A new approach to frequency charges

Report for the National IT & Telecom Agency

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Contents

This document includes references to the Danish Frequency Act and the European Authorisation Directive as the relevant legislative basis for administrative charges levied on spectrum licences but it is not a legal opinion.

Resumé

Denne rapport behandler spørgsmålet om, hvorledes man i fremtiden kan opkræve frekvensafgifter hos indehavere af frekvenstilladelser i Danmark på en hensigtsmæssig måde på baggrund af skiftet fra tjenestespecifikke tilladelser til fordel for tjeneste- og teknologineutralitet.

I Danmark beregner IT- og Telestyrelsen (ITST) en administrativ afgift for hver tilladelse som en sum af et fast beløb pr. tilladelse og et beløb, der varierer efter den tjenestetype, der gives tilladelse til i radiospektret. Denne afgiftsstruktur blev udviklet i 1999, gennemført i 2000, og afgiftsniveauet har ikke været revideret siden 2002. Imidlertid udsteder ITST nu tjeneste- og teknologineutrale tilladelser, hvor det er muligt. Den tjenestebaserede struktur for administrative afgifter er ikke forenelig med denne fremgangsmåde, idet forskellige tjenester med forskellige afgiftsstrukturer potentielt kan anvende samme frekvenser i radiospektret.

ITST har anmodet DotEcon om at undersøge, hvorledes afgiftsstrukturen kan revideres, således at den er forenelig med en tjeneste- og teknologineutral fremgangsmåde.

Fastsættelsen af, hvilket beløb der i alt opkræves af ITST, er anderledes end hos de tilsvarende myndigheder i Storbritannien, Norge og Sverige. Mens ITST's virksomhed er finansieret gennem statsregnskabet, så finansieres Ofcom, NPT og PTS af afgifter, der pålægges leverandører af nettjenester og indehavere af brugsrettigheder. Dette betyder, at administrative afgifter for frekvenstilladelser blot er én type af indtægt, som opkræves, hvor indtægtssummen skal være lig med de totale omkostninger ved regulering af sektoren.

I nærværende rapport opstilles en ny metodik for beregning af administrative afgifter for frekvenstilladelser i Danmark baseret på følgende principper:

- Afgifterne skal være tjeneste- og teknologineutrale.

- Afgifterne skal være opbygget på en sådan måde, at risikoen for underminering af en effektiv frekvensudnyttelse minimeres.

- Tilladelser til forsøg og prøvedrift takseres lavere end normale tilladelser.

- Den endelige afgiftsstruktur skal være let at forstå.

- Den anvendte struktur skal være robust over for yderligere liberalisering, f.eks. hvis der indføres rekonfigurering af tilladelser i det sekundære marked.

Rapporten angiver beregningsparametre for forskellige grupper af tilladelser og fastlægger en "top-down"-procedure til beregning af administrative afgifter for hver enkelt tilladelse. En vigtig beregningsparameter er vægtningen af afgifter i henhold til hvilke frekvenser tilladelsesindehaveren har rådighed over således, at tilladelsesindehavere i lavere frekvensbånd med mere værdifulde frekvenser bidrager mere til administrative afgifter pr. MHz end tilladelsesindehavere i højere frekvensbånd med mindre værdifulde frekvenser.

Afgifterne beregnes herefter i følgende trin:

Resumé

- Andelen af det totale indtægtsbehov, som skal pålægges hver gruppe af tilladelser, fastsættes ved at beregne andelen af relativ økonomisk værdi for radiospektret, som hver gruppe belægger.

- De enkelte tilladelser pålægges afgifter inden for hver tilladelsesgruppe i forhold til de enkelte tilladelsers relative økonomiske værdi, idet målestokken for relativ økonomisk værdi varierer i mindre grad på tværs af tilladelsesgrupperne.

Dette resulterer i en enkel afgiftsmodel, der nemt kan anvendes for eksisterende og nye tilladelser, efter følgende retningslinjer:

- Tilladelser til trådløse net: *X* kr. pr. MHz ganget med den relevante båndværdifaktor for en landsdækkende tilladelse, med justering efter andel af befolkningen for regionale tilladelser,

- Tilladelser til radiokæde (punkt-til-punkt): *Y* kr. pr. MHz pr. sender ganget med den relevante båndværdifaktor,

- Landmobile tilladelser: *Q* kr. pr. sendeposition ganget med fire, hvis der er mere end 30 mobile enheder, og

- Tilladelser med delt anvendelse: *P* kr. pr. tilladelse ganget med den relevante båndværdifaktor.

- Tilladelser til udsendelse af TV i form af DTT multiplex-tilladelser vil betale en afgift per multiplex. FM- og DAB-radio tilladelser kan muligvis inkluderes i gruppen af Tilladelser til trådløse net.

Ved anvendelse af denne fremgangsmåde kan ITST enten genberegne afgifterne hvert år, så den samlede sum svarer til styrelsens indtægtsbehov, eller fastsætte det pengemæssige beløb pr. tilladelse, der så kan justeres efter behov, når hovedvariablerne i beregningen ændrer sig.

Executive summary

This report considers the appropriate future arrangements for levying frequency charges on spectrum licensees in Denmark, in light of the shift away from service-specific licences in favour of service and technology neutrality.

In Denmark, the National IT and Telecom Agency (NITA) calculates an administrative charge for each licence as the sum of a fixed amount per licence and an amount that varies according to the type of service for which the spectrum is licensed. This charging structure was developed in 1999, implemented in 2000, and the level of charges has not been revised since 2002. However, NITA now issues service and technology neutral licences where possible. The service-based structure of administrative charges is incompatible with this approach, given that different services with different charging structures could potentially use the same spectrum.

NITA has asked DotEcon to determine how the charging structure could be revised so that it is compatible with a service and technology neutral approach.

The determination of the total amount to be collected by NITA is different compared to its peers in the UK, Norway and Sweden. Whereas NITA's activities are funded by the public budget, Ofcom, NPT and PTS are funded by charges levied on network service providers and usage rights holders. This makes administrative charges for spectrum licences just one type of revenue that is collected, the sum of which has to equal the total costs of regulating the sector.

In this report we derive a new methodology for calculating administrative charges to spectrum licences in Denmark based on the following principles:

- Charges should be service and technology neutral.

- Charges should be structured such as to minimise the risk of undermining the efficient use of spectrum.

- Licences for trial and test operations should be lower than normal licences.

- The final charging structure should be simple to understand.

- The structure used should be robust to further liberalisation, such as the introduction of licence reconfiguration in the secondary market.

We develop calculation parameters for different licence groups and set out a 'top-down' procedure to calculating administrative charges for each licence. An important calculation parameter is the weighting of charges according to which frequencies are licensed so that per MHz, licensees of lower frequency, high value spectrum contribute more to administrative charges than higher frequency, low value spectrum.

The charges would then be calculated in the following steps:

- Determine the proportion of the total revenue requirement that is to be allocated to each licence group by calculating the proportion of relative economic value of spectrum that each group occupies.

- Allocate charges to individual licences within each licence group in proportion to the relative economic value of individual licences where

the measure of relative economic value differs slightly across licence groups.

This results in a simple charging model, which can easily be applied to existing and new licences, with a charging structure along the lines of:

- Wireless network licences: DKK *X* per MHz multiplied by the relevant band value factor for a national licence adjusted according to share of population for regional licences;

- Fixed link (point-to-point) licences: DKK *Y* per MHz per transmitter multiplied by the relevant band value factor;

- Land mobile licences: DKK *Q* per transmitter location multiplied by four if more than 30 mobile units; and

- Shared use licenses: DKK *P* per licence multiplied by the relevant band value factor.

- TV broadcasting licences in the form of DTT multiplex licences will pay a charge per multiplex. FM radio and DAB radio broadcasting licences may potentially be included in the group of Wireless network licences.

Using this approach, NITA can either recalculate charges every year to match the total with its revenue requirement or set the monetary amount per licence, which could be adjusted occasionally when key variables of the calculation have changed.

1 Introduction and background

NITA manages radio spectrum in Denmark according to the Frequency Act. Section 48 of the Frequency Act[1] specifies that "The National IT and Telecom Agency shall collect a frequency charge from licence holders" and that "The amounts of the frequency charge […] shall be fixed annually in the Finance Act and shall be published by the National IT and Telecom Agency."

