BENCHMARKS FOR REVIEW OF RADIO FREQUENCY SPECTRUM PRICING

SUPPLEMENT TO CONSULTATION DOCUMENT

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Contents

1 Introduction

This benchmarking report is submitted in relation to the review of the radio spectrum fees policy and fee schedule for The Bahamas. The information in this report is based on international best practice and benchmarks whilst taking account of the current level of fees, the nature of spectrum use and specific policy objectives that impact on the spectrum fees policy in The Bahamas.

The structure of the report is as follows:

- Section 2 describes the policy context, the current situation in respect of spectrum fees and the issues that need to be addressed in this study.
- Section 3 addresses benchmarking of fees for spectrum used for mobile and broadband wireless access (BWA) services.
- Section 4 addresses benchmarking of fees for all other services.

2 Current situation and issues

2.1 Legal and policy context

The legal framework for setting fees is given by the Communications Act (the Act). The Act variously gives powers to the Minister and URCA to issue licences and set fees as described below.

The Minister may designate certain frequency bands as premium bands and shall decide the method of allocating frequencies in these bands (section 30(1) of the Act). To date certain bands used for cellular mobile and broadband wireless access services have been designated as premium spectrum (see Table 2-1). Other bands are referred to as standard spectrum.

Table 2-1: Premium spectrum bands

Band name	Frequency range
850MHz	824-849/869-894 MHz
1900MHz	1850-1910/1930-1900 MHz
1.7/2.1GHz	1710-1755/2110-2155 MHz
2.3 GHz	2305-2320/2345-2360 MHz

Source: Fee Schedule for 2013, ECS 27/2012[1]

In premium bands spectrum fees or the method of setting fees are determined by the Minister, advised by URCA, while in standard bands spectrum fees are set by URCA (section 30(2) of the Act). In all cases fees are to be set so as to ensure the optimal use of spectrum[2] (section 93(2) of the Act).

Mobile sector liberalisation is likely to stimulate demand for spectrum in cellular mobile bands (and possibly for backhaul), meaning that it is imperative that fees provide incentives for efficient spectrum use and a disincentive for hoarding spectrum in the cellular mobile bands. Universal service and SME policies both point toward setting relatively low fees in sparsely populated islands and cays, as compared with the fees set in the most populated islands of New Providence and Grand Bahama (which account for 70% and 15% of the Bahamas population respectively[3]).

2.2 The current fees

All entities that have been assigned radio spectrum under either an individual licence or a class licence requiring registration are required to pay a spectrum fee[4]. Licence fees are not paid by holders of class licences that do not need to be registered or licence exempt services. A service may be licence exempt under:

- A statutory provision – section 17 of the Act states that the Royal Bahamas Police Force, Royal Bahamas Defence Force, providers of fire brigade, ambulance, coast guard and other emergency services or military services authorised to operate in the Bahamas are exempt from licensing.

[1] http://www.urcabahamas.bs/download/042081600.pdf

[2] Section 93, Communications Act 2009

[3] Department of Statistics of the Bahamas, 2010 Census http://statistics.bahamas.gov.bs/download/082103200.pdf

[4] See Table 1, Guidance on the Licensing Regime under the Communication Act 2009, ECS 15/2009

- A determination issued by URCA – for example low power devices (as defined by Part 15 of Title 47 of the FCC's Code of Federal Regulations) are licence exempt[5].

Spectrum licensees that also have an operating licence are required to pay URCA annual fees (to cover URCA's administrative costs) and an application fee each time they apply for additional spectrum or a new spectrum licence. Application fees range from $10-$5000 depending on the service the spectrum is used to deliver. In addition, these licensees (which pay annual URCA Fees) are required pay a statutory Communications Licence Fee set at 3% of relevant turnover.

The current fees for premium and standard spectrum are set out in the Fee Schedule 2014[6] and are described below. Some of these fees were set taking account of benchmarks while others were set by URCA's predecessor, the Public Utilities Commission.

2.2.1 Fees for premium spectrum

Table 2-2 gives the premium spectrum fees all expressed as a fee/MHz[7]. As can be seen lower values apply to those bands where full mobility is not permitted. We understand that the restriction on mobility is likely to be lifted when the mobile sector is liberalised in which case a higher fee may be justified at that time on the grounds that the spectrum is then more valuable.

Table 2-2: Premium spectrum fees – all charged on a national basis

Band	Fee - S/MHz	Permitted services	Geography
850 MHz	10,000	Cellular mobile	National
1900 MHz	5,000	Cellular mobile	National
1.7/2.1GHz	600	Broadband wireless access (fixed or nomadic)	National
2.3 GHz	600	Broadband wireless access	National

Other bands that could in principle be used to provide cellular mobile services, i.e. the 700MHz and the 2.5 GHz bands, are not designated as premium spectrum at present. The fees for these bands are as follows:

- The fee for the 700MHz band is given at $6,000-8,000/ MHz (see Table 2-5) depending on the specific frequencies assigned and so is less than the fee for the 850MHz band, despite the two bands having similar propagation characteristics and supporting cellular mobile services.
- The fees for the 2.5 GHz band of $133/MHz is much lower than that for the 2.3 GHz band (see Table 2-4) again despite these frequencies having similar propagation characteristics and both being harmonised for use by mobile broadband services. We note that historically the 2.5 GHz band was reserved for point to multi-point broadcasting services (MMDS) though more recently it has been used for providing point to multipoint broadband wireless access in some of the Family Islands.

The variation in the fees/MHz across similar bands means that if a new set of fees more closely linked to spectrum value is put in place then there could be large changes in the fees paid in some bands.

[5] Spectrum Exemption, URCA, ECS 09/2009

[6] ECS 21/2013 available at www.urcabahamas.bs.

[7] Note that twice the amount shown is paid for 2 x1 MHz of paired spectrum.

2.2.2 Standard spectrum fees

Those standard spectrum fees that do not vary by bandwidth assigned are given in Table 2-3. In most cases the services share a common bandwidth with other licensees, though this is not the case for AM and FM radio where exclusive assignments must be granted to limit interference between users.

Table 2-3: Standard spectrum fees that do not vary by bandwidth – charge is applied on a per island basis

Service	Fee ($)	Comments
Aeronautical fixed ground station	300	Used for communication with aircraft
Ship Radio Telephone Station fitted with GMDSS equipment	150	Used for ship to shore communications
VSAT systems	500	Schedule states that payment depends on number of 64kbs channels though in practice charges for multiple channels are not levied.
Earth stations with dishes larger than 3.8 meters	4500	
Amateur radio station	25	For local amateurs and those from countries where there are reciprocal arrangements
Experimental radio station	100	
AM and FM radio	500	Same charge on all islands

The standard spectrum fees that vary by bandwidth assigned are shown in Table 2-4. These fees are all charged on a per island basis with no differences in the level of fees between islands. As can be seen when expressed as a fee/MHz the fees vary considerably between bands and services. If a new fee schedule that relates fees to bandwidth used is put in place then those applications that use wide bandwidths (e.g. TV services), and so have a low fee/MHz could face substantial fee increases.

