The Satellite Orbits ,Filing & Coordination

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Introduction

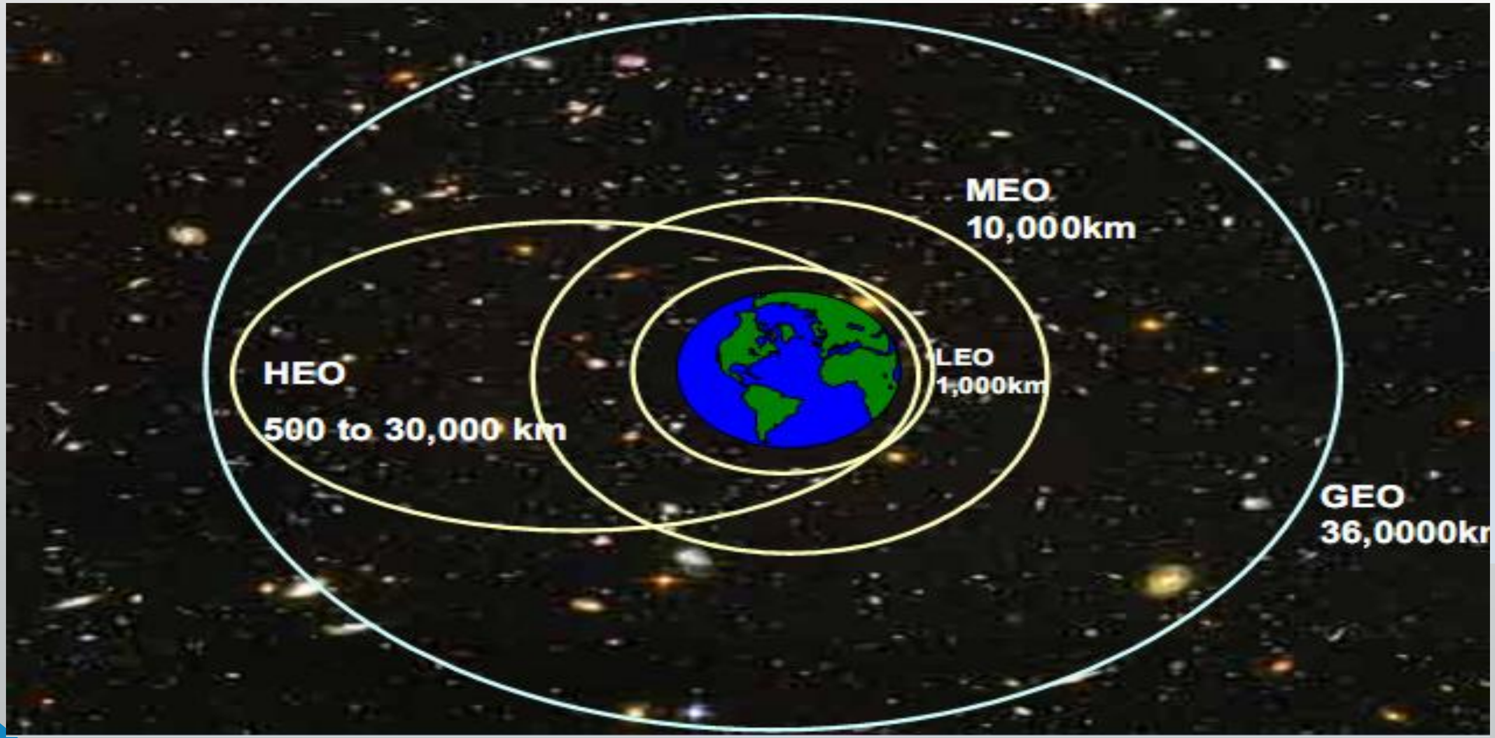
We'll discuss:

- Satellite Orbits , Services and Frequencies
- ITU Role and Procedures
- The Satellite Network Filing
- The Interference and Coordination

Satellite Orbits

✓**GSO**: Geostationary Satellite Orbit

✓**NGSO**: Non Geostationary Satellite Orbit



- **LEO**: Low Earth Orbit
- **MEO**: Medium Earth Orbit
- **HEO**: Highly Elliptical Orbit

Some Satellite Frequency Bands

Band	Frequency Range (Approx)	Major Services	Uses
L	1 – 2 GHz	BSS, MSS, RNSS	•INMARSAT/THURAYA mobile services •Digital Radio Broadcasting •GPS/GALLIEO Navigation
C	4 – 6 GHz	FSS	Commercial trunk applications and some VSAT
X	7 – 8 GHz	FSS, MSS	Military Communications
Ku	10 – 14 GHz	FSS, BSS	Commercial DTH, VSAT services
Ka	18 – 30 GHz	FSS, MSS	Military and Commercial

ITU Role:

- ITU is the United Nations specialized agency for information and communication technologies
- Responsible to allocate global radio spectrum and satellite orbits
- Also responsible of International coordination, notification and recording procedures for space systems and earth stations

Two mechanisms of access to orbit / spectrum:

<u>Coordination Approach</u>
Efficient use
First come, first served for actual requirements

<u>Planning Approach</u>
Equitable access
Plan for future use

Coordination Procedure "First Come, First Served"

- Right is acquired through coordination with administrations concerned by actual usage
- **Efficient** spectrum / orbit management
- Also referred to as the 'unplanned bands'
- Most widely used procedure for gaining access to the spectrum/orbit resource

Plan Procedure

- Guarantee for **equitable** access to the spectrum / orbital resources
  - Spectrum set aside for future use by all countries
  - Predetermined orbital position & frequency spectrum
- Plans exist for both BSS and FSS
- Generally less widely implemented than the unplanned bands.

Iraqi Satellite filings

- *Iraqi Files as Plans*

- BSS plan at 50°E
- FSS plan at 65.45°E

- *Iraqi Files as un planned*

- SUMER-1 network is at CR/C level (Valid until 13/02/2019)

- SUMER-2 network is at CR/C level (Valid until 13/02/2019)

Situation at 50°E

Position is unfavorable

- 48°E - Operations by EUTELSAT
- 48°E - Future operations by Ukraine
- 50°E - Operations by Intelsat
- 50°E - operations by Sri-Lanka
- 51°E - Operations by SES
- 52°E - operations by Turkmenistan Ministry of Communication (under filing from Monaco)
- 53°E - Operations by Yahsat

Situations at 65.45°E

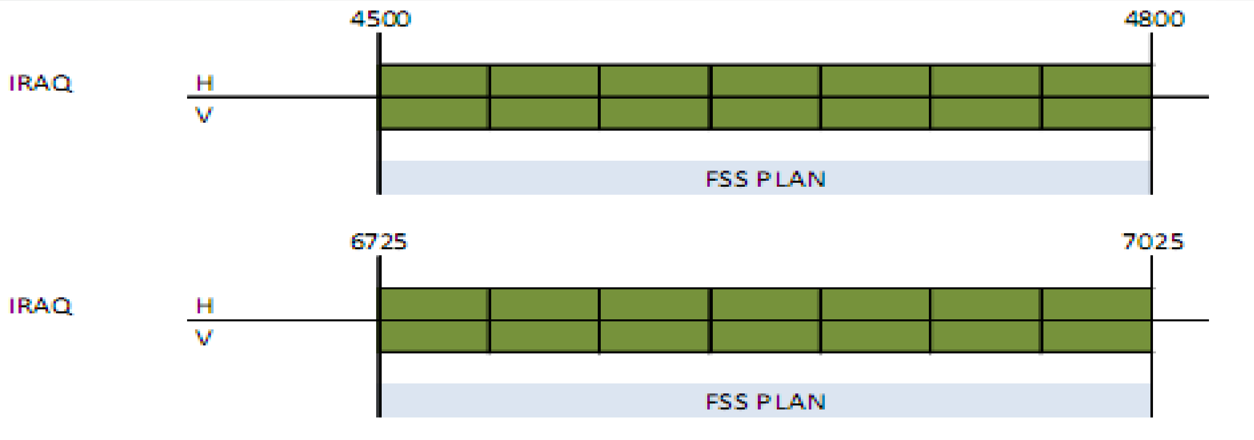
Position is favorable

FREQUENCY INFORMATION

BEAM NAME	EMISS/REC	FREQUENCY (MHZ)	BANDWIDTH (kHZ)	FREQUENCY MIN (MHZ)	FREQUENCY MAX (MHZ)	CLASS OF STN
IRQ00_06	R	6875.00000	300000	6725.000	7025.000	EC
IRQ00_13	R	13000.00000	500000	12750.000	13250.000	EC
IRQ00_04	E	4650.00000	300000	4500.000	4800.000	EC
IRQ00_11	E	10825.00000	250000	10700.000	10950.000	EC
IRQ00_11	E	11325.00000	250000	11200.000	11450.000	EC

