

Consultation

Spectrum Policy and Planning

Spectrum Policy and Planning

A Joint Consultation Issued by the Telecommunications Regulatory Authority (TRA) and the Ministry of Transportation of the Kingdom of Bahrain (MoT)

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The deadline for responses is
5pm on 21 December 2005

Purpose: Consultation on the implementation of the frequency allocation policy

MINISTRY OF TRANSPORTATION
KINGDOM OF BAHRAIN



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Spectrum Policy and Planning

Table Of Content

1	Executive summary	4
1.1	Introduction	4
1.2	Document Approval and issue	4
1.3	Structure of the Consultation	5
1.4	Overall principles	5
1.5	Specific applications and technologies	7
1.6	Options assessment and consultation questions	10
2	Introduction	31
2.1	Objectives of the document	31
2.2	Scope of the consultation	31
2.3	Timing of the consultation	31
2.4	Process for developing Bahrain's spectrum allocation strategy	31
2.5	Structure of the consultation	32
2.6	Importance of the consultation process	32
3	Spectrum allocation and assignment processes	33
3.1	Background on frequency management	33
4	General spectrum policy on award mechanisms and spectrum pricing	38
4.1	Summary	38
4.2	Award mechanisms	38
4.3	Pricing strategy	42
4.4	Overall pricing strategy for Bahrain	45
4.5	Discounts for bulk use	48
4.6	International benchmarks	48
5	The introduction of new technologies and services	51
5.1	Summary	51
5.2	Introduction	51
5.3	Management of individual assignments	53
5.4	Block assignments	55
5.5	Light licensing	56
5.6	Frequency licensing for special events	58
5.7	Temporary test and trial licences	61
6	Public Mobile Network	62
6.1	Summary	62
6.2	Introduction	62
6.3	"2G" – new GSM or CDMA licenses	64
6.4	"3G" - CDMA2000	72
6.5	"3G" – W-CDMA	83

Consultation

Spectrum Policy and Planning

7	Private mobile radio	89
7.1	Summary	89
7.2	Introduction	89
7.3	Analogue	91
7.4	Short-range radio	93
7.5	Digital PMR	94
8	Fixed wireless access	103
8.1	Summary	103
8.2	Introduction: technology, market and applications	104
8.3	2 GHz	108
8.4	2.4 GHz	110
8.5	2.5 to 2.7 GHz	111
8.6	3.5 GHz	112
8.7	5.8 GHz	115
8.8	10 GHz	119
8.9	26 and 28 GHz	121
8.10	40 GHz band	125
9	Short-range technologies	127
9.1	Summary	127
9.2	WiFi	128
9.3	WiMAX	132
9.4	Bluetooth	134
9.5	UWB	135
9.6	FSO	136
10	VSAT and other fixed satellite services	137
10.1	VSAT	137
10.2	Other fixed satellite services	140
11	Mobile-Satellite Service	141
12	Glossary	142

Consultation

Spectrum Policy and Planning

1 Executive summary

1.1 Introduction

The developments in the telecommunications sector and the demand for spectrum by licensees and prospective licensees, so as to offer new or more cost effective services, necessitated a review of the availability and usage of the spectrum of the Kingdom of Bahrain.

To meet these demands in the short term but also to plan for their long term implications in a way that best meets the needs of the Kingdom and its citizens, the Telecommunications Regulatory Authority together with the Ministry of Transportation of the Kingdom of Bahrain, are launching this joint consultation document.

The two bodies have their interrelated but distinct roles in this area. The Ministry is responsible for the allocation of frequency for use for telecommunications and the TRA for the assignment of the frequency allocated by the Ministry to licensees, save where the law provides otherwise. Thus it was considered that the most effective way forward in terms of future plans for the Kingdom was for the two entities to jointly invite comments so that the decisions to be taken take into account the views of all concerned.

Thus the TRA and the Ministry of Transportation (MoT) hereby invite comment on their proposals concerning their future frequency allocation and assignment policy.

1.2 Document Approval and issue

This document is issued pursuant to Section 3 (c) 12 and (f) of the Telecommunications Law. It is made publicly available via the TRA web site in order that interested parties may comment. Anybody who wishes to do so should respond in writing to the TRA during the public consultation period. Responses must be received no later than 5.00 pm on 21 December 2005.

The address for responses to this Consultation is:

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Consultation

Spectrum Policy and Planning

Alternatively, e-mail responses may be sent to the Authority's e-mail address at consult@tra.org.bh

The TRA will publish the comments as received unless respondents explicitly ask that their responses be treated as confidential, in total or in part. If any party wishes to have the whole of its submission withheld, it should state that clearly at the beginning of the submission. If the respondent wishes to have some parts withheld, it should put them in separate annexes and clearly mark them as such.

1.3 Structure of the Consultation

The consultation document defines the overall principles of the spectrum management policy in Bahrain. It presents possible options for the management of each frequency band and for the main telecommunication applications. Where relevant, it also raises specific questions for consultation. Respondents are advised to review the options and present their thoughts on each of the specific questions relevant to their existing and potential business. In addition, if the respondent thinks it is relevant, the TRA and the MoT would also accept views on areas discussed but for which a specific question has not been raised. All responses should be clearly attributed to the related section/sub-section number.

The executive summary highlights the key questions raised in the consultation document. For background, details, principles and technology discussions, the respondent is advised to read the accompanying detailed report.

In the executive summary, we will first cover overall principles and then present options under consideration at the TRA and the MoT for specific applications.

1.4 Overall principles

Spectrum allocation/assignment

- The MoT allocates frequency bands for telecommunications use upon request from the TRA
- Frequencies will be assigned by the TRA in an open, transparent and non-discriminatory manner. Future assignments will be based on international best practice and the best interests of consumers, the industry and the Kingdom of Bahrain as a whole.

Consultation

Spectrum Policy and Planning

- Respondents should not assume that, because a mechanism for frequency assignment has been used in the past, it will continue to be used in the future
- The TRA considers that in the future Auctions may be the most transparent and economically efficient mechanism for awarding spectrum, and could be the preferred mode of assignment for commercial use
- However, in situations where spectrum supply may occasionally exceed demand, the TRA could consider reverting to a First Come First Served (FCFS) approach
- The TRA and the MoT believe that the market is not ripe for introducing spectrum trading as yet. Licensees who believe that they would not need spectrum to be licensed to them should return the licence to the TRA
- A Master Frequency Register will be maintained by the MOT, which will capture every frequency assigned, the details of the licensee and the limits of use for the licensee. Where appropriate, and provided the request does not contravene any security concerns, relevant sections could be made available.

Spectrum pricing

- For spectrum assigned through an auction, the TRA assumes that the value of the spectrum is captured in the auction value. In addition, the TRA would charge a nominal fixed fee to cover administrative and monitoring costs
- Other assignments could be covered through market-value based pricing, where a price will be set based on the TRA's and the MOT's view on the value of the spectrum
- Spectrum pricing has been used in a large number of European countries as well as some GCC countries
- The MoT and the TRA are also considering suitable discounts for reused microwave frequencies and are proposing potential options for determining these discounts

Introducing new technologies and operations

- There will be four mechanisms by which the TRA will assign spectrum to operators for new operations – individual assignments, block assignments, assignments based on international co-ordination, and light licensing
- For individual licences, the TRA will manage the block of spectrum for that type of use (e.g. Fixed Wireless Access) and individually license each user, provided usage and equipment conditions are met

Consultation

Spectrum Policy and Planning

- Block assignments will be made to public wireless networks or large organisations where the number of operators is small (typically, less than five)
- Light licences are in many ways similar to licence-exempt applications seen in certain other countries in the world for low-power consumer use (e.g. home cordless, WiFi). The TRA cannot classify applications as being licence-exempt as it is not permitted by the Telecommunications Law, though it recognises the importance of light licensing to encourage take-up of evolving technology. The TRA proposes to create a class of licences called 'Light Licences' to take care of these low-power consumer devices for typically indoor use. However, both import of equipment and private use will be governed by type approval. Type approval is the regulatory procedure implemented in Bahrain for approving the telecommunications equipment specifications against local and international standards
- Licences based on international co-ordination will be limited to specific use categories – e.g. for aeronautical, maritime and satellite services

Short term licensing for trials or special events

- The TRA and the MoT welcome the testing of new technology for eventual introduction in Bahrain – provided there is available spectrum and existing users do not face interference problems. Temporary test licences will be issued. The TRA and the MoT suggest a time-bound process to enable access to temporary assignments for trials
- Licences will be granted to programme-making and special event (PMSE) users, typically on a 48-hour short-term assignment basis

1.5 Specific applications and technologies

The main application families are covered in the consultation. However, respondents are encouraged to make specific points about any application family or technology not covered in the report.

Public Mobile

- Public mobile covers a wide range of technologies – from analogue systems to third generation systems and both open standard and proprietary technologies
- The TRA does not plan to assign any first generation public mobile licences. This covers analogue public mobile, first generation TDMA systems, etc. The TRA does not plan to license usage for applications such as the Japanese PDC standard or PHS 'limited-mobile' technologies

Consultation

Spectrum Policy and Planning

- There are two public mobile licensees in Bahrain at present. The TRA will not review the possibility of licensing a new mobile operator in Bahrain in this consultation, as this will be the object of a separate consultation
- Any new licences for public mobile could be assigned through an auction, though potential bidders will need to pre-qualify
- In future, all licences will be assigned on a technology-neutral basis. Thus operators will be free to choose their preferred technology within the band (e.g. GSM/GPRS, W-CDMA, CDMA1x, UMTS TDD, Flash OFDM, etc.)
- The available bands for public mobile in the GSM bands include standard and extended GSM bands and the GSM1800 bands. GSM850 and GSM1900 (US bands), and GSM400 will not be made available until further notice. GSM-R spectrum will be reserved for future use
- The 1800/1900 public mobile bands will be allocated on a technology-neutral basis. Thus CDMA1x, W-CDMA and GSM 1800 could potentially co-exist, provided there are no interference issues
- Respondents are requested to share their views on their preferred technologies and specific bands

Private mobile radio (PMR) and public access mobile radio (PAMR)

- The TRA and the MoT will continue to support analogue PMR in Bahrain, although they would like to see and foster the eventual migration of users from analogue to digital
- The TRA and the MoT would like the use of illegal “walkie-talkie” bands to be reduced at the earliest. Consequently, the TRA and the MoT will explore alternative “walkie-talkie” technologies
- The TRA and the MoT will not further allocate and assign frequency for the roll-out of Short Range Biz Radio and Paging (SRBR/ SRBP)
- The TRA and the MoT may propose the deployment of commercial TETRA, but first need to assess the impact of frequency supply constraints. The TRA and the MoT may also propose the allocation of spectrum for private users of TETRA in the commercial TETRA band
- The TRA and the MoT may consider the roll-out of iDEN on a technology-neutral basis, but spectrum supply constraints are very likely to prevent any iDEN deployment in Bahrain
- For public commercial applications, the TRA recommends the use of auctions as the preferred mode of assignment. However, for private users (companies, closed user groups or individuals), the TRA recommends a First Come First Served approach which could revert to auctions if justified by demand

Consultation

Spectrum Policy and Planning

- Across all usages, the TRA proposes a nominal annual administrative fee to cover its administrative costs, in addition to the MoT fees for spectrum usage
- All telecommunications equipment will need type approval by the TRA prior to being authorised for import

Fixed wireless access (FWA) and wireless local loop (WLL)

- To the extent possible, FWA/WLL spectrum licences will be granted for applications and frequencies that are harmonised across the countries in Region I (mainly Europe). Notwithstanding this overall principle, specific FWA/WLL licences will be allocated on a case-by-case basis
- The TRA and the MoT are in the process of identifying frequency bands within 2.5-2.7GHz, 3.5GHz, 5.4-5.8GHz, 10GHz, 26-28GHz and 40GHz for FWA/WLL purposes. Respondents are advised to state which bands they would be interested in and for what purposes
- The MoT does not propose to allocate frequencies around 2GHz for DECT-based WLL systems
- The TRA will use the 'Light Licensing' approach to enable use of low-power consumer WiFi within the 2.4GHz and 5GHz bands
- The MoT will consider allocating frequencies around 5.4GHz for WiMAX based on internationally standardised bands
- Bands above 10GHz will be allocated on a First Come First Served (FCFS) basis, unless demand for spectrum commands an auction. Licensing of bands below 10GHz will be decided on a case-by-case basis. The TRA proposes to generally use auctions as the mechanism for assignment, but could revert to FCFS if demand does not exceed supply

Short-range applications

- Short-range applications cover technologies such as WiFi, Bluetooth, Ultra-Wideband (UWB), RFID, etc. They are typically low-power with predominantly indoor use. In many countries, some of these applications are licence exempt
- WiFi is short for 'wireless fidelity' and is used generically when referring to any type of 802.11 networks. In Bahrain, while the TRA and the MoT currently propose that WiFi operate in the 2.4 GHz and 5 GHz bands (WiFi bands in US and most of Europe), there are existing users in this band who may need to migrate
- If the above spectrum availability issues are resolved, indoor, non-commercial WiFi will be subject to 'Light Licences'. However, commercial WiFi networks (run by a commercial operator who charges customers for use) will be subject to full individual licensing

Consultation

Spectrum Policy and Planning

- Non-commercial WiMAX will be similarly considered for 'Light Licensing' when it is standardised and consumer deployments commence
- Bluetooth will also be covered by 'Light Licensing', as will RFID and home-based UWB (when approved)

VSATs and other fixed satellite communications

- The TRA and the MoT do not propose any further frequency allocations for VSAT, and new licences will be assigned within the allocated bands
- New licences will continue to be dealt with on a First Come First Served basis

1.6 Options assessment and consultation questions

1.6.1 Spectrum assignment processes

Options assessment: the objective of the TRA and the MoT is to establish a long-term spectrum planning strategy, as well as a procedure to ensure regular review and updating of the plan through a formal approval process.

Options assessment: in order to carry out this task properly, the TRA and the MoT propose to maintain a Master Frequency Register with full details of all frequency assignments, thus enhancing the current database of [Directorate of Wireless Licensing, Frequency and Monitoring \(DWLF&M\)](#).

Options assessment: in addition, the TRA and the MoT propose to establish a set of procedures, in line with ITU-R recommendations, to ensure that frequency allocation/assignment will not cause or be subject to interferences from existing users, within Bahrain or abroad.

Options assessment: the TRA does not normally certify wireless equipment for telecommunications usage, but rather accepts any international or national certification, including self-assessment, based on nationally or internationally accepted standards. This process has generally worked satisfactorily for other countries with limited regulatory resources. The TRA plans to maintain this process in the foreseeable future.

1.6.2 General spectrum policy on award mechanisms and spectrum pricing

a) Award mechanisms

Options assessment: the TRA considers auctions as the preferred mechanism for awarding licences, particularly where the nature of the spectrum available

Consultation

Spectrum Policy and Planning

indicates that the demand for licences is likely to exceed supply. In the case of assignments which attract more than one bidder, the awarding process is likely to be an auction rather than a 'beauty contest' or FCFS procedure. However, while as a general rule auctions could be regarded as the best option, it is important to make decisions on a case-by-case basis, rather than subscribe to a purely one-size-fits-all approach. For example, in the case of FWA spectrum, particularly when the demand for licences is unlikely to exceed supply, the TRA could decide to revert to the FCFS method of allocation. In addition, for non-public uses, such as private, individual and local assignment of spectrum for fixed links, auctions are irrelevant and FCFS should be the preferred method.

Consultation:

1. The TRA seeks respondent views, with reasons, on:

(1) the view that auctions should be the preferred spectrum assignment mechanism for Bahrain.

(2) whether the TRA should consider FCFS as an award mechanism if there is not enough demand to justify an auction.

(3) the use of the FCFS method as the preferred option for private, individual and local assignment of spectrum.

b) Spectrum pricing

Consultation:

2. The TRA and the MoT seek respondent views on:

(1) the services for which value-based spectrum fees should apply

(2) the importance of the four drivers to value-based spectrum fees – bandwidth used, frequency band, geography and power level

Consultation:

3. The TRA and the MoT seek respondent views, with reasons, on whether they should:

(1) use a combination of administrative charging and spectrum pricing in Bahrain.

(2) use spectrum pricing only in areas where congestion exists.

Consultation

Spectrum Policy and Planning

(3) use pricing mechanisms for every part of the spectrum.

Consultation:

4. The TRA and the MoT seek respondent views, with reasons, on whether discounts should apply for bulk use. What would be the respondents' preferred option for calculating the level of the discount?

1.6.3 The introduction of new technologies and services

a) Management of individual assignments

Consultation:

5. The TRA and the MoT seek respondent view, with reasons, on their intention to encourage proposals for the introduction of new technologies, and seek comments on the evaluation process outlined and on the balance to be struck between a full and rigorous technology approvals process and the rapid introduction of new technologies.

b) Block assignments

Consultation:

6. The TRA and the MoT seek respondent views, with reasons, on their intention to encourage proposals for the assignment of spectrum blocks to new technologies and/or services, and seek comments on the evaluation process outlined and on the balance to be struck between a full and rigorous technology approvals process and the rapid introduction of new technologies.

c) Light licensing regime

Consultation:

7. The TRA and the MoT seek respondent views, with reasons, on their intention to encourage proposals for the introduction of a light licensing regime, and seek comments on the evaluation process outlined and on the balance to be struck between a full and rigorous technology approvals process and the rapid introduction of new technologies.

Consultation

Spectrum Policy and Planning

d) Frequency licensing for special events

Consultation:

8. The TRA and the MoT seek respondent views, with reasons, on:

(1) the need for short-term licences for program making and special event (PMSE) purposes.

(2) the licensing procedures suggested and the proposed pricing mechanism.

e) Temporary test and trial licences

Consultation:

9. The TRA and the MoT seek respondent views, with reasons, on their proposal to introduce new temporary test licences, and on appropriate licence conditions which will both protect existing spectrum users and maximise the value of the tests carried out under such licences.

1.6.4 Public Mobile Network

a) GSM 400

Option assessment: in order to allocate spectrum for GSM 400, the TRA, the MoT and governmental users would have to assess whether the bands currently in use by governmental applications could be released and exchanged for other bands. The TRA and the MoT believe that spectrum should not be allocated and assigned unless there is a strong case for introducing a new mobile operator in the 400 MHz frequency bands. Although the better economics of GSM 400 network roll-outs have been evidenced in emerging markets with large coverage requirements, it is unlikely that the same would apply given Bahrain's topology and current mobile penetration. Furthermore, the assignment of spectrum for public mobile services would need to be reviewed in conjunction with the assignment of spectrum in the 1800 MHz frequency bands. The TRA and the MoT do not believe that licences in both the 1800 MHz and the 400 MHz bands could be assigned to public mobile services given the current conditions of the mobile market in Bahrain.

Note that CDMA450 could in theory be deployed in this band, and therefore a technology-neutral licence could be awarded for this frequency band.

Consultation

Spectrum Policy and Planning

Consultation:

10. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that spectrum should not be allocated for future public mobile services in the 400 MHz band.

b) GSM 850 and 1900

Option assessment: GSM 850 and 1900 are US standards. Established operators in Bahrain are currently on GSM 900, but there is potentially 2 x 10 MHz of bandwidth in the 850 MHz band which could be used for either GSM or CDMA networks. Assignment in the 1900 MHz band is technically possible but not optimal, as it would be in conflict with current public mobile assignments and future use for 3G. The TRA and the MoT will therefore only consider allocation in the 850 MHz band. Furthermore, the TRA and the MoT suggest that spectrum allocation in the 850 MHz band should only be used if the GSM 1800 allocation has to be ruled out because of supply constraints.

Consultation:

11. The TRA and the MoT seek initial respondent views, with reasons, on whether spectrum should be allocated for future public mobile services in the 850MHz band as an alternative to the 1800MHz band.

c) GSM 1800

Options assessment: there is currently enough free spectrum in the 1800 MHz band allocated to GSM to assign it for a public mobile network. It is therefore technically possible for the TRA to award another licence in the GSM band.

Consultation:

12. The TRA and the MoT seek initial respondent views, with reasons, on whether spectrum should be allocated for future public mobile services in the 1800MHz band.

d) Overall options

In summary, the TRA and the MoT believe that there are three options for future spectrum allocation and assignment for GSM:

Consultation

Spectrum Policy and Planning

- Option 1: allocate (and assign) spectrum to GSM 400 only (2x7.2MHz)
- Option 2: allocate (and assign) spectrum to GSM 850 only (2x10MHz)
- Option 3: award a new licence in the 1800 MHz band (2x(15+5) MHz)

Consultation:

13. The TRA and the MoT seek respondent views, with reasons, on which of these options would be preferable for future allocation and assignment of GSM spectrum.

e) Technology neutrality

Options assessment: for any new license, the TRA will conduct a technology-neutral award process. The TRA will therefore leave the technology decision between CDMA and GSM to the operator.

f) CDMA450

Options assessment: as regards GSM 400, the TRA and the MoT believe that the MoT should not allocate spectrum in the 400 MHz band for public mobile services.

Consultation:

14. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that spectrum should not be allocated for public mobile services in the 450 MHz band.

g) CDMA1800

Options assessment: although CDMA equipment availability will be limited in the 1800 MHz band, the TRA proposes that any awarding of a licence in this band be made on a technology-neutral basis (GSM or CDMA).

Consultation:

15. The TRA and the MoT seek initial respondent views, with reasons, on whether spectrum should be allocated for future public mobile services in the 1800MHz band on a technology-neutral basis.

Consultation

Spectrum Policy and Planning

h) CDMA1900

Options assessment: in assessing whether or not to allocate spectrum for additional mobile operator(s) in accordance with the 1900 MHz band plan, the TRA, the MoT and other stakeholders will need to consider amongst other factors:

- The benefits of an assignment which is equally favourable to both GSM and CDMA
- The disadvantages of limiting future access to the 3G band
- The disadvantages of precluding the deployment of DECT systems in the 1880 to 1900 MHz band

The TRA and the MoT's view is that, although technically possible, assignment of spectrum to a new mobile network in the 1900 MHz band is not optimal.

Consultation:

16. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that spectrum should not be allocated for future public mobile services in the 1900 MHz band (apart from the existing allocations).

i) TD-SCDMA

Options assessment: to date, no operator outside of China has expressed any interest in deploying the TD-SCDMA technology. The TRA and the MoT believe that little interest will be generated for this technology in Bahrain, and therefore do not plan to make any specific allocations for TD-SCDMA deployments. However, TD-SCDMA can be deployed in the UMTS – TDD spectrum, thus suggesting a technology-neutral use of the UMTS - TDD spectrum.

Consultation:

17. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that:

(1) the MoT should not plan to make any specific allocations for TD-SCDMA in Bahrain, although UMTS - TDD spectrum could be used to deploy the TD-SCDMA technology.

(2) the TRA and the MoT should therefore render the UMTS – TDD spectrum “technology-neutral”.

Consultation

Spectrum Policy and Planning

j) UMTS-TDD

Options assessment: MTC-Vodafone was granted UMTS-TDD frequencies as part of its 3G spectrum. The remaining spectrum has been allocated by the MoT for a potential two additional operators in addition to that set aside for Batelco. A few technologies could eventually be deployed in the UMTS – TDD band, for instance TD-SCDMA. Therefore, the TRA and the MoT suggest that future award of spectrum for UMTS-TDD bands should be technology-neutral.

Consultation:

18. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that:

(1) the MoT should continue with the current allocation of frequency bands for UMTS-TDD.

(2) future awarding of spectrum should be on a technology-neutral basis.

k) Flash OFDM

Options assessment: given the amount of interest generated by Flash-OFDM, the MoT plans to allocate frequency bands where the technology could be deployed. However, as spectrum is pretty scarce in the 2.1 – 2.3 GHz bands, the TRA and the MoT recommend deploying the technology at 450 MHz. To remain in line with a technology-neutral view, the TRA and the MoT recommend opening up spectrum on a technology-neutral basis in the 450 MHz band.

Consultation:

19. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that the TRA and the MoT should allocate and assign frequency bands in the 450 MHz band on a technology-neutral basis for the deployment of mobile or fixed mobile technologies such as Flash OFDM.

l) “3.5G” and “4G”

Options assessment: the TRA and the MoT do not plan to include any “3.5G” or “4G” development in the frequency allocation and planning. The TRA and the MoT believe they should leave the technological decisions on 3G future upgrades to market players.

Consultation

Spectrum Policy and Planning

Consultation:

20. The TRA and the MoT seek input from respondents, with reasons, on whether they agree with their approach to leave the future use of 3G spectrum (upgrade to “3.5G” and “4G”) to the discretion of market players.

m) “3G” – W-CDMA

Options assessment: the TRA and the MoT believe that the current spectrum allocation to 3G will cover the need of further 3G roll-out, is compliant with international standards and therefore should remain the same. Since the current potential usage of 3G spectrum for government applications has been discussed and clarified, the TRA and the MoT do not foresee any potential issue for future assignment of spectrum from public mobile services in the 3G band.

Consultation:

21. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that the current 3G spectrum allocation should remain the same.

1.6.5 Private mobile radio

a) Analogue PMR

Option assessment: the TRA and the MoT would like to leave open the option for further use of Analogue PMR. However, provided that spectrum supply issues can be resolved, the TRA and the MoT would like to promote the move from analogue to digital. The TRA and the MoT recommend that future spectrum be awarded through a First Come First Served mechanism, unless spectrum demand exceeds supply (in which case it could revert to an auctions mechanism). Spectrum pricing for Analogue PMR has traditionally been on the basis of spectrum charging. Although Administered Incentive Pricing has been used for Analogue PMR, the TRA and the MoT suggest that they continue with the spectrum charging method, unless significant additional interest is expressed. Finally, the importation of equipment for Analogue PMR will be governed by ETSI recommendations.

Consultation:

22. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

Consultation

Spectrum Policy and Planning

- (1) allocate additional spectrum for Analogue PMR if demand is expressed.*
- (2) promote the transition of analogue users to digital.*
- (3) award further spectrum for Analogue PMR use through FCFS, unless spectrum demand exceeds supply (in which case they could revert to an auctions mechanism).*
- (4) use administrative charging as the approach for spectrum pricing.*

b) “Walkie-talkies”

Option assessment: the TRA and the MoT recommend that walkie-talkie applications should be licensed by way of a light licensing regime in conjunction with type approval. The 350 MHz band is available in Bahrain, and the technology used in Japan for these applications could be deployed in this band (Option 1). Another option would be to ask the current user of this band to move to different frequencies (Option 2). For non-commercial uses, this band could be free of charge. Importation of equipment requires type approval and is governed by the relevant technical specifications.

Consultation:

23. The TRA and the MoT seek respondent views, with reasons, on which option they should select:

Option 1: allocate spectrum for walkie-talkie applications in frequency bands used for this purpose in other countries.

Option 2: ask current users of this band to move, if possible, to different frequencies.

c) Short Range Radio

Options assessment: the TRA and the MoT believe that SRBR and SRBP are not relevant for Bahrain. As a result, they propose not to allocate frequencies for these services.

Consultation:

24. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should not allocate spectrum for short range radio.

Consultation

Spectrum Policy and Planning

d) Digital PMR

Options assessment: Given the demographic and geographical characteristics of Bahrain, the TRA and the MoT do not propose to plan frequency allocation for co-existent technologies like TETRAPOL or DISCUS. The TRA and the MoT expect growth in these technologies to be small and limited to only a handful of highly populated countries in Western Europe, notably the UK. In addition, both TETRAPOL and DISCUS can be deployed using existing frequencies allocated to Analogue PMR. However, TETRAPOL and DISCUS could hold an interest for small user groups (such as taxis) willing to migrate to digital, as the only alternative would be TETRA, which is more suitable for large numbers of users. If, as a result of this consultation, significant interest is expressed for such a use, the TRA and the MoT could decide to promote migration from Analogue PMR to TETRAPOL and DISCUS.

Consultation:

25. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they:

(1) should not, at this point, allocate spectrum for TETRAPOL and DISCUS, as the technologies would re-use Analogue PMR spectrum.

(2) should decide to promote migration from Analogue PMR to TETRAPOL and DISCUS.

Options assessment: GSM-R is typically planned for use by railways in Region I. Bahrain does not currently have a railway system that needs GSM-R communications. However, the GCC countries are currently considering building a railway system which could require GSM-R. Therefore, the TRA and the MoT plan to hold discussions with other GCC authorities to assess whether they should plan to allocate spectrum for GSM-R in light of this project.

Consultation:

26. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should consult with other GCC countries to assess whether they should reserve spectrum for GSM-R for the GCC railway.

e) Digital PMR - TETRA

Options assessment: Commercial TETRA networks offer the opportunity to “upgrade” existing analogue PMR users to digital. Internationally in region I,

Consultation

Spectrum Policy and Planning

commercial TETRA is typically in the 410 – 430 MHz band. In Bahrain, there exist certain potential conflicts in this band:

- Governmental use of the 410 – 438 MHz band
- Possible interference from deployment in neighbouring countries. This could be resolved by coordination at GCC level

The 450 – 470 MHz band is not ready for roll-out at the moment, as handsets and equipment will be more expensive and difficult to obtain in Bahrain. If the frequency issues are settled and interest is generated as a result of this consultation, the preferred award mechanism for these frequencies would be auctions. Should the frequencies issues be resolved, the TRA and the MoT would also propose to allocate part of the 410 – 430 MHz band for private use. A potential allocation could be 2 x 4MHz for public commercial TETRA and 1 x 1 MHz for private users. If interest is expressed, the TRA and the MoT would discuss a migration plan with the current users in this band. The TRA and the MoT propose a nominal spectrum charge for this spectrum to cover only administration costs. Equipment for commercial TETRA – both base stations and handsets – requires type approval as specified by ETSI¹.

Consultation:

27. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

(1) assign spectrum for commercial TETRA networks in the 410 – 430 MHz band, provided that spectrum conflicts are resolved, using an auction mechanism.

(2) allocate part of the TETRA 410 – 430 MHz spectrum to private users.

(3) propose a migration plan for current users, to free up spectrum for commercial TETRA in this band.

(4) charge for spectrum an administrative fee covering administration costs.

f) Digital PMR - iDEN

Options assessment: there has been some interest in the iDEN technology in the region. The TRA's and the MoT's policy is technology-neutral and, provided there are available frequencies and guarantees of no interference in other bands, as well as demand, the TRA and the MoT assume that iDEN could bring viable

¹ EN 300 394-1 - Terrestrial Trunked Radio (TETRA); Conformance Testing Specification; Part 1: Radio and EN 303 035 TETRA specification

Consultation

Spectrum Policy and Planning

competition to the market. Unfortunately, there are frequency supply conflicts in Bahrain for all the recommended iDEN bands. It seems very unlikely that the current user of these bands would be willing to give up its existing rights for the spectrum. Therefore, the TRA and the MoT suggest not allocating or assigning spectrum for the deployment of iDEN in Bahrain.

Consultation

28. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that, given the spectrum supply constraints, they should not allocate and assign spectrum for iDEN in Bahrain.

1.6.6 Fixed Wireless Access

a) 2 GHz

Options assessment: assigning spectrum from the 1900 MHz band has a number of disadvantages with regard to the future deployment of public mobile networks. In particular, it restricts further assignments to GSM 1800 spectrum and also limits future assignments within the 3G band. It is therefore considered inappropriate to use this spectrum for fixed wireless access.

As regards a possible high power/public network deployment of the DECT technology, the frequencies used for the system are currently assigned for other purposes within Bahrain. In the light of the availability of other bands and the commercial availability of modern equipment in these other bands, it is also considered unnecessary to allocate the 1880 to 1900 MHz band for DECT systems (for high power/public systems).

Consultation:

29. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should not allocate and assign frequencies in the 2 GHz bands for fixed wireless access.

b) 2.5 – 2.7 GHz

Options assessment: the TRA and the MoT believe that it would be premature to assign spectrum from the 2.5 – 2.7 GHz band to either fixed or mobile services (as defined by IMT 2000). Instead, the TRA and the MoT propose to retain the status quo for the time being, but commence discussions with the current occupants of the band, with a view to releasing the band at a future date and

Consultation

Spectrum Policy and Planning

assigning spectrum to fixed and/or mobile services once market developments are better understood.

Consultation:

30. The TRA and the MoT seek respondent views, with reasons, on their proposal not to change the current spectrum allocation and assignment in the 2.5 – 2.7 GHz band for the time being, but to start reviewing with current users a potential migration plan out of this band.

c) 3.5 GHz

Options assessment: the amount of spectrum potentially available in the 3.5 GHz band would permit the licensing of at least two operators², but other factors, such as the current state of the broadband access market, will also have a bearing on the optimum number. The TRA and the MoT are in favour of technology-neutral licensing, but also recognise the advantages that a common standard can bring to the market place. Therefore, one consideration is whether or not any FWA licence should require that deployed systems be compliant with WiMAX or other standards.