In the current charging structure, frequency charges are calculated as the sum of a fixed amount per licence per year and an amount that varies according to the type of service for which the spectrum is licensed and in most cases the amount of bandwidth held. The service dependent element of charges is one of 70 different prices as listed in Annex 1. This charging structure was developed in 1998 and the level of charges has not been revised since 2002.

According to its Spectrum Policy Mandate,[2] NITA now issues service and technology neutral licences where possible. NITA also has plans gradually to ease restrictions on many existing categories of licence, which may result in changes of use. The service-based structure of administrative charges is incompatible with the shift to a service and technology neutral approach, given that different services with different charging structures could potentially use the same spectrum. For example, consider the forthcoming award of the 2.6GHz band (the so-called '3G expansion band') in Denmark. This spectrum could potentially be used for either cellular mobile or wireless access services. Under current arrangements, this would pose a dilemma for NITA when setting frequency charges for licences in the 2.6GHz band. Should it set an administrative charge of DKK 52,207 per 10MHz as charged to similar wireless access services in the 3GHz band, or DKK 522,000 as charged to similar cellular mobile services in the 2.1GHz band?

Against this background, NITA has commissioned DotEcon to propose a new structure for administrative charges, which is documented in this report. The remainder of this report is structured as follows. Section 2 provides a context for the existence of frequency charges and explains our terminology. Section 3 gives an overview of how administrative charges are levied in the UK, Sweden and Norway. Section 4 discusses the principles for a new charging structure. Section 5 sets out a set of calculation parameters according to the principles derived. Section 6 concludes and sets out recommendations. Annex 1 explains how band value factors capturing the difference in relative value of different bands have been derived.

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[1] Promulgation Order no. 680 of 23 June 2004.

[2] Executive Order no. 1128 of 18 November 2005.

2   What are frequency charges and why are they levied?

There are two broad types of charges that may be applied to spectrum licences:

- 'administrative charges', which are collected to cover the costs of the spectrum management authority; and

- 'scarcity charges', which reflect the need to ensure the efficient use of scarce resources.[3]

To be able to distinguish these two types of charges that serve fundamentally different purposes, we hereafter use the terms administrative charges and scarcity charges as defined above. Below, we provide a more detailed description of both types of charges and explain why they are levied.

2.1   Administrative charges

'Administrative charges' are intended to cover the administrative costs of the management, control and enforcement of electronic communications networks including the costs of frequency management.

NITA's annual operating expenditure was approximately DKK 160 million in 2006 and is budgeted at approximately DKK 180 million in 2007.[4] NITA has asked us to assume that the total sum of charges collected should not be greater than the current level of approximately DKK 60 million per annum.

2.2   Scarcity charges

Scarcity charges are used to promote the efficient use of scarce resources.

Where frequencies are scarce, in the sense that there are more users who wish to use these frequencies than can be accommodated, an efficient use of spectrum means awarding such scarce resources to the users who can generate most value from the use. Typically, the willingness to pay for spectrum will reflect the value that a user can generate from such spectrum.[5] Hence, we can generally assume that allocating scarce frequencies to the users that are willing to pay most for such frequencies

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[3] This definition is inspired by, but not identical to, the one used in Aegis, "Study on administrative and frequency fees related to the licensing of networks involving the use of frequencies", Report to the European Commission Directorate General Information Society, 14 Nov 2001. We have used the term, 'scarcity charges' rather than 'spectrum charges' to refer to scarcity rents as 'spectrum charges' is currently used by NITA to refer to a component of administrative charges.

[4] Finance Act 2007, notes to account 19.11.04.

[5] This may not be true in the case of downstream uses which generate high public value that is not captured in the aggregate willingness to pay of individual subscribers. Public service broadcasters could be one example of such users.

promotes efficient use. To that end, NITA uses auctions for the primary award of spectrum where spectrum is scarce.[6]

Owing to technological and market developments, the efficient allocation and assignment of spectrum may vary over time as the relative valuation of different uses and users changes. To facilitate dynamic efficiency gains, NITA allows trades in the secondary market so that licenses can change hands if a new or expanding user can generate greater value from the spectrum. NITA is currently working to improve the secondary market further and to liberalise the use of spectrum.[7] The existence of a secondary market and liberalisation of use exposes licensees to the opportunity costs of holding spectrum where this is scarce. This gives a licensee an incentive to sell spectrum, if its own use is no longer the most efficient.

When scarce spectrum is assigned using an administrative method or where auctioned licences have reached the end of their initial term, some regulators (e.g. Ofcom) impose 'administrative incentive pricing' (AIP) on licences. AIP charges are scarcity charges set administratively by the spectrum manager rather than determined by the market. The idea is to set charges at a level which reflects the opportunity costs of the current spectrum use. The opportunity costs can either be calculated as the valuation that the best alternative use would place on the spectrum or the current user's cost of replacing spectrum with another input, e.g. spectrum at different frequencies.

In conclusion, 'scarcity charges' represent a scarcity rent and may take the form of an auction price, a price agreed between parties in the secondary market or an administratively set price to reflect opportunity costs. Any scarcity charges collected by NITA in the form of auction proceeds are handed to the Ministry of Finance for the benefit of the public purse. Where spectrum is not scarce, NITA licences on a first-come, first-served basis for which there is no scarcity charge.

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[6] According the Frequency Act, NITA also has the option to consider public tenders for the award of scarce spectrum. However, award of spectrum by public tender is less likely to result in an efficient allocation of spectrum.

[7] This is discussed further in DotEcon and Analysis Consulting's report for NITA "Introduction of new instruments in spectrum management in Denmark" (June 2006) and the following hearing conducted by NITA in August/September 2006. NITA's mandate to liberalise spectrum use and further spectrum trading is set out in Supplementary Agreement of 20 June 2007 to the 1999 Telecoms Policy Statement.

3 Case studies

In this section, we describe the structure of administrative charges in the UK, Sweden and Norway. Whereas NITA's activities are funded by the public budget, Ofcom, NPT and PTS are funded by charges levied on network service providers and usage rights holders. This makes administrative charges for spectrum licences just one type of administrative charges that are collected, the sum of which is equal to the total costs of regulating the sector. In addition, Ofcom and NPT have structured their charges so that the various types of service providers do not pay a higher proportion of administrative costs than the proportion of total costs that relate to the regulation of those services.

3.1 UK

In the UK, the Office of Communications (Ofcom) is the regulator for the electronic communications industry and its duties include spectrum management.

Ofcom is an independent body that does not receive any government funding but funds its operating costs by levying administrative charges on industry players in accordance with the Communications Act 2002. Section 8(1) requires Ofcom to balance its total income with total expenditure in each financial year. Ofcom sets administrative charges by allocating costs to the various sectors it oversees, namely: electronic networks and services, television and radio. This is in accordance with sections 38 and 347, which require Ofcom to raise income from each of the sectors it regulates such that it covers the regulatory costs of that sector and that common, non-sector-specific operating costs should be distributed across these sectors in a proportionate manner.

In order to ensure an efficient allocation of scarce spectrum resources, Ofcom also charges scarcity charges in accordance with the Wireless Telegraphy 2006 part 1, section 3(2) and part 2, chapter 1, section 13. This includes both proceeds from spectrum auctions and AIP. The proceeds of scarcity charges are handed over to the government net of Ofcom's charges relating to spectrum management in accordance with the Communications Act, part 6(401).

