# METHOD FOR CALCULATING THE RESERVE PRICE OF A 50MHz BLOCKS TO OPERATE AND ESTABLISH A 5G MOBILE NETWORK IN THE 3.7 GHZ BAND IN MADAGASCAR

RANDRIAMITANTSOA P.A. [1], RAKOTONIRINA H.B. [2], RANDRIANA N.H.E[2], RANDRIAMIADANA Z.A. [2], RAKOTOMANANJARA D.F. [2], BAOVOLA M.A.[2], RAMASONDRANO A. [2], RABEVAHINY A.L.[2]

[1]*Thesis director, TASI, ED-STII, Antananarivo, Madagascar*
[2]*PhD student, TASI, ED-STIII, Antananarivo, Madagascar*

## ABSTRACT

*The 5G mobile technology in Madagascar uses the 3.7GHz (3.6GHz-3.8GHz) band. Our aim in this article is to provide a reserve price for the 50MHz blocks in Madagascar. To achieve this end, we used four model of calculation. Furthermore, to determine the final price, we calculate the mean of the total prices obtained from these methods.*
*From our calculation, the reserve price of a 50MHz block, for the case of Madagascar, is set to 48,500,000 euros.*
**Keyword**: *3.7GHZ, 50Mhz, 5G mobile, Licence, Frequency band, Madagascar*

## 1. INTRODUCTION

Far from the current 4G mobile system, the 5G mobile technology will enable a more reliable communication with a high transmission speed and a very low latency times, a better mobile terminal autonomy and a network segmentation depending on the application. These properties open the door to a new opportunity for innovation, in the mobile telecommunications services. The 5G mobile in Madagascar will be essentially based on the 3.7GHz (3.6-3.8 GHz) band. In this article, we will be calculating a reserve price for a 50MHz in this frequency band.

## 2. CALCULATION OF RESERVE PRICE OF A 50MHZ BLOCK IN MADAGASCAR

*Definition 1:*
We defined by the 3.7 GHz band as the frequency comprises between 3.6GHz and 3.8GHz.

The table 1 bellow represent the allocation of the frequency between 3.4 and 3.8GHz band, for the case of Madagascar:

**Table 1:** Allocation of the 3.4 to 3.4Ghz band in Madagascar

| Frequency | Sector attribution in Madagascar |
|---|---|
| 3,4 à 3,6 GHz | Attributed to embassies and air navigation |
| 3,6 à 3,8 GHZ | Band auctioned for the 5G mobile network deployment |

In Madagascar, we plan to subdivide the 200MHz blocks in the 3.7GHz frequency band into:

- 3 blocks of 50 MHz
- And 5 blocks of 10 MHz

The 50 MHz block has been allocated in order to achieve the objectives defined by the three applications domain and use cases cited bellow:

- **mMTC (Massive Machite Type Communications):** This is the communication between high number of objects with the needs of different services, specifically the Internet of Thing (IoT), the resource monitoring, Smart agriculture, Energy monitoring, Smart Home and remote surveillance.
- **eMBB (Enhanced Mobile Broadband):** This is the connections with very high peak data rates outside building and inside building with a stable quality of service, even in the cell border.
- **uRLLC (Ultra-reliable and Low Latency Communications):** This is a ultra-reliable communication for critical low latency needs, recovering all the application which need a low latency and ultra-high reliability like the telemedicine and autonomous vehicle.

There are several methods for calculating the frequency reserve price. Below are listed few of them:

- **Model 1:** Calculation and payment method of fees and redevances [1]
- **Model 2:** Calculation method of the Josas-ParisTech regulation [2]
- **Model 3:** Tariffication model of the IUT [3]
- **Method 4 :** Benchmarking [4]
- **Model 5 :** ARCEP - France model [5]
- **Model 6 :** CRTC - Canada model [6]
- **Model 7 :** IRL - Luxembourg model [7]
- **Model 8 :** Rguigue model [8]
- **Model 9 :** GSMA model [9]
- **Model 10 :** OECD model [10]
- **Model 11 :** Karamti model [11]
- **Model 12 :** Touré model [12]
- **Model 13 :** Diop model [13]

For determining the reserve price of a 50 MHz block in Madagascar, we use the following 4 models:

- **Model 1:** Calculation and payment method of fees and redevances
- **Model 2:** Calculation method of the Josas-ParisTech regulation
- **Model 3:** Tariffication model of the IUT
- **Method 5:** Benchmarking