In line with its policy of encouraging a modern competitive market in the provision of telecommunication services, and subject to the satisfactory resolution of any co-existence issues, the TRA therefore proposes to license one or two FWA operators in the 3.5 GHz band. These licences would prohibit the provision of mobile but not nomadic services. The licences would be technology-neutral, but any licensee would be required by the TRA and the MoT to demonstrate that the technology chosen would not cause interference to other users of the spectrum.

The most appropriate method of awarding the spectrum to potential operators depends on market conditions in Bahrain at the time, but the experience of other Administrations suggests that an auction-based process is likely to be appropriate.

Consultation:

31. The TRA and the MoT seek respondent views, with reasons, on their proposal to allocate spectrum and license fixed wireless access operators in the 3.5 GHz band, and further seek views on:

² Further study would be required to determine precisely what spectrum could be released for FWA usage.

Consultation

Spectrum Policy and Planning

(1) the number of operators to be licensed.

(2) the proposal to prohibit the provision of mobile services, and the length of time such prohibition should last.

d) 5.8 GHz

Options assessment: the TRA believes that it would be appropriate to permit a light licensing regime in this band. Although suitable equipment can effectively share spectrum in this way, the resulting quality of service can no longer be guaranteed but depends on the deployments made by others. In order to ensure that deployed equipment would be capable of sharing the spectrum in a satisfactory manner, certain technical specifications would be required (similar to those already applied by other Administrations).

The fact that the band and the equipment will be suitable for fixed wireless access services suggests that this is the most likely application to develop here (note that WLAN applications at 5 GHz will be well served by the 5.2 and 5.3 GHz bands). It is therefore proposed to allow commercial enterprises to operate public communication services in this band with no restrictions on the number of operators who might offer such services. The other options would be to:

- To permit only private use within the band
- To permit private use and the commercial offering of public communications services under a light licensing regime. To enable the commercial operators to differentiate their services, private users could be restricted to indoor environments and commercial operators to outdoor environments.

The indeterminate quality of service available in this situation suggests that any commercial services operated in this band would satisfy a different market to that served by licensed FWA operators as proposed, for instance, in the 3.5 GHz band.

Consultation:

32. Further study of the use of the 5.8 GHz band for FWA is required. In the meantime, the TRA and the MoT seek respondent views, with reasons, on:

(1) the proposal to allocate the band and issue licenses under a light licensing regime, subject to satisfactory alternatives being available for the current occupants.

(2) the proposal to permit commercial enterprises to operate public communication services in the band.

Consultation

Spectrum Policy and Planning

(3) the proposal not to limit the number of enterprises operating public communication services in the band.

(4) the alternatives of permitting only private use, or of permitting private use alongside commercial operation (under a light licensing regime) of public communication services.

(5) the timescale on which demand for the above services is likely to develop.

e) 10 GHz

Options assessment: provided that interest is expressed, the TRA and the MoT would suggest allocating and assigning spectrum for FWA in the 10.21-10.25 GHz bands, paired with the 10.560-10.6 GHz bands. This will give a potential FWA operator 2 x 40 MHz worth of spectrum. The TRA and the MoT do not believe at this point that they should enter into discussions with current users in the 10 GHz to free additional spectrum for FWA use, as a single licensed operator in this band should meet the needs of Bahrain. The TRA proposes to assign these frequencies through an auction, unless insufficient interest is expressed for the licence, in which case the award mechanism will revert to First Come First Served. The licence will be provided on a technology-neutral basis.

Consultation:

33. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

(1) allocate and assign 2 x 40 MHz frequency bands to, at the most, one FWA operator in the 10 GHz band.

(2) use an auction mechanism to award this spectrum and revert to First Come First Served if there is not enough interest expressed for the licence.

f) 26/ 28 GHz

Options assessment: the TRA and the MoT propose to allocate and assign 100 MHz of spectrum (paired) for FWA between 27.55 - 27.65 GHz and 27.63 - 27.73 GHz in the 28 GHz frequencies, unless significant requirements for other applications are expressed for spectrum in this band. The TRA proposes that it should consider licensing the 28 GHz spectrum first, using an auction process, and to keep in reserve the allocated spectrum in the 26 GHz band. Another option would be to allocate and assign spectrum for FWA only in the 28 GHz

Consultation

Spectrum Policy and Planning

band, and leave the 26 GHz band to be shared on a co-primary basis between the different services until significant interest is expressed in this band.

Consultation:

34. *The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:*

(1) allocate and assign spectrum (2 x 100 MHz) in the 28 GHz band to a fixed wireless operator.

(2) award this spectrum through an auction process.

(3) allocate spectrum (2 x 100 MHz) in the 26 GHz band for future use by a public operator, and keep it in reserve for the time being.

g) 40 GHz

Options assessment: although the band has interesting prospects, it seems premature for the TRA and the MoT to allocate and assign spectrum in the 40 GHz frequency. The TRA and the MoT also suggest waiting for the results of the assignment in the 26/28 GHz bands before acting on the 40GHz. Lastly, the TRA and the MoT are in favour of waiting for the initial feedback on the awarding of pioneer licences in this band in Europe. If enough interest is generated through this consultation for future use of this band for FWA, the TRA and the MoT will suggest reserving the 40.5-43.5 GHz spectrum for future FWA operator licences.

Consultation:

35. *The TRA and the MoT seek input from respondents, with reasons, on:*

(1) whether they agree that they should delay the allocation and assignment of spectrum in the 40 GHz band to FWA operators until the market has a better visibility of this band's future as regards high capacity fixed wireless services to businesses and consumers.

(2) reserving the 40.5-43.5 GHz spectrum for future FWA licences.

Consultation

Spectrum Policy and Planning

1.6.7 Short-range technologies

a) WiFi

Options assessment: the TRA and the MoT believe that, subject to suitable alternative arrangements being feasible, current users should migrate out of the WiFi band (2.4 GHz and 5 GHz bands). For the same reason, the TRA and the MoT believe that any licensed fixed wireless operator in this band would have to share the frequencies with multiple other users, and would therefore be unable to offer the quality of service normally associated with telecommunication services. The TRA does not believe, therefore, that it would be appropriate to license exclusive frequencies from this band to fixed wireless access operators.

Once the current users have vacated the band, it is the TRA's intention to assign spectrum in this band using a light licensing scheme in line with international technical standards. There will then be three options:

- To permit only private use within the band
- To permit both private use and the commercial offering of public communication services under a light licensing regime
- To permit private use and to licence (within a light licensing regime) the commercial offering of public communication services. To enable the commercial operators to differentiate their services, private users would be restricted to indoor environments and commercial operators to outdoor environments.

At the present time, the TRA retains an open mind as to which of these three options would be most suited to the requirements of Bahrain.

Consultation:

36. The TRA and the MoT seek respondent views, with reasons, on:

(1) the proposal to allocate the relevant spectrum but not to award exclusive FWA licences in the 2.4 GHz and 5 GHz ISM band.

(2) the proposal to assign spectrum in this band under a light licensing regime, subject to satisfactory alternatives being available for the current occupants.

(3) the advantages or otherwise of permitting service providers to offer commercial communication services on the basis of a light licensing regime.

Consultation

Spectrum Policy and Planning

b) WiMAX

Options assessment: WiMAX and WiMAX-compatible equipment operate over a range of frequencies already covered under the Fixed Wireless Access sections.

Although global deployment is still at an early stage, WiBro could generate some interest. If the spectrum conflicts can be resolved for the 2.3 GHz band, the MoT could reserve 100 MHz of spectrum for the future use of WiBro.

Consultation:

37. The TRA and the MoT seek respondent views, with reasons, on their proposal to reserve spectrum for WiBro in the 2.3 GHz band, provided spectrum conflict with current users can be resolved.

c) Bluetooth

Options assessment: Bluetooth, along with WiFi, is one of the most popular and widespread short-range wireless technologies. Bluetooth also operates in the same frequency bands as WiFi, and thus the conclusions on this technology are similar to those on WiFi. However, the TRA and the MoT do not believe there is sufficient demand for commercial Bluetooth services. Bluetooth will therefore be operated as a free-of-charge service governed by a light licensing regime.

d) UWB

Options assessment: The TRA and the MoT believe that it is currently premature to allocate spectrum for UWB in Bahrain. It is also untimely to allow the deployment of UWB equipment until trials can assess the impact of UWB on other spectrum users. The TRA and the MoT therefore propose to delay the frequency allocation, assignment and equipment type approval for UWB in Bahrain.

Consultation:

38. The TRA and the MoT seek respondent views, with reasons, on their proposals to postpone the frequency allocation, assignment and equipment type approval for Ultra Wide Band in Bahrain until the testing of the technology has proven successful.

Consultation

Spectrum Policy and Planning

e) FSO

Option assessment: since the technology uses light and not spectrum, FSO will not have a direct impact on frequency allocation. However, the TRA is currently involved in the type approval of the FSO equipment (please refer to the FSO type approval guideline on TRA's website). Users will be charged an administrative fee for the corresponding FSO equipment type approval (for private or public users).

Consultation:

39. The TRA and the MoT seek respondent views, with reasons, on their proposals to continue to regulate the use of Free-Space Optics through equipment type approval.

1.6.8 VSAT and other fixed satellite services

a) VSAT

Consultation:

40. The TRA and the MoT seek respondent views, with reasons, on their proposal to continue with the current allocation and assignment practices for VSAT, namely:

(1) no further frequency allocation for VSAT.

(2) new licences being dealt with on a First Come First Served basis.

(3) private and public users being charged a spectrum fee in addition to the licence fee.

b) Other fixed satellite services

Option assessment: another application of particular interest for this consultation is the use of fixed satellite services in planes or ships. In particular, Internet access in planes through satellite is becoming increasingly widespread. Spectrum allocation for these types of applications is usually set at the international level. However, as all other users of spectrum in Bahrain, planes and ships will need to obtain a licence from the TRA in order to use fixed satellite services when landing or docking in Bahrain.

Consultation:

41. The TRA seeks respondent views, with reasons, on its proposal that all planes and ships visiting Bahrain and using fixed satellite services should obtain the relevant licence.

Consultation

Spectrum Policy and Planning

1.6.9 **Mobile-Satellite Services**

Options assessment: nearly 100% of Bahrain's geographical area is currently covered by public mobile networks. As a result, the TRA and the MoT do not expect a large market for mobile satellite services in Bahrain. However, foreign mobile satellite providers whose customers travel to Bahrain will be required to obtain a licence from the TRA.

Consultation:

42. Respondents are invited to provide input, with reasons, on whether they believe there is interest in mobile satellite services in Bahrain and how they should deal with those operators that offer services in the region i.e. should they be licensed to offer services or be required to ensure that they have roaming agreements with local operators, where their systems allow them to do so.

Consultation

Spectrum Policy and Planning

2 Introduction

2.1 Objectives of the document

With the growing demand for spectrum and the proliferation of wireless technologies for a variety of applications, developing a long-term spectrum allocation strategy is critical for the future expansion of telecommunications in Bahrain. The TRA and the MoT therefore recognize the need to establish a national frequency plan and, through this public consultation, aim to:

- (1) suggest possible options for each frequency band under their jurisdiction.
- (2) gather input, from various stakeholders, including public and private users of spectrum, on the future allocation and assignment of spectrum in Bahrain.

2.2 Scope of the consultation

This public consultation is intended to review spectrum usage across all telecommunications frequency bands. However, as the TRA only has authority for the spectrum traditionally allocated to telecommunications applications, frequency bands assigned by ITU-R for Region I to broadcasting are excluded from the scope of this consultation.

2.3 Timing of the consultation

This consultation is open for public comment as of [date], and will close on [date].

2.4 Process for developing Bahrain's spectrum allocation strategy

Prior to publishing this document, the TRA and the MoT have carried out an initial review process based upon:

- (1) an international benchmarking of the best practices in terms of spectrum allocation strategy.
- (2) a review of the existing spectrum allocation and assignment in Bahrain.

The current consultation builds upon this review process, and for each of the relevant spectrum bands describes the potential technologies which could be deployed in these frequencies, reviews the current situation in Bahrain and details a number of options for future spectrum allocation and assignment. At the end of each relevant sub-section, the TRA and the MoT address a question to potential respondents, in order to gather the views of current and future spectrum uses on the options outlined in the consultation.

Consultation

Spectrum Policy and Planning

2.5 Structure of the consultation

The consultation has two goals. Firstly, it is intended to define the overall principles of spectrum management policy in Bahrain. These principles are reviewed in sections 3 and 4, which address the topics of spectrum award mechanisms (auctions, “beauty contests”, First Come First Served), spectrum pricing (administrative charging, administered incentive pricing) and the introduction of new technologies in Bahrain. Secondly, the consultation reviews each technology and the corresponding frequency bands in order to assess the current situation in Bahrain, propose options for spectrum allocation for these technologies and identify potential conflicts between current and future allocation.

2.6 Importance of the consultation process

The underlying goal of the consultation is to set the foundation for the optimal allocation of spectrum in Bahrain. Spectrum is a scarce resource and the TRA and the MoT foresee potential conflicts between spectrum users for the allocation and assignment of frequencies. In order to establish an optimal allocation of spectrum which will maximise the benefits of spectrum to users and the citizens of Bahrain, it is therefore essential that the TRA and the MoT receive during the period of the consultation feedback from all interested parties who wish to express their views on the future of the national frequency plan. The TRA and the MoT encourage all interested parties who want to have an impact on the future of spectrum allocation in Bahrain to participate in this consultation.

Consultation

Spectrum Policy and Planning

3 Spectrum allocation and assignment processes

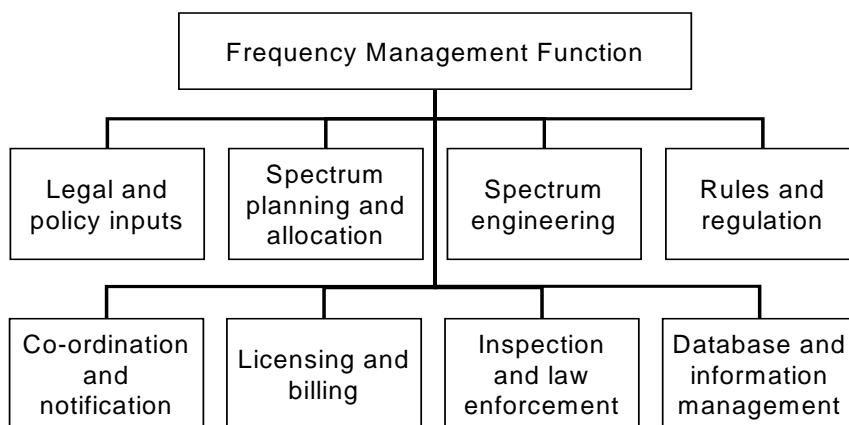
The objective of this section is to propose a set of new processes to put in place in Bahrain for spectrum allocation, assignment, co-ordination, notification and certification.

3.1 Background on frequency management

Spectrum management is the combination of the administrative, scientific and technical procedures necessary to ensure the efficient operation of radiocommunication equipment and services without causing interference. The goal of spectrum management is to maximise spectrum efficiency and minimise interference.

In the following sub-sections we summarise the key points to be considered in establishing best practice methods of spectrum management. There are a number of processes that constitute frequency management. These are shown generically in Exhibit 1. Unlike the rest of the consultation, the TRA and the MoT express views on the processes they have to implement in order to properly perform these functions, but do not explicitly formulate a consultation question. Should there be suggestions for improvements; respondents are encouraged by the TRA and the MoT to express them in their reply to this consultation.

Exhibit 1: Functions within frequency management



Consultation

Spectrum Policy and Planning

3.1.1 *Spectrum planning and allocation*

Use of national spectrum will be defined by the country's National Frequency Plan, which is derived from the ITU-R Allocation Table for the region (Region I for Bahrain).

Changing the use of parts of the spectrum, introducing new technology, and accommodating major new users or uses can take considerable time. It is important, therefore, to plan forward, so as to ensure that Bahrain's needs can be met as closely as possible. The National Frequency Plan should be reviewed and updated at regular intervals to reflect:

- Government policies
- The Administration's long term objectives and strategy
- Changes to ITU-R regulations and recommendations
- Current and likely future needs of the country for spectrum
- International developments in technology and markets which will impact radio usage in the country
- Consultation with government, users and other interested parties to ensure that the plan best meets the overall national interest

Options assessment: the objective of the TRA and the MoT is to establish a long-term spectrum planning strategy, with a procedure to ensure regular review and updating of the plan through a formal approval process.

3.1.2 *Spectrum assignment*

Spectrum assignment refers to the assignment of specific frequencies to specific users for use in specific geographical locations. Frequency in Bahrain will be assigned using an open, transparent and non-discriminatory method.

There will be a clear single policy on the method of selecting licensees which may be different for different services – for example, auctions or beauty contests for the provision of public telecommunication services, first come first served for fixed links. These will be clearly communicated to the industry. The preferred option for the assignment methodology is discussed in section 4.

The TRA also proposes to develop clear written procedures for the assignment of frequencies, which will ensure that harmful interference will not be caused to other licensed spectrum users, and that a satisfactory service will be obtained by the licensee.

Consultation

Spectrum Policy and Planning

The assignment procedures will:

- Restrict frequency assignments within a band or sub-band to one type of service where possible
- Assign frequencies in a way that prevents harmful interference between users
- Follow ITU-R channel plans where appropriate and possible
- Explicitly include the ITU-R co-ordination requirements

The assignment procedures will also ensure that:

- Licence applications are bona fide
- Assignments conform to the National Frequency Plan
- Assignments conform to international or regional agreements
- Assignments are checked for compatibility with existing assignments using the appropriate methods (ITU-R Recommendations should be followed wherever possible)
- The need for co-ordination with other Administrations (or other bodies) is assessed, and that the ITU Radiocommunications Bureau is notified where appropriate
- A complete and full record of all existing assignments is maintained and fully protected against loss or corruption
- Licences are properly prepared and licence conditions clearly stated
- Further licences do not have a negative effect on competition

In addition, the procedures will allow for licence renewal, cancellation and modification.

Options assessment: in order to perform this function properly, the MoT will maintain a Master Frequency Register with full details of all frequency assignments, thus enhancing the current database of the Ministry.

3.1.3 Co-ordination and Notification

Co-ordination is required whenever assignments have the potential to cause or be subject to interference to or from other licensed users across national borders. Co-ordination may also be required between different users within a country where there is co-channel use in adjacent regions or adjacent channel operation in a common region.

Consultation

Spectrum Policy and Planning

Co-ordination can be achieved through agreements between neighbouring administrations and through regional bodies.

A frequency assignment has to be reported to the ITU-R Radiocommunications Bureau if:

- Its use is likely to cause harmful interference
- It is to be used for international communications
- Its use is governed by a plan
- Its use is subject to a co-ordination procedure
- There is a desire to secure international recognition of its use

Once an assignment has gone through the necessary notification procedures (as prescribed by the ITU Radio Regulations) to ensure that it has no potential to cause interference to others (i.e. other assignments recorded in the Register), the assignment can be recorded in the Register. This assignment is then protected from other assignments which cause harmful interference to it³.

Co-ordination procedures for cross-border interferences need to be reinforced. In the first instance, it is suggested to initiate discussions with the other GCC regulatory authorities to agree on co-ordination criteria and procedures, as well as services or systems that may be co-ordinated through user or operator groups (e.g. the cellular mobile operators) in conjunction with, for example, the GCC Office.

Options assessment: in order to perform this function properly, the TRA proposes to establish a set of procedures, in line with ITU-R recommendations, to ensure that frequency assignment will not cause or be subject to interference to or from existing users, within Bahrain or in neighbouring countries

3.1.4 Certification

Equipment needs to meet certain technical parameters to ensure that it will operate correctly within the designated frequencies and not cause harmful interference to other legal users (or suffer harmful interference from other legal users). Parameters can include transmit power, out-of-band emissions, antenna gain, etc. Requiring that all equipment meet appropriate type approval tests is the conventional means to achieve this.

³ Many administrations only do this for a minority of assignments where protection is important

Consultation

Spectrum Policy and Planning

Certification of equipment can be a burdensome process, and a number of Administrations now delegate the responsibility to manufacturers and certified test houses for certain types of equipment. For a small country, it is best to accept equipment which meets other well-established national or international standards (e.g. GSM, CEPT, FCC).

Options assessment: the TRA does not normally carry out certification of wireless equipment for telecommunications usage but rather accepts any international or national certification, including self-assessment based on nationally or internationally accepted standards. This process has generally worked satisfactorily for other countries with limited regulatory resources. The TRA plans to maintain this process in the foreseeable future.

Consultation

Spectrum Policy and Planning

4 General spectrum policy on award mechanisms and spectrum pricing

4.1 Summary

This chapter considers the various mechanisms for spectrum award and pricing. The key proposals are:

- (1) It appears that auctions are the most transparent and economically efficient mechanism to award spectrum, and would therefore recommend the use of auctions for future licences.
- (2) Auctions give spectrum to the user who can make the most valuable use of it.
- (3) However, the TRA acknowledges that spectrum supply may occasionally exceed demand, and for such instances it could consider reverting to a First Come First Served approach.
- (4) FCFS is appropriate where users require assignments on a per base station or per link basis (and there is no specific SMO for the relevant block of spectrum).
- (5) Pricing enables the regulator to encourage efficient use of spectrum by charging an economic payment that reflects its market value.
- (6) The pricing policy will be a mix of administrative charging and spectrum pricing. For spectrum assignments that are not made through auctions, pricing will be based on either administrative cost recovery or incentive pricing. For spectrum assigned through auctions, a nominal charge for spectrum will be applied to cover administrative costs.
- (7) The TRA and the MoT would consider offering bulk users discounts on some applications, particularly fixed links.

4.2 Award mechanisms

4.2.1 Introduction

This chapter discusses the relative merits and limitations of different approaches to allocating spectrum licences that have been explored by the TRA and the MoT. Three spectrum assignment mechanisms have been considered. We did not detail the different flavours of each award mechanism, as this consultation only aims to identify general views on the preferred assignment mechanism for Bahrain.

Consultation

Spectrum Policy and Planning

4.2.2 Auction

Auctions comprise a bidding process whereby licences are awarded to those applicants who are prepared to pay most for them. Moreover, bidders are often only eligible to participate in such auctions if they pass certain pre-qualification thresholds. In this way, auctions typically result in spectrum being assigned to the users that value it most highly. From 2000 onwards, auctions were used to award UMTS third generation (3G) licences in many European countries, such as the UK, Italy, Germany and Greece, and have also increasingly emerged as the preferred allocation method for other licences (GSM spectrum, some FWA licences).

4.2.3 Beauty Contest

In beauty contests, or comparative selections, licences are assigned by the regulator to the applicants who best satisfy its selection criteria (for example, technical expertise, financial viability, network coverage and rollout speed). Rather than being controlled by market forces, spectrum allocation is determined by regulators, according to their judgement as to which of the competing applicants is the most highly qualified. Prior to 2000, the majority of European GSM licences were allocated via this mechanism, as was the first European UMTS licence to be awarded, in Finland in 1999. Even after this time, comparative selection was the standard method of assigning 3G spectrum in several European countries (for example, France, Portugal, Spain and Sweden).

4.2.4 First Come First Served (FCFS)

With the FCFS approach, spectrum is allocated to applicants according to the order of their application. Traditionally, in most countries radio frequencies were assigned on a FCFS basis. However, more recently, the increasing scarcity of spectrum has rendered this method less attractive. Given that demand for spectrum (the number of applicants) typically exceeds supply (the number of licences available), it is unlikely that a FCFS strategy will result in licences being awarded to those who are best qualified to use them to maximum economic advantage. In the case of Fixed Wireless Access (FWA) spectrum assignment, however, FCFS continues to play a significant role, as the recent level of interest generated by FWA licences has been relatively low.

4.2.5 Options for future spectrum policy

Auctions have several advantages over other spectrum-allocation methods. They are widely perceived to be transparent, open, and fair, since the licence outcome is determined by objective market forces rather than potentially biased decision criteria, as is the case with the beauty contest approach. Auctions are also

Consultation

Spectrum Policy and Planning

considered to be the most economically efficient means of allocating spectrum, since they ensure that this scarce resource is directed to those who value it most highly and are therefore likely to develop it most effectively. Consequently, carefully designed and well-organised auctions with well informed bidders will achieve market prices for the licences, thereby revealing a spectrum's true value. From a timescale perspective, too, auctions are very efficient. The competitive bidding process avoids the regulatory and logistical delays involved in beauty contests and, because they pay up-front, the winning bidders have a powerful incentive to bring services to the market as quickly as possible, rather than engage in "spectrum warehousing" in order to recoup costs. By avoiding the wasteful assignment of a limited resource, auctions also protect the public interest by ensuring that consumers recover the full value of the spectrum at the earliest opportunity.

However, while auctions provide an efficient means of allocating spectrum under certain conditions, when these no longer prevail, limitations of the auctioning process become apparent. For example, tacit collusion may emerge between the licence applicants, thereby bidding down the price of the spectrum. Instead of competing to push prices up, firms coordinate their bids, agreeing to share the spectrum at low prices, as was the case in the 1999 German GSM auction, where ten blocks of paired spectrum were auctioned to the four incumbents. Auctions may also lead to the artificial raising of the spectrum price. Since auctions generate significant amounts of revenue, the selling party has a clear incentive to maximise its returns from the bidding, for example by withholding spectrum to create greater scarcity of the resource, thereby artificially inflating the price, as was arguably the case in the European UMTS auctions. Such over-pricing of spectrum impacts negatively on consumers, who encounter higher prices as operators seek to recover their auction payments.

Elevated spectrum prices, together with high upfront fees, also discriminate against new entrants and smaller players in favour of incumbents and large operators with the 'deepest pockets'. In the UK UMTS licence auctions, for example, all new entrants with the exception of Hutchinson and NTL dropped out in the early rounds of the bidding and the eventual winners of the spectrum were all very large companies. This bias in favour of size operates as a barrier to entry, reducing effective competition and leading to industry consolidation.

Experiences such as the awarding of the UMTS licences illustrate the limitations of auctions and point to the opportunities available in other spectrum-assignment mechanisms. Beauty contests offer several benefits. They allow governments to ensure that specific policy goals such as public safety, national defence and industrial investment, which might not be as well served by using a competitive bidding mechanism, are also fulfilled. In France, for example, a

Consultation

Spectrum Policy and Planning

beauty contest method was chosen to assign UMTS spectrum, since ART and the French Ministry of Industry considered that more than purely financial considerations were important, placing value on other criteria such as network size, roll-out time, project consistency and service offering. Regulators can also attach conditions to the licence to ensure that the interests of specific groups, such as rural inhabitants, are protected. For instance, in Sweden, a beauty contest mechanism was employed to ensure connectivity throughout the whole country. Beauty contests can also have an indirect positive impact on consumer prices, as they remove from the operators the pressure to recoup their upfront investment in the licence. Finally, governments can intervene to restore fairness when unforeseen contingencies conspire to distort the market.

However, the extensive government involvement inherent within the beauty contest process can also prove disadvantageous. Intense lobbying and political intervention, for example, can threaten the transparency and objectivity of the entire procedure. In practice, governments have often failed to make the criteria for selection and assessment methods sufficiently clear or open to scrutiny. This not only prevents applicants from designing effective bids (for example, if there is insufficient guidance on the relative weightings given to each of the requirements), but may also render the process susceptible to legal challenge which can in turn lead to long delays in the awarding of licences. Another disadvantage of the beauty contest approach is that, unlike in an auction, there is no economic driver of efficiency, and thus valuable assets could potentially be given away at a fraction of their actual market value. Finally, comparative selection mechanisms are not always particularly easy to run, often placing a heavy burden on the regulator to review a large number of applications.

4.2.6 Options assessment

The TRA, subject to the input from the consultation, considers that auctions could be the preferred mechanism for awarding licences, particularly where the nature of the spectrum available indicates that the demand for licences is likely to exceed supply. In the case of an assignment which could attract more than one bidder, the process of this award is likely to be an auction rather than a beauty contest or FCFS procedure. However, while as a general rule auctions could be regarded as the best option, it is important to make decisions on a case-by-case basis rather than subscribe to a purely one-size-fits-all approach. For example, in the case of FWA spectrum, particularly when the demand for licences is unlikely to exceed supply, the TRA could decide to revert to the FCFS method of allocation. In addition, for non-public uses, such as private, individual and local assignment of spectrum for fixed links, auctions are irrelevant and FCFS should be the preferred method.

Consultation

Spectrum Policy and Planning

The TRA also recommends that if auctions ends up being the preferred option it should set up simplified auction processes and logistics in order to achieve faster and more efficient assignment of the spectrum. All in all, rather than relying on generic formats, the focus should be on bespoke auctions which are specifically tailored to the particular type of spectrum that is being allocated, in order to ensure an optimal solution for the market.

Consultation:

1. The TRA seeks respondent views on:

(1) the view that auctions should be the preferred spectrum-assignment mechanism for Bahrain.

(2) whether it should consider FCFS as an award mechanism if there is not enough demand to justify an auction

(3) the use of the FCFS method as the preferred solution for private, individual and local assignment of spectrum

4.3 Pricing strategy

This section considers the pricing strategy for radio spectrum within Bahrain. It draws on best practice from a range of countries and takes into account the specificities and current situation of the Bahrain market to derive a sensible approach to pricing radio spectrum.

It should be noted that in Bahrain charges for the use of spectrum are a combination of spectrum fees and administrative fees:

- The MoT receives spectrum fees
- The TRA receives administrative fees

4.3.1 Methodology

A key aspect of this consultation is to discuss options for spectrum pricing in order to develop a clear pricing strategy for Bahrain. This consultation does not aim to propose pricing levels for each individual application, but will propose generic pricing mechanisms which could be applied. There are four broad classes of pricing, and all four will be considered in this consultation:

- free, but users made aware of value (with potential pricing later)
- fixed charge based on costs

Consultation

Spectrum Policy and Planning

- fixed charge based on perceived value of spectrum (e.g. revenue share)
- market-determined charge (or auctions)

4.3.2 Evolution of pricing strategies

Historically, charges were levied to recover the costs of issuing, processing and renewing licences. Even today, administrative charging remains the key basis in uncongested parts of the spectrum.

Charges for the use of spectrum were first introduced to recover the costs associated with issuing licences, monitoring market behaviour and enforcing licence conditions, and still exist in most markets today. These costs include costs of maintenance, enforcement of licences and broader management of the radio spectrum, as well as indirect costs incurred by the licensing agency, such as personnel, training and overheads.

Some markets still charge purely as a means of recovering the administrative costs incurred by the telecommunications licensing agency (Australia, the Netherlands, Colombia, etc). However, as popular bands have become congested, governments are moving to charging for use based on value. Economic value-based prices are set at a level so as to influence the choices made by spectrum users. As a result, their use of, and requests for, spectrum reflect the value they place on it. Under such a regime, users (and potential users) have incentives to release unused or under-used spectrum, to consider alternative services or less congested frequency bands, and to implement more spectrally-efficient technologies⁴.

Both these mechanisms are discussed below.

4.3.3 Administrative charges

Administrative charges are either levied as a percentage of turnover or allocated at a set rate. Two approaches are generally adopted for recovering administrative costs:

- Application of fixed annual fee for each type of licence
- Levy based on licensee's turnover or profitability

Whilst a fixed fee is more directly related to the cost of a specific licence, levies reduce entry costs for smaller, less established entrants and are seen as more equitable. Levies are used in a number of European countries and currently in Bahrain to recover costs for some parts of the spectrum.

⁴ Radiocommunications Agency (RA), UK - Spectrum Pricing Study: Final Report Prepared by The Smith Group and NERA

Consultation

Spectrum Policy and Planning

Other methods are based on an allocation of the costs of the agency, often with reference to a specific licence type. The regulator would conduct a detailed cost allocation exercise to determine charges for each licence type.

4.3.4 Spectrum pricing based on market value

More recently, countries have introduced pricing mechanisms that encourage the efficient allocation of radio spectrum, particularly in congested parts of the spectrum. As radio spectrum has become more congested, new ways of using pricing to manage the spectrum have been introduced – specifically, economic value-based spectrum pricing.

Spectrum pricing is used in a significant number of countries to promote use and achieve an efficient allocation of radio spectrum.

- Spectrum pricing can lead to an outcome where the revenue generated exceeds the costs of the agency. This can be justified on the basis that it achieves an efficient allocation of scarce radio spectrum
- Conversely, if applied to sections of the spectrum where there is no scarcity, the revenue generated may fall below cost. For this reason, administrative costs are typically retained for sections of the spectrum where there are low levels of congestion

Spectrum pricing is best suited to those parts of the spectrum where:

- There is excess demand
- Use of the spectrum can change in response to the pricing
- There are no political or policy impediments to their use (e.g. international use of the spectrum, level of illegal use)
- The assignment has NOT been through an auction.

