|  |  |  |
| --- | --- | --- |
| APTlogogreen3 | ASIA-PACIFIC TELECOMMUNITY | |
| **SOUTH ASIAN TELECOMMUNICATIONS REGULATOR’S COUNCIL (SATRC)** |  |
|  |  |

**SATRC REPORT ON**

**Estimation of spectrum requirement for IMT systems in satrc countries**

**Prepared by**

**SATRC Working Group Spectrum**

**Adopted by**

**17th Meeting of the South Asian Telecommunications Regulator’s Council**

**4 - 6 October 2016, Dhaka, Bangladesh**

**EXECUTIVE SUMMARY:**

The rapid growth in internet usage makes the whole world realize the necessity of estimation on spectrum for International Mobile Telecommunications (IMT) system. ITU data released in July 2016 shows that the internet users in developing countries are 2.5 billion, where as in developed country it is only1 billion. It gives the idea that it is the right time to get prepared to meet the upcoming demand on internet in SATRC countries; and to do so, the required spectrum need to be estimated.

This report consists 4 sections that are comprised of 9 sub-sections. In the section-1, the need of this estimation is described in reference of ITU recommendations and reports. In section-2 of this report, the process to estimate the required spectrum including the calculation formula has been described. Section-3 contains a case study to estimate the requirement of spectrum using the method descries in this report.

As per the results of ITU studies, the total global spectrum requirement for IMT to be in the range of 1340 (for lower user density settings) to 1960 MHz (for higher user density settings) for the year 2020. In the Report ITU-R M.2078 & Report ITU-R M.2290 it has been calculated by ITU where the user density is the key factor to estimate the requirement. Under this work item we applied the user density settings in the ITU developed MS Excel tool ‘SPECULATOR’ for estimating the spectrum requirement for IMT in SATRC countries. The report is based on the forecasting method from the data received from the countries to forecast the user density of these countries.

The tool for calculating the spectrum requirements is given in the link- <http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/Pages/default.aspx> .The user guide for the tool as well as a detailed characterization of the spectrum calculation methodology is presented in the book “Spectrum Requirement Planning in Wireless Communications: Model and Methodology for IMT-Advanced”, edited by H. Takagi & B. H. Walke (John Wiley & Sons, 2008). In this study we used this software tool for computing the spectrum requirement. The lower and higher user density settings of the estimate are meant to reflect the variation of the mobile data growth in different countries.

As a case study, in this report, the data collected from Bangladesh, are used to estimate the requirement for Bangladesh. All the input parameters are same as mentioned in the Report ITU-R M.2290 except user density which is considered to be the main differentiator when considering the different geographical area. Session arrival rate per user, mean service bit rate, and average session duration are expected to possess similar characteristics in the different deployments. Moreover, the traffic (for packet-switching) is calculated as the multiplication of these four market parameters and if all are changed at the same time, the resulting traffic calculation may become unnecessarily complicated. Therefore, the user density is the only market setting parameter that differs in the different market settings [Report ITU-R M.2290]. This paper aims to estimate the spectrum requirements of Bangladesh based on the forecasted mobile subscriptions. To forecast the mobile subscriptions, first we measure the market potential and diffusion parameters from mobile subscriptions data of Bangladesh, applying diffusion of innovations theory and suing the Gompertz model (Gompertz, 1825) using nonlinear regression (NLS). Results of the forecasting procedure regarding mobile subscriptions were used to compute the user density and to estimate the spectrum requirement for IMT systems in Bangladesh. These models provide an S-shaped curve describing technology diffusion among specific populations. These models can provide demand forecasting at the aggregate (population) level, rather than at the individual customer level. The aggregated S-type diffusion models can be derived from a differential equation. In this study we would like to apply the Gompertz (Gompertz, 1825) model for forecasting the diffusion of telecommunication market in Bangladesh.

To forecast the mobile subscriptions, first the market potential and diffusion parameters from 2G and 3G mobile subscriptions data of Bangladesh (observed mobile subscriptions from 2000-2015 for 2G and 2013-2016 for 3G) has been measured, using nonlinear regression (NLS). It can be noted that 3G has been introduced here in 2012 and only four years data is available which are not sufficient for applying regression method, as a result we consider half yearly data for creating more observations.

As stated in the Report ITU-R.M 2290, only user density to be changed for different geographical area. In this view point, to determine the user density in Bangladesh, busy hour traffic data (number of active subscriber per BTS in busy hour and cell area) from the BTS located in the most densely populated area of dense urban, sub-urban and rural environment have been collected.

The observed mobile user density can be used for estimating the current spectrum requirement, but we are estimating the spectrum requirement in 2020 that’s why the forecasted user density to be applied to the ITU spectrum estimation tool (speculator version 2.5). The potential user density per square km in 2020 is computed by considering yearly population growth.

It can be mentioned that the potential user density is showing little bit higher value because of no separate data for observed penetration rates in dense urban, sub-urban and rural areas. We are computing spectrum requirement considering busy hour traffic data of the BTS’s located in the highest possible densely populated area. Additionally, it is not possible to count the population density and penetration rates in the office and public area where many floating people gathered every day. Moreover, it is also impossible to gather the penetration rates separately for dense urban, sub-urban and rural area. As a result country’s average penetration rates have been used.

The aggregate value of user density is distributed in each service category by multiplying the service penetration rates that is calculated by using service penetration rates. That penetration rates are estimated with respect to the user density assembled from ITU database. This parameter is derived from the users of a particular service and total number of users; therefore its value will not be more than 100% (Rec-ITU.R M1390). Then the market settings for Bangladesh is calculated from the ratio of BGD and ITU user density for each service category and market settings mentioned in ITU-R have been applied.

The calculated market settings applied to the spectrum estimation tools (SPECULATOR) and derived the estimated amount of spectrum of 1140 MHz that to be required in Bangladesh by 2020.

In this report, the algorithm underlying ITU’s methodology for calculating spectrum requirements of IMT systems have been analyzed. An approach for estimating the spectrum requirements using diffusion model has been proposed. According to ITU–R, the market parameters remain unchanged except user density for estimating the spectrum requirement for a specific country. Well know diffusion model to forecast the user density in Bangladesh and computed approximate user density for each service category have been applied.

Using the ITU-R spectrum estimation methodology, the spectrum requirements of IMT systems for lower and higher user density settings are 1340 MHz and 1960 MHz respectively for the year of 2020. The predicted total spectrum bandwidth requirements of Bangladesh for the year 2020 are calculated as 1140 MHz, which is lower than 1340 MHz. It happened because of slow growth of 3G subscriptions. Now 3G is almost matured in the most of the countries whereas penetration rate has been reported as only 13.97% in Bangladesh at the end of 2015.

These findings may help the regulators to seek additional spectrum to meet the future demand. Moreover, the proposed spectrum estimation model with subscriptions forecasting can be used to estimate the national spectrum requirement in SATRC countries.

Table of Contents

[EXECTIVE SUMMARY ……..….1](#_Toc456950439)

[CHAPTER-1: Objectives](#_Toc456950440)………………………………………………………………………………..4

[1.1](#_Toc456950441) Introduction………………………………………………………………………….………….….5

1.2 Identified spectrum bands for IMT……………………………………………………….…...7

[CHAPTER- 2: Spectrum Estimation Method of ITU](#_Toc456950445)……………………….…………………..7

[2.1 Method ..…..7](#_Toc456950446)

2.2 Input parameters for spectrum estimation.............................................................9

[2.2.1 Technical Parameters.............................................................................9](#_Toc456950452)

[CHAPTER 3: How to estimate spectrum requirements (case study in Bangladesh)](#_Toc456950456).11

[3.1. Telecommunications market of Bangladesh and spectrum assignment… 1](#_Toc456950457)2

[3.2 Forecasting mobile subscriptions using diffusion model 1](#_Toc456950458)4

[3.3 Computing market settings based on user density....………………....…....](#_Toc456950458)..........15

[3.3.1 Computing user density for each service category …………….16](#_Toc456950459)

[3.3.2 Spectrum estimation result 21](#_Toc456950461)

CHAPTER 4:[CONCLUSIONS 21](#_Toc456950465)

**References:…………………………………………………………………………………………….22**

[**Apendix-I: Questionnaire and answers from different countries 23**](#_Toc456950466)

**1. Objectives:**

ITU figures, released in July 2016, show that developing countries now count vast majority of Internet users, with 2.5 billion users compared with one billion in developed countries. The new edition of ITU's [**ICT Facts & Figures**](http://www.itu.int/en/ITU-D/Statistics/Pages/facts/default.aspx)reveals that mobile phone coverage is now near-ubiquitous, with an estimated 95% of the global population – or some seven billion people living in an area covered by a basic 2G mobile-cellular network. Advanced mobile-broadband networks (LTE) have spread quickly over the last three years and reach almost four billion people today corresponding to 53% of the global population. The number of mobile-broadband subscription continues to grow at double digit rates in developing countries to reach a penetration rate of close to 41%. Globally, the total number of mobile-broadband subscription is expected to reach 3.6 billion by the end of 2016, compared with 3.2 billion at the end of 2015. Mobile broadband (delivered) over smart phones and tablets has become the fastest growing segment of the global ICT market and is now more affordable than fixed broadband in some countries. According to the study report of Cisco 2016, Global mobile data traffic reached 3.7 exabytes per month at the end of 2015, up from 2.1 exabytes per month at the end of 2014. Overall mobile data traffic is expected to grow to 30.6 exabytes per month by 2020, an eight-fold increase over 2015 (Cisco, 2016).To ensure the socioeconomic returns of mobile broadband, the network system should enable a consistent and ubiquitous data rate of 5 Mbps as a minimum requirement for all users within 2020. This will definitely generate a huge traffic and put unusual stress on the spectrum resources, which is a prized and indispensable input for mobile services. Sufficient spectrum availability and service oriented spectrum management policy can ensure the smooth diffusion of mobile subscriptions and mobile broadband services through the next generation network technologies for mobile communications. On the above ground, estimating spectrum requirement is a daunting task to improve the productivity and efficiency of the telecom market. This report aims to provide the guidelines for estimating the spectrum requirement for IMT systems in SATRC countries and secure the new spectrum bands for meeting the forthcoming demand.

