ICASA Fundamental Skills Training

Module: Spectrum Fee Calculation

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Agenda

- What is Spectrum?
- Spectrum Fees
- Telecommunications uses of Spectrum
  - Explanation of Factors
  - Edge Cases
  - Worked Examples
- Satellite Communications
- Summary

Spectrum

- "Spectrum" is the range of electromagnetic frequencies of interest.
- ICASA regulates from 9 kHz to 1000 GHz (1 THz)
- FM Radio uses from 87.5 MHz to 104 MHz
- UHF TV Broadcasting uses from 470 – 860 MHz
- Cellphones use 900, 1800, 2100 MHz bands, etc.
- Visible light is 400 – 789 THz

Spectrum Fees

- Spectrum has traditionally been regarded as a “scarce” resource.
- Spectrum within a country is regarded as a national asset, and use of it is usually regulated by a Regulatory Authority – ICASA in our case.
- “Scarcity” is due to three factors: -
  - Poor technology – which has improved dramatically over the last century, and especially in the last decade.
  - Poor administration – due partly to old models of spectrum assignment
  - Popular uses for certain bands, due to availability of equipment and / or propagation characteristics of that frequency

Spectrum Fees 2

- One way of managing demand for a limited resource is to charge fees for its use.
- Fees reduce the incentive to "**hoard**" spectrum
- Spectrum is not "owned" by a licensee – he has **right of use**
- ICASA has introduced an "**Administrative Incentive Pricing**" system for telecommunications uses of spectrum
- **AIP** Spectrum Fees apply from 1st April 2012
- No fees charged – yet – for broadcast uses
- The new system means significant changes for some operators. Some will pay much less, some will pay much more. Most won't be affected much, but everyone needs to know how much they will pay

Spectrum Fees 3

- Annual Spectrum Fees are calculated using one of two formulae:

- Point-to-Point:
  - **Fee=(UNIT*BW*FREQ*CG*GEO*SHR*_HOPMINI_*UNIBI)**

- Point-to-MultiPoint:
  - **Fee=(UNIT*BW*FREQ*CG*GEO*SHR*_ASTERI_*UNIBI)**
  - Except for Amateur, aeronautical and maritime

Fee Principle

- Fundamental principle is paying for the amount of spectrum used:
  - Fee = Unit cost per MHz * Number of MHz
  - Fee = UNIT * BW
- Modified by a number of numerical factors
  - Adds “incentives”
  - Encourages some uses, discourages others
  - Basic cost is multiplied by the factors, to increase or decrease the final fee
- The minimum fee is defined as R120, to ease administration

Terms Used

• UNIT	Cost per MHz	ZAR
• BW	Bandwidth	MHz
• FREQ	Frequency Band	Factor
• CG	Congestion	Factor
• GEO	Geographical	Factor
• SHR	Sharing	Factor
• HOPMINI	Minimum Hop Length	Factor
• ASTER	Area Sterilisation	Factor
• UNIBI	Uni- or bi-directional	Factor

UNIT

- The cost per MHz is defined in the Appendix to the Regulations as UNIT = R2,000
- This means that the basic price is R2,000 per MHz per year
- This applies to all telecommunications uses, including satellite
- Does not apply to broadcasting uses

BW

- The Bandwidth used (BW) is the number of MHz assigned.
- When a single “block” is assigned, e.g. for TDD use, then BW = the size of the block
  - E.g. 2570 MHz to 2575 MHz = 5 MHz
- When a “pair” of blocks is assigned, e.g. for FDD use, then BW = the size of one of the blocks
  - E.g. 2500 MHz to 2505 MHz **UL** plus 2620 MHz to 2625 MHz **DL** = 5 MHz

FREQ

- Different frequencies have different propagation characteristics
- Higher frequencies have a shorter useful range, and are good to use in dense urban environments, because the reuse distance is smaller
- Lower frequencies have a longer useful range, and are good to use in rural environments, or for long distance PtP links, because the signal travels further
- A table in the Regulations assigns a numerical value to each band, with higher frequencies (FREQ) being cheaper

FREQ

FREQUENCY RANGE		FREQ FACTOR
FROM (MHz)	TO (MHz)	
30	174	1.00
174	880	0.75
880	1800	0.50
1800	5,000	0.40
5,000	10,000	0.30
10,000	17,000	0.20
17,000	23,000	0.15
23,000	30,000	0.10
> 30,000		0.05

Note that no factor is specified for 9 kHz to 30 MHz. Use a value of 1.00

CG

- The Congestion Factor indicates if the band is “congested” or not.
- This may be interpreted to be the equivalent of “High Demand”
- Defined as more potential users than spectrum available
- At ICASA’s discretion to specify
- Most bands are not congested, unless otherwise specified

CONGESTION	CG Factor
Congested	1.50
Not congested	1.00

GEO

- The Geographical factor depends on where in the country the spectrum is to be used.
- If it is not used in Gauteng or the Cape Town Municipality or the Durban Municipality then it's Low Density
- Otherwise, it's High Density
- It's ten times as expensive to use spectrum in Joburg than Putsonderwater
- Yes, we do mean it. It's not a mistake

GEO AREA	GEO Factor
High Density	1.00
Low Density	0.10

SHR

- Spectrum can be assigned in one of several ways, including "**Exclusive**" and "**Shared**"
- When exclusive use of spectrum is assigned, then ICASA is responsible for making sure, as far as possible, that no interference occurs
- When spectrum is shared, then the sharing parties are responsible for coordinating amongst themselves to avoid interference.
- You get a discount for this.