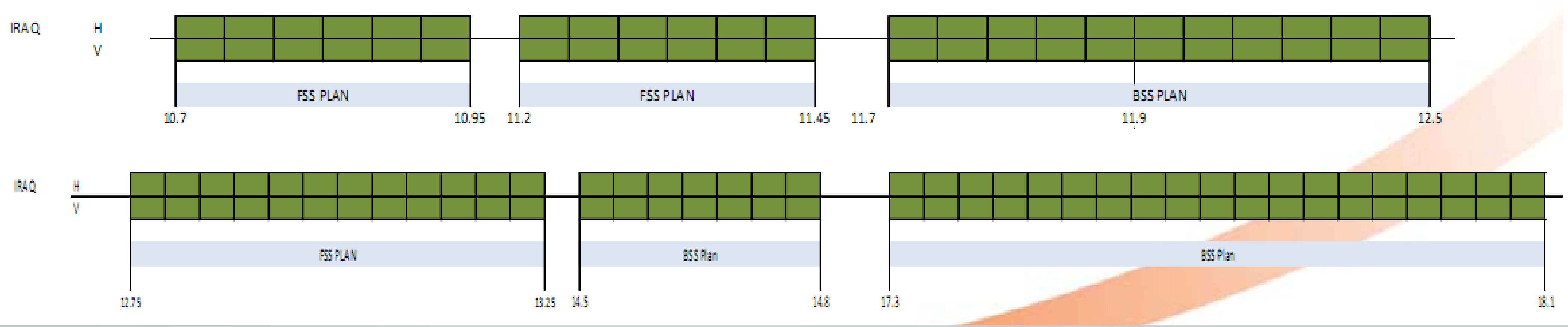
C-band mission for position 65.45°E

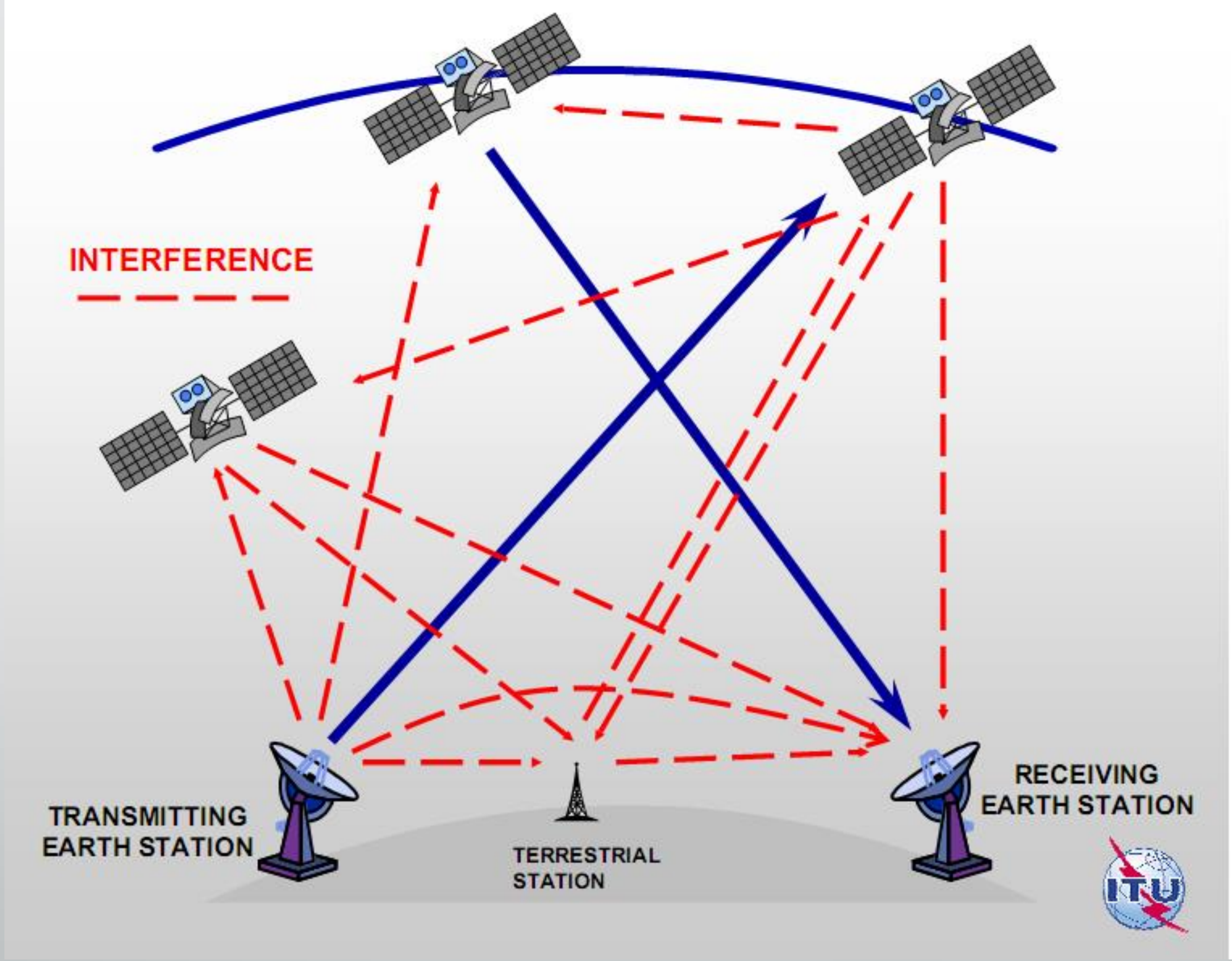
Band	Beam Designation	frequency band	direction	Polar	Nb of Transponders	Comments
C-band	Global, semi-global or regional	4500-4800 MHz	downlink	2 Polar.	14 x 36 MHz	FSS Plan
		6725-7025 MHz	uplink	2 Polar.		



Ku-band mission for position 65.45°E

Band	Beam Designation	frequency band	direction	Polar	Nb of Transponders	Comments
Ku-band	Regional Beam	10.7-10.95 GHz	downlink	2 Polar.	24 x 36 MHz	FSS Plan
		11.2-11.45 GHz	downlink	2 Polar.		
		12.75-13.25 GHz	uplink	2 Polar.		
		11.7-12.2 GHz	downlink	2 Polar.	22 x 36 MHz	BSS Plan
		14.5-14.8 GHz	uplink	2 Polar.		
		17.3-18.1 GHz	uplink	2 Polar.		




INTERFERENCE
TRANSMITTING EARTH STATION
TERRESTRIAL STATION
RECEIVING EARTH STATION
ITU

my Master Dissertation

Interference and Coordination between Satellite and Terrestrial Systems Operating at C-Band in Iraq

Distinction Grade

- The frequency spectrum is a limited natural resources.
- Usually a multi radio communication services share the same frequency
- Sharing between the services should enable the effective and efficient operation of shared services
- ITU had placed general restrictions on the emissions coming from satellite into terrestrial stations in term of power flux density of the satellite in specific reference bandwidth.

The Aim

The goal of this study is to analysis the interference between satellite services and terrestrial in the C-band in Iraq, with a focus on the interference resulting from space services towards the terrestrial services , the culmination of the project there will be a data base for satellites cover Iraqi territory in c-band with determining signal strength of these satellite and its impact on services in ground ,so to develop an interference map for Iraq quantifying the total interference signal power emanating from C-band into terrestrial antennas in microwave radio relay systems.