* 1. **Introduction:**

For the preparation of WRC-15 agenda item 1.1, Resolution **233 (WRC-12)** invited ITU-R to study additional spectrum requirements for International Mobile Telecommunications (IMT) and other terrestrial mobile broadband applications. Previously, ITU-R estimated the spectrum requirements for IMT in the preparatory studies for WRC-07 agenda item 1.4, the results of which are documented in Report ITU-R M.2078. Since the approval of Report ITU-R M.2078 in 2006, there has been significant advancement in IMT technologies and the deployment of IMT networks. Further, traffic growth in different mobile telecommunication markets, including those of IMT networks, has been shown in Report ITU-R M.2243.Taking into account the recent trends; the Report ITU-R M. 2290 of 2014 provides the results of new studies on estimated spectrum requirements for terrestrial IMT up to the year, 2020. In order to reflect the advancement in technologies and the deployments of IMT networks, the spectrum requirements are calculated using the updated methodology in Recommendation ITU-R M.1768-1. Furthermore, input parameter values to be used in this methodology have been updated from those employed in Report ITU-R M.2078 in order to reflect the recent developments in mobile telecommunication markets. It should be noted that the updated radio aspect parameters used in the methodology are contained in Report ITU-R M.2289. The Report ITU-R M.2289 provides a global perspective on the future spectrum requirement estimate for terrestrial IMT. The input parameters in this Report represent a possible set of global scenarios of the future mobile traffic growth. In some countries, the calculated spectrum requirements may depend on the specific market circumstances and the regulatory conditions, hence spectrum requirements can be lower than the estimate derived by lower user density settings and in some other countries, spectrum requirement can be higher than the estimate derived by higher user density settings. ITU estimated the spectrum requirement for higher and lower user density settings and the result is listed in table 1.

**Table 1: Total spectrum requirements for both RATG 1 and RATG 2 in the year 2020**

|  |  |  |  |
| --- | --- | --- | --- |
|  | RATG 1 | RATG 2 | Total |
| Lower user density settings | 440 MHz | 900 MHz | 1 340 MHz |
| Higher user density settings | 540 MHz | 1 420 MHz | 1 960 MHz |

The use of two market settings, lower and higher user density settings, permits modeling of the differences in markets between different countries. The two settings will result in two final spectrum requirements for IMT systems and the needs of the different countries could lie between these two extremes. This approach was taken in Report ITU-R M.2078 where the user density was considered to be the main differentiator when considering the different market settings. Session arrival rate per user, mean service bit rate, and average session duration are expected to possess similar characteristics in the different deployments. Moreover, the traffic (for packet-switching) is calculated as the multiplication of these four market parameters and if all are changed at the same time, the resulting traffic calculation may become unnecessarily complicated. Therefore, the user density is the only market setting parameter that differs in the different market settings (i.e. lower and higher user density settings) [Page no 9 of Report ITU-R M.2290]. Currently we know the penetration rates and population density of each country. But question is that what will be the user density and spectrum requirements in the SATRC countries in 2020? On this view, we have circulated a set of questionnaire (Appendix 1) to the SATRC members and receive partial data from India, Nepal and Bhutan. To estimate the market settings for user density in 2020, we would like to apply forecasting method to forecast the user density. Then we applied the user density settings in the ITU developed MS Excel tool ‘SPECULATOR’ for estimating the spectrum requirement for IM.

**1.2 Identified spectrum bands for IMT:**

The results of studies that estimate the total global spectrum requirements for International Mobile Telecommunications (IMT) to be in the range of 1340 (for lower user density settings) to 1960 MHz (for higher user density settings) for the year 2020. To meet the growing demand of spectrum, the following potential candidate bands were selected for conducting the sharing and compatibility study based on Resolution 233 (WRC-12).

470-694/698 MHz, 1350-1400 MHz, 1427-1452 MHz, 1452-1492 MHz, 1492-1518 MHz, 1518-1525 MHz, 1695-1710 MHz, 2700-2900 MHz, 3300-3400 MHz, 3400-3600 MHz, 3600-3700 MHz, 3700-3800 MHz, 3800-4200 MHz, 4400-4500 MHz, 4500-4800 MHz, 4800-4990 MHz, 5350-5470 MHz, 5725-5850 MHz, and 5925-6425 MHz .

The sector members of ITU expressed their views and proposals on the CPM report of WRC 2015 and finally the decisions have been incorporated in the Final Acts. According to the provision of RR the following bands are identified for mobile communication system in region 3.

Table 2: Identified spectrum bands for IMT in region 3.

|  |  |  |
| --- | --- | --- |
| Spectrum Band | Spectrum Range (MHz) | Total Spectrum |
|
| 450 MHz | 450-460/460-470 | 20 MHz |
| 700 MHz | 703-748/758-803 | 90 MHz |
| 800 MHz | 825-845/870-890 | 40 MHz |
| 900 MHz | 890-915/935-960 | 50 MHz |
| 1400 MHz [[1]](#footnote-1) | 1427-1452/1492-1518 | 52 MHz |
| 1800 MHz | 1710-1785/1805-1885 | 150 MHz |
| 1880 MHz | 1800 - 1900 | 20 MHz |
| 1900 MHz | 1900-1910/1980-1990 | 20 MHz |
| 2000 MHz | 2010-2025 | 15 MHz |
| 2.1 GHz | 1920-1980/2110-2170 | 120 MHz |
| 2.3 GHz | 2300 - 2400 | 100 MHz |
| 2.5 GHz | 2500-2690 | 190 MHz |
| 3.3 GHz[[2]](#footnote-2) | 3300 -3400 | 100 MHz |
| 3500 MHz | 3400-3500/3500-3600 | 200 MHz |
| Total | | 1167 MHz |

**2. Spectrum estimation method of ITU:**

**2.1 Method:**

Figure 1 summarizes the steps of the calculation algorithm employed in Recommendation ITU‑R M.1768-1 in conjunction with relevant input parameters. The methodology starts from market studies that characterize all of the traffic carried by IMT and other mobile systems, corresponding to Steps 2-3. In Step 4, the total traffic obtained from the market studies is distributed among different radio environments (cell layers) and RATGs according to factors such as traffic characteristics (required data rates and user mobilities), RATG capabilities (supported data rates, available cell types and their coverage), etc. The system capacity required to carry the offered traffic is then calculated in Step 5 using separate capacity calculation algorithms for reservation-based traffic and packet-based traffic respectively. Initial spectrum estimates are obtained from the capacity requirements by dividing the later by the spectral efficiencies (Step 6). Then, adjustments are made to take into account network deployments with the spectrum requirements being aggregated over the relevant deployments (Steps 7-8). Finally, the methodology outputs the overall spectrum requirements of RATG 1 and RATG 2, which collectively denote IMT systems (Step 9).



Fig 1: Steps of calculation algorithm and relevant input parameters

ITU developed MS Excel tool ‘SPECULATOR’ for estimating the spectrum requirements for IMT systems following the steps mentioned in fig 3. The tool implements the methodology for calculation of the spectrum requirements for the future development of the terrestrial component of IMT-2000 and IMT-Advanced, as defined in Recommendation ITU-R M.1768-1. The tool includes the final input parameter values as stated in Report ITU-R M.2078 and Report ITU-R M.2290 based on the market forecast provided in Report ITU-R M.2072 and the radio-related issues discussed in Report ITU-R M.2074 and Report ITU-R M. 2289 .The spectrum requirement calculations in Report ITU-R M. 2290 define two different usage scenarios denoted as the lower market setting (Set 1) and the higher market setting (Set 2). The tool includes the higher market setting (Set 2), which corresponds to higher user density, as the default scenario. To use the lower market setting changes need to be done manually. The tool for calculating the spectrum requirements is given in the following link. <http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/Pages/default.aspx> .The user guide for the tool as well as a detailed characterization of the spectrum calculation methodology is presented in the book “Spectrum Requirement Planning in Wireless Communications: Model and Methodology for IMT-Advanced”, edited by H. Takagi & B. H. Walke (John Wiley & Sons, 2008). In this study we used this software tool for computing the spectrum requirement.

**2.2 Input parameters for spectrum estimation:**

Report ITU-R M.2290 provides the results of studies that estimate the total global spectrum requirements for IMT. Since there are large differences between market developments and timing of network deployments around the world, the lower and higher user density settings of the estimate are meant to reflect the variation of the mobile data growth in different countries. ITU-R.M-1768 estimates the spectrum requirements based on the major input parameters demonstrated in fig 2. All these parameters are available in the ITU- Software Tool for spectrum estimation.



Fig 2 : Input parameters for spectrum estimation

**2 : Classification of input parameters**

**2.2.1 Technical parameters**

The spectrum requirement estimation methodology in Recommendation ITU-R M.1768-1 uses radio-related input parameters that are defined in Report ITU-R M.2074. The radio parameters are used to model real-life wireless networks in a highly simplified fashion via the RATG approach. The radio parameters are interrelated and their values should be derived using the same framework including propagation conditions, interference situations, QoS criteria, and system characteristics. If one of the radio parameters is changed, others may also be influenced. For example, an improvement in the application data rates could be achieved with reduced cell area. Here some important technical and market parameters are listed in the following tables.

**Table 3: Cell area (km2)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Radio environment** | **Teledensity** | | |
| **Dense urban** | **Suburban** | **Rural** |
| Macro cell | 0.10 | 0.15 | 0.87 |
| Micro cell | 0.07 | 0.10 | 0.15 |
| Pico cell | 0.0016 | 0.0016 | 0.0016 |
| Hot spot | 0.000065 | 0.000065 | 0.000065 |
|  | | | |

Table 4: Radio parameters (source: Report ITU-R M.2290)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Parameters** | **Macro cell** | **Micro cell** | **Pico cell** | **Hot spot** |
| RATG 1 | Application data rate (Mbit/s) | 20 | 40 | 40 | 40 |
| Supported mobility classes | Stationary/ pedestrian, low, high | Stationary/ pedestrian, low | Stationary/ pedestrian | Stationary/ pedestrian |
| Guard band between operators (MHz) | 0 | | | |
| Minimum deployment per operator per radio environment (MHz) | 20 | 20 | 20 | 20 |
| RATG 2 | Application data rate (Mbit/s) | 50 | 100 | 1000 | 1000 |
| Supported mobility classes | Stationary/ pedestrian, low, high | Stationary/ pedestrian, low | Stationary/ pedestrian | Stationary/ pedestrian |
| Guard band between operators (MHz) | 0 | | | |
| Minimum deployment per operator  per radio environment (MHz) | 20 | 20 | 120 | 120 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tele­density | Radio environments (RATG 1) | | | | Radio environments (RATG 2) | | | |
|  | Macro cell | Micro cell | Pico cell | Hot spot | Macro cell | Micro cell | Pico cell | Hot spot |
| Dense urban | 4 | 5 | 5 | 7.3 | 4 | 5 | 5 | 7.3 |
| Suburban | 4 | 5 | 5 | 7.3 | 4 | 5 | 5 | 7.3 |
| Rural | 4 | 5 | 5 | 7.3 | 4 | 5 | 5 | 7.3 |

Table 5 : Area spectral efficiency (source: Report ITU-R M.2290)

