

# **An Insight into Spectrum Price Benchmarks for the 410/450MHz bands**

K S Farhat, F Bou Dihh  
EICON (Engineering & Information Consultants)

1 July 2021

**CONTENTS**

1	Executive Summary .....	3
2	Overview .....	4
3	Benchmark Awards for the 410/450 Bands .....	4
4	Price Benchmarking Analysis.....	5
	4.1 Methodology.....	5
	4.2 Price Benchmarks for 410MHz.....	6
	4.3 Price Benchmarks for 450MHz.....	6
5	Summary Results .....	7

**LIST OF FIGURES**

Figure 1: The 400 MHz Band .....	4
Figure 2: Analysis of 410MHz prices by regression – all countries included .....	6
Figure 3: Analysis of 450MHz prices by regression (Sweden 2005 excluded) .....	6

**LIST OF TABLES**

Table 1: Value of 410 and 450MHz- Prices are in \$/MHz/pop.....	3
Table 2: Awards in the 410-430MHz band over the period 2000-2021 .....	5
Table 3: Awards in the 450-470MHz band over the period 2000-2021 .....	5
Table 4: Price benchmarks for 410MHz and 450MHz bands in \$/MHz/pop .....	7

**Copyright ©2021 – All Rights Reserved. No part of this document may be reproduced or used without written permission**

# 1 EXECUTIVE SUMMARY

A new type of interest is emerging in the use of the 400MHz bands (410-430MHz and 450-470MHz spectrum bands), referred to here as the 410 band and the 450 band. This is partly driven by demand from new technologies such as 5G and IoT, but predominantly for private networks. Recent examples of countries that have issued consultations on the future award or valuation of the 400MHz bands include among others: Norway, Greece, Ireland, Saudi Arabia, and UK.

This interest also raises a need for price benchmarking, and consultations have been issued for this purpose by: CITC (Saudi Arabia, May 2021), and Ofcom (UK, June 2021). Regulators are always intent on ensuring that whatever pricing mechanism is adopted, through auction or through an Administratively-set Incentive Price mechanism (AIP), that fees truly reflect the full market value of the spectrum being licensed. As such, Ofcom uses an AIP method to reflect the market value of spectrum based on its opportunity cost, and to promote its optimal use. Questions are also being asked as to whether the 410 band carries a similar value to the 450 band due to its similar propagation characteristics, available bandwidth, and frequency arrangement.

In this report we overview spectrum prices for both bands based on the market approach, with comparisons from recent awards and from more distant awards. For the purpose of the study, and in line with its objectives, the 400MHz band is broadly split into two ranges of interest, which shall be referred to as the 410 band and the 450 band, specifically:

- 410MHz covering the range 410-430MHz (or parts thereof)<sup>1</sup>
- 450MHz covering the range 450-470MHz (or parts thereof)<sup>2</sup>

Frequency authorizations based on wider blocks of spectrum awarded over the two bands in different countries are collected, and the corresponding spectrum fees are then used to calculate benchmarks. Adjustments for differences in license terms and country economic conditions are to compare fees on a par basis, and these include: converting prices to a common license duration, adjusting for inflation from the date of issue, and adjusting for Purchasing Power Parity (PPP). For the purpose of the study, the two bands are priced separately in order to estimate a pricing ratio between the two and to assess whether they are viewed as substitutes.

Two methods are used for valuation: (1) based on arithmetic mean; and (2) based on regression analysis, that links price benchmarks of countries in which the awards took place, by a first order correlation with their GDP/capita (PPP) values.

Based on the above, the mean value of 410 band prices is calculated as 0.0272\$/MHz/pop, and the mean value of 450 band awards is calculated as 0.0698\$/MHz/pop.

We take as an example Ofcom’s consultation<sup>3</sup> of June 2021 on the 410 band pricing, and we estimate values for both bands using the regression model.

As a result, for a 10-year license in the 410 band, we get a unit price of 0.0221\$/MHz/pop, with a present value license price of 1,495,599\$/MHz, which when annualised into 10 equal payments over 10 years, at a 5% discount rate, yields fixed annual payments of 193,687\$/MHz/year. Similarly for the 450 band, we get a unit price of 0.0649\$/MHz/pop, with a present value license price of 4,387,142\$/MHz.