**2.1 Calculation and payment method of fees and redevances [1]**

By applying the Decree No. 8235/99 of 1999, Repoblikan'i Madagasikara, defining the calculation and payment method of fees and readvances corresponding to the spectrum and frequency band usage and also electrical material by the Ministry of Posts and Telecommunication, the reserve price of a 50 MHz block is defined by the equation (1):

$$C_{l1} = R_{cm} + M_{Tf} + D_u \quad (1)$$

With: $C_{l1}$: Cost of the license

$R_{cm}$: Hardware control fee

$D_u$: Frequency usage fee

$M_{Tf}$: Total amount of spectrum and frequency band fees

**Step 1: Calculation of spectrum usage fees $D_u$ [1]**

The spectrum usage fee is calculated annually for each link according to its length, the number of tracks on this link as well as the number of terminal station and terminal relay stations. The table 2 illustrate the bit rate related to the usage fee, according to the decree. In Madagascar, for the data transmission, the spectrum usage fee is set by the table 2, with 1 UC = 100Ar [1].

**Table 2:** Bit rate according to the right of use [1]

| **Bit rate (DN)** | **Right of use** |
|---|---|
| DN < 19,2 kbits/s | 240 UC |
| 19,2 kbits/s < DN < 64 kbits/s | 1 500 UC |
| 64 kbits < DN < 512 kbits/s | 12 000 UC |
| 512 kbits/s < DN < 1 Mbits/s | 25 500 UC |
| 1 Mbits/s < DN < 2 Mbits/s | 51 000 UC |
| 2 x N Mbits/s | N x 51 000 UC |

Concerning the calculation of the usage fee $D_u$, for the case of the 5G mobile, we take the theoretical value of the data rate (DN) to approximately equal to 10 Gbps.

Then:

$$N= 5000$$

By using the table 2, the spectrum fee $D_u$ is equal to:

$$D_u = N \times 51000\ UC$$

$$D_u = 5\ 666\ 667\ €$$

**Step 2: Calculation of the hardware control fee $R_{cm}$**

It is calculated annually for all transmitter or transceiver exploited. It is calculated based on the number and nominal power of transmitters or transceivers.

**Table 3:** Control fees according to frequency categories [1]

| Category | Control fees |
|---|---|
| HF less than 1KW | EHF 150 UC / station / year |
| HF greater than 1KW | 400 UA / workstation / year |
| VHF / UHF / SHF / | 100 UA / workstation / year |

The approximative number of 5G mobile subscriber in Madagascar is 1 500 000 for the duration 15 year, which is the frequency usage duration from the year 2021. This number is obtained by taking into account all factors like the need in usage data rate, which is in total around 10 million subscribers.

The figure below represents this estimation:

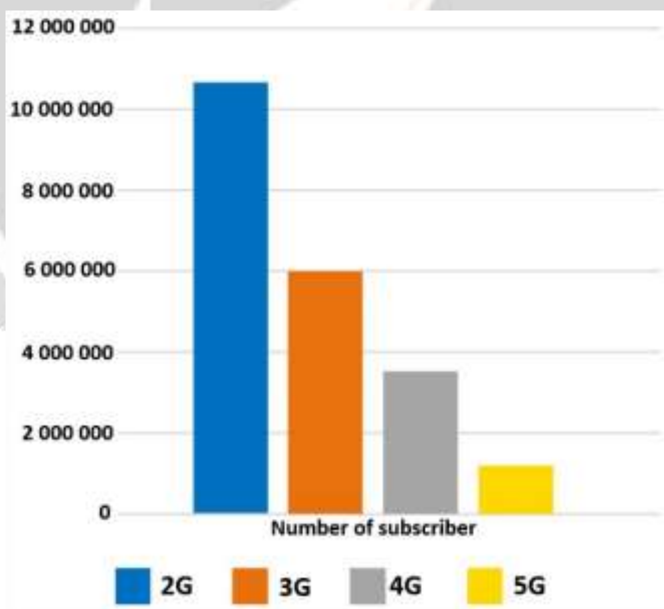


**Chart-1:** Number of subscribers according to the different types of networks [1]

As the 3.7GHz band is classified among the SHF frequency band, we can deduce that:

$$R_{cm} = 50\ 000\ 000\ € \quad (3)$$

**Step 3:** Calculation of the total amount of frequency fees and $M_{Tf}$ frequency band

It is calculated annually depending the number and type of frequencies or the total width of the assigned frequency bands. [1]

The total amount of the spectrum usage fee is equal to the sum of all the frequency band, the frequency pairs $F_q$ and the number of frequencies for the other transmission media multiplied by the frequency fee.