Table 6: Market attributes in 2020 for lower user density settings (source: Report ITU-R M.2290)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SC | *U* (%) | *Q* (%) | *R* (%) | µ(%) | Mobility ratio |
| 1 | 25 | 40 | 40 | 40 | 2 (No range M.2072) |
| 2 | 25 | 40 | 40 | 40 | 2 |
| 3 | 25 | 40 | 40 | 40 | 2 |
| 4 | 25 | 40 | 40 | 40 | 2 |
| 5 | 25 | 40 | 40 | 40 | 2 |
| 6 | 25 | 40 | 40 | 40 | 2 (No range M.2072) |
| 7 | 25 | 40 | 40 | 40 | 2 |
| 8 | 25 | 40 | 40 | 40 | 2 |
| 9 | 25 | 40 | 40 | 40 | 2 (No range M.2072) |
| 10 | 25 | 40 | 40 | 40 | 2 |
| 11 | 25 | 40 | 40 | 40 | 1 |
| 12 | 25 | 40 | 40 | 40 | 2 |
| 13 | 25 | 40 | 40 | 40 | 2 |
| 14 | 25 | 40 | 40 | 40 | 2 |
| 15 | 25 | 40 | 40 | 40 | 2 |
| 16 | 25 | 40 | 40 | 40 | 2 (No range M.2072) |
| 17 | 25 | 40 | 40 | 40 | 2 |
| 18 | 25 | 40 | 40 | 40 | 2 (No range M.2072) |
| 19 | 25 | 40 | 40 | 40 | 2 (No range M.2072) |
| 20 | 25 | 40 | 40 | 40 | 2 |

Table 7: Market attributes in 2020 for higher user density settings (source: Report ITU-R M.2290)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SC | *U* (%) | *Q* (%) | *R* (%) | μ (%) | Mobility ratio |
| 1 | 46 | 40 | 40 | 40 | 2 (No range M.2072) |
| 2 | 46 | 40 | 40 | 40 | 2 |
| 3 | 46 | 40 | 40 | 40 | 2 |
| 4 | 46 | 40 | 40 | 40 | 2 |
| 5 | 46 | 40 | 40 | 40 | 2 |
| 6 | 46 | 40 | 40 | 40 | 2 (No range M.2072) |
| 7 | 46 | 40 | 40 | 40 | 2 |
| 8 | 46 | 40 | 40 | 40 | 2 |
| 9 | 46 | 40 | 40 | 40 | 2 (No range M.2072) |
| 10 | 46 | 40 | 40 | 40 | 2 |
| 11 | 46 | 40 | 40 | 40 | 1 |
| 12 | 46 | 40 | 40 | 40 | 2 |
| 13 | 46 | 40 | 40 | 40 | 2 |
| 14 | 46 | 40 | 40 | 40 | 2 |
| 15 | 46 | 40 | 40 | 40 | 2 |
| 16 | 46 | 40 | 40 | 40 | 2 (No range M.2072) |
| 17 | 46 | 40 | 40 | 40 | 2 |
| 18 | 46 | 40 | 40 | 40 | 2 (No range M.2072) |
| 19 | 46 | 40 | 40 | 40 | 2 (No range M.2072) |
| 20 | 46 | 40 | 40 | 40 | 2 |

**3. How to estimate spectrum requirements (case study in Bangladesh):**

In this study spectrum is estimated by following Rec. ITU-R M.1768-1 and ITU developed MS Excel tool ‘SPECULATOR’. All the input parameters are same as mentioned in the Report ITU-R M.2290 except user density which is considered to be the main differentiator when considering the different geographical area. Session arrival rate per user, mean service bit rate, and average session duration are expected to possess similar characteristics in the different deployments. Moreover, the traffic (for packet-switching) is calculated as the multiplication of these four market parameters and if all are changed at the same time, the resulting traffic calculation may become unnecessarily complicated. Therefore, the user density is the only market setting parameter that differs in the different market settings [Report ITU-R M.2290]. This paper aims to estimate the spectrum requirements of Bangladesh based on the forecasted mobile subscriptions. To forecast the mobile subscriptions, first we measure the market potential and diffusion parameters from mobile subscriptions data of Bangladesh, applying diffusion of innovations theory and suing the Gompertz model (Gompertz, 1825) using nonlinear regression (NLS). Results of the forecasting procedure regarding mobile subscriptions were used to compute the user density and to estimate the spectrum requirement for IMT systems in Bangladesh.

**3.1 Telecommunications Market of Bangladesh and Spectrum Assignment:**

Bangladesh entered in to the cellular mobile communications era in 1993. Pacific Bangladesh Telecom Ltd launched in Dhaka city as a first mobile operator with AMPS technology. Their service was limited in Dhaka and Chittagong city only and they started to use CDMA technology from 1997. In 1996 Ministry of Posts and Telecommunications (MOPT) issued three more cellular mobile operator licenses to the Grameenphone Ltd, TMIB Ltd (Now Robi Axiata Ltd) and Sheba Telecom Pvt Ltd (Now Banglalink). These operators were assigned spectrum from GSM 900 MHz band and launched commercially in 1997. The telecommunications market of Bangladesh was regulated by MOPT until 2002. With the view of liberalization and market promotion, the Bangladesh Telecommunication Regulatory Commission (BTRC) was established in 2002. After that the telecommunications market of Bangladesh is regulated by BTRC. During the period of 1996-2005 the telecom market of Bangladesh observed very low growth rate because of absence of competition between the operators. In 2005, BTRC took the measures for increase the competition in the market by allowing foreign investment and issuing two new cellular mobile operator licenses. Teletalk Bangladesh Ltd and Warid Telecom Bangladesh Ltd (Now Airtel) commercially launched in 2005 and 2006 with GSM technology. After that the telecom market of Bangladesh observed booming growth of mobile subscriptions. Mobile subscriptions growth of Bangladesh is listed in table 8 and demonstrated in Fig 3. In addition, the market share between the operators is revealed in fig 4. Although a significant growth of mobile subscriptions are observed in Bangladesh but the scenario of spectrum usages is not encouraging. 3G has been launched in 2100 MHz band during 2013. Two operators are using 10 MHz and three operators are using 5 MHz spectrum from 2100 MHz band for 3G network.

**Table 8** : Cumulative number of mobile subscriptions in Bangladesh (1996-2013).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Cumulative subscriptions  (Million) | Subscriptions per 100 inhabitants | Year | Cumulative subscriptions (Million) | | Subscriptions per 100 inhabitants | |
|  | 2G | 2G |  | 2G | 3G | 2G | 3G |
| 1996 | 0.0079 | 0.007 | 2006 | 19.131 |  | 13.200 |  |
| 1997 | 0.0300 | 0.025 | 2007 | 34.3700 |  | 23.468 |  |
| 1998 | 0.0490 | 0.039 | 2008 | 44.6400 |  | 30.168 |  |
| 1999 | 0.0914 | 0.072 | 2009 | 51.3593 |  | 34.353 |  |
| 2000 | 0.2790 | 0.211 | 2010 | 67.9233 |  | 44.945 |  |
| 2001 | 0.5200 | 0.386 | 2011 | 84.3687 |  | 55.193 |  |
| 2002 | 1.0750 | 0.785 | 2012 | 97.1800 |  | 62.820 |  |
| 2003 | 1.3650 | 0.981 | 2013 | 113.7841 | 1.912 | 73.551 | 1.23 |
| 2004 | 2.7816 | 1.969 | 2014 | 120.3500 | 10.186 | 76.170 | 6.44 |
| 2005 | 9.0000 | 6.288 | 2015 | 133.7200 | 22.075 | 84.630 | 13.97 |

Source: (www.btrc.gov.bd)

Fig 3: Mobile subscription growth in Bangladesh (1996-2015)

Fig 4: Market share of the mobile operators

Spectrum assignment information of Bangladesh is listed in table 9, total of 254 MHz (Tx+Rx) spectrum is being used by six mobile operators from 800, 900, 1800 and 2100 MHz band. It can be revealed that this spectrum use is quite insufficient for 134 million of subscriptions.

Table 9: Spectrum assignment to the mobile operators:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Name of the  operator | Spectrum Band | Spectrum Range | | Assigned  Spectrum (MHz) | Total | Service type |
| To (MHz) | From (MHz) |
| Grameenphone Ltd | 900 MHz | 907.6 – 915.0 | 952.6 – 960.0 | 7.4 | 22 MHz | 2G |
| 1800 MHz | 1737.4 – 1752.0 | 1832.4 – 1847.0 | 14.6 |
| 2100 MHz | 1935 – 1945 | 2125 – 2135 | 10.0 | 10 MHz | 3G |
| Robi Axiata Ltd | 900 MHz | 900.20 – 907.60 | 945.20 – 952.60 | 7.4 | 14.6 MHz | 2G |
| 1800 MHz | 1730.0 – 1737.4 | 1825.0 – 1832.4 | 7.4 |
| 2100 MHz | 1950 – 1955 | 2140 – 2145 | 5 MHz | 5 MHz | 3G |
| Banglalink | 900 MHz | 895.20 - 900.20 | 940.20 – 945.20 | 5.0 | 15 MHz | 2G |
| 1800 MHz | 1752.0– 1762.0 | 1847.0 – 1857.0 | 10.0 |
| 2100 MHz | 1955 – 1960 | 2145 – 2150 | 5 MHz | 5 MHz | 3G |
| Teletalk | 900 MHz | 890.00 – 895.20 | 935.00 – 940.20 | 5.2 | 15.2 MHz | 2G |
| 1800 MHz | 1710.0 – 1720.0 | 1805.0 – 1815.0 | 10.0 |
| 2100 MHz | 1960 – 1970 | 2150-2160 | 10 | 10 | 3G |
| Airtel | 900 MHz | 885.00 – 890.00 | 930 – 935 | 5.0 | 15 MHz | 2G |
| 1800 MHz | 1720.0 – 1730.0 | 1815.0– 1825.0 | 10.0 |
| 2100 MHz | 1945 – 1950 | 2135 – 2140 | 5.0 | 5 MHz | 3G |
| PBTL | 800 MHz | 825 - 835 | 870-880 | 10.0 | 10 MHz | 2G |

**3.2 Forecasting mobile subscriptions using diffusion model:**

The best known diffusion models used for technology diffusion purposes are the Bass model (Bass, 1969), the Fisher–Pry model (Fisher & Pry, 1971), the logistic family models (Bewley & Fiebig, 1988), as well as the Gompertz model (Gompertz, 1825; Rai, 1999). All these models provide an S-shaped curve describing technology diffusion among specific populations. These models can provide demand forecasting at the aggregate (population) level, rather than at the individual customer level. The aggregated S-type diffusion models can be derived from a differential equation. In this study we would like to apply the Gompertz (Gompertz, 1825) model for forecasting the diffusion of telecommunication market in Bangladesh. This model can be written as;

F(t) = m (1)

To forecast the mobile subscriptions, first we measure the market potential and diffusion parameters from 2G and 3G mobile subscriptions data of Bangladesh (observed mobile subscriptions from 2000-2015 for 2G and 2013-2016 for 3G), using nonlinear regression (NLS). It can be noted that 3G has been introduced in 2012 and we have only four years data which are not sufficient for applying regression method, as a result we consider half yearly data for creating more observations. The NLS estimation results are listed in table 10. The regression result shows very high significant P-values which are less than 0.05 with high R-square values. Therefore, all the estimated parameters are acceptable. The estimated value will not be significant if the P-value is greater than 0.05. As stated in Fig 5, Gompertz model effectively describes the path of mobile subscriptions diffusion in Bangladesh with saturation level of 119.51% and 50.39% penetration rates and 188.84 million and 79.61 million potential subscriptions for 2G and 3G respectively. This curve indicates that the mobile subscriptions per 100 in habitants in Bangladesh is increased to 84.63% and 13.97% in 2015 and projected to 105.61% and 45.32% in 2020. Therefore the 105.61% and 45.32% subscriptions per 100 inhabitants to be used for the estimation of the spectrum requirements in Bangladesh for year 2020.