SHARING	SHR Factor
Exclusive Use	1.00
Shared Use	0.50

UNIBI

- The Unidirectional factor (UNIBI) takes into account inefficiencies inherent in only making unidirectional use of spectrum.
- For PtP uses, a slight discount (25%) is offered for unidirectional use.
- Specifically, it is phrased (*perhaps incorrectly*) in the Regulations as being linked directly to Paired or Unpaired spectrum for PtMP uses. Note that even Unpaired spectrum may be used for bidirectional communications, using TDD, for example.
- When unidirectional use is made of spectrum in a Point to Area usage, then a 50% discount is offered

UNIBI	FACTOR for PtP	Factor for PtMP
Unidirectional	0.75	0.50
Bidirectional	1.00	1.00

ASTER

- Radio Frequency propagation software is often used to draw a map of the area where one can expect a useful signal to be received.
- “Useful” is defined as a signal level >= 60 dBµV/m
- In the absence of topographical features, this area would be a circle or a sector
- We ignore the topographical features, for simplicity, so we work on a radius from the central transmitter
- This area is considered to be “sterilised”, insofar as with old-fashioned radio technology, no other central transmitter, operating on the same frequency with the same polarisation, can be close to the first transmitter
- It’s irrelevant if the spectrum is “shared” or not
- Only applies to PtMP uses of spectrum

ASTER

AREA (km^2)		ASTER Factor
From	To	
0	1	0.6
1	10	2
10	100	6
100	1,000	18
1,000	10,000	56
10,000	100,000	180
100,000	500,000	400
>500,000		600

The Regulations show 1,000,000 km^2 as the maximum value, even though the area of RSA > 1,200,000 km^2

HOPMINI

- As noted earlier, lower frequencies have a longer range.
- It's therefore a waste to use a low frequency for a short PtP link
- A table defines the minimum expected link length, based on the frequency band
- If the link length is greater than or equal to the minimum, or is unknown, then the value of this factor is taken as 1.00
- If the link length is shorter, then the factor is the square root of the minimum path length divided by the actual path length

$$\boldsymbol{HOPMINI} = \sqrt{\left(\frac{\boldsymbol{MINIMUM\ PATH\ LENGTH}}{\boldsymbol{ACTUAL\ PATH\ LENGTH}}\right)}$$

- It sounds more complicated than it is!
- The shorter the actual link compared to the defined minimum, the higher the factor, and therefore the more expensive
- Only applies to PtP uses of spectrum

HOPMINI

FREQUENCY BAND	MINIMUM PATH LENGTH (km)
400 MHZ	100
800 MHz	60
1.4 / 1.6 / 2 GHz	30
4 and 5 GHz	16
7.5 GHZ	14
10 and 11 GHz	10
13 / 14 / 15 GHz	9
17 / 18 GHz	4
22 23 GHz	3
25 / 26 GHZ	3
28 GHZ	2
31 and 32 GHz	1.5
38 GHZ	1
Higher	0

Edge Cases

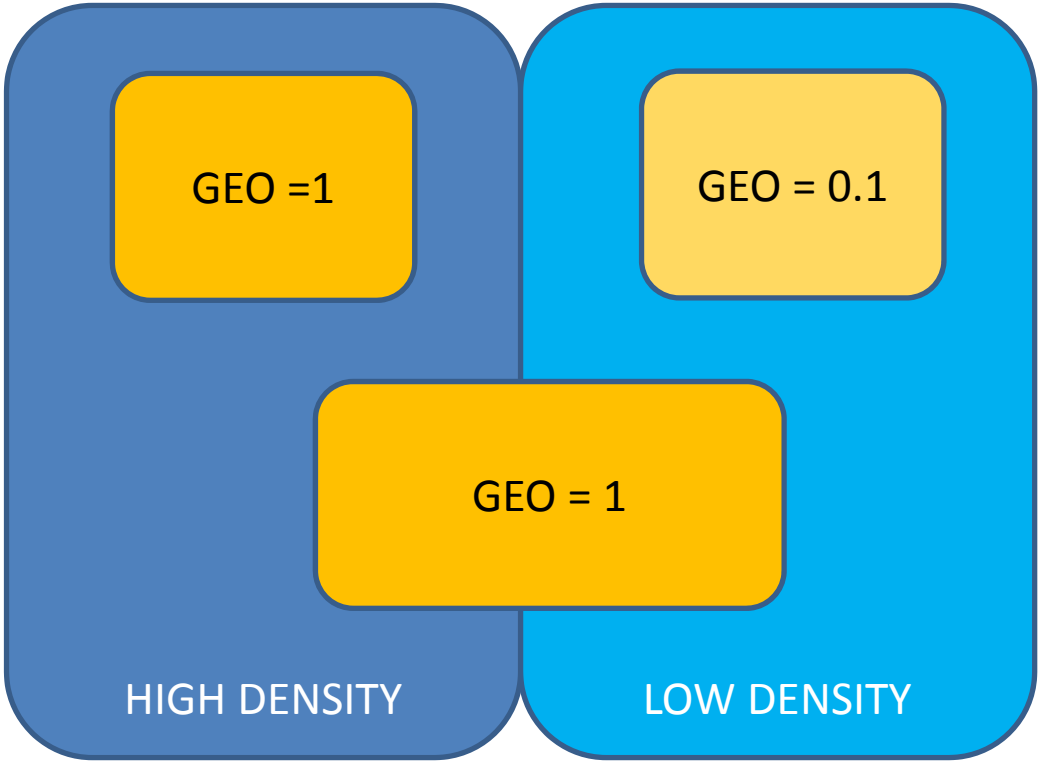
- There are instances where the answer is not obvious, perhaps because two different factors are potentially applicable, perhaps because the Regulations are badly worded.
- RULE OF THUMB: -
  - **Use the one <u>least</u> advantageous to you, as the licensee?**
  - **Use the one <u>most</u> advantageous to you, as the licensee?**
- Some examples follow