This total amount is defined by [1]:

$$M_{Tf} = \sum (F_i + F_q + N_f) \times R_f \qquad (4)$$

With $F_i$: Number of frequencies in the considered band

$F_q$ Number of frequency pairs

$N_f$: Number of frequencies used by other media

$R_f$: Licence fee, it is defined by table 4

**Table 4**: The licence fee depending the Type of frequencies [1]

| Frequency type | Frequency fees |
|---|---|
| HF | 400 UC |
| VHF/UHF/SHF/EHF | 500 UC |

As the 3.7GHz band is in the SHF band, in our case the frequency fee is equal to 500 UC. And we also posited that in the 50MHz band, there are 50 available frequencies. Using these data, we have the total amount of the spectrum fees equal to [1]

$$M_{Tf} = 556 \text{ €} \qquad (5)$$

Using equation (5) and the previous data, the license cost for a 50MHz block in the 3.7GHz band is equal to [1]:

$$C_{l1} = R_{cm} + M_{Tf} + D_u$$

$$C_{l1} = 55\ 667\ 223 \text{ €} \qquad (6)$$

### 2.2 Calculation method by using the Josas regulation-ParisTech

The second method is based on the calculation method by Josas regulation-ParisTech, the cost of the license is expressed as:

$$C_{l2} = \frac{C_{um}.N_p.D.T_c}{E(\beta)} \quad (7)$$

With: $C_{l2}$: Cost of the 5G license according to the ParisTech model

$C_{um}$: Average Unit Cost of license

$N_p$: Number of populations

$D$: Duration of the License

$T_c$: Exchange rate

β: Parameter of proportion between the license price for 4G and that of 5G

E (β): The mean value of β

**Step 1:** Calculation of the Average Unit Cost of $C_{um}$ license [2]

To find the Average Unit Cost of license ($C_{um}$) we will use data from several countries here in Africa and calculate the average. Table 5 shows us these data and we can deduce that the average unit cost of a telecommunication license in Africa is [2]:

$$C_{um} = 0{,}57625$$

**Table 5**: Calculation of the average unit cost of license [2]

| Country (operator) | Population (millions) | Year | Amount in millions of local currencies | License term (year) | $C_{um}$ (Price in dollar PPA/population/year) |
|---|---|---|---|---|---|
| Ghana (Voda fone,BLUSurfline) | 25,75 | 2014 | 35,30 | 15 | 0,06 |
| Morocco (IAM) | 33,96 | 2015 | 1000 | 20 | 0,29 |
| Morocco (INWI ) | 33,96 | 2015 | 500 | 20 | 0,14 |
| Morocco (Meditel) | 33,96 | 2015 | 500 | 20 | 0,14 |
| Tunisia (Oore doo) | 11,25 | 2016 | 160 | 15 | 1,28 |
| Tunisia (Orange) | 11,25 | 2016 | 156 | 15 | 1,25 |
| Tunisia (Tunisia Télécom) | 11,25 | 2016 | 155 | 15 | 1,24 |
| Kenya (Safaricom) | 45 | 2014 | 7 555 | 15 | 0,21 |
| AVERAGE 4G LICENSE UNIT COST IN AFRICA ($C_{um}$) = | | | | | **0,57625** |

**Step 2:** Calcul of β [2]

The value of β represents the ratio between the 4G license fees and that of the 5G license. We have done some calculation for a few specific countries (See Table 6) then we calculated the mean of the values obtained for the purpose to find E (β). After calculation, we have seen that E (β) is equal to 0.9. [2]

**Table 6:** Price comparison by country [2]

| Country | Total price of 4G mobile | Total price of 5G mobile | $\beta$ |
|---|---|---|---|
| France | 2,5 Million euros | 2,17 Million euros | 1,15 |
| England | 6 Million euros | 8 Million euros | 0,75 |
| Switzerland | 997 Million euros | 1,4 Milliard euros | 0,7 |
| $E(\beta)$ | | | 0,9 |

The table 7 summarizes the parameters used for the calculation of the 5G license fees.