**Table10: NLS estimation results**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Service | Parameter estimation | Value | Penetration rates | t-ratio | P-Value |  | Adj. |
| 2G | m in million | 188.84 | 119.51% | 15.14 | 0.0000 | 0.9975 | 0.9971 |
| α | -2.291 | -20.78 | 0.0000 |
| β | 0.208 | 12.70 | 0.0000 |
| 3G | m in million | 79.619 | 50.39% | 4.71 | 0.0052 | 0.9985 | 0.9979 |
| α | -2.2104 | -21.16 | 0.0000 |
| β | 0.4949 | 7.294 | 0.0007 |

**Table 13**  
 Forecasted subscriptions and penetration rates

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Forecasted  Subscriptions(Million) | | Forecasted penetration rates | | Year | Forecasted subscriptions (Million) | | Forecasted penetration rates | |
|  | 2G | 3G | 2G | 3G |  | 2G | 3G | 2G | 3G |
| 2016 | 142.01 | 36.94 | 89.88 | 23.38 | 2021 | 170.79 | 74.63 | 108.10 | 47.24 |
| 2017 | 149.83 | 49.85 | 94.84 | 31.55 | 2022 | 174.05 | 76.54 | 110.16 | 48.44 |
| 2018 | 156.51 | 59.85 | 99.06 | 37.88 | 2023 | 176.75 | 77.73 | 111.87 | 49.20 |
| 2019 | 162.14 | 66.90 | 102.62 | 42.34 | 2024 | 178.96 | 78.46 | 113.27 | 49.66 |
| 2020 | 166.86 | 71.61 | 105.61 | 45.32 | 2025 | 180.78 | 78.91 | 114.42 | 49.94 |

**Fig.5** The S-shaped sigmoid growth pattern of mobile subscriptions in Bangladesh using Gompertz model

**3.3 Computing market settings based on user density**

The market attributes are presented in table 6 and 7 for lower and higher market settings. As stated in the Report ITU-R.M 2290, only user density to be changed for different geographical area. In this view point, to determine the user density in Bangladesh we have collected busy hour traffic data (number of active subscriber per BTS in busy hour and cell area) from the BTS located in the most densely populated area of dense urban, sub-urban and rural environment. We use the following approach (equation 2) to compute the user density per square kilometer based on the traffic data gathered from six mobile operators and summed separately for 2G and 3G services. The observed mobile user density for 2G and 3G services are listed in table 12.

User Density/Sq. Km =(2)

**Table 12: Observed mobile user density per Sq. Km in 2015**

|  |  |  |  |
| --- | --- | --- | --- |
| 2G | Dense Urban | Home | 119006 |
| Office | 91245 |
| Public area | 111558 |
| Sub Urban | Home | 8735 |
| Office & Public area | 14192 |
| Rural | Rural | 1039 |
| 3G | Dense Urban | Home | 30185 |
| Office | 32820 |
| Public area | 33011 |
| Sub Urban | Home | 4384 |
| Office & Public area | 5637 |
| Rural | Rural | 497 |

The observed mobile user density can be used for estimating the current spectrum requirement, but we are undertaking to estimate the spectrum requirement in 2020 that’s why the forecasted user density to be applied to the ITU spectrum estimation tool (speculator version 2.5). The potential user density per square km in 2020 is computed by the equation 3 and 4 considering yearly population growth (1.38%, Census, 2011), average observed average penetration rates of 2015 (84.63%) and the forecasted 105.61 and 45.32 mobile phones per 100 inhabitants for 2G and 3G respectively.

Population density = (3)

Potential user density = Population density x Forecasted penetration rates in 2020 for 2G and 3G (4)

It can be mentioned that the potential user density is showing little bit higher value because we have no separate data for observed penetration rates in dense urban, sub-urban and rural areas. We are computing spectrum requirement considering busy hour traffic data of the BTS’s located in the highest possible densely populated area. Additionally, it is not possible to count the population density and penetration rates in the office and public area where many floating people gathered every day. Moreover, it is also impossible to gather the penetration rates separately for dense urban, sub-urban and rural area. As a result we are using country’s average penetration rates. Summary of the subsequent potential user density is presented in table 13.

**Table 13: Forecasted potential user density/sq.km**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Teledensity | Service environment | Actual user density at 2015 | | Population density | | Forecasted potential user density in 2020 | |
|  |  | 2G | 3G | 2015 | 2020 | 2G | 3G |
| Dense urban | Home (SE1) | 119006 | 30185 | 140619 | 150594 | 159042[[3]](#footnote-4) | 68249[[4]](#footnote-5) |
| Office (SE2) | 91245 | 32820 | 107817 | 115464 | 121942 | 52328 |
| Public area (SE3) | 111558 | 33011 | 131819 | 141169 | 149089 | 63978 |
| Sub-urban | Home (SE4) | 8735 | 4384 | 10321 | 11053 | 11673 | 5009 |
| Office (SE5) | 14192 | 5637 | 16770 | 17959 | 18967 | 8139 |
| Rural | Rural (SE6) | 1039 | 497 | 1228 | 1315 | 1389 | 596 |

**3.3.1 Computing user density for each service category**

The Report ITU-R M. 2072 provides a summary of the market analysis and forecast of evolution of mobile market and services for the future development of IMT-2000, systems beyond IMT-2000 and other systems. This Report describes analysis results information provided by about thirty administrations and organizations and derived market related parameters (user density, session arrival rates, mean service bit rate and mean session duration) and provided forecasts for 2010, 2015, and 2020 for the mobile market. These parameters are essential inputs in developing a spectrum estimate. The findings of this Report are based on internal and external studies to the year 2020 as well as detailed data on the traffic forecasts in different parts of the world and distributed the traffic parameters (user density, session arrival rates, mean service bit rate and mean session duration) in each service category and service environments. These database are provided in the Report ITU-R.M 2072, Report ITU-R.M 2078, Report ITU-R.M 2290 and spectrum estimation tool (SPECULATOR). ITU estimates spectrum requirements based on this database. The service environment, service category and service types are demonstrated in the following tables

Table 14: The identification of service environments

|  |  |  |  |
| --- | --- | --- | --- |
| **Teledensity**  **Service usage pattern** | **Dense urban** | **Suburban** | **Rural** |
| Home | SE1 | SE4 | SE6 |
| Office | SE2 | SE5 |
| Public area | SE3 |

**Table 15: Service categorization (**Source : Rec. ITU-R M.1768-1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic class**  **Service type** | | **Conversational** | **Streaming** | **Interactive** | **Background** |
| Super-high multimedia | | SC1 | SC6 | SC11 | SC16 |
| High multimedia | | SC2 | SC7 | SC12 | SC17 |
| Medium multimedia | | SC3 | SC8 | SC13 | SC18 |
| Low rate data and low multimedia | | SC4 | SC9 | SC14 | SC19 |
| Verylow rate data(1) | | SC5 | SC10 | SC15 | SC20 |
|  | (1) This includes speech and SMS. | | | | | |

Table 16: Service types and their peak bit rates

|  |  |  |
| --- | --- | --- |
| **Service type** | **Peak bit rate** |  |
| Very low rate data | < 16 kbit/s | Pre IMT 2000 (2G, 2.5G) |
| Low rate data and low multimedia | < 144 kbit/s |
| Medium multimedia | < 2 Mbit/s | IMT 2000 (3G) |
| High multimedia | < 30 Mbit/s | IMT Advanced (4G and beyond) |
| Super-high multimedia | 30 Mbit/s to 100 Mbit/s/1 Gbit/s |

For this study, the user density is derived from Bangladesh telecom market and listed in table 13. These user densities are distributed to the 20 service categories like ITU database. Then the user density is compared with ITU forecasted user density and market settings are computed for Bangladesh. As stated in the table 15 and 16, very low rate data and low rate data and low multimedia services are included in the pre IMT 2000 group (2G and 2.5G), therefore, we consider 2G user density at SC4,SC5, SC9,SC10, SC14, SC15, SC19 and SC20. Medium multimedia services are comprised in the IMT 2000 that is known as 3G. Hence, 3G subscriptions are included in SC3, SC8, SC13 and SC18. Super high and high multimedia (data rate 30 mbps to 1Gbps) services are treated as IMT advanced and these services are mostly provided through xDSL and FTTH. IMT advanced (4G) is introduced in many countries therefore the user density of super high and high multimedia is considered by ITU for estimating spectrum. Although 4G is not introduced in Bangladesh and SATRC countries but it seems not proper to ignore these services from our estimation for future requirement of spectrum. In that case we are assuming that 3G users will prefer these services when super high and high multimedia services will be introduced in Bangladesh. For that reason, 3G users are also distributed in SC1, SC2, SC6, SC7, SC11, SC12, SC16 and SC17. 2G network is matured and 3G is becoming popular and demonstrated higher growth rate, thus SC3, SC4, SC5, SC8, SC9, SC10, SC13, SC14, SC15, SC18, SC19 and SC20 are considered in higher market settings. On the other hand, super high and high multimedia services (SC1, SC2, SC6, SC7, SC11, SC12, SC16 and SC17) are not introduced yet and they are considered in lower market settings. The aggregate value of forecasted user density in Bangladesh and user density collected from ITU Tool for spectrum estimation are comprised in table 17. The aggregate value of user density is distributed in each service category by multiplying the service penetration rates that is calculated by using the equation 4. The service penetration rates are estimated with respect to the user density assembled from ITU database. This parameter is derived from the users of a particular service and total number of users; therefore its value will not be more than 100% (Rec-ITU.R M1390). Then the market settings for Bangladesh is calculated from the following formula where the ratio of BGD and ITU user density for each service category and market settings mentioned in ITU-R have been applied.

