FOREWORD

Botswana Telecommunications Authority (BTA) is mandated by the Telecommunication Act, 1996 [No. 15 of 1996] to ensure the rational use of the radio frequency spectrum in Botswana. The BTA assisted by the Teleplan AS from Norway in association with ICT Consultants (Pty) Ltd from Botswana, is in the process of developing a comprehensive Spectrum Management Strategy. The spectrum management strategy has the following components:

- Review the current national radio frequency plan;
- Develop a spectrum allocation strategy for various radio services;
- Develop a spectrum licensing policy for various frequency bands; and
- Develop a spectrum pricing policy

In January 2007, the BTA issued a consultation document for radio services dealing with preliminary views and recommendations relating to high demand spectrum . A workshop was held on 14 – 15 February 2007, during which the consultation document was presented and comments/input received from stakeholders. The consultation process for the high demand spectrum has been finalised and the BTA has already communicated it to the industry stakeholders.

This consultation document contains information and recommendations on other radio services that were not included in the first round of consultation. The document summarises the key findings from technology reviews, analysis of regional radio regulations, frequency plans (national, regional and international) and available radio equipment.

The Authority wishes to invite the industry stakeholders, (the operators, service providers, equipment suppliers, academics, and the public) to submit comments on the Consultation paper. The submissions should be clearly marked:- **"Response to Consultation document: Spectrum allocation strategy for Fixed Radio services, Satellite Radio Services, Mobile Radio Services and Other Radio Services"** and should be addressed as follows :

Chief Executive

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The submissions can be hand delivered, sent by post, facsimile or email and should reach the BTA on or before 5pm on 5 October 2007: Kindly note that the BTA will publish all submissions received unless the respondent has requested, with justification, that his/ her submission should not be published.

The Authority will hold an Industry Stakeholders consultation workshop on the **9-10 October 2007 at Gaborone International Conference Centre (GICC)** starting at 0800 A.M.

T. G. PHEKO

CHIEF EXECUTIVE OFFICER

Draft Report

Teleplan

In Association with

ICT Consultants

Submitted to

Botswana Telecommunications Authority

CONSULTATIVE DOCUMENT

Spectrum Allocation Strategy for Fixed Radio Services, Satellite Radio Services, Mobile Radio Services and Other Radio Services

September 2007

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1 Executive summary

The Botswana Telecommunications Authority (BTA) has retained Teleplan AS, in association with ICT Consultants (Pty) Ltd, Botswana, for consultancy services to develop a Spectrum Management Strategy in Botswana. The objectives of the consultancy were to undertake the following in consultation with industry stakeholders:

- Review the current national radio frequency plan;
- Develop a spectrum allocation strategy for various radio services;
- Develop a spectrum licensing policy for various frequency bands; and
- Develop a spectrum pricing policy.

The Consultants issued a consultation document for radio services with a high spectrum demand with preliminary views and recommendations in January 2007. A workshop was held on 14 – 15 February 2007, during which the consultation document was presented and comments/input received from stakeholders. In addition, stakeholders were requested to submit written comments/input to the consultation document. Subsequently the Consultants submitted a final report on High Demand Spectrum.

A second consultation document entitled, “A new policy for spectrum licensing and spectrum pricing in Botswana”, describes proposed spectrum management reforms that are recommended to ensure a successful implementation of the new licensing structure in Botswana. This document was submitted to BTA 13 August 2007.

This third consultation document contains information and recommendations on other radio services that were not included in the first consultation round. The document summarises the key findings from technology reviews, analysis of regional radio regulations, frequency plans (national, regional and international) and available radio equipment. The consultants’ views on issues, options and specific recommendations are presented.

Table 1 below shows an overview of the recommendations for the frequency bands considered in this consultation document[1].

[1] Note that this is not a complete list of all the frequency bands, which is available in the frequency plan.

Table 1: List of recommendations

Band	Existing use	Short term recommendations	Medium/long term recommendations	Other
531 – 1602 kHz	MW broadcasting	Follow terrestrial Broadcasting Frequency Plan		
68 – 87.5 MHz	PMR			
87.5 – 108 MHz	FM broadcasting	Follow terrestrial Broadcasting Frequency Plan		Allow micro FM transmitters on an unlicensed basis
146 – 174 MHz	PMR	Implement existing migration plan		
174 – 214 MHz	Analogue Television		DVB-T. Follow terrestrial Broadcasting Frequency Plan	
214 – 230 MHz	Analogue Television		T-DAB. Follow terrestrial Broadcasting Frequency Plan	
440 – 470 MHz	PMR	Implement existing migration plan		
446 – 446.1 MHz	PMR 446	PMR 446 unlicensed		
446.1 – 446.2 MHz		DMR 446 unlicensed		
470 – 806 MHz	Analogue TV broadcasting	Follow terrestrial Broadcasting Frequency Plan	DVB-T assignment	
864 – 868 MHz	CT2	No change in regulation		
914 – 915 MHz 959 – 960 MHz	CT1	No change in regulation		
1880 – 1900 MHz	DECT	No change in regulation		
3600 -4200 MHz	FSS Receive (C-band)		Possible FWA in 3600 – 3700 MHz	FSS shall have priority in the 3700 – 4200 MHz range
5925 – 6425 MHz	FSS transmit (C-band)	None		

Band	Existing use	Short term recommendations	Medium/long term recommendations	Other
6425 – 7125 MHz	BTC Fixed links	No change in regulation		
7110 – 7425 MHz	Fixed links	No change in regulation		
7425 – 7725 MHz	Fixed links	No change in regulation		
7725 – 8275 MHz	None	Fixed links. Site licenses, First come – first served		
8275 – 8500 MHz	None	Fixed links. Site licenses, First come – first served		
10.7 – 11.7 GHz	Satellite receive: 10.95 – 11.7 (mainly broadcasting in 10.95 – 11.2 and 11.45 – 11.7)	Fixed links. Site licenses, First come – first served		Start at 10.7 – 10.95 GHz paired with 11.2 – 11.45 GHz
11.7 – 12.7	Some satellite FSS downlink	FSS downlink. License exempt.		
12.75 – 13.25 GHz	None	Fixed links. Site licenses, First come – first served		
14 – 14.5 GHz	Some satellite FSS uplink	FSS uplink. License exempt.		
14.5 – 15.35 GHz	Government fixed links	No change in regulation		
17.7 – 19.7 GHz	Partly used by BTC	Fixed links. Block licenses. Demand assignment.		Grandfather existing BTC links
24.5 – 26.5 GHz	None	Fixed links + FWA. Block licenses. Demand assignment.		
27.5 – 29.5 GHz	None	Fixed links. Block licenses (for the part not used by satellite). Demand assignment / First come – first served		Shared between FSS and Fixed links
37 – 39.5 GHz	None	Fixed links. Block licenses + Site		

Band	Existing use	Short term recommendations	Medium/long term recommendations	Other
		licenses. Demand assignment / First come – first served		
40.5 – 43.5 GHz	None	Fixed links. Block licenses + Site licenses. Demand assignment / First come – first served		
51.4 – 52.6 GHz	None	Fixed links. Block licenses + Site licenses. Demand assignment / First come – first served		
55.78 – 57 GHz	None	Fixed links. Block licenses + Site licenses. Demand assignment / First come – first served		
57 – 59 GHz	None	Fixed links. General frequency assignment.		

Table 2: Summary of recommendations at different frequency bands

Page	***Recommendation***	***Description***
29	Fixed links	There are a number of frequency bands for Fixed Service that are currently not used in Botswana. It is recommended that they should be opened for licensing. It is recommended that a mix of block licensing and site licensing should be used, but with a bias towards the use of block licences. New bands should be subject to a First Come First Served licensing or Demand Assignment approach, in case demand is high than the available spectrum. Despite the expected increase in the demand for spectrum for Fixed Service, our evaluation shows that there should be sufficient spectrum for Fixed Service in Botswana in the foreseeable future.

Page	Recommendation	Description
42	Satellite C band	The C-band will continue to be the most important band for satellite earth stations in Botswana. The Fixed Satellite Service should be given priority in the frequency bands 3700-4200 MHz and 5925-6425 MHz. Individual licenses should be assigned to satellite earth stations in these bands.
42	Satellite Ku band	It is recommended that VSAT in the Ku-band should be exempted from licensing. It has been shown that with proper technical conditions, VSATs can operate without creating interference in the Ku-band. This band should remain exclusive to the FSS and no further Fixed Links should be assigned frequencies.
42	Mobile Satellite Services	Terminals in the Mobile Satellite Service that are fully developed and available for worldwide use in globally harmonised frequency bands should be exempted from licensing.
48	Switching from 25 kHz to 12.5 kHz channel bandwidth	It is recommended that the change from 25 kHz to 12.5 kHz channel spacing for PMR should be implemented in accordance with the procedure described in Section 5.5.
49	PMR 446	It is recommended that PMR 446 radio equipment should be granted licence-exempt status.
49	DMR 446	In the event the market for DMR 446 market develops in Botswana, it is recommended that this technology should also to be exempted from the need of individual licences.
53	Terrestrial broadcasting	The Consultants reviewed the terrestrial Broadcasting Frequency Plan which was produced and submitted to BTA in April 2007. The Consultants recommend that BTA should adopt and implement this plan.

Page	Recommendation	Description
57	Further exemption from licensing	It is recommended that the following radio equipment should be exempted from radio licensing: o All terminal equipment controlled by licensed (or authorised) network operators and low power devices (that meet BTA's type approval requirements); o Equipment operating in ISM bands for Region 1 of the ITU; o VSAT terminal operating in the *ku* band, 11 GHz (downlink)/14 GHz (uplink); o Land Mobile Satellite Service (e.g. Inmarsat at 1.6 GHz, Iridium at 2 GHz); o High Density Fixed Satellite Service at 28 and 31 GHz and; o CB Walkie Talkie Radios at 27 and 29 MHz. A list of radio equipment that is exempted from licensing should be made publicly available.
62	Ultra Wideband (UWB)	A decision on UWB regulation in Botswana is not urgent. However, it is recommended that BTA should follow international best practise and coordinate its actions with those of neighbouring countries.
63	Cognitive Radio (CR)	It is not necessary for BTA to make any specific decisions on Cognitive Radio, save to follow the technical developments with regard to this technology.
65	Cordless Telephony	Keep existing allocations for Cordless Telephony; DECT, CT1 and CT2. There is some illegal usage of CT1 in the GSM900 band. Sources of these CT1 transmissions should be identified and terminated.
68	450 MHz spectrum for rural areas	There seems to be approximately 2 x 4.5 MHz duplex spectrum available in the 450 – 470 MHz range that is either not used or only used in Gaborone. It is recommended that this spectrum be allocated or retained for use in rural areas, e.g. through the NTELETSA II project.

2 Introduction

2.1 General

The Botswana Telecommunications Authority (BTA) retained Teleplan AS, in association with ICT Consultants (Pty) Ltd, Botswana, for consultancy services to develop a Spectrum Management Strategy in Botswana.

Teleplan AS ('Teleplan') is a Norwegian-based international consultancy firm providing independent advisory services in the areas of telecommunications and information technology. ICT Consultants (Pty) Ltd ('ICT') is an independent consulting firm that specialises in information and communications technology engineering, regulation, policy and international trade.

The objectives of the consultancy study performed by Teleplan and ICT (the consultants) were to undertake the following in consultation with industry stakeholders:

- Review the current national radio frequency plan;
- Develop a spectrum allocation strategy for various radio services;
- Develop a spectrum licensing policy for various frequency bands; and
- Develop a spectrum pricing policy

BTA received a number of applications for cellular systems, fixed and broadband wireless access, mobile data service and Radio Local Area Networks and estimated that there was a high spectrum demand for these services.

Therefore, BTA requested the Consultants to prepare a consultation document that would address this high demand for spectrum first. Accordingly, the Consultants submitted the consultation document in February 2007. The consultation document was presented in a workshop held in Gaborone in March 2007. The workshop was followed by interviews with a number of key stake holders.

A second consultation document entitled, "A new policy for spectrum licensing and spectrum pricing in Botswana", describes proposed spectrum management reforms that are recommended to ensure a successful implementation of the new licensing structure in Botswana. This document was submitted to BTA 13 August 2007.

This third document deals with other services (such as Fixed Services, Fixed Satellite, etc.) which were not covered in the first consultation process.

The consultants' aim has been to propose a spectrum management strategy, spectrum allocation procedures and spectrum licensing procedures that will lead to the maximum impact on Botswana's economic and social development, with a view to addressing the national infrastructure deficit. This involved identifying bands that can address the infrastructure deficit and recommending appropriate licensing procedures.

2.2 Background

2.2.1 Basis of the Spectrum Allocation Strategy

The following were used as input in preparing this document:

- The BTA Frequency Register and current utilisation of radio spectrum in Botswana.
- The National Radio Frequency Plan.
- Frequency plans from neighbouring countries, the SADC Band Plan, Regional Frequency Plans and the ITU Radio Regulations.
- The Further Liberalisation Report.
- The outcome of the 2003 World Radio Conference.
- The outcome of the World Summit on Information Technologies (WSIS).
- A technology review of recent developments in international standardisation organisations and industry.
- The BTA's Service Neutral Licensing framework.
- The recommendations in *Spectrum Demand for Cellular Systems, Fixed Wireless Access, Mobile Data Services and Radio Local Area Networks.*
- A new policy for spectrum licensing and spectrum pricing in Botswana.

2.2.2 Outcome of the Further Liberalisation Report

The 2005 Report from Ovum (Recommendations on further liberalisation of the telecommunications industry of Botswana) proposed a three year period during which infrastructure based competition would be given an opportunity to develop. Then the BTA would review the developments, and in 2009 decide whether the market should be opened for full competition. As the market is opened to further liberalisation, access to radio spectrum will play a key role in facilitating the Government and BTA's objectives.

The Ovum Report states that licensed mobile operators should be permitted to provide their own network infrastructure as soon as possible. The consultants believe that access to frequency bands such as 38 GHz and 26[2] GHz could be instrumental in achieving such a goal.

Furthermore, it is recommended in the Ovum Report that BTA should invite applications for mobility services outside the 900 MHz band once it (BTA) has completed a thorough review of its spectrum management policy. The final report

[2] 26 GHz is both a frequency band suitable for Fixed Radio Links and Fixed Wireless Access. The band is treated in the First Consultation Document. However, it is potentially an important frequency band for providing backbone infrastructure to mobile operators and it is mentioned here for completeness.

Spectrum Demand for Cellular Systems, Fixed Wireless Access, Mobile Data Services and Radio Local Area Networks identified spectrum for such mobility services.

The Ovum Report identified Spectrum Management and Licensing as two key regulatory functions that have to be handled appropriately to ensure effective operation of a fully-liberalised environment. Recommendation 17 of that report states that:

OVUM Report Recommendation 17: *the BTA should review the following functions to ensure that they are compatible with effective regulation in a fully-liberalised environment:*

consumer protection and empowerment;

licensing;

price controls; and

spectrum management.

The Ovum Report also concluded that "there is a demand for spectrum to enable the provision of additional services outside the spectrum used for cellular mobile services, in particular for 3G data services and public mobile radio (PMR)" and that two-way radio communications PMR services offer a cost-effective approach to provide mobile services for certain applications.

The report on *Spectrum Demand for Cellular Systems, Fixed Wireless Access, Mobile Data Services and Radio Local Area Networks,* which was submitted in March 2007 after the first consultation process addressed the services that had high spectrum demand as identified in the Ovum Report. Proposals in respect of a new policy on spectrum licensing and spectrum pricing are contained in the second report which was submitted in August 2007.

2.2.3 Policy and Regulatory Environment

2.2.3.1 Policy Decision

Following consultation between BTA and the Ministry of Communications, Science and Technology (MCST), in respect of recommendations in the Ovum Report, the Ministry issued a press statement on 21st June 2006 which said that:

- The restriction on the provision of VoIP by value-added network service providers would be lifted by August 2006.
- Mobile operators would start self provision of transmission links by August 2006.
- The fixed line and cellular operators could apply for service-neutral licences by September 2006.

- New entrants could tender for service-neutral rural/district level licences that would be issued by September 2006.
- The liberalisation of the international voice gateway would take place by October 2006.
- New entrants could tender for service-neutral national licences in December 2009.

2.2.3.2 Technology and Service Neutrality

Recent discussions in international forums have focused on how spectrum policy could be modified to respond to changing market conditions and technological developments. The core issue in several countries now is how to create a balanced approach between the granting of exclusive spectrum rights through market-based mechanisms and a system of "commons", being open access to parts of the spectrum. This latter concept is often referred to as the use of General Authorisations. These issues are discussed in detail in the report on spectrum licensing and pricing which was submitted in August 2007.

2.3 General technology development

2.3.1 Technologies and suitable frequency bands for Rural Services

The Consultants are aware of the Rural Telecommunications Strategy, which is being implemented by the MCST with objective of improving the telecommunications infrastructure in rural areas by issuing licences through competitive bidding. Specifically the NTELETSA II licences will aim to cover specified areas in rural regions in four different parts of Botswana. The draft final report of the Universal Access and Service study initiated by BTA in conjunction with MCST also highlights the infrastructure deficit in rural areas, especially in respect to the lack of infrastructure to support internet services. The consultants have looked at frequency bands that can be exempted from licensing and could thus be particularly useful for bridging the digital divide in rural areas.