**Table 7: Summary of parameters [2]**

| | |
|---|---|
| $C_{um}$ | 0,5763 |
| **Number of populations** | 25 109 594 |
| **License duration (year)** | 10 |
| **PPA / Ar exchange rate** | 1 064 |
| **Euro / Ar rate (2020)** | 4 500 Ar |
| $E(\beta)$ | 0,9 |

Using equation (7), we have:

$$C_{l2} = 49\ 963\ 075\ € \qquad (8)$$

**2.3 Calculation method using the IUT model [3]**

The price of spectrum can be established from a number of separate elements based on a set of criteria or on only a few of them. These criteria are for example the quantity of spectrum used, the number of channels or links used, the degree of congestion, the efficiency of the radio equipment, the power of the transmitter and the area of coverage, the geographical location. The fundamental principle of this method consists of defining various technical parameters making it possible to measure the quantity of spectrum used or to define the “pollution zone” of a radio system in order to constitute a common basis for establishing the charges. [3]

The universal model is given by:

$$C_{l3} = \frac{V}{M} \times \frac{K_f K_s}{K_m} \times C_s \times K_p \tag{9}$$

With: $C_{l3}$: represents the price of the license according to the ITU method

$V$: represents the volume of space or geometric area occupied

$K_f$: represents the coefficient taking into account the particular characteristics of the frequency range used

$K_s$: represents the coefficient taking into account the region or the location of the radio station

$K_m$: represents the coefficient taking into account the social advantages of the radio system

$C_s$: represents the annual cost of spectrum management

$K_p$: represents the coefficient taking into account the level of demand for access to the spectrum in the band considered.

M: The number of subscribers

For the case of Madagascar, the data that we used for the calculation are given as follows:

$V$: 587 041 km$^2$

$M$: 1 500 000 Subscribers

$K_f$: 0.6

$K_s$: 0.4

$K_m$: 0.2

$C_s$: 107 317 886 Euro

$K_p$: 0.83

Thus, we obtained:

$$\boldsymbol{C_{l3} = 41\,831\,999,41}\ € \tag{10}$$

**2.4 Benchmarking method**

*Definition 2:*

The benchmarking method is defined by the study of frequency band price allocated for mobile service in other country [4]

We have considered two countries: Morocco with a reserve price for a 50 MHz block of € 60,948,744 and Egypt with a reserve price of € 92,994,500.

To implement these frequency price for the case of Madagascar, we have done:

- An arithmetic mean calculation
- And, we multiply by a factor $\alpha$

It is to know that the factor $\alpha$ depend of:

- The subscriber numbers
- The GDP
- The level of development in the country

This factor can take a value between $0 \leq \alpha \leq 1$

For the case of Madagascar, we took α = 0.6 [4] [14]

$$C_{l4} = \frac{\alpha}{n}\sum_{i=1}^{n} R_{DT_i}$$

With: $C_{l4}$: The reserve price of a 50 MHz block for the case of Madagascar according to the Benchmarking method

$n$: The number of countries to be taken into account for the standardization

$R_{DT_i}$: The reserve price in country i

$\alpha$: factor depending on the economy and the number of subscribers in a country

For the two African countries selected, mean n = 2, we have:

$$\boldsymbol{C_{l4} = 46\ 182\ 973,2}\ € \qquad (12)$$

**2.5 Proposal of a reserve price for the 50 MHz frequency block in Madagascar**

The 4 methods made it possible to determine the following prices:

- Model 1: $C_{l1} = 55\ 667\ 223$ €
- Model 2: $C_{l2} = 49\ 963\ 075$ €
- Model 3: $C_{l3} = 41\ 831\ 999{,}41$ €
- Model 4: $C_{l4} = 46\ 182\ 973{,}2$ €

By definition, the reserve price $C_{TL}$ of a 50MHz frequency block is the mean of the $i$ calculation method. Then, we have:

$$C_{TL} = \frac{\sum_{i=1}^{4} C_{li}}{4} \qquad (14)$$

With: $C_{li}$: the reserve prices obtained with the previous methods

$C_{TL}$: the final reserve price of the 50MHz block

For the case of Madagascar, the mean of the result obtained from the 4 previous method, using equation (14), is given by:

$$C_{TL} = 48\ 111\ 317{,}65\ €$$
$$\boldsymbol{C_{TL} \approx 48\ 500\ 000}\ €$$

The final reserve price of a 50MHz block, for the use of 5G mobile in Madagascar is then set to 48 500 000 €

The Table 8 bellow shows the reserve prices of a 50MHz block in a few countries located in Europa, Asia and Africa.