Service penetration rate[[5]](#footnote-6) = x100 (4)

User density of each service category = (5)

Market settings for BGD = (6)

**Table 17:** Computation of market settings

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SC | SE | User density gathared from ITU Spectrum estimation Tools[[6]](#footnote-7) | Forecasted potential user density for related service category[[7]](#footnote-8) | Service penetration rates | Distribution of user density in each service category for BGD | Ratio of BGD and ITU user density | Market settings given by ITU | Estimated market settings for BGD | |
| SC1 | SE1 | 0.00 | 68249 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 | 0 |
| SE2 | 0.00 | 52328 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE3 | 0.00 | 63978 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE4 | 0.00 | 5009 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE5 | 0.00 | 8139 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE6 | 0.00 | 596 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SC2 | SE1 | 52.00 | 68249 | 0.0327 | 22.31[[8]](#footnote-9) | 0.429 | 25 | 10.73 | 8.9 |
| SE2 | 57.00 | 52328 | 0.0467 | 24.46 | 0.429 | 25 | 10.73 |
| SE3 | 0.00 | 63978 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE4 | 21.00 | 5009 | 0.1799 | 9.01 | 0.429 | 25 | 10.73 |
| SE5 | 10.00 | 8139 | 0.0527 | 4.29 | 0.429 | 25 | 10.73 |
| SE6 | 1.00 | 596 | 0.0720 | 0.43 | 0.429 | 25 | 10.73 |
| SC3 | SE1 | 30894.54 | 68249 | 19.4254 | 13257.65 | 0.429 | 46 | 19.74 | 19.7 |
| SE2 | 61684.46 | 52328 | 50.5853 | 26470.41 | 0.429 | 46 | 19.74 |
| SE3 | 48288.88 | 63978 | 32.3894 | 20722.02 | 0.429 | 46 | 19.74 |
| SE4 | 3839.34 | 5009 | 32.8905 | 1647.56 | 0.429 | 46 | 19.74 |
| SE5 | 9422.48 | 8139 | 49.6790 | 4043.43 | 0.429 | 46 | 19.74 |
| SE6 | 700.26 | 596 | 50.4244 | 300.50 | 0.429 | 46 | 19.74 |
| SC4 | SE1 | 24041.46 | 159042 | 15.1164 | 24041.46 | 1.000 | 46 | 46.00 | 46 |
| SE2 | 24069.00 | 121942 | 19.7381 | 24069.00 | 1.000 | 46 | 46.00 |
| SE3 | 32037.00 | 149089 | 21.4886 | 32037.00 | 1.000 | 46 | 46.00 |
| SE4 | 16.14 | 11673 | 0.1383 | 16.14 | 1.000 | 46 | 46.00 |
| SE5 | 44.46 | 18967 | 0.2344 | 44.46 | 1.000 | 46 | 46.00 |
| SE6 | 15.76 | 1389 | 1.1348 | 15.76 | 1.000 | 46 | 46.00 |
| SC5 | SE1 | 67408.98 | 159042 | 42.3844 | 67408.98 | 1.000 | 46 | 46.00 | 45.16 |
| SE2 | 123763.12 | 121942 | 101.4938 | 121941.58 | 0.985 | 46 | 45.32 |
| SE3 | 83451.62 | 149089 | 55.9745 | 83451.62 | 1.000 | 46 | 46.00 |
| SE4 | 7788.14 | 11673 | 66.7188 | 7788.14 | 1.000 | 46 | 46.00 |
| SE5 | 15902.84 | 18967 | 83.8461 | 15902.84 | 1.000 | 46 | 46.00 |
| SE6 | 1534.70 | 1389 | 110.5108 | 1388.73 | 0.905 | 46 | 41.62 |
| SC6 | SE1 | 1743.00 | 68249 | 1.0959 | 747.97 | 0.429 | 25 | 10.73 | 5.4 |
| SE2 | 1743.00 | 52328 | 1.4294 | 747.97 | 0.429 | 25 | 10.73 |
| SE3 | 2324.00 | 63978 | 1.5588 | 997.29 | 0.429 | 25 | 10.73 |
| SE4 | 0.00 | 5009 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE5 | 0.00 | 8139 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE6 | 0.00 | 596 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SC7 | SE1 | 11366.75 | 68249 | 7.1470 | 4877.77 | 0.429 | 25 | 10.73 | 10.7 |
| SE2 | 35845.25 | 52328 | 29.3954 | 15382.13 | 0.429 | 25 | 10.73 |
| SE3 | 23151.50 | 63978 | 15.5287 | 9934.91 | 0.429 | 25 | 10.73 |
| SE4 | 2802.75 | 5009 | 24.0104 | 1202.73 | 0.429 | 25 | 10.73 |
| SE5 | 7518.25 | 8139 | 39.6392 | 3226.28 | 0.429 | 25 | 10.73 |
| SE6 | 564.25 | 596 | 40.6306 | 242.13 | 0.429 | 25 | 10.73 |
| SC8 | SE1 | 28996.12 | 68249 | 18.2318 | 12442.99 | 0.429 | 46 | 19.74 |  |
| SE2 | 29097.72 | 52328 | 23.8620 | 12486.59 | 0.429 | 46 | 19.74 |
| SE3 | 39220.86 | 63978 | 26.3071 | 16830.69 | 0.429 | 46 | 19.74 |
| SE4 | 21.00 | 5009 | 0.1799 | 9.01 | 0.429 | 46 | 19.74 | 19.7 |
| SE5 | 82.36 | 8139 | 0.4342 | 35.34 | 0.429 | 46 | 19.74 |
| SE6 | 12.36 | 596 | 0.8900 | 5.30 | 0.429 | 46 | 19.74 |
| SC9 | SE1 | 309.00 | 159042 | 0.1943 | 309.00 | 1.000 | 46 | 46.00 | 46 |
| SE2 | 412.00 | 121942 | 0.3379 | 412.00 | 1.000 | 46 | 46.00 |
| SE3 | 52.00 | 149089 | 0.0349 | 52.00 | 1.000 | 46 | 46.00 |
| SE4 | 52.00 | 11673 | 0.4455 | 52.00 | 1.000 | 46 | 46.00 |
| SE5 | 103.00 | 18967 | 0.5431 | 103.00 | 1.000 | 46 | 46.00 |
| SE6 | 10.00 | 1389 | 0.7201 | 10.00 | 1.000 | 46 | 46.00 |
| SC10 | SE1 | 5226.44 | 159042 | 3.2862 | 5226.44 | 1.000 | 46 | 46.00 | 46 |
| SE2 | 18581.58 | 121942 | 15.2381 | 18581.58 | 1.000 | 46 | 46.00 |
| SE3 | 11076.82 | 149089 | 7.4297 | 11076.82 | 1.000 | 46 | 46.00 |
| SE4 | 1562.64 | 11673 | 13.3867 | 1562.64 | 1.000 | 46 | 46.00 |
| SE5 | 4120.24 | 18967 | 21.7235 | 4120.24 | 1.000 | 46 | 46.00 |
| SE6 | 312.22 | 1389 | 22.4824 | 312.22 | 1.000 | 46 | 46.00 |
| SC11 | SE1 | 27.75 | 68249 | 0.0174 | 11.91 | 0.429 | 25 | 10.73 | 7.2 |
| SE2 | 43.50 | 52328 | 0.0357 | 18.67 | 0.429 | 25 | 10.73 |
| SE3 | 37.00 | 63978 | 0.0248 | 15.88 | 0.429 | 25 | 10.73 |
| SE4 | 0.00 | 5009 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE5 | 5.00 | 8139 | 0.0264 | 2.15 | 0.429 | 25 | 10.73 |
| SE6 | 0.00 | 596 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SC12 | SE1 | 22068.50 | 68249 | 13.8759 | 9470.17 | 0.429 | 25 | 10.73 | 10.7 |
| SE2 | 78431.00 | 52328 | 64.3185 | 33656.78 | 0.429 | 25 | 10.73 |
| SE3 | 47267.25 | 63978 | 31.7041 | 20283.61 | 0.429 | 25 | 10.73 |
| SE4 | 6539.25 | 5009 | 56.0199 | 2806.16 | 0.429 | 25 | 10.73 |
| SE5 | 17376.00 | 8139 | 91.6131 | 7456.49 | 0.429 | 25 | 10.73 |
| SE6 | 1305.25 | 596 | 93.9886 | 560.12 | 0.429 | 25 | 10.73 |
| SC13 | SE1 | 27380.70 | 68249 | 17.2160 | 11749.77 | 0.429 | 46 | 19.74 | 19.7 |
| SE2 | 24569.64 | 52328 | 20.1487 | 10543.47 | 0.429 | 46 | 19.74 |
| SE3 | 32234.92 | 63978 | 21.6213 | 13832.84 | 0.429 | 46 | 19.74 |
| SE4 | 951.66 | 5009 | 8.1526 | 408.38 | 0.429 | 46 | 19.74 |
| SE5 | 117.26 | 8139 | 0.6182 | 50.32 | 0.429 | 46 | 19.74 |
| SE6 | 190.52 | 596 | 13.7190 | 81.76 | 0.429 | 46 | 19.74 |
| SC14 | SE1 | 25951.08 | 159042 | 16.3171 | 25951.08 | 1.000 | 46 | 46.00 | 46 |
| SE2 | 25951.08 | 121942 | 21.2816 | 25951.08 | 1.000 | 46 | 46.00 |
| SE3 | 47725.38 | 149089 | 32.0114 | 47725.38 | 1.000 | 46 | 46.00 |
| SE4 | 106.10 | 11673 | 0.9089 | 106.10 | 1.000 | 46 | 46.00 |
| SE5 | 5391.62 | 18967 | 28.4267 | 5391.62 | 1.000 | 46 | 46.00 |
| SE6 | 416.58 | 1389 | 29.9971 | 416.58 | 1.000 | 46 | 46.00 |
| SC15 | SE1 | 57461.54 | 159042 | 36.1298 | 57461.54 | 1.000 | 46 | 46.00 | 31.71 |
| SE2 | 202177.54 | 121942 | 165.7987 | 121941.58 | 0.603 | 46 | 27.74 |
| SE3 | 121401.28 | 149089 | 81.4289 | 121401.28 | 1.000 | 46 | 46.00 |
| SE4 | 16813.84 | 11673 | 144.0394 | 11673.09 | 0.694 | 46 | 31.94 |
| SE5 | 44626.86 | 18967 | 235.2904 | 18966.71 | 0.425 | 46 | 19.55 |
| SE6 | 3352.82 | 1389 | 241.4301 | 1388.73 | 0.414 | 46 | 19.05 |
| SC16 | SE1 | 316.25 | 68249 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 | 3.58 |
| SE2 | 737.00 | 52328 | 0.0426 | 22.31 | 0.429 | 25 | 10.73 |
| SE3 | 548.25 | 63978 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE4 | 56.50 | 5009 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SE5 | 147.25 | 8139 | 0.0527 | 4.29 | 0.429 | 25 | 10.73 |
| SE6 | 12.00 | 596 | 0.0000 | 0.00 | 0.000 | 25 | 0.00 |
| SC17 | SE1 | 618.00 | 68249 | 0.1988 | 135.71 | 0.429 | 25 | 10.73 | 10.73 |
| SE2 | 1339.00 | 52328 | 0.6044 | 316.27 | 0.429 | 25 | 10.73 |
| SE3 | 21.00 | 63978 | 0.3677 | 235.27 | 0.429 | 25 | 10.73 |
| SE4 | 103.00 | 5009 | 0.4840 | 24.25 | 0.429 | 25 | 10.73 |
| SE5 | 72.00 | 8139 | 0.7764 | 63.19 | 0.429 | 25 | 10.73 |
| SE6 | 10.00 | 596 | 0.8641 | 5.15 | 0.429 | 25 | 10.73 |
| SC18 | SE1 | 515.00 | 68249 | 0.3886 | 265.20 | 0.429 | 46 | 19.74 |  |
| SE2 | 1030.00 | 52328 | 1.0981 | 574.60 | 0.429 | 46 | 19.74 |
| SE3 | 52.00 | 63978 | 0.0141 | 9.01 | 0.429 | 46 | 19.74 |
| SE4 | 52.00 | 5009 | 0.8824 | 44.20 | 0.429 | 46 | 19.74 | 19.74 |
| SE5 | 52.00 | 8139 | 0.3796 | 30.90 | 0.429 | 46 | 19.74 |
| SE6 | 10.00 | 596 | 0.7201 | 4.29 | 0.429 | 46 | 19.74 |
| SC19 | SE1 | 1030.00 | 159042 | 0.3238 | 515.00 | 1.000 | 46 | 46.00 | 46 |
| SE2 | 1030.00 | 121942 | 0.8447 | 1030.00 | 1.000 | 46 | 46.00 |
| SE3 | 2142.18 | 149089 | 0.0349 | 52.00 | 1.000 | 46 | 46.00 |
| SE4 | 103.00 | 11673 | 0.4455 | 52.00 | 1.000 | 46 | 46.00 |
| SE5 | 800.88 | 18967 | 0.2742 | 52.00 | 1.000 | 46 | 46.00 |
| SE6 | 63.36 | 1389 | 0.7201 | 10.00 | 1.000 | 46 | 46.00 |
| SC20 | SE1 | 316.25 | 159042 | 0.6476 | 1030.00 | 1.000 | 46 | 46.00 | 46 |
| SE2 | 737.00 | 121942 | 0.8447 | 1030.00 | 1.000 | 46 | 46.00 |
| SE3 | 548.25 | 149089 | 1.4368 | 2142.18 | 1.000 | 46 | 46.00 |
| SE4 | 56.50 | 11673 | 0.8824 | 103.00 | 1.000 | 46 | 46.00 |
| SE5 | 147.25 | 18967 | 4.2226 | 800.88 | 1.000 | 46 | 46.00 |
| SE6 | 12.00 | 1389 | 4.5624 | 63.36 | 1.000 | 46 | 46.00 |