Edge Cases 2

- COVERAGE
- Let us say that a licensee operates a PtP link from somewhere inside Gauteng to somewhere outside Gauteng.
  - **GEO Factor = 1 / 0.1** **The correct value is 1**
- A licensee operates a national PtMP network
  - **GEO Factor = 1**
  - **ASTER = 600**
- HOP LENGTH
- Let us say that a PtP link is in a band that is not listed in the HOPMINI table.
  - **HOPMINI = Larger distance / Smaller distance** **Smaller**
- FREQUENCY BAND
- It is possible that specific spectrum assigned may fall into two ranges listed in the FREQ Table
  - **FREQ = Higher frequency / Lower frequency** **Higher**

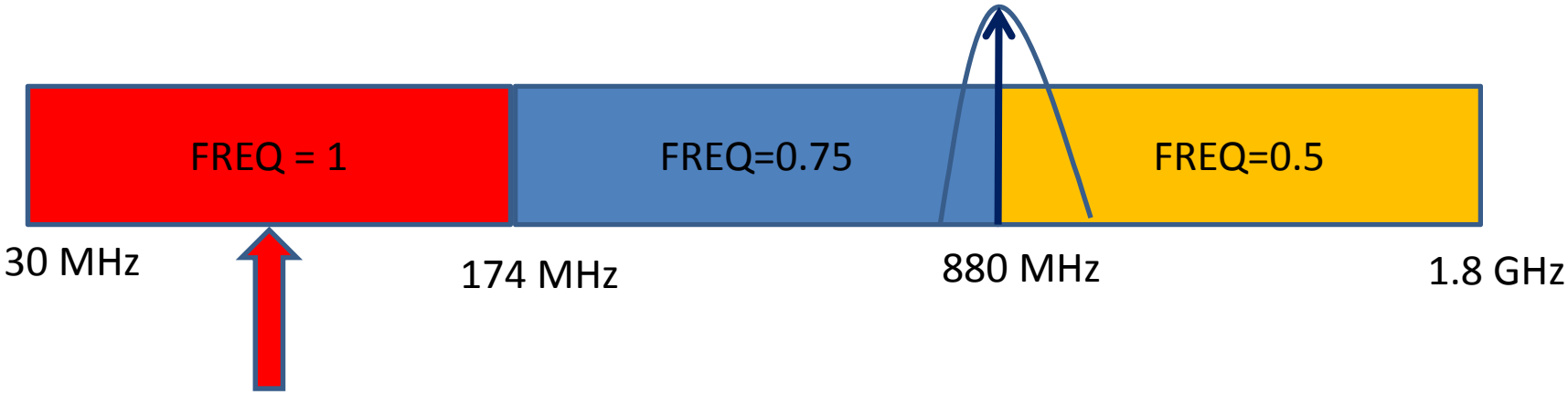
Edge Case: GEO Factor

GEO FACTOR



Edge Case: FREQ Band

FREQ FACTOR



Example: Channel with centre frequency of 880 MHz where paired spectrum is assigned and falls within two different bands the highest FREQ Factor frequency applies