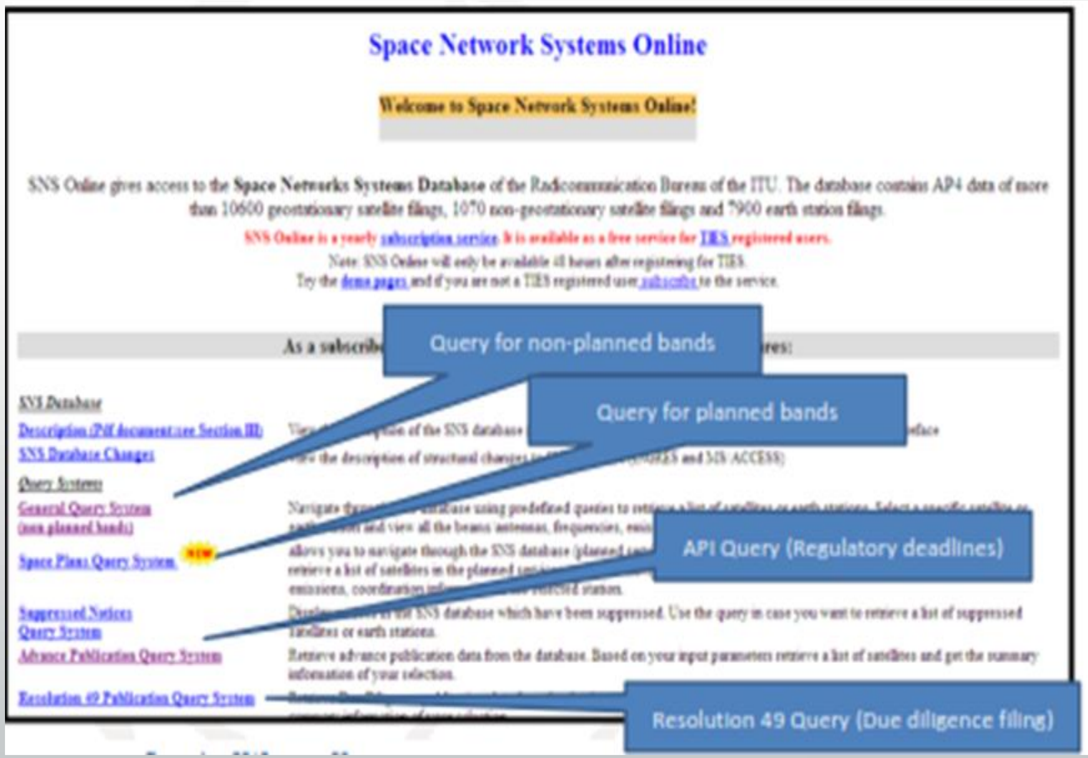
The Benefit

This study will be beneficial the Iraqi telecommunication sector in general in identifying interference analysis, also to have clear vision of the interference in C-band so that a correct plan of use can be put in place to the fixed terrestrial services in this band.

ITU Recourses to manage the interference from satellite services into terrestrial serveries

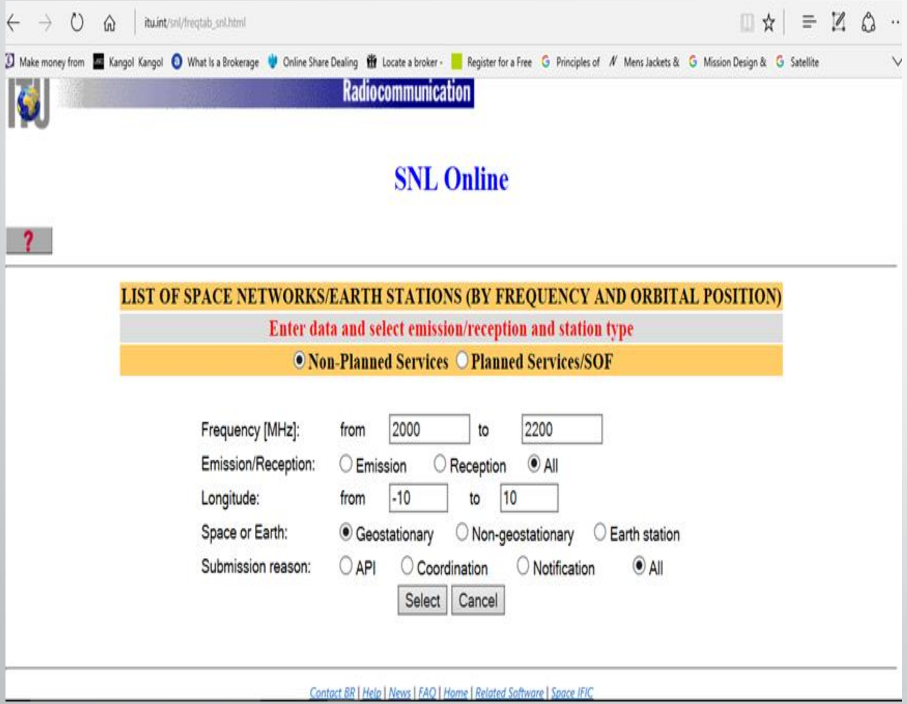
- **BR IFIC** for Space services: is an electronic document in DVD-ROM format, published by ITU- every two weeks contains contain many databases relating to satellite networks and earth stations recorded in the Master International Frequency Register (MIFR) of ITU

- **The Space Network Systems (SNS)** It is an online service produced by ITU which allows the user to review ITU database

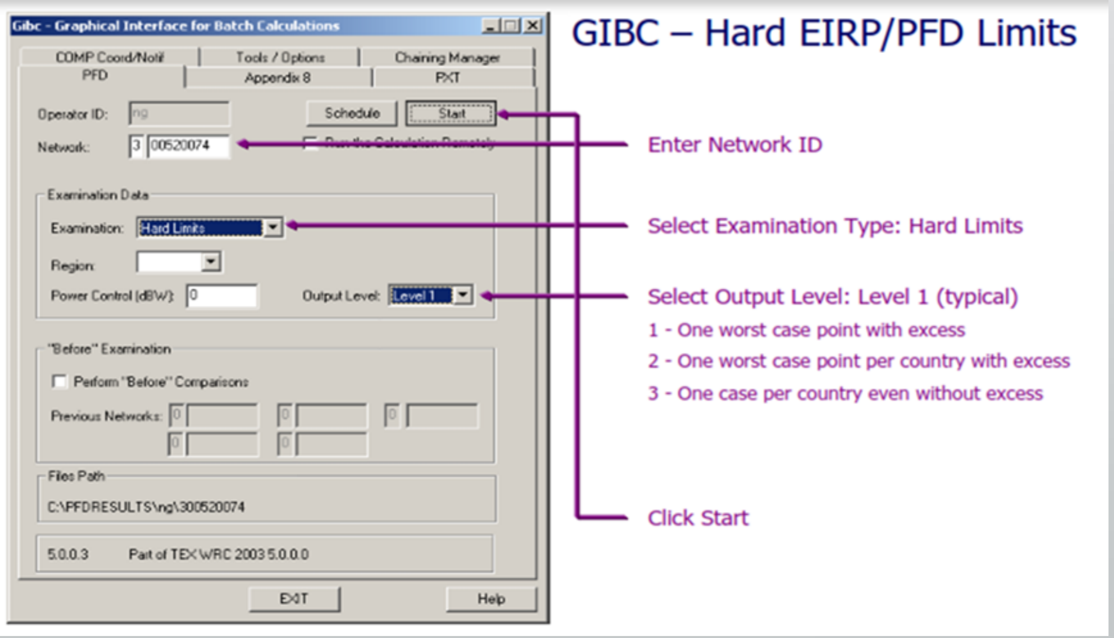


ITU Recourses to manage the interference from satellite services into terrestrial serveries (cont.)

- **The Space Network List (SNL) :**It is an online services containing a list of basic information relating to existing or planned space stations, radio astronomy stations and earth stations.