3.1.1 Funding requirement and cost allocation

Administrative charges are variable and fee levels change according to Ofcom's operating costs. For example, Ofcom's budget for 2007/08 is estimated to be £126.7 million, 5% lower in real terms than that of 2006/07 and 9.8% lower than 2005/06. This cost will be allocated to each sector according to the extent of work proposed for each sector.
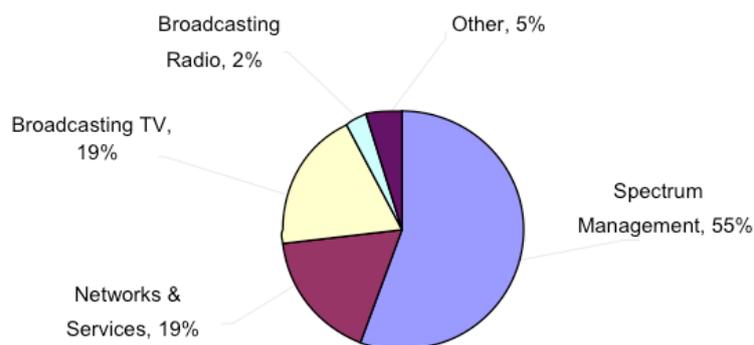
Cost allocation

There are two stages to allocating Ofcom's cost. The first stage involves allocating costs to projects, programmes and processes. In the second stage, the projects and processes are then allocated to regulatory sectors. Within each regulatory sector, various service providers or broadcasters may

have different regulatory requirements and hence costs. Consequently, tiers are in place within the regulatory sectors to account for this so that network service providers who generate more costs for Ofcom pay a larger share of Ofcom's costs.

Direct costs incurred from specific projects, programmes and processes will be allocated to those projects, programmes and processes and via the second stage to regulatory sectors. Indirect costs can either be allocated fully to a project, programme, process or regulatory sector where such costs can be assigned wholly to a single project, programme, process or regulatory sector or apportioned, where such costs are common and cannot be attributed to a specific project or sector. In the cost allocation procedure, Ofcom emphasises a clear differentiation between direct and apportioned cost as well as identifying the appropriate cost drivers so as to increase transparency of the cost allocation. In apportioning indirect costs, Ofcom will identify an appropriate cost driver, and use operational and/or financial data relevant to that driver to calculate an apportionment base. The result of this process is cost per regulatory sector and tier.

Figure 1 shows the breakdown of cost by activity for 2007/08.

Figure 1: Ofcom's cost allocation by activities 2007/08

Source: Ofcom's Tariffs Table 2007/08, published 30 March 2007

3.1.2 Raising income

After establishing the cost allocation between the sectors, Ofcom will then proceed to devise administrative charges in order to raise the necessary income. The common principles applied are:

- Use of turnover as a common tariff basis across all sectors. Turnover data is readily obtainable from all licensees and network and service providers, and provides a basis for ensuring that the specific fees charged are proportionate to ability to pay.

- Administrative charges and licence fees will be calculated for each regulatory sector and for each regulatory tier within the regulatory sector. This ensures reduced fees for regulatory tiers with lower regulatory costs.

- Spectrum management costs are funded out of scarcity charges and Ofcom transfers the net amount to the government.

A full table of current tariffs other than spectrum management costs is published in "Ofcom's Tariff Table 2007/08" [8].

3.2 Sweden

3.2.1 Introduction

The electronic communications and postal sectors in Sweden are monitored by the National Post and Telecom Agency (PTS). Like Ofcom, PTS is independent of government. While PTS receives funding from the state budget for the purpose of serving people with disabilities, the regulation of the communications and postal sectors must be funded by the collection of administrative charges by PTS. According to the Electronic Communications Act 2003, PTS can levy administrative charges to public communications network and service providers as well as holders of radio transmitter licences. The total cost of PTS's telecommunications and postal regulatory duties were SEK 229 million in 2006.

3.2.2 Cost allocation

All administrative charges for telecommunications are designed to cover both direct and indirect costs over a number of years. PTS has detailed knowledge of the share of total cost attributed to licensing, number planning and spectrum management, which is detailed in the accounts provided as part of its annual report.[9] Operating cost such as labour, rent, and other expenses are allocated to each of these areas. Similarly, for licence holders of radio transmitters, the administrative charges will cover the direct cost of issuing the licence as well as part of the common cost not directly linked to any specific activity.

3.2.3 Raising revenue

PTS has four main sources of revenue for its self-funded activities:

- administrative charges collected from all electronic communications services providers;

- charges for various types of transmitter licences which are typically not held by electronic communications services providers;

- charges for number resources; and

- charges collected from postal operators.

The first two types are relevant to the consideration of NITA's administrative charges. The administrative charges collected from electronic communications service providers are SEK 1000 per annum for undertakings

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[8] See http://www.ofcom.org.uk/about/accoun/tarifftable0708/

[9] See "PTS årsredovisning 2006", 19 February 2007, report number PTS-ER-2007:6, ISSN 1650-9862, Dnr 07-815 for the latest annual report.

with turnover less then SEK 5 million and 0.138% of relevant turnover for undertakings with turnover above the SEK 5 million threshold. Providers of electronic communications services are obliged to register with PTS and each year PTS will collect information about relevant turnover by issuing a questionnaire. Fixed telecoms operators, as well as mobile operators and other wireless network providers who use spectrum as an input, will be liable to pay these administrative charges.

In addition to this there are given charges for various types of transmitter licences which are typically not held by electronic communications service providers and hence the licensees will not be liable to pay an administrative charge based on relevant turnover. This transmitter licence charges apply to: [10]

- land mobile transmitter licences (PMR, telemetry, microphones etc.);

- aviation and maritime radio;

- radio and TV broadcasting;

- fixed links; and

- earth stations.

These charges are set as fixed amounts per transmitter and mobile unit in a similar way to NITA's charges for these licence types. The charges for land mobile transmitters for which PTS undertake the spectrum planning are SEK 350 per transmitter and SEK 90 per mobile unit or SEK1000 per transmitter with no limit on the number of mobile units used. Radio broadcasting licences are charged SEK 10,000 per transmitter over 0.5kW and SEK 6,000 at or below 0.6kW. TV broadcasting is charged SEK 7,000 to 30,000 per transmitter depending on the channel and DTT licences are charged SEK 15,000 per transmitter. Fixed link licences are charged SEK 250 per transmitter above 10 GHz or SEK 450 below or SEK 800 per transmitter where the licensee can undertake the spectrum planning itself.

3.3 Norway

The Electronic Communication Act 2003 specifies that the Norwegian Post and Telecommunications Authority (NPT) may impose administrative charges on providers of electronic communications networks, vendors of electronic communications equipment, spectrum rights holders and holders of rights to number, name and address resources. The objective of such administrative charges is to cover the relevant costs of related administrative duties. The total amount to be collected by NPT is decided each year as part of the state budget. In 2007, this is NOK 76.1 million.

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[10] See "Föreskrifter om ändring i Post- och telestyrelsens föreskrifter (2006:4) om avgifter enligt lagen (2003:389) om elektronisk kommunikation, lagen (2000:121) om radio- och teleterminalutrustning, postlagen (1993:1684) och lagen (2000:832) om kvalificerade elektroniska signaturer", 12 June 2007. PTSFS 2007:6

3.3.1 Cost allocation

NPT has developed a model for allocating administrative charges proportionately to those required to pay, which is set out in Regulation on Administrative Charges payable to NPT[11]. The total amount to be raised is divided by a fixed percentage among the different types of contributors whose activities are regulated by NPT as follows:

Table 1: Relative contribution to NPT's costs by type of service provider

Type of contributor	Contribution to total
Providers of electronic communications networks. Holders of licences for use of number, name and address resources	45.5%
Holders of radio frequency licences	45.5%
Registered importers, manufacturers dealers and installers. Holders of licences for aeromobile equipment and emergency beacons. Administrative charges for approval of radio and terminal equipment	6%
Postal operators	3%

The percentages have been derived with relation to the relative costs of NPT in administrating and regulating these different areas.

The share of charges to be paid by electronic communication network providers is divided proportionately to market players according to relevant turnover where this exceeds NOK 30 million. Holders of number, name and address licences pay administrative fees according to the type of licence they hold. Here, we focus on charges to licensees of radio frequency rights as this corresponds to those of NITA's administrative charges under review.

The amount to be charged to holders of radio frequency licences[12] is sub-divided according to the type of spectrum usage, in the following manner:

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[11] Regulations 21 February 2005 number 168 on Administrative Charges Payable to Norwegian Post and Telecommunications Authority.

[12] This is the 45.5% of total minus income from fees charged for issue of amateur radio licences and other charges that NPT may impose.