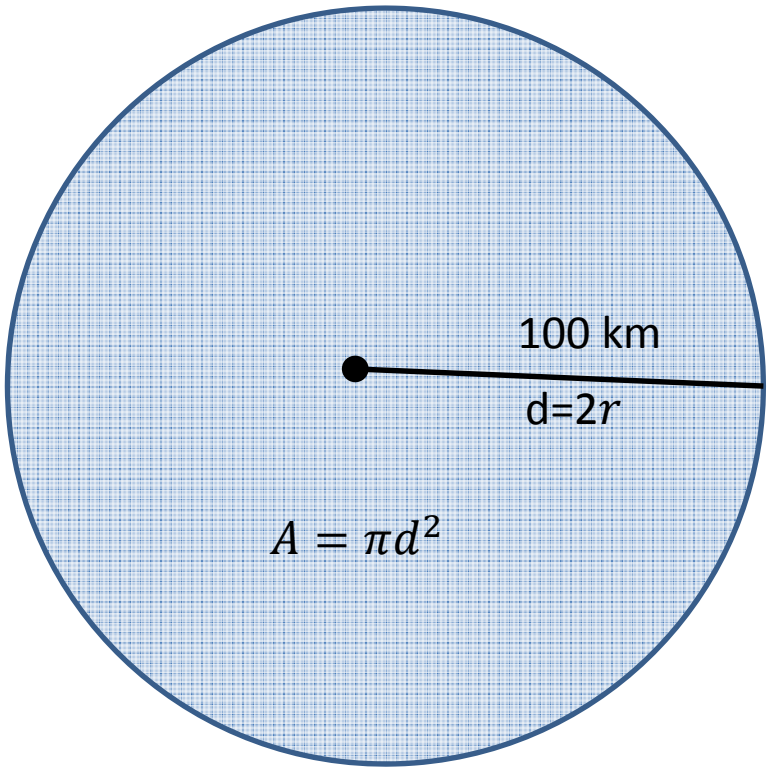
Errors in the Regulations

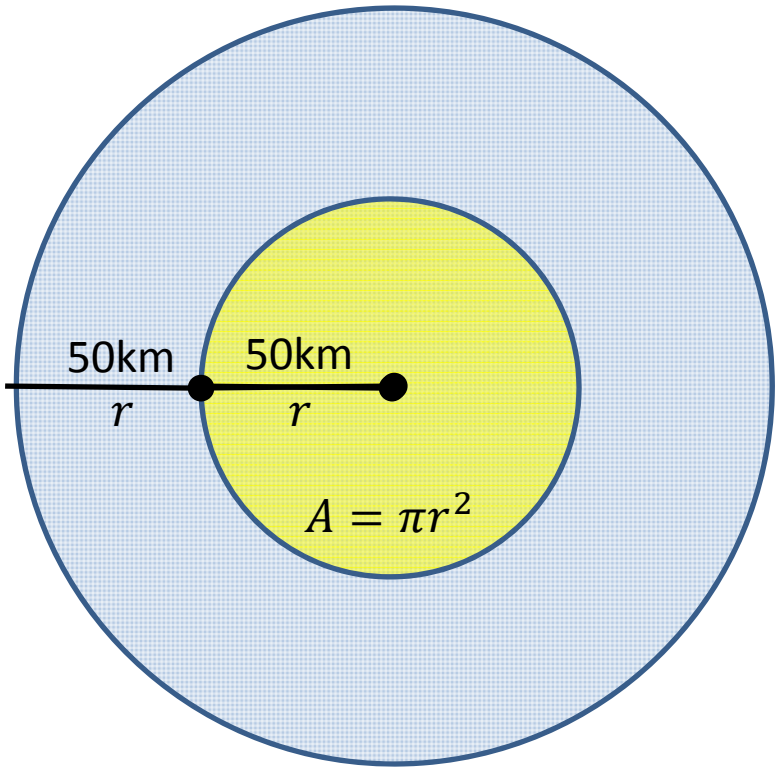
- There are a number of errors in the Regulations as published. Many of these can be corrected by a simple amendment process, rather than requiring reopening the hearings process. Those that may mean that the Regulations will not have the desired effect include: -
- 6(3) FREQ: Value of 1 for <30 MHz should apply
- 6(7) ASTER: RSA has an area of ~1,200,000 km^2 . Last line should read >500,000
- 6(8) HOPMINI: wording clarifications in (a) & (c)
- 6(9) UNIBI: Values may be reversed / confusing?
- 12 Commencement Date is 1st April 2012
- We intend to correct these errors after this workshop, so please don't rely on them!

