ITU Regional Radiocommunication Seminar 2024 for Asia and the Pacific (RRS-24-Asia&Pacific), Apia, Samoa, 16-21 September 2024

Spectrum Valuation and pricing; Economic Aspects of the Spectrum

The term pricing used in this section should be understood according to the No. 155 of the ITU Constitution and Convention (published in Basic Texts, 2023).

Thursday 19/09: Session 2 (10H00 -11H00, local time):

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Not all slides will be presented

Spectrum Management is performed by engineers, lawyers and economists

Geneva, October 2007
ITU Radio Assembly

Source: ITU / J.M. Ferré

Roles of the National Spectrum Management (1)

https://mazar.atwebpages.com/Downloads/ITU_RRS22AsiaSpectrumManagementMazarKeyNotePresentationFiji19Dec22.pdf

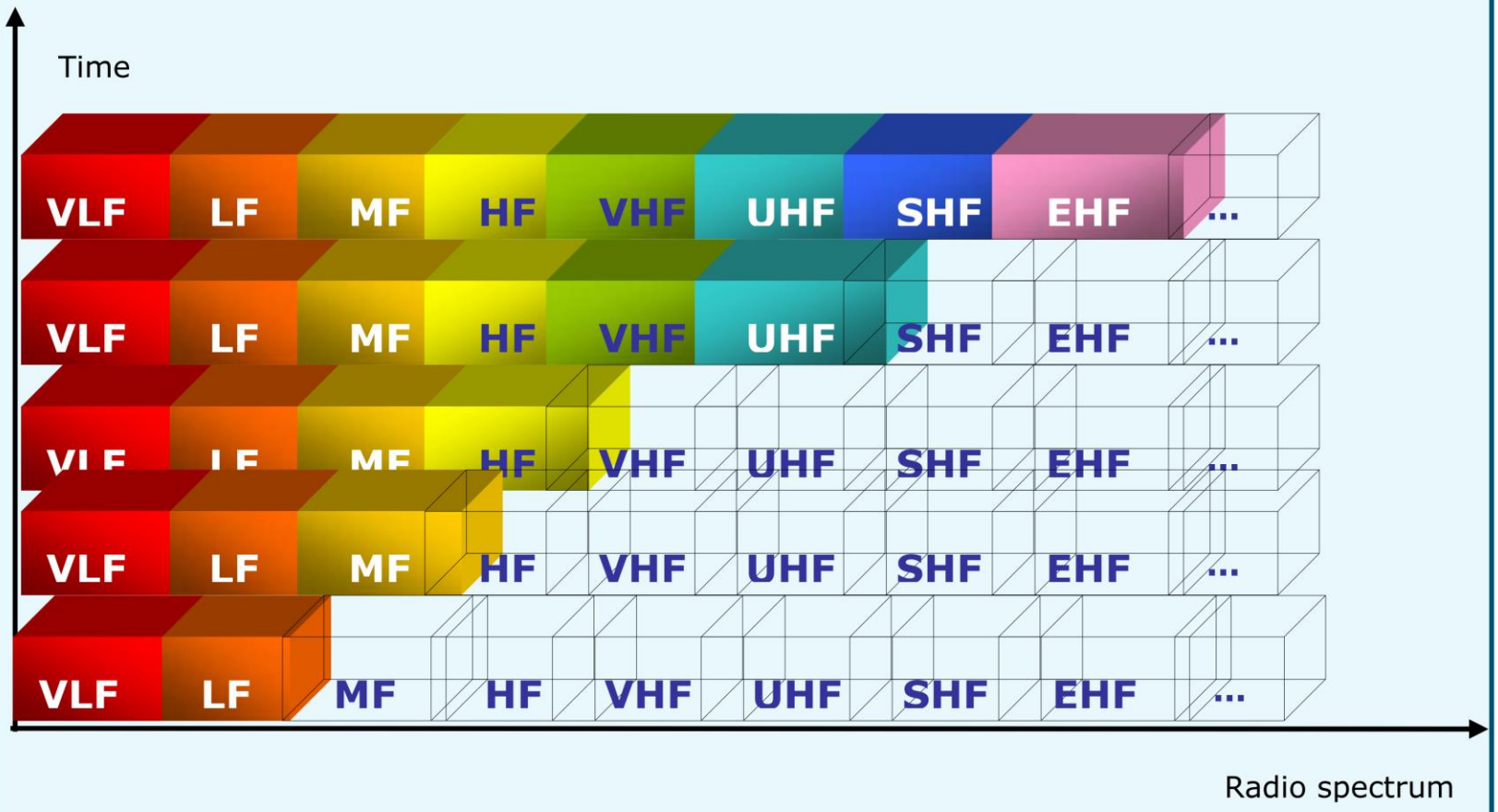
1. Follow RR Allocations
2. Reduce interference: lower-power, lower-altitude Above Sea Level, lower-altitude Above Ground Level
3. No discrimination; fairness, transparency & efficiency
4. Market-Dynamics: Intervene only when market-failure: lack of competition
5. Unused RF is a waste to economy: there is available RF: due to digital-dividends more RF than cellular competitors. Balanced annual-fees will avoid unproper auction results.
6. For cellular efficient usage, consider to oblige active RF sharing
7. Efficient use of spectrum: assign spectrum to those that will generate the greatest socio-economic benefit from its use
8. Promote investment and innovation in the sector
9. New technologies improve b/Hz/second
10. Convergence of mobile, fixed, broadcasting and Internet services
11. Try not to allocate RF when the Transmitter & the Receiver are fixed
12. Emphasize '*Caveat Emptor*': a Latin phrase "let the buyer beware."