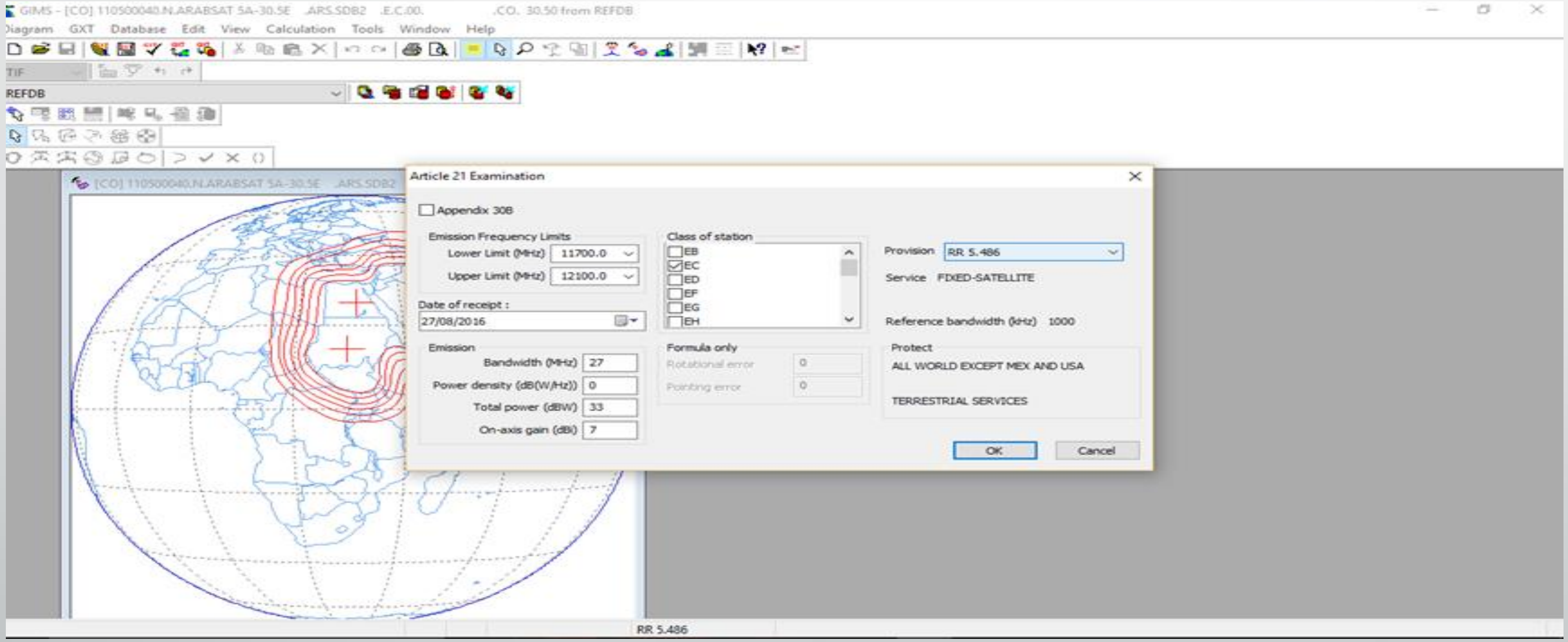


- **Graphical Interface for Batch Calculations (GIBC)** It is a software produced by ITU enables the user with the calculations on satellite networks to determine the coordination requirements on satellite networks, one of these calculations is a Power Flux Density (PFD) examination with respect to the PFD limits in Article 21 of radio regulation to protect the terrestrial services



ITU Recourses to manage the interference from satellite services into terrestrial serveries (cont.)

- **Graphical Interference Management System (GIMS)** It is a software published by ITU , is used for the capture and review of the graphical data relating to geostationary satellites. It also has the ability to perform PFD calculations according to article 21 of radio regulation to produce the list of countries where a pfd value is excessed.



The Methodology of Interference Calculation

The analysis is based on calculating the interference power coming from each satellite to radio relay station, then compare the interference power with thermal noise power of the radio relay station and the impact of this interface on the performance of this station, So in order to calculate the interface power the below procedures have to be followed

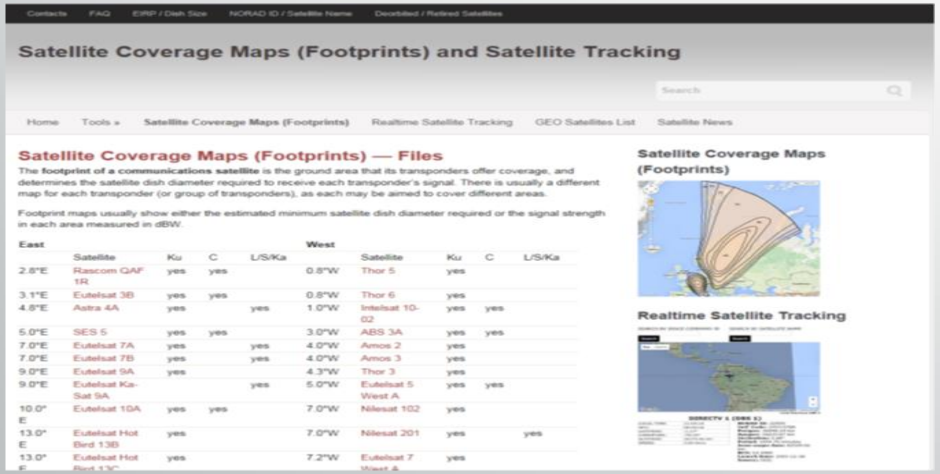
1. Specify the Visible Satellites: To determine the limits of the visible geostationary (GEO) orbit from each earth position depending on the value of elevation angles, basically when value of elevation angle is positive it means the orbital position will be visible otherwise when elevation angle is negative it means this orbital position invisible, After determine the Visible GEO orbit, the searching for the satellites which introduce C-band services can be done on many websites which introduce information about the footprint for operating satellites,

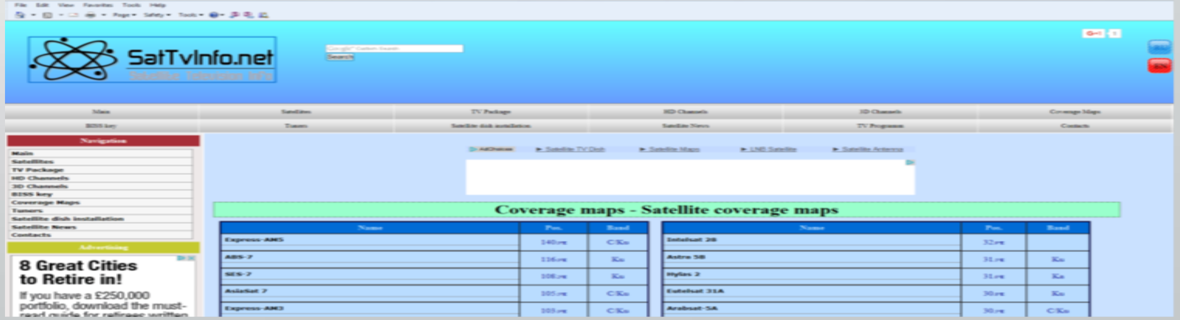
The Methodology of Interference Calculation (cont.)

Satellites Footprint

to review the satellites which cover Iraq in C-band , there are many websites introduce information about the footprint for the satellites in GEO orbit , these websites like :

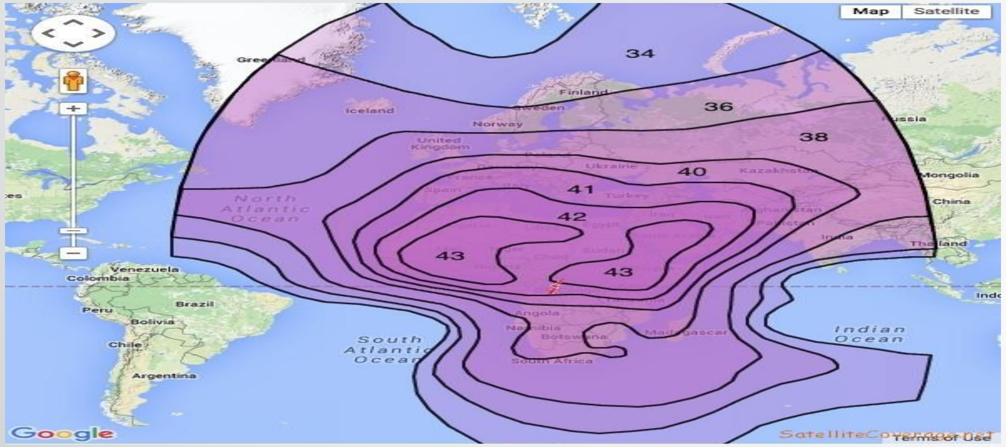
- https://satellitecoverage.net/satellite-coverage-maps-footprint-files
- http://sattvinfo.net/beam.php?lang=en
- http://www.satbeams.com/footprints