Furthermore, for rural areas providing low-cost backhaul solutions is a challenge, especially given the low population density in rural areas in Botswana. Alternatives include long hop fixed radio link solutions as well as satellite solutions. These possible solutions are discussed in this document.

2.3.2 Fixed wireless links as backbone infrastructure

There is a rapid increase in mobile communication usage, as well as an expected development towards increased use of mobile data services, both through the upcoming 3G mobile services as well as the existing GSM networks. Furthermore, strong interest is shown in Botswana for providing broadband wireless access services, e.g. through the WiMAX technology.

This evolution in broadband applications points to a substantially increased demand for backbone network capacity. A large portion of this is expected to be provided through fixed radio solutions. This will therefore strongly affect the need for fixed radio spectrum in Botswana. This is quantified and proportional recommendations are provided in this document.

2.3.3 Convergence of functionalities

Traditionally, the national regulator has made clear distinctions between mobile, fixed and broadcasting services. This distinction between services such as voice communication, data services and broadcasting is no longer clear due to the convergence of functionality of new technologies that deliver such services. In addition, there is also a trend towards new technologies that can deliver a set of services and at the same time are flexible with respect to the frequency bands they use. This means that radio spectrum may become increasingly scarce and this scarcity will not necessarily be limited to certain frequency bands.

It will become increasingly difficult for BTA to prioritise certain technologies and services in terms of access to frequency bands. This can be a major challenge when trying to apply a consistent regulatory framework. Service and technology neutrality will be useful tools in this development. Other market mechanisms such as spectrum trading may also need to be introduced.

2.3.4 International Experience and Best Practice

The international co-ordination of radio spectrum management is a constraint on the ability of a single country to conduct an autonomous policy for spectrum use within its own jurisdiction. For Botswana as a sparsely populated country, this multilateral approach can bring benefits to consumers and operators. In many areas, the economic value of spectrum in Botswana is driven to a great extent by international agreements on technology development and spectrum allocations. When frequency bands are assigned as non-exclusive rights in major markets, products which are designed to be used in such spectral environments will emerge. Within this framework, though, there remain many opportunities for Botswana to take a more flexible approach to spectrum management, while continuing to benefit from international harmonisation.

The one area of spectrum management reform that seems to have gained the largest international recognition in a relatively short period of time is the concept of technology and service neutrality. We have tried to take a technology neutral approach in this document. However, as this approach might lead to various challenging interference scenarios for BTA, we have described the most likely technologies in detail to take account of these various scenarios.

3 Fixed Radio Services

3.1 Introduction

This chapter provides an overview and considerations for the fixed radio service.

The overall most important items are

- A strong growth in demand for both high capacity short hops and low/medium capacity long hops fixed services is expected.
- A number of applicable frequency bands for fixed services for which equipment is widely available from major vendors is currently not used in Botswana. Comparing the available bands to the estimated total frequency need, it is not expected that frequencies for the fixed service will be a shortage in Botswana either in the short/medium or the long term
- A number of recommendations have been suggested. The consultants have in many cases suggested block licenses, as this provides the least overhead for BTA, and the required flexibility for the operators. Nevertheless, it should also remain possible to apply site licenses on a coordinated basis in certain bands.

Our overall view about Botswana's likely development in terms of fixed links is shown in Figure 1 below. The time scale should be seen as indicative.

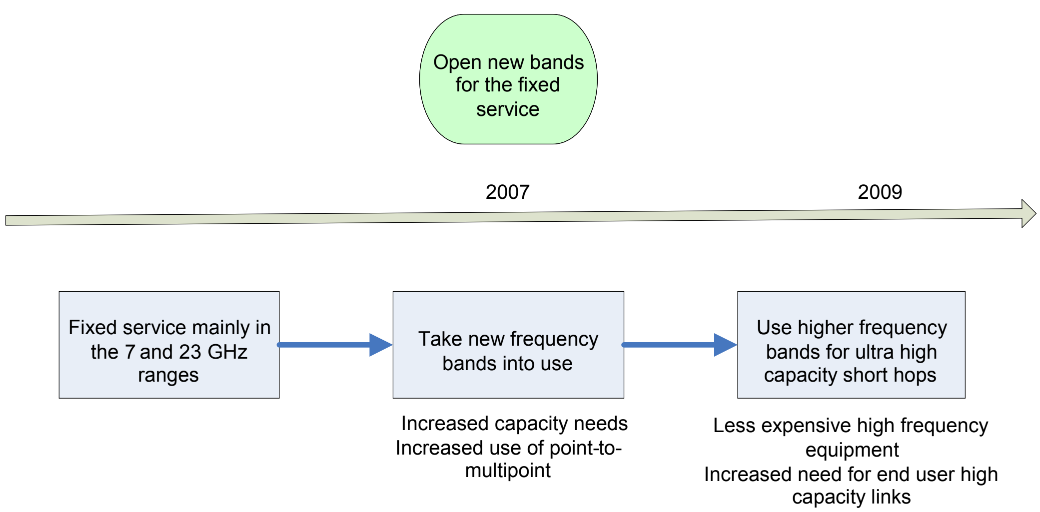

Figure 1: Roadmap Fixed links development in Botswana

Fixed radio links provide a transmission path between two or more fixed points for provision of telecommunication services, typically voice, data or video transmission. Main user sectors for fixed links are telecommunications companies (infrastructure, trunk networks), mobile operators, corporate users (private data networks, connection of remote premises) and private users.

Fixed radio links will often be the preferred solution, instead of fibre optic links, for the provision of telecommunications services in remote low population density areas (e.g. rural areas) where constraints such as cost and local topography are fundamental considerations.

It is expected that the demand for medium capacity long haul microwave links will increase significantly in the short to medium term. Similarly, the demand for high capacity short haul links (mainly in urban areas) is also expected to increase. The main reasons for this increased demand are:

- Increased number of mobile communications and fixed operators, and the ability for operators to self-provide.
- Increased broadband penetration, a substantial portion of which will be offered through wireless solutions.
- The increased uptake of high bandwidth communication services such as multimedia applications.

However, considering the unused frequency bands available in Botswana for which equipment is readily available from major infrastructure vendors, it is unlikely that there will be a shortage on frequency bands for fixed radio services in Botswana.

The consultants have in many cases suggested block licenses, as this provides least overhead for BTA and the required flexibility for the operators. Nevertheless, it should also remain possible to apply site licenses on a coordinated basis, as certain smaller operators will not require entire frequency blocks.

3.2 Overview of available technologies

In this chapter we will divide between different classes of fixed services, crudely based on application:

- Fixed Wireless Access
- Fixed links
- High Altitude Platform Stations (HAPS)
- High Density Fixed Service (HDFS)

Fixed Wireless Access[3] (FWA) refers to systems that provide end users with access to more advanced services with higher bandwidth demands. This topic has been thoroughly discussed in the report on *Spectrum Allocation Strategy for Cellular Systems, Fixed Wireless Access, Mobile Data Services and Radio Local Area Networks* (April 2007). The technology description will not be repeated here.

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[3] This term also entails Broadband Wireless Access (BWA). Some literature use the term Broadband Fixed Wireless Access (BFWA). The terms WLL, FWA, BFA and BFWA are often used interchangeably.

Fixed links are often called radio relay systems or point-to-point (ptp) systems, i.e. a system that establishes a connection between two end points only. To an increasing degree fixed link systems also entail point-to-multipoint systems (ptmp), particularly used e.g. for feeding base stations in cellular systems.

Most major equipment vendors supply equipment that can be used in multiple frequency bands, to adapt to regional regulation and frequency availability, for both high and medium capacity solutions. State of the art equipment support up to >300 Mbit/s in a 56 MHz channel (using 256 QAM).

WiMAX is becoming an alternative for point-to-multipoint solutions, and products are available in the 3.3 – 3.8 GHz and the 5 GHz bands. Typical maximal throughput is 18 Mbit/s in a 7 MHz channel.

A High Altitude Platform Station (HAPS) is an unmanned aerial vehicle which is to remain relatively stationary at high altitude. They can be used as communications platforms, for weather surveys, traffic reports, etc. Because of their relatively short distance from earth compared to satellites (20 km compared to up to 40,000 km) they could even be used to provide mobile telecommunication, without the need for ground based antennas, and without the long delays associated with satellite communication.

The term High Density Fixed Service (HDFS) describes a significant level of deployment of point-to-point and/or point-to-multipoint systems within a given geographical area. The driving factors for HDFS are frequency bands above 30 GHz; with the availability of small, lightweight equipment and the necessary propagation conditions to allow a high degree of frequency reuse. The term HDFS is not a sub-service in the Fixed Service. It is a description of a deployment scenario. The sharing scenario between HDFS and other services is so complex that it might prevent the deployment of other primary services in the ITU Radio Regulations. Accordingly, the deployment of HDFS should be handled with due care and caution.

3.3 Trends and developments

Point-to-point links are becoming increasingly important, principally due to the need to backhaul cellular systems. This trend will be strengthened by increased penetration and support for higher data rate services, e.g. through the introduction of 3G mobile communication. Point-to-multipoint solutions are also gaining increased interest, as they are suited for providing backhaul services for several base stations/access points from a single radio link station. However, point-to-point is still the dominating solution for radio based backhauling of mobile communications systems.

Similarly, the introduction of broadband wireless access services, through e.g. WiMAX, will lead to an increased demand for radio based high capacity backhaul solutions. There is also an increase in fixed links for other purposes, such as ad-hoc networks, or corporate radio links.

Typical trends in terms of demand for frequency bands are expected to develop as follows:

- Links for rural areas and low density areas in the periphery of urban centres will generally be confined to lower frequency bands, typically below 7 GHz.
- Links for urban areas and large villages will normally use higher frequency bands, typically above 10 GHz.
- Point-to-multipoint links are mostly confined to higher frequency bands, above 26 GHz. This is for the most part due to the high capacity demand in ptmp systems, only available in higher frequency bands.
- Some interest has been shown in using WiMAX as a backhaul solution for cellular systems, either mobile systems or self-backhauling of WiMAX systems. However, there has not been much development in terms of WiMAX equipment aimed for cellular backhauling.

There is a growing trend towards the use of higher frequency solutions due to increased demand for end user capacities and less expensive equipment at high frequencies. Multi rate solutions with support for higher order modulation (e.g. 128 or 256 QAM) are becoming readily available in the market. These developments will provide solutions whose spectrum efficiency will be dependent on link quality, meaning that longer hops will provide lower throughputs than for shorter hops. Furthermore, there is a growing trend towards IP and Ethernet support in fixed links.

The trend in terms of regulation is that most countries have adopted block assignments for most fixed services. Block assignments allow the maximum flexibility for the operators and at the same requires minimum overhead for the regulator. Nevertheless, block assignments would not be efficient for smaller deployments, thus some level of site-by-site licensing will have to be retained to allow spectrum sharing amongst users with small deployments.

The interest in HAPS solutions seems to have waned and the consultants do not see this as a viable solution for Botswana in the foreseeable future. The developments in respect of HDFS are still limited. Thus HDFS is not considered to be important for Botswana in the medium term.

3.4 Available Frequency Bands

Evaluation of fixed link frequency band needed for backhauling UMTS has been performed in *ECC Report 19, Guidance material for assessing the spectrum requirements of the fixed service to provide infrastructure to support the UMTS/IMT-2000 networks,* which provides guidelines about the use of frequency bands for fixed links used for backhaul purposes.

A large number of bands have been used for fixed links. In Europe attempts at harmonisation is ongoing, as described e.g. in *ECC Report 3, Fixed Services in Europe – Current Use and Future Trends*. The table below shows some frequency bands commonly used for fixed links. In this table, radio relay links (RRL) means point to point links that carry private or corporate communications. Trunk means point to point links that connect exchanges of telecommunications operators while infrastructure means backhaul used to connect base stations of mobile operators.

Band	Typical application	Trend in Europe
3600 – 4200 MHz	Trunk/infrastructure	Stable growth
5925 – 6425 MHz	RRL/trunk/infrastructure	Slow growth
6425 – 7125 MHz	RRL/trunk/infrastructure	Slow growth
10.7 – 11.7 GHz	Trunk/infrastructure	Decrease
12.75 – 13.25 GHz	RRL/infrastructure	Increase
14.5 – 15.35 GHz	RRL/infrastructure	High increase
17.7 – 19.7 GHz	Infrastructure	Increase
22 – 23.6 GHz	Infrastructure/RRL	Increase
24.5 – 26.5 GHz	Infrastructure/FWA	High increase
27.5 – 29.5 GHz	FWA/ptmp	Expected to increase
37 – 39.5 GHz	RRL/infrastructure	High increase

Table 3 Fixed links Frequency Bands and estimated development in Europe

Since Africa is in the same ITU Region (Region 1) as Europe, we expect Botswana to follow similar trends as regards the use of frequencies for fixed links.

3.4.1 Estimated frequency requirements for fixed links

The Consultants have evaluated the total frequency needs for fixed links in Botswana for the period up to 2015 based on the assumptions outlined below. This is crudely divided into *short hops, urban areas*, and *long hops, rural areas*. The frequency requirements are independent of whether the deployments will be ptp or ptmp. Thus no distinction was made between point-to-point and point-to-multipoint systems. The final number of operators will depend on the liberalisation process that the Government and the BTA will adopt and the Consultants are not privy to how this process will develop. In any case the liberalisation process is outside the scope of this work.

The estimates for fixed links requirements are based on the following assumptions:

- There will be 4 national 3G mobile communications networks, each will deploy approximately 3 duplex 5 MHz carriers. Most of the 3G deployments will be in urban areas and possibly some large villages.
- There will be 4 national 2G mobile communications network, each with approximately 100 duplex 200 kHz carriers for high capacity areas. The 2G deployments will be in urban and rural areas.
- There will be 4 wireless broadband providers per region, each with approximately 30 MHz spectrum. Most of the broadband deployments will be in urban areas.

We adopted the methodology described ECC Report 19, and assumed a maximum user density of 100 000 / km^2 for Botswana. For a 3G/UMTS micro cellular structure assuming 8 Mbit/s/cell, the corresponding fixed link requirement is conservatively in the order of 13 x 7 MHz, as per ECC Report 19.

It is assumed that the 2G/GSM sites will be mostly co-located with the 3G/UMTS sites. It can then be assumed that the total backhaul capacity requirement for a combined 2G and 3G network will be approximately 150 % of that of a 3G / UMTS network only.

The wireless broadband networks are assumed to have approximately the same capacity need as the 3G networks.

The estimated fixed link frequency requirements for short hops in urban areas is:

- 2G / 3G mobile communications networks: *Number of networks x Bandwidth per carrier x Number of carriers needed for 3G x Factor for 2G+3G combined* = 4 x 7 x 13 x 1.5 ≈ 550 MHz
- Wireless broadband networks: *Number of networks x Bandwidth per carrier x Number of carriers needed for 3G* = 4 x 7 x 13 ≈ 370 MHz
- Other services[4]: ≈ 500 MHz
- <u>Total: ≈ 1500 MHz</u>

We estimate that long hops in rural area will require about half the total spectrum requirements as that of urban centres. The estimated fixed link frequency requirements for long hops for rural areas is therefore estimated to be <u>750 MHz</u>.

Bandwidth for ultra high capacity short hops has not been estimated. It is foreseen that this could play a role in the longer term. Government and military usage is not included in these estimates.

Table 5 shows an overview of available spectrum for fixed links, based on the recommendations outlined later in this section. Crudely, frequencies up till 12 GHz can

[4] This is a relatively crude estimate based on typical apportionment between mobile /wireless broadband and other services.

be assumed to be used for long hops, and frequencies above 12 GHz used for short hops. As can be seen from Table 5, the amount of available spectrum is considerably higher than the estimated demand.

Short hops		Long hops	
Band	**Spectrum**	**Band**	**Spectrum**
6425 – 7125 MHz	700 MHz	12.75 – 13.25 GHz	500 MHz
7110 – 7425 MHz	300 MHz	17.7 – 19.7 GHz	2000 MHz
7425 – 7750 MHz	325 MHz	22 – 23.6 GHz	1600 MHz
7725 – 8275 MHz	525 MHz	24.5 – 26.5 GHz	1000 MHz[5]
8275 – 8500 MHz	225 MHz	27.5 – 29.5 GHz	2000 MHz
10.7 – 11.7 GHz	1000 MHz		
Total:	**3075 MHz**	**Total:**	**7100 MHz**

Table 4: Spectrum availability for short and long hops, respectively

3.5 Frequency band and hop lengths

The table below shows achievable hops lengths for various frequency bands. It should be noted that in practice, hops lengths depend on a number of parameters in addition to the frequency band. For example, the capacity and type of modulation used have an impact on the hop length. Thus a 34 Mb/s radio will operate over a longer hop than a 155 Mb/s radios operating in the same frequency band. This is due to the fact that the 34 Mb/s radio could use a low level modulation scheme with a lower symbol rate (bits/transmitted symbol) but is less susceptible to fading (e.g. QPSK) while the 155 Mb/s radio would have to use a high level modulation scheme which has a higher symbol rate to cater for the required high transmission rate but is more susceptible to fading (e.g. 128 QAM). As a result, there is always a trade-off between distance and capacity on the same frequency band. Thus the longer distances would generally be achieved with low capacity radio systems operating at lower frequencies.