Roles of National Spectrum Management (2)

1. Avoid and solve interference
2. Design long and short term RF spectrum
3. Support Engineering: propagation, coverage…
4. Use APT Frequency Information System http://www.aptafis.org/; it is similar to European ECO Frequency Information System https://efis.cept.org/
5. Coordinate with other Administrations; like European Frequency Co-ordination Agreement European HCM-Agreement
6. Use the ITU tools developed for GEO6 Agreement, for analogue to digital switch off
7. Coordinate with military wireless applications
8. Advance new wireless technologies (such as cognitive radios; digital audio and video)
9. Advance new technologies and efficient import
10. Serve your clients, the public: be transparent
11. Reduce RF human hazards, by providing more RF to cellular Operators (see slide)

Scarcity of Radio Frequencies

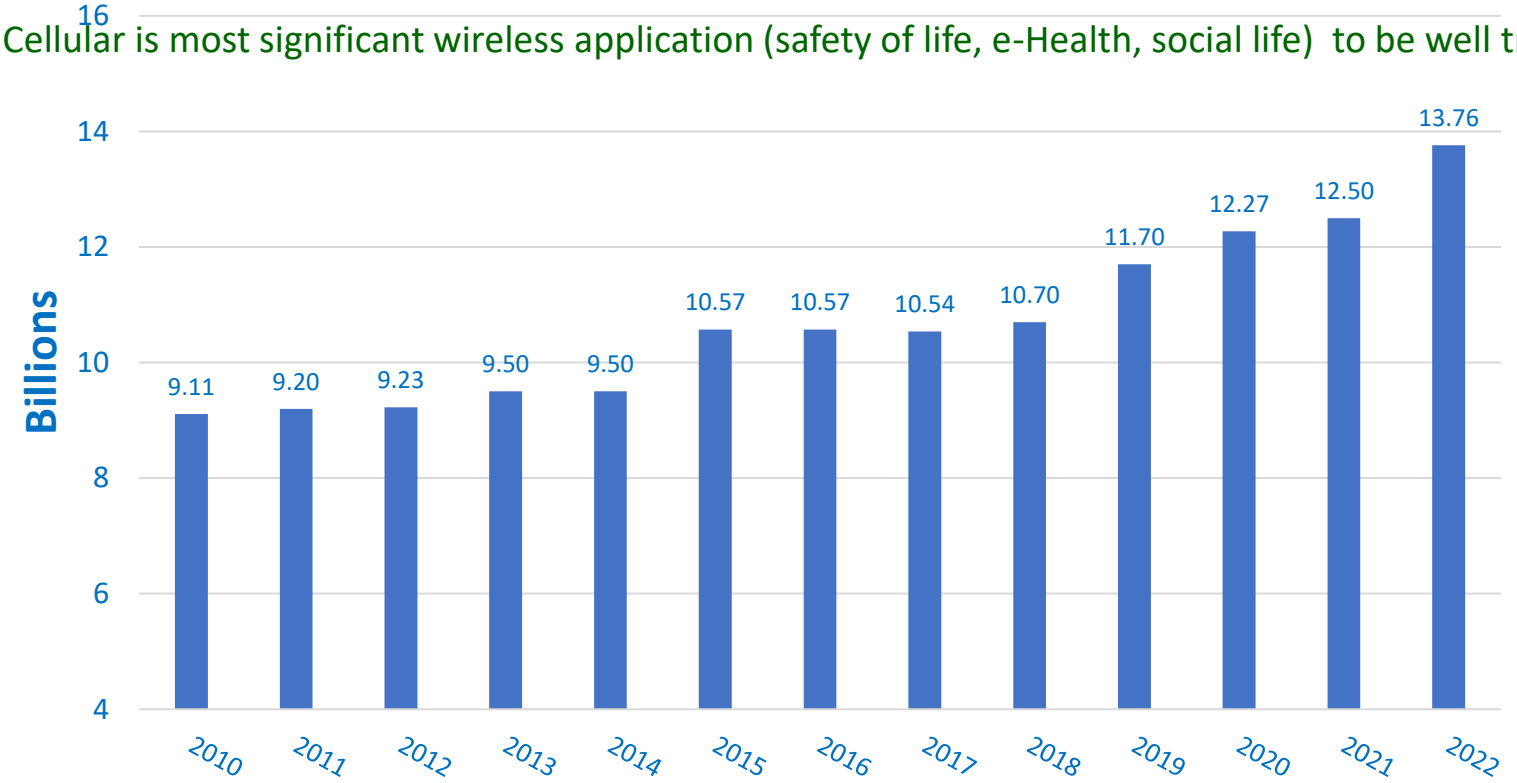
ITU-D Resolution 9 Final Report; 2014 Fig. 1

