	-4	peak	-1.58
FSL	-205.82	FSL	-205.87
Ges	41.5	Ges(θ)	14.71
BW (Hz)	22000		32000000
Tes	200		

Carrier	-144.32	Interference	-140.84
Noise	-162.17		
C/N	17.85		
C/I basic	-3.48		
adj factor	-31.63		
C/I adj	28.15		
C/I required	30.05		C/N+12.2
Margin	-1.90		
to add 1.87	-0.03		Wanted Carrier is Digital



Mitigation Methods

- Improve sidelobe performance
 - better performance antenna
 - use larger antennas
- Limit service area
- Power reduction
- Limitation of number of carriers
- Analog to digital
- Frequency planning
 - Transponder planning
- Polarization
- Establishment of point of contacts / procedures
- Business collaboration – JVs
- Etc.

Constraints

- Cost
- Feasibility
- Types of services
- Existing users
- Flexibility
- Quality of Service
- Type of Applications (DTH, VSAT, TV Headend,etc)
- Design considerations
- Etc.