Table 1 summarises mean and regression unit benchmark prices based on the market approach. The results indicate that, despite similarities in maximum channel bandwidth, duplex arrangement, and propagation characteristics, the 450 band has a market value typically up to 3 times that of the 410 band.

Table 1: Value of 410 and 450MHz- Prices are in \$/MHz/pop

Band (MHz)	Based on Mean	UK, 2021 (Price based on Regression)
410	0.0272	0.0221
450	0.0698	0.0649

1 Allocation of 410 -430MHz in all regions as per Radio Regulations  
 410- 420MHz; FIXED MOBILE except Aeronautical Mobile; SPACE RESEARCH (S/S) (5.268)  
 420-430MHz; FIXED MOBILE except aeronautical mobile Radiolocation (5.269 5.270 5.271)

2 Allocation of 450-470MHz  
 FIXED MOBILE 5.286AA- 5.286AA; For use by Administrations wishing to implement IMT - see Resolution 224 (Rev.WRC-19)

3 [www.ofcom.org.uk/consultations-and-statements/category-2/annual-licence-fees-for-412-mhz?showall=1](http://www.ofcom.org.uk/consultations-and-statements/category-2/annual-licence-fees-for-412-mhz?showall=1)

## 2 OVERVIEW

Spectrum bands below 1GHz play an important role in providing wide area coverage in suburban and rural environments, and for providing better indoor signal reception. Networks operating in the 450 band have been deployed for wireless telephony from the early days of mobile technology in the 80's, in sparsely and low-density populated areas where coverage involves large distances.

The 450 band has an established use history, particularly in the Nordic European countries, where NMT-450 analogue mobile was adopted, later migrated to GSM and CDMA, and more recently to LTE-450. The band has also played a pivotal role in the provision of critical services such as PMR, and more recently for utilities infrastructures such as smart grids, smart metering, and PPDR.

For broadband applications, the 450 band is better positioned as a complementary band rather than a primary band due to its narrow bandwidth, hence its low base-station throughput (typically 8Mbps total capacity/sector). However, the band is essential and key for mission-critical reliable networks, both narrowband and wideband.

On the other hand, in view of its propagation characteristics, the 410 band has been used for decades for narrowband private mobile radio, trunked radio networks, and for wide-area mission critical networks. Until recently, the band has raised little interest in wideband/broadband applications. However, with developments of LTE band specifications in 3GPP, particularly eUTRA bands 87 and 88, interest is being revised. While the economic value and ecosystem development in emerging technologies such as LTE/5G-NR, NB-IoT is yet to be developed, its propagation and penetration characteristics despite its relatively narrow bandwidth and low throughput make it a plausible band for private networks, business radio networks including IoT and smart grids.

Recent examples of applications on the 410 band include: Ireland, where 2x3 MHz were allocated for energy and mission-critical applications (2013); Poland, where a license used for CDMA-based mobile dispatch, telemetry services, and internet access was renewed (2020). Norway, Greece, and Saudi Arabia also carried out consultations on the use of the 410 band in 2020 and 2021. Both Norway and Greece decided to reassess the needs in 2022/2023. Saudi Arabia is yet to make a final decision on the 410 band but decided to award the 450 band in Q2-2021 for critical non-public-safety applications.

Figure 1 below depicts the full range of the 400 MHz band, together with its band nomination<sup>4</sup>.

Figure 1: The 400 MHz Band (450alliance)<sup>4</sup>

410	412.5	415	417.5	420	422.5	425	427.5	430	432.5	435	437.5	440	442.5	445	447.5	450	452.5	455	457.5	460	462.5	465	467.5
	Band 88				Band 88					Band 31							Band 31				Band 31		
				Band 87						Band 72							Band 72				Band 72		
										Band 73							Band 73				Band 73		

## 3 BENCHMARK AWARDS FOR THE 410/450 BANDS

This document addresses the valuation of the 410 and 450 bands based on spectrum licenses awarded in previous years, whether by auction or by administrative procedures. Analysis focuses on the market approach. For the purpose of this study, the two bands are priced separately in order to come-up with a pricing ratio between the two.

Spectrum award data is extracted from Eicon's database of over 4,000 awards covering the period 1985-2021, gathered from public data, and some obtained directly from Regulators (Denmark, Finland, and Sweden).