Possible applications where the respondent can expect the regulator to implement spectrum pricing based on market value are in fixed links (microwave) and other fixed access which has not been licensed through an auction.

The TRA and the MoT propose the following methodology for determining the incentive-based charge, where applicable:

- Usage of greater frequency bandwidth will be charged more (i.e. ,for example, 2x30KHz charged less than 2x50KHz)
- Usage at the higher bands which have less demand and pose fewer interference problems will be charged less (thus fixed links at 3 GHz will be charged more than fixed links at 11 GHz)

Consultation

Spectrum Policy and Planning

- Usage at higher power will be charged more (especially at lower frequencies) as it reduces ability to reuse
- National assignments will be charged at a higher rate than specific location assignments (thus a licensee who takes, say, a 3 GHz fixed link across Bahrain will be charged more than a licensee taking a specific link between two offices in, say, Muharraq).

This basis can be expressed as a formula:

Charge = Bandwidth x (Frequency, Geography) x Power x Constant

Where:

- *Bandwidth*: reflects the amount of bandwidth used (e.g. frequency band/25KHz)
- *Frequency*: values vary across the spectrum - higher values for the most congested parts
- *Geography*: national vs. specific location assignment
- *Power*: used to reflect level of interference caused to other users
- *Constant*: will be used to calibrate the result to acceptable levels for Bahrain; based on local operating conditions and cost

A number of countries in Asia and Europe have adopted a similar approach to incentive-based spectrum pricing. These include France, Italy, Greece and Malaysia, to name but a few.

Consultation:

2. The TRA and the MoT seek respondent views on:

(1) the services for which value-based spectrum fees should apply

(2) the importance of the four drivers to value-based spectrum fees – bandwidth used, frequency band, geography and power level

4.4 Overall pricing strategy for Bahrain

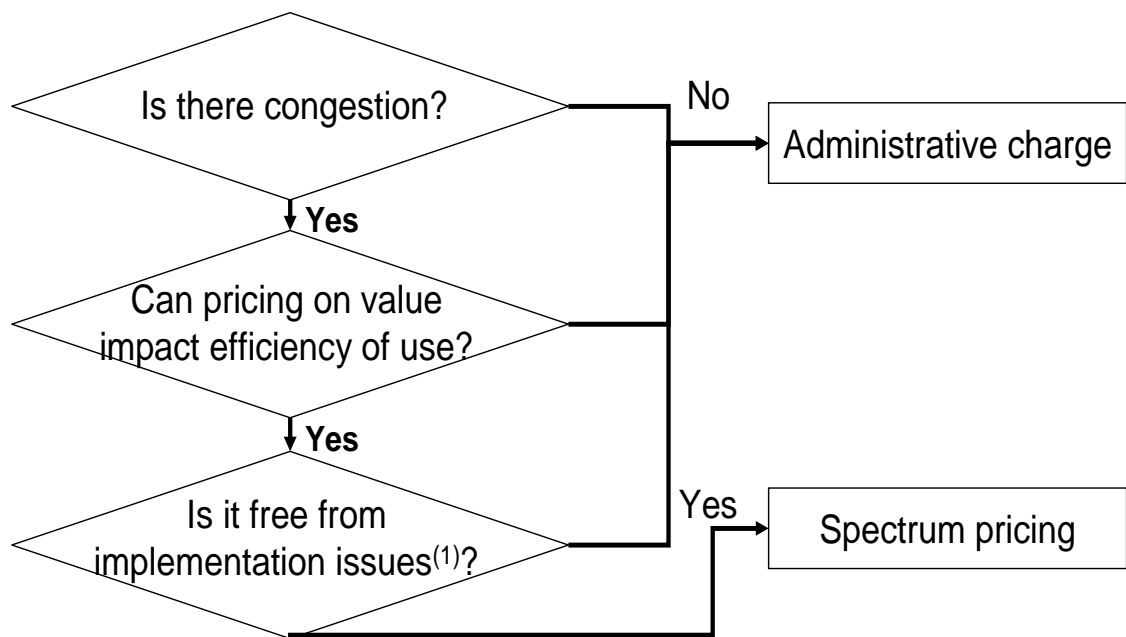
The TRA and the MoT recommend a combination of administrative charge levies and spectrum pricing. It is also recommended that spectrum pricing be adopted only in those areas where there is congestion and where an auction has not been the licensing mechanism used.

Consultation

Spectrum Policy and Planning

The following flowchart depicts the methodology used to determine which applications are conducive to the adoption of spectrum pricing.

Exhibit 2: Methodology used to evaluate which applications are conducive to spectrum pricing



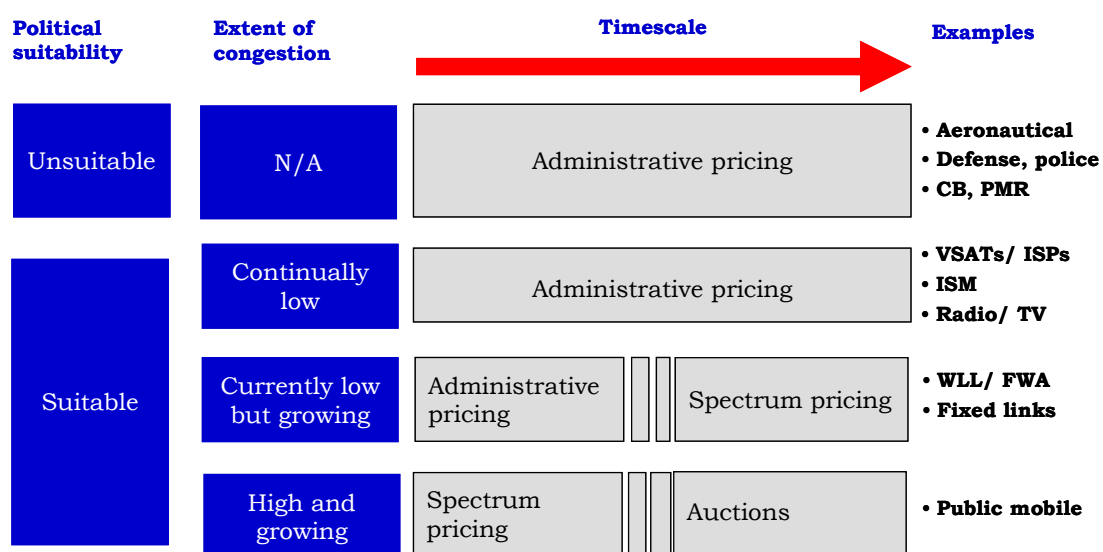
Note: (1) For example complexity of the pricing formula, degree of change needed, government control etc.

Judging from the current situation, the TRA and the MoT assume that incentive-based spectrum pricing will be used only for applications where there is high commercial demand and potential future interference, and where the assignment has not been through an auction. Possible applications that could merit the use of spectrum pricing are public mobile applications (where not auctioned), fixed wireless access operators (where not auctioned), and fixed links in the congested bands (e.g. 3.5 GHz, 5.8 GHz). Our recommendation on which method to use for which application is shown in Exhibit 3 below.

Consultation

Spectrum Policy and Planning

Exhibit 3: Applications and recommended pricing approach



Therefore the following pricing mechanisms are recommended for each of the technology and frequency bands discussed in this consultation:

Exhibit 4: Spectrum pricing proposal for Bahrain

Technology	Proposed pricing	
Public Mobile	Auction + Administrative charge	
PMR and PAMR	Analogue	Administrative charge
	TETRA commercial	Auction + Administrative charge
Fixed Wireless Access	Auction (or FCFS) + Administrative charge	
Short Range/ WiFi	Administrative charge	
VSAT	Administrative charge	

Consultation

Spectrum Policy and Planning

Consultation:

3. The TRA and the MoT seek respondent views, with reasons, on whether they should:

- (1) use a combination of administrative charging and spectrum pricing in Bahrain.
- (2) use spectrum pricing only in areas where congestion exists.
- (3) use pricing mechanisms for every part of the spectrum.

4.5 Discounts for bulk use

The MoT has received requests for discounts on spectrum charges from bulk users. The MoT would like to make the following points:

- The MoT and the TRA are not averse to allowing discounts for bulk users
- The MoT would prefer that discounts do not result in inefficient use
- One area where discounts are particularly applicable is that of fixed links (typically microwave). Mobile network operators are typical examples of bulk users of fixed links
- The MoT is considering the following options for discounts to bulk users:
 - discount on the total annual spectrum charge paid to the MoT
 - discount based on the number of links that have been licensed

Consultation:

4. The TRA and the MoT seek respondent views, with reasons, on whether discounts should apply for bulk use. What would be the respondents' preferred option for calculating the level of the discount?

4.6 International benchmarks

While this consultation does not aim to discuss specific prices, the TRA and the MoT would like respondents to be aware of typical spectrum charges in other countries in Region I, especially in Europe. Europe is often cited as a benchmark because spectrum-pricing regimes are much more evolved and pricing benchmarks are often used as one of the many inputs to setting prices in Asia. Of course, cost structures in Asia are very different compared to Europe – thus the benchmarks are to be seen only as guides.

Consultation

Spectrum Policy and Planning

It is also worth noting that countries from the GCC, including Saudi Arabia and Qatar, have introduced spectrum pricing, and other countries such as UAE are currently in the process of implementing spectrum pricing.

4.6.1 GSM mobile

The following are the key trends seen in Europe:

- Administrative charges are applied on GSM operators across Europe, with very few exceptions. Administrative charges are based on cost, though the various countries follow a range of different approaches
- Both initial and recurring annual administrative charges apply to operators. The charge is often separate for GSM 900 and GSM 1800 (e.g. in the UK). Some countries levy a fixed charge per operator (e.g. Germany) while others charge according to the frequency assigned (e.g. UK)
- The charges vary quite significantly between the countries:
 - Belgium: about €25,000 per 2x200KHz channel per year
 - Germany: fixed per network operator at about €200,000 per year
 - France: varies by frequency assigned – about €300,000 per MHz (simplex) per year
 - UK: differentiates between GSM 900 and GSM 1800, and charges are about £180,000 per 2 x 200 KHz (GSM 900) and approximately 30% lower for GSM 1800. The GSM operators pay about £12m-£14m each per year as annual GSM spectrum charges.

4.6.2 3G mobile

Most countries in Europe have licensed 3G spectrum through auctions. A few countries have used beauty contests, for example, Spain, Portugal, and Ireland. Spectrum charges vary very significantly between the two classes of countries.

- For countries which have assigned the frequencies through auctions, a nominal administrative fee is charged. For example, in the Netherlands, about €8,000 is charged per 2 x 1 MHz per year
- Some countries which have assigned the frequencies through auctions charge no additional fee – e.g. the UK and Italy
- Spain, which awarded the licence through a beauty contest, has a much higher annual spectrum charge – above €150m per year was agreed at the time of the award, though there have been reductions since.

Consultation

Spectrum Policy and Planning

4.6.3 *Fixed Links*

Fixed links are also referred to as microwave links or radio relays. Most countries charge for fixed links by way of value-based formulae – very similar to the one the TRA and the MoT are considering for Bahrain. Value-based pricing is popular as a method of charging for fixed links, as the links are typically assigned on a FCFS basis and often in bands where there is high demand. Fixed links are used both by large telecom networks (e.g. mobile operators) as well as smaller non-telecom operators (e.g. banks, utility companies, etc.). Public mobile operators typically tend to be much larger users, and in some countries they are offered a discount for re-use.

Key trends in charging for fixed links include:

- Fixed links are typically awarded by FCFS, and hence value-based charging is prevalent
- Charges are typically determined by bandwidth used, frequency of use, length of the link and power levels
- Fees are higher for lower, congested bands. Belgium, Italy, the UK, France and Ireland have explicit tables which charge a much higher amount for the lower, congested frequencies
- Some countries, such as Italy, also charge based on the length of the link. Charges can also be higher for congested (urban and built-up) areas compared to sparsely populated regions of the country
- Some countries, such as France and Italy, also have specific discounts for bulk users, offering a reduction of up to 75% of the charge for links beyond the 80th link licensed (builds up from 10% from the 10th link with the discount reaching 75% for the 81st link and beyond)

4.6.4 *VSATs*

Spectrum fees for VSATs are usually based on administrative charges for monitoring and licensing. Charges can be per Earth station and per licensed user. Significant discounts are offered as the number of licences increases. Some countries also charge depending on the amount of bandwidth used per Earth station/per licence (e.g. Ireland, Spain). Charges for an operator with, for example, a single Earth station and 30 terminals operating at 11/14GHz with 150 KHz bandwidth vary from €500 per annum (Netherlands) to €6,000 per annum (UK).

Consultation

Spectrum Policy and Planning

5 The introduction of new technologies and services

5.1 Summary

This chapter considers the approach that the TRA and the MoT propose to take in order to encourage the deployment of new and advanced services and technologies in Bahrain. The key aims are:

- (1) To solicit proposals from all quarters for the introduction of new services and technologies and, where appropriate, proposals for the corresponding allocation or assignment of new spectrum
- (2) To evaluate all such proposals in a thorough yet rapid process that balances the need to ensure continued availability of interference-free spectrum with the advantages to be gained from the rapid introduction of new services and technologies
- (3) To perform the evaluations in a public and transparent manner, to take account of the overall benefits to Bahrain and its citizens, and to consult on all resulting proposals
- (4) To introduce a temporary test licence to enable interested parties to carry out tests on new wireless systems
- (5) To define a clear set of licensing procedures and pricing mechanisms for spectrum assigned to Programme Making and Special Events (PMSE)

5.2 Introduction

Ensuring that emissions from one radio system do not cause unacceptable interference to other wireless systems is an essential part of the work of a spectrum management organisation. In the case of deployed systems and equipment, appropriate equipment licensing conditions, spectrum monitoring, and enforcement are the means to ensure that the spectrum is suitable for use by all legitimate users. In the case of new technologies, it is necessary to ensure that they can co-exist with existing systems before widespread deployment takes place.

New systems have to co-exist not only with existing deployments within a jurisdiction, but also with wireless operations of neighbouring countries. These are covered by coordination arrangements between countries and by international agreements.

Many of the new systems and equipment that can be expected to be deployed within Bahrain will already have been deployed elsewhere. They will have been well characterised and the conditions for successful co-existence with other

Consultation

Spectrum Policy and Planning

systems will usually be well understood. In such situations the TRA will usually be able to assess the compatibility of the new system with existing users in a relatively straightforward manner.

However, the TRA and the MoT wish to encourage new technologies that may benefit the economy and the citizens of Bahrain. They also recognise that wireless and communications technology is undergoing rapid change and that a long and cumbersome approvals process can reduce or even negate the benefits of a new technology. They are therefore seeking views as to the optimum balance between a full and rigorous technology approval process and the rapid introduction of new technologies.

For the purpose of this discussion, it is useful to differentiate between four different approaches to spectrum assignment:

- The TRA manages a block of spectrum allocated by the MoT and makes individual frequency assignments within the band - in this case the TRA is responsible for ensuring that all assignments are made in a compatible manner and that new assignments do not cause unacceptable levels of interference to others. An example would be the assignment of individual PMR channels to businesses
- The TRA assigns a block of spectrum allocated by the MoT to an organisation, which then takes responsibility for the planning and deployment of equipment and for ensuring that individual frequency assignments are compatible with the correct operation of the system. A typical example would be a public mobile operator or an organisation using a wireless system in support of its internal activities. The TRA, in licensing the operator/user, has a responsibility to ensure that the correct operation of the system will not cause interference to other users of the spectrum, particularly those using the adjacent spectrum, or contravene international regulations
- A number of assignments, particularly in the aeronautical, maritime and satellite services, are determined by international agreements on a regional or global basis. Decisions on technologies and co-existence are usually taken by appropriate international bodies, and we do not consider this situation further
- Light licensing regimes – although end users of spectrum made available through light licensing regimes, are on a “free for all” basis with no exclusive use the TRA is responsible both for ensuring successful co-existence with other licensed users and for ensuring that users of spectrum can co-exist with other users of the same spectrum

Consultation

Spectrum Policy and Planning

It is important to remember at this point the different responsibilities of the MoT and the TRA regarding spectrum. While the MoT is responsible for spectrum allocation to classes of usages, the TRA is in charge of the assignment of spectrum to individual users.

5.3 Management of individual assignments

The TRA and MoT's general approach is to follow the appropriate ITU-R Recommendations and channel plans, and to licence equipment meeting the appropriate type approval specifications. To encourage the introduction of new technologies, the TRA and the MoT are considering the following approach:

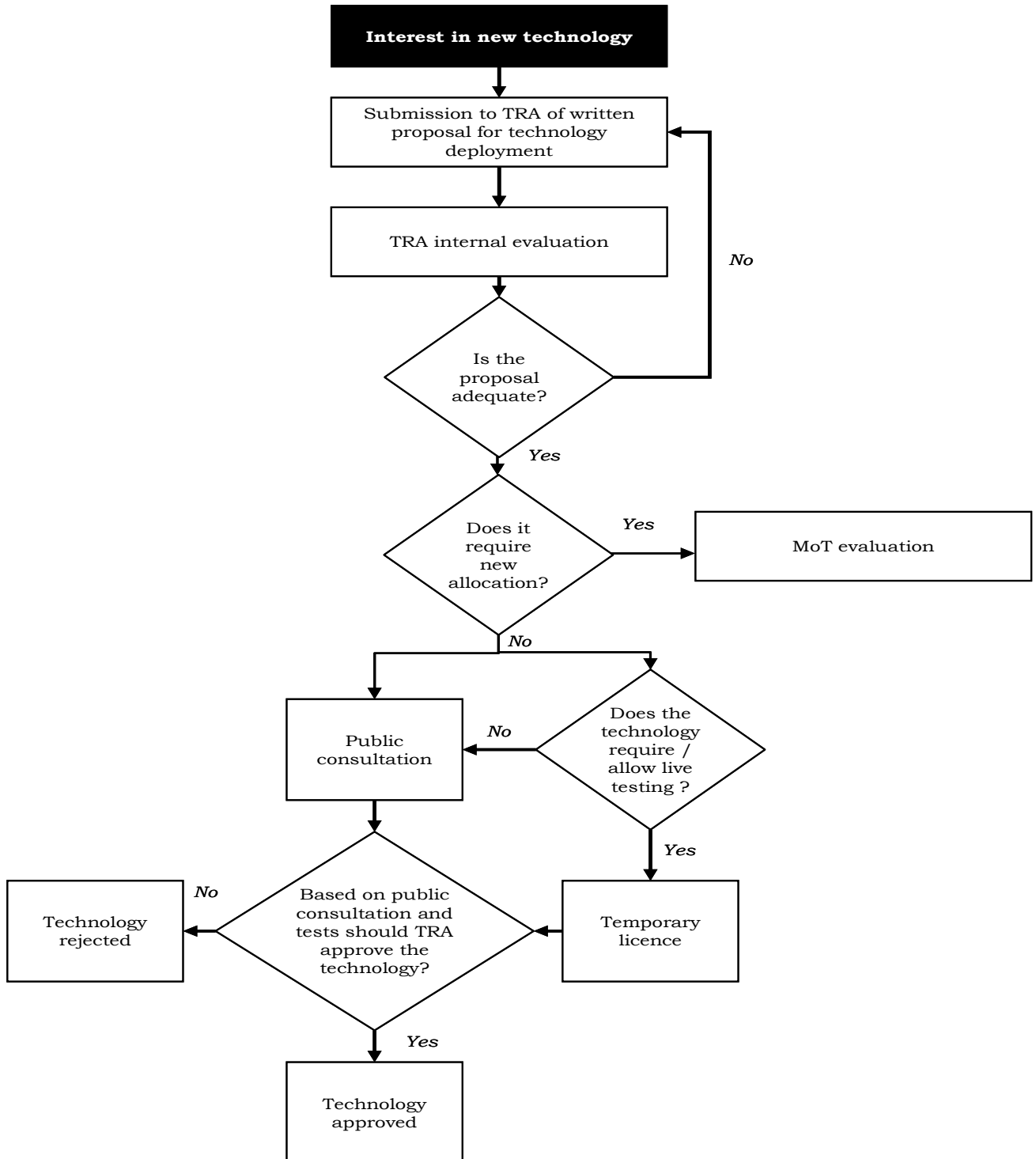
- Proposals for new technologies and/or standards will be acceptable from any source
- The proposer will be required to submit written evidence as to how the new technology can be introduced without detriment to other spectrum users, and on the benefits to be gained. This evidence may be in any form, but evidence of actual operation elsewhere, co-existence studies by recognised standards bodies, and assignments by other Administrations will be considered as strong evidence
- The TRA will evaluate the evidence submitted and publish both the original proposal and its own evaluation, and invite comments from the public
- Should the evidence provided be determined to be inadequate, the proposer will be given the opportunity to prove compatibility by means of tests, measurements and demonstrations
- Should the introduction of the technology require a new or modified spectrum allocation, the TRA will refer the issue to the MoT for assessment
- Again, the TRA will evaluate the evidence, publish its response, and invite further comments from the public. If appropriate, the TRA may decide to award a limited number of temporary licences to allow live testing of the technology
- Finally, in the light of all the evidence and comments received, the TRA will decide whether or not the new technology is to be approved, and will make its decision public

Where relevant, the TRA and the MoT may need to consider issues arising from the need to coordinate use of the new technology with neighbouring countries.

Consultation

Spectrum Policy and Planning

Exhibit 5: Processes for new technology approval



Consultation

Spectrum Policy and Planning

Consultation:

5. The TRA and the MoT seek respondent view, with reasons, on their intention to encourage proposals for the introduction of new technologies, and seek comments on the evaluation process outlined and on the balance to be struck between a full and rigorous technology approvals process and the rapid introduction of new technologies.

5.4 Block assignments

Block assignments of spectrum will normally be made to operators of public wireless networks or to large organisations with a need for their own wireless system. Through the normal process of planning, the TRA will identify and the MoT will allocate spectrum for future services and technologies, and the spectrum will be awarded through the appropriate process. In addition, the TRA will be open to proposals that blocks of spectrum be assigned to new services and technologies. Block assignments of spectrum will follow the same process as outlined above in Exhibit 5. Proposals may be made for the provision of public services or for private use. In outline, the approach being considered is as follows:

- Proposals for new services or technologies (including new or emerging standards) will be acceptable from any source
- The proposer will be required to submit written evidence as to how the new technology can be introduced without detriment to other spectrum users, what frequency bands would be required, how any existing users of the spectrum could be accommodated elsewhere, and what the market demand for the services and the benefits to be gained would be. This evidence may be in any form, but evidence of actual operation elsewhere, co-existence studies by recognised standards bodies, and assignments by other Administrations will be considered as strong evidence
- The TRA will evaluate the evidence submitted and publish both the original proposal and its own evaluation, and invite comments from the public
- Should the evidence provided be determined to be inadequate, the proposer may be given the opportunity to prove compatibility, performance and capability by means of tests, measurements and demonstrations, provided suitable spectrum can be made available

Consultation

Spectrum Policy and Planning

- Should the introduction of the technology require a new or modified spectrum allocation, the TRA will refer the issue to the MoT for assessment
- Again, the TRA will evaluate the evidence, publish its response, and invite further comments from the public. In making its evaluation, the TRA will take into account technical issues, the availability of spectrum, ITU-R allocations and recommendations, cross-border coordination issues and other relevant international developments, as well as the market demand in Bahrain. The TRA will also evaluate the impact of the introduction of the new technology on competition.
- Finally, in the light of all the evidence and comments received, the TRA and the MoT will decide whether or not spectrum should be allocated to the new service/technology. The TRA will then, possibly through a process of public consultation, determine the process through which the spectrum is to be assigned and set out the licence conditions. Note that the TRA may decide to permit services or technologies other than those originally proposed

Consultation:

6. The TRA and the MoT seek respondent views, with reasons, on their intention to encourage proposals for the assignment of spectrum blocks to new technologies and/or services, and seek comments on the evaluation process outlined and on the balance to be struck between a full and rigorous technology approvals process and the rapid introduction of new technologies.

5.5 Light licensing

Many countries in Europe and the Americas have licence exempt spectrum. However, licence exempt spectrum is currently not allowed under the Telecommunications Law in Bahrain. The TRA acknowledges the importance of the concept and wants to encourage growth of new services. The TRA has decided to develop a light licensing regime, replicating the licence exempt conditions for end users:

- All users, including service providers, retailers and end users, will have to get a “light” licence (low cost or no cost, easy to get through an online registration, for example)
- All users will be governed by type approval of equipment
- For end-users, the TRA will explore options to make the licensing process as easy and time efficient as possible

Consultation

Spectrum Policy and Planning

It should be noted that the allocation of spectrum under a light licensing regime does not imply that there should be no restrictions on the equipment that can be used or on the emissions that may be radiated. As a minimum, there will be limits on the power that may be radiated both within the band and in the adjacent band. However, as such bands are intended to be shared by multiple users without coordination, it is often appropriate to additionally require that equipment meet certain standards which optimise the use that users can make of the spectrum in this environment. Similarly, it can be appropriate to limit a licence-exempt band to a specific application in order to maximise its utility for a particular purpose. An example would be the licence-exempt PMR 446 service in Europe, which is restricted to “walkie-talkie” operation.

The TRA and the MoT will monitor international developments related to licence-exempt spectrum and, where appropriate to the specific situation in Bahrain, will assign spectrum under a light licensing regime and issue the appropriate regulations governing the use of the band.

In addition, the TRA and the MoT are open to suggestions for the allocation/assignment of spectrum under a light licensing regime. The basic approach to evaluating such proposals follows similar steps to those described above (see Exhibit 5), namely:

- Proposals for new light licensing allocations will be acceptable from any source
- The proposer will be required to submit written evidence as to how the new band can be introduced without detriment to other spectrum users, what frequency band should be used, how any existing users of the spectrum could be accommodated elsewhere, and what the market demand for the services and the benefits to be gained would be. This evidence may be in any form, but evidence of actual operation elsewhere, co-existence studies by recognised standards bodies, and assignments by other Administrations will be considered as strong evidence
- The TRA will evaluate the evidence submitted and publish both the original proposal and its own evaluation, and invite comments from the public
- Should the evidence provided be determined to be inadequate, the proposer will be given the opportunity to prove compatibility by means of tests, measurements and demonstrations⁵

⁵ Note, however, that it may be impractical to test operation in heavily loaded situations where the ability to share the spectrum in an equitable manner becomes critical. Simulations can provide an alternative means of demonstrating performance.

Consultation

Spectrum Policy and Planning

- Should the introduction of the technology require a new or modified spectrum allocation, the TRA will refer the issue to the MoT for assessment
- Again, the TRA will evaluate the evidence, publish its response, and invite further comments from the public
- Finally, in the light of all the evidence and comments received, the TRA will decide whether or not the new band is to be allocated under a light licensing regime, will determine the regulations that will apply to the band, and will make its decision public

Consultation:

7. The TRA and the MoT seek respondent views, with reasons, on their intention to encourage proposals for the introduction of a light licensing regime, and seek comments on the evaluation process outlined and on the balance to be struck between a full and rigorous technology approvals process and the rapid introduction of new technologies.

5.6 Frequency licensing for special events

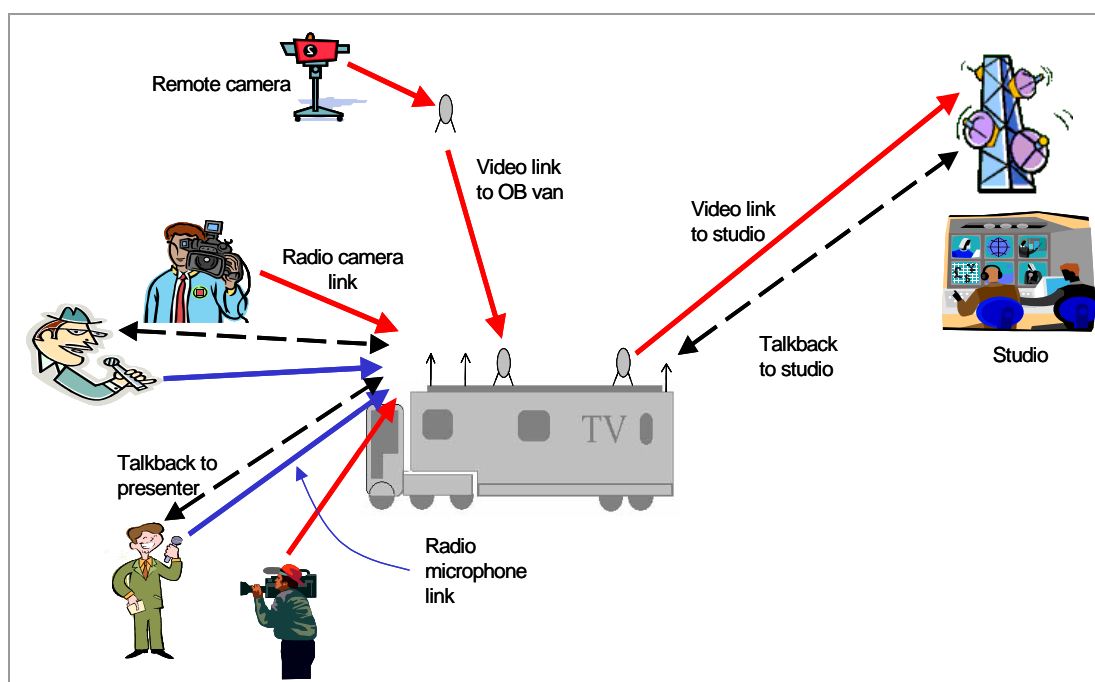
Special events are typically used by media and broadcast companies for the production of an event or programme. We refer to this class of use as Programme Making and Special Events (PMSE). Typical use includes theatrical performances, radio and television programmes, rock and pop shows, sporting events and conferences.

Typical applications include radio-microphones, talkback and in-ear monitors (IEMs), audio links for high-power talkback, programme links for wireless television cameras, data links to remote control television cameras, and point-to-point links to connect an Outside Broadcast (OB) event to a studio.

Consultation

Spectrum Policy and Planning

Exhibit 6: **Typical usage for a special event (example: outside broadcast)**



These applications work across a wide range of frequency bands. Radio-mics and talkback typically use Bands IV&V (470 – 854 MHz) and Channel 69 (854 – 862 MHz) within the UHF broadcasting bands, but are also available within Band III (173 – 255 MHz) and UHF1/UHF2 (420 - 469.9 MHz) bands. Programme Links are typically above 1.5 GHz and wireless cameras typically in the 2 GHz – 5 GHz ranges.

Most PMSE use is secondary – that is, the primary use is with existing operators and government users. Thus, spectrum for special PMSE use is ‘borrowed’ from existing primary licensees – for example, using interleaved broadcast spectrum in Bands IV&V for radio-mics/talkback.

5.6.1 **Licensing authority**

The TRA would be the authority responsible for assigning frequency licences for PMSE purposes on a secondary basis. It would examine the request and explore with the primary licensees which bands could be assigned for use.

Regulators in some countries have ‘outsourced’ the management of licences for secondary PMSE purposes to external spectrum management organisations (SMOs). For example, in the UK, JFMG Ltd has been contracted by Ofcom

Consultation

Spectrum Policy and Planning

(previously the Radiocommunications Agency (RA)) since April 1997 to manage and license the part of the radio spectrum used for Programme Making and Special Events (PMSE).

However, the TRA considers it too early to outsource PMSE spectrum management to an external party in Bahrain.

5.6.2 **Licensing procedure**

All short-term use for special events will require a licence and non-licensed use will be illegal. This licence will be handled by the TRA in coordination with the MoT. Users will need to make a written request to the TRA well in advance of the event, specifically stating the details of the intended use. This would cover, but would not be limited to:

- Details of the party making the request
- Details of the proposed use – application needing licence (e.g. radio-microphone), number of licences needed (e.g. 10 radio-mics), preferred spectrum bands needed for the event (though the TRA may not be able to access these bands from primary users and requests will be met on a best-effort basis), specific location of use, power of application and duration of use
- Evidence of approval by the appropriate authority to broadcast the relevant event.

Licences will be issued on a short-term basis – typically in multiples of 48 hours.

Only news gatherers will be allowed to ask for long-term assignments. At present, Bahrain has only state broadcasters. Thus, until further notice, long-term assignments for PMSE purposes will be limited to the state broadcaster.

5.6.3 **Pricing**

Prices will be fixed for each 48-hour assignment. The price will be computed on the basis of recovery of administrative and spectrum costs.

Consultation:

8. *The TRA and the MoT seek respondent views, with reasons, on:*

(1) the need for short-term licences for program making and special event (PMSE) purposes.

(2) the licensing procedures suggested and the proposed pricing mechanism.