Worked Examples

Worked Examples

STERILISATION AREA WITH PROTECTION

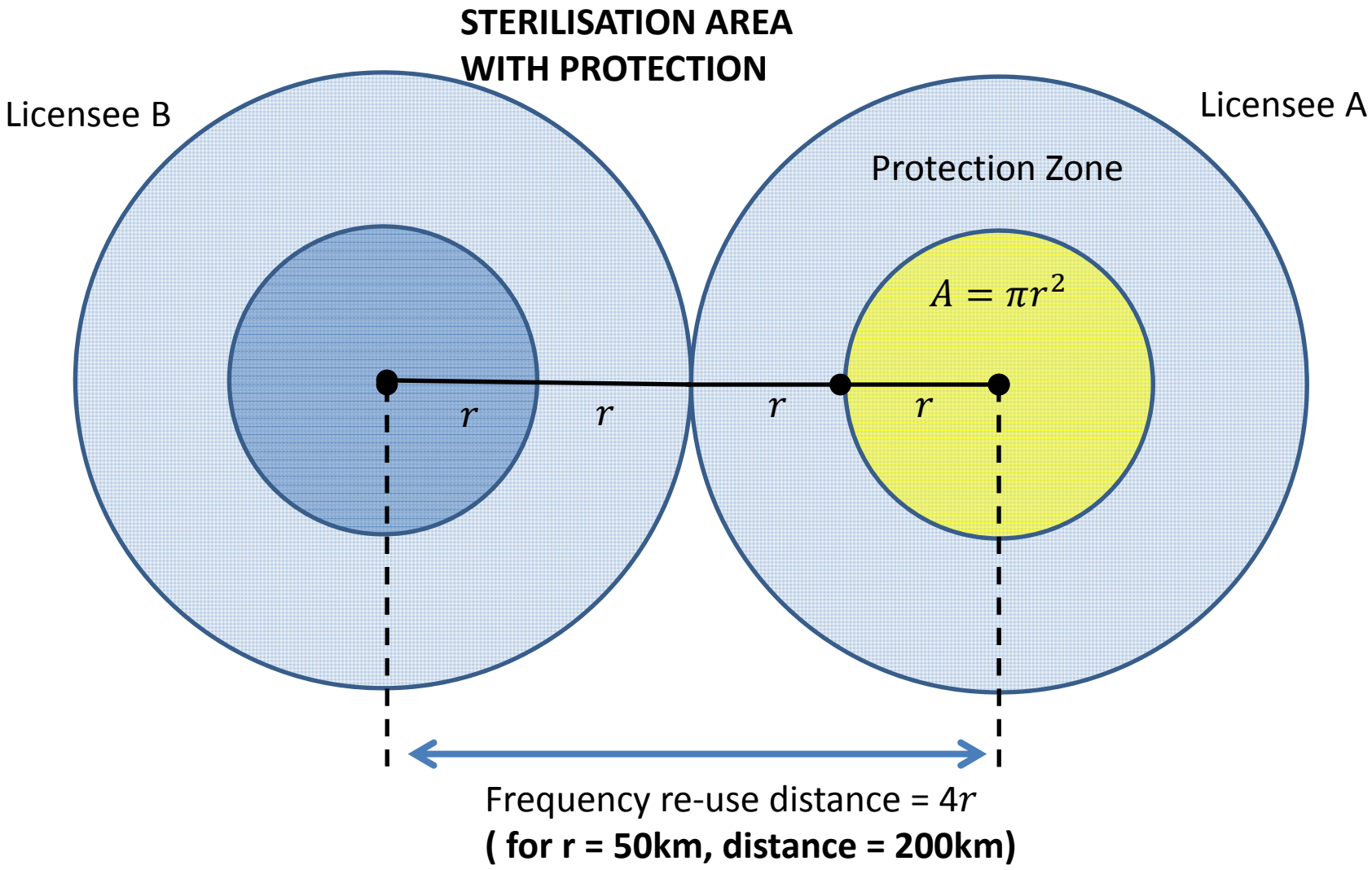




$A = \pi d^2$ = 3.14*100 km*100km
= 31,400 km^2

$A = \pi r^2$ = 3.14*50 km*50km
= 7,850 km^2

Worked Examples



Worked Examples

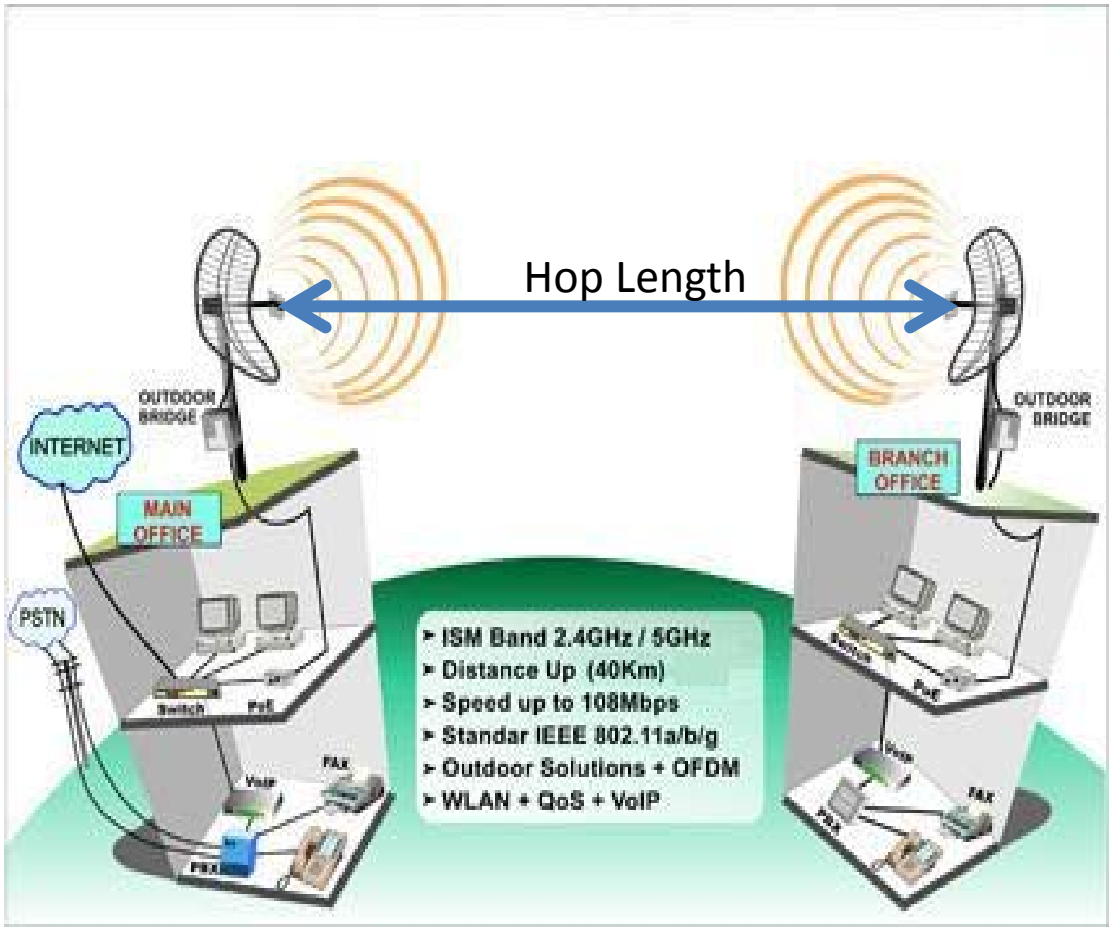
AREA STERILISED without Protection Zone (A= 7,850 km²)