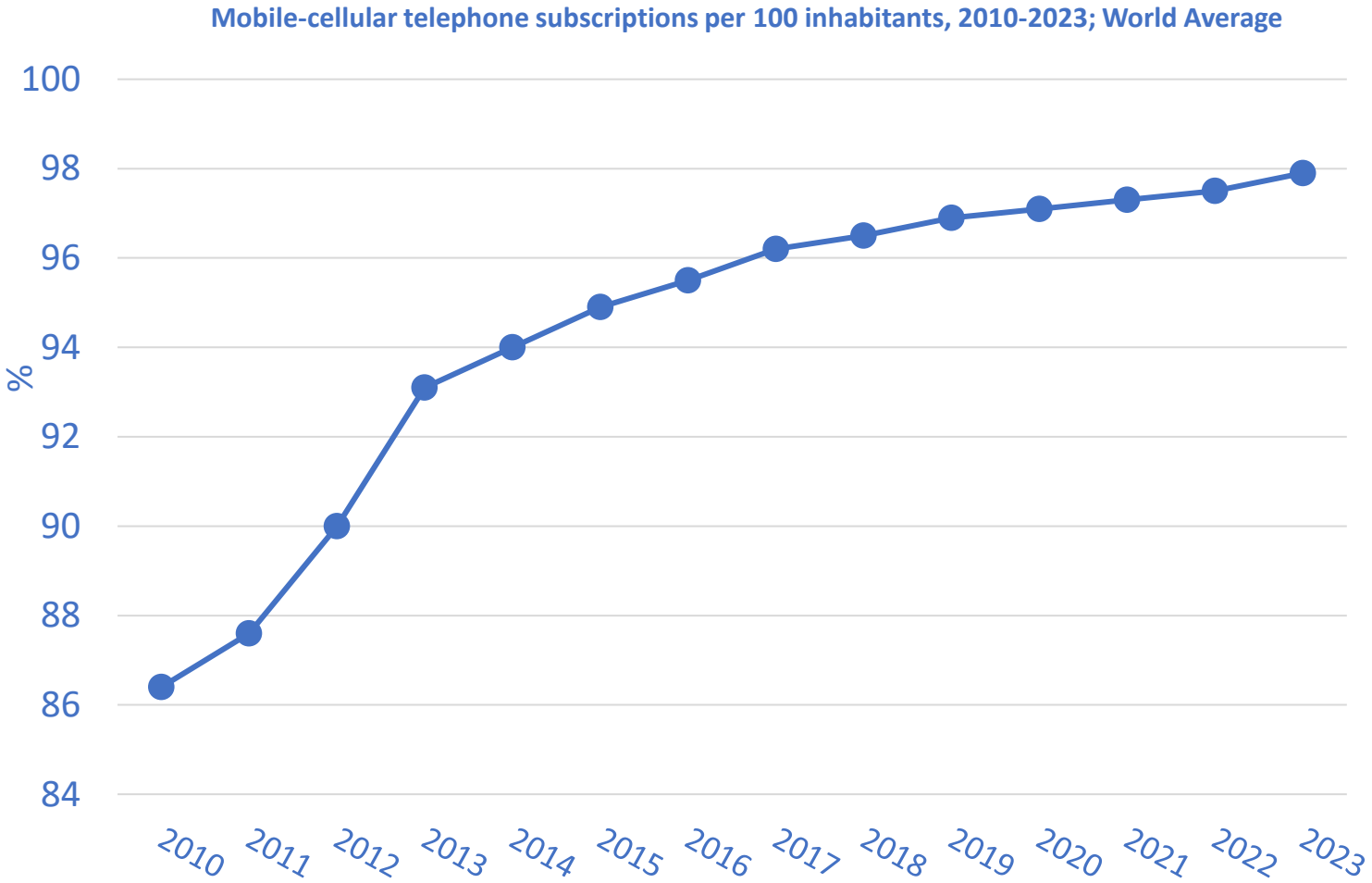


Mobile-cellular telephone subscriptions per 100 inhabitants, 2010-2023

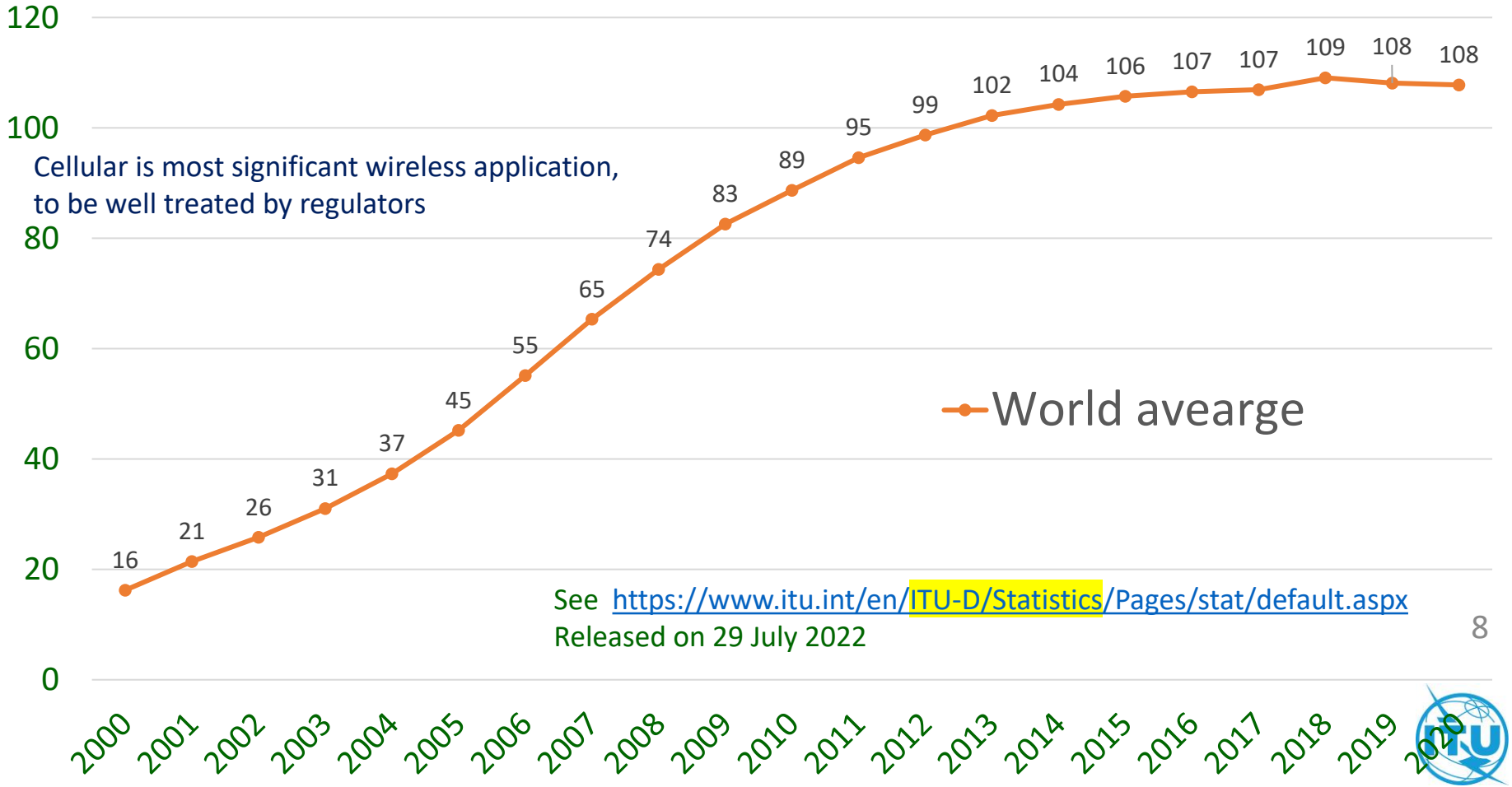
this and the following three slides are based on See https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx; retrieved 16 September 2024;

Cellular is most significant wireless application (safety of life, e-Health, social life) to be well treated by regulators