Consultation

Spectrum Policy and Planning

5.7 Temporary test and trial licences

The TRA and the MoT recognise that operators and other parties may wish to test new wireless systems prior to purchase or in relation to proposals for the introduction of new services, technologies or bands as discussed above. The TRA therefore plans to introduce temporary test licences. The process under consideration is outlined below:

- Applicants will be required to identify the system they wish to test, the characteristics of the radio emissions, the amount of spectrum required and the preferred frequencies, the area over which test transmissions will be made, the duration of the tests, and the precautions that will be taken to ensure that interference is not caused to other users of the spectrum
- The TRA will evaluate the proposal. The evaluation will be primarily concerned with ensuring that the tests can be conducted without detriment to other legitimate users, but will be dependent on the availability of suitable spectrum
- When a proposal is approved, a test licence will be issued. The licence will specify the conditions under which tests may be carried out. It will be for a fixed and limited period, will confer no rights on the licensee beyond those specified in the licence, and will not commit the TRA to any further licensing, allocation or assignment of spectrum

Consultation:

9. The TRA and the MoT seek respondent views, with reasons, on their proposal to introduce new temporary test licences, and on appropriate licence conditions which will both protect existing spectrum users and maximise the value of the tests carried out under such licences.

Consultation

Spectrum Policy and Planning

6 Public Mobile Network

6.1 Summary

Public mobile comprises a wide range of technologies and frequency bands. Although GSM is the incumbent standard in Bahrain, the TRA and MoT's overall position is a technology-neutral approach to future spectrum award. Even though a few options are technically available for future spectrum award, the TRA and the MoT acknowledge that the opportunity to introduce a third mobile licence in Bahrain will be dictated by economics and market forces. This document will not consult on the market opportunity for a third mobile licence, but will focus only on the technical feasibility of such a licence. The possibility of awarding a third mobile licence will be the subject of another consultation published at a later stage.

Within the scope of this consultation, the TRA and the MoT have reviewed the current use of spectrum in Bahrain for public mobile networks and developed the following options for future allocation, assignment and policy:

- (1) The TRA and the MoT recommend that future spectrum awarding be made on a technology-neutral basis.
- (2) Although spectrum is available in the 400 MHz band, the TRA and the MoT do not suggest spectrum allocation for GSM 400 or CDMA450, as equipment availability is limited in these bands and other options are available for the third licence.
- (3) Allocation of spectrum using US standards has to be ruled out for the 1900 MHz band, but could be considered for the 850 MHz band if no other solution is available because of supply constraints.
- (4) There is enough free spectrum in the allocated 1800 MHz band to assign a third mobile license.
- (5) The TRA and the MoT propose to put in place a "safeguarding" approach to future assignment in the 3G band by potentially working with current users of the band on a plan of migration to an alternative set of frequencies.

6.2 Introduction

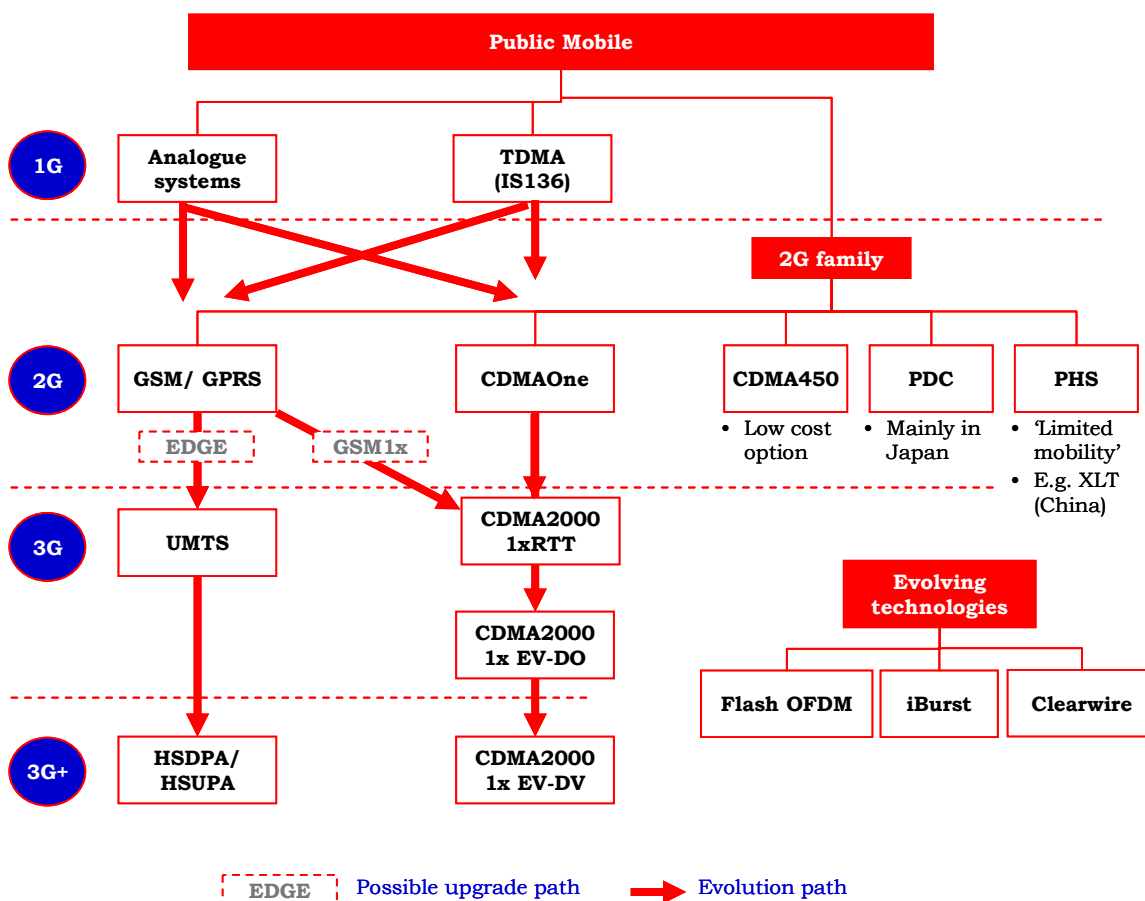
6.2.1 Scope

Public mobile covers a very wide range of technologies and frequency bands. The TRA and the MoT are technology-neutral in their approach, and view this class of technologies under a broader "Public mobile" heading. The "Public mobile" family is described in this section.

Consultation

Spectrum Policy and Planning

Exhibit 7: Public mobile technologies



This section focuses on the main technologies outlined above and their implications on frequency management. The document does not explicitly focus on the following public mobile technology, as the TRA and the MoT believe they are of less relevance to Bahrain:

- First generation (1G) systems – analogue and TDMA mobile (no deployments over the past 10 years)
- PDC – implementation limited to NTT DoCoMo in Japan. NTT DoCoMo is migrating subscribers to WCDMA
- PHS – the technology for a ‘poor man’s mobile’ with implementation limited mainly to China (through Xialingtong’s use of the technology in rural and suburban areas of China)

Consultation

Spectrum Policy and Planning

As illustrated in Exhibit 7, the GSM technology standard has an evolution path to the UMTS third generation (3G) technology and beyond, whilst CDMA2000 1xRTT has a migration path to CDMA2000 1x EV-DO and beyond.

For all technologies covered in this consultation, we will:

- discuss the technical background as well as the current market trends
- outline the current spectrum allocation and assignment for the technologies
- express the TRA and MoT's views on spectrum allocation and assignment
- formulate a series of questions to be answered by respondents to the consultation

6.2.2 *Context in Bahrain*

Mobile telephony service in Bahrain is currently provided by two operators, and its introduction has been very successful, with a penetration rate now in excess of 100%⁶. Both the current operators use GSM technology, and the continuous development of this and other technologies enables operators to offer new and enhanced services, such as mobile internet. Looking forward, the TRA and the MoT wishes to ensure that these developments can be employed to the best advantage of Bahrain and its citizens. With this in mind, the TRA will publish a consultation on the awarding of a third mobile licence in Bahrain at a later stage.

In this section we describe the current market for mobile services in Bahrain, and subsequently discuss and seek views on the future technology related options for Bahrain. We will first address the potential evolution of the 2G market in Bahrain and the implications for frequency allocation. We will then focus on the two main 3G technologies, W-CDMA and CDMA2000, on which future developments might be based.

6.3 "2G" – new GSM or CDMA licenses

6.3.1 *Background and trends*

GSM is the incumbent mobile communications technology in Bahrain. Both mobile companies in Bahrain, MTC-Vodafone and Batelco, run GSM networks.

⁶ 106% in 2Q05, source: Middle East and Africa Wireless Analyst August 2005

Consultation

Spectrum Policy and Planning

GSM uses Time Division Multiple Access (TDMA) as its air interface standard, although it is not compatible with TDMA IS-136. While in principle the GSM system can be implemented in any frequency band, there are far fewer bands where GSM handsets are available. There are five frequency bands used by GSM mobile phones: GSM 900, GSM 1800, GSM 850, GSM 1900 and GSM 400. Of these, GSM 900 and GSM 1800 are used in most parts of the world, with GSM 850 and 1900 limited mainly to the Americas. GSM 400 has seen very little deployment so far.

GSM 900

Three bands are used for GSM 900:

- **Standard:** GSM 900 uses 890 - 915 MHz for the uplink and 935 - 960 MHz for the downlink, providing 124 RF channels spaced at 200 kHz. Duplex spacing of 45 MHz is used.
- **Extended GSM:** In some countries the GSM 900 band has been extended to cover a larger frequency range. This 'extended GSM', E-GSM, adds the frequency range 880 - 890 MHz (uplink) and 925 - 935 MHz (downlink), thus adding 50 traffic channels to the original GSM 900 band.
- **GSM-R:** The GSM specifications also describe a variant, providing specialised services for use by railways. This is intended to operate in the adjacent frequencies, 876 - 880 MHz (uplink) and 921 - 925 MHz (downlink).

GSM 1800

GSM 1800 uses 1710 - 1785 MHz for the uplink and 1805 - 1880 MHz for the downlink, providing 299 channels. Duplex spacing is 95 MHz. GSM 1800 is also called PCS in Hong Kong⁷.

GSM 850 and GSM 1900 (US standard frequencies for GSM)

GSM 850 and GSM 1900 are used in the United States, Canada, and many other countries in the Americas. GSM 850 is also sometimes called GSM 800. PCS is an acronym for Personal Communications Service, and merely represents the original name in North America for the 1900 MHz band. Cellular is the term used to describe the 850 MHz band, as the original analogue cellular mobile

⁷ Note that this uses different frequencies from the US version of PCS..

Consultation

Spectrum Policy and Planning

communication system was allocated in this spectrum. Providers commonly operate in one or both frequency ranges.

The specific bands used are:

- GSM 850 uses 824 - 849 MHz for the uplink and 869 - 894 MHz for the downlink
- GSM 1900 uses 1850 - 1910 MHz for the uplink and 1930 - 1990 MHz for the downlink

GSM 400

A much less common GSM version is GSM 400. It uses the same frequency as, and can co-exist with, old analogue NMT systems⁸. It operates in either 450.4 - 457.6 MHz paired with 460.4 - 467.6 MHz, or 478.8 - 486 MHz paired with 488.8 - 496 MHz.

GPRS

The General Packet Radio Service (GPRS) is an enhancement of the basic GSM standard. It enables operators to offer higher rate and always on data services (such as mobile email and mobile internet access). GPRS is now very widely deployed amongst GSM operators world-wide. GPRS achieves data rates of up to 40kbps.

The upgrade of a GSM network to GPRS requires both changes on the radio side and the addition of an overlay data network through which the data packets are transported and routed.

EDGE

EDGE stands for Enhanced Data Rates for GSM. EDGE builds upon and enhances GPRS by increasing the GPRS data rates by a factor of two to three. The higher data rate is achieved by using a higher-order modulation technique than that used by GSM/GPRS. It uses the same radio channel structure as GSM/GPRS and essentially the same overlay data network as GPRS. In many cases it is possible to upgrade a GPRS capable network to EDGE with software upgrades and minor hardware changes.

After a slow start, EDGE deployments took off in 2002 with operators such as VoiceStream, AT&T Wireless and Cingular all announcing plans to deploy EDGE.

⁸ NMT is a first generation (1G) mobile phone system which was primarily used in Nordic countries, Eastern Europe and Russia prior to the introduction of GSM

Consultation

Spectrum Policy and Planning

The enthusiasm in Europe has been far less, with TIM being the only operator to actively promote EDGE.

The higher data rates available with EDGE mean that it can be used to provide many of the services available with 3G networks. It therefore provides mobile operators with at least an interim step towards 3G.

Options assessment: Neither GPRS nor EDGE inherently require additional spectrum. However, the provision of higher data throughputs occupies network capacity and, depending on the amount of GPRS/EDGE traffic carried, can lead to a requirement for additional capacity which may be obtained through additional spectrum. The TRA and the MoT will not include this potential capacity issue in this consultation, as they believe it is premature.

6.3.2 Current allocation, assignment and mechanisms

a) Market development in Bahrain

The mobile market in Bahrain was the first area to open to competition. In April 2003, a second licence was awarded to MTC-Vodafone via a “beauty contest”, effectively ending Batelco’s monopoly on mobile services. Following the award of the second licence, Bahrain’s mobile penetration jumped from 64% in 2003 to 92% in 2004⁹. Today, Bahrain’s mobile penetration is over 100%, one of the highest of the region.

In January 2005, Batelco had 83% of mobile subscribers¹⁰, although MTC has rapidly managed to acquire market share. In line with other countries of the region (cash-based economies), most mobile services are currently pre-paid (around 80%).

b) Current allocation

The spectrum allocated for GSM follows the standard GSM 900 and GSM 1800 frequencies allocation (see Exhibit 8).

Both standard GSM 900 and extended GSM 900 frequency bands are allocated for the technologies in Bahrain.

No frequency band has been allocated for the deployment of GSM 400.

⁹ Source: Paul Budde Communications, June 2005

¹⁰ Source: Paul Budde Communications, June 2005

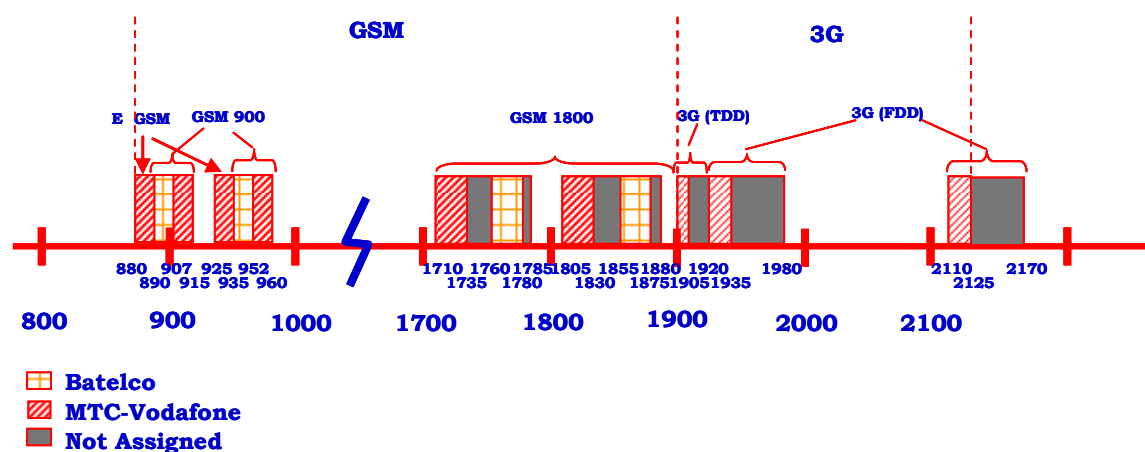
Consultation

Spectrum Policy and Planning

c) Current assignment

Public mobile spectrum is currently split between Batelco and MTC-Vodafone. The two companies have been granted different total amounts of frequency bands. It should also be noted that Extended GSM 900 spectrum has only been assigned to MTC-Vodafone.

Exhibit 8: **Public Mobile spectrum assignments in Bahrain**



d) Licensing mechanisms

The second mobile licence was awarded using a “beauty contest” mechanism. Ten operators participated in the “beauty contest” and three were short-listed, namely, the winner MTC-Vodafone, Wataniya Telecom and Kalaam.

As part of the general licence conditions, a grace period of two years was granted to Batelco and MTC whereby no further licence should be issued until April 2005. The potential introduction of a new mobile licence is therefore now open.

6.3.3 Options for future spectrum policy

As mentioned above, this document does not discuss the possibility of awarding a third mobile licence in this document, but will focus instead on the technical feasibility of such a licence.

GSM 400 spectrum allocation

Consultation

Spectrum Policy and Planning

Although there seems to be interest in the additional allocation of spectrum at 400 MHz for GSM, there are supply constraints:

- The 450.4 - 457.6 MHz paired with 460.4 - 467.6 MHz bands are allocated to government and private and public operator use for fixed and mobile services. Parts of these bands are currently assigned to government users. Further analysis will have to be performed in order to assess whether enough spectrum could be freed in this band to allow for spectrum assignment to a GSM 400 operator
- The 478.8 - 486 MHz paired with 488.8 - 496 MHz are allocated to Broadcast services, outside the remit of TRA. The TRA does not therefore propose to recommend the allocation of spectrum for GSM 400 in these bands

It should be noted that the amount of spectrum potentially available is limited to 2 x 7.2 MHz, and this is around the minimum amount of spectrum required for a practical network. Both GSM and CDMA networks could be deployed in this band, and thus an assignment here would favour neither technology. Finally, another issue that operators would need to consider is the short supply of GSM 400 equipment, as the technology has not been widely deployed.

Option assessment: in order to allocate spectrum for GSM 400, the TRA, the MoT and governmental users would have to assess whether the bands currently in use by governmental applications could be released and exchanged for other bands. The TRA and the MoT believe that spectrum should not be allocated and assigned unless there is a strong case for introducing a new mobile operator in the 400 MHz frequency bands. Although the better economics of GSM 400 network roll-outs have been evidenced in emerging markets with large coverage requirements, it is unlikely that the same would apply in this case, given Bahrain's topology and current mobile penetration. Furthermore, assignment of spectrum for public mobile services would need to be reviewed in conjunction with the assignment of spectrum in the 1800 MHz frequency bands. The TRA and the MoT do not believe that licences in both the 1800 MHz and 400 MHz frequency bands could be assigned to public mobile services, given the current conditions of the mobile market in Bahrain.

Note that CDMA450 could in theory be deployed in this band, and therefore a technology-neutral licence could be awarded for this frequency band.

Consultation:

10. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that spectrum should not be allocated for future public mobile services in the 400 MHz band.

Consultation

Spectrum Policy and Planning

Option assessment: GSM 850 and 1900 are US standards. Established operators in Bahrain are currently on GSM 900, however, there is potentially 2 x 10 MHz of bandwidth in the 850 MHz band which could be used for either GSM or CDMA networks. Assignment in the 1900 MHz band is technically possible but not optimal, as it would be in conflict with current public mobile assignments and future use for 3G. The TRA and the MoT will therefore only consider allocation in the 850 MHz band. Furthermore, the TRA and the MoT suggest that spectrum allocation in the 850 MHz band should only be used if the GSM 1800 allocation has to be ruled out because of supply constraints.

Consultation:

11. The TRA and the MoT seek initial respondent views, with reasons, on whether spectrum should be allocated for future public mobile services in the 850MHz band as an alternative to the 1800MHz band.

E-GSM and GSM 900 spectrum assignment

Both E-GSM and GSM capacity have been fully allocated to MTC Vodafone and Batelco (see Exhibit 8), and therefore no additional spectrum assignment can be made in these bands.

GSM 1800 spectrum assignment

Options assessment: there is currently enough free spectrum in the 1800 MHz bands allocated to GSM to assign it for a public mobile network. It is therefore technically possible for the TRA to award another licence in the GSM band.

Consultation:

12. The TRA and the MoT seek initial respondent views, with reasons, on whether spectrum should be allocated for future public mobile services in the 1800MHz band.

In summary, there appear three options for future spectrum allocation and/or assignment for GSM:

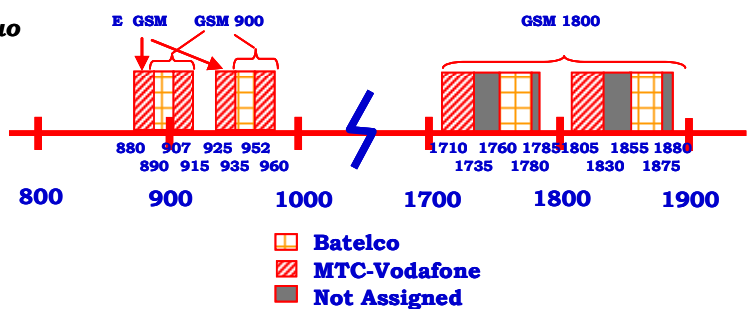
- Option 1: allocate (and assign) spectrum to GSM 400 only (2x7.2MHz)
- Option 2: allocate (and assign) spectrum to GSM 850 only (2x10MHz)
- Option 3: assign a new licence in the 1800 MHz band (2x(15+5) MHz)

Consultation

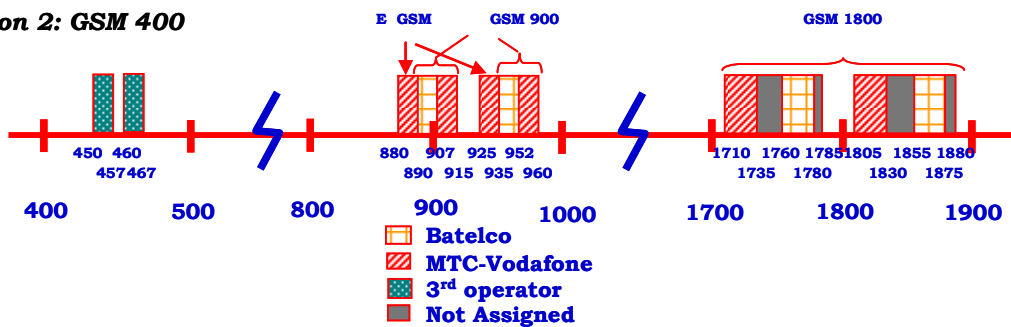
Spectrum Policy and Planning

Exhibit 9: Options for future GSM spectrum assignment

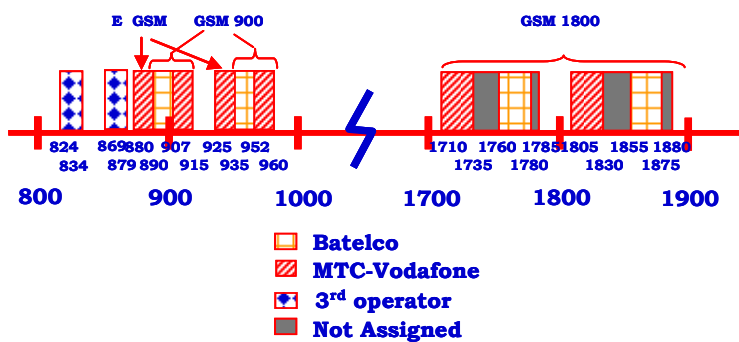
Option 1: Satus quo



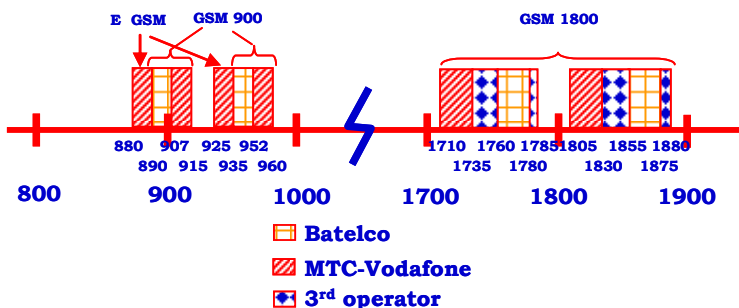
Option 2: GSM 400



Option 3: GSM 850



Option 4: GSM 1800



Consultation

Spectrum Policy and Planning

Consultation:

13. The TRA and the MoT seek respondent views, with reasons, on which of these options would be preferable for future allocation and assignment of GSM spectrum.

6.4 “3G” - CDMA2000

6.4.1 Background and trends

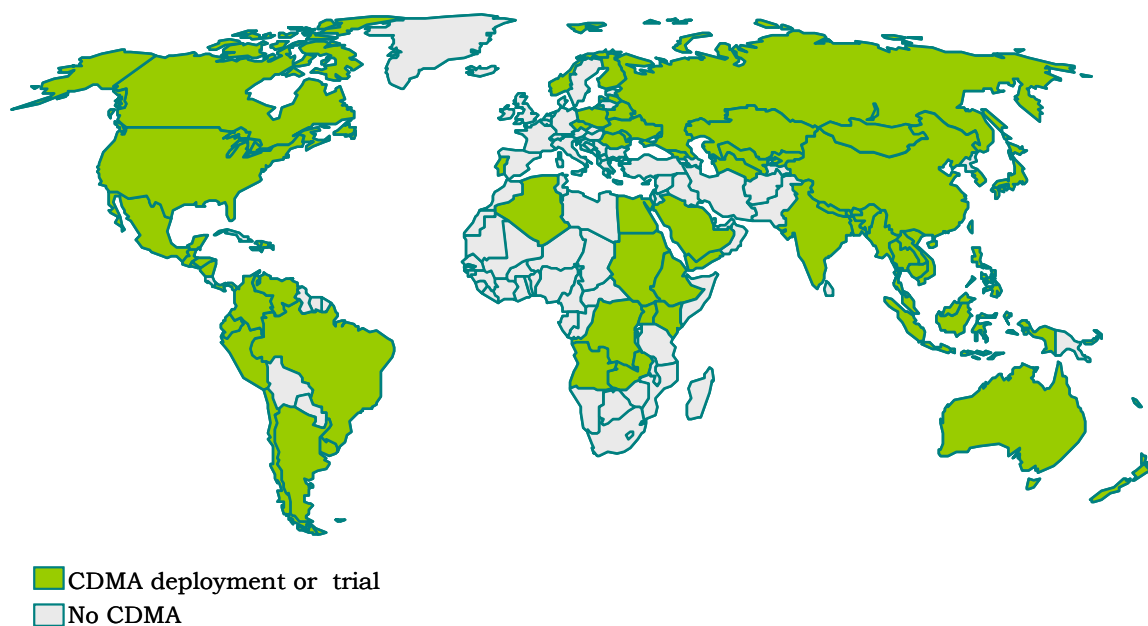
CDMA2000 is one of the approved radio interfaces for the ITU's IMT-2000 standard, and a successor to 2G CDMA (IS-95, branded CDMA-One). CDMA2000 has a relatively long technical history, and remains compatible with the older CDMA telephony methods (such as CDMA-One) first developed by Qualcomm, a commercial company, and holder of several key international patents on the technology. CDMA2000 is an incompatible competitor of the other major 3G standard W-CDMA (UMTS).

There are currently over 270m CDMA users in the world, mostly concentrated in North America and Asia-Pacific (see Exhibit 10). In a few countries (e.g. Australia, China, India, US), both CDMA and GSM technologies co-exist, a situation which could potentially be replicated for Bahrain. Globally, CDMA2000 has about 47% of the deployment contracts versus 53% for W-CDMA. Most CDMA2000 operators have deployed CDMA2000 1x (100 commercial deployments), although CDMA2000 1xEV-DO is gaining ground (21 commercial deployments). Not surprisingly the North America region has the highest number of CDMA2000 contracts, followed by the Asia-Pacific region.

Consultation

Spectrum Policy and Planning

Exhibit 10: CDMA deployments or trials worldwide (2005)



Most of the CDMA deployments have occurred in the 1800 MHz (Americas) and 1900 MHz (elsewhere). Additionally, mobile spectrum is allocated to CDMA in the 800 and 900 MHz. More recently, a few operators rolled out wireless and fixed wireless networks using CDMA450 (in the 450 MHz band) especially in developing countries (Sudan, Romania, etc).

The frequency bands allocated to CDMA2000 are:

- 825–845 MHz paired with 870–890 MHz (as used in the Americas);
- 890–915 MHz paired with 935–960 MHz (as used in Europe);
- 1710–1785 MHz paired with 1805–1880 MHz (as used in the Americas);
- 1920–1980 MHz paired with 2110–2170 MHz (as used in Europe)

Like W-CDMA, CDMA2000 comprises a series of releases, with each new release adding more functionality, offering enhancements to the existing standard, and fixing known bugs in the prior releases¹¹.

¹¹ Before cdma2000, the IS-95 CDMA standard had two releases. IS-95A (1994) improved the capacity for voice services, while IS-95B (1998) reportedly increased network capacity by an additional 20% and offered a potential maximum data rate of 78.6 kbps or 115.2 kbps, depending on its implementation, with the advertised maximum rate being 64 kbps.

Consultation

Spectrum Policy and Planning

The evolution path for the CDMA2000 family consists of:

- CDMA2000 1xRTT
- CDMA2000 1xEV-DO
- CDMA2000 1xEV-DV
- CDMA2000 3x

We briefly describe each of these below. It is important to note that, unlike the GSM to W-CDMA upgrade, there is no impact on frequency assignments in the CDMA2000 upgrades.

CDMA2000 1x / CDMA2000 1xRTT

CDMA2000 1x, also known as 1xRTT, is the core CDMA2000 technology. The designation 1x is used to identify the version of CDMA2000 radio technology that operates in one pair of 1.25 MHz radio channels.

CDMA2000 1xRTT (Radio Transmission Technology) is the basic layer of CDMA2000, which supports up to 144 kbps packet data speeds. While 1xRTT officially qualifies as 3G technology, 1xRTT is usually considered to be a 2.5G (or sometimes 2.75G) technology. Although capable of higher data rates, most deployments have limited the data rate to around 150 kbps.

CDMA2000 1xEV-DO

CDMA2000 1xEV (Evolution) is CDMA2000 1x with High Data Rate (HDR) capability added. Phase 1 of CDMA2000 1xEV, CDMA2000 1xEV-DO (Evolution-Data Optimized) supports downlink data rates of up to 3.1 Mbps and uplink rates of up to 1.8 Mbps in a radio channel dedicated to carrying high-speed packet data.

CDMA2000 1xEV-DO has been deployed commercially nationwide in Japan since December 2003 with transfer rates of 2.4Mbps, which is about 6 times faster than UMTS in the first development stage in major cities of Europe (around 2005). Verizon Wireless in North America has begun nationwide deployment of 1xEV-DO, and Alaska Communications Systems, or ACS, has begun deployment of 1xEV-DO in the main population centres of Alaska. Sprint PCS, also in North America, has announced its intention to deploy 1xEV-DO nationally.

CDMA2000 1xEV-DV

CDMA2000 1xEV-DV (Evolution-Data and Voice), supports downlink data rates of up to 3.1 Mbps and uplink rates of up to 1.8 Mbps. 1xEV-DV can also support

Consultation

Spectrum Policy and Planning

concurrent operation of legacy 1x voice users, 1xRTT data users, and high speed 1xEV-DV data users within the same radio channel.

Apart from a few tests in South Korea, there are no major commercial deployments of 1xEV-DV. Sprint PCS in the US had announced plans to deploy a 1xEV-DV network on top of their existing CDMA network. However, due to delays in the availability of 1xEV-DV equipment and competitive pressures from other American networks deploying 3G networks, Sprint announced, in June 2004, its intention to broadly deploy 1xEV-DO. Qualcomm has recently put the development of EV-DV on hold, due to lack of carrier interest, mostly because both Sprint and Verizon are using EV-DO.

CDMA2000 3x

CDMA2000 3x utilizes a pair of 3.75 MHz radio channels (i.e., 3 X 1.25 MHz) to achieve higher data rates. The 3X version of CDMA2000 is sometimes referred to as Multi-Carrier or MC. The 3x version of CDMA2000 has not been deployed and is not under development at present.

Other technologies- recent developments

TD-SCDMA

TD-SCDMA (Time Division Synchronous Code Division Multiple Access) was originally submitted by the Chinese standards body CWTS (China Wireless Telecommunication Standard) in 1998 as its recommended 3G standard. The ITU approved TD-SCDMA as a 3G standard in 2001, and the 3GPP has included it in the UMTS standard.

TD-SCDMA is a hybrid technology that incorporates aspects of TDMA and CDMA. The "S" in TD-SCDMA refers to the synchronization (like CDMA2000, but unlike W-CDMA which is asynchronous) between the base station and terminal in order to eliminate traffic collisions due to multiple devices located at various distances from the base station all trying to transmit at the same time.

TD-SCDMA can operate in a bandwidth of only 1.6 MHz. TD-SCDMA can reportedly support data rates of up to 2 Mbps in a 1.6 MHz channel¹², with dynamic allocation between the uplink and downlink according to user and network demands.

In Europe, 3G licensees with TDD spectrum and an interest in TD-SCDMA would most likely deploy three 1.6 MHz carriers in each 5 MHz of TDD spectrum, with the remaining spectrum used for guard bands.

¹² TD-SCDMA also has a 5 MHz mode supporting 6 Mbps data rates.