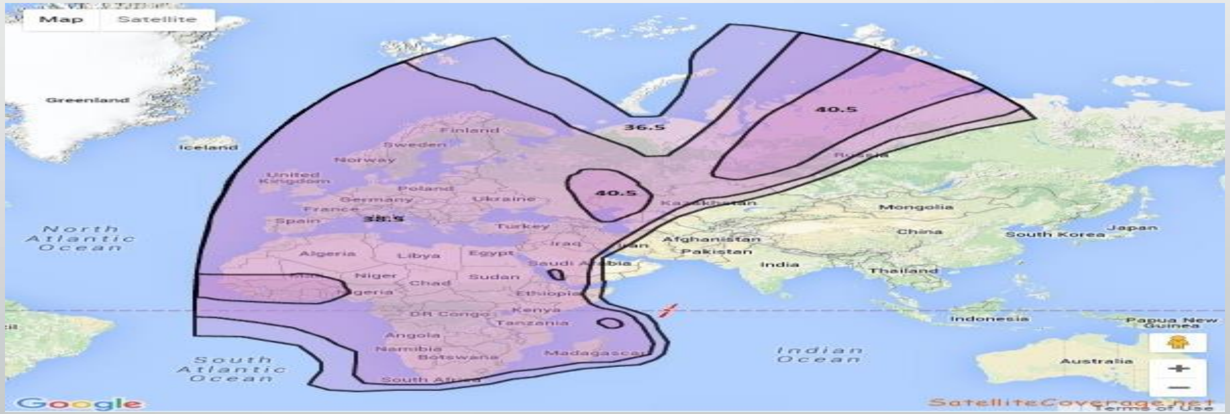
The Methodology of Interference Calculation (cont.)

Satellite Footprints



Arabsat-5C, position 20° E , the eirp for Iraq is 42 dBW

Intelsat 904 , position 60.0° E , Global C-band Beam eirp for Iraq is 37 dBW



Intelsat 904 , position 60.0° E , West hemi C-band Beam, , eirp for Iraq is 38.5 dBW

The Methodology of Interference Calculation (cont.)

Table of the satellites cover Iraq territory in C-band

No.	The Satellite Name	Orbit Position	The Beam Name	E.I.R.P
1	Rascom QAF 1R	2.8°E	Continental C-band Beam	39 dBW
2	Eutelsat 3B	3.1°E	Global C-band Beam	38 dBW
3	SES 5	5.0°E	- Global C-band Beam	34 dBW
	SES 5	5.0°E	- West Hemi C-band Beam	37 dBW
4	Eutelsat 10A	10.0°E	Global C-band Beam	41 dBW
5	Amos 5	17.0°E	Pan African C-band Beam	37.5 dBW
6	Arabsat 5C	20.0°E	Wide C-band Beam	42 dBW
7	Badr 6	26.0°E	- High C-band Beam	43 dBW
	Badr 6	26.0°E	- Medium C-band Beam	40 dBW
8	Arabsat 5A	30.5°E	- C-band Beam	41 dBW
	Arabsat 5A	30.5°E	- Middle East C-band Beam	41 dBW
9	Paksat 1R	37.8°E	C-band Beam	37 dBW
10	Express AM7	40.0°E	C-band Beam	41 dBW
11	AzerSpace 1 / Africasat 1a	46.0°E	Central Asia & Europe C-band Beam	42 dBW
12	Intelsat 10	47.5°E	Global Beam	34.8 dBW
13	Yamal 202	49.0°E	Wide C-band Beam	38.5 dBW
14	Turksat 4B	50.0°E	Africa C-band Beam	36 dBW
15	Chinasat 5D	51.5°E	Africa C-band Beam	38 dBW
16	Y1A	52.5°E	Global C-band Beam	40 dBW
17	Express AM6	53.0°E	- C-band Fixed Zone 2 beam	35 dBW
	Express AM6	53.0°E	- C-band Global beam	34.5 dBW
18	NSS 12	57.0°E	- Global C-band Beam	34 dBW
	NSS 12	57.0°E	- West hemi C-band Beam	35 dBW
19	Intelsat 904	60.0°E	- Global C-band Beam	37 dBW
	Intelsat 904	60.0°E	- West hemi C-band Beam	38.5 dBW
	Intelsat 904	60.0°E	- NE zone C-band Beam	38 dBW
20	Intelsat 902	62.0°E	- Global C-band Beam	31 dBW
	Intelsat 902	62.0°E	- West hemi C-band Beam	38.7 dBW
	Intelsat 902	62.0°E	- NE C-band Beam	38 dBW
21	Intelsat 906	64.2°E	- Global A C-band Beam	31 dBW
	Intelsat 906	64.2°E	- West hemi C-band Beam	37.8 dBW
	Intelsat 906	64.2°E	- NE zone C-band Beam	39.4 dBW
22	Intelsat 26	66.0°E	Landmass C-band Beam	39 dBW
23	Intelsat 17	66.0°E	- Global C-band Beam	34.9 dBW
	Intelsat 17	66.0°E	- Landmass C-band Beam	36.9 dBW
	Intelsat 17	66.0°E	- West hemi C-band Beam	38.9 dBW
24	Intelsat 20	68.5°E	Landmass C-band Beam	38.1 dBW
25	Intelsat 22	72.1°E	West hemi C-band Beam	35.8 dBW
26	Eutelsat ABS 2	75.0°E	- Global C-band Beam	37 dBW
	Eutelsat ABS 2	75.0°E	- West hemi C-band Beam	41 dBW
27	Apstar 7	76.5°E	Global C-band Beam	38.5 dBW
28	Thaicom 5	78.5°E	Global C-band Beam	36 dBW

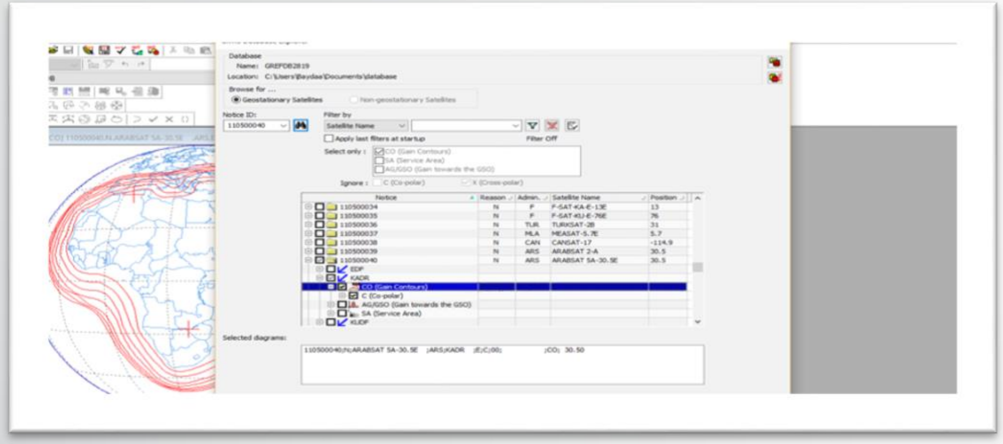
The Methodology of Interference Calculation (cont.)