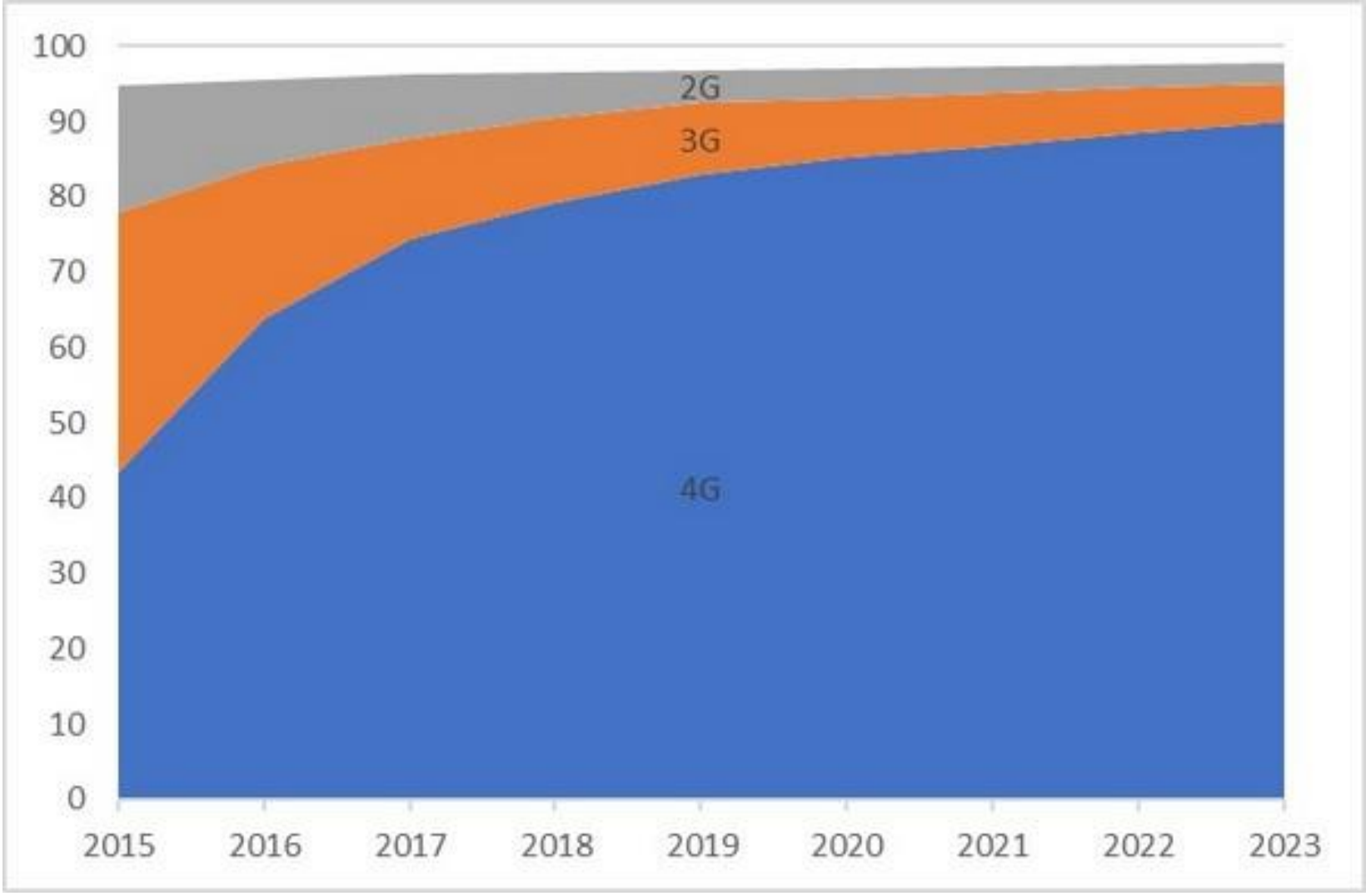



Mobile-cellular telephone subscriptions per 100 inhabitants, 2010-2023; World Average
100
98
96
94
92
90
88
86
84
%
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

Mobile-cellular per 100 inhabitants, 2000-2021; world-average vs Fiji



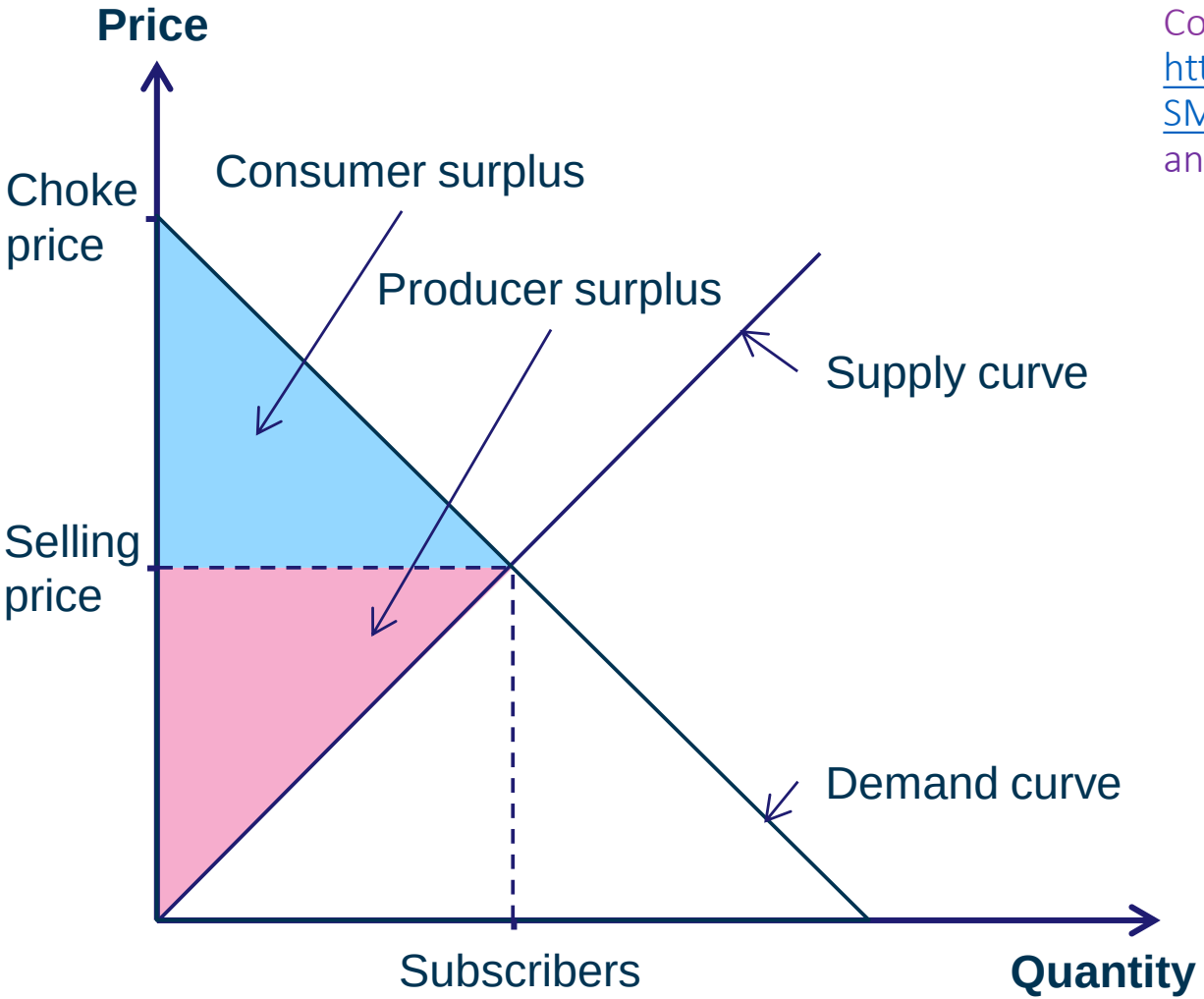
See https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
Released on 29 July 2022