Table 2-4: Standard spectrum fees that vary with bandwidth – all charged on a per island basis

Band	Fee ($)	Fee (S/MHz)	Service
150-174MHz, 400-470MHz	250 - single 25kHz channel 500 - 25kHz pair	$10,000/MHz	Land mobile fixed station, some fixed point to point links and telemetry
VHF (174-216 MHz) and UHF TV (470-698MHz) bands	3000 per 6MHz bandwidth	$500/MHz	TV
806-821/851-866Hz	390 – private trunking (125kHz paired) 1300 – public trunking (125 kHz paired)	$1580/ MHz; $5200/MHz	Private trunked radio; Public trunked radio
929-932 MHz	100 - private Paging (25 kHz) 1300 – public paging (25 kHz)	$4000/MHz; $52000/MHz	Private paging; Public paging
944-951 MHz	250 – per 100 kHz	$2500/MHz	Studio to transmitter links
2.5 GHz	800 – per 6 MHz	$133/MHz	Point to multi-point
3.5 GHz	$2000/MHz for the first pair of 1MHz channels; $1000/MHz for additional pairs of 1Mhz channels	$2000/MHz for the first pair of 1MHz channels; $1000/MHz for additional pairs of 1Mhz channels	Point to multi-point
Many bands above 1 GHz	Up to 50 kHz - $450link 50kHz to 3.5MHz – $620/link 3.5-30MHz - $800/link 30MHz and more - $1200/link	Varies with link bandwidth e.g. 25kHz - $10,000/MHz 3.5MHz - $229/MHz 7 MHz - $114/MHz 56 MHz - $21/MHz	Fixed point to point services

2.2.3 Fees for newly opened bands

The fees set in 2012 for newly opened bands are all expressed as a value/MHz on a national basis as shown in Table 2-5.

Table 2-5: Spectrum fees for newly opened standard spectrum bands: 700MHz, 11 GHz, 12 GHz and 42 GHz – all national

Frequency band	$/MHz	Services
700MHz	6-8,000[8] (depending on the block assigned)	Cellular mobile
11 GHz	20	Point to point links
12 GHz	20	Point to multi-point
42 GHz	10	Point to point and point to multi-point

URCA's decision on these fees sets out a general fee structure for point to multipoint services in any newly opened bands in the frequency ranges from 300MHz to above 30GHz – see Table 2-6.

Table 2-6: Interim spectrum fees for point to multi-point services in newly opened bans - 2012

Frequency range	Fee/MHz (The Bahamas)	Fee – specific services
300-500Mhz	$16,000/MHz	$10/kHz (land mobile)
500-960 MHz	$8,000/MHz	$5.2/kHz (public trunking) $1.56/kHz (private trunking)
960-2.6 GHz	$4,000/MHz	
2.6-6.7 GHz	$2,000/MHz	
6.7-30 GHz	$20/MHz	Fixed point to point services: Up to 50 kHz - $450link 50kHz to 3.5MHz – $620/link 3.5-30MHz - $800/link 30MHz and more - $1200/link
Above 30GHz	$10/MHz	Fixed point to point services: Up to 50 kHz - $450link 50kHz to 3.5MHz – $620/link 3.5-30MHz - $800/link 30MHz and more - $1200/link

2.3 Issues with the current fee schedule

2.3.1 Structure and scope

The current fee schedule is structured around particular applications and/or frequency bands. This results in a fee structure that is not consistent across bands, even where these bands are used by the same services and means that each time a new band is opened up a new set of fees has to be determined. Similarly if a new application uses a particular band then in principle a new set of fees would need to be developed. The issue was recognised when several new bands were opened up in

[8] The amount paid depends on whether the specific block assigned is allocated for fixed or mobile services.

2012, and an interim fee schedule that is more comprehensive was proposed incorporating some elements of the existing fee schedule.

In the aeronautical and maritime area only communications stations are licensed. The coastguard is licence exempt but this is not the case for aeronautical use of spectrum. The fees schedule does not cover a number of uses of the aeronautical bands by airports, e.g. radars.

2.3.2 Promoting optimal spectrum use

A key issue this study must address is: does the existing fee schedule promote optimal spectrum use? The answer to this question depends on both the level as well as the structure of fees. Most fees are related to the bandwidth assigned to a licensee and this should provide an incentive for efficient use (e.g. not hoarding spectrum) if fees are set at the right level.

However, fees in New Providence are in many cases the same as those in other islands which is unlikely to promote optimal spectrum use – rather it could well deter use on islands where spectrum is plentiful. Also if fees in New Providence are too low then there could be excess demand. Universal service and SME policies would be best promoted through lower fees on less populated islands – as is recognised in the interim fees for newly opened bands.

Two characteristics of the fee schedule suggest that some fees may not be set at the right level, namely the wide variation in the levels of fees/MHz across bands below 4GHz (shown in Table 2-2 and Table 2-4) and that the same fees apply for all bands above 4GHz. The interim fee schedule for newly opened bands partially addresses this issue by setting a fee/MHz that declines with frequency.

2.3.3 URCA's spectrum management cost recovery

URCA passes the fees it raises to government which means that the costs of spectrum management are recovered through the URCA Fee and not spectrum fees. This is required under the Communications Act but means that non-spectrum users are paying spectrum management costs. URCA would like to see an arrangement under which spectrum users pay spectrum management costs.

2.4 Principles

Widely recognised best practice requires that licence fees be set in a fair, objective and transparent manner without incurring undue administrative costs while promoting efficient spectrum use.

- Fairness and objectivity mean that fees should be based on objective factors and all licence holders in a given frequency band should be treated on an equitable basis. This would preclude, for example, different treatment of different users in a given frequency band.
- Transparency requires that the basis on which fees are calculated should be made clear in a published document. All fees should be set based on a published schedule.
- Administrative costs will be low if the fee schedule is simple to administer. The simplest fee schedule would be one involving a flat fee payment; however this would not promote efficient spectrum use in many circumstances.
- Administrative simplicity needs to be balanced against the requirement to encourage efficiency of spectrum use if fees are set taking account of parameters such as bandwidth, frequency band or coverage.

To provide incentives for efficient spectrum use, spectrum fees should be related to the amount of spectrum assigned, because users can then reduce their payments by reducing their spectrum holdings. Fees with incentives for efficient use must also be set at the right level – if they are too low then users may continue to hoard spectrum while if they are too high spectrum will be left idle needlessly.

2.5 Fees structure

For the purposes of setting fees spectrum assignments can be characterised by three dimensions[9] – bandwidth, geographic area and time. So when referring to the amount of spectrum assigned the following measures are typically used:

- Bandwidth – this is measured by the number of kHz or MHz assigned
- Geographic area – strictly speaking this should be the area over which use is denied to other licensees (sometimes referred to as the area sterilised)
- Time – duration of use in fraction of a day, week, year

Fees formulae that reflect these ideas typically take the form of:

Fee= C x FBF x CF x TF x BW

Where:

C = constant value/MHz that may (or may not) vary by frequency band or service to reflect a mix of commercial and social factors that depend on the services that may use the band

FBF = Frequency Band Factor, which reflects the increased utility and more limited availability of spectrum in lower frequency bands and in some cases the higher spectrum management costs associated with those bands (due to increased probability of interference)

CF = Coverage Factor, which reflects the area over which use by other licensees is denied, i.e. it is the area sterilised by an assignment. Some regulators set this factor to also vary by the (approximate) size of the population served in the coverage area or may use an urban/rural differentiation in fees through this factor.

TF = Time factor which is set to a fraction of a day, week or year that the frequencies are assigned.

BW = Licensed Bandwidth in MHz

In general the bandwidth and duration of assignments is specified in licences and so is known. In most cases the value of the time factor will be 1, but there may be some cases of temporary licences where the value could depend on the number of months of use or where licensees share frequencies by time (e.g. this happens in London with some community radio stations).