The calculated market setting for user density is listed in table 18. Finally, the calculated market settings applied to the spectrum estimation tools (SPECULATOR) and derived the estimated amount of spectrum of 1140 MHz that to be required in Bangladesh by 2020.

Table 18: Market attributes setting for Bangladesh

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SC | U(%) | Q/R/ μ (%) | Mobility ratio | SC | U(%) | Q/R/μ (%) | Mobility ratio |
| SC1 | 0 | 40 | 2 | SC11 | 7 | 40 | 1 |
| SC2 | 9 | 40 | 2 | SC12 | 11 | 40 | 2 |
| SC3 | 20 | 40 | 2 | SC13 | 20 | 40 | 2 |
| SC4 | 46 | 40 | 2 | SC14 | 46 | 40 | 2 |
| SC5 | 45 | 40 | 2 | SC15 | 32 | 40 | 2 |
| SC6 | 5 | 40 | 2 | SC16 | 4 | 40 | 2 |
| SC7 | 11 | 40 | 2 | SC17 | 11 | 40 | 2 |
| SC8 | 20 | 40 | 2 | SC18 | 20 | 40 | 2 |
| SC9 | 46 | 40 | 2 | SC19 | 46 | 40 | 2 |
| SC10 | 46 | 40 | 2 | SC20 | 46 | 40 | 2 |

[(U-User density to be changed), (Q-Session arrival rate, μ-Session duration, R-Mean service bit rate)]

**3.3.2 Spectrum Estimation Result:**

**Table 19: Spectrum estimation result in Bangladesh for 2020**

|  |  |  |
| --- | --- | --- |
| Bangladesh | | ITU |
| RATG1 | 420 MHz | 1340 MHz for higher user density settings |
| RATG2 | 720 MHz | 1960 MHz for lower user density settings |
| Total | 1140 MHz |

**4. Conclusion:**

In this report, we analyzed the algorithm underlying ITU’s methodology for calculating spectrum requirements of IMT systems. We proposed an approach for estimating the spectrum requirements using diffusion model. According to ITU–R, the market parameters remain unchanged except user density for estimating the spectrum requirement for a specific country. We applied well know diffusion model to forecast the user density in Bangladesh and computed approximate user density for each service category. The user density database of ITU is generated based on the information gathered from 30 countries, where user density is distributed over 20 service category. To estimate the spectrum requirement for a specific country, this database to be used for computing the user density in each service category, because each country can calculate overall user density from the observed penetration rates, population density and BTS traffic data. But it is difficult to identify how many subscribers are available in the 20 service categories mentioned in the ITU-R and ITU software tools. Moreover this database is not well matched for the particular country. Therefore, it may show a little bit different result for a particular country. Using the ITU-R spectrum estimation methodology, the spectrum requirements of IMT systems for lower and higher user density settings are 1340 MHz and 1960 MHz respectively for the year of 2020.The predicted total spectrum bandwidth requirements of Bangladesh for both the RATG 1 and RATG 2 for the year 2020 are calculated as 1140 MHz, which is lower than 1340 MHz. It happened because of slow growth of 3G subscriptions. Now 3G is almost matured in the most of the countries whereas penetration rate has been reported as only 13.97% in Bangladesh at the end of 2015. Moreover, overall penetration rate of 84.63% indicates that the market is not diffusing at reasonable level. Mobile penetration rate of each country has been published in ICT indicators database of ITU and reported more than 100% in many developing countries (Cambodia 155.11%, Ghana 114.82%, Srilanka 103.16% and Vietnam 147.11%). This study realizes that the inadequate spectrum usages and the delay of launching 3G services hinder the diffusion speed of mobile subscriptions in Bangladesh. We hope that these findings will help the regulators to seek additional spectrum to meet the future demand. Moreover, the proposed spectrum estimation model with subscriptions forecasting can be used to estimate the national spectrum requirement in SATRC countries.

**References:**

Cisco.(2010).Cisco visual networking index: Global mobile data traffic forecast update, 2010–2015.Retrieved from <http://www.cisco.com>

H.Takagi, H.Yoshino, N.Matoba, and M. Azuma,“Methodology for Calculation of Spectrum Requirements for the Next Generation Mobile Communication Systems,” *IEICE Trans.on Communications*, vol. J89-B, no. 2, Feb.2006, pp.135-142.

ITU (2010).Key2000–2010countrydata.Retrievedfrom <<http://www.itu.int/ITU-D/ict/statistics/index.html>>

Rec. ITU-R M.1390, Methodology for the Calculation of IMT- 2000 Terrestrial Spectrum Requirement, ITU, 2000.

Rec. ITU-R M.1645, Framework of the Future Development of IMT-2000 and Systems beyond IMT-2000,ITU, 2003.

Rec. ITU-R M.1768, Methodology for Calculation of Spectrum Requirements for the Future Development of IMT-2000and Systems beyond IMT-2000, ITU, 2006

Rec. ITU-R M.1768-1, Methodology for Calculation of Spectrum Requirements for the terrestrial component of IMT,ITU, 2013

Rogers, E.M. (1995). Diffusion of innovations (4th ed.).New York: Free Press.

Rep. ITU-R M.2023, Spectrum Requirements for IMT-2000, ITU, 2000.

Rep. ITU-R M.2290-0, Future spectrum requirements estimate for terrestrial IMT, ITU-12/2013

Rep. ITU-R M.2072, World Mobile Telecommunication Market Forecast, ITU, 2005.

Rep. ITU-R M.2074, Radio Aspects for the Terrestrial Component of IMT-2000 and Systems beyond IMT-2000, ITU,2005

Rep. ITU-R M.2078, Spectrum Requirements for the Future Development of IMT-2000 and Systems beyond IMT-2000, ITU, 2006

SPECULATOR for estimating the spectrum requirements for IMT systems developed by IST-WINNER projects.