Table 2: Division of frequency charges by band

Type of spectrum use	Contribution[13]
Professional Mobile Radio	44%
Broadcasting bands	12%
Transmitter licences other than PMR or broadcasting	11%
Spectrum licences in mobile or broadcasting bands	23%
Spectrum licences other than PMR, mobile or broadcasting	10%

Professional Mobile Radio

Each licensee pays a fixed charge of NOK 100,000 as well as NOK 6250 per 12.5kHz channel with the rest of the amount to be recovered from PMR divided out according to number of mobile and base stations. Base stations are assigned 5 points and mobile stations 1, and hence each licensee pays according to the number of points their licence accounts for relative to the total.

Broadcasting

Each licensee pays a fixed charge per network (higher for national network than local or regional) with the rest of the amount to be recovered from broadcasting divided according to the number of transmitters held, whether the frequencies used are below or above 30MHz and the power level of the transmitter.

Other transmitter licences

This category includes satellite earth stations, radio telemetry, point to point and point to multipoint licences, where licensees entail the right to use spectrum at given positions. Transmitters are assigned points according to type and power level and the amount to be charged to each licensee is calculated according to the fraction of total points that its transmitters represent.

Spectrum licences in mobile and broadcasting bands

Licensees in mobile and broadcasting bands other than PMR pay a fixed charge of NOK 50,000 per contiguous block assigned as well as a charge depending on the bandwidth held and at which frequencies. Where licences are regional, the charges are prorated according to the share of the population living in the licence area.

Spectrum licences other than PMR, mobile and broadcasting

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[13] Note the allocation percentages used for 2007 are slightly different to those set out in the Regulations from 2005. PMR was higher at 46%, transmitter licences other than PMR and broadcasting were lower at 10% and spectrum licences other than mobile and broadcasting were lower at 9%.

Half of the amount to be recovered from this group of users is divided equally based on the number of contiguous frequency blocks and half is divided out based on bandwidth held. Where licences are regional, the amount is prorated according to the share of the total population living in the licence area.

4 Principles for a new approach to administrative charges

In this section we discuss the principles for a new charging structure. Drawing in part on guidance from NITA, we have identified five principles for setting administrative charges:

- Charges should be service and technology neutral.

- Charges should be structured such as to minimise the risk of undermining the efficient use of spectrum.

- Charges for licences for trial and test operations should be lower than those for standard licences.

- The final charging structure should be simple to understand.

- The structure used should be robust to further liberalisation, such as the introduction of licence reconfiguration in the secondary market.

In its further work to implement the new charging model, NITA may find that there are additional considerations, which it will have to bear in mind.

We discuss each of the five principles below.

4.1 Service and technology neutrality

The main driver for restructuring administrative charges is the unsuitability of the current service based model. Hence as a first principle, administrative charges must be derived independently of the service that a licensee provides or the technology that it uses to produce such services.

4.2 Avoid distortions to efficient use of spectrum

The overall objective for NITA's frequency management is to promote the efficient use of spectrum and promote competition in downstream markets. This is primarily done through the use of market mechanisms and scarcity charges. Administrative charges, which are capped at DKK 60 million a year cannot play a major role in promoting efficiency. Nonetheless, we should make sure that administrative fees are set so they do not:

- undermine efficient use of spectrum; or

- weaken competition in downstream markets.

Thus administrative charges to individual licences should be apportioned in a way that will not affect their use, assuming that the value of the licence to an individual licensee exceeds NITA's administrative effort in relation to awarding and administering the licence.

Such apportioning could be done by allocating the total revenue requirement according to the relative economic value of licences, which would minimise the risk of pricing off demand. There are other possible charging structures that would not undermine efficient use, e.g. to allocate the required revenue according to NITA's relative cost of administrating different licences.

There is one caveat to the principle of levying charges according to the relative economic value of licences and that is those licences for which scarcity charges were paid, i.e. licences that were initially sold by auction or

which have been transacted in the market since award. For such licences, spectrum users would have already taken into account the level of existing administrative charges as part of the total price of the spectrum: the higher the administrative charges, the lower the scarcity charge that they would have been willing to pay for the licence. For this reason, we should check that total charges under a new model do not increase significantly for licences for which scarcity charges were paid. The risk of any distortion would be small though if the scarcity charges paid were large compared to administrative charges.

4.3 Reduced charges for licences awarded for trial and test operations

NITA wants to encourage research and development into wireless applications and the deployment of new technologies in Denmark. As a principle, NITA has therefore suggested that charges should be lower for licences issued for trial and test operations, as such use may encourage the earlier adoption of innovative technologies.

4.4 Simplicity

NITA has also requested that the charging structure should be as simple as possible. This fits well with the Authorisation Directive, article 12, section 1 (b), which specifies that, any administrative charges must be imposed upon individual licensees in "an objective, transparent and proportionate manner, which minimises additional administrative costs".

4.5 Future proofing

NITA is considering whether and how to allow reconfiguration of licenses in the secondary market. It would, therefore, be practical if a new approach was easily adjustable according to typical reconfigurations, which NITA expects might include:

- division of licences into smaller portions of frequencies;
- division of licences according to geographical area; and
- division of licences according to time of day.

Moreover, it would potentially facilitate trades and improve the workings of the secondary market if market participants could easily predict what the administrative charges for reconfigured licences would be. This may be important for licences where the administrative charges would be a significant proportion of the overall charge.

5   New calculation methodology

Having discussed the principles for a new charging model, we now consider how charges would be calculated according to those principles.

5.1   Structure of charges

We suggest that NITA continues its current practice of setting charges for each licence that include a fixed element as well as a variable element depending on the amount of spectrum resources a licensee occupies.   This is in line with the principle that charges should not undermine the efficient use of spectrum as discussed in section 4.2.

5.1.1   Fixed element

NITA currently applies a fixed element of DKK 180 per licence per year regardless of the type or amount of spectrum held. This amount has not been adjusted since 2000 and appears low today. The purpose of the fixed charge is to deter non-serious users from applying for spectrum, thereby increasing NITA's administrative costs unnecessarily. In order for the fixed charge to have this effect, it would seem appropriate to charge a higher fixed element to each licence. We would therefore suggest a higher fixed element per licence, for example DKK 500 per licence. Alternatively, NITA could consider introducing a one off fee for issuing new licences.

The fixed element would apply to all licences. Where for example a trade in the secondary market resulted in a licence being divided into two separate licences, the fixed element would be applied to both.

5.2   Value drivers for allocation of charges

The sum of fixed charges across all licences will fall short of the total revenue requirement with the remainder to be allocated according to the relative economic value of licences. As NITA strives to issue service neutral licences, the relative economic value cannot be determined by the type of service or the technology to be deployed, but must be approximated in a manner that does not refer to spectrum use. In this section we consider bandwidth, frequency, geographic coverage and time as potential drivers of economic value before discussing the mechanics of allocating charges according to these drivers in the following sections.

5.2.1   Bandwidth

Most licences are issued with reference to the bandwidth that can be used under the licence. The amount of bandwidth has an impact on the economic value of a licence because more bandwidth allows more data to be transmitted simultaneously, so the more bandwidth assigned to a user, the higher the economic value of that licence and hence in our calculation methodology, the higher the charge would be.

We propose that charges are made proportional to the amount of spectrum held. This would imply that paired spectrum is charged twice as much as

unpaired spectrum. Some technologies will require spectrum in given amounts, e.g. UMTS applications require spectrum in lots of 5MHz contiguous spectrum. Nonetheless we need to structure charges on a common basis in order to achieve a service neutral regime and the fact that bandwidth is required in different amounts does not prevent the charging unit from being the same.

5.2.2 Spectrum band value factors

The economic value of spectrum is obviously also closely related to which services particular frequencies can be used for. Historically this was to a large extent because certain frequencies were assigned to particular services (e.g. mobile, FWA or broadcasting) and equipment was mass-produced for these bands. However, even if the use of frequencies were liberalised fully, it remains the case that propagation characteristics of spectrum are better, the lower the frequency. This would suggest that 1MHz of spectrum is generally more valuable the lower it is, and that the charge per MHz should vary accordingly. NITA's current charging structure reflects this to some extent with a single 'break' at 3GHz where, for those services that are licensed at different frequencies, charges are ten times higher below this break.

We have used DotEcon's Spectrum Awards Database[14] to estimate where 'breaks' in the value of spectrum are and how different the relative value is. The methodology is explained in Annex 1 and the results are summarised in Table 3 below with normalised values showing the relative value of the defined bands.