However, the area sterilised is not always known. It depends on both the technical characteristics of the transmission (e.g. height of antennas, frequency range, power, modulation, etc.) and their interaction with the geographic features of the area served (e.g. tall buildings or hills may block transmissions). Planning tools would need to be used to determine the area precisely. It is for this reason that approximate measures of the area sterilised are sometimes used by regulators, e.g. transmission power giving an average transmission distance or the inverse of the frequency reuse factor observed in practice. Also for point to point services the area sterilised is not a circle unlike

[9] Polarisation may give another dimension but is not usually specified by the Regulator and is only feasible for certain applications. It is not explicitly considered here.

point to multi-point services, and so again approximations are required. An example of the application of this approach is given in Figure 3-1.

Figure 3-1: Example of spectrum fees schedule for Bahrain (2010)

Power/coverage / Frequency Band	Spectrum Charge, BD per MHz					
	Nationwide	≥ 25W e.r.p	≥1 W and < 25W	≤ 1W	Fixed P-P	Earth Stn and VSAT
1. VLF/LF/MF (3kHz – 3MHz)	4338	3904	2169	1085	434	434
2. HF (3 – 30MHz)	6507	5857	3254	1627	651	651
3. VHF (30 – 300MHz)	4338	3904	2169	1085	434	434
4. UHF1 (300 – 470MHz)	3254	2928	1627	813	325	325
5. UHF2 (470 – 2700MHz)	6507	5857	3254	1627	651	651
6. SHF (2.7 – 10 GHz)	1085	976	542	271	108	108
7. SHF/EHF (10 – 55 GHz)	434	390	217	108	43	43
8. EHF (55 – 275GHz)	Fixed fee of BD1,000 per fixed link, independent of bandwidth.					

Source: Bahrain Telecommunications Regulatory Authority Schedule of Fees for 2010, July 2010

This general approach to setting fees assumes use of a frequency in a given location denies use to other users. This is sometimes not the case:

- Land mobile users may share a frequency and risk interrupting/interfering with each other's transmissions.
- Spectrum licence holders share frequencies from a common pool as occurs with aircraft, ship or amateur station licences and licences in some shared satellite bands.

The first situation occurs for a limited number of services (e.g. land mobile) and in locations where spectrum is very congested (e.g. London). The second situation occurs in all countries (including The Bahamas) and the standard approach internationally is to set a flat rate fee per station.

A best practice approach to deriving fees has been to consider bands that are or could be used to provide cellular mobile services (see Section 3 below) separately from bands for all other services (see Section 4 below). This is because of differences in spectrum value and because cellular mobile assignments in The Bahamas are national while other assignments are generally localised.

2.6 Level of fees

A key consideration that affects the fee level is whether the frequencies assigned are in a band that is congested, in the sense that demand for the spectrum is likely to exceed demand at low prices. In these cases it is economically efficient to set fees that reflect the commercial value of the spectrum as may be revealed through a market. This is the reason why auction benchmarks are often used to set these fees.

In The Bahamas at present only the FM radio band on New Providence is congested in the sense that there are no more frequencies available. Those bands that could in future be offered to new mobile

operators are likely to become congested in the immediate future are: 700MHz; 850MHz; 1900MHz and 1.7/2.1 GHz (the AWS band). In the longer term the 2.5 GHz or 3.5 GHz band and any new bands made available for mobile below 3GHz (e.g. the 600MHz band[10], extensions to the 850MHz band and extensions to the AWS band[11]) could be in high demand. In Section 3 below we discuss the level of these fees based on auctions and other benchmarks. It is assumed that all spectrum assigned for cellular mobile will be assigned on a national basis and so values are derived per MHz.

For bands that are not congested, fees should broadly recover the costs of spectrum management unless there are good policy reasons to do otherwise. The reason for using the costs of spectrum management to set a floor on fee levels is that this ensures the benefits from spectrum use exceed the costs of making the spectrum available. If this was not the case then assignments should not be made. These principles are reflected, for example, in the European Union Authorisation Directive which requires that administrative charges levied on spectrum licensees should recover spectrum management costs, be objective and transparent. National regulators are required to publish an annual overview of administrative costs and the total sum of charges collected. The total sum of charges must cover the costs of spectrum management, however, charges for individual services do not need to be cost reflective.

[10] http://www.fcc.gov/topic/incentive-auctions

[11] http://www.fcc.gov/rulemaking/12-70

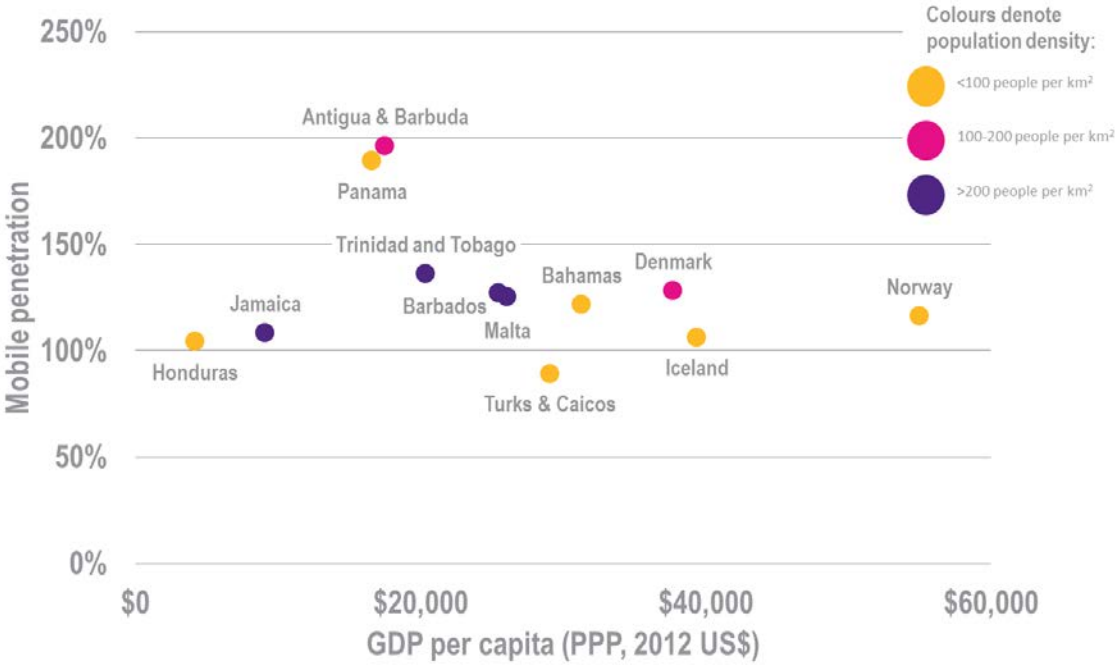
3 Benchmarking fees for mobile and BWA frequency bands

3.1 Introduction

This Section considers fees for frequency bands used to provide mobile services or broadband wireless access. Our approach is to benchmark values in The Bahamas against those in other comparable countries – taking particular note of values determined by an auction as these arguably give the most reliable indicator of value in a competitive situation[12].