Consultation

Spectrum Policy and Planning

UMTS — TDD

UMTS-TDD stands for Universal Mobile Telecommunications System — Time Division Duplex and is part of the 3G standard (UMTS) being deployed primarily by GSM operators in Europe and elsewhere around the world.

The intent of UMTS is to use the FDD spectrum for voice and data services, while the TDD spectrum will eventually be used to provide high data rates in 3G "hot spots."

There are two companies targeting this market, California-based IPWireless (IPW), and Pennsylvania-based InterDigital, with IPW being much further ahead in the development cycle and having gained the most traction from potential customers and partners.

There are a number of deployments of TDD across the world, including UK Broadband (UK), Airdata (Germany) and Whoosh (New Zealand).

Flash-OFDM

Flash-OFDM (orthogonal frequency division multiplexing) is a mobile broadband wireless access solution proposed by U.S.-based Flarion Technologies. The flash-OFDM solution achieves its results by using a new radio interface (flash-OFDM) and a new MAC¹³ layer. Flarion considers its offering, which is commercially available today, as an alternative solution for mobile and fixed operators who wish to take advantage of the performance and cost efficiencies of an all-IP wireless network and deliver true broadband access in a mobile, nomadic or fixed environment.

There has been a lot of interest and activity surrounding the company, especially in Asia. Hanaro Telecom (2.3 GHz), Korea Telecom and SK Telecom (800 MHz) have completed network trials, with SKT becoming an investor in the company. Qualcomm now owns Flarion.

U.S.-based Nextel Communications has also conducted a trial of Flarion's technology in Northern Virginia and has publicly announced that flash-OFDM would become part of its commercial wireless offering.

Flarion is also an active participant in the recently formed IEEE 802.20 Standards Board and is looking to get standards approval for its technology.

¹³ Media Access Control

Consultation

Spectrum Policy and Planning

6.4.2 **Current allocation, assignment and mechanisms**

In Bahrain, no frequency bands are currently allocated to CDMA.

6.4.3 **Options for future spectrum policy**

General view on technology neutrality

A few countries, including India, Malaysia, the US and Australia, have adopted a technology-neutral view to spectrum allocation. In Australia, technology neutral licence auctions (1999) have created a mix of GSM and CDMA networks (see Australia Case Study - Exhibit 11).

The TRA and the MoT adopt a technology-neutral approach, and mobile operators in the future will be free to choose any technology for public mobile services, provided there is frequency available, it does not interfere with other bands and there is a precedent for deployment.

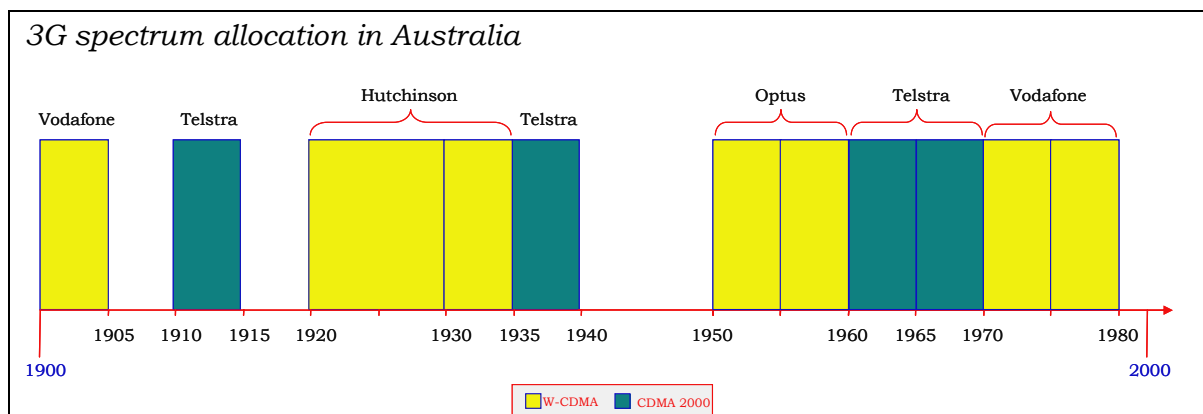
Exhibit 11: Australia Case Study

Cellular operators in Australia

Operator	Cellular Standard	Launch
Telstra	<ul style="list-style-type: none">GSM (1800MHz)CDMA (1900MHz)	<ul style="list-style-type: none">19932000
C&W Optus	<ul style="list-style-type: none">GSM (1800MHz)	<ul style="list-style-type: none">1993
Hutchinson	<ul style="list-style-type: none">CDMA (800MHz)	<ul style="list-style-type: none">2000
Vodafone	<ul style="list-style-type: none">GSM (1800MHz)	<ul style="list-style-type: none">1993

Consultation

Spectrum Policy and Planning



Options assessment: For any new license, the TRA will conduct a technology-neutral award process. The TRA would therefore leave the technology decision between CDMA and GSM to the operator.

450 MHz spectrum assignment

The great majority of CDMA deployments have been in the 800 MHz and 1900 MHz bands, with some deployments at 450 MHz, 850 MHz, 1700 MHz and 2100 MHz. Thus a network based on CDMA technology could be deployed in the 450 – 470 MHz band discussed earlier (with respect to GSM 400), subject to an assessment of what spectrum could be made available in this band.

It should be noted that the amount of spectrum potentially available is limited to 2 x 7.2 MHz, and this is around the minimum amount of spectrum required for a practical network. Both GSM and CDMA networks could be deployed in this band, and thus an assignment here would favour neither technology.

Options assessment: as for GSM 400, the TRA and the MoT believe that the latter should not allocate spectrum in the 400 MHz band for public mobile services.

Consultation:

14. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that spectrum should not be allocated for public mobile services in the 450 MHz band.

1800 MHz Spectrum assignment

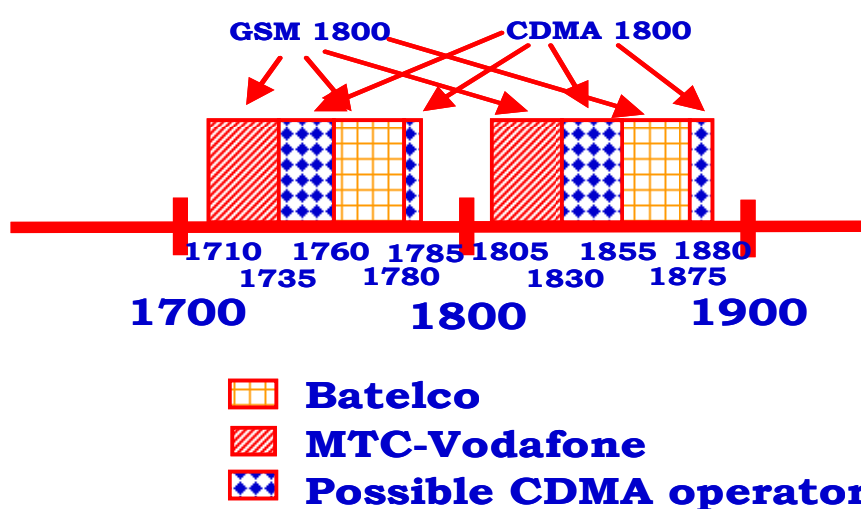
There is currently enough spare spectrum within the 1800 MHz band to assign to new mobile operators (one block of 2 x 25 MHz plus one of 2 x 5 MHz). However,

Consultation

Spectrum Policy and Planning

with no current deployment of the CDMA technology in this band, equipment may be expensive or unobtainable.

Exhibit 12: Assignment within the 1800 MHz band



Options assessment: although CDMA equipment availability will be limited in the 1800 MHz band, the TRA proposes that, subject to spectrum allocation by the MoT, any awarding of a licence in this band be made on a technology-neutral basis (GSM or CDMA)

Consultation:

15. The TRA and the MoT seek initial respondent views, with reasons, on whether spectrum should be allocated for future public mobile services in the 1800MHz band on a technology-neutral basis.

1900 MHz spectrum assignment

Many CDMA networks have been deployed in the 1900 MHz band, and equipment is readily available. However, the placement of the 1900 MHz and 1800 MHz bands means that they overlap each other. Given the assignments already made at 1800 MHz (and to MTC-Vodafone in the 3G band), the amount of spectrum that could be made available for mobile operator licences in accordance to the 1900 MHz band plan would be limited to 2 x 25 MHz (1875 – 1900 MHz

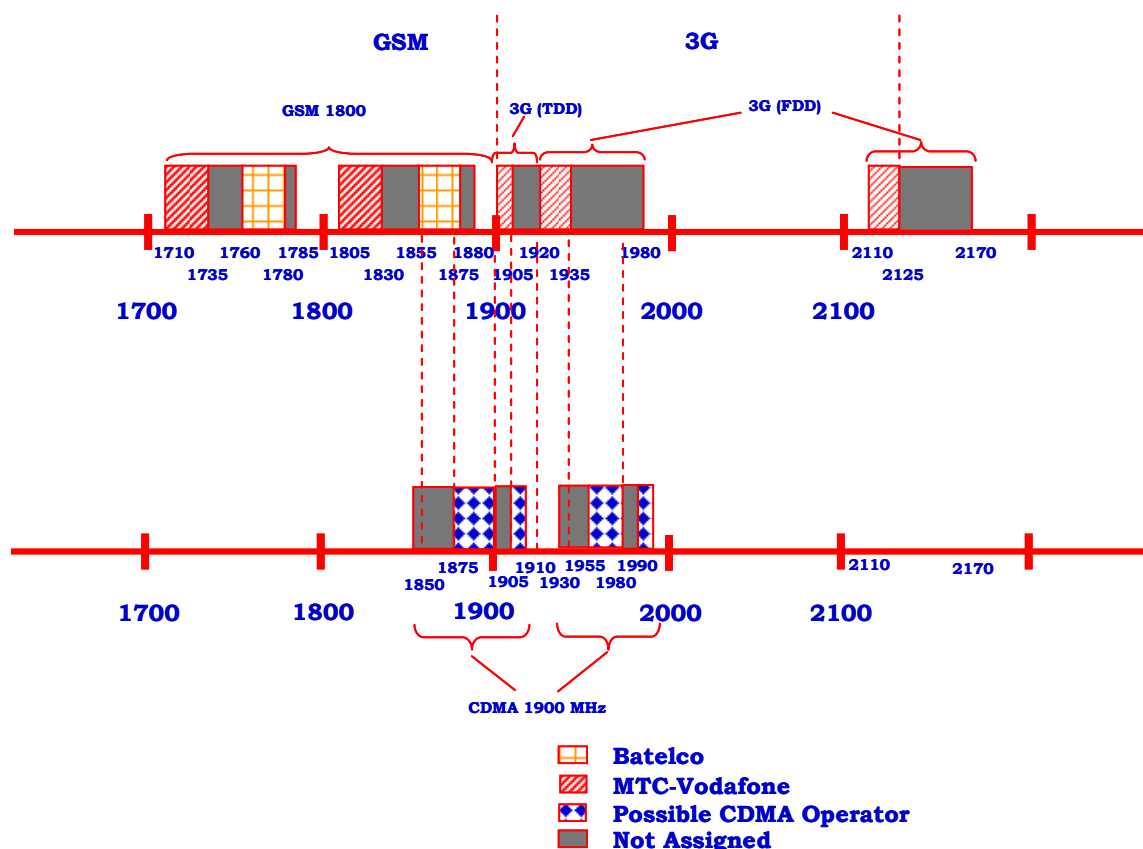
Consultation

Spectrum Policy and Planning

paired with 1955 – 1980 MHz) plus 2 x 5 MHz (1905 – 1910 MHz paired with 1935 – 1940 MHz).

This is illustrated in Exhibit 13, which also shows how such an assignment would prevent the assignment of 2 x 5 MHz within the 1800 MHz band (1780 – 1785 MHz paired with 1875 – 1880 MHz) and also limit future assignments in the 3G band to one block of 2 x 20 MHz (1935 – 1955 MHz paired with 2125 – 2145 MHz) plus one block of 1 x 5 MHz (1910 – 1920 MHz).

Exhibit 13: Assignment within the 1900 MHz band



It should also be noted that the band 1880 to 1900 MHz is widely used for DECT cordless telephone and WLL systems, and any such use in Bahrain would be precluded by an assignment in accordance with the 1900 MHz band plan. In addition, GSM systems are also available for the 1900 MHz band, thus an assignment from this band would favour neither the GSM nor CDMA technologies.

Consultation

Spectrum Policy and Planning

Options assessment: in assessing whether or not to allocate spectrum for additional mobile operator(s) in accordance with the 1900 MHz band plan, the TRA, the MoT and other stakeholders will need to consider amongst other factors:

- The benefits of an assignment which is equally favourable to both GSM and CDMA
- The disadvantages of limiting future access to the 3G band
- The disadvantages of precluding the deployment of DECT systems in the 1880 to 1900 MHz band

The TRA and MoT's view is that, although technically possible, assignment of spectrum to a new mobile network in the 1900 MHz band is not optimal.

Consultation:

16. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that spectrum should not be allocated for future public mobile services in the 1900 MHz band (apart from the existing allocations).

Other technologies – recent developments

TD-SCDMA

Options assessment: to date, no operator outside of China has expressed any interest in deploying the TD-SCDMA technology. The TRA and the MoT believe that little interest will be generated for this technology in Bahrain, and therefore do not plan to make any specific allocations for TD-SCDMA deployments. However, TD-SCDMA can be deployed in the UMTS – TDD spectrum, thus suggesting a technology-neutral use of the UMTS - TDD spectrum.

Consultation:

17. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that:

(1) the MoT should not plan to make any specific allocations for TD-SCDMA in Bahrain, although UMTS - TDD spectrum could be used to deploy the TD-SCDMA technology.

(2) the TRA and the MoT should therefore render the UMTS – TDD spectrum “technology-neutral”.

Consultation

Spectrum Policy and Planning

UMTS-TDD

Options assessment: MTC-Vodafone was granted UMTS-TDD frequencies as part of its 3G spectrum. The remaining spectrum has been allocated for a potential three additional operators¹⁴. When conducting the allocation of additional 3G spectrum, the TRA and the MoT will need to consider assignment of UMTS-TDD for potential new operators. A few technologies could eventually be deployed in the UMTS – TDD band, for instance TD-SCDMA, and therefore, the TRA and the MoT suggest that future award of spectrum for UMTS-TDD bands should be technology-neutral.

Consultation:

18. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that:

(1) the MoT should continue with the current allocation of frequency bands for UMTS-TDD.

(2) future awarding of spectrum should be on a technology-neutral basis.

Flash OFDM

Options assessment: given the amount of interest generated by Flash OFDM, the MoT plans to allocate frequency bands where the technology could be deployed. However, as spectrum is pretty scarce in the 2.1 – 2.3 GHz bands, the TRA and the MoT would recommend deploying the technology at 450 MHz. To remain in line with a technology-neutral view, the TRA and the MoT would recommend opening up spectrum on a technology-neutral basis in the 450 MHz band.

Consultation:

19. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that the TRA and the MoT should allocate and assign frequency bands in the 450 MHz band on a technology-neutral basis for the deployment of mobile or fixed mobile technologies such as Flash OFDM.

¹⁴ This includes spectrum reserved for Batelco to utilize in accordance with its license for mobile telecommunications.

Consultation

Spectrum Policy and Planning

6.5 “3G” – W-CDMA

6.5.1 *Background and trends*

Universal Mobile Telecommunications System (UMTS) is the solution proposed by ETSI (European Telecommunications Standards Institute) for 3G. The ITU (International Telecommunication Union) has established certain 3G performance standards that apply regardless of the underlying technology standards. These standards are called IMT-2000. The IMT stands for International Mobile Telecommunications. 2000 stands for the targeted frequency in which 3G was intended to operate, as well as the initial launch date.

UMTS uses Wideband CDMA (W-CDMA) as its radio interface technology; thus, “UMTS” and “W-CDMA” are sometimes used interchangeably. Additionally, UMTS is sometimes referred to as 3G, even though there are other 3G solutions that are completely different from UMTS (CDMA2000).

Terrestrial services will operate in the FDD mode in the bands 1920 - 1980 MHz paired with 2110 - 2170 MHz, with mobile stations transmitting in the lower sub-band and base stations transmitting in the upper sub-band. The bands 1885 - 1920 MHz and 2010 - 2025 MHz are unpaired for TDD operation¹⁵.

There are additional bands that have been identified. WRC 2000 identified an additional 190 MHz of spectrum, on a global basis, for IMT-2000. It also earmarked the present second-generation mobile bands for IMT 2000, to facilitate evolution/reframing in future. The new IMT-2000 bands are as follows:

- 806 - 960 MHz (includes the GSM 900 allocation)
- 1710 - 1885 MHz (includes the GSM 1800 allocation)
- 2500 - 2690 MHz

The additional bands identified are 2520 - 2670 MHz for the terrestrial component and 2500 - 2520 / 2670 - 2690 MHz for the satellite component, although terrestrial services could be implemented in the whole band.

Other developments

At this stage, the TRA and the MoT do not believe that the recent developments in UMTS 3G will impact the frequency allocation strategy of Bahrain. One key technology development is the movement to ‘3.5G’, an upgrade more commonly referred to as HSDPA/ HSUPA.

¹⁵ Source: GSMA

Consultation

Spectrum Policy and Planning

3.5G: High-Speed Downlink Packet Access (HSDPA)

The first evolution beyond W-CDMA is called High-Speed Downlink Packet Access (HSDPA). HSDPA, which is part of Release 5, promises data rates of up to 10Mbps in the downlink¹⁶. The 3GPP is the organizational body addressing this standard.

HSDPA is beginning to reach deployment status in North America. Cingular has announced that it will begin to deploy UMTS with expansion to HSDPA in 2005. Cingular faces competitive pressure from operators such as Verizon who use a competing 3G technology, CDMA2000 1xEV-DO, and who have already deployed a similar high-speed data service.

In Japan, KDDI has been commercially deploying 3.5G services based on a nationwide CDMA2000 1xEV-DO network since December 2003. Docomo has recently announced (2005) that it will introduce HSDPA from 2006.

In Germany, T-Mobile will officially introduce its HSDPA service at the CeBIT 2006.

3.75G: High-Speed Uplink Packet Access

HSUPA, High-Speed Uplink Packet Access, is a data access protocol for mobile phone networks with extremely high upload speeds of up to 5.8 Mbps. Similar to HSDPA (High-Speed Downlink Packet Access), HSUPA is considered 3.75G or sometimes 4G.

In Austria, T-Mobile is planning to introduce HSUPA in 2007 or 2008. NTT DoCoMo has also announced its intention to move to HSUPA, but no date has been set.

- The specifications for HSUPA are still under development as of July 2005 and will be included in UMTS Release 6.

4G (no standards yet)

4G is the successor of 3G and is typically used to describe a number of different but overlapping ideas:

- *High-speed mobile wireless access* with a very high data transmission speed, of the same order of magnitude as a slow local area network connection (up to 20 Mbps). It has been used to describe wireless LAN technologies like WiFi, as well as other potential successors of the current 3G mobile telephone standards.

¹⁶ By using a different modulation scheme, MIMO (multiple-input, multiple-output) antennas, faster radio link adaptation to adjust to changes in the radio link and faster retransmission of packets.

Consultation

Spectrum Policy and Planning

- “*Pervasive networks*” is an amorphous and presently entirely hypothetical concept, whereby the user can be simultaneously connected to several wireless access technologies and can seamlessly move between them. These access technologies can be WiFi, UMTS, EDGE or any other future access technology. This concept also includes smart-radio technology to efficiently manage spectrum use and transmission power, as well as the use of mesh routing protocols to create a pervasive network¹⁷

These standards do not exist at the moment and the concept of ‘4G’ is only at the discussion level in this consultation.

Options assessment: the TRA and the MoT do not plan to include any “3.5G” or “4G” development in the frequency allocation and planning. The TRA and the MoT believe they should leave the technological decisions on 3G future upgrades to market players.

Consultation:

20. The TRA and the MoT seek input from respondents, with reasons, on whether they agree with their approach to leave the future use of 3G spectrum (upgrade to “3.5G” and “4G”) to the discretion of market players.

6.5.2 Current allocation, assignment and mechanisms

Spectrum allocation

FDD and TDD bands between 1900 MHz and 2170 MHz have been allocated to public operator use for fixed and mobile services, and more specifically for 3G use. In particular, the following bands have been allocated for 3G:

- FDD: 1920 MHz – 1980 MHz paired with 2110 MHz – 2170 MHz
- TDD: 1900 MHz – 1920 MHz

In many European countries, the band 2010 MHz – 2025 MHz has been reserved for self-provided 3G systems, that is for systems (such as WLANS) which would be installed and operated by the end user, probably on a licence-exempt basis. To date, however, the standards do not support a self-provided mode of operation and there has been no use of this band for 3G.

¹⁷ www.wikipedia.org; <http://www.alcatel.com/publications>

Consultation

Spectrum Policy and Planning

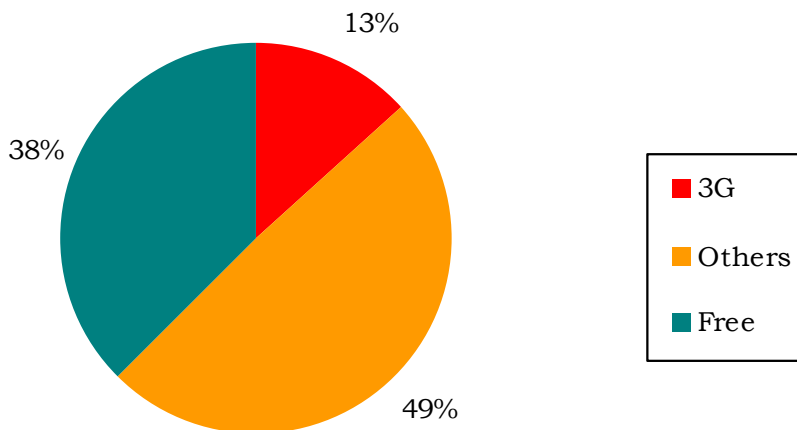
Spectrum assignment

To date, only MTC-Vodafone has been assigned 3G frequency spectrum as part of the award of the second mobile licence. It was assigned 1 x 5 MHz within the 1900 – 1920 MHz TDD band, and 2 x 15 MHz within the 1920 – 1980 MHz / 2110 – 2170 MHz FDD band.

The spectrum between 1427 MHz and 2700 MHz is currently in use by governmental applications. Its specific usage in the 3G bands is between 1935 and 2062.5 MHz. This does not cause any conflict with the existing assignment to MTC-Vodafone but, as illustrated in Exhibit 15 below, it does potentially restrict further use of the 3G bands.

There is an additional 97.5 MHz free in this band (15 MHz + 37.5 MHz + 35 MHz, see Exhibit 15)¹⁸.

Exhibit 14: % assignment of spectrum in the 1900 MHz-2175 MHz band

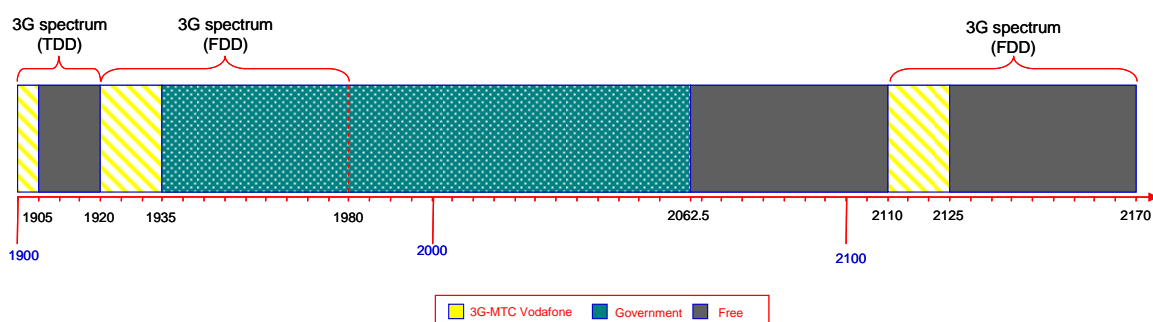


¹⁸ This includes spectrum reserved for utilization of Batelco in accordance with its license for mobile telecommunications.

Consultation

Spectrum Policy and Planning

Exhibit 15: Current use of spectrum in the 1900 MHz – 2170 MHz band



The current usage of these frequencies for government applications has been discussed and clarified. There does not, at present, seem to be any usage in the 3G spectrum that could interfere with future 3G assignment.

Licensing mechanism

The first 3G spectrum was granted to MTC-Vodafone as part of the 2003 “beauty contest”. Currently, MTC-Vodafone is the only public operator with 3G frequencies assignment. The annual price per channel is 800 BD p.a. or 140,000 BD p.a. for the overall 3G spectrum granted to MTC-Vodafone. On top of this charge, MTC-Vodafone pays 1% of its gross revenues for mobile licence activities.

6.5.3 Options for future spectrum policy

Spectrum allocation

MTC-Vodafone is the only user of 3G spectrum at present. The current allocation of spectrum to 3G is in line with international standards and provides Bahrain with enough room for future development: 75% of the WCDMA FDD and TDD spectrum is still unassigned to mobile operators. Given the demographics of Bahrain, there is sufficient available spectrum to support two to four additional W-CDMA networks. However, it is also unlikely that, given Bahrain’s population and the high existing penetration levels, the market would support this number of networks. New operators will need to take part in an auction. Finally, future technology upgrades such as HSUPA/HSDPA will be left to the market to decide.

Options assessment: the TRA and the MoT believe that the current spectrum allocation to 3G is guaranteed to cover the need for further 3G roll-out, is compliant with international standards, and therefore should remain the same. Since the current potential usage of 3G spectrum for government applications

Consultation

Spectrum Policy and Planning

has been discussed and clarified, the TRA and the MoT do not foresee any potential issue for future assignment of spectrum from public mobile services in the 3G band.

Consultation:

21. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that the current 3G spectrum allocation should remain the same.

Consultation

Spectrum Policy and Planning

7 Private mobile radio

7.1 Summary

Private Mobile Radio (PMR) is a generic term used to describe a range of land mobile radio services, including three main branches: Analogue, Short Range Radio and Digital.

The TRA and the MoT have reviewed the current use of spectrum in Bahrain for these mobile radio services and developed the following options for future governance and policy:

- (1) The TRA and the MoT will continue to support analogue PMR in Bahrain, although they would like to see and foster eventual migration of users from analogue to digital.
- (2) The TRA and the MoT will explore alternative “walkie-talkie” technologies similar to PMR 446, as the 446 MHz band is currently in use by other applications. The TRA and the MoT will also initiate discussions with the entity using the 446MHz band to see if they are willing to surrender the spectrum.
- (3) The TRA and the MoT would not recommend the roll-out of Short Range Biz Radio and Paging (SRBR/ SRBP).
- (4) The TRA and the MoT would favour the deployment of commercial TETRA, but need to assess the impact of frequency-supply constraints.
- (5) The TRA and the MoT could have considered the roll-out of iDEN on a technology-neutral basis, but spectrum-supply constraints are very likely to prevent any iDEN deployment in Bahrain.
- (6) For public commercial applications, the TRA considers the use of auctions as the preferred mode of assignment. However, for private users (companies, closed user groups or individuals), the TRA considers a First Come First Served approach which could revert to auctions if justified by demand.
- (7) Across all usages, the TRA and the MoT propose a nominal annual administrative fee to cover the TRA’s costs in addition to the MoT’s fees for the spectrum usage.
- (8) All equipment will need type approval prior to being authorised for import.

7.2 Introduction

Private Mobile Radio (PMR) is a generic term used to describe a range of land mobile radio services. PMR provides professional users with immediate access to

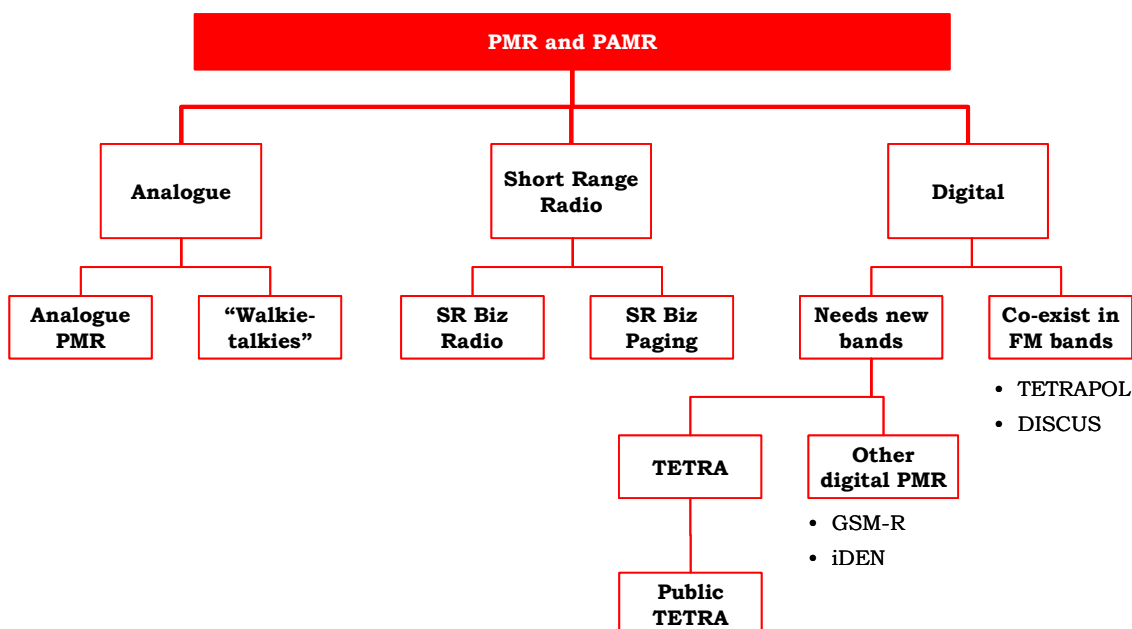
Consultation

Spectrum Policy and Planning

2-way tailored networks, customised features and specific coverage for voice and data, using appropriate signalling and protocols through owned or shared infrastructures with easily controllable costs even when connected to PSTN networks.

Exhibit 16 below describes the various technology options that reside under the PMR umbrella.

Exhibit 16: **Technologies under the PMR umbrella**



In Region-I (Europe), PMR operates in a range of frequency bands from 26 MHz to 5.8 GHz, from onsite paging using 26 MHz through to WLANs at microwave frequencies. PMR mainly operates with 12.5/25 kHz channels offering services such as voice and low data rates (<28Kbits/s).

We present each technology within the PMR family and discuss potential implications of spectrum allocation on the roll-out of these technologies in Bahrain.

Consultation

Spectrum Policy and Planning

7.3 Analogue

7.3.1 Analogue PMR

a) Background and trends

Analogue PMR is part of the land mobile radio service based on the use of simplex, half duplex, and possibly full duplex at the terminal level in order to provide closed user group communications.

Analogue PMR continues to see high use across the world, despite issues of interference that have arisen. In Western Europe, since 2001, there has been a significant rise in demand for data services on analogue PMR channels, especially in the taxi/vehicle management sector. In addition, many Local Authorities have installed Private Wide-area trunked systems with data capabilities.

Cost-conscious users prefer analogue PMR systems at present to achieve cost advantages and additional functionality. However, in some markets, Analogue PMR generated less demand, as regulators push usage away from analogue to digital (e.g. Denmark). Regulators across Region I would like to assist in the introduction of Private Digital PMR services, so that the private user can use services at least comparable to those now provided by public digital cellular operators (source: Ofcom/Radio Agency – UK Spectrum 2002).

In terms of frequency allocation, analogue PMR is available across a number of bands up to 1000MHz.

b) Current allocation, assignment and mechanisms

As in many other countries, Analogue PMR is currently widely employed by private users. There are still a number of additional bands available for further usage of Analogue PMR.

c) Options for future spectrum policy

The use of Analogue PMR is likely to remain important in Bahrain. Therefore, these bands should continue to be available in the next few years. Given the percentage of spectrum availability in the Analogue potential PMR bands, there is also scope for additional growth.

Option assessment: the TRA and the MoT would like to leave open the option for further use of Analogue PMR. However, and provided that spectrum-supply issues can be addressed, the TRA and the MoT would like to promote the move from analogue to digital. The TRA and the MoT recommend that future spectrum be awarded through a First Come First Served mechanism, unless spectrum

Consultation

Spectrum Policy and Planning

demand exceeds supply (in which case it could revert to an auctions mechanism). Spectrum pricing for Analogue PMR has traditionally been on the basis of administrative charging. Although Administered Incentive Pricing has been used for Analogue PMR, the TRA and the MoT believe that unless significant additional interest is expressed, they will continue with the administrative charging method. Finally, the import of equipment for Analogue PMR will be governed by ETSI recommendations.

Consultation:

22. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

(1) allocate additional spectrum for Analogue PMR if demand is expressed.

(2) promote the transition of analogue users to digital.