Table 3: Spectrum 'breaks' and relative value

Frequencies	Band value factor
0- 300MHz	200
300MHz–1GHz	400
1–3GHz	200
3–10GHz	20
10–33GHz	2
Above 33GHz	1

We suggest that these relative values are applied as weights to the price of 1MHz in the different bands of spectrum.

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[14] DotEcon's Spectrum Awards Database contains information on over 170 spectrum awards across 51 countries as published by National Regulatory Authorities and other publicly available information from 1994 onwards.

5.2.3 Geographic area

We suggest that the allocation of charges to each licence also depends on the geographical areas covered.[15] It does not seem unreasonable to assume that the value of a licence depends on the area that can be reached as the services produced with the licensed spectrum will in most cases be more valuable, the greater area covered. This is easy to see for wireless networks (such as mobile and FWA) as the more people covered, the better revenue potential an operator would have. In this case, a simple way of adjusting for the coverage area for licenses that are defined with reference to a geographical area would be to adjust according to the proportion of the total population of Denmark that lives in the licensed area.

There are clearly other geographical and demographic factors, which could have an impact on the economic value of licences:

- A higher than average number of businesses may be more valuable to mobile operators but probably not to a commercial broadcaster and hence an adjustment based on the number of business would not be service neutral.

- Topography can play a role as it can be more expensive to provide wireless coverage in regions with more rugged landscape. However, as the Danish landscape is quite similar across the country this would only lead to minor variations in charges.

- The population density will have an impact on the value of licences because the denser populated an area is, the cheaper it is to provide wireless coverage. NITA could calculate weights according to relative population density and apply these in a similar manner to the relative weights for different spectrum bands. However, the charging model would become a great deal more complicated for a modest gain in accuracy.

Finally, the economic value may not be linearly related to population. However, as we are only using relative economic value as a proxy in order to allocate a required amount of revenue onto individual licences and this amount is less than the actual value of licences, we do not need to estimate the value of licences with the same accuracy as one might for administrative incentive pricing.

On balance, it would therefore seem that the objective to keep the charging model simple would suggest that licences pay a proportion of the national fee in accordance with the relative share of the population that the licences cover. This may be calculated by postcode or administrative area depending on how the licences are delineated.[16] This simple approach has the added

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[15] Geographical coverage refers to the protected right of the licensee not the actual coverage for a particular service.

[16] Hence, a set of regional licences, which in aggregate covered all of Denmark would in total pay the same share of the required revenue as a national licence for the same frequencies (whilst each paying the fixed element).

benefit that it is straightforward for the market to copy and work out how the administrative charge should be divided if licences were to be divided into smaller geographical units ahead of transactions in the secondary market.

For other licence categories where the reach of the licence is not specified with reference to geographical areas but for example implied by given transmitter locations and allowed transmitter power levels, the charge will obviously have to be derived differently in accordance with how the licences are defined. For fixed link licences, the number of positions that a licensee can transmit from/to has an impact on the reusability of the frequencies and hence the more stations, the higher the economic value of the licence. For land mobile licences, NITA also specifies how many associated mobile units can be used under a transmitter licence because the intensity of use determines whether NITA can licence the same frequencies to another user at neighbouring positions or needs to leave gaps between. Hence the more mobile units allowed under a licence, the higher the opportunity cost and hence economic value of that licence as it sterilises the frequencies at nearby positions.

5.2.4 Time of day as potential allocation factor

NITA has also requested that we consider whether administrative charges should be calculated according to time of day. No licences are currently issued according to the time of day that frequencies may be used, i.e. all licences are for the use of particular frequencies for 24 hours a day.

It is possible that some licences may be reconfigured and traded in the secondary market according to the time of use although we do not anticipate this being common. Whilst there may be shared use, this is more likely to be agreements to share the use of a licence (e.g. a leasing arrangement) rather than actual divisions of licences in which case the licensee remains responsible for the payment of frequency charges to NITA. Unless there was evidence of substantial demand for spectrum on a time share basis, a licensee would be concerned that dividing a licence according to time of day would reduce the value of the spectrum, i.e. that the sum of the parts would be less than the total, and hence would be reluctant to divide spectrum into separate licences.

However, the question for NITA in structuring administrative charges, is whether it would be willing to issue time-based licences if anybody should apply for such? We see at least two reasons why this is undesirable:

- How should the charges vary according to the time share? The simplest solution would be to charge a proportion of what the equivalent full time licence would cost according to the proportion of the day for which the licence is valid, e.g. 18/24 of the full charge for a licence valid from 06:00 to 24:00. However, our principle is to mark up for common costs according to the economic value of licences, and there would be a notion that access to spectrum would be more valuable at certain times of the day, for example daytime versus night. But as time share is not common we have no data to suggest how much.

- If charges are lower for 'part time' licences, there is an incentive for users who only need the spectrum part time to apply for that in order to save on administrative charges. Unless other users had matching requirement for the unused times, this would not lead to greater efficiency of spectrum use. But it would leave NITA with a potentially much greater register of licences and an extra dimension to consider for spectrum availability.

In conclusion, we do not anticipate that many transactions in the secondary market will divide licences according to time. The introduction of time based licences may in itself create demand for part time licences but not necessarily lead to more efficient spectrum use.

If NITA were to introduce time based licences, we would however suggest a straight forward weighting of charges according the proportion of the day for which the spectrum is licensed as it is difficult to suggest a more accurate measure. This could apply to any group of licences whether these were issued with respect to transmitter stations and the number of mobile units used or the frequency and bandwidth.

5.3 Allocation of required revenue to licences

As licences are currently issued according to different parameters, it is difficult to imagine a single structure of variable charges that can capture the impact of bandwidth and in particular geographic coverage on the relative value across all licence types. This means the allocation of the total revenue requirement to individual licences according to relative value has to be broken down into two steps.

Without violating the principle that charges must be service and technology neutral, we can divide licences into groups according to the parameters with which they are issued as a basis for assigning charges to individual licences:

- Wireless network licences, which are issued with reference to bandwidth and a geographically defined coverage area.

- Fixed link (point-to-point) licences, which are issued with reference to bandwidth, transmitter locations and maximum power level.

- Broadcast licences, which are currently issued with reference to bandwidth and transmitter locations, height and power level. It may be practical to separate this category further into TV broadcasting and FM radio broadcasting.

- Land mobile licences, which are defined with reference to bandwidth, transmitter locations and number of mobile units allowed.

- Licences with shared use of frequency bands, such as microwave, transmission of measurement, radar, SNG earth stations, VSAT earth stations and aeronautical land stations. These are shared uses and licences are awarded on a non-exclusive basis for a whole frequency band.

The first step of calculating variable charges based on the overall revenue requirement is to allocate revenue to these licence groups and the second

step is to allocate the proportion of revenue attributed to each licence group to individual licences.

5.3.1 Allocation of revenue requirement to licence groups

We propose that NITA compiles a list of all frequencies issued by each licence group. Applying the band value factors discussed in section 5.2.2 and summing the spectrum endowment by group, NITA can calculate the relative proportions of economic value held by each group of licences. For those bands that have been licensed across the entire country (though this may be split into several regional licences), we do not need to take geography into consideration in the first step. However in the bands where frequencies have been licensed on a regional or transmitter basis and where there are available frequencies in between the licensed frequencies, NITA will have to take into account the extent to which frequencies in the bands are licensed to users.

Table 4 below provides a simplified calculation example for illustration purposes using a few select bands only and assuming that frequencies in those bands are all awarded across the entire country.

Table 4: Allocation of total revenue requirement to licence groups – simplified calculation example

Licence group	Frequencies	Band-width (MHz)	Band value factor	Weighted sum	Percent of total
Wireless networks	410-430 MHz	20	400	8,000	
	880-960 MHz	80	400	32,000	
	1900-2170 MHZ	270	200	54,000	
	3400-3800 MHz	400	20	8,000	18%
Fixed links	1450-2350 MHz	900	200	180,000	
	7000-8000 MHz	1000	20	20,000	
	12-16 GHz	4000	20	80,000	
	37-39 GHz	2000	1	2000	49%
TV broadcast	470-862 MHz	392	400	156,800	27%
FM radio	87-108 MHz	21	200	4200	1%
Land mobile	69-74 MHz	5	200	1,000	
	146-152 MHz	6	200	1,200	
	162-174 MHz	12	200	2,400	1%
Shared use	9.5-11 GHz	1500	20	30,000	
	27-30 MHz	3	200	600	5%

In this example, 18% of the total revenue requirement of DKK 60 million would be allocated to Wireless network licences, 49% to Fixed links licences, 1% to FM radio broadcast, 27% to TV broadcast licences, 1% to Land mobile licences and 5% to Shared use licences.