To select relevant benchmarks we focus on countries with similar characteristics to The Bahamas, for example in terms of population, GDP per capita, geography and state of development of the mobile industry. The starting point is to examine neighbouring Caribbean countries. Ideally auctions would be the best proxy for the market value of spectrum but there have not been many auctions among the Caribbean countries (Puerto Rico, US Virgin Island values are from US auctions). Most Caribbean countries still charge annual fees based on a fee schedule. To give a bigger sample of auction values we have extended the sample to include some neighbouring Central America countries and small affluent countries in Europe that have a low population density. This led to the inclusion of Honduras, Panama, Denmark, Iceland, Malta and Norway. Figure 3-1 shows the benchmark countries based on mobile penetration, GDP per capita and population density.

Figure 3-1: Characteristics of benchmark countries



Source: Plum Consulting, ITU, World Bank, CIA World Factbook, Cable & Wireless

When comparing values across different countries it is necessary to control for differences in size of population, exchange rates and the time at which values apply. Hence when making comparisons we have converted all values to a value/MHz/pop and denominated values in USD and 2013 prices.

[12] Note value with a monopoly should be higher than in a competitive situation but as sector liberalisation is anticipated we consider that competitively determined benchmarks are most appropriate.

One other important difference between countries is the extent to which they levy charges that vary with the amount of spectrum held additional to the auction payment and/or spectrum licence fee. In most cases in the Caribbean though not in Europe or the US significant fees related to revenues but not directly related to spectrum holdings – though there is an indirect link if additional spectrum allows higher revenues to be earned. As the link is indirect (and the amounts paid are not known and in the US and Europe other taxes may be paid) we do not adjust for these fees. However, where published annual spectrum fees are charged in addition to auction payments we have adjusted the benchmarks to include these payments.

3.2 Frequency bands and their relative value

The frequency bands used for cellular mobile services and BWA services are grouped together in the ITU Radio Regulations under the label of IMT bands, now that WiMAX has been classed as an IMT technology. The bands harmonised for IMT services in the ITU Radio Regulations are as follows[13]: 450 – 470 MHz; 698 – 960 MHz; 1710 – 2025 MHz; 2110 – 2200 MHz; 2300 – 2400 MHz; 2500 – 2690 MHz; and 3400 – 3600MHz

The specific frequency bands used for cellular mobile and BWA services in The Bahamas are aligned with those used in the US but there are comparable bands used in Europe (see Table 3-1) and we also use data for these bands in our analysis. In both Europe and the US there is current regulatory activity to find more harmonised spectrum for cellular mobile services. Both regions seem likely to harmonise the 3.5 GHz band for this purpose and increase the spectrum below 3 GHz for mobile services, e.g. in the US the 600MHz band, extension to the 850MHz band and extensions to the AWS band seem likely to occur.

The relative value of different frequency bands is determined in part by their physical characteristics. Lower frequencies travel further and so are particularly good for providing wide area coverage and penetrating buildings. Higher frequencies offer more capacity which is particularly useful for broadband services.

[13] http://www.itu.int/net/newsroom/wrc/2012/features/imt.aspx

Table 3-1: Harmonised frequency bands for mobile services in Europe and the US

Europe		US	
Band Identifier	**Frequencies**	**Bandwidth identifier**	**Frequencies**
450 MHz	450-457/460-467 MHz	-	-
800 MHz	791-821/832-862 MHz	700MHz	698-716/728-746 MHz 746-757/776-787 MHz 716-728 MHz
900 MHz	880-915/925-960 MHz	850 MHz	824-849/869-894 MHz
1800 MHz	1710-1785/1805-1880 MHz	1900 MHz	1850-1910/1930-1990 MHz
2100 MHz	1920-1980/2110-2170 MHz 1900-1920 MHz 2010-2025 MHz	AWS	1710-1755/2110-2155 MHz 2000-2020/2180-2200 MHz
2.3 GHz[14]	2300-2400MHz	2.3 GHz	2305-2315/2350-2360 MHz
2.6 GHz	2.5-2.69 GHz	2.5 GHz	2496-2690 MHz

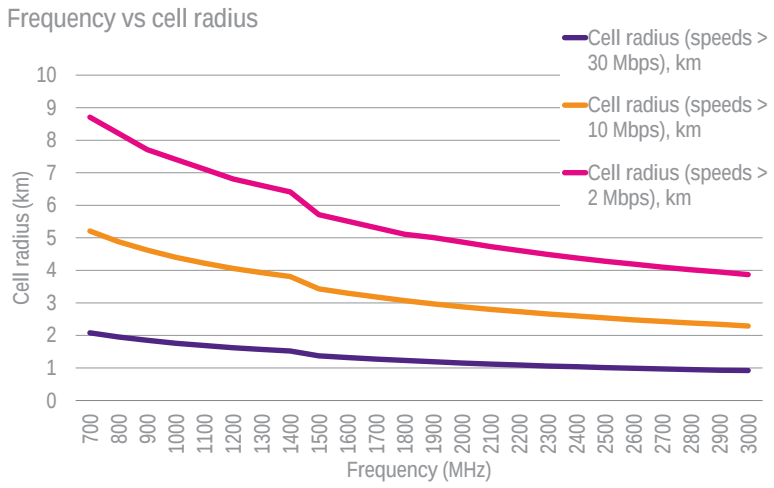
The relationship between frequency and cell radius[15] for different mobile broadband speeds is shown in Figure 3-2 assuming LTE technology, 2x10MHz and rural outdoor coverage[16]. As can be seen sub-1 GHz spectrum offers significant gains in terms of coverage compared to frequencies above 1 GHz and this is the case across different assumed data rates. Nevertheless it might be expected that frequencies below 1 GHz would be worth 60-80% more than those above 1 GHz. In addition the greater supply at higher frequencies in itself reduces the market (i.e. auction) value for these frequencies.

[14] This band is not yet harmonised in Europe but there is on-going technical work to achieve harmonisation in 2014/15.

[15] Calculated by Aegis Systems using the Extended Hata model, see http://tractool.seamcat.org/wiki/Manual/PropagationModels/ExtendedHata
We assume a base station height of 30 metres, mobile height of 1.5 m and base station EIRP of 58 dBm (typical of a large macro site). The discontinuity apparent at 1500 MHz reflects the two different formulae used above and below this frequency, which produce a difference of 1.1 dB in the predicted path loss at the crossover frequency.

[16] See also: van Hooft, L, Building next generation broadband networks in emerging markets. In "Making Broadband Accessible for All", Vodafone Policy Paper Series, May 2011; Markendahl, J; Makitalo,O; Molleryd, B; and Werding,J., "Mobile broadband expansion calls for more spectrum or base stations: analysis of the value of spectrum and the role of spectrum aggregation", Conference paper, 21st European Regional ITS Conference, Copenhagen, September 2010.