(3) award further spectrum for Analogue PMR use through FCFS, unless spectrum demand exceeds supply (in which case they could revert to an auctions mechanism).

(4) use administrative charging as the approach for spectrum pricing.

7.3.2 “Walkie-talkies”- e.g. PMR 446

a) Background and trends

This popular analogue voice-only service operates on a harmonised European basis (Region I). It provides low cost, licence-exempt (in Europe) 2-way wireless communications.

This service has been highly successful, with many high street retailers selling the radios because of the high demand and ease of operation without a licence in those jurisdictions. For example in the UK, PMR 446 ‘walkie-talkies’ can be purchased for as little at £5 a pair. It is estimated that over 350,000 PMR 446 sets have been sold within the UK (source: Motorola, UK).

In terms of frequency allocation, PMR 446 is in the band 446-446.1 MHz.

b) Current allocation, assignment and mechanisms

PMR 446 is not currently licensed in Bahrain, and frequencies are not currently available in the 446 band.

Consultation

Spectrum Policy and Planning

However it would appear that, walkie-talkie applications are currently popular in Bahrain, but most users buy imported walkie-talkies functioning in illegal bands (commonly referred to as Tiger phones or Chinese walkie-talkies).

c) Options for future spectrum policy

The illegal use of walkie-talkies described above causes major interferences and is discouraged. In most other countries, the PMR walkie-talkie band is free of charge. The PMR walkie-talkie band is licence exempt in most countries and would be subject to a light licensing regime in Bahrain. Since the 446 band is not available in Bahrain, the TRA and the MoT would recommend a similar application in bands used in other regions, for instance the 350 MHz band used in Japan. In the US, there also exists the “Family Radio Service”, operating in the 462/467 MHz band, which is unfortunately already in use in Bahrain. Licences will be needed to buy and sell the equipment, in order to ensure compliance with the relevant technical specifications.

Option assessment: the TRA and the MoT recommend that walkie-talkie applications be licensed by way of a light licensing regime using type approval. The 350 MHz band is available in Bahrain, and the technology used in Japan for these applications could be deployed in this band (Option 1). Another option would be to ask the current user of this band to move to different frequencies (Option 2). For non-commercial uses, this band will be free of charge. Imports of equipment require type approval and are governed by the relevant technical specifications.

Consultation:

23. The TRA and the MoT seek respondent views, with reasons, on which option they should select:

Option 1: allocate spectrum for walkie-talkie applications in frequency bands used for this purpose in other countries.

Option 2: ask current users of this band to move, if possible, to different frequencies.

7.4 Short-range radio

a) Background and trends

Short-range radio covers short-range business radio and short-range business paging. Both services were licensed in Europe under a First –Come –First Served

Consultation

Spectrum Policy and Planning

regime in the mid 1990s, but have since become obsolete with the mass adoption of public mobile services and the success of PMR 446.

For example, in the UK, Short-Range Business Radio (SRBR) was a successful entry-level business radio service in the 1990s. Licences were available until 30th September 1999. With the introduction of PMR 446, licensees were notified that SRBR would be phased out. All existing SRBR frequencies were withdrawn at the end of 2003.

SRBR is complemented by a similar paging service known as Short-Range Business Paging (SRBP) operating in the 450-470 MHz band. This is an unprotected although licensed service for which no licence fee was payable in the UK. This service has also been withdrawn in the UK. It is in terminal decline in all other markets.

b) Options for future spectrum policy

Options assessment: the TRA and the MoT believe that SRBR and SRBP are not relevant for Bahrain. Therefore, they do not propose to allocate frequencies for these services.

Consultation:

24. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should not allocate spectrum for short range radio.

7.5 Digital PMR

Digital technology is widely regarded as the best option available for meeting business needs to communicate by both voice and data. Digital PMR digitises voice as well as providing user data rates that are usually above those provided by Analogue PMR. Additional features, such as power control and error correction, are typical.

The case of TETRAPOL and DISCUS

Two types of Digital PMR exist:

- PMR technology that does not efficiently co-exist with analogue FM systems and therefore does require guard bands, i.e., TETRA, iDEN and GSM-R. This technology is more suitable for high-capacity networks, which currently have dedicated frequency bands;

Consultation

Spectrum Policy and Planning

- PMR technology that can co-exist efficiently in the same spectrum as analogue FM and without guard bands and using a 12.5 kHz channel spacing is TETRAPOL and DISCUS.

Options assessment: given the demographic and geographical characteristics of Bahrain, the TRA and the MoT do not propose to plan frequency allocation for co-existent technologies like TETRAPOL or DISCUS. The TRA and the MoT expect growth in these technologies to be small and limited to only a handful of highly populated countries in Western Europe, notably the UK. In addition, both TETRAPOL and DISCUS can be deployed using existing frequencies allocated to Analogue PMR. However, TETRAPOL and DISCUS could have an interest for small user groups (such as taxis) willing to migrate to digital, as the only alternative would be TETRA, which is more suitable for large numbers of users. If, as a result of this consultation, significant interest is expressed in such a use, the TRA and the MoT could decide to promote migration from Analogue PMR to TETRAPOL and DISCUS.

Consultation:

25. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they:

(1) should not, at this point, allocate spectrum for TETRAPOL and DISCUS, as the technologies would re-use Analogue PMR spectrum.

(2) should decide to promote migration from Analogue PMR to TETRAPOL and DISCUS.

GSM-R

Options assessment: GSM-R is typically used by railways in Region I. Bahrain does not currently have a railway system that needs GSM-R communications. However, the GCC countries are currently planning to build a railway system which could require GSM-R. Therefore, the TRA and the MoT plan to hold discussions with other GCC regulators, in order to assess whether they should allocate spectrum for GSM-R in light of this project.

Consultation:

26. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should consult with other GCC countries to assess whether they should reserve spectrum for GSM-R for the GCC railway.

Consultation

Spectrum Policy and Planning

7.5.1 TETRA

a) Background and trends

Terrestrial trunked radio (TETRA) is the modern digital private mobile radio (PMR) and public access mobile radio (PAMR) technology utilities, public access, fleet management, closed user groups, factory site services, mining, etc.

The standard is defined by the European Telecommunications Standards Institute (ETSI), which established a memorandum of understanding (MoU) in 1994 and now has 56 members across 19 countries. The Technical Body has over 150 representatives involved in the various technical working groups, with support from the TETRA MoU Association providing further expertise in specialist areas. Besides representatives from Europe, activity has now extended worldwide to include the US, China, Asia and the Middle East.

TETRA Market

The total number of TETRA contracts has grown to 505 (in 2004) and expanded to 65 countries in the world (55% contract-growth and 16% country-growth over the last 9 months). The fastest-growing sectors are oil, gas and the industrial sector, while the fastest-growing regions are Northern Europe and the Middle East.

TETRA Technology

TETRA offers the automatic operation and frequency efficiency of trunking combined with the terminal autonomy of a conventional PMR. TETRA has a multi-mode capability as a result of combining these two modes, trunking and direct (conventional), into a single terminal equipment, and it also provides the standardised way of inter-working between these two modes. TETRA is designed to offer bandwidth-on-demand, a facility that has a variable amount of bandwidth allocated for the call duration, depending on the application.

TETRA is also designed for emergency situations, where almost instantaneous communication is required, both between individuals and within a group of an unlimited size. Priority calls can be made, backed by call pre-emption if required, and, on occasion, an all-informed communication.

Benefits of TETRA

TETRA offers fast call set-up time, group communication support, direct mode operation between radios, packet data and circuit data transfer services, frequency economy and security features. TETRA uses time division multiple access (TDMA) technology with four user channels on one radio carrier and 25 kHz spacing between carriers. This makes it inherently efficient in the way that it uses the frequency spectrum.

Consultation

Spectrum Policy and Planning

For civil systems in Europe, the frequency bands 385 - 389.9 MHz and 395 - 397.9 MHz, 410 - 420 MHz and 420 - 430 MHz, 450 - 460 MHz and 460 - 470 MHz, 870 - 876 MHz and 915 - 921 MHz have been allocated for TETRA.

A TETRA trunking facility provides a pooling of all radio channels, which are then allocated on demand to individual users, in both voice and data modes. By the provision of national networks, countrywide roaming can be supported, allowing the user to be in constant seamless communication with his colleagues. TETRA supports point-to-point and point-to-multipoint communications, both through the TETRA infrastructure and by the use of direct mode without infrastructure.

Applications

Generally used for Public Safety networks, but recent applications also involve industry solutions:

- TETRA for Emergency Services: disasters – both natural and man-made (PPDR*), major accidents/ fires, incidents, RTA (Road Traffic Accidents), routine policing
- TETRA for Utilities: TETRA technology provides users with dependable communication for the installation and maintenance of power lines and gas pipes, which is especially critical at times of earthquakes, flooding, storms, and other natural or man-made disasters
- TETRA for Transportation: TETRA technology provides transportation users with mobile communication designed for their applications, e.g. fleet management or passenger information

Frequencies used

Region-I usage of TETRA is typically under recommendations from the CEPT, and employs the harmonised bands for digital radio. The bands typically assigned are:

- Spectrum within the 410 - 430 MHz band is typically assigned to public access mobile (PAMR) TETRA operators. In the UK it was assigned to the public TETRA operator Dolphin (which went into administration in September 2001)
- Additional bands are also available for TETRA in Europe. Again, in the UK, Ofcom has made available 40 channels in 871 - 872 MHz/ 916 - 917 MHz for TETRA; however, there are no PMR licensees in this band. This is mainly due to the lack of available equipment

b) Options for future spectrum policy

Commercial TETRA networks

Consultation

Spectrum Policy and Planning

Options assessment: commercial TETRA networks offer the opportunity to “upgrade” existing analogue PMR users to digital. Internationally in Region I, commercial TETRA is typically in the 410 – 430 MHz band. In Bahrain, there exist certain potential conflicts in this band:

- Government use of the 410 – 438 MHz band
- Possible interference from deployment in neighbouring countries. This would be addressed by coordination at a GCC level

The 450 – 470 MHz band is not prepared for roll-out at the moment , as handsets and equipment will be more expensive and difficult to obtain in Bahrain. If the frequency issues are resolved and there is interest as a result of this consultation, the preferred award mechanism for these frequencies will be auctions. Should the frequency issues be resolved, the TRA and the MoT would also propose to allocate part of the 410 – 430 MHz band for private use. A potential allocation could be 2 x 4MHz for public commercial TETRA and 1 x 1 MHz for private users. If interest is expressed, the TRA and the MoT propose to discuss a migration plan with the current users in this band. The TRA and the MoT propose a nominal spectrum charge for this spectrum to cover administration costs. Equipment for commercial TETRA – both base stations and handsets – need type approval as specified by ETSI¹⁹.

Consultation:

27. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

(1) assign spectrum for commercial TETRA networks in the 410 – 430 MHz band, provided that spectrum conflicts are resolved, using an auction mechanism.

(2) allocate part of the TETRA 410 – 430 MHz spectrum to private users.

(3) propose a migration plan for current users, to free up spectrum for commercial TETRA in this band.

(4) charge for spectrum an administrative fee covering administration costs.

¹⁹ EN 300 394-1 - Terrestrial Trunked Radio (TETRA); Conformance Testing Specification; Part 1: Radio and EN 303 035 TETRA specification

Consultation

Spectrum Policy and Planning

Exhibit 17: **UK Case study: Commercial TETRA network**

In the UK, there is a provision for offering digital PAMR services through TETRA technology. The frequencies occupied were at 410 - 430 MHz. The services were operated by Dolphin, which, however, went into administration in 2001. Dolphin was formed from two original public digital PAMR operators, Tetralink Telecommunications Limited and National Band Three Limited. A consultation on the award process of Dolphin's frequencies is planned for Autumn 2005, with award scheduled for 2006/07.

In addition, spectrum was allocated for private usage of TETRA in the 900 MHz bands.

7.5.2 ***iDEN***

a) Background and trends

First introduced in 1994, Motorola's integrated Dispatch Enhanced Network (iDEN™) brought to the market next generation wireless solutions designed for a variety of vertical market mobile business applications. Today, iDEN wireless handsets are utilized in a variety of work environments, ranging from manufacturing floors to executive conference rooms as well as mobile sales forces.

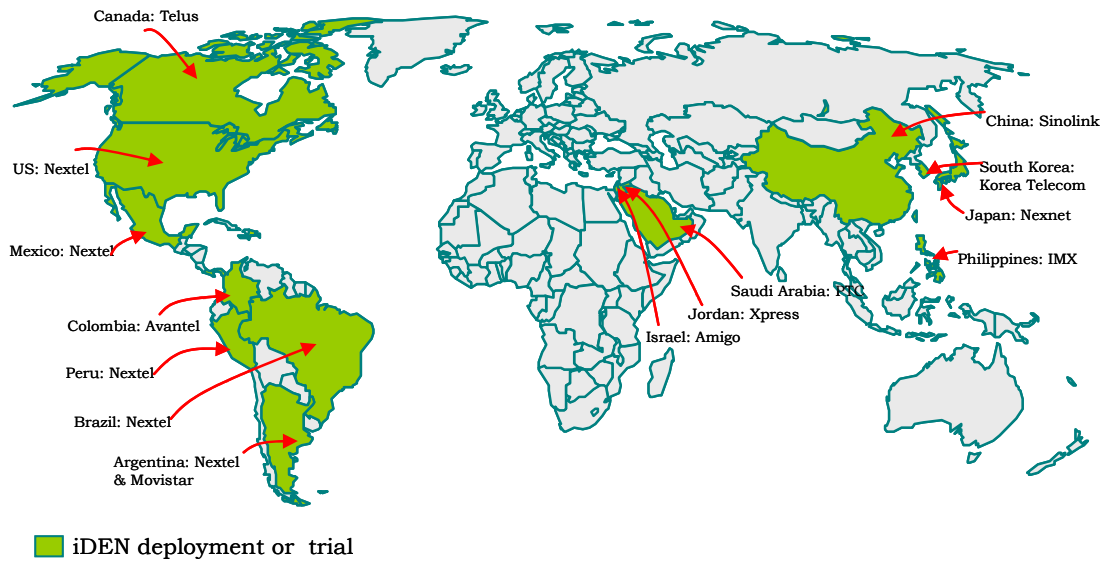
Network roll-out

Implementation so far included Middle-East countries such as Jordan (Xpress) and Saudi Arabia (PTC consortium), and other iDEN commercial networks. iDEN has been deployed by around 15 operators in the world, mostly in the Americas, due to the influence of Nextel and its close relationship with Motorola.

Consultation

Spectrum Policy and Planning

Exhibit 18: iDEN global deployment or trials by operators



Future Developments: WiDEN

Wideband integrated Dispatch Enhanced Network, or WiDEN, is a software upgrade developed by Motorola for its iDEN enhanced specialised mobile radio (or ESMR) wireless telephony protocol. WiDEN allows compatible subscriber units to communicate across four 25 kHz channels combined, for up to 100 kbps of bandwidth. The protocol is generally considered 2.5G wireless cellular technology.

Consultation

Spectrum Policy and Planning

Frequency allocation and licensing

Exhibit 19: Frequency allocation for iDEN

Range (MHz)	Channel spacing	Carrier pairs (MHz)	Link	Spacing	Offset
806-821	25kHz	806-821	Uplink	45MHz	12kHz
		851-866	Downlink		
821-825	25kHz	821-825	Uplink	45MHz	12kHz
		866-870	Downlink		
896-901	25kHz	896-901	Uplink	39MHz	12kHz
		935-940	Downlink		
1453-1465	25kHz	1453-1465	Uplink	48MHz	12kHz
		1501-1513	Downlink		

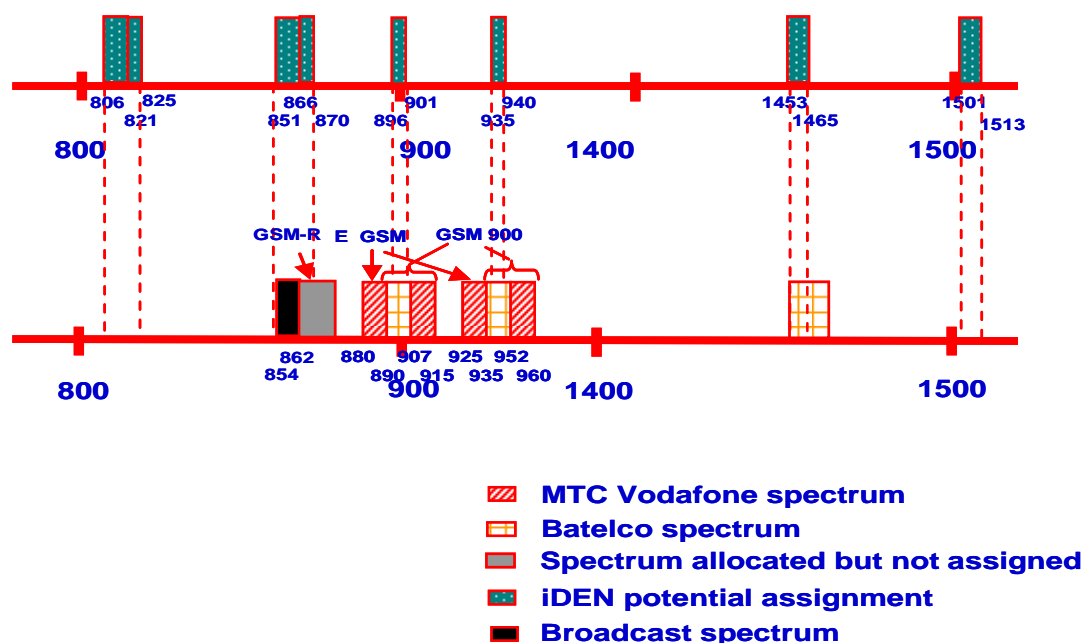
b) Options for future spectrum policy

Options assessment: there has been some interest in the iDEN technology in the region. The TRA and MoT's policy is technology-neutral and, provided there are available frequencies, guarantees of no interference in other bands, and demand, the TRA and the MoT assume that iDEN could bring viable competition to the market. Unfortunately, there are frequency supply conflicts in Bahrain for all the recommended iDEN bands. It seems very unlikely that the current user in these bands will be willing to give up its existing rights for the spectrum. Therefore, the TRA and the MoT have no plans to allocate and assign spectrum for the deployment of iDEN in Bahrain.

Consultation

Spectrum Policy and Planning

Exhibit 20: Spectrum conflicts for iDEN



Consultation

28. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that, given the spectrum supply constraints, they should not allocate and assign spectrum for iDEN in Bahrain.

Consultation

Spectrum Policy and Planning

8 Fixed wireless access

8.1 Summary

Fixed Wireless Access systems cover a wide range of frequencies and include point-to-point and point-to-multi-point technologies. As they can be deployed across a wide range of spectrum, and given that the take-up of many of these popular technologies has been fairly recent, FWA deployments often face potential spectrum conflicts with existing users of these bands. In this consultation, we review each technology by frequency bands, assess the current situation in Bahrain, and set out the following options for future allocation, assignment and policy:

- (1) Although spectrum could technically be deployed for FWA in the 2 GHz band, the TRA and the MoT do not believe that this would be the optimal use of spectrum, and therefore do not propose to assign frequencies in the 2 GHz band.
- (2) The TRA and the MoT propose to preserve the status quo in the 2.5 to 2.7 GHz band until it becomes clearer how convergence of mobile and fixed mobile services could occur in this band. In the meantime, the TRA and the MoT intend to start discussions with current users for a potential migration plan.
- (3) The 3.5 GHz band is fairly free from current assignments. It is a very popular band amongst equipment vendors (notably for WiMAX) and is one of the recommended FWA bands by CEPT. Provided that the interference issues can be resolved, the TRA and the MoT would recommend the award of one or more FWA licences in this band.
- (4) Operation of FWA services in the 5.8 GHz band, even at low power, has the potential to interfere with current usages. However, the band is popular with equipment vendors. Therefore, if co-existence between FWA and current users can be attained in this band, a light licensing regime without exclusive licensing would be the preferred option. No guarantee of service will be provided, and the TRA and the MoT will consult with current users of this band in order to establish a potential migration plan.
- (5) Although there are potential conflicts with current users within the 10 GHz, the TRA and the MoT estimate that a single FWA licence could be awarded (2 x 40 MHz) in this band. Since this should satisfy the needs of Bahrain for an FWA operator at these frequencies, the TRA and the MoT propose to postpone discussions with government users for this band.

Consultation

Spectrum Policy and Planning

- (6) Currently, there is a significant amount of spectrum available for FWA in the 26/28 GHz band. The TRA and the MoT propose to allocate spectrum for one or two future licences, one in the 28 GHz band, another possibly in the 26 GHz band (2 x 100 MHz).
- (7) The 40 GHz band holds interesting prospects for future high-bandwidth services, but interest is limited so far and the TRA and the MoT propose to wait for the results of “pioneer” licences in other countries before making any allocation in this band.

8.2 Introduction: technology, market and applications

Fixed Wireless Access technologies use a radio link instead of cable or fibre for the transmission of voice and data. FWA can be used for internet access, videoconferencing, etc. The communication goes from a transmitter to fixed terminals, fitted, for example, on the roof of a building, in contrast to mobile telephony where the communication goes from a transmitter to mobile terminals.

In most cases, FWA systems in the frequency range 3 - 29.5 GHz can be provided by using either point-to-multipoint or multipoint-to-multipoint technology, operating in frequency bands allocated to the fixed service. However, in some cases, point-to-point FWA technology can be used to connect subscribers. FWA technology can provide data rates from 9.6kbps up to several Mbps.

According to the ITU, Fixed Wireless Access (FWA) is encompassed by the definition of Wireless Access (WA), also known as Wireless Local Loop (WLL). WA is threefold: FWA, Mobile Wireless Access (MWA) and Nomadic Wireless Access (NWA). The latter two variants are not considered in this section.

The target markets for these services include small/medium enterprises (SMEs), small offices/home offices (SOHOs) for tele-working, and sectors of the residential market where always-on, high-speed internet and e-mail are required. Higher bandwidth services may also be particularly attractive to users such as colleges and business parks.

The main applications of FWA include:

- **Link (Point-to-Point):** FWA systems can be used to connect high-capacity users to a telecom network. The user premises are equipped with a base station in line of sight (LOS), with the receiving counterpart in the vicinity of a network node
- **Connection of users in rural areas:** For obvious cost reasons, the FWA solution, typically with a small/ medium capacity, is suitable for the connection of rural areas where land lines are impractical to deploy. In some

Consultation

Spectrum Policy and Planning

European countries this solution is commonly used to comply with the Universal Service required by authorities from telecom operators

- **Wireless Local Loop:** Congestion, bandwidth requirements and terrain constraints can force telecom operators to consider wireless as an alternative to copper / cable / fibre. This solution offers different bit rates depending on the technology used

There are a number of frequency bands that can (and do) accommodate FWA operations.

Frequency allocation for FWA

It is difficult to derive a generic trend on FWA frequency allocation. FWA bands are particularly fragmented between countries – despite a number of attempts at harmonisation.

The use of harmonised frequency bands will ease frequency co-ordination between adjacent countries and with other radio services.

Key take-outs from the harmonisation efforts are summarised here:

- In Region I, a single common harmonised frequency band is not available yet. According to the CEPT, full harmonisation of FWA frequency bands cannot be accomplished for the time being
- However, harmonised channel arrangements for point-to-multipoint fixed service systems that could be used for FWA applications have already been developed within CEPT for the frequency bands 3.4 - 3.6 GHz (CEPT/ERC/REC 14-03), 3.6-3.8 GHz (CEPT/ERC/REC 12-08, Annex B, part 2) and 10.15 - 10.30 GHz/10.50 - 10.65 GHz (CEPT/ERC/REC 12-05).
- Specifically, CEPT recommends that
 - frequency bands 3.400 - 3.600 GHz and 10.15 - 10.30 GHz/10.50 - 10.65 GHz be identified as the preferred bands for FWA applications within CEPT
 - parts of the frequency band 24.5 - 26.5 GHz be identified as the preferred bands for FWA applications within CEPT

The lower frequency bands (<6 GHz) have the general characteristic of permitting transmission over radio paths that may be partially obscured from a direct line of sight. This makes them particularly useful for communication to the sites of small and medium businesses which are typically located in low rise blocks at the edge of cities, in business parks and in residential shopping precincts, where other buildings and trees can make antenna-placement with Line of Sight radio paths difficult. The ability of signals in these bands to be transmitted without a

Consultation

Spectrum Policy and Planning

direct line of sight makes short-range connections to portable terminals of nomadic users (a typical Wireless LAN deployment) a possible alternative scenario.

Exhibit 21: UK Case Study - Fixed Wireless Access frequency bands (<6GHz)

Frequency band designation	UK assignment	UK status	Assignment per operator	Availability	Technical characteristics and capabilities	Remarks
2.4 GHz	2.4 - 2.4835 GHz	Licence exempt	Wide Band modulation techniques allow operation across the band	Commercial public services allowed since July 2002	Limited power at 100mW EIRP restricting range. Up to 54 Mbps and 11 Mbps throughput	Free access but proliferation of devices may cause congestion. Equipment type approval (IR2005 802.11b and 802.11g)
3.4 GHz	3.48-3.50 GHz paired with 3.58-3.60 GHz	Licensed	2x20 MHz per licence	15 regional licences awarded in June 2003 following an auction to 3 operators	Range typically 10 km. New technologies may facilitate non-line of sight operation. Bandwidth of 2Mbps per customer	Good equipment availability
3.6 GHz	3.605-3.689 GHz paired with 3.925-4.009 GHz	Licensed	2x36 MHz	Licensed nationally to Pipex Communications. Serves urban areas in selected	Data services at 384 kbps per customer but higher rates possible	Band under consideration for further licences. Co-ordination needed

Consultation

Spectrum Policy and Planning

Frequency band designation	UK assignment	UK statuses	Assignment per operator	Availability	Technical characteristics and capabilities	Remarks
5 GHz Band A	5.15-5.35 GHz	Licence exempt	Not applicable	Commercial public services allowed from 12 February 2003	Indoor use only. Limited power at 200mW EIRP. Can provide up to 54 Mbps. Mobile/nomadic use only allowed	Technical requirements set out in IR 2006 Interface
5 GHz Band B	5.47 - 5.725 GHz	Licence exempt	Not applicable	Commercial public services allowed from 12 February 2003	Limited power at 1W EIRP restricting range. Up to 54Mbps throughput Mobile/nomadic use only allowed	Technical requirements set out in IR 2006 Interface
5 GHz Band C (5.8 GHz)	5.725-5.850 GHz	Licensed (light electronic Registration)	Users will be able to operate across 5.72-5.85 GHz, with the exception of 5.79 – 5.81 GHz and some geographical exclusion zones (protect other users	Licence holders able to register terminals from 2 February 2004	Power limited to 2W EIRP. Up to 155Mbps. Up to 54Mbps using 802.11 equipment but depends on no. of users. 802.16 equipment also expected to be used (QoS. Fixed use only.	Final version of IR 2007 sets technical requirement for DFS and TPC

The higher frequency bands (>10 GHz) have propagation characteristics that require a clear line-of-sight radio path, and they need to also allow for rainfall

Consultation

Spectrum Policy and Planning

attenuation. However, there is more bandwidth available than in the more crowded lower frequency bands.

8.3 2 GHz

8.3.1 *Background and trends*

There have been a number of proprietary point-to-multipoint wireless access systems operating in country-specific frequency bands around 2 GHz. However, few if any are now commercially available, as interest has moved to the higher frequencies where the greater bandwidth available enables higher throughput rates to be achieved. An exception is Digital Enhanced Cordless Telecommunications (DECT), used as a WLL technology (high power, public network).

DECT uses a number of frequencies, each of which utilises TDMA to provide access to multiple concurrent users. The system is designed to allow the uncoordinated deployment of separate systems, each of which automatically selects the most appropriate channel and time slot to maximise capacity and minimise interference to neighbouring systems. Duplex communication is achieved by using TDD, and operation is in the 1880 to 1900 MHz band. DECT provides both voice and data communications, and can support very high user densities (up to 100,000 handsets per square kilometre are claimed²⁰).

DECT is most commonly used to provide cordless communications in residential, business and industrial situations, but it can also be configured as a WLL system to provide voice and data (up to a few hundred kbps) communications. Such high-power, public network systems have been deployed in a limited number of countries (for example, South Africa).

WLL systems derived from the CDMA-One standard have also been deployed in a number of locations (for example, Nepal). These FDD systems operate in the US 1900 MHz band, and therefore overlap with both the GSM 1800 MHz band and the IMT-2000 band, as mentioned in the Public Mobile section.

²⁰ The DECT Forum

Consultation

Spectrum Policy and Planning

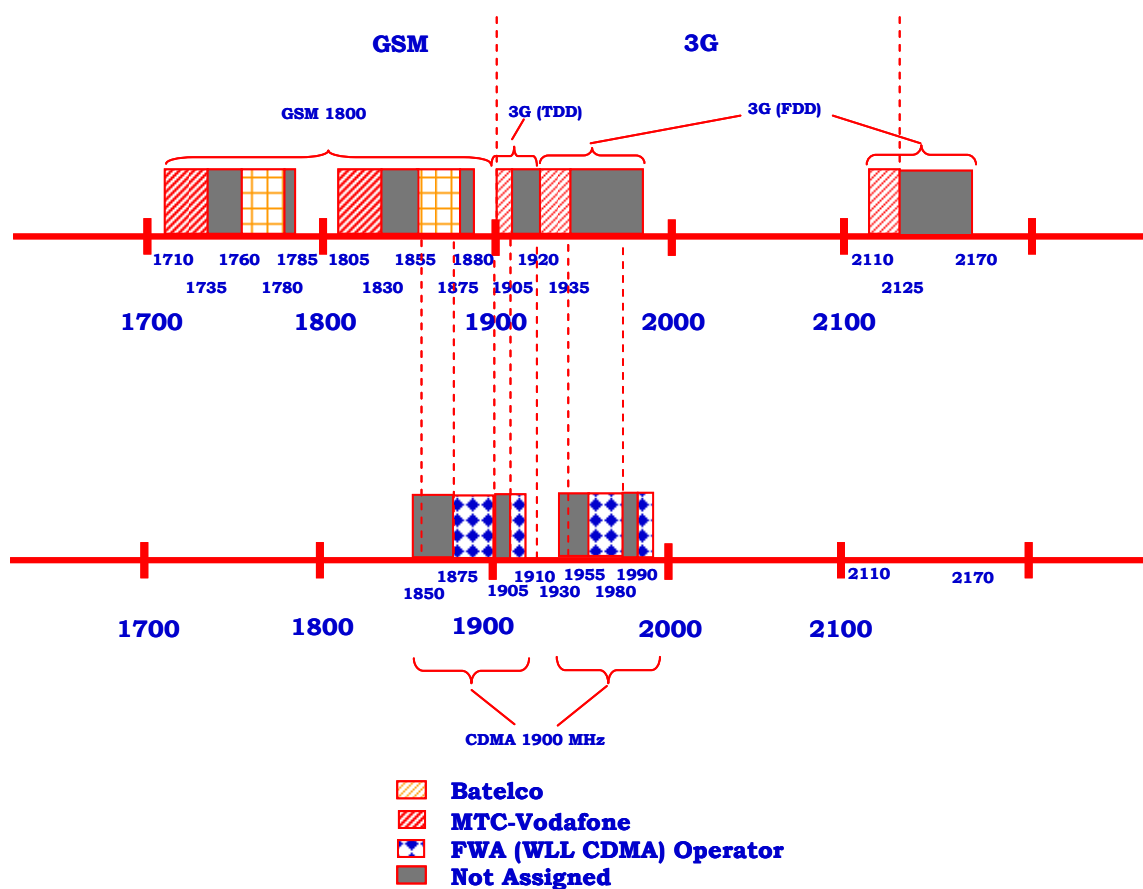
8.3.2 Current allocation, assignment and mechanisms

No spectrum is currently allocated to fixed wireless access systems around 2 GHz.

8.3.3 Options for future spectrum policy

Options assessment: assigning spectrum from the 1900 MHz bands has a number of disadvantages with regard to the future deployment of public mobile networks. In particular, it restricts further assignments to GSM 1800 spectrum and also limits future assignments within the 3G band, as shown in Exhibit 23 below. It is therefore considered inappropriate to use this spectrum for fixed wireless access.