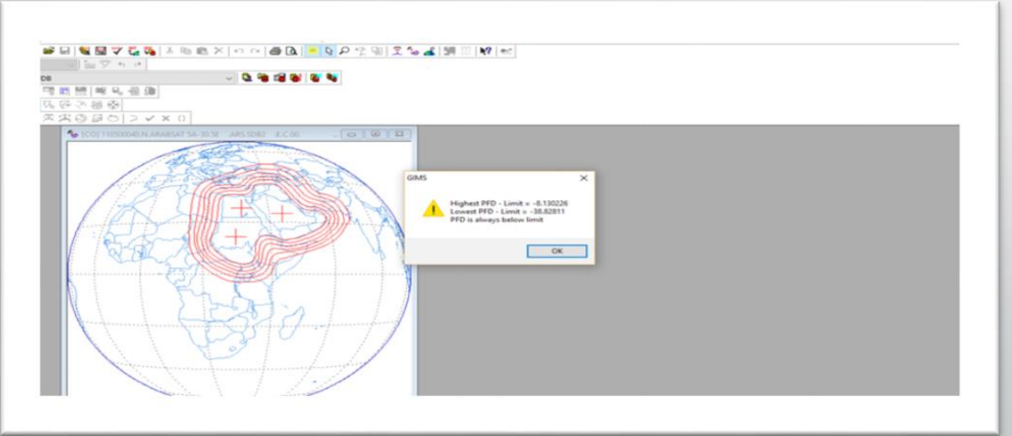
Table of the satellites cover Iraq territory in C-band

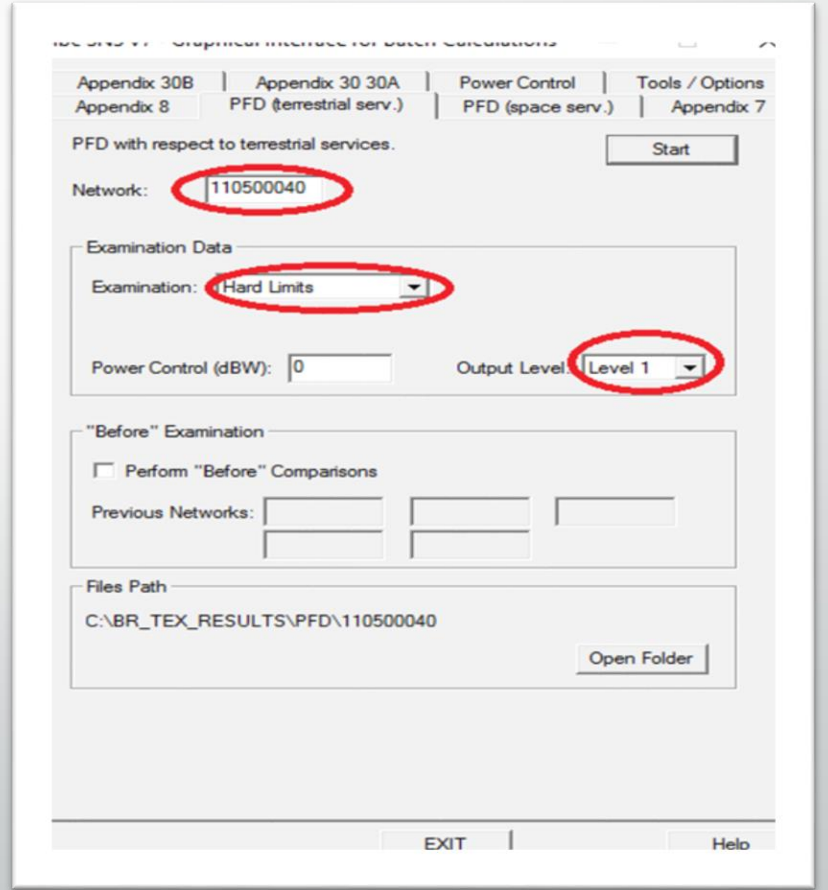
29	Express AM2	80.0°E	Fixed C-band Beam	36.5 dBW
30	Insat 4A	83.0°E	India C-band Beam	41 dBW
31	ChinaSat 12	87.5°E	Global C-band Beam	37.5 dBW
32	ST 2	88.0°E	Extended C-band Beam	40 dBW
33	Yamal 401	90.0°E	Russian C-band Beam	43 dBW
34	Measat 3	91.5°E	Global C-band Beam	35 dBW
35	Measat 3a	91.5°E	Global C-band Beam	35.5 dBW
36	Insat 4B	93.5°E	ECC C-band Beam	40 dBW
37	ChinaSat 11	98.0°E	C-band Beam	38 dBW
38	AsiaSat 5	100.5°E	C-band Beam	39 dBW
39	Express AM3	103.0°E	Fixed C-band Beam	37 dBW
40	AsiaSat 7	105.5°E	Global C-band Beam	36 dBW
41	ChinaSat 10	110.5°E	C-band Beam	40 dBW
42	Palapa D	113.0°E	Asian C-band Beam	36.14 dBW
43	ChinaSat 6B	115.5°E	C-band Beam	39 dBW
44	AsiaSat 4	122.2°E	C-band Beam	38 dBW
45	Intelsat 10-02	1.0°W	- Global C-band Beam	33.5 dBW
	Intelsat 10-02	1.0°W	- East hemi C-band Beam	40 dBW
	Intelsat 10-02	1.0°W	- SE zone C-band Beam	36.5 dBW
46	ABS 3A	3.0°W	- Global C-band Beam	35 dBW
	ABS 3A	3.0°W	- Easthemi C-band Beam	40 dBW
47	Eutelsat 5 West A	5.0°W	Global C-band Beam	38 dBW
48	Express AM44	11.0°W	- C-band Beam	40.2 dBW
	Express AM44	11.0°W	- Global C-band Beam	36 dBW
49	Express AM8	14.0°W	Europe and Africa C-band beam	39.5 dBW
50	Express A4	14.0°W	- Tp 1 C-band Beam	32 dBW
	Express A4	14.0°W	-Tp 6 C-band Beam	39 dBW
51	Intelsat 901	18.0°W	- Global C-band Beam	32 dBW
	Intelsat 901	18.0°W	- SE zone C-band Beam	36.5 dBW
52	NSS 7	20.0°W	- East hemi C-band Beam	37 dBW
	NSS 7	20.0°W	- NE zone C-band Beam	43 dBW
53	SES 4	22.0°W	- Global C-band Beam	33 dBW
	SES 4	22.0°W	- East Hemi C-band Beam	38 dBW
54	Intelsat 905	24.5°W	- Global C-band Beam	31 dBW
	Intelsat 905	24.5°W	- East hemi C-band Beam	38.1 dBW
	Intelsat 905	24.5°W	- SE zone C-band Beam	38.9 dBW
55	Intelsat 907	27.5°W	- Global C-band Beam	31 dBW
	Intelsat 907	27.5°W	- East hemi C-band Beam	38.6 dBW
	Intelsat 907	27.5°W	- SE zone C-band Beam	39.4, dBW
56	Intelsat 701	29.5°W	- East hemi C-band Beam	35.1 dBW
	Intelsat 701	29.5°W	- NE zone C-band Beam	34.1 dBW
57	Intelsat 25	31.5°W	Africa & US C-band Beam	32 dBW
58	Intelsat 903	34.5°W	- Global C-band Beam	31 dBW
	Intelsat 903	34.5°W	63- East hemi C-band Beam	38.3 dBW
	Intelsat 903	34.5°W	-SE zone C-band Beam	37.1 dBW

The Methodology of Interference Calculation (cont.)

- Using GIBS and GIMS software to exam the PFD value for the satellite networks if within ITU limitation or exceed:







The Methodology of Interference Calculation (cont.)

2. Determine the elevation angle(θ)

it is the angle between the horizontal and the line of sight from visible satellite to the earth position

$$\theta = \tan^{-1}\left(\frac{\cos G \cos(Lat-k)}{\sqrt{1-\cos^2(G)}}\right)\cos^2(Lat)$$

Where:

$$k = \frac{\text{Radius of earth (Re)}}{\text{Radius of orbit (Rs)}} = \frac{6378.137\text{Km}}{42164.17Km}$$
=0.1512

G= Difference between the Satellite Longitude and earth station Longitude

Lat= is the latitude of the radio-relay station.

3. Determine the slant range (S)

The Slant range is the line-of-sight distance between the satellite and radio-relay station, the formula of calculate the slant range:

$$S = Re\sqrt{\left(\frac{1}{k}\right)^2 - cos^2(\theta)} - \sin(\theta)$$

The Methodology of Interference Calculation (cont.)