5.3.2 Allocation of charges to individual licences

Once the revenue requirement per licence group is derived and the sum of fixed charges per licence group deducted (the number of licences multiplied by the fixed element per licence), the remaining revenue has to be allocated as charges to individual licences. Using the same methodology, the revenue is allocated according to estimates of the relative economic value of individual licences, only the measures of relative economic value vary by licence group. In the following sections we discuss how the revenue may be allocated for each licence group. The mathematical formulae for the allocations are provided in Annex 2.

Wireless network licences

Wireless network licences (such as GSM, UMTS, FWA) are specified by the bandwidth a licensee is allowed to used at given frequencies and the geographical coverage area as well as a spectrum mask. The purpose of the spectrum mask is simply to avoid interference (primarily to neighbouring users within the band) and as long as the same principles are applied to all licensees within this licence group, the relative economic value of licences can be approximated by bandwidth adjusted by the band value factor and geographic coverage area without reference to the spectrum mask.

This means that charges in this licence group can be allocated to individual licences according to the:

bandwidth x *band value factor* x *population coverage*

of each licence compared to the total of this category. For a straightforward way of calculating charges that is easy to understand for licensees and can be applied to new licences issued between revisions to the charges, NITA can solve the following equation for *X*:

bandwidth (MHz) x *band value factor* x *population coverage (%)* x *X (DKK/MHz)*

= total charges to Wireless networks licences – sum of fixed charges from Wireless network licences,

where *X* is the charge per MHz per band value factor for a national licence with regional licences paying a fraction according to percentage of total population in the licensed area. This can then be applied to licences combined with the band value factors in Table 3 and the population of their licensed area.

Fixed link (point-to-point) licences

Fixed licences are currently specified according to the geographic points that a licensee can transmit between and the bandwidth and the frequency that can be used. The frequencies used for fixed links vary from 1450MHz up to 39GHz, so the spectrum band value factors should also be used to allocate charges in this group. The allowed power level is also specified however we understand that this is a less relevant factor for the geographical coverage of fixed links as the antennae point the signal very specifically in the given direction. Hence we propose to use the number of transmitters as a proxy for the geographical coverage. Charges to individual licences are derived by summing across all licences, equating to the fixed link charges to be recovered from variable charges:

number of transmitter locations x *band value factor* x *bandwidth (MHz)* x *Y (DKK/MHz)*

= total charges to Fixed link licences – sum of fixed charges from Fixed link licences

and solving for *Y*, the fixed link charge per MHz per transmitter location per band value factor.

If there are national fixed link licences where a licensee has the sole right to use a given bandwidth, such licences can be grouped with Wireless network licences for the purpose of calculating frequency charges.

Broadcast licences

TV broadcasting: Denmark is planning to switch off analogue terrestrial TV transmission on 31 October 2009. The frequencies that will be freed up by the switch off will allow eight multiplexes in total to be allocated to digital terrestrial television (DTT) and other services. The current analogue local TV broadcasting licences will be revoked.

Following digital switchover, the structure of charges to the DTT multiplex operators can be relatively simple as there will be eight national multiplexes which all have the same number of channels within the same band so charges can be allocated to the muxes in equal proportions.[17] The amount of bandwidth used for each channel may vary slightly in order to protect users from interference risks, which vary slightly by channel. However the broadcast output that licences are able to achieve with each mux should be identical.

FM radio broadcasting: There are four national FM licences, two 'near national' licences and a number of local and regional FM licences. Each national licensee has access to one channel of 300kHz (or 0.3MHz) at given locations with given emission power level (although the specific frequency to be used varies across locations). The local and regional FM licences are specified according to a given frequency, transmitter location and power level (typically 160W or 500W). The frequency charges to FM licensees are currently specified as a set charge per frequency per position of DKK 522 where the emission power level is 160W or below and DKK 1044 where the emission power is above 160W.

Commercial radio broadcasters will aspire to achieve the most possible listeners for their advertisers and hence the relative value of licences will be closely correlated with the number of potential listeners who can receive a given station, i.e. the population coverage of the signal. Within this methodology our preferred allocation key would therefore be population (or percent of total population) covered.

If NITA knows or can estimate the approximate population coverage of each licence, including the local and regional licences, we suggest that the administrative charge to each licensee can be calculated by summing across all FM licences:

population coverage (%) x *Z (DKK/channel)*

= total charges to FM radio licences – sum of fixed charges from FM radio licences

and solving for *Z*, the charge per channel, which for each licensee is then adjusted accorded to population coverage.

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[17] Though some of these may be charged less as one multiplex is to be set aside for research and development from 1 November 2009 to 31 October 2010 and NITA wants to charge licences issued for research and development less. This is discussed further in section 5.4 below. Two multiplexes are placed in an 'innovation reserve' for later award.

As the FM licences all have the right to use a given bandwidth, the FM licences could potentially also be absorbed into the Wireless network licence group for calculation purpose. The bandwidth and band value factors should of course be applied in that case.

If NITA is not able to estimate the population coverage of each local or regional FM licence, NITA could instead allocate the charges to be paid by FM licences as described in the following: Assuming that local and regional FM licenses share one channel (i.e. in place of all local and regional licences, the same spectrum resources would enable one national FM licence), the amount to be charged to FM licences could first be allocated out in portions to each national channel as above, weighting according to population coverage, counting all local and regional licences as one channel with full coverage.[18] Subsequent to this, the charges to local and regional FM radio broadcasters would have to be distributed to individual licences. Lacking any better measure, this could be done by the number of transmitters and emission power level as currently used, assuming that the current charge ratio of 2:1 for higher power transmitters reflects the increased coverage area achieved, so that the charge per transmitter for local and regional FM licences is calculated by summing across all local and regional FM licences and equating to their share of administrative charges:

no. of transmitters x *2 (if above 160W)* x *W (DKK/transmitter)*

= total charges to local and regional FM radio licences

and solving for *W*, the charge per transmitter.

DAB radio broadcasting: There are two DAB radio transmission licences, which each have one channel of about 1.5 MHz on a national basis although the channel is not the same across all regions. These licences can be included in the Wireless network licences group for the purpose of calculating frequency charges.

Land mobile licences

All land mobile licences use the same frequency and bandwidth of 25kHz (or 0.025MHz). As the bandwidth does not vary across licences, it is not necessary to consider bandwidth in order to estimate the relative value of licences within this group. Hence we can focus on the relative size of coverage areas, which as discussed in section 5.2.3, we will approximate by the number of transmitters as well as the number of mobile units. NITA's current charges for land mobile charges include 25 step changes as shown in Annex 3, e.g. 1 unit, 2-5 units, 6-10 units, 11-15 units, 16-20 units, 21-30 units and so on up to 4501-5000 units. However, it would seem there is scope to simplify this by reducing the number of price points. We understand that the threshold NITA works with in its planning of this band is 30 mobile units, i.e. if a user wishes to use more then 30 mobile units, NITA

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[18] I.e. DR P1, P2, P3 and P4 would all have weight 100% corresponding to its population coverage, the fifth FM channel would have weight 80%, the sixth channel 37% and all local and regional stations counted together would be attached weight 100%.

cannot assign the same channel at neighbouring transmitter locations. If we assume that a transmitter location has on average four neighbouring locations, a given frequency cannot be reused at four other locations once it is allocated at one. We can then calculate the charge per location by summing across licences:

no. of transmitters locations x band value factor x 4 (if above 30 mobile units) x Q (DKK/transmitter location)

= total charges to Land mobile licences – sum of fixed charges for Land mobile licences

and solving for *Q*, the charge per transmitter location per band value factor for licences with less than 30 mobile units.