Exhibit 22: Assignment of frequencies to FWA from within the 1900 MHz band and conflicts with potential mobile assignments in the GSM 1800 and 3G bands

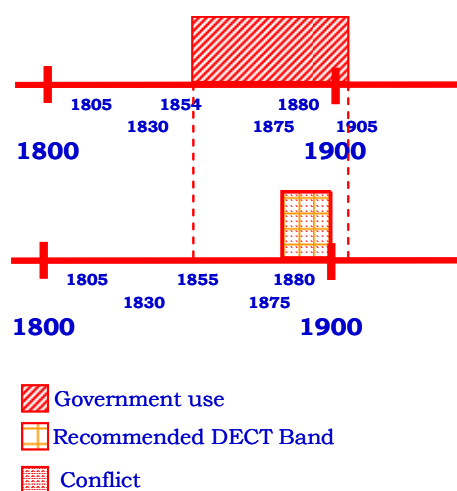


Consultation

Spectrum Policy and Planning

As regards the possibility of a high-power/public network deployment of the DECT technology, the frequencies used for the system are currently assigned for other purposes within Bahrain. Furthermore, given the availability of other bands and the commercial availability of modern equipment in these bands, it is considered unnecessary to allocate the 1880 to 1900 MHz band for DECT systems (for high-power/public systems).

Exhibit 23: The overlap of DECT spectrum with that already assigned to other uses in Bahrain



Consultation:

29. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should not allocate and assign frequencies in the 2 GHz bands for fixed wireless access.

8.4 2.4 GHz

The 2.4000 GHz– 2.4835 GHz band is internationally designated as an Industrial, Scientific and Medical (ISM) band, and many devices such as microwave ovens emit radiation within the band. In addition, many countries have permitted low-power communication devices to operate on a licence-exempt basis in the band, and several different technologies now operate at these frequencies. These include IEEE 802.11b & g, Bluetooth, Zigbee and HomeRF. IEEE 802.11 and Bluetooth are now de facto international standards and

Consultation

Spectrum Policy and Planning

routinely integrated in many devices such as laptop computers and mobile phones. Some countries have permitted service providers to offer commercial services using this band.

We consider the frequency policy of this band in the Short-Range Technologies chapter on WiFi (section 9.2).

8.5 2.5 to 2.7 GHz

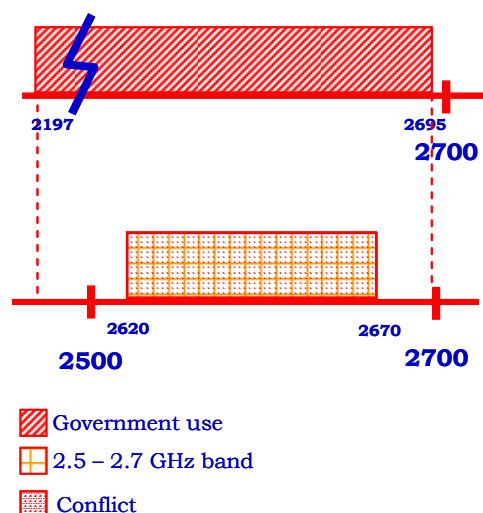
8.5.1 Background and trends

This band was recommended as a fixed wireless access band by the CEPT Administrations, and used for MMDS services in North America and elsewhere. However, at WRC 2000 it was decided to harmonise the use of the 2.50 to 2.69 GHz band for third generation mobile services. In Europe, this band will be made available for 3G services from the end of 2007, and some observers suggest that converged mobile and fixed wireless access operators may emerge at this point (based, perhaps, on WiMAX or TDD-CDMA technology).

8.5.2 Current allocation, assignment and mechanisms

A government organisation currently has a MMDS licence in this frequency band (2420 MHz to 2625 MHz). In addition, most of the band is currently assigned to other users.

Exhibit 24: Current assignments in Bahrain within the 2520 to 2670 MHz band



Consultation

Spectrum Policy and Planning

8.5.3 Options for future spectrum policy

At present it is not clear how much demand there will be for either mobile or fixed access services in Bahrain over the coming years, nor is it clear how convergence between fixed and mobile services will take place. Nevertheless, it seems appropriate to ensure the availability of this band, in order to take advantage of such convergence when it occurs.

Options assessment: the TRA and the MoT believe that it would be premature to assign spectrum from the 2.5 – 2.7 GHz band to either fixed or mobile services (as defined by IMT 2000). Instead, the TRA and the MoT propose to preserve the status quo for the time being, while commencing discussions with the current occupants of the band, with a view to releasing the band at a future date and assigning spectrum to fixed and/or mobile services once market developments are better understood.

Consultation:

30. The TRA and the MoT seek respondent views, with reasons, on their proposal not to change the current spectrum allocation and assignment in the 2.5 – 2.7 GHz band for the time being, but to start reviewing with current users a potential migration plan out of this band.

8.6 3.5 GHz

8.6.1 Background and trends

The 3.6- 4.2 GHz band is allocated on a co-primary basis to Fixed services in all three ITU-R regions, and the potential for a global market has made it popular with vendors of fixed wireless access equipment. It has been recommended as a preferred band throughout ECC/CEPT countries for FWA systems, and several countries have licensed 'exclusive use' spectrum to operators.

Early deployments of FWA systems provided POTS voice or Basic Rate ISDN. Other systems have been based on cable modem technology and offered IP data and voice. The latest generation of 3.5 GHz FWA systems have included a considerable amount of technological innovation and have moved performance standards forward significantly. Individual or combined use of adaptive modulation techniques, adaptive access schemes, multiple-carrier and multiple antenna beam techniques have led to potential base-station capacities in the region of hundreds of Mbps. Together with non-line-of-sight capability and quality-of-service mechanisms, these 3.5 GHz systems can support high-speed IP traffic, multiple E1/T1 circuits, and offer a credible alternative to leased lines.

Consultation

Spectrum Policy and Planning

Multi-tenant solutions and backhaul of cellular mobile networks are just two applications that have become feasible with the latest generation of 3.5 GHz FWA systems.

The IEEE802.16 standards group in North America has developed, and continues to develop, advanced Physical and Medium Access Control (MAC) Layer standards that have resulted in new generation solutions with very high performance. In Europe, air interface standards addressing systems, which will operate in this frequency band, are under development in the "HIPERMAN" activity within the ETSI Broadband Radio Access Systems (BRAN) project. There is close cooperation between the two groups, and the HIPERMAN standard and a subset of the IEEE 802.16 standard will interoperate seamlessly. Both standards are intended principally to provide broadband wireless DSL for the fixed and nomadic markets, and cover a wide range of frequencies and technical options.

Industry has also recognised that a proliferation of proprietary technologies would likely slow the uptake of BFWA, and a coalescence around the IEEE 802.16 standard under the umbrella of the WiMAX Forum is now under way. The WiMAX Forum develops test specifications to ensure interoperability between 802.16 products from different manufacturers. WiMAX is expected to incorporate HIPERMAN specifications.

Recognising the importance of the 3.5 and 5 GHz bands, the first two groups of products to be covered by the WiMAX certification process will be:

- FDD and TDD systems for the 3.4 to 3.6 GHz band
- TDD systems for the 5.725 to 5.850 GHz band

A number of manufacturers have already announced WiMAX-compliant products, and more are expected to follow.

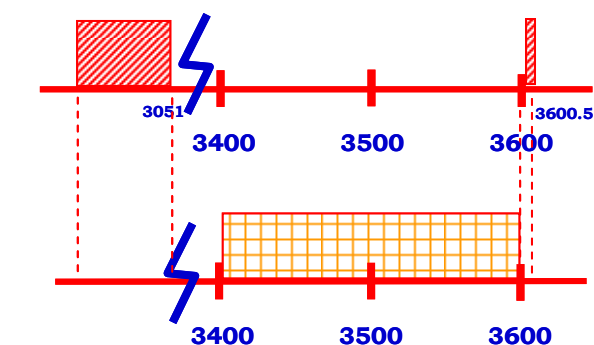
8.6.2 Current allocation, assignment and mechanisms




In Bahrain there are no assignments to fixed wireless access at 3.5 GHz, and the 3.40 to 3.60 GHz band is currently unassigned. However, other services are allocated close to this band that have protection requirements. As a result, other Administrations have found it necessary to restrict the frequencies assigned to fixed wireless access to less than the full 3400 to 3600 MHz band, but have still been able to release adequate spectrum. Further study is required to confirm what restrictions, if any, would be necessary in Bahrain.

Consultation

Spectrum Policy and Planning

Exhibit 25: Current assignments in Bahrain within the 3400 to 3600 MHz band



-  Government use
-  3.5 GHz band
-  Conflict

8.6.3 Options for future spectrum policy

Modern fixed wireless access systems provide the means to quickly deploy DSL, such as broadband services, and to introduce choice and competition into the market. Equipment will be available first in the 3.5 GHz band, and several manufacturers are now offering WiMAX-compliant equipment with more expected to follow.

Modern fixed wireless access systems are capable of providing nomadic access (that is, subscribers can use the FWA network to gain access from multiple locations, in the office, at home and in conference centres, but cannot use it on the move). Fixed wireless access systems can, therefore, provide a degree of competition to the existing public mobile operators. An issue for consideration is, thus, whether the market in Bahrain is developed to the extent that it would be to the consumers' benefit to permit FWA operators to provide nomadic as well as fixed access. It should be noted, however, that attempting to prevent subscribers from using nomadic access is unlikely to be practical.

Options assessment: the amount of spectrum potentially available in the 3.5 GHz band would permit the licensing of at least two operators²¹, but other

²¹ Further study would be required to determine precisely what spectrum could be released for FWA usage.

Consultation

Spectrum Policy and Planning

factors, such as the current state of the broadband access market, will also have a bearing on the optimum number. The TRA and the MoT are in favour of technology-neutral licensing, but also recognise the advantages that a common standard can bring to the market. A consideration is therefore whether or not any FWA licence should require that deployed systems be compliant with WiMAX or other standards.

In line with its policy of encouraging a modern competitive market in the provision of telecommunication services, and subject to the satisfactory resolution of any co-existence issues, the TRA therefore proposes to license one or two FWA operators in the 3.5 GHz band. These licences would prohibit the provision of mobile but not nomadic services. The licences would be technology-neutral but any licensee would be required by the TRA and the MoT to demonstrate that the technology chosen would not cause interference to other users of the spectrum.

The most appropriate method of awarding the spectrum to potential operators would depend on market conditions in Bahrain at the time, but the experience of other Administrations suggests that an auction-based process is likely to be appropriate.

Consultation:

31. The TRA and the MoT seek respondent views, with reasons, on their proposal to allocate spectrum and license fixed wireless access operators in the 3.5 GHz band, and further seek views on:

(1) the number of operators to be licensed.

(2) the proposal to prohibit the provision of mobile services, and the length of time such prohibition should last.

8.7 5.8 GHz

Note that we are here referring to the 5.725 to 5.850 GHz band (also referred to as Band C), and not to the internationally designed lower “licence exempt” allocations at 5.15 – 5.35 GHz and 5.47 – 5.725 GHz.

8.7.1 Background and trends

High-speed data Fixed Wireless Access services have been deployed in North America and other countries using the IEEE802.11 standard equipment. Other

Consultation

Spectrum Policy and Planning

equipment standards under development by North American bodies include work within IEEE802.16 (MAN standards).

In Europe, the ETSI HiPERMAN project is considering the inclusion of elements within the standard air interfaces under development for licence-exempt deployment in this band.

The harmonised use of the 5.8 GHz band in Europe is still a matter of work within the ECC/CEPT frequency coordination body, where sharing with satellite and other services is being studied. In Ireland, the ODTR²² permitted licence-exempt FWA use in July 2002. In the UK, the band was opened for fixed broadband services on February 2, 2004. The new services are licensed under a light regime that requires electronic registration of all transmitting terminals at a nominal licensing cost of £1 per terminal installed per year (subject to a minimum of £50 per year). All FWA services in this band are licensed on a non-protected and non-interference basis and have to comply with minimal technical standards. In the USA, the band is licence-exempt.

The technical requirements on equipment differ slightly between the US and Europe, with the Europeans requiring the addition of transmit power control and dynamic frequency selection to minimise the chance of interference to other services.

8.7.2 Current allocation, assignment and mechanisms

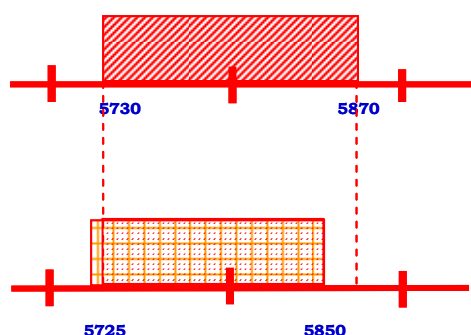
At present, no FWA licences have been granted in the 5.8 GHz band, and licence-exempt operation is not permitted. Moreover, the spectrum between 5730 and 5879 MHz is currently assigned to other users.




²² Now replaced by ComReg.

Consultation

Spectrum Policy and Planning

Exhibit 26: Current assignments in Bahrain within the 5725 to 5850 MHz band.



-  Government use
-  5.8 GHz band
-  Conflict

8.7.3 Options for future spectrum policy

The operation of FWA services in this band, even at low transmit power levels, has the potential to interfere with other services allocated to the band on a primary basis. These include radar and FSS earth-to-satellite links. Further study of the need for protection is required, but exclusion zones and the avoidance of particular frequencies has been necessary in other Administrations. Based on the outcome in other Administrations, it is likely that transmit powers will need to be restricted to relatively low levels.

In the longer term, however, the TRA and the MoT consider it likely that the global spread of equipment intended for licence-exempt operation in this band will lead to a proliferation of such equipment in Bahrain. They therefore believe that, subject to suitable alternative arrangements being made, the current users should be migrated out of this band.

For the same reason, the TRA and the MoT believe that any licensed fixed wireless operator in this band would find themselves in the position of sharing the frequencies with multiple other users, and would therefore be unable to offer the quality of service normally associated with telecommunication services. The TRA and the MoT do not believe, therefore, that it would be appropriate to licence exclusive frequencies from this band to fixed wireless access operators. However, the technical requirements placed on unlicensed operation in this band by other

Consultation

Spectrum Policy and Planning

Administrations (in particular the higher permitted radiated powers) make it and the available equipment suitable for fixed wireless access applications.

Options assessment: the TRA and the MoT believe that it would be appropriate to permit a light licensing regime in this band. Although suitable equipment can effectively share spectrum in this way, the resulting quality of service can no longer be guaranteed, but depends on the deployments made by others. In order to ensure that the deployed equipment was capable of sharing the spectrum in a satisfactory manner, certain technical specifications would be required (similar to those already applied by other Administrations).

The fact that the band and the equipment will be suitable for fixed wireless access services suggests that this is the most likely application to develop here (note that WLAN applications at 5 GHz will be well served by the 5.2 and 5.3 GHz bands). The TRA and the MoT would therefore propose to allow commercial enterprises to operate public communication services in this band, with no restrictions on the number of operators who might offer such services. The other options would be:

- To permit only private use within the band
- To permit private use and commercial offering of public communications services under a light licensing regime. To enable the commercial operators to differentiate their services, private users could be restricted to indoor environments and commercial operators to outdoor environments.

The indeterminate quality of service available in this situation would suggest that any commercial services operated in this band would satisfy a different market to that served by licensed FWA operators, as proposed, for instance, in the 3.5 GHz band.

We will discuss the specific case of WiFi in this spectrum band in the WiFi section (9.2).

Consultation:

32. Further study of the use of the 5.8 GHz band for FWA is required. In the meantime, the TRA and the MoT seek respondent views, with reasons, on:

(1) the proposal to allocate the band and issue licenses under a light licensing regime, subject to satisfactory alternatives being available for the current occupants.

(2) the proposal to permit commercial enterprises to operate public communication services in the band.

Consultation

Spectrum Policy and Planning

(3) the proposal not to limit the number of enterprises operating public communication services in the band.

(4) the alternatives of permitting only private use, or of permitting private use alongside commercial operation (under a light licensing regime) of public communication services.

(5) the timescale on which demand for the above services is likely to develop.

8.8 10 GHz²³

8.8.1 Background and trends

The 10 GHz band is also identified by ECC/CEPT as a preferred band for FWA, but it is only available in a few countries due to sharing issues with other services. ETSI standards similar to those covering the 3.5 GHz band are also applicable to systems in this band, and there is interest in its use outside Europe.

Specifically, CEPT (CEPT/ERC/REC 12-05) has defined the 10.15 – 10.3 GHz and 10.5 – 10.65 GHz as the standard allocation in the 10 GHz bands.

Exhibit 27: UK case study

In the UK, the following bands have been assigned:

- 10.125 GHz -10.225 GHz paired with 10.475 -10.575 GHz
- Core bands were assigned in 1996/7 for Fixed Wireless Access services, and two national licences were issued. However, these have both now been surrendered
- At present, 10.125 to 10.155 GHz bands are licensed in the UK. NTL is licensed to operate FWA services in the 10 GHz band (data services to SME users)
- Other operators have surrendered their licences and Ofcom is considering whether the spectrum should be re-assigned for FWA. One of its considerations will be the Ministry of Defence's interest in using the band

²³ Within the frequency band 11.7 - 12.5 GHz, some European countries are considering the introduction of terrestrial Fixed Service and/or Broadcasting service (Point - to - Multipoint) especially for radio and television distribution. It is a similar activity to that in the US band 12.2 - 12.7 GHz used for MVDDS - Multichannel Video Distribution and Data Services.

Consultation

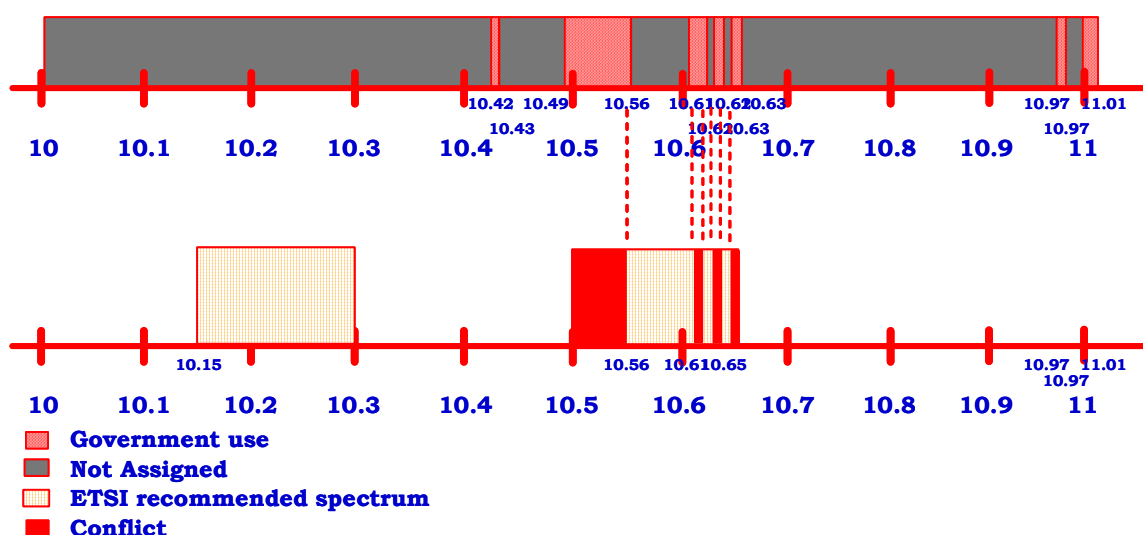
Spectrum Policy and Planning

8.8.2 Current allocation, assignment and mechanisms

There is currently no assignment for FWA in Bahrain in these bands.

As in many other countries, there are conflicts in Bahrain between the currently assigned spectrum in the 10 GHz bands and the proposed CEPT spectrum allocation for FWA (see Exhibit 29), particularly in the 10.5-10.56 GHz and 10.61-10.65 GHz bands, these bands being already assigned to government use.

Exhibit 28: Current frequency allocation 10GHz Bahrain



8.8.3 Options for future spectrum policy

Given the spectrum constraints described above, the TRA and the MoT believe that there is, at the most, enough spectrum to allocate frequency to a single FWA operator in the 10 GHz bands. Given the demographics of Bahrain and the potential to allocate FWA licences in other parts of the spectrum, the TRA and the MoT believe that one FWA licence in the 10 GHz spectrum should be sufficient for the needs of the Kingdom. Furthermore, as part of this consultation, the TRA and the MoT will try to assess the market interest in deploying FWA in this band.

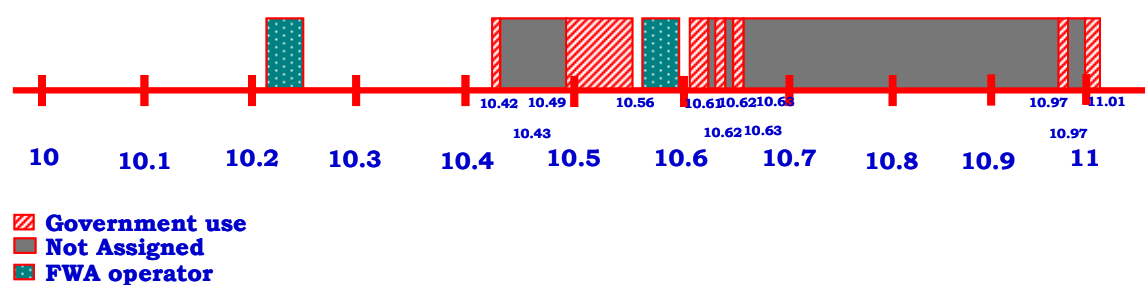
Options assessment: provided that interest is expressed, the TRA and the MoT would suggest allocating and assigning spectrum for FWA in the 10.21-10.25 GHz paired with the 10.560-10.6 GHz bands. This will give a potential FWA operator 2 x 40 MHz worth of spectrum. The TRA and the MoT do not believe at this point that they should enter into discussions with government users in the

Consultation

Spectrum Policy and Planning

10 GHz to free additional spectrum for FWA use, as one licensed operator in this band should meet the needs of Bahrain. The TRA proposes to assign these frequencies through an auction, unless insufficient interest is expressed for the licence, in which case the award mechanism will revert to First Come First Served. The licence will be provided on a technology-neutral basis.

Exhibit 29: Proposed allocation/ assignment for FWA spectrum in the 10GHz bands



Consultation:

33. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

(1) allocate and assign 2 x 40 MHz frequency bands to, at the most, one FWA operator in the 10 GHz band.

(2) use an auction mechanism to award this spectrum and revert to First Come First Served if there is not enough interest expressed for the licence.

8.9 26 and 28 GHz

8.9.1 Background and trends

These bands, actually 24.5 to 26.5 GHz and 27.5 to 29.5 GHz, are also preferred bands by ECC/CEPT for FWA, and in some cases shared with fixed point-to-point links and satellite services. The larger bandwidth available makes these allocations useful for high-capacity connections to large business premises.

Point to multi-point solutions are now being installed which can share capacity between many user sites, providing a leased line performance for sub STM1 rates

Consultation

Spectrum Policy and Planning

at a lower cost per user compared to a dedicated point-to-point microwave link. These multi-point solutions can compete with fibre and point-to-point radio solutions.

Operators rolling out services in these bands had initially been providing dedicated high bit rate services to a few large premises. As the number of large business sites is limited and the service providers' competition is high for these markets, the strategy has shifted to address smaller sites which require more flexible and cost-effective solutions. To this end, second generation equipment shares the capacity more economically by implementing a very adaptive air interface protocol to flexibly match user demands. This solution can be particularly cost-effective for a large number of user sites served within the base station coverage area. The ETSI BRAN HIPERACCESS project and the IEEE 802.16 Wireless MAN committee have published air interface standards (in addition to ETSI co-existence standards) that could be applied to this usage.

Exhibit 30: UK case study – 28 GHz bands

In the UK, the following bands have been assigned:

- Parts of the 27.5-29.5 GHz band (28.0525-28.4445 GHz paired with 29.0605-29.4525 GHz) have been allocated to BFWA (in accordance with ERC Decision ERC/DEC/(00)09)
- Regional licences were awarded following a spectrum auction in November 2000. The licences remaining unsold were made available in a further award process that started in October 2001. Licences were awarded on a First Come First Served basis unless there were competing bids for a particular licence in a region. In this case, licences in that region were awarded by auction
- 42 licences were offered in the UK (three in each of 14 regions) and 15 of them were finally sold. The licensees are at various stages of deploying their networks: in particular, Your Communications is offering broadband to corporate organisations in selected regions. A second award process closed in October 2002 without any more licences having been awarded

8.9.2 *Current allocation, assignment and mechanisms*

There is currently no assignment for FWA in Bahrain in either the 26 GHz or 28 GHz bands.

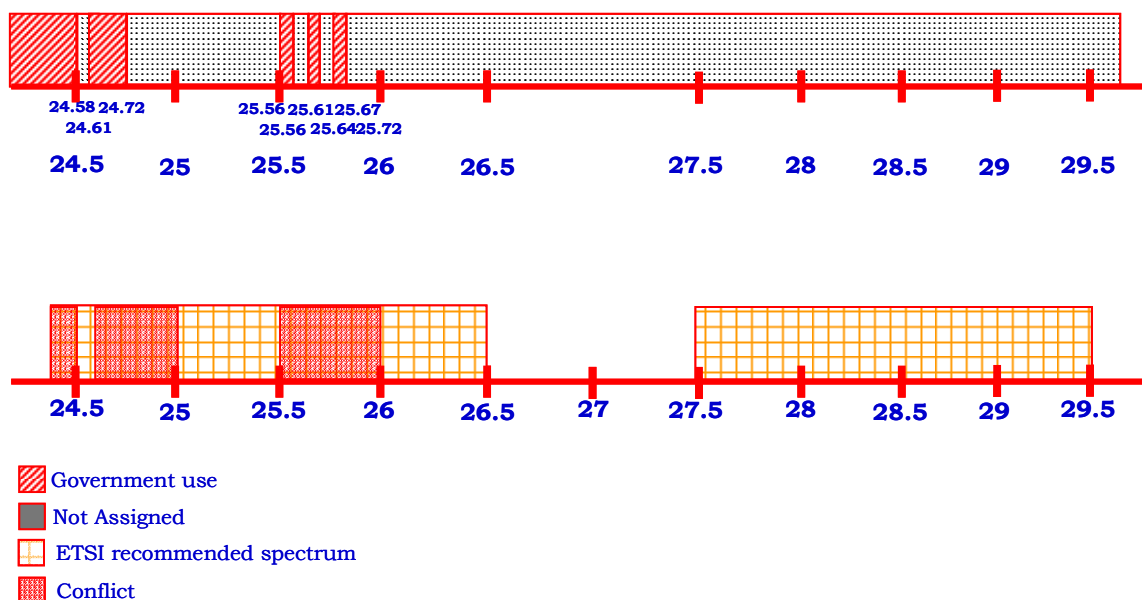
The two bands have very different current assignment profiles:

Consultation

Spectrum Policy and Planning

- The 26 GHz band (24.5 GHz to 26.5 GHz) is currently partly used by government users (see Exhibit 32). Part of the spectrum (100 MHz) from 24.65 GHz to 24.75 GHz paired with 100 MHz in the 25.5 – 27 GHz band is currently allocated for public operator use
- The 28 GHz band (27.5 GHz to 29.5 GHz) is currently free of any assignment and could be used for FWA. The band is shared on a co-primary basis between Fixed Services, Fixed Satellite Services and Mobile Services

Exhibit 31: Current frequency allocation 26/ 28 GHz in Bahrain



8.9.3 Options for future spectrum policy

The two bands (26 GHz and 28 GHz) represent a significant amount of spectrum, which could be assigned for civil use and public operators. However, experiences in other countries show that the commercial roll-out of FWA services has been challenging. Given the size of Bahrain, the TRA and the MoT believe that only a limited number of licences awarded to public FWA operators will eventually be commercially viable. Therefore, the TRA and the MoT should carefully take into account all requirements for spectrum by different types of users.

Options assessment: The TRA and the MoT propose to allocate and assign 100 MHz of spectrum (paired) for FWA between 27.55 - 27.65 GHz and 27.63 - 27.73 GHz in the 28 GHz frequencies, unless significant interest for other applications

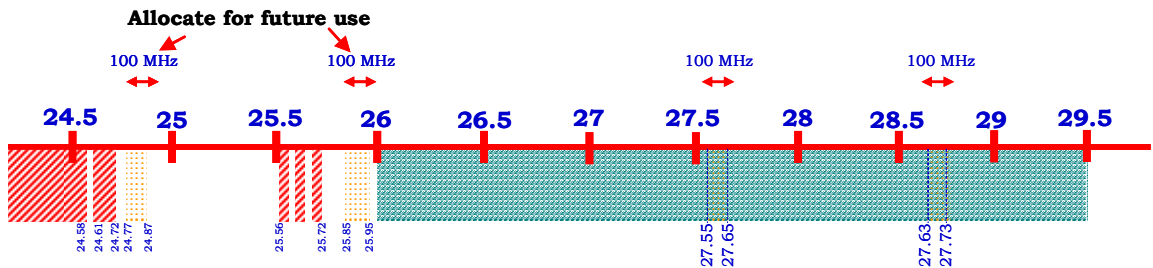
Consultation

Spectrum Policy and Planning

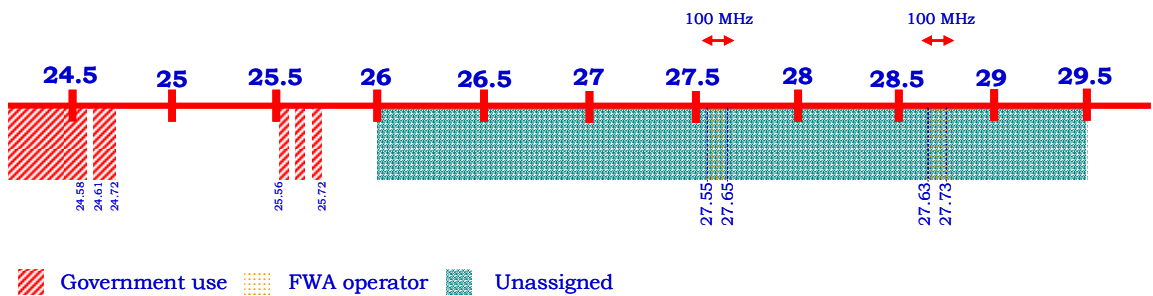
is expressed for spectrum in this band. The TRA proposes to license the 28 GHz spectrum first, using an auction process, and to keep in reserve the allocated spectrum in the 26 GHz band. Another option would be to allocate and assign spectrum for FWA in the 28 GHz band only, and leave the 26 GHz band to be shared on a co-primary basis between the different services until significant interest is expressed in this band.

Exhibit 32: Options for spectrum allocation 26/ 28 GHz bands

Option 1 (preferred)



Option 2



Consultation:

34. The TRA and the MoT seek input from respondents, with reasons, on whether they agree that they should:

(1) allocate and assign spectrum (2 x 100 MHz) in the 28 GHz band to a fixed wireless operator.

(2) award this spectrum through an auction process.

(3) allocate spectrum (2 x 100 MHz) in the 26 GHz band for future use by a public operator, and keep it in reserve for the time being.

Consultation

Spectrum Policy and Planning

8.10 40 GHz band

8.10.1 *Background and trends*

This band was designated "Multimedia Wireless Systems" (MWS) by ECC/CEPT in June 1999. MWS refers to terrestrial multipoint systems that provide fixed wireless services with very high bandwidth (sufficient for a host of broadcast services as well as high speed two-way telecommunications - VoD, gaming, etc.). This band is potentially a key resource for developing the next generation of broadband services.

Frequency-planning regimes have been developed and allow greater flexibility in order to encourage greater convergence between traditional telecommunications and broadcasting. Both ETSI projects BRAN HIPERACCESS and ETSI JTC DVB have developed air interface standards that target this band, and ETSI coexistence standards have been developed. Symmetric and asymmetric point to multi-point and mesh (multi-point to multi-point) topologies is being considered. Large amounts of bandwidth are usually available in the band (block allocations of several hundred MHz are anticipated, permitting the delivery of high bit rate services).

Given the high cost of the systems, the potential market was initially limited to business telecom services. Many doubts exist over the creation in this band of commercially viable services for consumers. Any commercial roll-out will require a high take-up rate in a locality to justify the expense of either a base station or a mesh network for connecting the traffic to the backbone network. Additionally, these solutions will be in competition with the widespread adoption of rival residential delivery mechanisms, including digital terrestrial, satellite TV, and cable. However, cheaper systems are now being developed to make solutions in this band viable for a mass market.

8.10.2 *Current allocation, assignment and mechanisms*

The band is currently allocated to a range of services. The 40.5 - 42.5 GHz band is allocated on a co-primary basis to broadcasting, broadcasting-satellite, fixed and fixed satellite, while the 42.5 - 43.5 GHz band is allocated to fixed, fixed satellite and radio astronomy services. There is currently no assignment for any service in this band in Bahrain.

Consultation

Spectrum Policy and Planning

Exhibit 33: UK case study: 40 GHz bands

During the summer of 2002, Ofcom held discussions with a range of interested companies on the scope for developing the 40.5 to 43.5 GHz band for multimedia wireless systems. Companies generally supported opening the band, but believed that there would not be a market for services at very high bandwidths before 2005. Ofcom intends to explore future use of the band, including the feasibility of offering commercial trial licences. However, at present, interest in these bands is very low.