[5] Shared with FWA, assumed 50 – 50 sharing

Hop Length Distance	Frequency band	Achievable Distance
Very long	< 10 GHz	Up to 70 km
Long	10 -13 GHz	Up to 45 km
Medium	13 - 20 GHz	10-25 km
Short	20 - 26 GHz	5-10 km
Very short	26 - 40 GHz	2-5 km
Extremely short	40 - 60 GHz	< 0.5 km

Table 5: Guidelines on hop lengths vs. frequency bands

The table below shows the recommended use and channel plans for the various frequency bands.

Band	Recommendation	Channel plan	Sharing/migration
3600 – 4200 MHz	Shall be used on a national basis for high capacity, core network, point-to-point fixed links.	ITU-R Recommendation F.635 Annex 1.6	Shared with FSS on a strictly co-ordinated basis.
5925 – 6425 MHz	Shall be used for high capacity, core network telecommunication services (point-to-point fixed links) over long hop lengths.	ITU-R Recommendation F.383	Shared with FSS
6425 – 7125 MHz	Shall be used on a national basis for high capacity, core network telecommunication services (point-to-point fixed links).	ITU-R Recommendation F.384	Shared with NGSO MSS (space-to-Earth) feeder links and geo-stationery orbit (GSO) FSS (Earth-to-space) systems on a co-ordinated basis.
7110 – 7425 MHz	Shall be used on a national basis for medium to high capacity telecommunications service (point-to-point fixed links).	ITU-R Recommendation F.385-6, Annex 3	Migration plan suggested
7425 –	Shall be used on a national	ITU-R	Migration plan

Band	Recommendation	Channel plan	Sharing/migration
7750 MHz	basis for medium to high capacity telecommunications service (point-to-point fixed links).	Recommendation F.385-6, Annex 3	suggested
7725 – 8275 MHz	Shall be used on a national basis for high capacity, core network telecommunication services (point-to-point fixed links) over long hop lengths.	ITU-R Recommendation F.386 Annex 1	
8275 – 8500 MHz	Shall be used on a national basis for low to medium capacity telecommunication services (point-to-point fixed links) over long hop lengths.	ITU-R Recommendation F.386 Annex 3	
10.7 – 11.7 GHz	Shall be used on a national basis for high capacity telecommunication services (point-to-point fixed links) over medium hop lengths.	ITU-R Recommendation F.387	The bands 10.95-11.2 GHz and 11.45-11.7 GHz are shared with FSS. Assignments of channels should therefore start at the lower end of the band.
12.75 – 13.25 GHz	Shall be used on a national basis for low and medium capacity telecommunication services (point-to-point fixed links) over medium hop lengths.	ITU-R Recommendation F.497	
14.5 – 15.35 GHz	Shall be used on a national basis for low and medium capacity telecommunication services (point-to-point fixed links) over medium hop lengths.	ITU-R Recommendation F.636	
17.7 – 19.7 GHz	Shall be used on a national basis for medium and high capacity telecommunication services (point-to-point fixed	ITU-R Recommendation F.595 Annex 1	

Band	Recommendation	Channel plan	Sharing/migration
	links) over medium hop lengths.		
22 – 23.6 GHz	Shall be used on a national basis for medium and high capacity telecommunication services (point-to-point fixed links) over medium hop lengths.	CEPT Recommendation T/R 13-02 Annex A provides a channel arrangement for this band that is not affected by HDTV. This recommendation cannot be used unless a migration plan for the existing equipment is introduced.	
24.5 – 26.5 GHz	Roughly 40 % of the spectrum to be used for point-to-point fixed links and roughly 60 % of the spectrum to be used for Fixed Wireless Access systems.	CEPT Recommendation T/R 13-02[6]	Sharing between ptp fixed and FWA
27.5 – 29.5 GHz	Shall be used as a shared band between the Fixed Service (point-to-multipoint) and the Fixed Satellite Service	CEPT/ERC/DECISION (00)09	Sharing between ptmp fixed and FSS
37 – 39.5 GHz	Shall be used on a national basis for low, medium and high capacity point-to-point fixed links over very short hop lengths.	ITU-R Recommendation F.749 Annex 1	
51.4 – 52.6 GHz	Short range digital radio links in high density networks	CEPT Recommendation 12-11	
55.78 – 57 GHz	Short range digital radio links in high density networks	CEPT Recommendation 12-12	

[6] In the *Spectrum Allocation Strategy For Cellular Systems, Fixed Wireless Access, Mobile Data Services and Radio Local Area Networks* (April 2007) the CEPT REC 13-02 E is recommended

Band	Recommendation	Channel plan	Sharing/migration
57 – 59 GHz	Short range radio links in high density networks	CEPT Recommendation 12-09	

Table 6 Recommended frequencies and channels plans for fixed links

The existing National Radio Frequency Plan proposes a migration for the bands 7110 – 7425 MHz and 7425 – 7750 MHz. Given the extensive usage of these bands in Botswana, the consultants recommend that the proposed migration in the National Frequency Plan should not be implemented. This new recommendation is intended to avoid a costly and disruptive migration process. Instead, alternative frequency bands will be identified as described later in the chapter.

3.6 Current users and refarming issues

Existing use of fixed links in Botswana is summarized in the table below.

Band	Usage	Comments
3600 – 4200 MHz	No fixed links in this band	Used for FSS Rx
5925 – 6425 MHz	No fixed links in this band	Used for FSS Tx
6425 – 7125 MHz	Used by BTC for point-to-point fixed links	
7110 – 7425 MHz	Used for fixed links, 168 MHz duplex spacing, 3.5, 7, 14 or 28 MHz bandwidth. In accordance with ITU Rec. ITU-R F.385-7 Annexure 3	
7425 – 7725 MHz	Used or fixed links, 161 MHz duplex Spacing, 3.5, 7, 14 or 28 MHz bandwidth. In accordance with Rec. ITU-R F.385-6	
7725 – 8275 MHz	Not used in Botswana	
8275 – 8500 MHz	Not used in Botswana	

Band	Usage	Comments
10.7 – 11.7 GHz	Not used in Botswana	
12.75 – 13.25 GHz	Not used in Botswana	
14.5 – 15.35 GHz	Partly used by government for fixed links. 490 MHz duplex distance. 7/28 MHz bandwidth.	
17.7 – 19.7 GHz	Partly used by BTC for fixed links. 340 MHz duplex distance	
22 – 23.6 GHz	Used for fixed links. 1008 MHz duplex distance. 3.5, 7, 14 or 28 MHz bandwidth.	
24.5 – 26.5 GHz	Not yet used in Botswana	Recommended for fixed links or FWA following CEPT Rec. 13-02 E, with 112 MHz carrier spacing
27.5 – 29.5 GHz	Not yet used in Botswana	
37 – 39.5 GHz	Not yet used in Botswana	
51.4 – 52.6 GHz	Not yet used in Botswana	
55.78 – 57 GHz	Not yet used in Botswana	
57 – 59 GHz	Not yet used in Botswana	

Table 7: Current usage of frequencies for fixed links in Botswana

3.7 Assignment methods

Two assignment methods are predominantly used for the fixed service on an international basis:

- Frequency assignment of each individual link and;
- Frequency block assignment.

The decision as regards which method to use for a particular frequency band will be influenced by a number of factors, such as the current usage of the band and regulatory or technology considerations. Even administrations that have introduced market based spectrum regulation will generally use both methods, mainly due to historical reasons.

In addition, the choice between these assignment procedures is also influenced by administrative factors such as whether the regulator has the manpower, expertise and tools to handle applications for frequency assignment within reasonable time. Speedy access to fixed frequency bands is very important for operators as they try to respond to market and customer requirements. Thus, assigning some frequencies as block assignments gives operators some flexibility in the way they rollout their infrastructure.

Block assignments is the easiest and fastest assignment solution. This can easily be seen in case of the rollout of PTMP systems with a high number of links. However, this assignment method restricts the number of operators that can have access to a given frequency band and precludes the access to other potential users on a per site/link basis. There are also historical reasons that may require BTA to continue with individual assignments in some frequency bands. For example, some frequency bands have been used by existing operators such that it may not be possible to partition them into block assignments.

For fixed links in higher frequency bands (typically above 26 GHz), we recommend increased use of technology neutral and flexible block licences to promote efficiency. This is consistent with international best practices and in line with our general recommendations for licensing. Block licences provide a more predictable and favourable environment for investments. The transaction costs associated with change of use in response to evolving technologies and markets are lower than for traditional site-licences. Administrative costs will be reduced and the incentives to use spectrum efficiently will be stronger.

If a holder of a block licence should wish to sell or lease the spectrum to others as site-licences or even to make it available to other users on a non-exclusive basis, then that should generally be permitted. Since it is generally less costly to sub-divide than to aggregate usage rights, the BTA should err on the block licence side rather than using site-licences whenever there is uncertainty about the optimal size of the usage rights.

The consultants believe that point-to-multipoint configurations are best served within the frequency bands identified for Fixed Wireless Access and in bands where block licenses are assigned. In bands managed by BTA for assignment of each individual link such configurations can only be introduced on a case by case basis. An individual assignment of each single link could produce an unnecessary administrative burden for both the operators and BTA. In bands where block assignments are used, the operators can decide on configurations themselves, within the technical limits specified by BTA.

A third assignment method, called a general frequency assignment, where operators are given general authorisations to use frequencies subject to adhering to specified technical specifications is suitable for very high frequency bands where the oxygen absorption is high. This method can be used for example in the 57-59 GHz band where the propagation conditions together with some basic technical restrictions should ensure the co-existence amongst many FS links without their prior co-ordination. A procedure for registering the operators using the general frequency assignment in a particular band, without specifying which part of the band they operate in, would be sufficient.

3.8 Recommendations

The majority of fixed links in Botswana are currently confined to the frequency bands

- 6425 – 7125 MHz, 7110 – 7425 MHz, 7425 – 7750 MHz. These are typically long haul links used in rural areas.
- 22 – 23.6 GHz. These are typically short haul links used in urban areas.

The future fixed link frequency requirements for Botswana are expected to increase significantly, due to continued deployment of mobile communications including 3G, deployment of FWA systems, and the ability for operators to self provision. Section 3.4.1 provides the long term (up to 2015) spectrum requirements as follows:

- 750 MHz for long hops, rural areas
- 1500 MHz for short hops, urban areas

The following recommendations are based on international regulation, technology trends, existing use and are intended to address the estimated fixed frequency requirements.

Recommendation 1: There are a number of bands that could be used for Fixed Service that are not yet in use in Botswana. It is recommended that they be opened for licensing. The assignment of frequencies should be a mix of block licensing and site licensing, with a bias towards block licensing.

The recommendations in the existing NRFP are for the most part still valid.

The bands 6425 – 7125 MHz (ITU-R Recommendation F.384), 7110 – 7425 MHz (ITU-R Recommendation F.385-6, Annex 3), 7425 – 7750 MHz (ITU-R Recommendation F.385.6 Annex 1) shall continue to be used for fixed links, typically long hops, in the same manner as in the current regulation.

The frequency range 22 – 23.6 GHz should continue to be used for fixed links, typically short hops, in the same manner as in the current regulation, following CEPT Rec. T/R 13-02 Annex A.

It is recommended that additional fixed link bands identified in Table 7 should be opened for assignment in Botswana. No restrictions on the usage (point-to-point versus point-to-multipoint) should be imposed. However, frequencies below approximately 10 GHz are mostly suited for long hops, whereas frequencies above approximately 10 GHz are mostly suited for short hops. Most major equipment vendors will provide equipment with a wide range of options in terms of frequency usage.

Despite the expected increase in spectrum demand, our evaluation shows that there should be sufficient spectrum for fixed links in Botswana in the foreseeable future, if BTA adopts our recommendations.

Band	Licenses	Assignment method	Recommendations/Comments
7725 – 8275 MHz	Site licenses	First Come – First Served	ITU-R Recommendation F.386 Annex 1
8275 – 8500 MHz	Site licenses	First Come – First Served	ITU-R Recommendation F.386 Annex 3
10.7 – 11.7	Site licenses	First Come – First Served	Co-existence with FSS, start at 10.7-10.95 paired

Band	Licenses	Assignment method	Recommendations/Comments
GHz			with 11.2-11.45 ITU-R Recommendation F.387
12.75 – 13.25 GHz	Site licenses	First Come – First Served	ITU-R Recommendation F.497
17.7 – 19.7 GHz	Block licenses	Demand assignment	ITU-R Recommendation F.595 Annex 1 Grandfather existing BTC links
24.5 – 26.5 GHz	Block licenses	Demand assignment	CEPT Rec. 13-02 E Shared with FWA
27.5 – 29.5 GHz	Block licenses (for the part of the band not used by satellite)	Demand assignment / First Come – First Served	CEPT/ERC/DECISION (00)09 Shared with FSS
37 – 39.5 GHz	Block licenses + Site licenses	Demand assignment / First Come – First Served	ITU-R Recommendation F.749 Annex 1
40.5 – 43.5 GHz	Block licenses + Site licenses	Demand assignment / First Come – First Served	
51.4 – 52.6 GHz	Block licenses + Site licenses	Demand assignment / First Come – First Served	CEPT Recommendation 12-11
55.78 – 57 GHz	Block licenses + Site licenses	Demand assignment / First Come – First Served	CEPT Recommendation 12-12
57 - 59 GHz		General frequency assignment	CEPT Recommendation 12-09

Table 8 Fixed links recommendations

We do not see a requirement for HAPS in Botswana, and thus we do not recommend the allocation of frequencies for HAPS. This recommendation can be re-evaluated if the need arises in future.

4 Satellite Radio Services

Satellite communication is an alternative platform for electronic communication services. Satellite can provide national coverage and thus offer the possibility of bridging the digital divide in rural and remote areas of the country.

By far the most important frequency bands for satellite communications in Botswana are the C-band and the Ku-band[7]. Other important frequency bands are the bands around 1.5 GHz used by Inmarsat and other satellite organisations and the 149 MHz band which has been reserved for low earth orbiting mobile satellite services. Satellite services above 14.5 GHz have not been licensed in Botswana.

4.1 Introduction

Fixed and mobile satellite systems have been allocated a large number of frequency bands between 1 GHz and 15 GHz on a global basis. Fixed and mobile satellite services often share allocations on a co-primary basis in the ITU frequency allocation table and in the National Frequency Table of Botswana.

The most important frequency band for the fixed satellite service in Botswana is the C-band while the use of the Ku-band is also growing rapidly. Satellite systems in the C-band and the Ku-band are used to support a range of commercial applications. These applications typically include telecommunications backbone for broadband services, alternative backbone transmission for service providers, internet and television and radio broadcasting networks.

4.2 Fixed-Satellite Service

A large amount of spectrum, especially between 2.5 and 31 GHz, is allocated to the Fixed Satellite Service (FSS). Almost all the FSS allocations are shared on a co-primary basis with terrestrial services. A majority of the FSS services in operation today are provided from satellites in Geostationary Satellite Orbits (GSO). GSO satellites are also called Geostationary Earth Orbit (GEO) satellites. A GSO satellite revolves around the earth at fixed distance above the earth and at such a speed so as to maintain the same position relative to the earth at all times. Thus the satellite appears to be stationary. Most satellite systems are commercial use, but some are used for military purposes. Most satellites are GSO. However, there are new satellite systems that use non-geostationary orbits.

The FSS can be defined as a radio communication service between earth stations at given positions, when one or more satellites are used; the given positions may be specified fixed points or any fixed point within specified areas. In some cases this

[7] The C-band and Ku-band are imprecise definitions used in the satellite industry to describe satellite operations in the bands 3-7 GHz and 11-15 GHz respectively. In this document, the C-band will mean a portion of the electromagnetic spectrum ranging from 3600-4200 MHz (downlink) and 5925-6425 MHz (uplink) while Ku-band will mean a portion of the electromagnetic spectrum ranging from 11.7-12.7 GHz (downlink) and 14-14.5 GHz (uplink).

service includes satellite-to-satellite links, which may be operated in the Inter-Satellite Service. The fixed-satellite service may also include feeder links for other space radio communication services.

With appropriate earth stations, fixed-satellite networks can provide a variety of services such as:

- International connections between public telephone networks;
- Trunk telephone connections between regional centres;
- Transfer of broadcasting content from the point of origin to locations where they will be included in broadcast programmes;
- Distribution of broadcasting programme signals to earth stations that feed the signals to terrestrial broadcasting stations;
- Private communications networks;
- Telecommunications facilities between earth stations serving isolated communities and;
- Point-to-point low-capacity data network.