4. Calculate the Power flux density (Pfd)

the Power Flux Density, it is the amount of energy for unit area, the formula to calculate pfd value:

$Pfd = \frac{eirp}{4\pi S^2}$ in W/m²

In decibel form:

Pfd= eirp -10log(4π) – 20log(S)in dBW/m²

Pfd = eirp -11 -20log(S) - 10log (Bt/4KHz)   in dBW/m² per 4KHz
Pfd = eirp -11 -20log(S) - 10log (Bt/1 MHz)   in dBW/m² per 1MKHz

Where

S= slant range

eirp = the effective isotropic radiated power

eirp= Pt. Gt

Pt = the power of transmission

Gt = the antenna gain of transmission

5. Determine the power flux density limitation

According to ITU recommendation (ITU-R F.1107-1, 1994), the equation below is used to calculate the value of power flux density depending on the elevation angle value for each satellite:

F(Ө)=

$$\begin{cases} -152 \quad for\ 0° \le \theta \le 5° \\ -152 + 0.5(\theta - 5) \quad for\ 5° \le \theta \le 25° \\ -142 \quad for\ \ 25° \le \theta \le 90° \end{cases}$$

The Methodology of Interference Calculation (cont.)

6. Determine the Azimuth Angle (Az)

The Azimuth angle is the angle form geographic north to the projection of satellite,

$$Az = \tan^{-1}\left(\tan\left(\frac{G}{\sin(lat)}\right)\right)$$

Where:

G= Difference between the Satellite Longitude and earth station Longitude

Lat= is the latitude of the radio-relay station.

Note: the actual azimuth is computed according to earth position from the equator, as for the countries that lay on north of equator like Iraq, the actual Azimuth angle (Az) should be,

Az=Az-180

7. Determine the delta angle (Δ)

The delta angle is the angle between the incidence of the interfering satellite pfd level and the pointing direction of the radio-relay station:

$$\Delta = \cos^{-1} \cos\Theta \cos(Az - \delta)$$

Where

Θ= the elevation angle

Az= the azimuth angle

δ = is the pointing direction of the radio-relay station receiver

The Methodology of Interference Calculation (cont.)

8. Determined the antenna gain pattern G(Δ)

To calculate the antenna gain of the radio relay station in the direction of the interfering satellite depending on delta angle (Δ)between the incidence of the interfering satellite and the pointing direction of the radio-relay station, the ITU Recommendation (ITU-R F.699, 2006)

$$G(\Delta) = G_{max} - 2.5 \times 10^{-3} \left(\frac{D}{\lambda}\Delta\right)^2 \quad \text{for } 0° < \Delta < \Delta_m$$

$$G(\Delta) = G_1 \quad \text{for } \Delta_m \leq \Delta < 100 \frac{\lambda}{D}$$

$$G(\Delta) = 52 - 10 \log \frac{D}{\lambda} - 25 \log \Delta \quad \text{for } 100 \frac{\lambda}{D} \leq \Delta < 48°$$

$$G(\Delta) = 10 - 10 \log \frac{D}{\lambda} \quad \text{for } 48° \leq \Delta \leq 180°$$

Where:

$G(\Delta)$ = gain relative to isotropic antenna

G_{max}: the gain of main lobe in (dBi)

Δ: angle off-axis (degrees)

D: antenna diameter, λ: wavelength — expressed in the same units

G_1: first side-lobe gain= $2 + 15 \log \frac{D}{\lambda}$

Δm= 20λ/D (Gmax-G1) ½

Gmax = 20log (D/λ) + 7.7

9. Calculate the interference Power According to ITU recommendation (ITU-R F.1107-1, 1994), The interference power received at the radio-relay station as shown in below formula:

$$I = f(\theta) * g(\Delta) * \lambda 2 / 4\pi L$$

where:

I = interference power

$f(\theta) = 10F(\theta)/10$

$g(\Delta) = 10G(\Delta)/10$

λ= carrier's wavelength

L= feeder loss

The Methodology of Interference Calculation (cont.)

10. Interferences Evaluation

According to ITU recommendation (ITU-R F.1170-2, 2011), the assessment of interference into radio relay system could be done by calculating the interference to noise ratio (I/N) for each station which equal the fractional degradation of performance (FDP) .

$$FDP = \frac{I}{N}$$

where:

I:the total interference from visible satellites

N: thermal noise power of radio relay station

N= KTB (the result in watt)

In decibel form N will be:

N= 10log(K)+10log(T)+10log(B) (the result in dBW)

where:

k = 1.38 x 10^{-23} J/K (Boltzmann constant)

T = noise temperature, Kelvin

B = bandwidth (Hz).

The Methodology of Interference Calculation (cont.)