Mobile-cellular per 100 inhabitants, See https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx Retrieved on 16 September 2024

Report ITU-R SM.2012-6 (06/2018) 'Economic aspects of spectrum management'

1. Strategies for economic approaches to national spectrum management and their financing
2. Assessment, for spectrum planning and strategic development purposes, of the benefits arising from the use of the radio spectrum
3. Alternative methods of national spectrum management



Consumer and producer surplus; https://www.itu.int/pub/R-REP-SM.2012-6-2018 (Fig1) and source UK report 2012 Fig. B.1

The pricing formula and parameters (1)

For all services, it is an opportunity cost and Administered Incentive Pricing (AIP) fee formula, represented by the following general, simple, functional and linear (with bandwidth) form:

$$\text{Cost} = \alpha \times F \times B \times \rho \times \sigma \times l \times M_{pub} \qquad \frac{\text{Cost}}{B} = \alpha \times F \times \rho \times \sigma \times l \times M_{pub}$$

Dividing the two parts of the equation by the bandwidth B, the following fee formula per MHz is obtained:

Except Cost unit in the national currency (cur), α (cur/MHz) and *B* (MHz), all except cost unit are in the national currency (cur), α (cur/MHz) and *B* (MHz), all parameters serve as modifiers

The Model determines the fees only for transmitters; i.e. VSAT earth stations operators pay only for their transmitters' bandwidth; FM and TV receivers don't pay spectrum utilization fee (SUF).

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Next slide indicates the definitions of all parameters:

The pricing formula and parameters (2)

Cost (cur): spectrum cost in national currency

B (MHz): total assigned bandwidth

α (cur/MHz): basic price unit. Based on the market dynamics, the country's vision of the ICT sector and international best practice. α is the value of 1 MHz for cellular service below 6 000 MHz

F: depends solely on centre frequency; *F* equals 1 for frequencies below 6 000 MHz and 6 000/*f* for higher frequencies. *F* is uncorrelated to the service

ρ: regional factor; equals 1 for national license, and proportional (less than 1) to the number of administrative areas (regions, provinces) covered by non-national license

σ: operator's sharing factor; equals to one for exclusive RF. As two or more operators may share the same RF, particularly, point to point (PtP) links, σ might be less than 1; 1/2 for two users sharing same RF, 1/3 for three, etc.

l: site location: urban or rural (site outside the urban area) areas. It defines the socio-economic development within different districts and classifies different fees. *l* may get two values, e.g. full price in urban; 25% full price in rural areas. Administrations may decide other value, or provide additional classes like remote, etc.

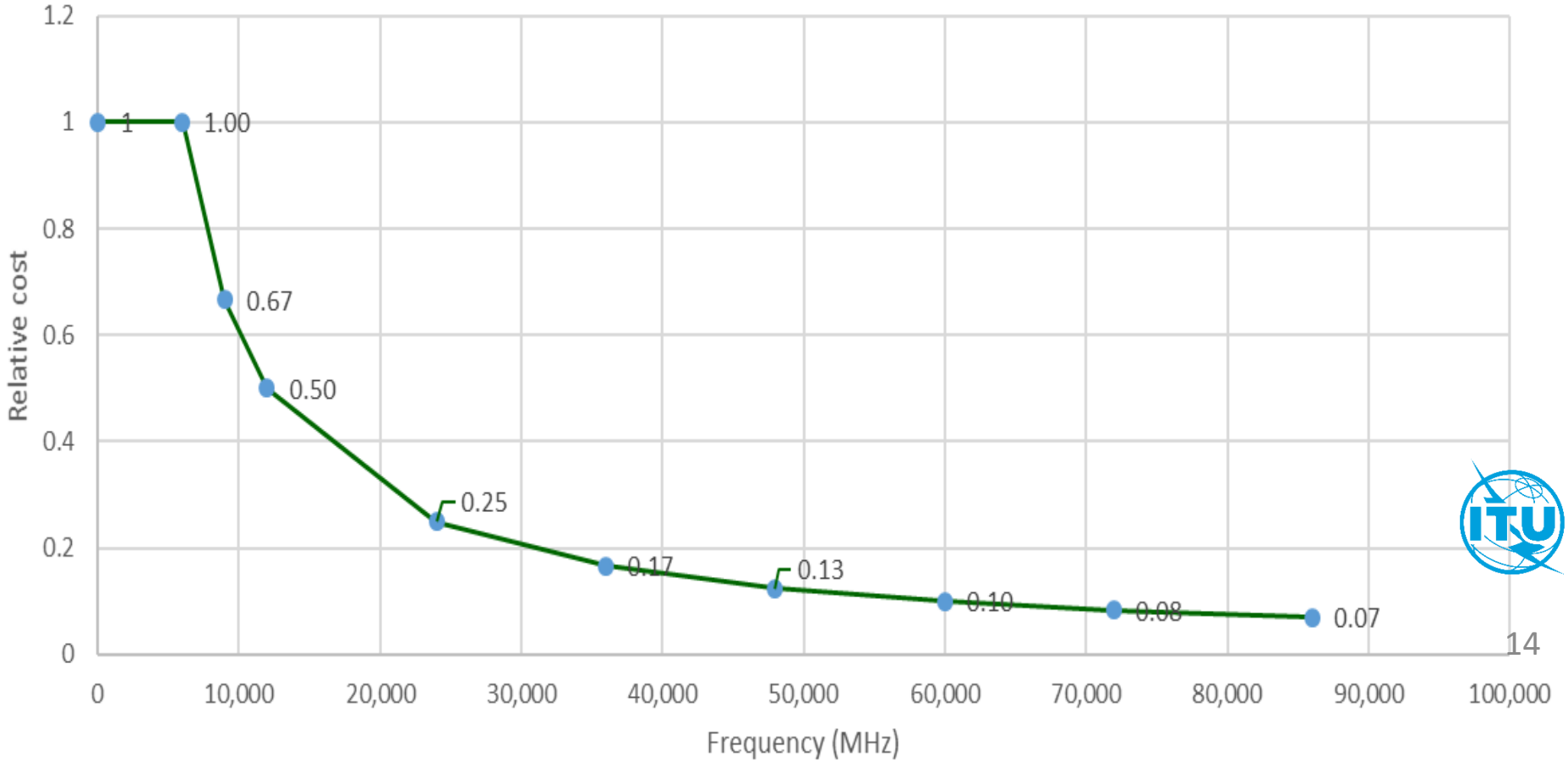
M_{pub}: The public moderator to takes into account a differentiation among services. M_{pub} actually defines the fees. M_{pub} equals 1 for the cellular service. For other services, M_{pub} numbers are arbitrary and predetermine the annual cost of the service. For example, for free-to-air television M_{pub} may be significantly lower. M_{pub} serves as framework for holding the values of different services.