4.3 High Density Fixed Satellite Service (HDFSS)

The term High Density Fixed Satellite Service (HDFSS) describes a significant level of deployment of point-to-point and/or point-to-multipoint systems within a given geographical area. The driving factors for HDFSS are frequency bands above 28 GHz; with the availability of small equipment and the necessary propagation conditions to allow a high degree of frequency reuse. The term HDFSS does not describe a particular sub-service in the Fixed Satellite Service. It is a description of a deployment scenario.

4.4 Broadcasting-Satellite Service

The Broadcasting-Satellite Service (BSS) provides both sound and television broadcasting services.

4.4.1.1 Broadcasting Satellite Service Sound

In 1987, the European Commission established the Eureka Project 147 to develop a digital audio broadcasting (DAB) standard for sound and data to fixed, portable or mobile receivers. The output of this project was the development of European Standard ETS 300 401 for DAB. The World Administrative Radio Conference of 1992 (WARC-92) allocated the band 1452 - 1492 MHz on a co-primary basis for use by the Broadcasting Service and Broadcasting Satellite Service to provide terrestrial digital audio broadcasting (T-DAB) and satellite audio broadcasting (S-DAB), respectively. In 1994 the ITU adopted the ETS 300 401 standard through ITU-R Recommendation BS.774 and ITU-R Recommendation BO.789, thus making the DAB standard an international one.

Table 10 and Figure 2 show the split between Terrestrial Digital Audio Broadcasting (T-DAB) and Satellite Digital Audio Broadcasting (S-DAB) as per the National Frequency Plan and the SADC Plan.

DAB Channel bandwidth = 1.536 MHz

Guard band between channels = 0.176 MHz

Lower Guard band = 0.192 MHz

Upper Guard band = 0.608 MHz

T-DAB Channels		S-DAB Channels	
(1452 - 1467 MHz)		(1467 - 1492 MHz)	
Channel No.	Centre Frequency	Channel No.	Centre Frequency
1	1452.960	10	1468.368
2	1454.672	11	1470.080
3	1456.384	12	1471.792
4	1458.096	13	1473.504
5	1459.808	14	1475.216
6	1461.520	15	1476.928
7	1463.232	16	1478.640
8	1464.944	17	1480.352
9	1466.656	18	1482.064
		19	1483.776
		20	1485.488
		21	1487.200
		22	1488.912
		23	1490.624

Table 9: L-Band Channel Plan for Digital Audio Broadcasting

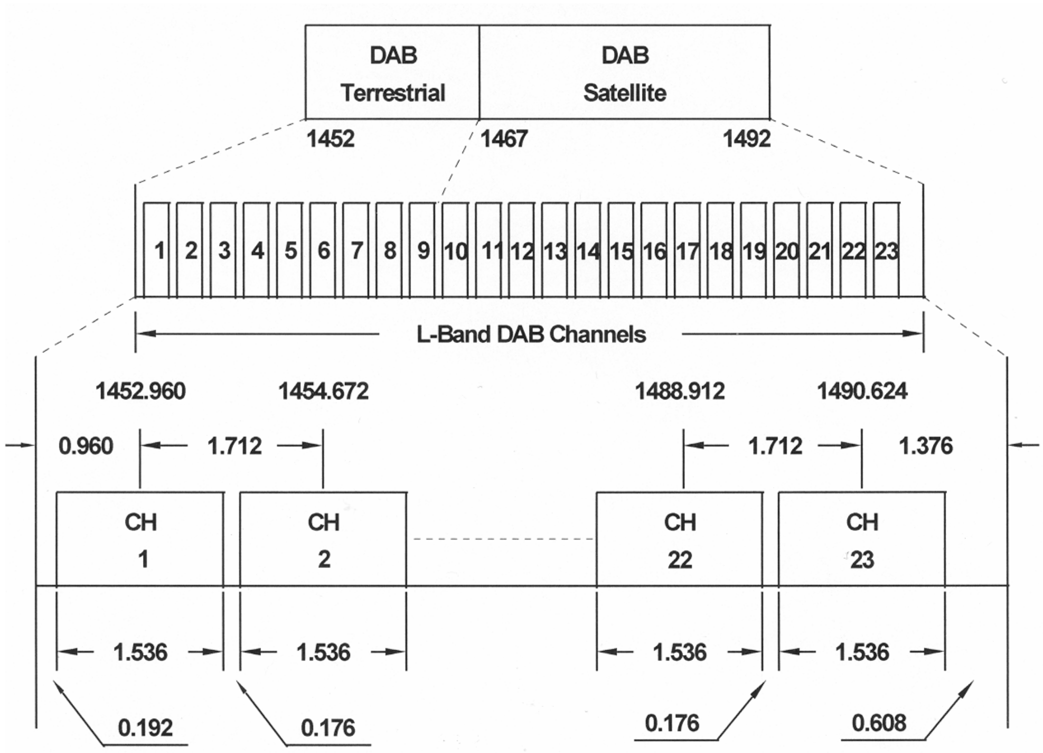

Figure 2: Use of the L-band in NFP and SADC Plan for Digital Audio Broadcasting

Initially the European Conference of Postal and Telecommunications Administrations (CEPT) had a similar band split between T-DAB and S-DAB as shown above. However, this was modified in 2002 by allocating seven additional blocks to T-DAB as follows:

- The band 1452 - 1479.5 MHz for Terrestrial Digital Audio Broadcasting (T-DAB), Maastricht and
- The sub-band 1479.5 – 1492 MHz for use for Satellite Digital Audio Broadcasting (S-DAB) and complementary terrestrial transmitters, in areas where there is no satellite coverage.

The World Space International operates two satellites, AfriStar and AsiaStar, which provide S-DAB services to parts of Africa, Middle East and Asia. Figure 3 shows the coverage of these satellites.

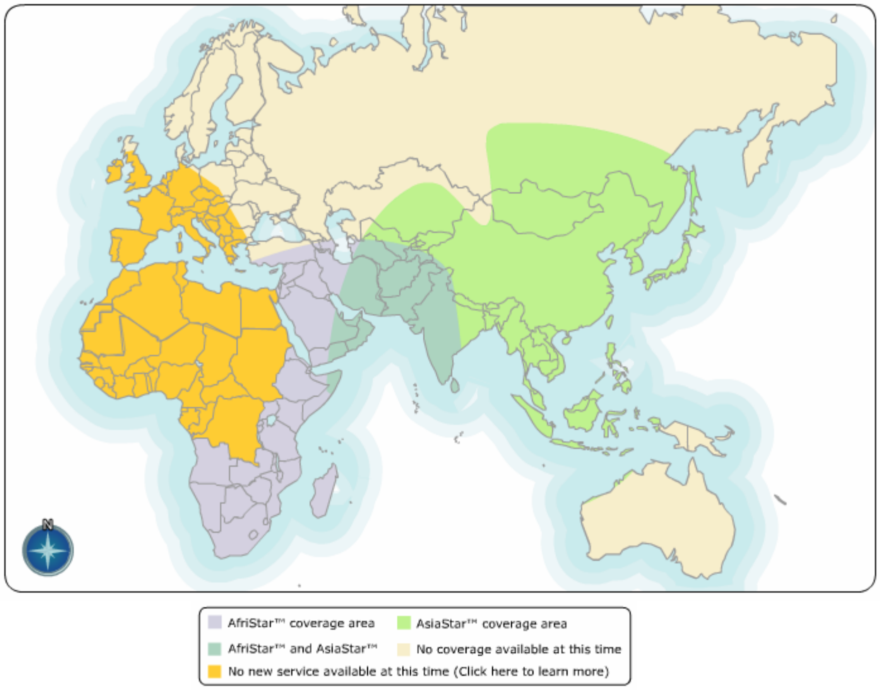

Figure 3: Coverage of AfriStar and AsiaStar[8]

4.4.1.2 Television Broadcasting Service

In the 1970s and 1980s, satellites became a leading means of long distance radio communication and facilitated worldwide TV program distribution in real time. Satellite broadcasting made it possible to have direct reception of TV programs in rural areas that could not be served by terrestrial TV broadcasting stations and cable TV systems. Such reception facilities included the use of TV Receive Only (TVRO) receivers and were connected to parabolic antennas with diameters of 2 to 5 meters. For almost two decades, TV program delivery by satellites was done in the 4/6 GHz and 11/14 GHz bands.

One of the most well known satellite broadcasting service in Southern Africa is that offered by MultiChoice, a South African based company that provides subscription television services. The programs are grouped into bouquets, the most popular being the DSTV service. A recent development in the provision of satellite broadcasting services was the launching of GTV which will also provide subscription broadcasting services in sub-Saharan Africa.

One of the most important satellites for delivery of broadcasting satellite services in Southern Africa is Intelsat 7 (IS-7), formerly owned by PanAMSat and called PAS-7. The satellite is on the Indian Ocean at 68.5º East.

[8] www.worldspace.com

The following table shows key parameters[9] of the satellite:

Key Parameters		
Total Transponders	C-Band: Ku-Band:	14 x 36 MHz 30 x 36 MHz
Polarization	C-Band: Ku-Band:	Linear - Horizontal or Vertical Linear - Horizontal or Vertical
e.i.r.p. (Edge of Coverage to Beam Peak)	C-Band:	33.0 up to 37.8 dBW
Uplink Frequency	C-Band: Ku-Band:	6425 to 6725 MHz 13.75 to 14.25 GHz
Downlink Frequency	C-Band: Ku-Band:	3400 to 3700 MHz 10.95 to 11.70 GHz
G/T (Edge of Coverage to Beam Peak) C-Band		-9.0 up to -3.1 dB/K
G/T (Edge of Coverage to Beam Peak) Ku-Band	Europe/ME: Europe/ME/S.Africa: S. Africa: India/China:	Up to +6.6 dB/K Up to +6.6 dB/K Up to +6.4 dB/K Up to 11.0 dB/K
SFD (0.0 dB/K and 0 dB attn.)	C-Band: Ku-Band	-95.5 dBW/m² -98.0 dBW/m²

Table 10: Key parameters of Intelsat 7

The satellite transmits in the C and Ku bands. The Ku band transmission has spot beams (foot prints) that cover China, India, Europe/Middle East and Southern Africa. Figure 4 shows the Ku band coverage of the Southern Africa spot beam of IS-7.

[9] www.intelsat.com/flash/coverage-maps/

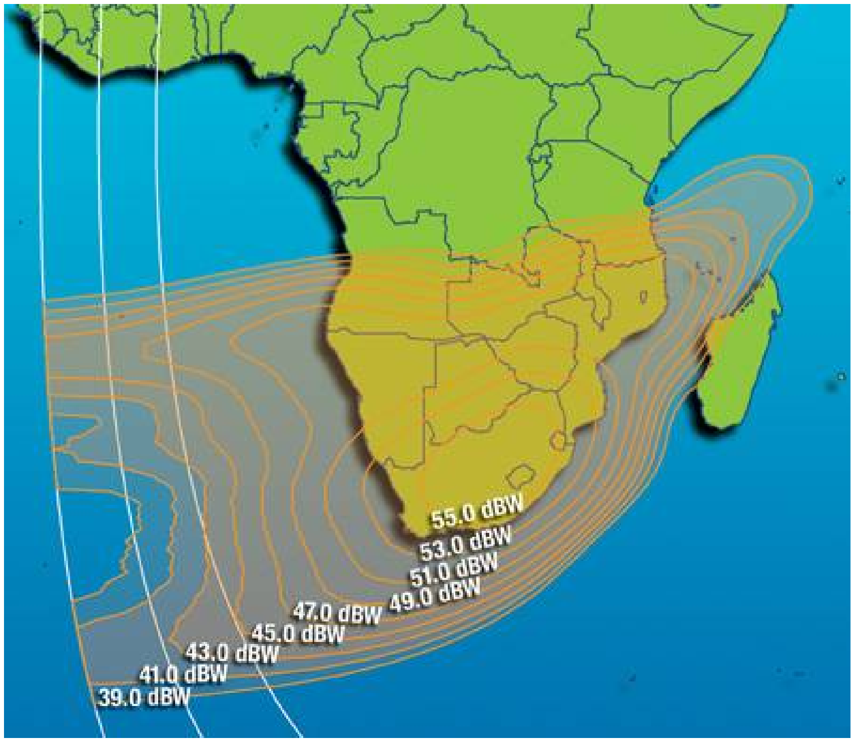

Figure 4: Coverage of Southern Africa by the Ku Band spot Beam of IS-7[10]

The Ku band provides most services in Southern Africa because of the smaller sizes of receiving antenna that are required. For example, most of the antennas used for television reception in most parts of Botswana have diameters that are less than 1.2 m.

Another important satellite for Southern Africa is the Eutelsat W3A at 7^0 East. Its coverage and frequency plan are shown in Figures 5 and 6, respectively. This satellite also provides a host of services, from broadcasting to telecommunications services.

[10] Ibid

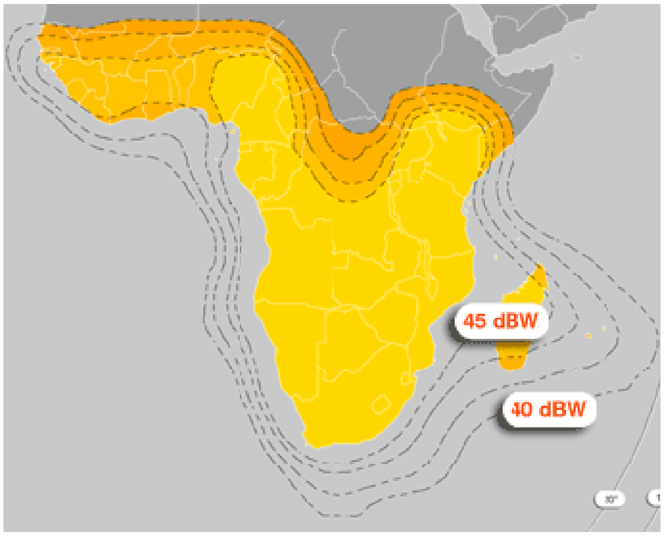

Figure 5: Coverage of sub-Saharan Africa by Eutelsat W3A[11]

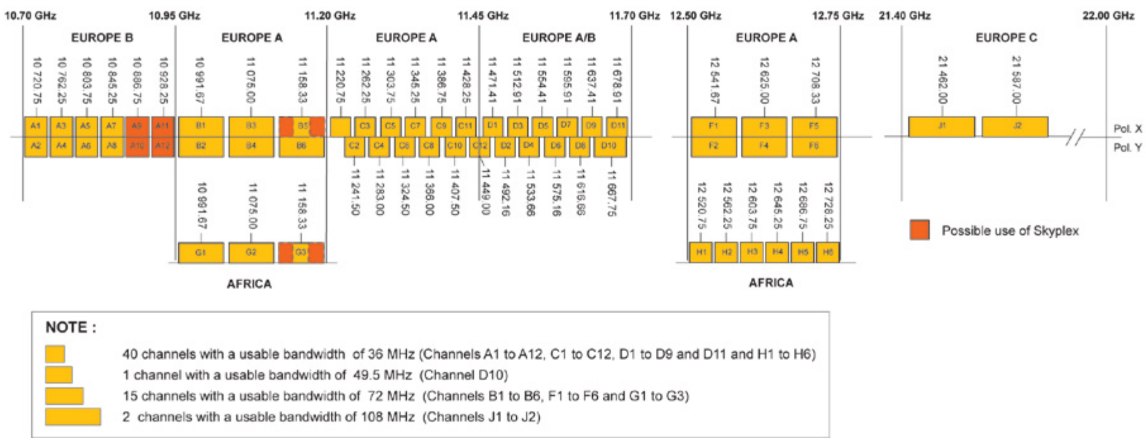

Figure 6: Frequency plan for Eutelsat W3A[12]

4.5 Mobile-Satellite Service (MSS)

In the 1980's, mobile-satellite service technology advanced from initial concepts to practical system design and service provision. Today, the competition to build global satellite networks is strong. Companies around the world have proposed to use satellites to deliver mobile services, which are expected to generate large revenues. For communication service providers and users, satellite-based systems offer ubiquitous coverage of large geographical areas.

[11] http://www.eutelsat.com/satellites/7e_w3a_popd.html#

[12] http://www.eutelsat.com/satellites/fp/w3a_fp.html

A number of mobile satellite systems were proposed during the 1990s, however, the business associated with these systems were affected by two factors:

- The high launch costs and long lead times for these systems;
- The high level of competition and extended coverage in the mobile and broadband markets which had been targeted by these systems.

As a result, there has been a number of market failures associated with companies that proposed commercial satellite systems for the provision of mobile and broadband services.

In the long term, the demand for spectrum for satellite systems will depend on:

- The ability of satellite systems to compete against terrestrial systems in provision of broadcasting and broadband services;
- Improvements in efficiency of data transmission protocols within satellite systems and the impact on spectrum requirements; and
- Technical advances such as smaller spot beams and dynamic bandwidth allocation procedures that may improve the possibility of spectrum sharing between satellite systems and other services.

The International Maritime Satellite (Inmarsat) consortium has been providing voice and data services on portable terminals since the early 1990's. Inmarsat's activities have since expanded beyond its nautical root, and now it also offers land-mobile data services in remote areas to users whose needs cannot be met by existing cellular services. Its smallest terminal is the briefcase sized Inmarsat-M phone system. Almost all these satellite services offer a combination of all-digital transparent voice, data, fax and paging services to and from hand-held telephone devices.