MATLAB Functions

To determine the Interference power for each C-band satellite toward Iraqi territory, below the Matlab functions to determine the visible orbit, the elevation angle, slant range, power flux density, the azimuth angle, delta angle, the power flux density limitation, the gain for the radio relay station antenna, finally to find the interference power.

```
➢ function [E] = visible_satellites (Lat, Lon)
➢ function [E] = elevation_angle (Lat, Lon)
➢ function [S] = Slant_Range (E)
➢ function [PFD]= Power_flux_density (S)
➢ function [F] = pfd_limit (E)
➢ function [Az] = Azimuth_angle (Lat, Lon)
➢ function [delta] = differnce_angle(E,Az,T)
➢ function [G] = cal_gai (Delta)
➢ function [I] = Interfernce_cal (F,G)
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Interferences calculations for Baghdad

The Latitude =33.35°N, Longitude =44.41 E

- **Scenario 1-1:** *When antenna of radio relay station pointing at direction of 100° form the south, within ITU limitation of pfd*
- **Scenario 1-2:** *When antenna of radio relay station pointing at direction of 100° form the south, with exceed pfd = -75 (dBW/m^2)*
- **Scenario 2-1:** *When antenna of radio relay station pointing at direction of 200° form the south, within ITU limitation of pfd*
- **Scenario 2-2**: *When antenna of radio relay station pointing at direction of 200° form the south, with exceed pfd = -75 (dBW/m^2)*
- **Scenario 3-1:** *When antenna of radio relay station pointing at direction of 300° form the south, within ITU limitation of pfd*
- **Scenario 3-2:** *When antenna of radio relay station pointing at direction of 300° form the south, with exceed pfd = -75 (dBW/m^2)*

Interferences calculations for Baghdad

The Results (within pfd limitation)

Scenario 1-1: When antenna of radio relay station pointing at direction of 100° form the south,

total interference power=5.94E-16 watt

the thermal noise power for typical radio relay station = 2.07E-13 W

FDP = I/N * 100%= 0.028 %= -15.5 dB

Scenario 2-1: When antenna of radio relay station pointing at direction of 200° form the south:

total interference power = 4.53E-17 watt

the thermal noise power for typical radio relay station = 2.07E-13 W

then FDP = I/N * 100%= 0.022 % = -16dB

Scenario 3-1: When antenna of radio relay station pointing at direction of 300° form the south:

total interference power = 4.57E-17 watt

the thermal noise power for typical radio relay station = 2.07E-13 W

FDP = I/N * 100%=0.022 % = -16dB

Interferences calculations for Baghdad

The Results (pfd exceed the limitation)

Scenario 1-2: When antenna of radio relay station pointing at direction of 100° form the south,

total interference power =3.273E-09 (W)

the thermal noise power for typical radio relay station = 2.07E-13

FDP = I/N* 100%= 1581160x 10^6 %= 62 dB

Scenario 3-2: When antenna of radio relay station pointing at direction of 300° form the south:

total interference power = 3.367E-10 (W)

the thermal noise power for typical radio relay station = 2.07E-13

then FDP = I/N * 100%= 162657 % = 52 dB

Scenario 2-2: When antenna of radio relay station pointing at direction of 200° form the south:

total interference power = 3.09E-10 (W)

the thermal noise power for typical radio relay station = 2.07E-13

then FDP = I/N * 100%= 149275 % = 51.7 dB

Drawing the Interference Map from C-band satellites cover Iraq territory

In order to draw the interference map for the emissions comes from visible C-band satellites that cover Iraq territory, that would be done by following the same procedures of calculating the interference power that used in calculating the total interference power in Baghdad for all Iraqi Provinces as their locations in longitude and latitude

No.	The Name of Province	Latitude, longitude position
1	Misan	Lat=32.52°N, Lon=45.85° E
2	Al-Najaf	Lat=31.98° N, Lon =44.33° E
3	Thi Qar	Lat=31.03° N, Lon= 46.27 ° E
4	Al-Anbar	Lat=33.42° N, Lon= 43.28°E
5	Al-Sulaimaniyah	Lat=35.55° N, Lon = 45.43° E
6	Babil	Lat=32.48° N, Lon =44.42° E
7	Baghdad	Lat=33.35° N, Lon= 44.41° E
8	Diyala	Lat=34.02° N, Lon=45° E
9	Al-Basrah	Lat=30.50° N, Lon= 47.83° E
10	Arbil	Lat=36.18° N, Lon = 44.02° E
11	Karbala	Lat=32.60° N, Lon = 44.03° E
12	Kirkuk	Lat=35.46° N, Lon =44.43° E
13	Nineveh	Lat=36.35° N, Lon = 43.13° E
14	Salah al-Din	Lat=34.63° N, Lon = 43.60° E
15	Dohuk	Lat=36.87° N, Lon = 42.95° E
16	Wasit	Lat=32.5° N, Lon = 45.85° E
17	Al-Muthanna	Lat=31.3° N, Lon = 45.27° E
18	Al-Qadisiyah	Lat=31.95° N Lon=44.91°E

Drawing the Interference Map from C-band satellites cover Iraq territory

The Total Interference power from C-band satellites in Iraqi Provinces, according three different scenarios

No.	The Name of Province	I/N *100% Scenario A	I/N *100% Scenario B	I/N *100% Scenario C
1	Misan	0.0216 %	0.0297 %	724 %
2	Al-Najaf	0.0219 %	0.0299 %	714 %
3	Thi Qar	0.0217 %	0.0289 %	695 %
4	Al-Anbar	0.0218 %	0.0308 %	744 %
5	Al-Sulaimaniyah	0.0213 %	0.0314 %	782 %
6	Babil	0.0218 %	0.0301 %	724 %
7	Baghdad	0.0217 %	0.0305 %	734 %
8	Diyala	0.0215 %	0.0306 %	753 %
9	Al-Basrah	0.0217 %	0.0285 %	685 %
10	Arbil	0.0214 %	0.0323 %	797 %
11	Karbala	0.0218 %	0.0302 %	729 %
12	Kirkuk	0.0215 %	0.0317 %	782 %
13	Nineveh	0.0214 %	0.0325 %	806 %
14	Salah al-Din	0.0216 %	0.0314 %	768 %
15	Dohuk	0.0385 %	0.0121 %	816 %
16	Wasit	0.0216 %	0.0297 %	719 %
17	Al-Muthanna	0.0219%	0.0294 %	705 %
18	Al-Qadisiyah	0.0218 %	0.0298 %	714 %

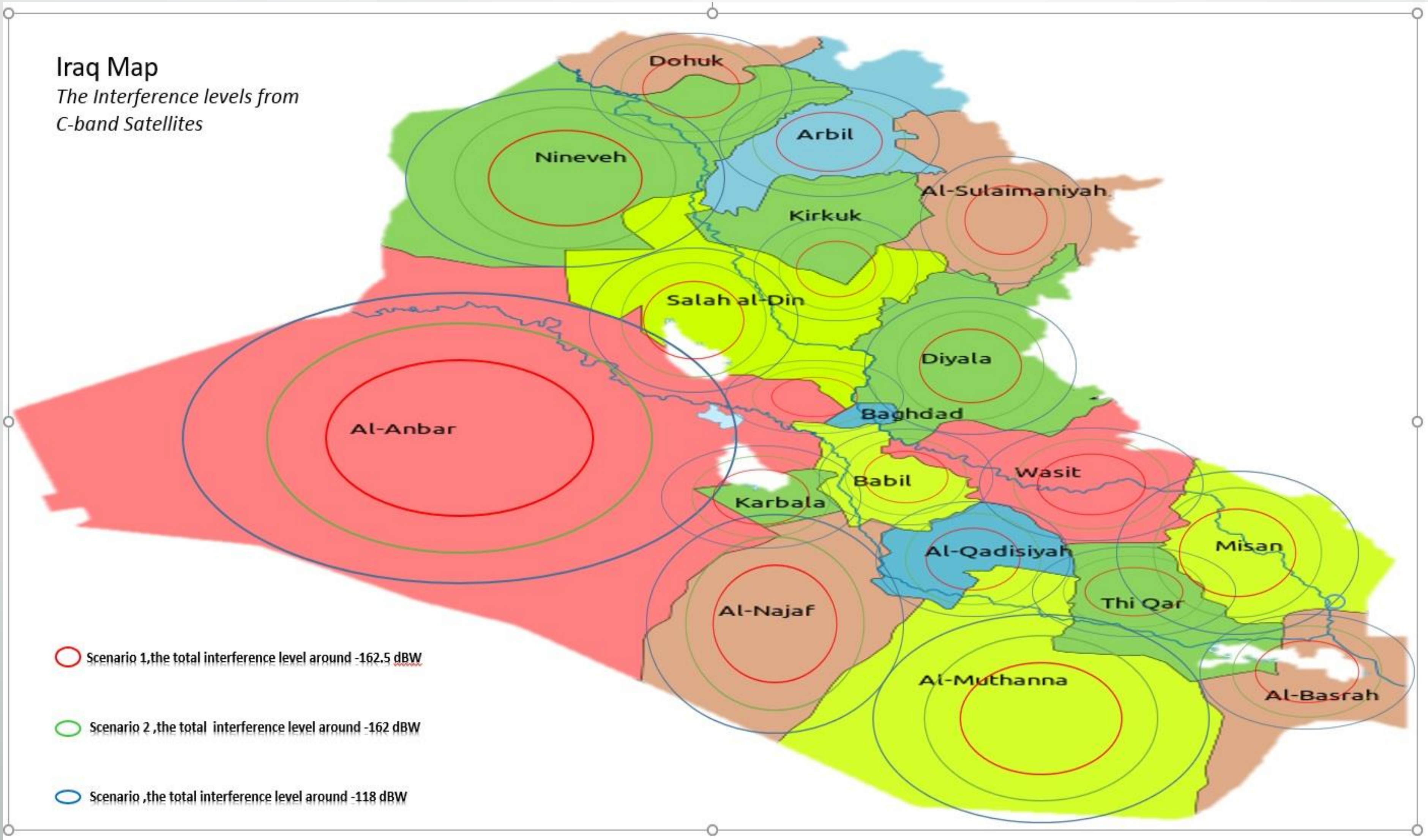
Scenario A: *the total interference* power from C-band satellites *cover Iraq territory within ITU limitation pfd values, with terrestrial antenna azimuth equal 25°.*

Scenario B*: the total interference power from C-band satellites cover Iraq territory within ITU limitation pfd values, with terrestrial antenna azimuth equal 225°*

Scenario C*: the total interference power from C-band satellites cover Iraq territory within exceed pfd values (pfd =-100 dBW/m²), and terrestrial antenna azimuth equal 225°.*

Interference Map from C-band satellites cover Iraq territory

The Interference Levels Map for Iraq (C-band)



The Conclusion

- the total interference power within the ITU limitation for pfd it could be considered as preassemble interference where the fractional degradation of performance for typical radio relay station is around 0.03%,
- According to ITU Recommendation (ITU-R F.758, 2015), the preassemble percentage of fractional degradation of performance should not exceed 10% for analogue radio relay station and not exceed 25% for digital radio relay station.
- when the pfd value is assumed to exceed in scenario 3 for Baghdad to -75 dBW/m^2 and to -100 dBW/m^2 for scenario C for all the Iraqi provinces, the percentage of fractional degradation of performance increase to very huge values for scenario 1-2 reached to 1.58×10^6 % when the azimuth of the radio relay antenna equal to 100° and for scenario C reached to 800% for Dohuk city, these high values are a great concern for panic
- Therefore should not accept to exceed the power flux density for the satellite more than the ITU limitations, Even the ITU allowed the satellite to operator and to exceed these limitation if the affected country accept, of course before accepting to exceed these limitation the interference should be analysed in order to decide if it is acceptable or not.
- It should be noted that the ITU limitation of pfd values in the band between (3400 to 5216 MHz) depending on considering the reference bandwidth is 4 KHz, of course this bandwidth is applicable for voice channel for analogue systems, but practically the services in this band may be not used just for voice service, especially with new trend of the communication which are depending on data services so the reference bandwidth of 4 KHz, is not applicable for all services.

Thanks ….