The specific values of α, *l* and M_{pub} are subjective and defined by the regulator.

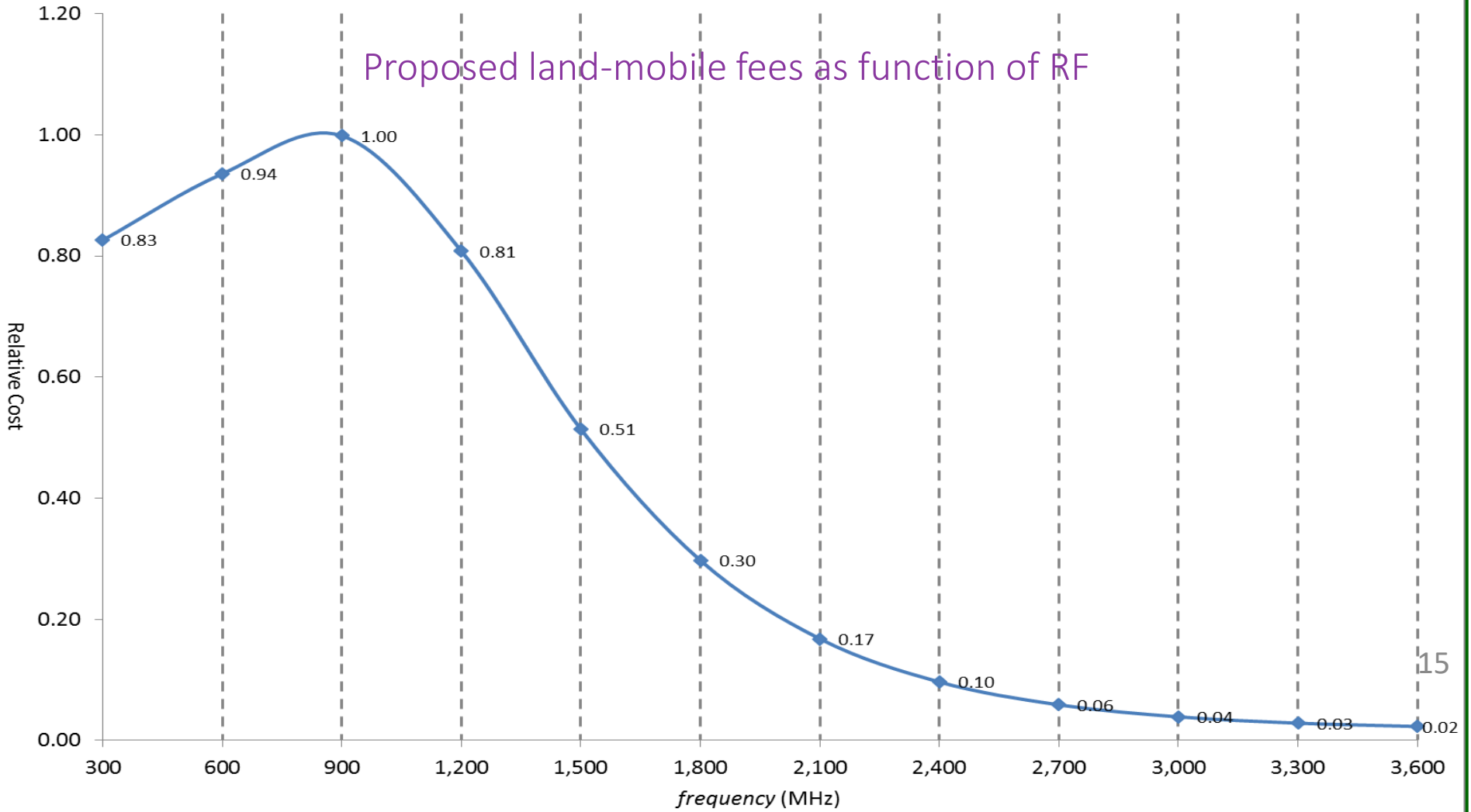
This factor could be excluded in case of agreements among operators on spectrum sharing, under the provisions of national regulations; see Report ITU-R SM.2404 – Regulatory tools to support enhanced shared use of the spectrum.

The fees should be related to the **propagation characteristics** (less obstacles higher-price) of the **frequencies** (higher RF lower-price) and **site location** (more population-density , higher-price); Higher RF – lower fees, for all services; see next-page figure.