We understand that NITA is currently reviewing how it specifies licences and it is possible that licences may be specified according to defined geographical areas rather than transmitter locations (as well as bandwidth and frequency). In that case, the whole land mobile licence group could be merged with the wireless network group for calculation purposes as all licences in this group would be defined according to the same parameters. Note, a change in the allocation of licences between groups should be reflected in the allocation of total revenue to licence groups as discussed in section 5.3.1.

Shared use licences

The last group of licences are other licences such as microwave, telemetry, radar, SNG and VSAT earth stations, which are a mix of licences that are given particular frequencies to use but these are not exclusive to the individual licensee. Currently these licences are all charged the same charge of DKK 163 (in addition to the fixed element of DKK 180). However, as these services use different bands, the relative value of which varies quite significantly (as captured in the band value factors), the methodology would suggest that these services are charged different amounts according to which band they use. We can derive the charge per licence by summing across all these licences:

band value factor x P (DKK/licence)

= total charges to Shared use licences – sum of fixed charges from Shared use licences

and solving for *P*, the charge per licence per band value factor.

5.4 Licences for trial and test operation

In the current charging structure, there are separate prices for trial and test operations (items 36-38 in Annex 3) according to bandwidth and whether the frequencies are below or above 3GHz or shared frequencies. This has had the unintended consequence that the administrative charges for licences for trial and test operations may sometimes be charged more than a normal licence. To avoid such adverse situations and to accommodate the principle that licences for trial and test operations should be charged less, we recommend that trial and test licences are charged according to the same structure as other licences but at a discount to be decided in advance. This fits into the calculation methodology explained in the previous sections as

such licences would be weighted by a certain percentage figure lower than 100% in the calculations of the relevant categories. Alternatively, licences could only be charged the fixed element at an estimated DKK 500 per licence. Although trial and test licences would always be charged less than full licences, this simple solution has the disadvantage that trial and test licences would be charged the same whether they were using highly valuable spectrum under 1 GHz or trying to develop commercial applications for higher frequency ranges. This is relevant to consider in the light of the proposal to set aside two DTT multiplexes for research and innovation, which would indeed be using relatively valuable spectrum under 1GHz.

6 Conclusion and recommendations

There are several plausible ways that administrative charges for spectrum licences can be structured. NITA is concerned that administrative charges should not undermine efficiency, and hence we recommend that all licensees continue to pay a fixed charge to cover the minimum costs directly attributable to their licence and that the remaining required revenue is allocated in proportion to the relative economic value of licences.

As the economic value of licences varies with the bandwidth, the band and the geographical area covered, we recommend that these factors are used to allocate charges to individual licences in a top-down calculation. However, as licences are specified according to different parameters, this calculation has to be broken down into steps.

The charges would then be calculated in the following steps:

- Determine the proportion of the total revenue requirement that is to be allocated to each licence group by calculating the proportion of total spectrum value that each group occupies. The relative spectrum value is calculated as the sum of the product of the licensed bandwidth and the relevant band value factor, which captures that fact that some frequencies are more valuable than others.

- For each licence group, calculate the sum of fixed charges, which will be the fixed element times the number of licences.

- Calculate the variable charges by licence group as the difference between the revenue requirement by licence group and the sum of fixed charges.

- Allocate the variable charges within each licence group as appropriate and in proportion to the relative economic value of licences.

- Check that administrative charges for licences acquired by auction do not exceed current charges in real terms for licences where this has been indicated in the terms of the auction.

As TV and FM radio broadcasting licensing is about to undergo major changes, it may be sensible to have the introduction of new administrative charges to TV and FM radio broadcasting coincide with digital switchover and the introduction of the new FM band structure (if relevant) respectively.

It is worth bearing in mind, that the calculation of administrative charges as described in this report needs to be set up once only. Thereafter NITA has a simple charging model, which can easily be applied to existing and new licences, with a charging structure along the lines of:

- Wireless network licences: DKK X per MHz multiplied by the relevant band value factor for a national licence adjusted according to share of population for regional licences;

- Fixed link (point-to-point) licences: DKK Y per MHz per transmitter multiplied by the relevant band value factor; and

- Land mobile Licences: DKK *Q* per transmitter location multiplied by four if more than 30 mobile units.

NITA can either recalculate charges (X, Y and Q in example above) every year to match total charges with its revenue requirement exactly or carry over the monetary amount per unit, which can then be adjusted occasionally when key variables of the calculation may have changed. In the latter approach the total revenue may then vary slightly from year to year depending on the number and type of licences.

If NITA changes the parameters with which land mobile licences are specified as is currently being considered, the model may be simplified further and the number of licence groups reduced.

The relatively simple structure of charges means that licensees should be able to predict the implication on administrative charges of potential licence reconfigurations that they may be considering ahead of transactions in the secondary market.

Annex 1: Spectrum breaks and band value factors

According to Ofcom, the UK spectrum manager: "The usable spectrum currently ranges from 9kHz to around 100GHz (the upper limit has risen over the years as technological progress has allowed higher frequencies to be exploited). Within this very wide range, different frequency bands have very different characteristics. At the lowest frequencies radio signals are capable of travelling very long distances but can carry relatively little data. At the highest frequencies they are capable of carrying large amounts of information but can only travel short distances and can be impeded by trees and buildings, or even rain at the very highest frequencies. Intermediate frequencies offer different mixes of distance and information carrying capacity. The 'prime' spectrum for communications services is sometimes considered to be between 100MHz and 3GHz as this offers the optimum combination of distance and information carrying capacity."[19]

ITU divides spectrum into categories that are used in the ITU radio regulations, as illustrated in Table 5.

Table 5: Standard frequency designations from ITU radio regulations

Designation		Frequency	Wavelength
VLF	very low frequency	3kHz to 30kHz	100km to 10km
LF	low frequency	30kHz to 300kHz	10km to 1km
MF	medium frequency	300kHz to 3000kHz	1km to 100m
HF	high frequency	3MHz to 30MHz	100m to 10m
VHF	very high frequency	30MHz to 300MHz	10m to 1m
UHF	ultra-high frequency	300MHz to 3000MHz	1m to 10cm
SHF	super-high frequency	3GHz to 30GHz	10cm to 1cm
EHF	extremely high frequency	30GHz to 300GHz	1cm to 1mm

However, the ITU divisions do not take any account of how spectrum is used in practice and, in particular, which bands are most attractive for commercial use (owing to factors such as pan-European availability and equipment availability). Either side of the category boundaries, there may be spectrum with similar characteristics and similar use. The 'majority' of spectrum use (in terms of number of consumers) and most valuable applications, such as mobile and TV, are concentrated in the UHF band (300MHz-3GHz). Within this band, there is significant variation in value; in general, the lower frequencies (300 or 400MHz up to around 1GHz) are

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[19] Ofcom, November 2004, Spectrum Framework Review, page 10.

considered most attractive, as they offer superior distance and building penetration. Above 1GHz, the value tends to diminish with higher frequencies; although such differences may be swamped by other factors, such as availability of cost-effective equipment for particular applications.

These issues suggest that it would be sensible to sub-divide the 300MHz-3GHz band into two or three categories. Further, it would also appear sensible to adjust the boundaries between charging categories such that, where possible, bands that are similar in frequency and use are in the same category.

Considering these issues, we have developed a two-step approach to determine the boundaries between charging categories and calculate the relative charges between categories as follows:

1. Undertake a review of the main commercial uses of spectrum with the objective of identifying natural boundaries based on differences in frequency and types of use.

2. Use data from international spectrum awards to estimate the value of specific bands. Bands of similar value will be grouped under the same category. The average value of each category is calculated, proportioned across the value of entire spectrum then normalised to determine relative share of administrative charges.

We describe these steps further in the following sections "Setting boundaries based on broad categorisation of types of use" and "Values of frequency bands" respectively.

Setting boundaries based on broad categorisation of types of use

Figure 2 provides a visual illustration of the main existing commercial uses of spectrum in Denmark. Unsurprisingly, in many cases, similar uses can be found in adjacent frequency ranges. Further, there are a number of frequency 'gaps'[20] between the different commercial uses that may provide natural boundaries for the charging bands.

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[20] These gaps do not imply that the spectrum is unused; many of the 'gaps' on the chart are spectrum allocated to non-commercial uses, such as the military.