For the purpose of the study, and for the 410 band, a total of six (6) awards with license details are available for analysis over the period 2006-2021. Specific details used during the analysis are: price (USD), duration (years), and assigned bandwidth (MHz).

For the 450 band, 39 awards are logged over the period 1985-2021, but analysis is restricted to the period 2000-2021, and for awards for which full data is available. Hence the analysis is strictly based on 14 awards. The higher number of licenses awarded in the 450 band results from the type of services addressed by these licenses (GSM, CDMA, and LTE), which increases competition and band value.

<sup>4</sup> <https://450alliance.org/more-bands-in-400-mhz-standardized-by-3gpp/>

It may justifiably be argued that awards dating further back than 5-10 years may not be indicative of today's market conditions and value, but these are kept here as an indication.

Awards for the 410 band and for the 450 band are shown in Table 2 and Table 3 below, where license prices include annual payments and are shown in USD value at award date.

Table 2: Awards in the 410-430MHz band over the period 2000-2021

Country	Date	Operator	Term, Yr.	Price, \$M
Poland	Nov-2020	Polish cellco Plus	15	5.7
Ireland	Dec-2019	ESB Networks	15	1.2
Denmark	Dec-2010	Nordisk Mobiltelefon	14	0.8
United Kingdom	Oct-2006	Arqiva Limited	15	2.8
Romania	Sep-2008	Romtelecom	10	1.08
Poland	May-2006	Nordisk Polska	14	5.2
Czech Republic	May-2005	MobilKom	-	-

Table 3: Awards in the 450-470MHz band over the period 2000-2021

Country	Date	Operator	Term, Yr.	Price, \$M
Germany	Mar-2021	450connect	20	129.91
Denmark	Jun-2020	Ice Danmark	16	0.85
Norway	May-2020	ICE Norge	20	6.96
Czech Republic	Feb-2018	O2 Czech Republic	15	9.66
Sweden	Feb-2018	Net1	25	4.6
Latvia	Nov-2016	Triatel	10	-
Finland	Apr-2016	Alcom	9	0.0035
Sweden	May-2015	Net1	-	-
Finland	May-2014	Ukkoverkot	11	-
Austria	Jun-2013	Schrack Mediacom	17	0.28
Austria	Jun-2013	Kapsch CarrierCom	17	0.20
Estonia	Apr-2012	Tele2 Eesti	6	-
Latvia	Aug-2011	Triatel	10	-
Denmark	Dec-2010	Nordisk Mobiltelefon	11	0.86
Denmark	Jan-2007	Nordisk Mobiltelefon	15	4.16
Estonia	Nov-2006	Televorgu	-	-
Austria	Apr-2006	Green Network	15	6.1
Austria	Apr-2006	T-Mobile Austria	15	1.4
Mongolia	Apr-2006	G-Mobile	-	-
Denmark	Sep-2005	Nordisk Mobiltelefon	15	-
Denmark	Sep-2005	Nordisk Mobiltelefon	15	-
Russia	Sep-2005	SkyLink	10	-
Sweden	2005	Nordisk Mobiltelefon	15	11.5
Norway	Jun-2004	Nordisk Mobiltelefon	15	8.26
Tajikistan	2004	TK Mobile	-	-
Uzbekistan	2003	Uzbektelecom	-	-

Fields with "-": data not available

## 4 PRICE BENCHMARKING ANALYSIS

### 4.1 Methodology

In order to analyse benchmarks and obtain indicative market values, adjustments are made to the data to account for differences in licence duration (Term) and economic indicators in the corresponding countries. The concept involves calculation of what we refer to as 'unit prices' represented in \$/MHz/pop (USD). The following adjustments are specifically made:

1. Annual fees are included in license prices as applicable, and where such information is available. License prices are calculated as the sum of (a) upfront payments (award/auction price, plus administrative fees paid at the time of award), plus (b) annual spectrum fees discounted at a rate of 5% per annum
2. License prices are converted to USD using World Bank market exchange rate at date of award
3. For comparison purposes, adjustments for duration are made by converting all license prices to a common duration, to get an NPV of the license, and assuming a 5% discount rate. Here, we arbitrarily select a duration of 10 years, but the analysis can be applied to any duration as required
4. License prices are also adjusted for inflation by converting prices to this date (2021), using USD IMF inflation rates