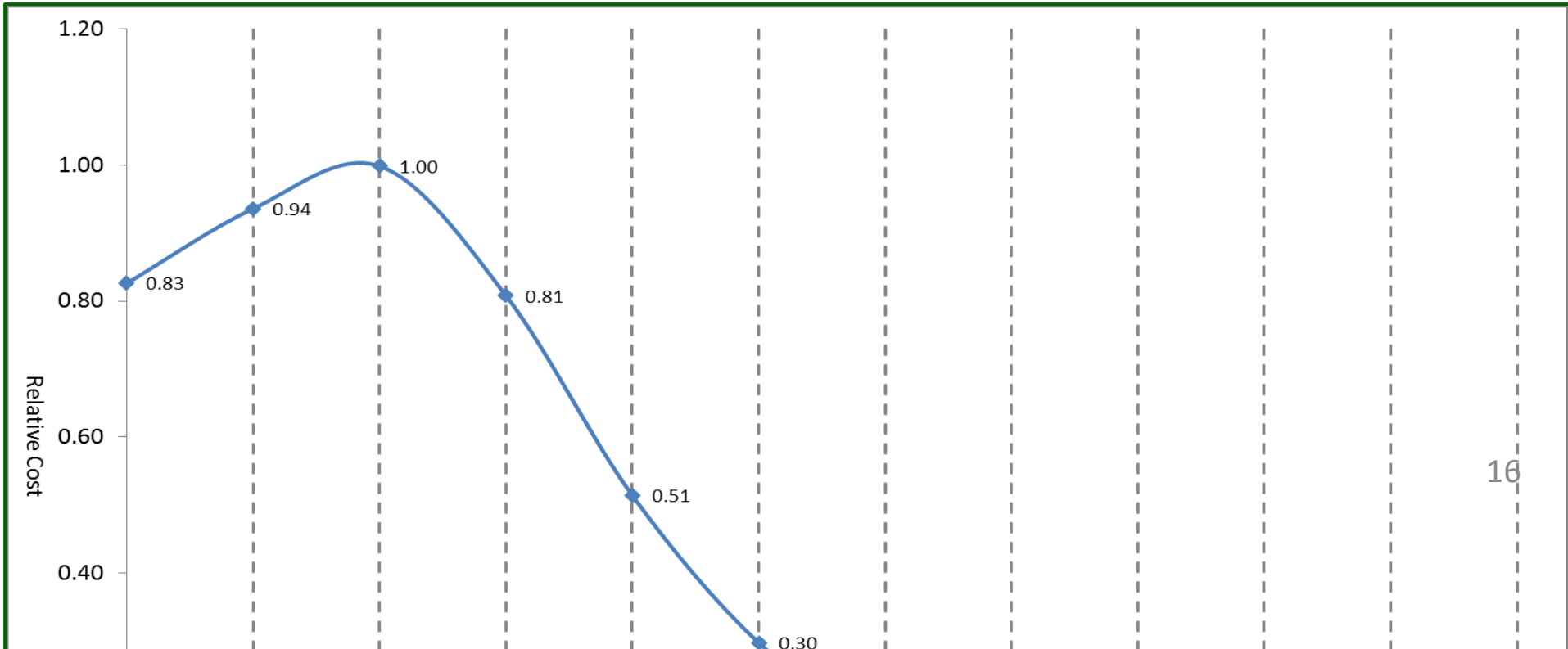
Relative fees (coefficient F) depend on frequency



Proposed land-mobile fees as function of RF

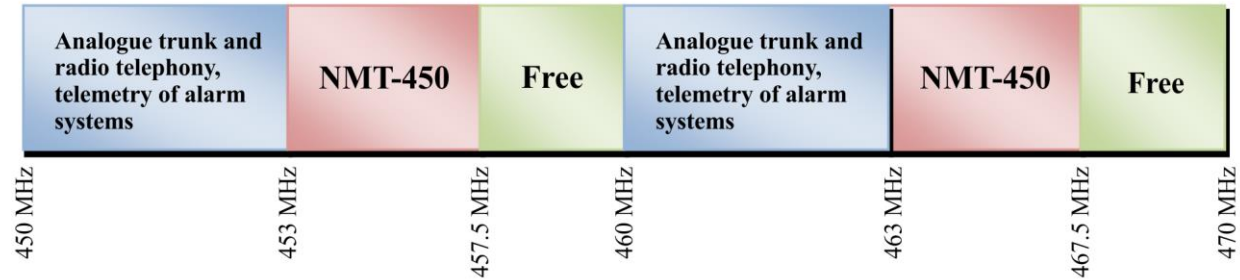


Proposed Point 2 Point coefficient F as function of RF

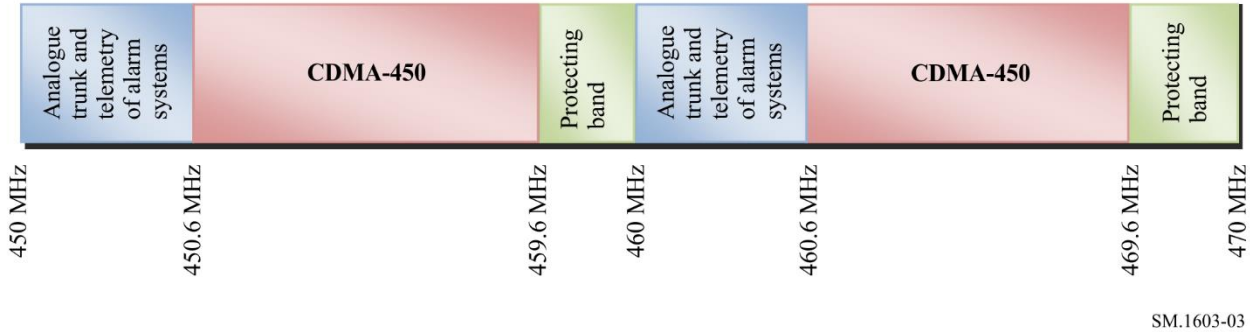


Recommendation ITU-R SM.1603-2 (08/2014) Spectrum redeployment as a method of national spectrum management

Evolution of the occupation of the spectrum before and after the redeployment; Benin