The satellite IMT-2000 services can be provided in the existing MSS allocations. The 2 GHz MSS bands have already been identified for IMT-2000 and should be used at least in part by satellite IMT-2000 systems. It would also be possible to satisfy some satellite IMT-2000 spectrum requirements in other MSS allocations, in particular those allocations, which are not heavily used by MSS today, e.g. the 2.5/2.6 GHz MSS allocations.

4.6 Trends and developments

The C-band is the most important frequency band for satellite communications in Botswana. In many parts of the world, C-band is the only reliable satellite band because the C-band signals are impervious to atmospheric conditions, particularly for areas with heavy rainfall such as Equatorial Africa, the Americas and Asia. The C-Band satellite downlink spectrum today provides essential and basic communications services in many parts of the world. These services include:

- Basic telephony, internet, TV and broadband services;

- Services that are geared towards development such as tele-education and tele-medicine; and
- Those services that are fundamental to disaster management such as disaster relief communications and meteorological tracking (e.g. tsunamis).

Approximately 160 geostationary satellites utilize the C-band on a global basis. No alternative bands exist with the signal quality, spectrum efficiency, availability and reach of the C-band. Studies have also shown that sharing of this band with terrestrial mobile technologies is technically challenging and might lead to interference between satellite systems and terrestrial bile systems.

Very Small Aperture Terminal (VSAT) is a small satellite terminal that can be used for communications (receive-only or interactive) via satellite. The term usually refers to any fixed satellite communication terminal with an antenna size that is less than 1.8 meter (for Ka-band), 3.8 meter (for Ku-band) or 7.8 meter (for C-band). Technology development has ensured a trend towards bandwidth on demand, affordable terminals and the possibility of Internet access via satellite. Several countries in Europe have implemented exemption from individual licensing for VSAT terminals in the Ka- and Ku-bands. The exemptions are for VSATs in Ku-band subject to the following parameters:

- operation of the satellite terminal shall be in the band 12.5-12.75 GHz (space-to-Earth) and 14-14.25 GHz (Earth-to-space)
- Transmitter power shall be less than 2 Watts
- EIRP shall be less than 50 dBW
- No operation within 500 m from the boundary of an airport.

Some countries extend the uplink band to 14.5 GHz and even allow higher EIRPs (up to 80 dBW has been noted). In these countries the licensing procedures have become significantly easier and less costly and reduced the barrier for facilitating VSAT services. This development shows that even equipment with high output power can be exempted from licensing when the conditions are right. In the case of VSATs, it is clear that:

- Although the output power is high, the antenna beam is narrow and pointed towards the satellite;
- The satellite operator will assign the necessary frequency and bandwidth;
- Any interference can be mitigated by the satellite operator without reference to the regulator;

HDFSS systems have not received much interest. However, frequencies have been identified for use by HDFSS (e.g. parts of the 28 GHz band) in Botswana, in case there is a demand for HDFSS in future. With the correct regulatory conditions, HDFSS can be implemented under a licence-exempt regime. However, the consultants do not foresee any considerable demand for HDFSS in Botswana in the medium to long term.

4.7 National radio frequency plan

A large part of the spectrum between 2.5 and 31 GHz is primarily allocated for a wide variety of satellite services, but almost all of these frequency allocations are shared with other primary services. The Consultants have not identified any major changes necessary in the Table of Frequency Allocations to accommodate new satellite services.

The band 3600 – 4200 MHz is allocated to Fixed and Fixed-Satellite, with a secondary allocation to Mobile. This band is reserved for Fixed links (point-to-point) and to VSAT/SNG on a coordinated basis.

In the Consultation Document for services with a high demand for spectrum, it was noted that “The information available about current FSS usage in C-band is not complete. The consultants are not aware of any downlink sites that operate below 3700 MHz. Nevertheless, BTA’s records seem to show permissible operation down to 3625 MHz. Therefore sharing criteria must be established for co-existence, in order to protect the FSS stations. Thus BTA should establish actual operating frequencies for VSAT that have been allowed to operate in a range (e.g. 3625 – 4200 MHz for US Embassy, 3625 – 4200 MHz for OPQ Net, etc.). In addition, there appears to be some FSS terminals (e.g. for a Call Centre in Broadhurst Industrial, near BJ Builders, and another in Ericsson’s offices) that do not appear to be in BTA’s frequency register. BTA should also obtain the occupied bandwidth for all operating VSATs. Occupied bandwidths are required during interference analysis.”

Fixed Wireless Access was proposed in the frequency band 3.6-3.7 GHz. The Ku-band has been reserved for VSAT/SNG use in Botswana. There are currently 2 Fixed Links assignment in the uplink band in the Frequency Register.

Terminals operating in the Mobile Satellite Service (e.g. Inmarsat terminals) within the globally allocated mobile satellite bands and the bands used for Satellite Personal Communication Systems[13] can easily be exempted from licensing. There are no terrestrial spectrum users in these bands in Botswana and such an exemption would have any negative impact on current users of the spectrum. Such terminals can only be used within their own networks (e.g. Inmarsat) and the internationally co-ordinated frequencies which are available to such networks. The National Frequency Plan has been updated with the latest revision of frequency bands for the Mobile Satellite Service that were adopted at WRC-2003.

[13] 1525-1559 MHz (downlink) and 1626.5-1660.5 MHz

4.8 Assignment methods

Individual satellites are assigned frequencies on an international basis as part of the process for assigning orbital slots and associated radio frequencies in those slots through a well-defined process at ITU. The orbit slots shall be used for satellites in accordance with the technical information laid down in the submitted filings to the ITU.

Earth stations in Botswana are then licensed to use the uplink and downlink frequencies between satellites and earth stations at fixed locations (fixed satellite service) or mobile locations (mobile satellite service). Satellite terminals can be exempted from licensing when the risk of interference is minimal. Having a lightweight regulatory framework for satellite communications will benefit the users of such communications and stimulate the development of broadband services.

4.9 Recommendations

Recommendation 2: The C-band will continue to be the most important band for satellite earth stations in Botswana.

The Fixed Satellite Service should be given priority in the frequency bands 3700-4200 MHz and 5925-6425 MHz. Individual licences should be assigned to satellite earth stations in these bands.

Recommendation 3: VSATs in the Ku-band should be exempted from licensing.

It has been shown that with the proper technical conditions, VSATs can operate without creating interference in the Ku-band. This band should remain exclusive to the FSS and no further Fixed Links should be assigned frequencies.

Recommendation 4: Terminals in the Mobile Satellite Service that are fully developed and available for worldwide use in globally harmonised frequency bands should be exempted from licensing.

In making these recommendations, the Consultants have only considered the spectrum and interference aspects of the Satellite Service and not any additional licensing requirements or policies in Botswana that may override these recommendations.

5 Reduced Channel Spacing – VHF/UHF land mobile services

5.1 Introduction

The basic principle of PMR/PAMR spectrum management is to serve the maximum of existing demands in a limited spectrum. Where individual users for small PMR systems require frequencies, it would be advantageous that such systems use narrow band channels to maximise the number of users that can be served. Conversely, for regional or national PAMR systems, it is more efficient to license a dedicated block of spectrum so that the operator has flexibility to plan its network and adjust the capacity in line with variable demand across the coverage area.

5.2 Overview of available technologies

While several, smaller PMR users will continue to operate existing analogue systems, there is a clear trend towards more sophisticated PMR services that require digital technologies. The migration within the market for larger PMR and PAMR systems in some cases follows a two step process, initially migrating from analogue to digital narrow band systems and then in a second step to wideband systems to provide the additional required high-speed data services. However, the number of smaller PMR users in Botswana has raised the issue of moving from 25 to 12.5 kHz channel separation to accommodate more users in designated frequency bands.

With the evolution of technologies, the digital PMR/PAMR technologies follow the general evolution in the radio communication sector and may be described, in line with the definitions used in ITU-R and CEPT for Public Protection and Disaster Relief (PP&DR), as narrowband, wideband and broadband systems with the following technical and operational description:

Narrow band digital systems

Digital narrowband systems provide digital voice and low speed data applications (e.g. pre-defined status messages, data transmission of forms and messages, access to databases).

Wide band digital systems

Wide band technologies will carry data rates of several hundred kilobits per second and might be used for services matching the capacity of current cellular operations. Wide band systems offer the possibility of both having a large volume of users and a high volume of data at various moments in time.

Systems for wideband PMR/PAMR applications are under development by various standards organisations with channel bandwidths dependent on the use of spectrally efficient technologies. ETSI has standardised TETRA Advanced Packet Service (TAPS) and TETRA Enhanced Data Services (TEDS) for wideband applications while a CDMA platform also has been developed.

Broadband systems

Several standards organisations are working on systems for broadband PP&DR applications enabling a new level of functionality with additional capacity to support higher speed data and higher resolution images.

5.3 Trends and developments

Even with the large growth experienced in cellular markets, the worldwide demand in the land mobile service has been increasing due to increased growth in user requirements for new data-based services. This demand makes assigning frequencies increasingly difficult and has led to the development of more spectrally efficient technologies utilizing narrowband, digital and in many cases trunking technologies.

In the United States, the FCC started as early as 1992 to refarm the land mobile service to create more radio channels. In 1993 FCC formally started phasing in narrowband equipment and to phase out 25 kHz channels over the next 10 years. This process was separated into 4 stages:

1) All 25 kHz radio equipment may continue to operate until January 1, 2013. After this date, all radio equipment must operate completely on 12.5 kHz channels.
2) Equipment with 25 kHz channel spacing cannot be manufactured, imported or sold after 2011.
3) FCC will not certify new 25 kHz models after 2005
4) FCC will not issue licences for 25 kHz channel spacing after 2011.

A similar process is being undertaken in Canada up to the year 2010, but in this case the process in only limited to congested areas.

5.4 Available Frequency Bands

The most commonly used frequency bands for PMR in Botswana are 138 - 144 MHz and 146 -174 MHz band. The UHF band (400 – 470 MHz) is not used as much as the VHF band. A variety of channel separations, uses of sub-bands allocated, duplex spacing, choice of base transmitting frequency and transmitting power are in use on a worldwide basis.

5.5 Changing from 25 kHz to 12.5 kHz spacing

In 2001/2002, BTA adopted a plan to migrate from 25 kHz to 12.5 kHz channel spacing. The main purpose of the migration procedure was to increase the number of frequencies, especially in the VHF band, and to partly re-organise the split between simplex and duplex sub-bands. Subsequently, BTA informed radio dealers to start using the 12.5 kHz channels spacing. However, radio dealers were not advised about how they should treat users whose radios had 25 kHz channels. In addition, it appears that when BTA assigns frequencies, it does not specify the channel spacing that should be used. In addition, BTA's database does not show which customers have 25 kHz spacing radios and which ones have 12.5 kHz channel spacing.

Some radio dealers[14] were interviewed as part of the current assignment to find out how they handle the channel spacing issue.

- All interviewed radio dealers said that they use 12.5 kHz channel spacing for all new radios. That is, in cases where the user purchases a new set of radios and does not have an existing set with 25 kHz channel spacing.
- There are differences in implementation in cases where the user has existing radios that operate at 25 kHz channels spacing:
  - Some radio dealers change the old radios from 25 kHz to 12.5 kHz channel spacing and thus the whole system ends up operating with a 12.5 kHz channel spacing.
  - Other radio dealers set the new radios to 25 kHz and thus the whole system ends up operating with a 25 kHz channel spacing.
- Dealers with customers that have 25 kHz radios estimate that such radios would represent from 10% to 30% of all radios operated by their customers.
- Most of the radio dealers said that they knew which customers have 25 kHz channel spacing radios.

It is recommended that BTA should follow the migration steps outlined below:

5.5.1 Proposed migration steps

The migration process has different steps some of which will have to be undertaken parallel. BTA should:

- Request all radio dealers to submit contact details of all their customers that have radios that operate with a 25 kHz channel spacing. In each case the dealers should state the location/area where the radios are used and the number of radios.
- For each customer, the radio dealers should specify the number of radios that can be changed from 25 kHz to 12.5 kHz through a simple selection and those with old radios that do not have such a facility.
- Write to each user with radios that have a selectable channel spacing to make arrangements to have their radios changed from 25 kHz to 12.5 kHz channel spacing within a maximum period of period of 12 months from the date of the letter.
- Advise all users of old radios that do not have a facility to change the channel spacing from 25 kHz to 12.5 kHz to make arrangements to purchase new radios within a period of 24 months from the date of notice. This requirement should only apply to users that are within a radius of 70km of urban centres (Gaborone and Francistown) and other areas with high usage of radios. Radios

[14] Interviewed radio dealers include, CLS Systems, Kudu Communications, Radio Active, Power Serve, and ZS Botswana.

that operate with a 25 kHz channel spacing in areas with low radio usage should be allowed to operate up to the end of their useful life.

- Instruct radio dealers to only to sell radios with 12.5 kHz bandwidth with immediate effect. If the user wants to purchase new radios to add to existing radios that operate at 25 kHz channel spacing then the radio dealer should only sell the radios provided the user changes the old radios to 12.5 kHz channel spacing.
- In general, strive to ensure that radio channels are shared amongst users. The level of sharing will vary depending on the type of users and the activities for which they use radios. Thus BTA will have to decide on the level of sharing on a case-by-case basis. In general, up to 100 users from 3 to 4 networks can share a frequency[15]. Thus BTA should study all its current assignment, especially in the VHF band. All frequencies that have been assigned to less than say 50 radios within the same area should be monitored using the monitoring system to measure channel occupancies. Occupancy measurements should be automated and done over a period of at least seven days during working hours. All frequencies found to have average continuous idle periods (e.g. 15 minutes with no activity) should be considered for licensing to other users in the same area.
- Emergency and security organisations should not be subjected to such sharing criteria and their requirements should be subject to special considerations as necessary.
- In parallel with the above steps, BTA should use the monitoring system to schedule automated monitoring of all frequencies that appear in the database but whose licences have not been renewed. Any such frequencies that show no activity over a measurement period of one week should be removed from the activity database and put in cancelled licence database.

In Gaborone and other areas with high radio usage:

- Individual organisations should be allowed a maximum of two frequencies in the VHF band for the same service in the same area, unless requirements for more frequencies can be justified.
- It may become necessary to apply higher radio licence fees for radios that use 25 KHz channel spacing compared to those that use 12.5 kHz channel spacing. For example the fee for the 25 kHz radios could be set to more than double that of radios using 12.5 kHz channel spacing.
- To encourage migration to the UHF band in urban areas, it might be necessary to impose higher licence fees for radios in the VHF band compared to those in UHF band. However, the current licence fees are relatively low compared with the cost of radio terminals and will have little or no effect unless the quantity of terminals is very high.

[15] ERC Report 52

5.5.2 The use of signalling in shared frequencies

When there are a number of users that share a frequency in the same area, it is desirable that each user's receiver should only have to listen to communication on that radio that is intended for him/her or the group of listeners to which he/she belongs. Motorola invented the signalling system called Continuous Tone Coded Squelch System (CTCSS) and patented it as the "Private line (PL)" which allows receivers that operate on the same frequency to squelch the audio and only open the squelch if the transmission comes from a transmitter that has the same signaling code as the receiver. Subsequently, other radio manufacturers developed similar signaling systems and called them various names such as “Tone Lock”, "Channel Guard", "Quiet Channel", "Call Guard," and many other names for the same thing to avoid lawsuits for marketing a patented system.

Transceivers with CTSS are equipped with a coder/decoder which adds a specific low-frequency tone to the normal audio signal in the transmitted signal. Each user group is assigned its own tone which is configured in their transceivers. The tone decoder in each transceiver monitors the output of the receiver for tones and will open the receiver only when it detects the set tone in the received signal, otherwise the receiver will remain muted. There are 32 standardised tones.

To avoid accidental transmissions over a communication that is under way, some systems employ a channel activity monitoring system. Some of these implement a lockout system in the Press To Talk (PTT) circuitry which makes it impossible to transmit if the channel is already engaged in a transmission related to another tone (i.e. from another user group).

Shared repeaters used by several groups with different CTCSS tones can be configured to retransmit the CTCSS tones and thus allow communications between users that belong to the same groups.

Digitally Controlled Squelch (DCS) is a form of signalling which uses low-rate, low-level continuous binary digital signals to control the squelch of transceivers. The main difference between CTCSS and DCS is that the latter allows more coding (up to 104 combinations compared to 32 for CTCSS). In addition, DCS provides faster response times.

In some countries (e.g.UK), CTCSS/DCS codes are assigned by the regulator during frequency assignment. In other countries the regulator only recommends that users should implement CTCSS/DCS codes. To ensure consistency in the use of the codes, we would recommend that BTA should assign the codes when it assigns frequencies.

5.6 Current users and refarming issues

The most commonly used frequency bands for PMR in Botswana are 138 - 144 MHz and 146 -174 MHz band. Save for Government usage, the UHF band (400 – 470 MHz) is not used as much as the VHF band.

A migration strategy for the 146 – 174 MHz and 440 – 470 MHz ranges has been described in the NRFP.