5. To account for differences in prices and in levels of affluence between countries, prices are adjusted by the PPP conversion rate using IMF GDP data
6. Following all adjustments, prices are calculated in \$/MHz/pop figures for comparison purposes
7. For cases where multiple awards are issued in the same country, on the same band, during the same award/auction process, and under the same conditions, one unit price value is obtained by averaging all unit prices. In our study here, two such cases occur, and these are Austria (2013), and Austria (2006), for which unit prices are calculated as the average of all unit prices within the same award process

Next, we present the analysis for estimating unit prices for the two bands. Two methods are used to produce the valuations: (1) based on arithmetic mean; and (2) based on regression analysis.

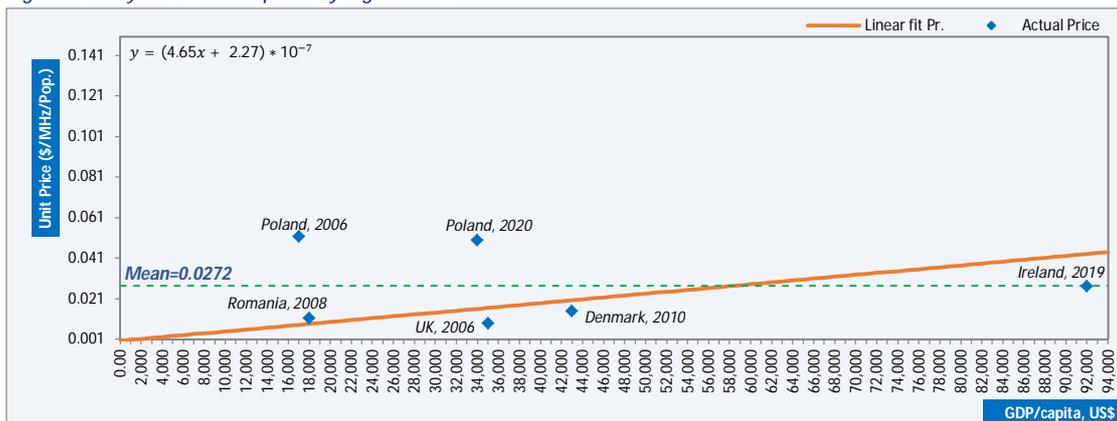
Aside from demand for the spectrum on offer, it is generally accepted that unit prices should also reflect economic conditions in the country. This is usually included in the analysis by taking into account the GDP/capita (PPP) of each of the countries as on the date of award. Regression presents one such way to assess the extent to which a dependent variable, in this case price of spectrum (\$/MHz/pop), is dependent on a single variable (GDP/capita). Regression derives a linear relationship between the two, providing spectrum unit price in a country in relation to its economic conditions.

### 4.2 Price Benchmarks for 410MHz

Based on the adjustments listed in Section 4.1, and calculations presented above, we deduce a mean value of 0.0272\$/MHz/pop from the unit prices of the 410 band. Unit prices of individual awards in \$/MHz/pop after adjustments are shown in Figure 2 below, and a first order regression fit is obtained.

Therefore, it is possible to estimate the 410 band unit price based on the market approach. The model applies to a valuation at the current date, for the same license duration as assumed here (10-years).

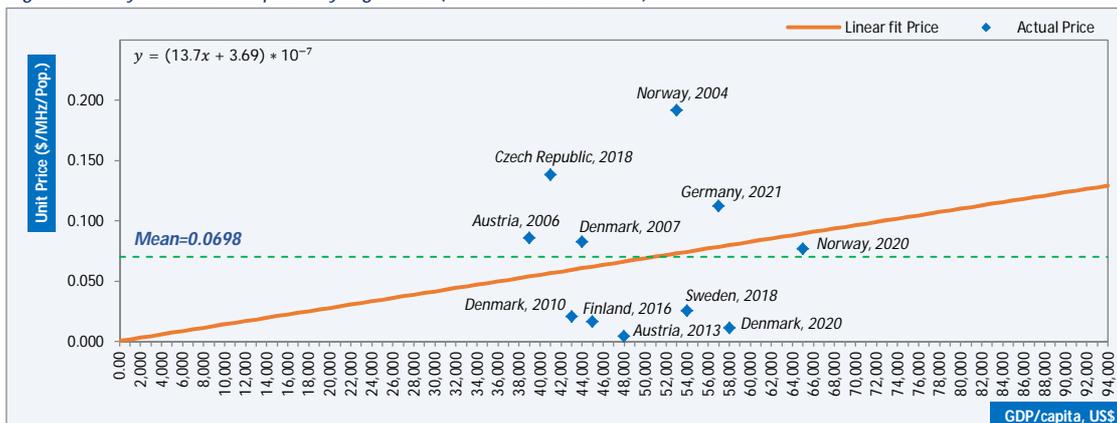
Figure 2: Analysis of 410MHz prices by regression – all countries included