8.10.3 Options for future spectrum policy

Options assessment: although the band holds interesting prospects, it seems premature for the TRA and the MoT to allocate and assign any frequency in the 40 GHz band. The TRA and the MoT also intend to wait for the results of the assignment in the 26/ 28 GHz bands before acting on the 40GHz. Lastly, the TRA and the MoT are in favour of waiting for the initial feedback on the awarding of pioneer licences in this band in Europe. If enough interest is generated through this consultation for future use of this band for FWA, the TRA and the MoT will suggest reserving the 40.5 - 43.5 GHz spectrum for future FWA operator licence(s).

Consultation:

35. The TRA and the MoT seek input from respondents, with reasons, on:

(1) whether they agree that they should delay the allocation and assignment of spectrum in the 40 GHz band to FWA operators until the market has a better visibility of this band's future as regards high capacity fixed wireless services to businesses and consumers.

(2) reserving the 40.5-43.5 GHz spectrum for future FWA licences.

Consultation

Spectrum Policy and Planning

9 Short-range technologies

9.1 Summary

Short-range technologies include a variety of standards used for short-range wireless applications, such as hands-free mobile calls, PC/peripheral connections and wireless internet access (“hotspots”). WiFi for internet access, Bluetooth for mobile hands-free calls and, to a lesser extent, WiMAX for wireless LANs are the most popular short-range and licence-exempt technologies. However, other technologies, such as Ultra Wide Band (UWB) and Free-Space Optics (FSO), also present potentially interesting opportunities.

WiFi operates in the so called licence-exempt 2.4 GHz band and the 5GHz band. A few countries have adopted a dual approach through licensing public use of WiFi by operators. Although spectrum conflicts will need to be resolved, the TRA and the MoT propose to license spectrum for WiFi use in the 2.4 GHz and 5GHz bands using a light licensing regime approach.

WiMAX operates over a wide range of spectrum, mostly already allocated to ISM uses by ITU standards. However, WiMAX equipment is currently mainly developed for the 3.5 GHz and 5 GHz bands. The TRA and the MoT propose to continue with the current allocation scheme for WiMAX in Bahrain.

Bluetooth, like WiFi, operates in the 2.4 GHz band and should also be governed by a light licensing regime. Bluetooth use will present the same spectrum conflicts as WiFi, and the TRA and the MoT will review options to resolve these conflicts.

UWB (Ultra Wide Band) is an emerging technology used for high-speed and short-range applications. It is currently under review by a few countries with regard to interference issues with other users. The TRA and the MoT propose to wait until the results of these reviews are published, before allowing UWB deployment in Bahrain.

Lastly, FSO (Free-Space Optics) has experienced limited take-up so far, mostly for campus networks. Although the technology does not impact spectrum allocation, regulators could intervene on equipment approval. The TRA and the MoT propose that FSO equipment be managed in the same way as other technologies in Bahrain using type approval.

Consultation

Spectrum Policy and Planning

9.2 WiFi

9.2.1 *Background and trends*

WiFi is short for “wireless fidelity” and is meant to be used generically when referring to any type of 802.11 network. Initially developed at the beginning of the 1990s, the 802.11 standard was approved by IEEE, and the specifications for the Physical and Data Layer were produced. At the time, the technology worked with a data rate of 1-2 Mbps using radio waves in the 2.4 GHz and 5 GHz bands. Due to the limited bandwidth, the standard experienced a relatively slow start until 1997, when the technology evolved to provide a much higher bit rate of up to 11Mbps. In parallel, major electronics companies realized the need to provide compatible and interoperable wireless equipment to their customers. The success of this new and improved WiFi awoke the industry’s interest and diffusion began.

Technical Specifications

At the data link layer, two possible solutions are available in the 802.11 standard. The first is to use infrared (not widespread), and the second is to use radio waves with FHSS and DSSS technology. Each extension to the original 802.11 standard appends a unique letter to the name (802.11a, 802.11b, etc.). However, some extensions have experienced greater market acceptance than others. 802.11a, 802.11b and 802.11g are the most popular WiFi standards today:

802.11a operates in the 5 GHz band and offers bit rates from 22 Mbps to 54 Mbps. The distance coverage is limited to about 20 meters and is not compatible with 802.11b. Because of its reduced coverage, solutions using this technology are expensive, given that several access points need to be deployed.

802.11b operates in the 2.4 GHz band and offers a bit rate of 11 Mbps. Using the DSSS technology provides coverage of 80-100 meters. The protocol makes it possible to vary the transmission speed, to automatically select the less-congested transmission band, to select the access point with the higher signal and traffic, and to provide transparent roaming.

802.11g is the most diffused of all, because it offers the advantages of the previous two, uses the 2.4 GHz band, provides coverage of 80-100 meters, and has a transmission speed of up to 54 Mbps using an OFDM modulation.

Main Applications

WiFi systems allow nomadic and mobile broadband connections. They are used extensively to deliver broadband to individuals in “hotspots” within such public places as airports, hotels and retail locations. They are predominantly used with laptop computers for wireless data connection, but other devices may also use

Consultation

Spectrum Policy and Planning

the functionality. They are also used to build low-power community broadband networks.

Additional recent applications include meshed WiFi networks used by local authorities and municipalities to deploy wireless broadband internet access in urban areas.

Frequency allocation

In most regions (Europe in Region I), spectrum allocation has been harmonised in the 2.4 GHz band. However, the 5 GHz bands are still dealt with by each individual country.

Exhibit 34: Global WiFi Spectrum Allocation at 2.4 GHz (IEEE 802.11)

Region	Allocated Spectrum
US	2.4000 – 2.4835 GHz
Europe	2.4000 – 2.4835 GHz
Japan	2.471 – 2.497 GHz
France	2.4465 – 2.4835 GHz
Spain	2.445 – 2.475 GHz

Exhibit 35: WiFi case study: Italy

Licensing practices for WiFi in Italy

According to the current Italian law since 1 January 2002, the WiFi licensing practice has finally been clarified. The regulation distinguishes between two different applications:

Indoor applications (licence-exempt): intended for applications provided within a private property and implemented with certified equipment (EEC certifications, but WiFi certification not requested). A typical application is the RLAN, whereby offices or private premises are equipped with access points and WiFi terminals (PC with WiFi card, etc.). These solutions do not require licences and are not taxable, as long as the service can be used exclusively within private territory.

Outdoor applications (licensed): applications provided in public places. The service provider must request a licence from the Ministry of Communication and pay an annual tax (very low). However, providers can deploy the system immediately after sending a formal request. The application is subject to the “silent permission” law, which means that no response received by the Ministry within a period of 4 weeks corresponds to an automatic granting of the licence.

Consultation

Spectrum Policy and Planning

9.2.2 *Current allocation, assignment and mechanisms*

Although the 2.4 GHz band in Bahrain has been allocated to ISM use, part of this band is currently in use for other applications, mainly by governmental bodies. As detailed in Exhibit 37, the 2.4 - 2.4835 GHz band (recommended WiFi band in Europe) is currently fully utilised by a public service. However, it is very unlikely that the TRA or the MoT can or should limit the use of WiFi in the 2.4 GHz band. Most laptops currently come equipped with WiFi cards installed for this frequency band, and it is the TRA and MoT's view that they should encourage the development of a technology which has been very popular in most other markets.

Additionally, temporary WiFi licences are being granted in Bahrain since September 2005. The frequencies assigned are in the standard WiFi band (2.4 - 2.4835 GHz). The licence sets out specific restrictions and conditions on the power of the WiFi units²⁴. The TRA will closely monitor the evolution of this temporary licence in terms of interference, and will incorporate the results in its frequency-assignment proposal for WiFi.

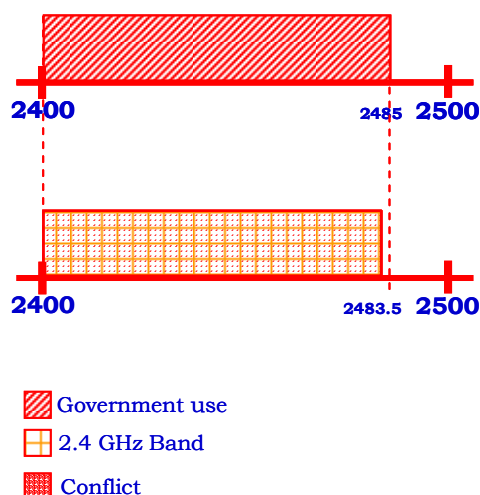
Even if WiFi has gained more popularity in the 2.4 GHz band, WiFi deployment in the 5 GHz band also needs to be considered for Bahrain, especially for the business market. The WiFi band for 5 GHz is 5.725 – 5.850 GHz. As described in exhibit 27 of section 8.7, there are currently certain spectrum conflicts in this band, which could present an issue for WiFi deployment even for low-power devices.

²⁴ Less than -10 dBW (100 mW) EIRP

Consultation

Spectrum Policy and Planning

Exhibit 36: Current assignments in Bahrain within the 2400 to 2483.5 MHz band.



In terms of assignment, the TRA believes it should adopt a dual model for WiFi licensing, in line with the Italian model described above, except that all users will have to be licensed in accordance with the light licensing regime described in earlier sections.

9.2.3 Options for future spectrum policy

Worldwide there is already a very large number of devices operating in this band, and it would be difficult for the TRA and the MoT to prevent their import and use, should they wish to do so. Although these devices operate at low power, the large number of potential users and their widespread and unpredictable locations mean that, with time, the band is likely to become largely unusable for other services.

Options assessment: the TRA and the MoT believe that, subject to suitable alternative arrangements being possible, the current users should be migrated out of the WiFi bands (2.4 GHz and 5 GHz bands). For the same reason, the TRA and the MoT believe that any licensed fixed wireless operator in this band would have to share the frequencies with multiple other users, and would therefore be unable to offer the quality of service normally associated with telecommunication services. The TRA does not believe, therefore, that it would be appropriate to license exclusive frequencies from this band to fixed wireless access operators.

Consultation

Spectrum Policy and Planning

Once the current users have vacated the band, it is the TRA's intention to assign spectrum in this band using a light licensing scheme in line with international technical standards. There will then be three options:

- To permit only private use within the band
- To permit both private use and the commercial offering of public communication services under a light licensing regime
- To permit private use and to license (within a light licensing regime) the commercial offering of public communication services. To enable the commercial operators to differentiate their services, private users would be restricted to indoor environments and commercial operators to outdoor environments.

At the present time, the TRA retains an open mind as to which of these three options would be best suited to the requirements of Bahrain.

Consultation:

36. The TRA and the MoT seek respondent views, with reasons, on:

(1) the proposal to allocate the relevant spectrum but not to award exclusive FWA licences in the 2.4 GHz and 5 GHz ISM band.

(2) the proposal to assign spectrum in this band under a light licensing regime, subject to satisfactory alternatives being available for the current occupants.

(3) the advantages or otherwise of permitting service providers to offer commercial communication services on the basis of a light licensing regime.

9.3 WiMAX

9.3.1 Background and trends

Commonly referred to as WiMAX, or less commonly as WirelessMAN, IEEE 802.16 is a specification for fixed broadband wireless metropolitan access networks (MANs) that use a point-to-multipoint architecture. Published in April 2002, the standard defines the use of bandwidth between the licensed 10 GHz and 66 GHz and between the 2 GHz and 11 GHz (licensed and unlicensed) frequency ranges, and defines a MAC layer that supports multiple physical layer specifications customized for the frequency band of use, and their associated regulations. 802.16 supports very high bit rates in both uploading to and downloading from a base station up to a distance of 30 miles, to handle such services as VoIP, IP connectivity and TDM voice and data.

Consultation

Spectrum Policy and Planning

It should be noted that WiMAX is currently evolving to a limited mobility standard. Further extension or developments are expected and could lead to full mobility under the 802.16 and 802.20 standards.

Technology

802.16a is a wireless metropolitan area network (MAN) standard that provides broadband wireless connectivity to Fixed, Portable and Nomadic devices. It can be used to connect 802.11 hot spots to the Internet, provide campus connectivity, and deliver a wireless alternative to cable and DSL for last-mile broadband access. It provides up to 50 kilometres of service-area range, allows users to get broadband connectivity without needing direct line of sight with the base station, and has data rates of up to 280 Mbps per base station, which is enough bandwidth to simultaneously support hundreds of businesses with T1/E1-type connectivity and thousands of homes with DSL-type connectivity with a single base station.

802.16d is the latest published WiMAX standard and allows for indoor antennas and nomadicity.

802.16e is planned to be an extension to the approved IEEE 802.16/16a standard. The purpose of 802.16e is to add limited mobility to the current standard, which is designed for fixed operation. IEEE 802.16e is not intended to compete with 3G or other truly mobile efforts. Work on this extension is expected to be completed by the end of 2005.

Main applications

The applications of WiMAX fall under the fixed broadband wireless metropolitan access networks. In particular, they can be leased lines for businesses, backbone for Hot Spots, or nomadic coverage for portable devices.

Many WiMAX company members are active in both the IEEE 802.16 standards development and the IEEE 802.11 efforts for Wireless LAN, and envision the combination of 802.16a and 802.11 creating a complete wireless solution for delivering high-speed Internet access to businesses, homes, and WiFi hot spots.

The case of WiBro

A hybrid version of the WiFi/ WiMAX standards was developed for the Korean market: WiBro. In particular, WiBro was developed to address the shortcoming of WiFi in terms of coverage. In February 2002, the Korean government allocated 100MHz of electromagnetic spectrum in the 2.3GHz band, and in late 2004 WiBro Phase 1 was standardized by the TTA (Telecommunications Technology Association) of Korea.

Consultation

Spectrum Policy and Planning

WiBro base stations will offer an aggregate data throughput of 30 to 50 Mbps and cover a radius of 1-5 km.

SK Telecom and Hanaro Telecom have announced a partnership to roll out WiBro nationwide in Korea, excluding Seoul and six provincial cities, where independent networks will be rolled out. In November 2004, Intel and LG Electronics executives agreed to ensure compatibility between WiBro and WiMAX technology. In September 2005, Samsung Electronics signed a deal with Sprint Nextel Corporation to provide equipment for a WiBro trial.

9.3.2 **Current allocation, assignment and mechanisms**

There are currently no specific allocations for WiMAX or WiBro in Bahrain.

9.3.3 **Options for future spectrum policy**

WiMAX and WiMAX-compatible equipment operates over a range of frequencies already covered in the Fixed Wireless Access section (section 8) of this document.

Although global deployment is still at an early stage, WiBro could generate some interest. If the spectrum conflicts can be resolved for the 2.3 GHz band, the MoT could reserve 100 MHz of spectrum for future use of WiBro.

Consultation:

37. The TRA and the MoT seek respondent views, with reasons, on their proposal to reserve spectrum for WiBro in the 2.3 GHz band, provided spectrum conflict with current users can be resolved.

9.4 Bluetooth

The Bluetooth 1.0 specifications were first released in July 1999 and, owing to a significant price reduction of the equipment, Bluetooth has become a widely used wireless technology²⁵.

Bluetooth uses Gaussian frequency shift keying (GFSK) to modulate the data to frequencies around 2.4 GHz, and , in theory, offers data speed of up to 1 Mbps. Bluetooth is capable of point-to-point or point-to-multipoint communication.

²⁵ The cost of a Bluetooth radio chip has dropped from \$20 to approximately \$5.

Consultation

Spectrum Policy and Planning

This flexibility allows it to be used in a wide variety of applications. Because power consumption is always a concern for mobile devices, Bluetooth has three power classes that can be used, depending on how far apart the communicating devices are from one another.

Bluetooth's applications have been mostly very short-range applications such as hands-free mobile headsets, Bluetooth car toolkits for mobile, and PDA data transfer both for private and business uses (e.g. payments in restaurants).

Options assessment: Bluetooth, along with WiFi, is one the most popular and widespread short-range wireless technologies. Bluetooth also operates in the same frequency bands as WiFi, and therefore the conclusions on this technology are similar to those on WiFi. However, the TRA and the MoT do not believe there is a market for Bluetooth services in Bahrain. Bluetooth will therefore be operated as a free-of-charge service governed by a light licensing regime.

9.5 UWB

Ultra Wide Band (UWB) is currently being developed by two bodies, Multiband OFDM and SUWB. It uses a very wide band of spectrum with a very low signal at any point of the spectrum, so that it should not interfere with other users. UWB is also best suited for very short-range uses requiring high data rates (UWB can deliver 100 to 200 Mbps) such as digital home networking.

UWB operates in two bands of the spectrum, 3.2-4.8 GHz and 6-10 GHz.

The main issue with UWB comes from potential interferences with other users, particularly if UWB becomes widely popular and a large number of UWB units get deployed. Currently, the US and Europe are trialling the technology and assessing the potential impact of UWB on other spectrum users.

Options assessment: the TRA and the MoT believe that it is currently premature to allocate spectrum for UWB in Bahrain. It is also untimely to allow the deployment of UWB equipment until trials in other countries determine the impact of UWB on other spectrum users. The TRA and the MoT therefore propose to delay the frequency allocation, assignment and equipment type approval for UWB in Bahrain.

Consultation

Spectrum Policy and Planning

Consultation:

38. The TRA and the MoT seek respondent views, with reasons, on their proposals to postpone the frequency allocation, assignment and equipment type approval for Ultra Wide Band in Bahrain until the testing of the technology has proven successful.

9.6 FSO

Free-Space Optics is an alternative technology to traditional fibre optics that uses laser beams between buildings with line of sight. Like traditional fibre, FSO can deliver data rates of up to 2.5Gbps; however, it has the limitations of line of sight and distance (a maximum range of 4km). The technology is therefore best suited for Metropolitan Area/Campus Networks types of applications.

Options assessment: since FSO uses light and not spectrum, it will not have a direct impact on frequency allocation. However, the TRA currently type approves the FSO equipment (cf. the FSO type approval guideline on the TRA's website). Users will in due time be charged an administrative fee for the corresponding FSO equipment type approval (for private or public users).

Consultation:

39. The TRA and the MoT seek respondent views, with reasons, on their proposals to continue to regulate the use of Free-Space Optics through equipment type approval.

Consultation

Spectrum Policy and Planning

10 VSAT and other fixed satellite services

10.1 VSAT

10.1.1 *Background and trends*

Technology

Short for “very small aperture terminal”, a VSAT is an earthbound station used in satellite communications of data, voice and video signals, excluding broadcast television. A VSAT consists of two parts, a transceiver placed outdoors in direct line of sight to the satellite and a device placed indoors to interface with the end user's communications device (e.g. PC). The transceiver receives or sends a signal to a satellite transponder in the sky. The satellite sends and receives signals from a ground station computer that acts as a hub for the system. Each end user is interconnected with the hub station via the satellite, forming a star topology. The hub controls the entire operation of the network. For one end user to communicate with another, each transmission has to first go to the hub station, which then retransmits it via the satellite to the other end user's VSAT.

The most popular of VSAT topologies is the star topology around a central earth station known as the hub. This network is more suitable for centralized data applications, for instance in organizations with centralized data-processing requirements (e.g. banks).

In the other topology, the mesh topology, a group of VSATs communicate directly with any other VSAT in the network without going through a central hub. These networks are more suitable for telephony applications. They have also been adopted to deploy point-to-point high-speed links.

Main Applications

VSAT is a well-established telecoms solution, with more than 500,000 terminals installed in more than 120 countries. Miniaturization of components and increased economies of scale have further lowered costs, enabling service providers to offer an increasing range of VSAT-based solutions, including rural telecoms, distance learning, telemedicine, disaster recovery, offshore networks, as well as a host of corporate and government applications.

10.1.2 *Current allocation, assignment and mechanisms*

There are a number of VSAT licences in Bahrain both for public operators and private users or closed user groups. Private users hold VSAT licences and are

Consultation

Spectrum Policy and Planning

subject to a licence fee. Public operators using VSAT for commercial uses need to hold an International Telecom Facilities Licence (IFL) subject to a licence fee.

The various frequency bands usually assigned to VSAT services are the following:

Exhibit 37: Frequency bands – VSAT

Frequency Band	Uplink (GHz) Earth Station to satellite	Downlink (GHz) Satellite to Earth Station
C Band	5.925 to 6.425	3.700 to 4.200
Extended C Band	6.725 to 7.025	4.500 to 4.800
Ku Band	14.000 to 14.500	10.950 to 11.700

Internationally, the Ku-Band is a popular frequency band. By virtue of its higher frequency, the Ku-Band can support traffic with smaller antenna sizes in comparison to the C/Extended-C Band. It is, however, susceptible to rain outages, making it unsuitable for use in South East Asian regions but very suitable for the GCC countries. Accordingly, VSAT services deployed in Bahrain are in the Ku-Band. Bahrain has allocated frequencies in the 14-14.4 GHz /10.95-11.7 GHz to VSAT services. There is still unassigned spectrum in this bands, and therefore the potential for future licensing.

VSAT licences in Bahrain have been assigned on a First Come First Served basis. The private VSAT licences are free, whereas the commercial licences (or IFL) are subject to charges of BD5000 for the initial fee and a recurring charge of 1% of gross annual turnover attributable to licensed activity.

10.1.3 Options for future spectrum policy

Frequency allocation and assignment

The frequency bands allocated in Bahrain for VSAT services are in line with international standards, and there is no current conflict on spectrum assignment in these bands. The TRA and the MoT therefore suggest continuing with the current frequency allocation and will handle individual licence requests on a First Come First Served basis.

Consultation

Spectrum Policy and Planning

Pricing

Currently, VSAT pricing in Bahrain is proportional to the amount of activity generated by the VSAT licence. Going forward, there will be a licence fee and a spectrum fee for private and public users.

Exhibit 38: UK Case Study: VSAT

In the UK, the spectrum allocated to VSAT services is 12.5GHz to 12.75 GHz primarily used for downlink paired with 14GHz to 14.25 GHz for uplink.

A licence is required. The licensing scheme requires each site to be individually approved. The UK has not signed the ERC decisions on exemption from individual licensing, but it is currently developing a lighter-touch regime in consultation with the industry via its Satellite Consultative Committee and its various working groups. At the end of 2001, the Ad Hoc Working Group on Spectrum Pricing and New Licence Products agreed upon a new network licence structure. In the course of 2002, the network licence was implemented and currently uses an on-line clearance and registration system called SatClear²⁶.

The (indicative) annual fee for VSAT licences is based on the number of terminals (located in the UK) in a network. The fee is charged on an incremental block basis as shown below.

Annual licence fees – VSAT UK

Number of VSATs	Fee (€)
1-20	3,181
21-100	9,574
101-300	19,148
301-500	31,810
501-1000	63,620

Each additional group of 100 terminals or part thereof above 1000 will cost 4,000 £ (€6,362) per annum.

²⁶ Satellite antennas larger than 0.9 m size in diameter may require authorisation from the local Planning Authority.

Consultation

Spectrum Policy and Planning

Consultation:

40. The TRA and the MoT seek respondent views, with reasons, on their proposal to continue with the current allocation and assignment practices for VSAT, namely:

(1) no further frequency allocation for VSAT.

(2) new licences being dealt with on a First Come First Served basis.

(3) private and public users being charged a spectrum fee in addition to the licence fee.

10.2 Other fixed satellite services

Options assessment: another application of particular interest for this consultation is the use of fixed satellite services in planes or ships. In particular, Internet access in planes through satellite is becoming more and more widespread. Spectrum allocation for these types of applications is usually set at the international level. However, as all other users of spectrum in Bahrain, planes or ships will need to obtain a licence from the TRA in order to use fixed satellite services while visiting Bahrain.

Consultation:

41. The TRA seeks respondent views, with reasons, on its proposal that all planes and ships visiting Bahrain and using fixed satellite services should obtain the relevant licence.

Consultation

Spectrum Policy and Planning

11 Mobile-Satellite Service

The Mobile-Satellite Service, through a range of regional and global mobile-satellite systems, provides voice, telemetry and data services for a wide range of applications in land, maritime and aeronautical services. The mobile satellite industry has been successful in niche markets, notably the aeronautical and maritime communities and remote communications in areas without access to public mobile networks.

Options assessment: Almost 100% of Bahrain's geographical area is currently covered by public mobile networks. As a result, the TRA and the MoT do not expect a large market for mobile satellite services in Bahrain. However, foreign mobile satellite providers whose customers travel to Bahrain will be required to obtain a licence from the TRA or ensure that their equipment have roaming facilities for GSM when in Bahrain following on from an agreement with a local operator.

Consultation:

42. Respondents are invited to provide input, with reasons, on whether they believe there is interest in mobile satellite services in Bahrain and how they should deal with those operators that offer services in the region i.e. should they be licensed to offer services or be required to ensure that they have roaming agreements with local operators, where there systems allow them to do so.

Consultation

Spectrum Policy and Planning

12 Glossary

2G: second generation of digital mobile telephony systems

2.5G: term used to describe the enhancements of 2G systems to support data facilities. These include GPRS and EDGE

3G: third generation digital mobile telephony systems currently being deployed, offering higher data rates than previous generations

3.5G: term used to describe the enhancements of 3G systems. These are technologies under development with no established standardisation

4G: term used to describe the concepts behind the next generation of mobile telephony systems. Although the term is currently used, it does not refer to a specific existing technology

AIP: Administrative Incentive Pricing. A fee charged to users of the spectrum to encourage them to make economically efficient use of their spectrum

Allocation: the process of identifying specific ranges for specific applications; or a frequency band entered in a table of frequency allocations, for use by a particular category of service

Analogue: as opposed to digital. The traditional method of modulating signals so that they can carry information

Assignment: authorisation given by a licensing authority for an entity or individual to use a specific band of spectrum under specified conditions

Band: a defined range of frequencies that may be allocated for a particular service (telecom or broadcast) or shared between services

CDMA: Code Division Multiple Access, a radio transmission method where individual traffic transmissions use the same frequency, but where users' traffic is separated by means of different codes. Technology used for mobile networks around the world and particularly in the Americas. CDMA and GSM are the dominant digital mobile standards

CDMA2000: 3G mobile phone standard built on the CDMA technology. One of the IMT-2000 family of standards

CDMA450, CDMA1800, CDMA1900: terms used to describe CDMA technologies deployed in these specific bands (450 MHz, 1800 MHz, 1900 MHz)

CDMA-One: commercial name of the 2G mobile phone systems based on CDMA

Consultation

Spectrum Policy and Planning

CEPT: Conference of European Postal and Telecommunications administrations, comprising over 40 European administrations

Co-ordination: refers to the process under which a new user seeks the agreement of existing users to share access to a particular range of frequencies while avoiding harmful interference

DECT: Digital Enhanced Cordless Telecommunications: an access technology used in private cordless telephone equipment

Digital PAMR: a fully digital implementation of PAMR in both management and traffic relayed

DSL: Digital Subscriber Line: a technology allowing data transmission over existing copper telephone cables that increases the data capacity above that of traditional dial-up rates

E-GSM: Extended GSM. Extension of the GSM band to cover a larger frequency range

EDGE: Enhanced Data Rates for Global Evolution: an access technology that delivers broadband-like data speeds to mobile devices at data speeds faster than is possible with GSM/GPRS

EIRP: Equivalent Isotropically Radiated Power: theoretical measure of the power radiated by a transmitter/ antenna – defined as the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna

ETSI: European Telecommunications Standards Institute. A Europe-based industry group that addresses standards for telecommunications equipment

FDD: Frequency Division Duplex. A transmission method where the downlink/downstream and the uplink/upstream path are separated by frequency

Fixed Links: communications links between fixed points. Such links may be uni-directional or bi-directional

FS: Fixed Services. Radio service where all ground-based transmissions are to and from fixed, non mobile, stations

FSO: Free-Space Optics. Alternative technology to traditional fibre optics using laser beams between buildings with line of sight

FSS: Fixed Satellite Services. A satellite system where the ground or earth station is fixed during transmission and/or reception

Consultation

Spectrum Policy and Planning

FWA: Fixed Wireless Access. Radio link to the home or office from a base station giving access to telecommunications services

Guard band: frequency band deliberately kept vacant between assignments to give a level of protection to users on either side from causing interference to each other

GHz: Gigahertz. A unit of frequency equal to one billion Hz or cycles per second

GPRS: General Packet Radio Services: a method of increasing the data capacity of 2G to allow real-time data services, such as internet browsing and emails

GSM: Global System for Mobile communications or “Groupe Spécial Mobile”. A 2G mobile technology behind the vast majority of 2G mobile phones used across Europe. GSM and CDMA are the dominant digital mobile standards

GSM 400, GSM 900, GSM 1800, GSM 1900: terms used to describe GSM technology deployed in these frequency bands (400, 900, 1800 and 1900 MHz)

GSM-R: variant of the GSM standard developed specifically for use by railways

HSDPA/HSUPA: High-Speed Downlink/Uplink Packet Access: an add-on access component used to enhance the data speed to the end user on 3G/UMTS networks

IEEE: Institute of Electrical and Electronics Engineers. US-based standardisation organisation that produces equipment standards for, amongst other things, radio access systems

IMT-2000: International Mobile Telephony 2000. A family of global standards for mobile phone networks proposed by the ITU. Also referred to as 3G

Interference: the effect of unwanted signals on the reception of a wanted signal in a radio system, resulting in the degradation of performance and misinterpretation or loss of information compared with that which would have been received in the absence of the unwanted signal

ITU: International Telecommunication Union: international organisation within the United Nations system where governments and the private sector coordinate, discuss and agree the logistics of global telecom networks and services

kHz: kilohertz. A unit of frequency equal to 1000 Hz or cycles per second

Licence exemption: allowing anyone to use the spectrum for any application under certain specified restrictions but typically with maximum power levels. Licence exemption is not allowed by law in Bahrain

MHz: megahertz. A unit of frequency equal to 1 million Hz or cycles per second

Consultation

Spectrum Policy and Planning

Mobile satellite: a service between mobile earth stations and one or more space stations

MoT: Ministry of Transportation of the Kingdom of Bahrain

MWS: Multimedia Wireless Systems. Term created within the CEPT project teams to describe a converged wireless platform that would supply two data services, video on-demand and broadcasting

OB: outside broadcast. The use of radio in the production of film and television programming

Ofcom: Office of Communications. UK regulator

PAMR: Public Access Mobile Radio. A mobile radio service where a number of different organisations have access to a common radio system

PDC: an alternative to 2G mobile systems which is used in Japan

Point-to-Multipoint: fixed radio system that transmits from a central point to multiple users and/or multiple sites

Point-to-Point: fixed radio system that transmits between two users

PMR: Private Mobile Radio. A private radio service installed and operated by businesses and public sector organisations to provide mobile communications for their own workforce

PMSE: Programme Making and Special Events: a collective term used to describe the provision of news, film, television, stage, concert and sports programming through the use of radio

Primary: term used to indicate that a frequency allocation for a particular service has priority over other services in the same band. Services can also be “co-primary” (e.g. fixed and mobile), in which case both services have equal priority

Primary assignment: initial allocation of spectrum by the regulator

Radio spectrum: a section of frequencies of electromagnetic radiation in the range of approximately 10 kHz to 3000 GHz

Secondary: term applied to services which can be assigned spectrum with a lower level of priority. Stations of a secondary service shall not cause harmful interference to primary services or claim protection from harmful interference from primary services

Spectrum trading: process through which spectrum licence holders are able to transfer some or all of their rights to a third party

Consultation

Spectrum Policy and Planning

TDD: Time Division Duplex. A transmission method where the downlink/downstream path and the uplink/ upstream path are separated by time

Terrestrial radio service: any radio service other than a space service or radio astronomy

TETRA: Terrestrial Enhanced Trunked Radio Access. An ETSI standard for digital mobile radio utilised by fleets of vehicles such as emergency services, courier companies, etc.

TRA: Telecommunications Regulatory Authority

UHF: Ultra High Frequency. Term used to describe frequencies in the range 300 MHz to 3 GHz

UMTS: Universal Mobile Telecommunications System. A 3G mobile phone standard built on W-CDMA technology. One of the IMT-2000 family of standards. This is the standard being deployed by the vast majority of European mobile phone operators to offer 3G services

UWB: Ultra Wide Band. A technology that spreads a low power signal over a wide range of frequencies

VHF: Very High Frequency. Term used to describe frequencies in the range 30 to 300 MHz

W-CDMA: Wideband-CDMA. A version of CDMA that has a bandwidth wider than that defined in the original CDMA consideration. W-CDMA is considered the 3G upgrade path from GSM networks

WiFi: short range wireless broadband technology that allows internet access on a nomadic basis (e.g. in hotspots such as hotels, airports, coffee shops, etc.). WiFi is built on the IEEE802.11 standard

WiMAX: similar to WiFi but with an extended range. WiMAX has a reach of several miles. WiMAX is built on the IEEE802.16 and ETSI HiperMAN standards

WRC: World Radiocommunications Conference