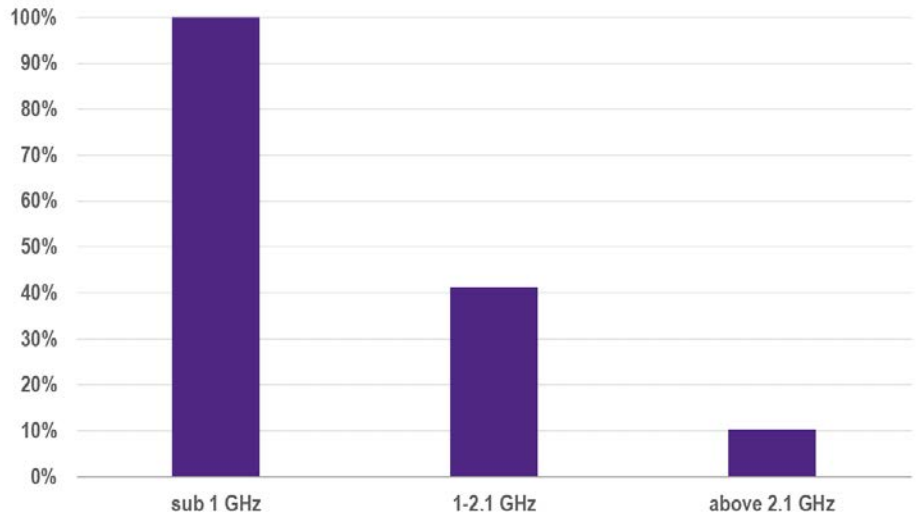
Figure 3-2: Frequency versus cell radius for cellular mobile



Source: Aegis Systems calculation

Figure 3-3 shows the relative average values for sub 1 GHz, 1-2.1 GHz and above 2.1 GHz mobile spectrum based on our database of international auctions from 2005 onwards. Sub 1 GHz spectrum is most highly valued by mobile operators followed by 1-2.1 GHz spectrum which is around 60% less. Values for frequencies above 2.1 GHz (2.3 GHz and 2.5 GHz) are only around a tenth of sub 1 GHz values. While the results depend to some extent on the particular countries where auctions have been held they support the findings in respect of the physical characteristics of the frequencies.

Figure 3-3: Relative decline in value by frequency band



Note: Based on 114 data points from auctions conducted from 2005 onwards
Source: Plum database

3.3 Benchmark values

When considering the benchmark values, it is important to note the timing of assignment – in particular, those values for 850/900 MHz and 1800/1900 MHz which were assigned before the mobile-smartphone era (i.e. pre-2007) and thus used mainly for provision of 2G voice and text

services. These values may not be accurate indicators of current and future value given the change in market circumstances. We therefore exclude data before 2005 and focus on benchmark values from recent auctions and fees which have been revised.

Table 3-2 and Table 3-3 present the Caribbean benchmarks and other international benchmarks respectively. To enable comparison the values are annual fees expressed in USD/MHz/pop. Fees for auctions are in green cells and, where necessary, annualised values are derived using a 10% discount rate. For auctions, values are calculated based on market exchange rates and population at time of auction and then adjusted to USD 2013 prices. Where annual fees are charged on top of auction fees, the reported values reflect both (e.g. Norway and Denmark). Appendix A provides more details on the benchmark data.

Table 3-2: Annual fee benchmarks – Caribbean countries (USD/MHz/pop), June 2013

Frequency band	Turks & Caicos	Trinidad & Tobago	Jamaica	Antigua & Barbuda	Barbados	Puerto Rico-US Virgin Islands	Puerto Rico	US Virgin Islands
700	0.0804	**0.0369**	**0.0780***			**0.0474**	**0.1173**	**0.0505**
850	0.0925	0.0316		0.0416 (all bands)	0.0845			
900	0.0925	0.0316			0.0845			
1800	0.1234	0.0316			0.0845			
1900	0.4811	0.0316			0.0845			**0.1831**
AWS						**0.0107**	**0.0110**	**0.0144**
2300		**0.0007**						
2500		**0.0051**						

Notes: * Jamaica (JAM) 700 MHz fee is based on reserve price for upcoming auction. PRI-VIR refers to licences covering Puerto Rico (PRI) and US Virgin Islands (VIR). Barbados (BRB) fees are calculated based on a typical operator holding 56 MHz across the bands.

Values in cells marked green are auction based on auction results

Table 3-3: Annual fee benchmarks – international (USD/MHz/pop), June 2013

Frequency band	Honduras	Panama	Norway	Denmark	Iceland	Malta
800				**0.0428**		
900			0.0179	**0.0070**	0.0065	0.1401
1800			0.0173	**0.0028**	0.0065	0.1401
1900	**0.0311**	**0.0929**				
2100			**0.0242**	**0.0637**	0.0065	0.0568
2300			**0.0016**			
2500			**0.0055**	**0.0210**		

In general the benchmarks indicate that sub-1 GHz spectrum is more valuable than frequencies above 1 GHz, aside from some Caribbean countries for which the fee schedules do not differentiate fees by frequency band (e.g. Antigua & Barbuda, Barbados, Trinidad & Tobago) or the fees deviate from the normal pattern (i.e. Turks & Caicos – fees rise with frequencies increase). The decline in

value for higher frequencies is expected given the better propagation characteristics of lower frequencies which provide better coverage.

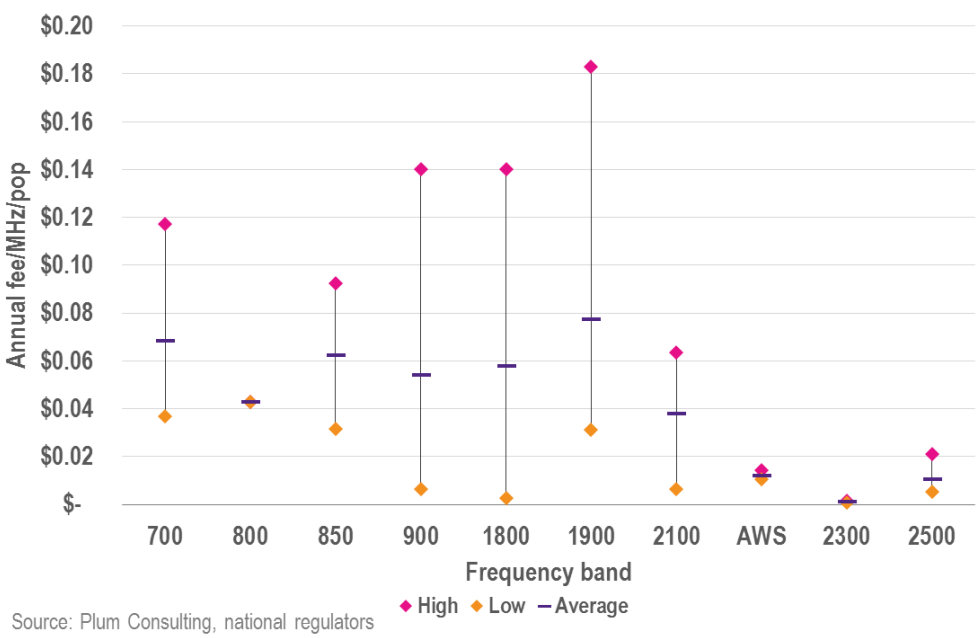
Table 3-4 and Figure 3-4 show the average value and the range for each band. The Turks and Caicos 1900 MHz fee is excluded as it is a clear outlier. The averages indicate that the sub-1 GHz and the 1-2.1 GHz values are similar with those frequencies above 2 GHz considerably lower by an order of magnitude. While the range within each band is wide particularly around 850/900 MHz and 1800/1900 MHz, this is not unexpected considering that some of the older fees are likely to be either technology-specific or set for voice rather than broadband data services (e.g. Barbados and Trinidad & Tobago schedules are from 2006).

Table 3-4: Annual fee benchmarks by frequency band (US$/MHz/pop), June 2013

Frequency band	High	Low	Average
700	0.1173	0.0369	0.0684
800	0.0428	0.0428	0.0428
850	0.0925	0.0316	0.0625
900	0.1401	0.0065	0.0543
1800	0.1401	0.0026	0.0580
1900	0.1831	0.0311	0.0775
2100	0.0637	0.0065	0.0378
AWS	0.0144	0.0107	0.0120
2300	0.0016	0.0007	0.0012
2500	0.0210	0.0051	0.0105

Note: * excludes the Turks & Caicos outlier.