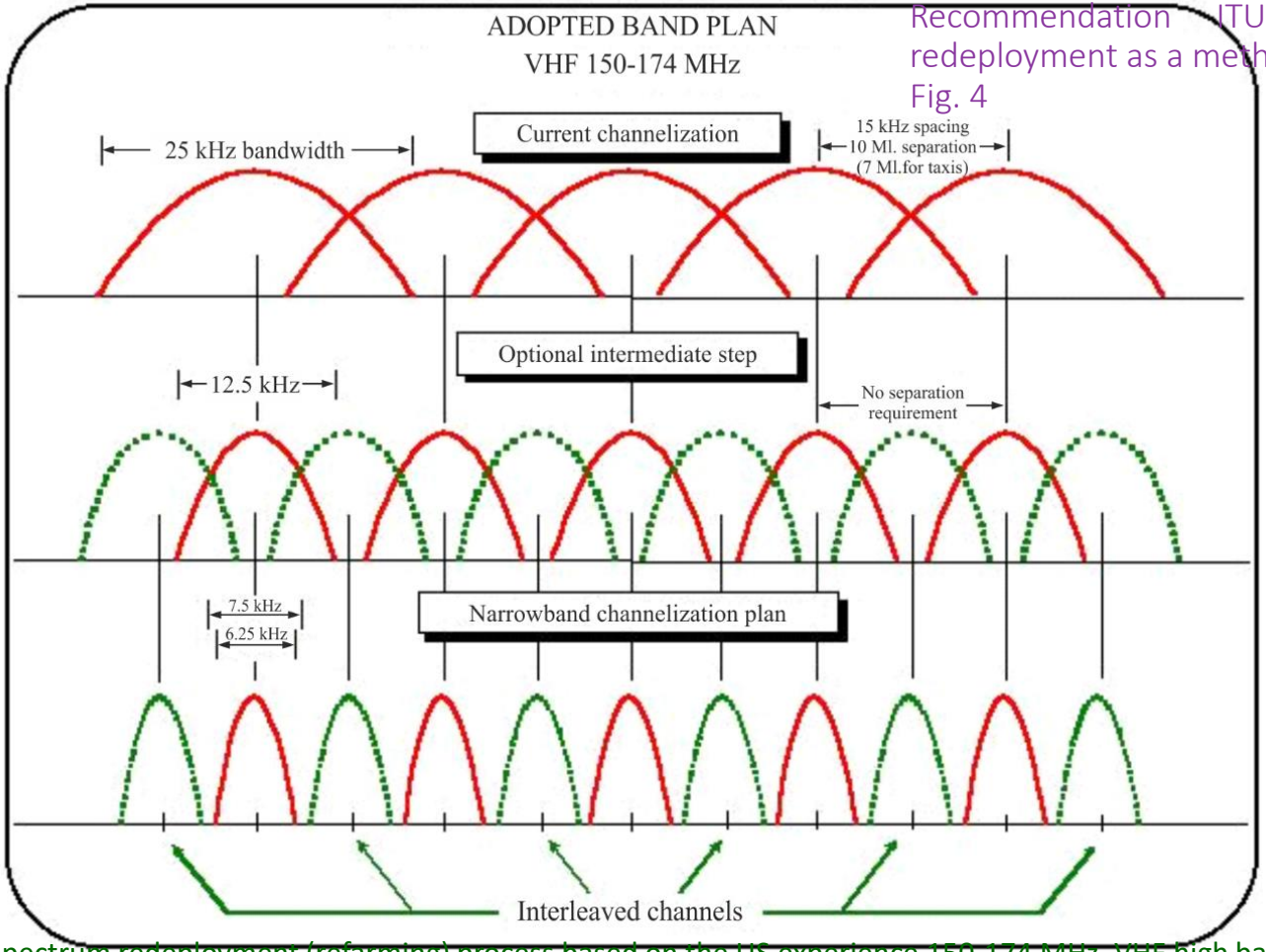


Frequency use in the band 450-470 MHz before redeployment; Ukraine;



Frequency use in the band 450-470 MHz after redeployment; Ukraine;

Recommendation ITU-R SM.1603-2 (08/2014) Spectrum redeployment as a method of national spectrum management
Fig. 4



Spectrum redeployment (refarming) process based on the US experience 150-174 MHz, VHF high band; available nationwide, channels are generally spaced every 7.5 kHz, authorized bandwidth is 20 kHz, 11.25 kHz or 6 kHz

Auctions- Strategies

1. Consult with stakeholders on RF pricing, before implementing the proposed pricing models
2. Auctions define the true value per MHz of RF spectrum
3. if RF supply is higher than demand; there is no urgent need to advance Auctions, as it wouldn't advance straightforwardly the wireless communications and rural coverage

For a given network (technology, number of sites, RF spectrum, quality of service), better coverage is achieved by transmitting at higher effective power (for both downlink and uplink channels), installing base stations at higher altitude above ground level (less signal attenuation) and using lower radio frequency.

Max. channel capacity for each communications link in a given network is derived from Shannon Hartley monumental paper (**Shannon 1948 p.43, theorem 17**), relating *c*apacity (bit/s), RF *b*andwidth (Hz) and the *s*ignal to *n*oise (dimensionless) ratio; ultimate Shannon data rate :

$$c = b \times log_2\left(1 + s/n\right)$$

Moreover, in urban scenario *s*/*n* is small. LTE RSRQ (Reference Signal Received Quality) quantifies the capacity; UE measures this parameter as reference signal. Values higher than −9dB guarantee the best subscriber experience; the range between −9 and −12dB can be seen as neutral with a slight degradation of Quality of Service. So for *s*/*n* very small relative to 1; Using Taylor series expansion of a function about 0: Maclaurin series, thus:

$$c = b \times log_2\left(1 + s/n\right) \approx b \times \frac{s/n}{\ln 2} \approx 1.44 \times b \times s/n$$

Therefore, staying with the same *capacity c*- less base-stations (reduced *signal*) can be compensated by more frequency *band* (*b*). The capacity is limited by power *s* & noise density n_o.

Cellular capacity is limited by power & noise; **adding RF to base stations decreases the number of BSs.** More RF for a specific site doesn't necessarily increase EMF around BS.

Around active RF shared BSs the EMF increases! This file doesn't analyse the total EMF derived from active sharing, as it depends on technologies and based on the cellular planning.

Additional Mazar files on Spectrum Valuation and pricing; Economic Aspects of the Spectrum

1. 'Economic Environment' including these sections 'Economic Valuation of the RF spectrum', 'National Cost Accounting: the RF Spectrum as an Non-Produced Asset', 'Fee Policy', 'Different Types of Auctions' and 'Determining the Annual-Fees' in his Wiley 2016 book 'Radio Spectrum Management: Policies, Regulations, Standards and Techniques'

2. The Radio Spectrum Management: Policies, Regulations, Standards and Techniques' models of the RF fees are implemented in Bhutan

3. The formulas this presentation slide are documented in ATDI's contributions to ITU: 'proposed revision of report ITU-R SM.2012 'Economic aspects of spectrum management' document 1B/205, 13 Nov. 2017. See SM.2012-6 (06/2018) section 4.8 'Opportunity cost and administrative incentive pricing: simple, functional and linear equations'

4. Recruited by ITU to conduct on 30 Sept.–4 Oct. 2019 a mission in Zambia 'Auctioning Training & Technical Assistance'

5. Original presentation in Zanzibar Workshop, on 3 March 2020 Zanzibar2_March2020_SpectrumUseEfficiencyEconomicValue&Refarming_Mazar.pdf