**Appendix 1:**

**Spectrum Band Identified for IMT and Current status in SATRC countries:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Country | Spectrum Band  (MHz) | Total Spectrum  in MHz | Assigned to the operators | Available spectrum for new assignment (MHz) | Future Plan |
| Bangladesh | 450-460/460-470 | 2x10 | 0 | 2x10 |  |
| 703-748/758-803 | 2x45 | 0 | 2x45 | This band to be assigned very soon for 4G |
| 825-845/870-890 | 2x20 | 2x15 | 2x5 |  |
| 890-915/935-960 | 2x25 | 2x25 | 0 |  |
| 1710-1785/1805-1885 | 2x75 | 64.40 | 2x10.60 | Operators have demand for technology neutrality. It is a prominent band for future development of IMT advanced. Remaining 10.6 MHz to be assigned very soon |
| 1800 - 1900 | 20 | 0 | 20 |  |
| 1900-1910/1980-1990 | 2x10 | 0 | 2x10 |  |
| 2010-2025 | 15 | 0 | 15 |  |
| 1920-1980/2110-2170 | 2x60 | 2x35 | 2x25 | Remaining spectrum to be released very soon. |
| 2300 - 2400 | 100 | 35 | 65 | This band to be used for TD-LTE |
| 2500-2690 | 190 | 75 | 115 | After releasing 700, 1800 and 2100 MHz band, BTRC will assign this band for LTE |
| 3400-3500/3500-3600 | 2x100 | 2x94.5 | 2x5.5 | This band is reserved for IMT and currently using by ISP’s. This band can be re-farmed after releasing the band plan from ITU |
| Bhutan | 450-460/460-470 | 2x10 | 0 | 2x10 | Not decided |
| 703-748/758-803 | 2x45 | 2x20 | 2x25 | Other 2x20MHz will be assigned to other Mobile operator for 4G LTE |
| 825-845/870-890 | 2x20 | 2x20 | 0 |  |
| 890-915/935-960 | 2x25 | 2x20 | 2x5 | Not decided |
| 1710-1785/1805-1885 | 2x75 | 2x30 | 2x45 | For IMT and IMT advanced services |
| 1800 - 1900 | 20 | 0 | 20 | Not decided |
| 1900-1910/1980-1990 | 2x10 | 0 | 2x10 | Not decided |
| 2010-2025 | 15 | 0 | 15 | Not decided |
| 1920-1980/2110-2170 | 2x60 | 2x10 | 2x50 | Not decided |
| 2300 - 2400 | 100 | 0 | 100 | Intending to deploy point to point and point to multipoint MMDS services |
| 2500-2690 | 190 | 0 | 190 | Intending to deploy point to point and point to multipoint MMDS services |
| 3400-3500/3500-3600 | 2x100 | 0 | 2x100 | Not decided |
| India | 450-460/460-470 | 2x10 |  |  |  |
| 703-748/758-803 | 2x45 |  | 2x45 | 2 x 35 (likely to be auctioned in 2016-17) |
| 825-845/870-890 | 2x20 | 2x20 |  |  |
| 890-915/935-960 | 2x25 | 2x20 | 2x5 |  |
| 1710-1785/1805-1885 | 2x75 | 2x55 | 2x20 |  |
| 1800 - 1900 | 20 |  |  |  |
| 1900-1910/1980-1990 | 2x10 |  |  |  |
| 2010-2025 | 15 |  |  |  |
| 1920-1980/2110-2170 | 2x60 | 2x35 | 2x25 |  |
| 2300 - 2400 | 100 | 60 |  |  |
| 2500-2690 | 190 | 40 |  |  |
| 3400-3500/3500-3600 | 2x100 |  |  |  |
| Nepal | 450-460/460-470 | 2x10 |  |  |  |
| 703-748/758-803 | 2x45 |  |  | Auction |
| 825-835/870-880 | 2x20 | 2x9 |  | Refarming |
| 880-915/925-960 | 2x35 | 2x34.4 |  | Technical Neutrality |
| 1710-1785/1805-1885 | 2x75 | 2x47 |  | Technical Neutrality |
| 1800 - 1900 | 20 |  |  |  |
| 1900-1910/1980-1990 | 2x10 |  |  |  |
| 2010-2025 | 15 |  |  |  |
| 1920-1980/2110-2170 | 2x60 | 2x20 |  | Auction |
| 2300 - 2400 | 100 | 30 |  | Auction plan for ISP and cellular operator |
| 2500-2690 | 190 |  |  | Auction |
| 3400-3500/3500-3600 | 2x100 |  |  | Auction |

**Response from SATRC countries regarding questionnaire on Estimation of Spectrum Requirement**

**India:**

**Q1.** How many Cellular Mobile Operator licensees are in your country? When these licenses have been awarded?

**Response**

**Licensed Cellular (GSM & CDMA) Service Providers as on 31st December 2015**

|  |  |  |
| --- | --- | --- |
| **Sl. No** | **Service Provider** | **Licence Area** |
| 1 | Bharti | All India (22) |
| 2 | Aircel Group | All India (23) |
| 3 | Reliance Communications | All India (except Assam & NE) (20) |
| 4 | Reliance Telecom | Kolkata, MP, WB, HP, Bihar, OR, Assam & NE (8) |
| 5 | Vodafone | All India (23) |
| 6 | Tata Teleservices | All India except Assam, NE & J&K (19) |
| 7 | IDEA | All India (22) |
| 8 | Sistema Shyam | Delhi, Kol, Guj, KTK, TN incl. Chennai, Kerala, UP-W, Raj, WB(9) |
| 9 | BSNL | All India (except Delhi & Mumbai) 20 |
| 10 | MTNL | Delhi, Mumbai (2) |
| 11 | Telenor Communications Pvt. Ltd. | MH, Guj, AP, UP-W, UP-E, Bihar (6) |
| 12 | Videocon Telecommunications. Ltd. | Guj, Har, UP-W, UP-E, MP, Bihar (6) |
| 13 | Reliance Jio Infocomm Ltd | All India (22) |
| 14 | Quadrant | Punjab (1) |

**Q2.** How many operators are providing Mobile Broadband Service?

**Response**

List of wireless broadband service providers

|  |  |
| --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator |
| 1 | Bharti Airtel Limited |
| 2 | Vodafone India Limited |
| 3 | Idea cellular Limited |
| 4 | Reliance Communications Limited/  Reliance telecom Limited |
| 5 | Bharat Sanchar Nigam Limited |
| 6 | Aircel Cellular Limited |
| 7 | Tata Teleservices Limited /  Tata Teleservices (Maharashtra) Ltd. |
| 8 | Sistema Shyam |
| 9 | Mahanagar Telephone Nigam Limited |
|  | **Total** |

**Q3.** Please provide information of the Cellular Mobile Operator as below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator | Spectrum Band | Assigned Bandwidth (MHz) | Total Assignment (MHz) | Service Type (2G/3G/4G/Tech. Neutral) |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

[Table-3 of the draft report submitted to SWG-2 can be used as example for understanding]

Response:

Average spectrum holding (in MHz) of the TSPs \*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator | 800 MHz  (Paired) | 900 MHz  (Paired) | 1800 MHz  (Paired) | 2100 MHz  (Paired) | 2300 MHz  (Unpaired) |
| 1 | Bharti Airtel Limited | - | 5.3 | 4.6 | 5.0 | 20.0 |
| 2 | Vodafone India Limited | - | 6.4 | 6.5 | 5.0 | - |
| 3 | Idea cellular Limited | - | 5.9 | 6.9 | 5.0 | - |
| 4 | Reliance Communications Limited/ | 5 | 5.0 | 4.7 | 5.0 | - |
| Reliance telecom Limited |
| 5 | Bharat Sanchar Nigam Limited | 2.5 | 6.3 | 3.4 | 5.0 | 20.0 |
| 6 | Aircel Cellular Limited | - | 5.3 | 4.6 | 5.0 | 20.0 |
| 7 | Tata Teleservices | 2.5 | - | 4.5 | 5.0 | - |
| 8 | Telenor | - | - | 6.2 | - | - |
| 9 | Sistema Shyam | 3.75 | - | 4.4 | - | - |
| 10 | Videocon | - | - | 5.0 | - | - |
| 11 | Mahanagar Telephone Nigam Limited | - | 6.2 | 2.2 | 5.0 | - |
| 12 | Quadrant | 2.5 | - | 4.4 | - | - |
| 13 | Reliance Jio | 5 | - | 5.9 | - | 20.0 |

\* For the purpose of granting spectrum license for access services, India is divided into 22 service areas. Spectrum is assigned and managed separately for each service area. Therefore the above spectrum holding are average of the assigned spectrum for each TSP. A TSP may not be having the above-indicated spectrum on a pan-India basis.

**Q4.** What is the number of Subscriber of the Cellular Mobile Operator in 2015?

|  |  |  |
| --- | --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator | Number of Subscriber (in millions) |
|  |  |  |

Response: Wireless subscribers as on 31st December-2015

|  |  |  |
| --- | --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator | Number of Subscriber (in millions) |
| 1 | Bharti Airtel Limited | 243.29 |
| 2 | Vodafone India Limited | 193.60 |
| 3 | Idea cellular Limited | 171.91 |
| 4 | Reliance Communications Limited/  Reliance telecom Limited | 100.89 |
| 5 | Bharat Sanchar Nigam Limited | 82.51 |
| 6 | Aircel Cellular Limited | 85.63 |
| 7 | Tata Teleservices | 60.73 |
| 8 | Telenor | 50.70 |
| 9 | Sistema Shyam | 8.01 |
| 10 | Videocon | 6.96 |
| 11 | Mahanagar Telephone Nigam Limited | 3.61 |
| 12 | Quadrant | 3.05 |
|  | **Total** | **1,010.89** |

**Q5.** Please provide the Information regarding the status of IMT bands in your country as below:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| As per the NFAP | | | As per the Assignment | | | | Future plan |  |
| Spectrum Band | Spectrum Range (MHz) | Total Spectrum (MHz) | Mobile | BWA | ISP | PSTN |  |  |
|  |  |  |  |  |  |  |  |  |

[Table-12 of the draft report submitted to SWG-2 can be used as example for understanding]

Response:

|  |  |  |
| --- | --- | --- |
| Spectrum Band | Total spectrum | Spectrum allocated for commercial telecom operations |
| 700 MHz | 2 x 45 | 2 x 35 (likely to be auctioned in 2016-17) |
| 800 Mhz | 2 x 20 | 2 x 20 |
| 900 MHz | 2 x 25 | ≅ 2 x 20 |
| 1900 MHz | 2 x 75 | 2 x 55 |
| 2100 MHz | 2 x 60 | 2 x 35 |
| 2300 MHz | 100 | 60 |
| 2500 Mhz | 190 | 40 |

**Q6.** What are the probable bands that your country may consider for future IMT identification in WRC-19?

**Its too early to comment.**

**Nepal**

**Q1.** How many Cellular Mobile Operator licensees are in your country? When these licenses have been awarded?

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Name of the Cellular Mobile Operator** | **License Issued Year** |
| 1 | Nepal Doorsanchar Company Limited | 1999 May |
| 2 | Ncell Pvt. Ltd. | 2004 September |
| 3 | Smart Telecom Pvt. Ltd. | 2013 April |

**Q2.** How many operators are providing Mobile Broadband Service?

Two operators are providing Mobile Broadband Service

**Q3.** Please provide information of the Cellular Mobile Operator as below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S. No.** | **Name of the Cellular Mobile Operator** | **Spectrum Band** | **Assigned Bandwidth (MHz)** | **Total Assignment (MHz)** | **Service Type (2G/3G/4G/Tech. Neutral)** |
| 1 | Nepal Doorsanchar Company Limited | 800 MHz  900 MHz  1800 MHz  2100 MHz  2300 MHz | 2x6 MHz  2x9.6 MHz  2x15 MHz  2x10 MHz  30 MHz | 111.2 MHz | 2G  2G  2G  3G  4G |
| 2 | Ncell Pvt. Ltd. | 900 MHz  1800 MHz  2100 MHz | 2x8 MHz  2x11 MHz  2x10 MHz | 58 MHz | 2G  2G  3G |
| 3 | Smart Telecom Pvt. Ltd. | 900 MHz  1800 MHz | 2x5 MHz  2x12 MHz | 34 MHz | 2G  2G |

[Table-3 of the draft report submitted to SWG-2 can be used as example for understanding]

**Q4.** What is the number of Subscriber of the Cellular Mobile Operator in 2015?

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Name of the Cellular Mobile Operator** | **Number of Subscriber (in millions)** |
| 1 | Nepal Doorsanchar Company Limited | 13.07 |
| 2 | Ncell Pvt. Ltd. | 13.87 |
| 3 | Smart Telecom Pvt. Ltd. | 1.36 |