5.7 Recommendations

Recommendation 5: It is recommended that the change from 25 kHz to 12.5 kHz channel spacing for PMR should be implemented in accordance with the procedure described in Section 5.5.

6 PMR 446

6.1 Introduction

PMR 446 is the name given to "Walkie Talkies" operating in a small frequency segment around 446 MHz.

PMR 446 is defined as radio equipment with the following characteristics:

- It operates in the frequency band 446.0 – 446.1 MHz with a channel plan based on 12.5 kHz spacing and with the lowest frequency carrier at 446.00625 MHz.
- It conforms to ETSI standard ETS 300 296.
- It uses only integral antenna and an effective radiated power less than 0.5 W to maximise sharing of spectrum and minimise interference.

PMR was standardised and harmonised by ETSI and CEPT at the end of the 1990's when there was a huge demand from industry and users for short range voice communications operated under relaxed licensing conditions on collective frequencies shared by many users on an uncoordinated basis. The band 446.0-446.1 MHz was selected because it offered the best possibilities for the introduction of PMR 446 in a majority of countries.

This technology has proved extremely popular with a range of radio users. The current market for PMR 446 equipment in Europe is estimated to be approximately 3.6 million terminals each year. Because of the large volumes of production and relaxed regulatory framework (mainly licence exempt) in most countries, PMR 446 equipment has found its way into many countries, including Botswana.

6.2 Trends and developments

In some European countries, PMR 446 has been augmented with 100 kHz of spectrum adjacent (446.1-446.2 MHz) to the PMR spectrum for digital short range voice communications. This application is called DMR 446. It was first proposed as a harmonised standard in ETSI in 2004, leading to an ECC Decision in 2006.

License exempt digital PMR 446 applications within the band 446.1-446.2 MHz are envisaged as complementing the current analogue PMR 446 applications by providing additional features. The handheld terminals with integral antennas are suitable for simplex, digital peer-to-peer voice and data communications with low bit rates. Initially two variants for low cost handheld digital PMR 446 equipment with integral antenna were under consideration in order to provide solutions optimised for business and consumer user market segments. These are both FDMA systems using either a 12.5 kHz bandwidth according to ETSI TR 102 335-1 V1.1.2 (2004-10), or using 6.25 kHz bandwidth according to ETSI TR 102 433. In future there may possibly be other systems covering digital PMR 446 applications. Due to the lack of implementation of the ECC Decision in several countries, it has been difficult for manufacturers to commit to DMR 446 equipment development.

6.3 National radio frequency plan

PMR 446 is not identified in the Table of Frequency allocations or in BTA's Frequency Register. However, the Consultants understand PMR 446 radios are available in Botswana through big shops, notably Game City.

There is a licensed user in Gaborone in the frequency band 446-446.1 MHz. Experience from other countries that have allowed PMR 446 radios on license exempt basis has shown that the risk of interference from these radios to other radio systems is low. In the unlikely event that this user does experience interference arising from PMR 446 users, this user should be offered an alternative assignment outside of this band. Users of PMR 446 cannot be afforded protection from interference which may be caused by the licensed user.

PMR 446 has been specifically designed to operate under relaxed licensing conditions on collective frequencies shared by many users on an uncoordinated basis. Such equipment is being used in many countries on license exempt basis. We recommend that BTA should also formally recognise PMR 446 as being licence exempted and ease any licensing that may have been required for these users.

6.4 Recommendations

Recommendation 6: It is recommended that PMR 446 radio equipment should be granted licence-exempt status.

Recommendation 7: In the event the market for DMR 446 market develops in Botswana, it is recommended that this technology should also to be exempted from the need of individual licences.

7 Terrestrial Broadcasting

This section provides an overview of frequencies for sound and television broadcasting. A detailed terrestrial Broadcasting Frequency Plan produced by ICT and ATDI SA in April 2007 is available at BTA for interested readers.

7.1 Medium Wave Frequencies (300 kHz – 3000 kHz)

The broadcasting operators in Botswana and the neighbouring countries operate in the band 531 – 1602 kHz. The Medium Wave frequency plan is based in the Geneva 1975 Agreement (GE 75 Agreement).

Botswana uses only 44 % of the frequencies coordinated in the GE 75 Agreement. ICT and ATDI concluded that it would not be feasible to identify additional medium wave frequencies through bilateral negotiations between Botswana and neighbouring countries because of the problems of long range propagation in medium wave frequency bands. Accordingly, medium wave frequencies can only be coordinated at competent international conferences that would enable all countries that could be affected by medium wave frequency transmitters from Botswana to voice their views on such proposals.

The report concluded that in view of these difficulties and the low usage of the medium wave frequencies, Botswana should use the available MW frequencies to the maximum before considering proposals for additional medium wave frequencies. The Figure below shows the location and coverage of Medium Wave Transmitters.

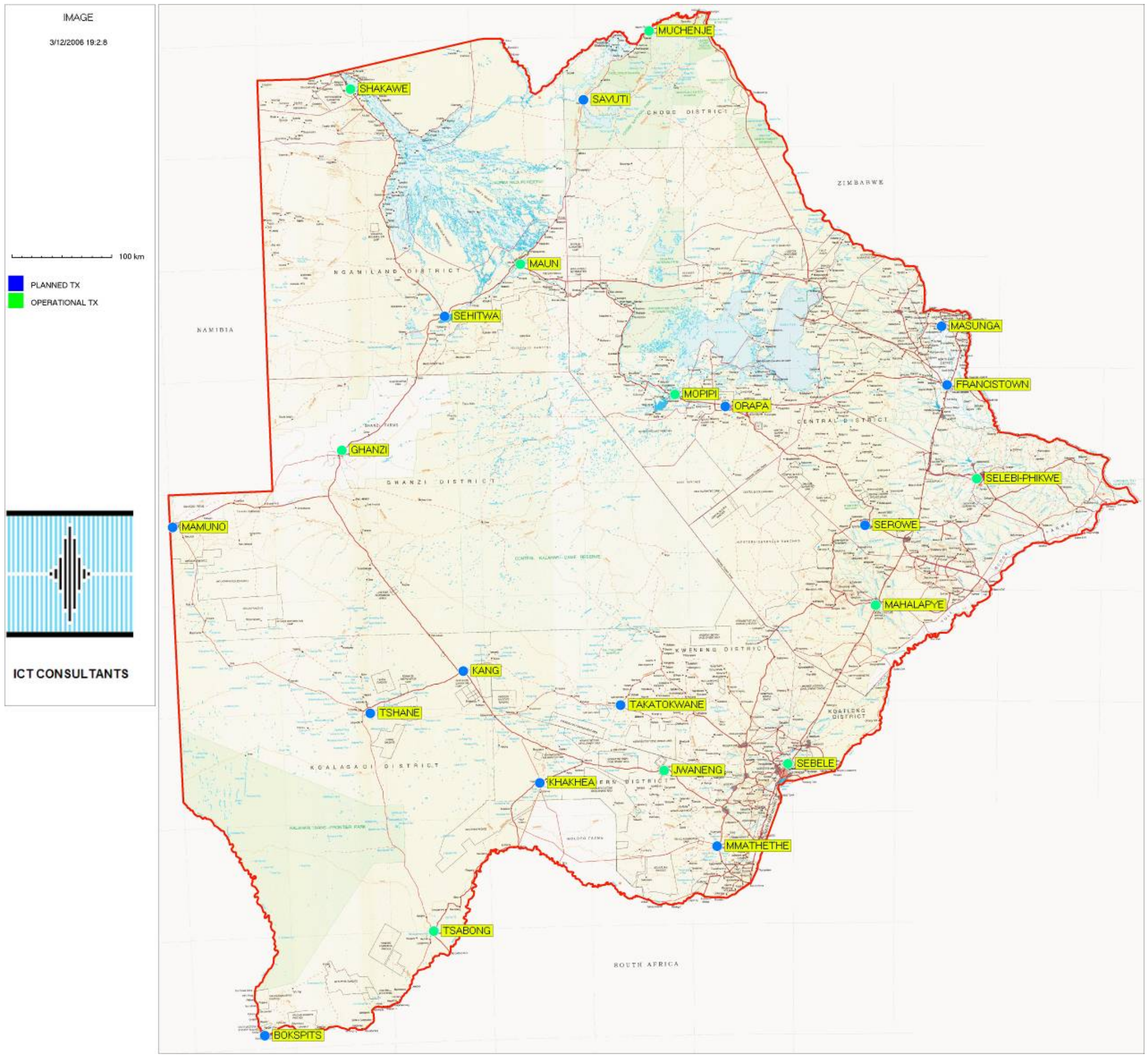

Figure 7: Location of planned and operational Medium Wave Transmitters

7.2 FM Frequencies (87.5 – 108.0 MHz)

The Broadcasting Plan revised the Geneva 84 Plan to align the coordinated FM frequencies with the population growth that has taken place since 1984 and to align frequencies with current and future demands.

The plan proposed 46 sites, each with six frequencies for each site, except two sites (Artesia and Olifant’s Drift) that could only be assigned three frequencies each due to congestion along the border with South Africa. In addition, six additional frequencies were assigned for Gabane (Gaborone), Selebi-Phikwe, Francistown and Maun. Thus these four stations have a total of 12 frequencies each. Sekakangwe could only be assigned five additional frequencies because the sixth frequency of the additional block of six has been assigned to Plumtree by Zimbabwe.

Frequencies that require coordination (negotiations) with neighbouring countries and those that do not need such coordination have been identified. In addition the sources and levels of interference were identified for all the affected frequencies in the plan. The Figure below shows the location and coverage for the FM transmitters.

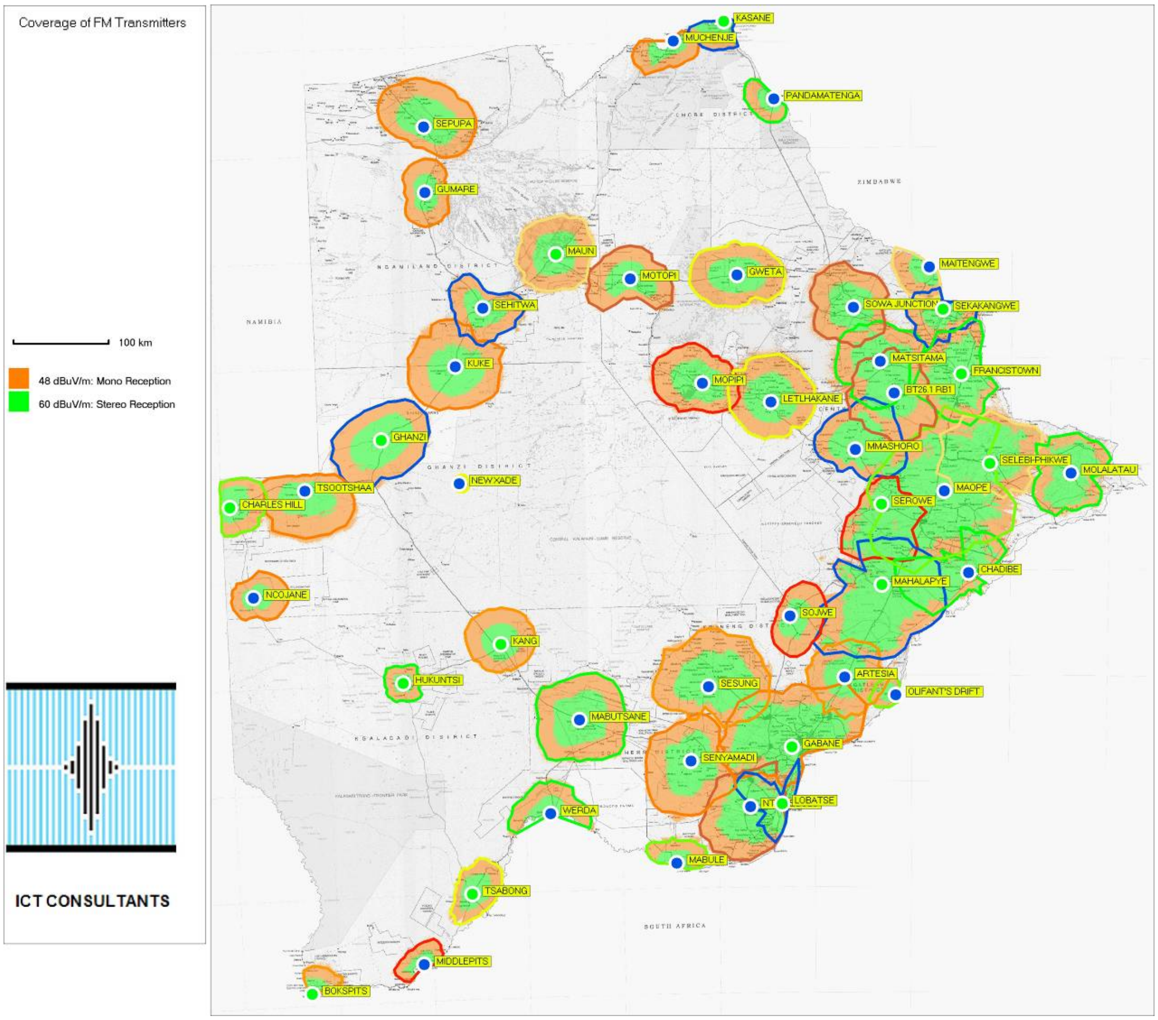

Figure 8: Location and coverage of FM transmitters

7.3 Terrestrial Digital Audio Broadcasting (T-DAB)

T-DAB is a digital radio system, which was developed by the Eureka 147 Project. It offers CD-quality sound, more stations, additional radio and data services, the ease of tuning and interference-free reception for the listener, plus the information potential of data, graphics and text. T-DAB operates in the VHF Band (174 – 230 MHz) and in the L Band (1452 – 1467 MHz).

Countries in Region 1 of the ITU (Europe, Africa and the Middle East) held a regional conference, the Regional Radiocommunication Conference 2006 (RRC06) in May/June 2006 in Geneva, to agree the allocation of frequencies for T-DAB and Terrestrial Digital Video Broadcasting (DVB-T). T-DAB was only allocated VHF band while DVB-T was allocated VHF and UHF frequencies. Details of frequencies that have been allocated to T-DAB and DVB-T are available in the Broadcasting Plan which is available at BTA.

Botswana and many other countries adopted the approach of splitting the 174 – 230 MHz band into two sub-bands, one dedicated to T-DAB and the other dedicated to DVB-T. DVB-T was allocated 174 – 214 MHz, while T-DAB was allocated 214 to 230 MHz. T-DAB requirements were in the form of ”allotments”, which means that a country was given the right to broadcast a T-DAB channel over a given geographical area, in the future, without specifying the details of the broadcasting site or transmitter, but only specifying the threshold field strength to be protected inside a specified area. RRC06 did not deal with the use of L Band for T-DAB.

7.4 Digital Video Broadcasting, Terrestrial (DVB-T)

DVB-T is the digital broadcasting system that is intended to replace the analogue television broadcasting which is based on the Geneva 89 Agreement. The Broadcasting Plan revised the Geneva 89 Plan to align the coordinated TV frequencies with the population growth that has taken place since 1984 and to provide more frequencies to cater for current and future demands.

At RRC06, Botswana coordinated 32 assignments in Band 3 (174 – 214 MHz) and 266 assignments in Bands IV and V (470 – 806 MHz). The coordinated frequencies for DVB-T are generally at the same locations shown for FM transmitters in Figure 4. Botswana limited coordination of Band V to 802 MHz in accordance with SADC decision which recommended that the band 806 – 862 MHz should be made available for fixed wireless access system.

7.5 Recommendations

Recommendation 8: The Consultants reviewed the terrestrial Broadcasting Frequency Plan which was produced and submitted to BTA in April 2007. The individual recommendations in the said plan will not be repeated here, however, the Consultants recommend that BTA should adopt and implement this plan.

8 Candidate Equipment for Licence Exemption

8.1 Low Power Devices

When frequency bands are assigned as non-exclusive rights in major markets, products which are designed to be used in such spectral environments will emerge. Due to the sizes of e.g. the EU or the US market, products can be produced in large volumes at low costs. The existence of such products increases the value of the use of similar, non-exclusive rights in small markets like Botswana as well. At the same time, the availability of such products increases the cost of protecting exclusive rights to those bands. During the last few years, global harmonisation has become increasingly important for many Low Power Devices (LPD) and has been a significant factor in the growth of systems such as Radio LANs. In the case of FM Micro transmitters, consumer demand and market developments have led to regulatory provision for such devices being implemented in Europe.

Low Power Devices are particularly suited for use in non-exclusive frequency bands; either in bands assigned for such use only or in bands where their use has secondary status to other uses in the said bands. In general, Low Power Devices operate in shared bands, they should not be permitted to cause harmful interference to other radio services and they cannot claim protection from other radio services. Implementing LPDs as licence-exempt radio equipment reduces the regulatory burden on users of these devices, other users of the same bands and BTA.

In this section, the Consultants identify Low Power Radio Equipment which should be exempted from individual licensing. The recommendations are based on the use of such equipment in large markets, in particular Europe, as well as existing use in Botswana.