AREA STERILISED with Protection Zone (A= 31,400 km²)

AREA (km²)		ASTER Factor
From	To	
0	1	0.6
1	10	2
10	100	6
100	1,000	18
1,000	10,000	56
10,000	100,000	180
100,000	500,000	400
>500,000		600

Worked Examples

HOPMINI



FREQUENCY BAND	MINIMUM PATH LENGTH
400 MHZ	100
800 MHz	60
1.4 / 1.6 / 2 GHz	30
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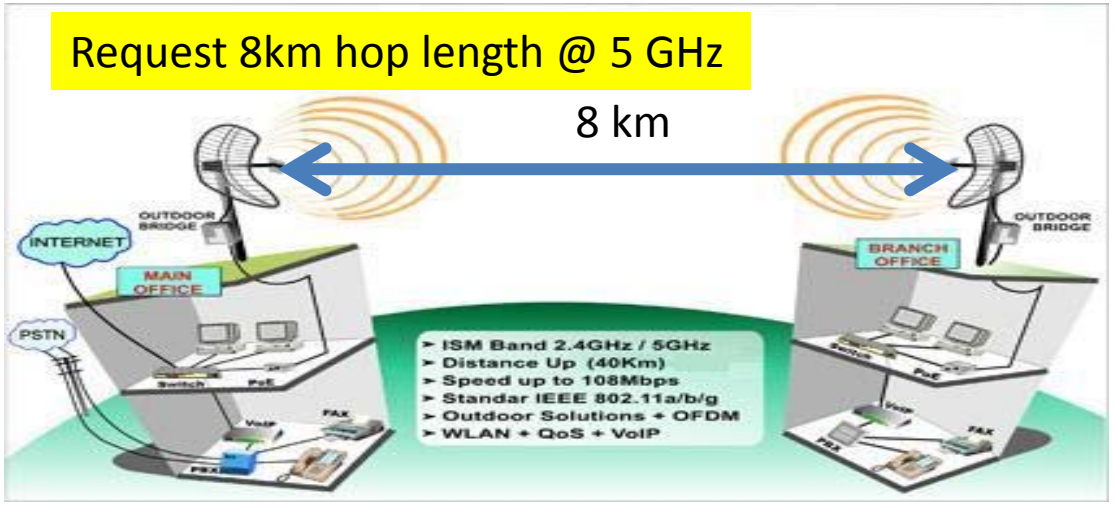
13 / 14 / 15 GHz	9
17 / 18 GHz	4
22 23 GHz	3
25 / 26 GHZ	3
28 GHZ	2
31 and 32 GHz	1.5
38 GHZ	1
Higher	0