Figure 3-4: Annual fee benchmarks by frequency band (US$/MHz/pop), June 2013



Source: Plum Consulting, national regulators

Looking at the sub-1 GHz band, there is some recent activity in the Caribbean around the assignment of 700 MHz spectrum which gives a useful indication of the value. In particular, Turks & Caicos (TCA) has recently assigned a total of 46 MHz to Digicel and Islandcom[17] while Jamaica (JAM) have announced details of the upcoming 700 MHz auction.[18] The annual fees for TCA and JAM benchmarks are around $0.08/MHz/pop which is about twice the Puerto Rico-US Virgin Islands values from the US 700 MHz auction in 2008. The 700 MHz Puerto Rico-only value of $0.12/MHz/pop is the upper bound. The overall sub-1 GHz average is $0.057/MHz/pop. A reasonably conservative benchmark for Bahamas would be around $0.04/MHz/pop.

For frequencies between 1-2.1 GHz, the overall average is $0.0483/MHz/pop. This is slightly skewed by the 1900 MHz fees which have the highest value among the Caribbean countries. Furthermore, some of the AWS frequencies (1700/2100 MHz) within the Caribbean are still being used for broadband wireless access rather than AWS which account for their lower fees. The fees for AWS in Puerto Rico and Virgin Islands and 2100 MHz in Europe, where these frequencies are already widely used for 3G mobile data services give a better indication of the possible range going forward, i.e. between $0.01-0.06/MHz/pop. A reasonable benchmark for Bahamas would be around $0.02/MHz/pop.

For bands above 2.1 GHz, the overall average is $0.0059/MHz/pop and the values are significantly lower than the sub-1 GHz and 1-2.1 GHz benchmarks. The 2.3 GHz band is a globally harmonised band for mobile under the 3GPP standards but is only now starting to be allocated by regulators for mobile (e.g. it is not a mobile band in Europe, only 2x15 MHz may be used by mobile in the US). The main markets where it has been designated for mobile use are India and China but deployment in networks is not expected for some time and so it will not be supported by mass market mobile handsets in the near term. Where assigned it has been used mainly for BWA/WiMAX although it is likely to become an LTE band in future. The 2.5 GHz band is already used for LTE in Europe and the US but mainly to provide capacity rather than coverage. Given that there are unlikely to be significant capacity constraints in The Bahamas outside of New Providence, we expect the value of these bands to be considerably lower than sub-1 GHz and 1-2.1 GHz. A reasonable benchmark would be around $0.002/MHz.

3.4 Initial recommendations

Table 3-5 and Figure 3-5 summarise the benchmark values and our preliminary recommendations for The Bahamas.

Table 3-5: Benchmarks and preliminary views on annual fees for The Bahamas

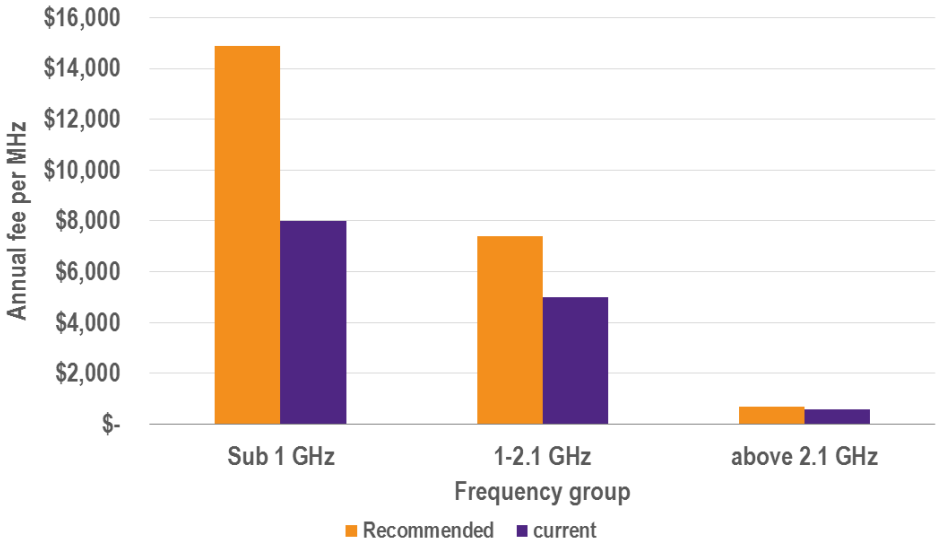
Band grouping	Overall average (US$/MHz/pop)	Recommended (US$/MHz/pop)	Recommended (US$/MHz)	Current Bahamas fees (US$/MHz)
Sub 1 GHz	0.0570	0.04	14900	8000
1-2.1 GHz	0.0463	0.02	7400	5000
above 2.1 GHz	0.0059	0.002	700	600

Notes: All values are in June 2013. Bahamas 2012 population 371960 (World Bank). Sub-1 GHz value for Bahamas based on average of 700 MHz and 850 MHz fees in the Fee Schedule (ECS 27/2012)

[17] http://www.telecommission.tc/content/root/files/20130220142254-Decision-2013-2-Prime-700MHz-Spectrum-Assignment-Feb-20-20131.pdf

[18] The Jamaica benchmarks are based on the average reserve price of the 2 lots (704-716/734-746; 746-758/776-788 MHz) up for auction.

Figure 3-5: Comparison of recommended and current fees



4 Benchmarking fees for all other spectrum bands/uses

The proposals for setting spectrum fees given in this Section distinguish between fees for applications that share a common pool of frequencies – referred to as station licence fees – and fees for applications that deny access to spectrum – referred to as bandwidth related fees. For the latter we explore the possibility of using a fees formula like that discussed in Section 2.

4.1 Station licence fees

Station licence fees are set on a per station basis independent of the number of radios or bandwidth used. In most countries such fees apply where a licence authorises access to a pool of radio frequencies that is designated internationally for the licensed use and that is intended to be shared by other holders of such licences. Such fees typically apply to amateur radio licences, aeronautical ground station and aircraft station licences, and ship station licences.

In The Bahamas station fees also apply to use of spectrum by experimental radio stations, broadcast radio licensees and VSAT systems and satellite earth stations, as shown in Table 4-1. For experimental radio stations we see no reason to change the current fee given the desire to promote experimental radio use and the plentiful availability of spectrum in many bands.

The subsections below consider whether there are good reasons to change either the structure or level of fees for the other applications.

Table 4-1: Standard spectrum fees that do not vary by bandwidth – charge is applied on a per island basis

Service	Fee ($)	Comments
Aeronautical fixed ground station	300	Used for communication with aircraft
Ship Radio Telephone Station fitted with GMDSS equipment	150	Used for ship to shore communications
VSAT systems	500	Schedule states that payment depends on number of 64kbs channels though in practice charges for multiple channels are not levied.
Earth stations with dishes larger than 3.8 meters	4500	
Amateur radio station	25	For local amateurs and those from countries where there are reciprocal arrangements
Experimental radio station	100	
AM and FM radio	500	Same charge on all islands

4.1.1 Amateur, aeronautical and ship station fees

Starting with amateur, aeronautical and ship station licences there is little reason to change the current fees. While different fees levels are found in other countries there is no systematic variation or consensus around the levels except they are kept low. Hence we suggest keeping the fees at current levels.