8.2 Examples of Low Power Devices

The term Low Power Devices refers to a wide variety of technologies, from equipment where interference is managed by simple limitations on output power and duty cycle to equipment with more advanced interference mitigation techniques.

<u>Micro FM Transmitters</u>

Micro FM transmitters are designed to facilitate connection between devices such as MP3 sources and FM broadcast receivers via a radio link. They operate by transmitting an extremely low power radio signal in the broadcasting band 87.5-108 MHz and enable the user to play music from a MP3 player through a radio. These devices exploit the fact that there is "unused" or "white portions" of the sound broadcasting frequency band in all geographical areas.

There has been a significant consumer demand for such devices in all parts of the world and they were initially sold illegally in countries where they had not been exempted from licensing.

Based on a large number of measurements results, practical tests and simulations, it has been shown that in the worst case scenario (traffic jam), Micro FM transmitters at a distance of more than 10 m will not interfere with FM radio receivers even in co-channel operation. Additionally, this interference probability may be decreased further by the fact that users are likely to tune away from broadcast transmission frequencies if they want to receive their signal interference free.

ETSI developed the technical standard EN 301 357 for micro FM transmitters. In many European countries, this standard is generally implemented together with the accompanying power limits in the CEPT regulation[16]. Similar equipment has been allowed in the North American and Asian markets for several years.

The ETSI technical specification describes the following features for Micro FM transmitters:

- Output power is limited to 50 nanoWatts;
- Adjacent channel power is limited;
- Users are able to select unused frequencies;
- Devices are required to stop transmitting when not in use.

All licence-exempt devices have a small risk of interfering with other users of the spectrum. In the case of Micro FM transmitters however, this risk has been shown to be extremely low. The alternatives to licence-exempt is to ban the equipment from the market in Botswana (which will likely lead to illegal use anyway) or implement individual licensing (which will be impractical and burdensome for both consumers and BTA).

Inductive devices

Inductive systems are increasingly being used for very short range applications. The operating ranges for these applications are from one tenth to a few metres with frequencies in the range of a 9 kHz up to 30 MHz. National inductive limits have been in force for years in various parts of the world without any significant reported interference. CEPT has recently harmonised inductive limits in several frequency bands. Inductive equipment is typically used for alarm systems, cable detection, personal identification, antitheft systems and data transfer.

[16] Annex 13d of CEPT ERC Recommendation 70-03

8.3 Other radio equipment suitable for licence exemption

Radio licence exemption can also be applied to cases where the regulator only needs to define the technical parameters that must be met by the equipment in order to ensure compatibility with other users operating in the same band. Thus it is recommended that BTA should exempt radio equipment from radio licensing requirement if:

- The equipment has been designed to be used on collective frequencies such as frequencies used for Industrial, Scientific and Medical (ISM) in Region 1 of the ITU, the Citizen Band (Amateur) Radios operating at 27 MHz and 29 MHz;
- The radio equipment that operates in bands where frequencies are assigned and controlled by the network operator and not regulator (for example GSM handset, VSAT terminals, Land Mobile Satellite Service (e.g. Inmarsat terminals, Iridium terminals, etc.).

Thus it is recommended that the following categories of equipment should be exempted from radio licences:

- All terminal equipment controlled by licensed network operators;
- Equipment operating in ISM bands for Region 1;
- VSAT terminal operating in the *ku* band, 11 GHz (downlink)/14 GHz (uplink);
- Land Mobile Satellite Service (e.g. Inmarsat at 1.6 GHz, Iridium at 2 GHz);
- High Density Fixed Satellite Service at 28 and 31 GHz and;
- CB Walkie Talkie Radios at 27 and 29 MHz.

It could be that BTA may want to retain licensing for some of this radio equipment, not on account of radio spectrum management imperatives, but on some other considerations (e.g. service licensing considerations) which are not part of this study. In such cases, the licensing should then be issued in terms of the said considerations (e.g. service licences) and not radio licences.

8.4 Licensing Procedures

The use of radio equipment in Botswana is governed by Section 42 of the Telecommunications Act, 1996:

a. 42 (1)(a) deals with licensing a radio communication networks;
b. 42 (1)(b) deals with licensing a radio communication equipment;
c. 42 (1)(c) deals with erection of radio communication network;

Section 42 (2) exempts receiving equipment from requirement for licensing.
Section 42 (3) exempts:

a. The Botswana Defence Force;
b. The Botswana Police Force;
c. The Department of Civil Aviation and
d. Botswana Railways from the requirement for radio licensing.

Section 42 (3)(e) gives the Botswana Telecommunications Authority the power to exempt other persons, by regulation.

From the foregoing, all radio transmitters are subject to license, including mobile phones and low power devices (cordless phones, remote control devices, etc.). As far as the Consultants are aware of, while BTA has the power to exempt any other person (by regulation), none of the users of these devices have been exempted.

8.5 Recommendations

Recommendation 9: It is recommended that the following radio equipment should be exempted from radio licensing:

- All terminal equipment controlled by licensed (or authorised) network operators and low power devices (that meet BTA's type approval requirements);
- Equipment operating in ISM bands for Region 1;
- VSAT terminal operating in the *ku* band, 11 GHz (downlink)/14 GHz (uplink);
- Land Mobile Satellite Service (e.g. Inmarsat at 1.6 GHz, Iridium at 2 GHz);
- High Density Fixed Satellite Service at 28 and 31 GHz and;
- CB Walkie Talkie Radios at 27 and 29 MHz.

Recommendation 10: A list of radio equipment that is exempted from licensing should be made publicly available.

The following Low Power Devices should as a minimum be exempted from licensing in Botswana.

Frequency Band	Power/Magnetic Field	Duty Cycle	Channel Spacing	Comment
87.5-108 MHz	50 nW e.r.p	Up to 100 %	200 kHz	Requirements in ETSI EN 301 367 applies

Table 11: Micro FM Transmitters

Frequency Band	Power/Magnetic Field	Duty Cycle	Channel Spacing	Comment
6765-6795 kHz	42 dBμA/m at 10 m	No restriction	No spacing	
13553-13567 kHz	42 dBμA/m at 10 m	No restriction	No spacing	
26.957-27.283 MHz	10 mW e.r.p	No restriction	No spacing	
434.040-434.790 MHz	10 mW	Up to 100 %	Up to 25 kHz	Audio and voice not allowed
2400-2483.5 MHz	10 mW e.i.r.p			
5725-5875 MHz	25 mW e.i.r.p	No restriction	No spacing	
24.00-24.25 GHz	100 mW	No restriction	No spacing	
61-61.5 GHz	100 mW	No restriction	No spacing	
122-123 GHz	100 mW	No restriction	No spacing	
244-246 GHz	100 mW	No restriction	No spacing	

Table 12: Non-specific Low Power Devices

Frequency Band	Power/Magnetic Field	Duty Cycle	Channel Spacing	Comment
9-59.750 kHz	72 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
59.750-60.250 kHz	42 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
60.250-70.000 kHz	69 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
70-119 kHz	42 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
119-135 kHz	66 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
135-140 kHz	42 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
140-148.5 kHz	37.7 dBμA/m at 10 m	No restriction	No spacing	Only loop coil antennas allowed for external use
6765-6795 kHz	42 dBμA/m at 10 m	No restriction	No spacing	
7400-8800 kHz	9 dBμA/m at 10 m	No restriction	No spacing	
13.553-13.567 MHz	42 dBμA/m at 10 m	No restriction	No spacing	

Table 13: Inductive Applications

9 New Technologies and other services

9.1 Ultra Wide Band

9.1.1 General

Ultra-Wideband (UWB) refers to technology for transmitting information spread over a large bandwidth that should, in theory and under the right circumstances, be able to share spectrum with other users. Ultra Wideband was traditionally accepted as pulse radio, but the FCC and ITU-R now define UWB in terms of a transmission from an antenna for which the emitted signal bandwidth exceeds the lesser of 500 MHz or 20% of the centre frequency. Thus, pulse-based systems - wherein each transmitted pulse instantaneously occupies the UWB bandwidth, or an aggregation of at least 500 MHz worth of narrow band carriers, for example in orthogonal frequency-division multiplexing (OFDM) fashion—can gain access to the UWB spectrum under the rules.

The IEEE 802.15.3a task group has been working to standardise the technology and describes the two contending proposals for the standard, the Direct Sequence-Ultra Wideband (DS-UWB) supported by the UWB Forum, and the Multi-Band Orthogonal Frequency Division Modulation (MB-OFDM) supported by the WiMedia Alliance. Due to the low emission levels currently allowed by regulatory agencies, UWB systems tend to be short-range and for the most part indoors.

The FCC approved the deployment of UWB on an unlicensed basis in the 3.1–10.6 GHz band in 2002. The essence of this ruling is to limit the power spectral density (PSD) measured in a 1 MHz bandwidth at the output of an isotropic transmit antenna to a spectrum mask, which is shown in the figures below for indoor and outdoor environments, respectively.

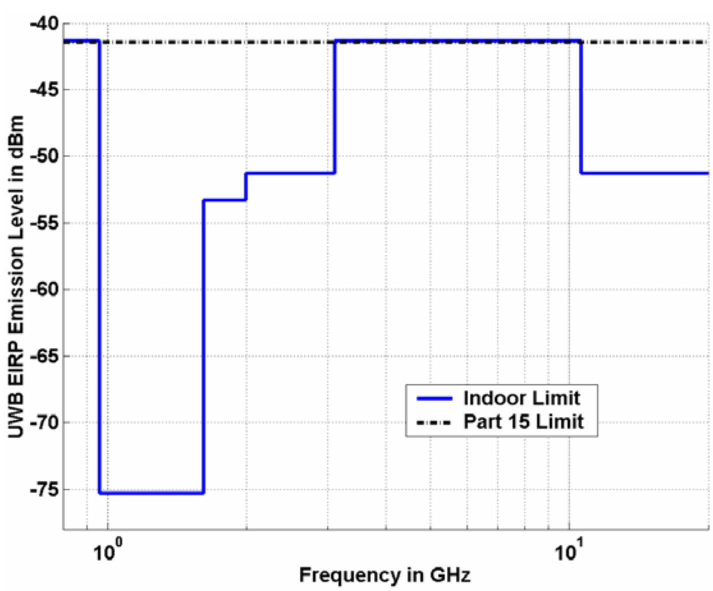

Figure 9: FCC UWB spectrum mask, indoor

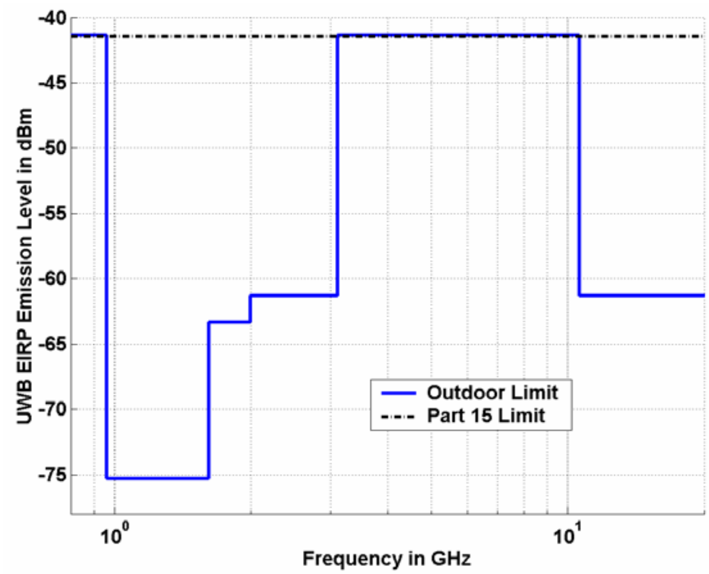

Figure 10: FCC UWB spectrum mask, outdoor

The CEPT ECC Report 64 evaluates the maximum allowable UWB transmit power to protect different types of radio equipment, and it was concluded that "the majority of the considered radio communications services require up to 20-30 dB more stringent generic UWB Power Spectral Density limits than defined in the FCC masks, indoor as well as outdoor."

The consolidated European UWB mask is shown in the figure below.

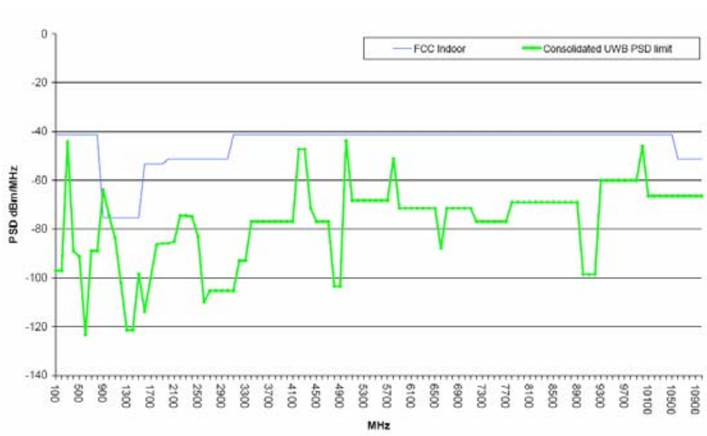

Figure 11: CEPT ECC spectrum mask, indoor

9.1.2 Recommendation

UWB represents a new approach to frequency usage. The principal usage of these types of systems is expected to be short range data equipment. A number of concerns have been raised in relation to the interference protection properties for these solutions. Internationally, the two approaches mostly referred to are the ones in North America (FCC) and Europe (CEPT), respectively. The European approach is somewhat more restrictive in terms of allowed transmit powers.

Neither South Africa (ICASA) nor SADC seem to have taken a decision on UWB regulation.

Recommendation 11: A decision on UWB regulation in Botswana is not urgent. However, it is recommended that BTA should follow international best practise and coordinate its actions with those of neighbouring countries.

9.2 Cognitive Radio

9.2.1 General

Cognitive radio (CR) is a paradigm for wireless communication in which either a network or a wireless node changes its transmission or reception parameters to communicate efficiently without interfering with licensed users. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behaviour and network state.

Depending on the set of parameters taken into account in deciding on transmission and reception changes, and for historical reasons, we can distinguish certain types of cognitive radio. The two main types are:

- Full Cognitive Radio: in which every possible parameter observable by a wireless node or network is taken into account.
- Spectrum Sensing Cognitive Radio: in which only the radio frequency spectrum is considered.

For the purposes of frequency regulation, spectrum sensing CR is most important. It makes equipment able to sense whether a channel or part of the frequency spectrum is in use and act accordingly, e.g. search for a different channel. This has the following advantages:

- More efficient spectrum sharing; By using CR operators and users can more efficiently share a common spectrum, e.g. in ISM bands.
- Service co-existence; Mandatory CR can allow usage in bands that would otherwise have to be used exclusively by services that need to be protected

Dynamic Frequency Selection (DFS) can be seen as a form of cognitive radio.

Typical applications include:

- IEEE802.15 (WPAN – Wireless Personal Area Network) defines mechanisms for CR to improve co-existence with other technologies, such as Wi-Fi.
- CR could be used to allow usage of TV spectrum for other services.
- CR could be used to allow usage of radiolocation, radar and satellite spectrum for other services.

The most widely referenced use of CR is the FCC decision to allow use of locally unused TV spectrum in the 700 MHz range, by means of CR techniques. The idea is to better exploit so-called TV band "white space", which consists of frequencies that are allocated for television broadcasting but are not actually in use in a given area.

9.2.2 Recommendation

It is our belief that Cognitive Radio technology will become an important tool for improving the possibility for interference free co-existence between different radio technologies, and to improve the overall spectrum utilization.

Recommendation 12: It is not necessary for BTA to make any specific decisions on Cognitive Radio (CR), save to follow international developments with regard to this technology.

CR is already applied in some practical systems, e.g. Dynamic Frequency Selection for RLAN equipment in the 5 GHz range is a form of cognitive radio functionality. Thus CR may be important on a case-by-case basis.

It is not recommended to allow the use of TV frequencies for other services based on CR functionality in Botswana at the moment. However this view should be evaluated in future taking into account market, regulatory and technological developments in this area.

9.3 Cordless telephony

9.3.1 General

Cordless telephony is distinguished from mobile telephony in that it is simply a wireless connection to a fixed telephony access point (PSTN / ISDN), and that no mobility is supported. The most widely used technologies are briefly described below.

DECT (Digital Enhanced Cordless Telecommunications) is an ETSI standard for digital portable phones, commonly used for domestic or corporate purposes. DECT can also be used for wireless data transfers. DECT is recognised by the ITU as fulfilling the IMT-2000 requirements and thus qualifies as a 3G system, as a part of the IMT-2000 group of technologies.

DECT uses TDMA/TDD with 24 time slots per carrier (12 uplink and 12 downlink), and 1.728 MHz carrier spacing. The maximum Tx power is 250 mW. Typical frequency band is 1880 – 1900 MHz.

CT1 (Cordless telephone generation 1) is an analogue cordless telephony standard that was standardized by CEPT in 1984. The initial set of frequencies provided for a set of 40 duplex channels using 25 kHz separation, with the uplink in the 914-915 MHz band and the downlink in the 959-960 MHz band.