**Q5.** Please provide the Information regarding the status of IMT bands in your country as below:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **As per the NFAP** | | | **As per the Assignment** | | | | **Future plan** | **Remarks** |
| **Spectrum Band** | **Spectrum Range (MHz)** | **Total Spectrum (MHz)** | **Mobile** | **BWA** | **ISP** | **PSTN** |  |
| 700 MHz | 6703-748 MHz paired with 758-803 | 2x45 MHz |  |  |  |  | Auction |  |
| 800 MHz | 824-834 MHz paired with 869-879 MHz | 2x10 MHz | 2x9 MHz |  |  |  | Refarming | Some spectrum assigned to regional mobile operators |
| 900 MHz | 880-915 MHz paired with 925-960 MHz | 2x35 MHz | 2x34.4 MHz |  |  |  | Technical Neutrality |
| 1800 MHz | 1710-1785 MHz paired with 1805-1880 MHz | 2x75 MHz | 2x47 MHz |  |  |  | Technical Neutrality |
| 2100 MHz | 1920-1980 MHz paired with 2110-2170 MHz | 2x60 MHz | 2x20 MHz |  |  |  | Auction |  |
| 2300 MHz | 2300-2400 MHz | 100 MHz |  | 30 MHz |  |  | Auction plan for ISP and cellular operator |  |
| 2400 MHz | 2400-2483.5 MHz | 83.5 MHz |  |  | 83.5 MHz |  |  | ISM Band |
| 2600 MHz | 2500 - 2570 paired with 2620 -2690 MHz  2570-2620 MHz | 2x70 MHz (FDD)  45 MHz (TDD) |  |  |  |  | Auction |  |
| 3300 MHz | 3300-3400 MHz | 100 MHz |  |  |  |  | Auction |  |
| 3400 MHz | 3400-3600 MHz | 200 MHz |  |  |  |  | Auction |  |
| 3600 MHz | 3600-3800 MHz | 200 MHz |  |  |  |  |  | C-Band Satellite Terminals using some spectrum in this band |

[Table-12 of the draft report submitted to SWG-2 can be used as example for understanding]

**Q6.** What are the probable bands that your country may consider for future IMT identification in WRC-19?

Not Identified yet

**BHUTAN**

**Q1. How many Cellular Mobile Operator licensees are in your country? When these licenses have been awarded?**

Ans: We have two Cellular Mobile Operators in Bhutan, viz: Bhutan Telecom Limited (State-owned) and Tashi InfoComm Limited (Private-owned). The Tashi InfoComm Limited was licensed in 2007. The Bhutan Telecom Limited came into existence on 1st July 2000 as a fully state-owned company with the corporatization of the erstwhile Department of Telecommunications which was established in 1970. However, the detailed Cellular Mobile License Terms and Conditions were signed in 2008 after the establishment of regulator BICMA.

**Q2. How many operators are providing Mobile Broadband Service?**

Ans: Both the operators are providing Mobile Broadband Service.

**Q3. Please provide information of the Cellular Mobile Operator as below:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator | Spectrum Band | Assigned Bandwidth (MHz) | Total Assignment (MHz) | Service Type (2G/3G/4G/Tech. Neutral) |
|  | Bhutan Telecom Limited | GSM 900 | 890-910 MHz, 935-955 MHz | 2x10MHz | 2G |
| GSM1800 | 1730-1740 MHz, 1825-1835 MHz | 2x10MHz | 4G |
| GSM1800 | 1720-1730MHz, 1815-1825MHz | 2x10MHz | 2G |
| 850MHz | 834-844 MHz, 879-889 Mhz | 2x10MHz | 3G |
| 1900MHz | 1920-1930 MHz, 2110-2120 MHz | 2x10MHz | 3G |
| 2. | Tashi InfoComm Limited | GSM900 | 900-910, 945-955 MHz | 2x10MHz | 2G |
| GSM1800 | 1710-1720 MHz, 1805-1815 MHz | 2x10MHz | 2G |
| 850MHz | 824-834 MHz, 869-889 MHz | 2x10MHz | 3G |
|  | 703-723 MHz, 758-778 MHz | 2x20MHz | 4GLTE |

[Table-3 of the draft report submitted to SWG-2 can be used as example for understanding]

**Q4. What is the number of Subscriber of the Cellular Mobile Operator in 2015?**

|  |  |  |
| --- | --- | --- |
| Sl. No. | Name of the Cellular Mobile Operator | Number of Subscriber (in millions) |
| 1. | Bhutan Telecom Limited | 0.477091 millions (as of March 2016) |
| 2. | Tashi InfoComm Limted | 0.196058 millions (as of March 2016) |

**Q5.** Please provide the Information regarding the status of IMT bands in your country as below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Spectrum Band** | **Spectrum Range**  **(MHz)** | **Total Spectrum** | **Assigned to the operators** | **Total Spectrum Remaining** | Future Plan |
| **Mobile** |
| 450 MHz | 450-460/460-470 | 20 MHz |  | 20MHz | Not decided |
| 700 MHz | 703-748/758-803 | 2x45 MHz | 2x20MHz | 2x25MHz | Other 2x20MHz will be assigned to other Mobile operator for 4G LTE |
| 800 MHz | 825-845/870-890 | 2x40 MHz | 2x40MHz | None |  |
| 900 MHz | 890-915/935-960 | 50 MHz | 2 x 20MHz | 2x5MHz | Not decided |
| 1800 MHz | 1710-1785/1805-1885 | 150 MHz | 2x30MHz | 2x45MHz | For IMT and IMT advanced services |
| 1880 MHz | 1800 - 1900 | 20 MHz |  | 2x20MHz | Not decided |
| 1900 MHz | 1900-1910/1980-1990 | 20 MHz |  | 2x10MHz | Not decided |
| 2000 MHz | 2010-2025 | 15MHz |  | 15MHz | Not decided |
| 2100 MHz | 1920-1980/2110-2170 | 120 MHz | 2x10MHz | 100MHz | Not decided |
| 2300 MHz | 2300 - 2400 | 100 MHz |  | 100MHz | Intending to deploy point to point and point to multipoint MMDS services |
| 2500 MHz | 2500-2690 | 190 MHz |  | 190MHz | Intending to deploy point to point and point to multipoint MMDS services |
| 3500 MHz | 3400-3500/3500-3600 | 200 MHz |  | 200MHz | Not decided |
| Total | | 1015 MHz |  |  |  |

**QUESTIONNAIRE**

Q.1. How much spectrum is assigned for cellular mobile communications?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name of the operator | Spectrum band | Assigned spectrum | | Service |
| Tx | Rx |
|  |  |  |  |  |

Q.2. Yearly mobile subscription data from the beginning to date

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Mobile subscriptions (million) | | Average Penetration rate |
|
|  | 2G | 3G |  |
|  |  |  |  |

Q.3. Mobile (voice and data) penetration rates according to the geographical area

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Geographical area | | |
| Dense Urban | Sub-Urban | Rural |
| December 2015 |  |  |  |

Q.4. Traffic data: (Traffic data to be collected from a BTS located in the following area. Please send the following data separately if you have separate network for 2G and 3G).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name of the operator | BTS Location (only one BTS located in each area) | | | | |
|  | Dense Urban | BTS in home area | Sub-urban | BTS in home | Rural  (BTS in rural area) |
| BTS in office area | BTS in office & public area |
| BTS in public area |

N.B (Home-Residential area, Office-Commercial area, Public area-market or railway station)

1. No of call access per base station in busy hour (Voice, SMS, data, multimedia)
2. Area per cell.
3. Average busy hour call access per user.
4. Population growth rate
5. Average number of active subscriber per BTS in busy hour

Q.5. Do you have any possibility for generating multicast traffic within 2020?

Q.6.How many BTS installed in each year from the early date of assignment of spectrum?

Macro BTS:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Operator name | Year | Spectrum band | 2G/3G | No of installed BTS in different geographical area | | | | | |
| Dense urban | Average cell area | Sub Urban | Average cell area | Rural | Average cell area |
|  |  |  |  |  |  |  |  |  |  |

Micro BTS:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Operator name | Year | Spectrum band | 2G/3G | No of installed BTS in different geographical area | | | | | |
| Dense urban | Average cell area | Sub Urban | Average cell area | Rural | Average cell area |
|  |  |  |  |  |  |  |  |  |  |

Pico/Hot spot/Small cell:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Operator name | Year | Spectrum band | 2G/3G | No of installed BTS in different geographical area | | | | | |
| Dense urban | Average cell area | Sub Urban | Average cell area | Rural | Average cell area |
|  |  |  |  |  |  |  |  |  |  |

\_\_\_\_\_\_\_\_\_\_\_\_

1. The frequency bands 1 427-1 452 MHz and 1 492-1 518 MHz are identified for use by administrations in Region 3 wishing to implement International Mobile Telecommunications (IMT) in accordance with Resolution **223 (Rev.WRC-15)**. [↑](#footnote-ref-1)
2. *Additional allocation:* in Saudi Arabia, Bahrain, Bangladesh, Benin, Brunei Darussalam, Cambodia, Cameroon, China, Congo (Rep. of the), Korea (Rep. of), Côte d'Ivoire, Egypt, the United Arab Emirates, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Japan, Jordan, Kenya, Kuwait, Lebanon, Libya, Malaysia, Oman, Uganda, Pakistan, Qatar, the Syrian Arab Republic, the Dem. Rep. of the Congo, the Dem. People’s Rep. of Korea, Sudan and Yemen, the frequency band 3 300-3 400 MHz is also allocated to the fixed and mobile services on a primary basis. The countries bordering the Mediterranean shall not claim protection for their fixed and mobile services from the radiolocation service. (WRC-15) [↑](#footnote-ref-2)
3. 150594x1.0561 [↑](#footnote-ref-4)
4. 150594x0.4532 [↑](#footnote-ref-5)
5. Penetration rate is calculated from number of user and population. But service penetration rates to be calculated from users of a particular service and total number of users(Rec-ITU.R M1390) . [↑](#footnote-ref-6)
6. These are the uplink data set is gathered from ITU Spectrum estimation tools. User density for SC1, SC2, SC6, SC7, SC11, SC12, SC16 and SC17 are acquired from lower market settings and rest of the service categories are considered in higher market settings. [↑](#footnote-ref-7)
7. This data set is an aggregate value collected from table 13 and to be distributed to the each service category by multiplying the service penetration rates. Forecasted 3G subscriptions are placed in SC1, SC2, SC3, SC6, SC7, SC8, SC11, SC12, SC13, SC16 SC17 and SC18 and 2G subscriptions are placed in SC4,SC5, SC9,SC10, SC14, SC15, SC19 and SC20. [↑](#footnote-ref-8)
8. Example: (68249x0.327)/100 = 22.31 [↑](#footnote-ref-9)