Worked Examples

EXAMPLE OF HOPMINI CALCULATIONS

Request 8km hop length @ 5 GHz



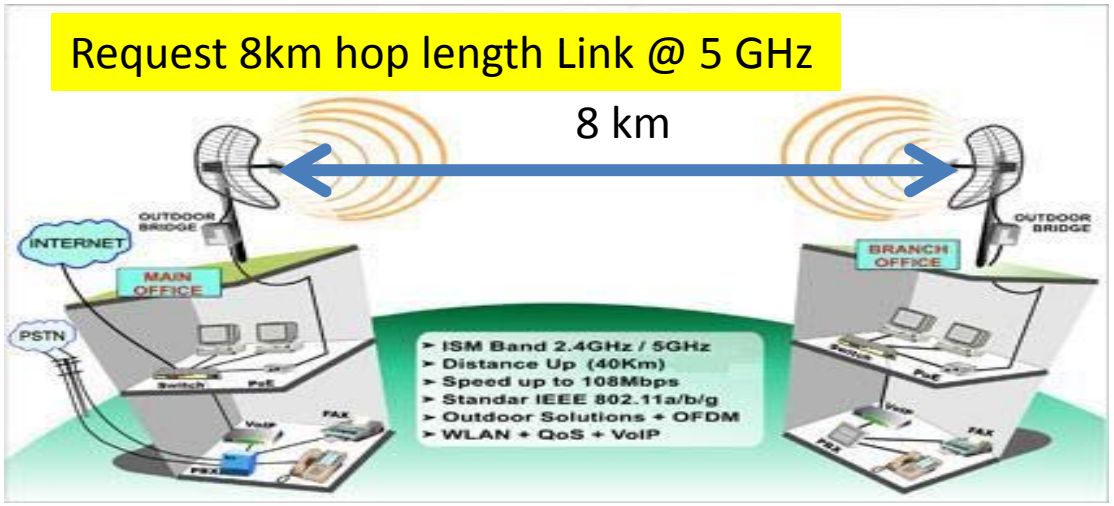
Advise –use from 17 GHz upwards

FREQUENCY BAND	MINIMUM PATH LENGTH
400 MHZ	100
800 MHz	60
1.4 / 1.6 / 2 GHz	30
4 and 5 GHz	16
7.5 GHZ	14
10 and 11 GHz	10
13 / 14 / 15 GHz	9
17 / 18 GHz	4
22 23 GHz	3
25 / 26 GHZ	3
28 GHZ	2
31 and 32 GHz	1.5
38 GHZ	1
Higher	0

Worked Examples

WHAT NEXT….

Request 8km hop length Link @ 5 GHz



If Applicant insists on request. PREMIUM IS CHARGED by calculating HOPMINI

Advise –use from 17 GHz onwards

If Applicant accepts advice then NO PREMIUM Charged. HOPMINI = 1

Worked Examples

Premium charged for insisting to deploy an 8 km Hop length link at 5 GHz will be calculated as follows:

$$HOPMINI = \sqrt{\frac{MINIMUM\ PATH\ LENGTH}{ACTUAL\ PATH\ LENGTH}}$$

$$= \sqrt{\frac{16km}{8km}}$$

$$= 1.414$$

The premium to be paid is 1.414 times the normal fee for the 5 GHz band.

Worked Examples

CALCULATIONS OF FEES FOR POINT TO AREA

Fee = (UNIT * FREQ * BW * CG * GEO * SHR * ASTER * UNIBI)

EXAMPLE 1

- A licensee in Johannesburg deploys point-to-area system (repeater, tracking, alarm …) at 150 MHz.
- The requested bandwidth is 25 KHz= 0.025 MHz (Simplex/Unpaired);
- Assuming that this particular band is congested in Johannesburg
- And that the requested coverage are is 1,256 km² (or alternatively a radius of 20 Km ($A = \pi r^2$))
- No protection zone (determined by the Authority)

NB: Services like alarms and tracking are Multipoint to Point in practice and can be treated As Point to Multipoint for the purpose of the calculations.

Worked Examples

CALCULATIONS OF FEES FOR POINT TO AREA

Fee = (UNIT * FREQ * BW * CG * GEO * SHR * ASTER * UNIBI)

EXAMPLE 1 contd.

- Unit Price = R 2000,00
- Frequency Factor (FREQ) = 1 [150 MHz falls within 30 MHz and 174 MHz]
- Bandwidth Factor = 0.025
- Congestion Factor (CG) = 1.5 [Congestion in Johannesburg]
- Geographical Factor (GEO) = 1 [JHB falls under high density area]
- Sharing Factor (SHR) = 1 [Exclusive assignment]
- ASTER = 56 [Sterilised area : between 1,000 and 10,000]
- UNIBI = 0.5 [unidirectional]

The annual fee would then be:
R2000*1*0.025*1.5*1*1*56*0.5 = R 2,100

Point to Area Spreadsheet

Spreadsheet

Bandwidth	**BW**	0.025	(MHz)						
Frequency	**FREQ**	150	(MHz)						
High Demand Spectrun	**CG**	Yes	Yes / No						
High Density Geograph	**GEO**	High Densit	Low / High						
Shared Usage?	**SHR**	Exclusive U	Exclusive / Shared						
Unidirectional?	**UNIBI**	Unidirectio	Bi- / Uni-		Area Selecte		Area factor		
Area Sterilised	**ASTER**	1 256	km^2		1 000	km^2	56		
Fee =		**UNIT ***	**BW ***	**FREQ**	**CG ***	**GEO**	**SHR ***	**UNIBI**	**ASTER**
ANNUAL SPECTRUM FEE =									
R 2 100.00	**= Π (**	R 2 000.00	0.03	1	1.5	1	1	0.5	56 **)**

Worked Examples

CALCULATIONS OF FEES FOR POINT TO AREA

Fee = (UNIT * FREQ * BW * CG * GEO * SHR * ASTER * UNIBI)

EXAMPLE 2

A licensee has been assigned 28 MHz bandwidth (duplex) in the 26 GHz band to deploy point to multi-point links on a national basis (exclusive).