Table 5-2: Examples of station fees

Country	Amateur	Aeronautical station	Coastal station
Antigua	$20	$80	$100
Bermuda	$60	$470	$465
Jamaica	0	$29	$23
New Zealand[19]	$40	$240	$240
Portugal	Not available	$66	$66
Trinidad & Tobago	$15	$100	$30
UK	$30 (one-off fee)	Depends on area covered – national fee is $15,000 per 25 kHz channel[20]	$270
The Bahamas	$25	$300	$150

4.1.2 Satellite services fees

It is common international practice for satellite earth station fees to vary by bandwidth and frequency band used, much as would be the case with other applications that require interference protection over a defined geographic area and so deny use of spectrum to other licensees (see Table 4-3). However, this is not the case in The Bahamas. In practice URCA does not vary fees by the number of channels used as per the schedule because it has no way of determining the number of channels used by a system.

The very low use of satellite bands in The Bahamas means that there may be little reason to change the current fee structure, though to the extent that satellite services share bands with other fixed services (point to point and point to multi-point) there could be a case on consistency grounds for applying a bandwidth related charge. However information on the bandwidth of the earth stations and VSAT systems in use is incomplete.

[19] http://www.rsm.govt.nz/cms/licensees/fees/annual-fees

[20] http://stakeholders.ofcom.org.uk/binaries/consultations/bespoke-fees-aeronautical/statement/8197_statement.pdf

Table 4-3: Examples of parameters used to calculate satellite earth station fees

	Bandwidth	Frequency band	No of terminals/earth stations	Type of service (e.g. VSAT or not)
Bahrain	Yes	Yes		
Hong Kong	Yes	Yes		Yes
Jamaica				Yes
New Zealand			Yes	
Norway	Yes	Yes		
Portugal	Yes			Yes
Trinidad and Tobago	Yes			
UK	Yes	Yes	Yes	Yes

On balance we conclude that a flat fee structure should continue to be applied, as there are very few satellite assignments in The Bahamas and varying the fee structure would simply introduce administrative costs.

We propose simplifying the current fees schedule so that:

- a single fees is charged irrespective of the number of channels carried by the satellite earth station
- a single breakpoint is introduced for the size of the satellite earth station such that all earth stations at or above 3 meters are charged a higher fee than those below 3 meters. We note that most VSAT dishes are less than 3 meters.

Table 4-4 shows some international examples of VSAT and earth station fees. The current levels in Bahamas fall within the range of values shown and we suggest continuing with the current level of fees of $500 for a VSAT system and $4500 for an earth station.

Table 4-4: Examples of VSAT and earth station fees

	VSAT	Earth station
Jamaica	$5,000	$10,000
New Zealand	$240/transmitter	$240/transmitter
UK	$300/terminal requiring co-ordination	Minimum of $750. Could be $10,000 and more depending on bandwidth, band etc.
The Bahamas	$500	$4,500

4.1.3 Broadcast radio

A charge of $500 per assignment – FM or AM - is made and the charge does not vary by island. AM transmissions extend a long distance and could be said to be national. Historically broadcasters also paid a broadcasting operating licence fee related to their revenues but this no longer exists. Demand for FM radio licences in New Providence is high (with 28 radio stations in operation) such that there are now no spare frequencies. It is possible that fees should be raised to ration demand.

Broadcast radio is a point to multi-point application much like land mobile and we consider that it should face fees on the same basis as other point to multi-point services, given that use of spectrum by one licensee denies use to others.

4.2 Bandwidth related fees

How might a general fees formula such as the following be applied in The Bahamas?

Fee= C x FBF x CF x TF x BW

4.2.1 Bandwidth factor

The bandwidth factor is straightforward as this is known for all licensees that are assigned exclusive access to a given bandwidth with the exception of some satellite uses where we suggest (above) that a flat fee is applied. The database of assignments and invoices do not contain consistent data for some bandwidths which is an issue that must be resolved.

4.2.2 Time factor

All licences are for are least one year and no discounts are offered if licences are returned during a year or start part-way through a year hence the time factor would always be 1.

4.2.3 Coverage factor

Assignments are made on a per island basis, apart from those for cellular mobile services which are national, and so in principle the coverage factor could be one per island (as is the case at present for all standard spectrum). However, there are a number of good reasons for fees to vary broadly with the island population, including:

- Value to users supplying services to the public will be higher on bands with larger populations
- Universal service and SME objectives will be promoted if lower values are applied to sparsely populated islands.

Census data shows the population distribution is as shown in Table 4-5.

Table 4-5: Percentage distribution of population by island in 2010

Island	Population	Percentage
All Bahamas	353,658	100
New Providence	248,948	70.4
Grand Bahamas	51,756	14.6
Abaco	16,692	4.7
Eleuthera	7,826	2.2
Andros	7,386	2.1
Exuma and Cays	7,314	2.1
All other islands and cays	13,736	3.9

Source: Department of Statistics, http://statistics.bahamas.gov.bs/download/082103200.pdf

We suggest there is an Island Factor (IF) rather than having a coverage factor in the fees formula, where the factor would be lower for islands with small populations. The Interim fees schedule for newly opened bands suggests such a factor with:

- National and New Providence both having a value of 1
- Grand Bahamas having a value of 0.2
- Any other island having a value of 0.1.

We suggest having some differentiation between fees for New Providence and The Bahamas to discourage licensees applying for national licences when they do not need them. It is proposed that the national value is set at 30% higher than that for New Providence, i.e. with a value of 1.3 broadly reflecting the population difference.

In the Fee Schedule options given below we show the impact of the following Island Factor.

- National assignment = 1.3
- New Providence = 1
- Grand Bahamas = 0.2
- Any other island = 0.1.

There are few assignments (other than those for cellular mobile services) that are national so this proposal means that fees will either not change or be reduced in value.

4.2.4 Frequency band factor

The frequency band factor (FBF) should reflect the characteristics of different frequency ranges in terms of the total available bandwidth, typical channel widths, and versatility (i.e. the range of applications that can be delivered in a particular frequency range, in particular the suitability for mobile and broadcast services that can only be delivered by means of radio). In general, higher frequencies in the microwave range tend to provide less coverage and less versatility as they become increasingly limited to line of sight transmission and are subject to increasing attenuation with frequency.

In setting the FBF values for specific frequency bands, it is suggested that URCA seek a balance between:

- Reflecting the physical characteristics of different frequency bands, in particular the relative transmission range that can be achieved;
- Avoiding undue complexity in the application of the fee formula.
- Encouraging the use of vacant higher frequencies

We have defined a limited number of broad frequency ranges, corresponding to the main frequency bands currently or expected to be in use in The Bahamas, and applying an FBF value in the lower frequency ranges that reflects the approximate relative transmission range achievable in each frequency range[21].

The six proposed frequency ranges and band factors are shown in Table 4-6.