CT2 is a cordless telephony standard that is considered the precursor to the DECT system. CT2 is frequently referred to by the marketing name "Telepoint." It used 100 kHz carriers and TDD.

Internationally, the trend is somewhat away from cordless telephony solutions to offer public telephony. This segment is to an increasing degree taken over by cellular systems, providing equally or more cost efficient solutions. The previously popular Personal Handyphone System (PHS) in Japan e.g. seems to be losing market shares to cellular services.

DECT is principally used as a domestic or corporate telephony solution and has its primary allocation in the 1880 – 1900 MHz range in Region 1 of the ITU.

CT1 is for the most part used in the band 914-915 MHz paired with 959-960 MHz.

CT2 uses for the most part the range 864 – 868 MHz.

9.3.2 NRFP and existing usage

In the existing National Radio Frequency Plan it is recommended that the frequency spectrum 1880 MHz - 1900 MHz should remain allocated to DECT.

CT1 is recommended to remain in the band 914-915 MHz paired with 959-960 MHz.

The 1880 – 1900 MHz range is used by BTC for its old DECT wireless local loop system. However, our understanding is that BTC intends to decommission this system by mid 2008. The 914 – 915 MHz paired with 959 – 960 MHz is used for CT1. There also seems to be some illegal use of CT1 in the 904 – 905 MHz range. 864.1 – 868.1 is used for CT2. BTA’s frequency register shows that the range 862 – 864 MHz has been assigned for Digital Cordless Telephones (DCT).

9.3.3 Recommendations

We see no reasons to make substantial changes to the current regulation on cordless telephony.

Recommendation 13: Keep existing allocations for Cordless Telephony

The following allocations should be retained:

- DECT can be used in the range 1880 – 1900 MHz.
- The 914 – 915 MHz paired with 959 – 960 MHz can be used for CT1;
- The range 864.1 – 868.1 can be used for CT2.

There is some illegal usage of CT1 in the GSM900 band. Sources of these CT1 transmissions should be identified and terminated, and usage should be limited to the bands identified above.

10 Migration Plans

In general forced migration from one frequency band to another should be limited to the maximum degree possible. There is always a cost involved, and regulation should as a general rule not impose additional costs on the actors unless absolutely necessary. Furthermore, enforcing and supervising the migration can be a resource demanding process.

Nevertheless, in certain cases, it is necessary to migrate existing services because the frequency bands in question must be freed up for other applications.

The table summarizes the recommended migration plans in prioritized order:

Priority	Band	Existing use	Rationale	Description	Time frame
1	Core 3G FDD band: 1920 – 1980 MHz 2110 – 2170 MHz	Government fixed links (especially 2110 – 2170)	The core mobile communication bands shall receive special protection due to its high importance for the national infrastructure. It is recommended that 3G licensing in Botswana should be accelerated to	A migration plan has been suggested by the BTA, and is endorsed by the consultants. During 2007 all fixed links that occupy the 3G spectrum should be vacated except four frequencies. Remaining frequencies shall only be used on a	Short term

Priority	Band	Existing use	Rationale	Description	Time frame
			start in 2007.	limited number of links and the complete migration should be finalised no later than 2009	
2	GSM900: 890 – 915 MHz 935 – 960 MHz	Some illegal CT-1 Some other use	The core mobile communication bands shall receive special protection due to its high importance for the national infrastructure.	Migrate illegal CT-1 usage, and "other uses" from the core GSM900 frequency band.	Short term
3	1900 – 1920 MHz	Fixed link MCST (1900 – 1920)	This band is part of the core IMT-2000 band, most commonly used for 3G TDD	No immediate decision on this band has been made for Botswana, due to the uncertainty on 3G TDD technologies internationally. Nevertheless, in the medium term a plan for the migration of fixed links in this frequency range should be developed to make the band available for mobile communication services	Medium
4	450 – 470 MHz[17]	Private mobile Government	A migration plan for this band is	Implementation of the suggested	Medium term

[17] More detailed description below

Priority	Band	Existing use	Rationale	Description	Time frame
		use	described in the existing NRFP. The band has been identified as being particularly suited for services in rural areas.	frequency plan will provide better exploitation of this band.	
5	825 – 835 MHz	Government	This band has been identified for possible future use for CDMA.	No decision on this band has been recommended at this point in time. However, future use must be aligned with digital TV migration, and also coordinated with GSM900.	Medium /Long term

Table 14: List of migration plans in prioritized order

<u>450 – 470 MHz</u>

The 450 – 470 MHz range has been identified as being particularly suited for communication systems in rural area. Therefore the consultants have inspected the frequency register to identify bands that can be allocated in the short term.

- The frequency band 450 – 452 MHz paired with 460 – 462 MHz is not in use in Botswana
- The frequency band 453 – 454 MHz paired with 463 – 464 MHz is only used in Gaborone
- The frequency band 457.5 – 459 MHz paired with 467.5 – 469 MHz is only used in Gaborone

Recommendation 14: There is spectrum available in the 450 MHz band that could be used in rural areas.

Form BTA's frequency register, there seems to be approximately 2 x 4.5 MHz duplex spectrum available in the 450 – 470 MHz range that is either not used or only used in Gaborone. It is recommended that this spectrum be allocated or retained for use in rural areas, e.g. through the NTELETSA II project.

11 Conclusion

This consultation document complements the previous two documents, one entitled *Spectrum Allocation Strategy For Cellular Systems, Fixed Wireless Access, Mobile Data Services and Radio Local Area Networks* and the other entitled *A new policy for spectrum licensing and spectrum pricing in Botswana*.

This Consultation document contains information and recommendations on other radio services not included in the first consultation round. Recommendations have been provided for all the services considered, a list of the recommendation can be found at the beginning of this document.

12 Request for stakeholders' comments

Stakeholders are requested to comment on any issues and recommendations in this document. Stakeholders are request to put forward alternative proposals/solutions in cases where they disagree with proposals in this document.

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Annex 1 Vocabulary

16QAM	16 Quadrature Amplitude Modulation (modulation method)
2G	Second-generation mobile communications technologies
3G	Third-generation mobile communications technologies
3GPP	Third-generation Partnership Project (standardisation body producing specifications that are based on evolved GSM, typically UMTS)
3GPP2	Third-generation Partnership Project 2. (standardisation body producing specifications that are based on evolved CDMA, typically CDMA2000)
8PSK	8 Phase Shift Keying (modulation method)
Allocation	The regulation of spectrum by dividing various frequency bands into one or more services
ATIS	Alliance for Telecommunications Industry Solutions (US based standardisation body, committed to rapidly developing and promoting technical and operations standards for the communications industry)
Auction	A Bidding process to award spectrum to those prepared to pay the most for it
Beauty contest	A process where the regulator awards licences to those with the most convincing case (usually with regard to some published requirements)
BWA	Broadband Wireless Access (same as BFWA)
BFWA	Broadband Fixed Wireless Access (a wireless alternative to copper and fibre connections to homes and offices – often used in connection with the frequency bands 3.5, 10, 26/28 and 40 GHz))
BTA	Botswana Telecommunications Authority (Botswana regulator)
BTC	Botswana Telecommunications Corporations (Botswana incumbent fixed operator)

CDG	CDMA Development Group (an international body dedicated to promote the global uptake of CDMA)
CDMA	Code Division Multiple Access (also refer to cellular systems that make use of this access scheme)
CDMA450	CDMA in the frequency band 450-470 MHz
CDMA850	CDMA in the 850 MHz frequency band
CDMA2000	A family of third-generation standards (1x, 1xEV-DO and 1xEV-DV are standard radio interfaces)
cdmaOne	2^{nd} generation mobile communications standard
CEPT	European Conference of Postal and Telecommunication Administrations (a Europe wide organisation which, among other things, intends to harmonise the use of spectrum)
CR	Cognitive Radio – A radio which can sense when a part of the spectrum is not used and then transmit in that spectrum
Command and Control	A term describing a way of managing the spectrum where the regulator describes licence conditions in detail
CPE	Costumer Premises Equipment
CT-1	Cordless Telephone Generation One (cordless telephony standard, using analogue FM)
DCS1800	Digital Cellular System 1800 (term used for GSM in the 1800 MHz band)
DFS	Dynamic Frequency Selection (technique to dynamically choose the frequency/channel with the best interference conditions)
DMR446	Digital version of PMR446
EC	European Commission (the executive body of the European Union)
ECC	Electronic Communications Committee (of the CEPT)
EDGE	Enhanced Data rates for GSM Evolution (an enhancement to GSM and GPRS allowing higher data rates, up to 473 kbit/s)
E-GSM	Extended band GSM (GSM in the frequency bands 880-890/925-935 MHz)

e.i.r.p.	Equivalent isotropic radiated power (the amount of power that would have to be emitted by an isotropic antenna to produce the peak power density observed in the direction of maximum antenna gain)
EV-DO	Evolution – Data Optimised (Evolution of CDMA2000 allowing higher data throughput, up to 2.4 Mbit/s.)
Enforcement	The regulators maintenance of violations of unauthorised use of spectrum, resolutions of complaints regarding spectrum use etc.
ETSI	European Telecommunications Standards Institute (a standard-making body)
FCC	Federal Communications Commission (US regulator)
FDD	Frequency Division Duplex (duplex method where uplink and downlink are separated by frequency)
FDMA	Frequency Division Multiple Access (access scheme)
Flash-OFDM	Fast Low-latency Access with Seamless Handoff Orthogonal Frequency Division Multiplexing (MBWA system developed by Flarion, later acquired by Qualcomm)
FSS	Fixed Satellite Services
FWA	Fixed Wireless Access (wireless local loop connections)
GMSK	Gaussian Minimum Shift Keying (modulation method)
GPRS	General Packet Radio Services (a packet radio data solution based on the GSM air interface)
GSM	Global System for Mobile Communications
GSMA	GSM Association (A global trade association representing GSM operators)
Grandfathering	To exempt (one involved in an activity or a business) from new regulations. In spectrum management, the term is often used to describe a situation where e.g. block-licenses are assigned for a frequency band in which some radio stations already operate. If the existing stations are allowed to continue in operation even if the block licences are assigned to other users, then they are often referred to as “grandfathered” stations.

HC-SDMA	High Capacity Spatial Division Multiple Access (same as iBurst)
HSCSD	High-Speed Circuit-Switched Data (a technique to increase the speed of circuit switched data in GSM by allowing each user more than one time slot)
HSDPA	High Speed Downlink Packet Access (part of the UMTS 3G standard allowing for higher data transfer speeds on downlink, up to 14.4. Mbit/s)
HSPA	High Speed Packet Access (common term used for HSDPA and HSUPA)
HSUPA	High Speed Uplink Packet Access (part of the UMTS 3G standard allowing for higher data transfer speeds on uplink, up to 5.6. Mbit/s)
iBurst	A mobile broadband wireless technology using adaptive antennas developed by Arraycom. May adapt to various frequency bands around 1800 MHz. Also called HC-SDMA - High Capacity Spatial Division Multiple Access
ICASA	The Independent Communications Authority of South Africa (the regulator of telecommunications and the broadcasting sectors in South Africa)
IEEE	Institute of Electrical and Electronics Engineers (a developer of industrial standards)
IEEE 802.11	Wireless Local Area Network standard (WirelessLAN)
IEEE 802.16	Broadband Wireless Access standards (WirelessMAN)
IMT-2000	International Mobile Telecommunications – 2000 (global standard for third-generation mobile technology defined by ITU)
In-band Deployment	The introduction of e.g. UMTS in GSM900 and GSM1800 frequency bands (requires minimum 5 MHz bandwidth and regulatory approval)
Interference	Two or more signals on the same frequency which the receiver is not able to distinguish clearly
IP	Internet Protocol
IS-95	Interim Standard 95 (designator for the cdmaOne standard)

ISM	Industrial, Scientific, Medical (radio band originally intended for non-commercial use. Often unlicensed or licence exempt)
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
Licence exempt	To allow anyone to use the spectrum for any application under certain specified technical conditions, typically by describing maximum power levels
Licence neutrality	A generic licence allowing operators to offer a variety of different services and applications (a term often used when WLL operators are allowed to offer mobile services)
MBWA	Mobile Broadband Wireless Access (a generic term used for new radio technologies such as iBurst, and Flash-OFDM)
MBMS	Multimedia Broadcast Multicast Service (an add-on to UMTS for support of multicast and broadcast functionality)
MMDS	Multimedia Distribution Systems
MTO	Major Telecommunication Operators
MWA	Mobile Wireless Access (term used by ITU-R)
NRFP	National Radio Frequency Plan
NWA	Nomadic Wireless Access (term used by ITU-R)
OFDM	Orthogonal Frequency-Division Multiplexing (a technique where the frequency spectrum is divided into several narrowband sub-channels for efficient spectrum utilisation. Used e.g. in WiMAX)
Ofcom	Office of Communications (UK regulator)
OFDMA	Orthogonal Frequency Division Multiple Access (a multi-user version of OFDM. Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users.)
PAS	Personal Access System (cordless telephony system, same as PHS, used mainly in Asia)
PCMCIA	Personal Computer Memory Card International Association (PC card)

PCS1900	Personal Communications Service 1900 (a term used for GSM in the 1900 MHz band, most often used in the Americas)
PDA	Personal Digital Assistant (an electronic device, originally an electronic organizer, but these days much more versatile)
PHS	Personal Handy-phone System (cordless telephony system. Used mainly in Asia)
PMP	Point-to-MultiPoint
PMR446	“Walkie Talkie like” radio equipment in the frequency band 446-446.1 MHz
PTO	Public Telecommunications Operator
PTP	Point-To-Point
Refarming	Spectrum refarming is a combination of present and future administrative, financial and technical measures within the limits of frequency regulation in order to make a specified frequency band available for a different kind of usage or technology
RLAN	Radio Local Area Network
RTTT	Road Transport and Traffic Telematics
RTO	Regional Telecommunication Operator
SADC	Southern African Development Community (an organization that aims to promote Southern African regional cooperation in economic development)
SDMA	Space Division Multiple Access (access scheme where users can be separated spatially, by use of adaptive antennas)
Spectrum Liberalization	The relaxation of restrictions on spectrum use
Service Neutrality	When a licence allows an operator to offer a variety of different services and applications
SNG	Satellite News Gathering (mobile communications equipment for the purpose of worldwide newscasting)
Spectrum Reform	A change in spectrum regulation (usually used as a positive term)

Spectrum Trading	The ability of licensees to buy, sell and lease spectrum
TD-CDMA	Time Division Code Division Multiple Access (a TDD radio mode of WCDMA primarily designed for asymmetrical throughput/capacity needs. Same as UMTS-TDD)
TDD	Time Division Duplex (duplex method where uplink and downlink is separated in time)
TDMA	Time Division Multiple Access (access scheme used e.g. in GSM)
TD-SCDMA	Time Division Synchronous Code Division Multiple Access (a variant of 3G TDD, primarily developed for the Chinese market)
Technology Neutrality	A spectrum right or a licence to use certain spectrum is technology neutral if the rights holder can use any technology or standard it wishes in order to provide services within its band (subject to interference restrictions)
TPC	Transmitter Power Control (a mechanism used to control transmit power in order to limit unwanted interference between different network elements)
Transparency	A term describing openness, visibility, communication and accountability. When the regulator opens laws, regulations, decisions and allocation processes for discussion they are seen as transparent.
TRASA	Telecommunications Regulators Association of Southern Africa
UMTS	Universal Mobile Telecommunications System (a third-generation mobile technology)
UMTS Forum	An international body dedicated to promote the global uptake of UMTS
UNII	Unlicensed National Information Infrastructure (a term used in the United States for certain licence-exempt equipment)
Unlicensed	Frequency spectrum that can be used by anyone without a licence
VAO	Value Added Operator
VoIP	Voice over Internet Protocol. (routing of voice conversations over the Internet or through any other IP-based network)

VSAT	Very Small Aperture Terminal (satellite terminal, smaller than approximately 3 m antenna diameter)
WBA	Wireless Broadband Access
W-CDMA	Wideband Code Division Multiple Access (air interface used in UMTS)
WiBRO	Wireless BROadband (term used for the mobile broadband solution deployed in South Korea, harmonized with the WiMAX standard)
WiFi	Wireless fidelity (a certification mark given to equipment that meets certain conformity and interoperability tests for the IEEE 802.11 standards)
WiFi Alliance	A trade group devoted to perform testing, certify interoperability of products, and to promote the WiFi technology.
WiMAX	Worldwide Interoperability for Microwave Access (a certification mark given to equipment that meets certain conformity and interoperability tests for the IEEE 802.16 standards)
WiMAX Forum	Forum formed in June 2001 to promote conformance and interoperability of the IEEE 802.16 standards
WLAN	Wireless Local Area Network (most common standard IEEE802.11)
WLL	Wireless Local Loop (the use of wireless communication for “last mile” connections). WLL might also be called FWA.
WARC-92	World Administrative Radio Conference 1992 (identified the core frequency bands for IMT-2000 technology)
WRC	World Radiocommunications Conference (a conference held to revise the Radio Regulations of ITU)
WSIS	World Summit on the Information Society (a series of United Nations-sponsored conferences about information, communication and the information society that took place in 2003 and 2005)