- Unit Price = R 2000,00
- Frequency Factor (FREQ) = 0.1 [26 GHz falls within 23 GHz and 26 GHz]
- Bandwidth Factor = 28
- Congestion Factor (CG) = 1 [Not high demand]
- Geographical Factor (GEO) = 1 [National]
- Sharing Factor (SHR) = 1 [Exclusive assignment]
- ASTER = 600 [Sterilised area : > 500,000 km^2]
- UNIBI = 1

The annual fee would then be: R2000*0.1*28 *1*1*1*600*1= R 3,360,000

Point to Area Spreadsheet 2

Bandwidth	**BW**	28	(MHz)							
Frequency	**FREQ**	26 000	(MHz)							
High Demand Spectrun	**CG**	No	Yes / No							
High Density Geograph	**GEO**	High Density	Low / High							
Shared Usage?	**SHR**	Exclusive Use	Exclusive / Shared							
Unidirectional?	**UNIBI**	Bidirectional	Bi- / Uni-		Area Selected		Area factor			
Area Sterilised	**ASTER**	1 200 000	km^2		500 000	km^2	600			
Fee =		**UNIT ***	**BW ***	**FREQ ***	**CG ***	**GEO ***	**SHR ***	**UNIBI ***	**ASTER**	
ANNUAL SPECTRUM FEE =										
R 3 360 000.00	**= Π (**	R 2 000.00	28	0.1	1	1	1	1	600	**)**

Worked Examples

CALCULATIONS OF FEES FOR POINT TO POINT

Fee = (UNIT * FREQ * BW * CG * GEO * SHR * HOPMINI*UNIBI)

A licensee operates a hop length of 8 km using 28 MHz of Bandwidth (Duplex) in the 5GHz band in a low density area.

- Unit Price = R2,000
- Frequency factor FREQ = 0.3
- Bandwidth factor BW = 28MHz
- Congestion factor CG = 1.0 (no congestion)
- Geographical factor GEO = 0.1 (low density)
- Sharing Factor SHR = 1.0
- HOPMINI = 1.414 - [Premium, Slide 32]
- UNIBI = 1

The annual fee would then be: R2000 * 0.3 * 28 * 1 * 0.1 * 1 * 1.414 * 1 = R 2,375.88

Point to Point Spreadsheet

Bandwidth	**BW**	28	(MHz)							
Frequency	**FREQ**	5 000	(MHz)							
High Demand Spectrun	**CG**	No	Yes / No							
High Density Geograph	**GEO**	Low Densit	Low / High							
Shared Usage?	**SHR**	Exclusive U	Exclusive / Shared							
Unidirectional?	**UNIBI**	Bidirectiona	Bi- / Uni-		Band Selected		Minimum Hop		Factor	
Hop Length	**HOPMI**	8	km		5000		16	km	1.414	
					-5					
Fee =		**UNIT ***	**BW ***	**FREQ ***	**CG ***	**GEO ***	**SHR ***	**UNIBI**	**HOPMINI**	
ANNUAL SPECTRUM FEE =										
R 2 375.88	**= Π (**	R 2 000.00	28	0.3	1	0.1	1	1	1.414	**)**

Satellite Communications

- Satellite communications uses spectrum, in just the same way as does terrestrial communications.
- Satellites can be used in a point-to-point mode, or in point-to-multipoint.
- Satellite communications requires at least one Ground Station, although this does not have to be within the borders of RSA.
- If the Ground Station is in RSA, then a fee of R50,000 per annum is due
- There is no annual fee per Satellite terminal (the CPE)
- Satellite communications are important, as they are often the only economically viable option for providing Broadband connectivity in remote underserved areas.

Satellite Communications 2

- It is often difficult to calculate the spectrum fee due for satellite operations, especially when used for supplying Internet connectivity to end users
- This is because the Licensee is paying the Satellite Operator on a Mbps basis, not a MHz basis.
- In addition, the Licensee doesn't know at the beginning of a year how much bandwidth he will be consuming by the end of that year
- Figures vary, but 45 Mbps out of 36 MHz is typical, i.e. 1.25 bps / Hz
- The only practical solution is for the Licensee to make an estimate, and to adjust that estimate in the light of experience every year.

Satellite Communications 3

- The PtP formula doesn't make a lot of sense with a hop length of 72,000 km!
- Similarly, with coverage areas of a single satellite transponder possibly much larger than RSA, the PtMP formula doesn't make much sense either.
- The solution is to ignore the AIP formulae, and revert to the basic formula of UNIT * BW

Satellite Example

- A new Licensee has its Ground Station in Europe, for a geosynchronous satellite owned by a third party, providing **Ku-band** coverage over Southern Africa.
- He has no current customers, but estimates that he will have 1000 Internet access customers consuming a total of 45 Mbps Downlink and 15 Mbps Uplink by the end of the year. This is a PtMP application.
- No PtP satellite Links are envisaged.

Satellite Example 2

- Ground Station **R0**
- Terminals
  - 0 at beginning of year and 1000 at end of year = 500 average * R0 p.a. each = **R0**
- Bandwidth Downlink
  - 0 Mbps at beginning of year and 45 Mbps at end of year = 22.5 Mbps average ~= 18 MHz * R2,000 = **R36,000**
- Bandwidth Uplink
  - Already covered by Downlink fee (paired spectrum) **R0**
- Total annual Fee = **R36,000**

Multi Year Licences

- For some applications, such as Amateur, Aeronautical and Ship Stations (all of which attract the Minimum Fee of R120), it's to both party's benefit to offer the facility to pay for several years at once.
- A discount structure applies.
- Multiply the fee for one year by the factor

Years	1	2	3	4	5
Factor	1	1.91	2.74	3.49	4.17

Questions and Discussion