Table 4-6: Proposed frequency band factor values for spectrum fee formula

Frequency	FBF	Principal services using the band
Up to 470MHz	1	Broadcasting (TV and radio), land mobile, aeronautical and maritime
470-960 MHz	0.5	UHF TV broadcasting, trunked radio, paging, cellular mobile, studio to transmitter links
960-2200 MHz	0.25	Aeronautical, fixed links, cellular mobile
2.2 – 6.7 GHz	0.125	BWA, C band satellite links, fixed links, (cellular mobile in future at 2.5 GHz)
6.7-30 GHz	0.0625	Fixed links (medium range), Ku and Ka satellite bands
Above 30 GHz	0.0312	Short range fixed links

4.2.5 Constant

In setting the constant factor we have primarily focussed on the impact on the level of fees. As spectrum is generally plentiful in The Bahamas we see no merit in increasing the overall level of fees (though some fees may go up and others down because of the change in the fees structure) as this will simply deter the productive use of spectrum.

Having tested a variety of possible values for the constant factor we have settled on the following two options for discussion with URCA:

- One with the constant set at $10,000/MHz for all services. This value was chosen is the range of values/MHz implied by the current fees schedule (see Tables 2-4-2.6).
- One with a constant of $10,000/MHz for all services, except fixed point to point services, where we propose a fee $1000 so that fees for these services come down to a reasonable level.

4.2.6 Minimum fee

Whatever the value calculated by application of the formula, it is standard practice to set a minimum fee per licensee. The level varies from place to place but a value of $100 would seem reasonable in The Bahamas.

[21] The free space transmission range is inversely proportional to frequency it is appropriate to apply a ratio of 2 to the FBF values in adjacent frequency ranges.

4.3 Recovery of spectrum management costs

The usual reason why regulators are set up to be self-funding by levying fees on those they regulate, rather than being funded by general government revenues, is to preserve their independence from government. This approach also has the advantages that it requires there to be transparency in how fees are determined and in the basis for any industry levies. Similar arguments could be applied to arguing that URCA's spectrum management activities should be funded from the revenues it collects.

In The Bahamas there are two ways in which the costs of spectrum management could be recovered through spectrum fees, namely:

- Levying cost recovery charges separate from and additional to charges intended to recover the market value of spectrum (in congested bands); or
- Levying cost recovery charges for standard spectrum and applying other charges in premium bands

A separate cost recovery charge has the advantages of clarity and efficiency in that users pay for the spectrum management costs they impose.

Practice on cost recovery for spectrum management varies greatly between countries – in some countries such as the Netherlands and Norway fees are set to recover costs and are retained by the regulator while in others such as the UK there is no distinction made between fees intended to recover costs and fees set to reflect economic value fees. Furthermore in the UK all revenues are in principle remitted to the Treasury, although in practice Ofcom receives a budget that takes account of the spectrum fees it raises though not monies raised by it from auctions.

Appendix A: Cellular mobile benchmarks

Table A-1: Examples of licence fees in several Caribbean countries for applications other than cellular services ($US)

Licence categories	Bahamas	Barbados	Jamaica	Trinidad & Tobago	British Virgin Islands
Ship radio licence	$150	0	$23	$30	$30
Aeronautical telecommunications licence	$300	0	$29	$100	$20
Land mobile		Bandwidth less than 1MHz $250/25 KHz Bandwidth>1 MHz $10,000 for first MHz and $250 for each subsequent MHz			
Business land station	$250 per 25kHz		$29-260 depending on frequency and power	$8 per 2x1 kHz	$35
Business mobile station	-		-	-	$35
Trunked radio	$390-1300/2x125kHz		$29-260 depending on frequency and power	$8 per 2x1 kHz	$35
Amateur	$25	0	0	$15	$20 ($15 examination fee)
Fixed links	$450/50kHz link - $12000/30 MHz link	$250	Depends on bandwidth from $100/MHz	$600 per 2xMHz	0
Fixed satellite	VSAT - $500 Dish > 3m $4500 Earth station $4500	Formula where basic fee is $250[22]	VSAT is $5,000 Earth station $10,000	$600 per 2x1 MHz	0
Broadcast – audio-visual and sound	$500/200 kHz for FM radio $3000/6MHz TV channel	Not known	$500	$4/kHz for TV and $40/kHz for FM radio	$2,000

Source: Regulator websites

[22] See p75 of the Spectrum Handbook, 2006

Table A-2: Benchmark data sources for mobile spectrum

Country	Band	Date assigned	Type of fee	Source
Antigua & Barbuda	850, 900, 1800, 1900	NA	Annual spectrum fee (Public Mobile Telecommunications Cellular)	Ministry of Information, Broadcasting and Telecommunications
Barbados	any band (public/private communications)	NA	Annual spectrum fee (exclusive use of > 1 MHz)	Telecommunications Unit Barbados, Spectrum Handbook
Denmark	800	Jun-12	Auction fee, annual spectrum fee	Danish Business Authority
Denmark	900	Oct-10	Auction, annual spectrum fee	Danish Business Authority
Denmark	1800	Oct-10	Auction, annual spectrum fee	Danish Business Authority
Denmark	2100	Dec-05	Auction, annual spectrum fee	Danish Business Authority
Denmark	2500	May-10	Auction, annual spectrum fee	Danish Business Authority
Honduras	1900	Dec-07	Auction	Conatel
Iceland	900	NA	Annual spectrum fee	Post and Telecom Administration Act, December 2006
Iceland	1800	NA	Annual spectrum fee	Post and Telecom Administration Act, December 2007
Iceland	2100	NA	Annual spectrum fee	Post and Telecom Administration Act, December 2008
Jamaica	700	2013	Auction fee	SMA Information Memorandum, Licensing the 700 MHz band, April 2013
Malta	900	NA	Annual spectrum fee	Electronic Communications Networks and Services (General) Regulations, SL399.28, 12 July 2011
Malta	1800	NA	Annual spectrum fee	Electronic Communications Networks and Services (General) Regulations, SL399.28, 12 July 2012
Malta	2100	Aug-05	Annual spectrum fee	Malta Communications Authority, 3G Licence, August 2005
Norway	900	NA	Auction, NPT management fee, Ministry fee	NPT

Country	Band	Date assigned	Type of fee	Source
Norway	1800	NA	Auction, NPT management fee, Ministry fee	NPT
Norway	2100	Nov-12	Auction, NPT management fee, Ministry fee	NPT
Norway	2300	Sep-06	Auction, NPT management fee	NPT
Norway	2500	Nov-07	Auction, NPT management fee	NPT
Panama	1900	May-08	Auction	ASEP
Puerto Rico	700	Mar-08 Jul-11	Auction	FCC
Puerto Rico	AWS	Aug-08	Auction	FCC
Puerto Rico-US Virgin Islands	700	Mar-08	Auction	FCC
Puerto Rico-US Virgin Islands	AWS	Sep-06 Aug-08	Auction	FCC
Turks & Caicos	700	Feb-13	Annual spectrum fee	TCI Telecommunications Commission, Spectrum Policy Decision 2012
Turks & Caicos	850	NA	Annual spectrum fee	TCI Telecommunications Commission, Telecommunications Fee Structure Regulations 2007
Turks & Caicos	900	NA	Annual spectrum fee	TCI Telecommunications Commission, Telecommunications Fee Structure Regulations 2007
Turks & Caicos	1800	NA	Annual spectrum fee	TCI Telecommunications Commission, Telecommunications Fee Structure Regulations 2007
Turks & Caicos	1900	NA	Annual spectrum fee	TCI Telecommunications Commission, Telecommunications Fee Structure Regulations 2007
US Virgin Islands	700	Mar-08	Auction	FCC
US Virgin Islands	1900	Feb-05	Auction	FCC
US Virgin Islands	AWS	Sep-06	Auction	FCC