### 4.3 Price Benchmarks for 450MHz

The 450 band benchmark prices include all awards with valid license data as listed in Section 3, with the exception of Sweden (2005) which is assumed to be an outlier. Spectrum unit prices for the remaining 11 benchmarks are shown after adjustment in Figure 3.

Figure 3: Analysis of 450MHz prices by regression (Sweden 2005 excluded)



Analysis of the 450 band awards data result in a mean unit price of 0.0698\$/MHz/pop for the band. Therefore, it is possible by regression to estimate the 450MHz unit price based on the market approach using the regression model shown. The model applies to a valuation at the current date, for the same license duration (10-years). Both assumptions can of course be varied, such that one may calculate spectrum unit price at any set date, and for any license duration.

## 5 SUMMARY ANALYSIS

Two methods are used to come-up with valuations: (1) based on arithmetic mean; and (2) based on regression analysis that links price benchmarks by a first order correlation with GDP/capita (PPP) values, of the countries in which an award took place.

Based on the above, the mean value of 410 band unit prices is calculated as 0.0272\$/MHz/pop, and the mean value of 450 band unit prices is calculated as 0.0698\$/MHz/pop.

For regression analysis, we take as an example Ofcom's consultation<sup>5</sup> of June 2021 on the 410 band pricing, and we estimate values for both bands using the regression model. For the UK with a GDP/capita of \$47,089 (IMF data 2021), and based on the regression model, the 410 band analysis yields a unit price of 0.0221\$/MHz/pop for a 10-year license, which gives a present value license price of 1,495,599\$/MHz. When annualised into 10 equal payments over 10 years, at a 5% discount rate, the license price yields fixed annual payments of 193,687 \$/MHz/year.

Similarly, for the 450 band, we get a unit price of 0.0649\$/MHz/pop, with a present value license price of 4,387,142\$/MHz.

below summarises mean and regression unit benchmark prices for the 410MHz and 450MHz bands based on the market approach. The results indicate that, despite the two bands having similar bandwidth arrangement and propagation characteristics, the 450 band carries a market value typically three times greater than that of the 410 band.

Table 4: Price benchmarks for 410MHz and 450MHz bands in \$/MHz/pop

Band (MHz)	Based on Mean	UK, 2021 (Price based on Regression)
410	0.0272	0.0221
450	0.0698	0.0649

This difference in pricing may be attributed to the fact that the 450 band was allocated to IMT for the three regions at WRC-2007, almost 15 years earlier than the 410 band. This may have increased demand for its use, hence its market value. On the other hand, it is only recently in 2019, that the 3GPP organization standardized specifications for the use of the 410 band for LTE services.

The difference in pricing could also be attributed to a lower perceived economic value. The 3GPP broadband ecosystem support in the 410 band compared to higher sub-1GHz bands including 450MHz remains an issue, as the ecosystem has to develop from scratch. The fragmented user base also complicates migration and sharing conditions, for wideband channel deployments and systems to have economies of scale.

Moreover, the possible complex legacy land mobile systems and PMR/PAMR user base deployed across the band, in addition to requirements for protecting other mobile and non-mobile critical services in adjacent bands, makes the 410 band perceived to have a lower value compared to other bands identified for IMT below 1GHz, particularly the 450 band. Should the band be allocated to IMT at the next World Radio Conference (WRC-23), then this may well increase demand, thereby raising its market value, and reducing the price gap difference.

*(End of document)*

<sup>5</sup> [www.ofcom.org.uk/consultations-and-statements/category-2/annual-licence-fees-for-412-mhz?showall=1](http://www.ofcom.org.uk/consultations-and-statements/category-2/annual-licence-fees-for-412-mhz?showall=1)