**Table 8: Reserve price of 50MHz in few countries**

| Country | Price of a 50MHz block |
|---|---|
| Italy | 1 000 000 000 € |
| Germany | 779 000 000 € |
| United Kingdom | 380 000 000 € |
| France | 350 000 000 € |
| Hong Kong | 277 000 000 € |
| Latvia | 250 000 000 € |
| Luxembourg | 150 000 000 € |
| Finland | 121 000 000 € |
| Spain | 107 400 000 € |
| Egypt | 92 994 500 € |
| Morocco | 60 948 744 € |
| Madagascar | 48 500 000 € |

## 3. CONCLUSION

According to our calculation, the reserve price for attributing a 50 MHz frequency block in the 3.7 GHZ band, for the case of Madagascar, is set to 48.5 Million euros. By the concept of "auction" with engagement for fixing the price of 50MHz frequency block, this can be for the regulator a time to make the operator holding a 5G mobile license assume entirely their responsibilities. The idea is that the operator who give the best price is considered to be the one whose 5G mobile project is the most well-structured.

This concept, simple, has been theorized and implemented more and more frequently, at the beginning of the year 2000, for different country located in America, Europa, Asia and Africa. It becomes even a corporate event for the choice of the operator holding a mobile license from the extravagant financial amount proposed during the competition.

## 4. REFERENCES


[1] Arrêté N° 8235/99 du 20 Août 1999, « *Définissant les modes de calcul et de paiement des droits et redevances relatifs à l'utilisation des fréquences et des bandes de fréquences ainsi que des appareils radioélectriques* », Ministère des Postes et des Télécommunications, Repoblikan'i Madagasikara.

[2] J.A. Rojas Rojas, « *Développement d'avantages concurrentiels dans les marches des communications électroniques en Amérique du sud : les CAS de l'Argentine, du Brésil et du Chili* », These de doctorat en science économique, Unité d'Economie Appliquée – ParisTech - ENSTA, Ecole Doctorale EPS, Université Paris I Pantheon Sorbone, 18 janvier 2018.

[3] COSITU, « *Le modèle de l'UIT pour le calcul des coûts, tarifs et taxes d'interconnexion relatifs au service téléphonique* », ITU, 2014.

[4] ARCEP, « *Modalités et conditions d'attribution des fréquences dans la «bande cœur» de la 5G (3,4 – 3,8 GHz)* », République Française, Septembre 2020.

[5] ARCEP, « *Décision n° 2020-1254 de l'ARCEP en date du 12 novembre 2020 autorisant la société Bouygues Telecom à utiliser des fréquences dans la bande 3,4 - 3,8 GHz en France métropolitaine pour établir et exploiter un réseau radioélectrique mobile ouvert au public* », République Française, 2020.

[6] H. Intven, M. C. Tétrault, « *Vue d'ensemble de la réglementation des télécommunications* », Gouvernement du Canada, Conseil de la Radiodiffusion et des Télécommunications Canadiennes, 2000.

[7] Service des médias, des communications et du numérique, « *Enchères en vue de l'octroi des fréquences destinées à la 5G : détail du montant des redevances* », Institut de Régulation Luxembourgeois, 2020.

[8] G. Vincent, « *Evaluation des projets et estimation des coûts* », LAMSADE-Université Paris-Dauphine, 2010.

[9] GSMA, «*Réformer la fiscalité de la téléphonie mobile à Madagascar*», Ernst et Young Global Limited,Mars 2019.

[10] OCDE, « *La tarification de l'accès dans le secteur des télécommunications* », Les Editions de l'OCDE, 2004.

[11] C. Karamti, « *Indices de prix pour les services de la téléphonie mobile en France : Application de la méthode des prix Hédoniques* », Institut des Sciences et Technologies ParisTech, 9 mars 2007.

[12] P.G. Touré, « *Calculer le coût de revient des services* », TactiKom, Genève, 2016.

[13] S. Diop, « *Vers une rationalisation de la méthode de détermination du prix* », Licences Télécoms Afrique, Microeconomix, 2015.

[14] Commission des participations et des transferts, « *Avis n° 2019 - A. – 8 relatifs à l'évaluation de lots de fréquences hertziennes dans la bande de 3,4-3,8 GHz* », République Française, 22 novembre 2019.

[15] ARCEP, « *Avis n° 2019 1851 sur le projet d'arrêté permettant le lancement de la procédure d'attribution de la bande 3,4 3,8 GHz en métropole* », République Française, 17 Décembre 2019.

[16] « *Les premiers terminaux 5G devraient arriver l'année prochaine* », Le Quotidien du People, 24 Avril 2018.

[17] J.M. Chaduc, « *La gestion des fréquences* », Hermes Science-Lavoisier, 2005.