Figure 2: Major use of spectrum at different frequencies
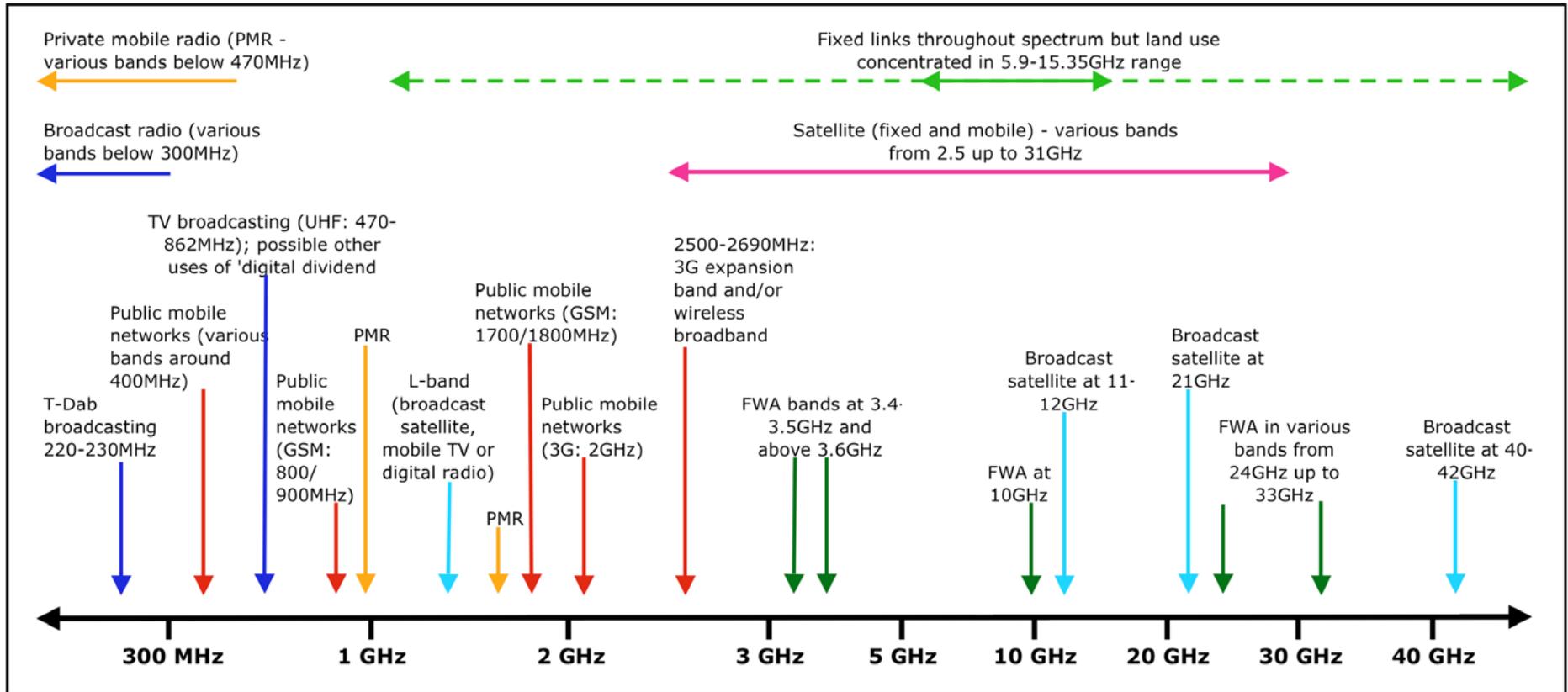
Specifically, we can identify the following natural 'boundaries':

- *Up to 300MHz.* Commercial use of spectrum below 300MHz is dominated by broadcast radio and private mobile radio (PMR). Many applications can be run with very small allocations of spectrum, e.g. less than 1MHz.

- *300MHz to 1GHz.* Commercial use of spectrum between 300MHz and 1GHz is dominated by high-value, mass-market services, such as television and mobile telephony. A significant amount of spectrum in this band may become available in the near future for new uses, owing to digital switchover of terrestrial television and the replacement of GSM with new mobile technologies. This is prime spectrum for new services, such as mobile TV. These mass-market services could, in some cases, be launched using as little as 5MHz or 2x5MHz of spectrum.

- *1GHz to 3GHz.* Between 1400MHz and 2700MHz, there are a number of high-value commercial bands, including the L-band (suitable for mobile TV and satellite broadcasting), the GSM 1800MHz band, 3G spectrum at 2.1GHz, and the so-called 3G expansion band (also suitable for TDD wireless broadband applications) at 2500-2690MHz. Most services in this range will require at least 10MHz or 2x10MHz, with requirements rising for the higher frequencies.

- *3GHz to 10GHz.* There are a number of bands currently allocated for fixed wireless access (FWA) services at around 3.4GHz-3.8GHz. These services typically use 2x28MHz blocks of spectrum or higher. Satellite (fixed and mobile) is common throughout this part of the spectrum. Fixed link use is concentrated in the spectrum from 5.9GHz up to 15.7GHz.

- *10GHz to 33GHz.* There is a concentration of spectrum typically licensed to FWA in spectrum at 10-11GHz and from 24GHz up to 33GHz. Licences in this range are often sized at around 2x64MHz or 2x128MHz, much larger than FWA licences in the 3.4-3.8GHz band suggesting consequent difference in value between this category of frequencies and the previous. The UK auction of spectrum in the 10GHz, 28GHz, 32GHz and 40GHz bands, scheduled for later this year, may provide a valuable proxy for how the value per MHz declines with higher frequencies. Ofcom has decided on the lot endowments and eligibility points per lot for these bands, as illustrated in Table 6 below. These provide an indication of Ofcom's view on the likely value ratio of the spectrum. These figures suggest that 28GHz and 32 GHz may be treated a single category, but that 10GHz should be in a higher charging category and 40GHz in a lower charging category. The outcome of the auction may of course produce different valuations.

Table 6: Eligibility points of various frequencies in upcoming Ofcom spectrum auction

Band	Number of lots	Spectrum endowment	Eligibility pts per lot	MHz per eligibility pt (implied value ratio)
10 GHz national	10	2 x 10 MHz	1	20 MHz
28 GHz national	2	2 x 112 MHz	6	37.3 MHz
32 GHz national	6	2 x 126 MHz	6	42 MHz
40 GHz national	6	2 x 250 MHz	3	166.7 MHz

Source: Ofcom, "Auction of spectrum: 10GHz, 28 GHz, 32 GHz and 40 GHz, Information Memorandum", published 7 Aug. 2007

- *Above 33GHz.* There is very little licensed commercial use of spectrum above this level. Very large endowments (e.g. 2x250MHz or higher) will typically be required for a viable application at these high frequencies.

In summary, a high-level review of usage suggests dividing up the spectrum into up to six charging categories as illustrated in Figure 3.

Figure 3: Spectrum charging categories
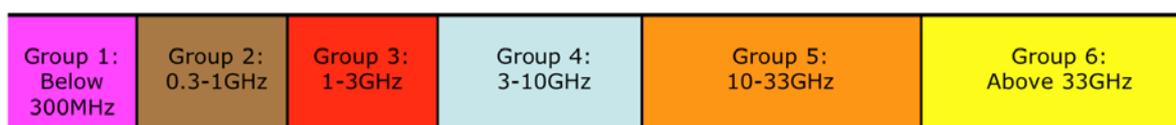
Values of frequency bands

We then use data of international spectrum awards to establish the difference in value between the categories of spectrum frequencies. Spectrum value can be measured by the price paid for a spectrum licence in a competitive award as this price reflects the willingness to pay for the spectrum depending on bidders' views of the potential revenue streams and network roll out costs.

Spectrum price data is taken from DotEcon's Spectrum Awards Database, which contains information on over 170 spectrum awards across 51 countries as published by National Regulatory Authorities and other publicly available information. The database contains information on spectrum awards from 1994 onwards.

The price of individual licences are calculated on a per population per MHz basis and converted to a common currency, US dollars, in order to achieve comparable figures.

In order to determine if the value of the six groups of frequencies do indeed differ from each other, a weighted average of individual licence price per pop per MHz in USD was calculated for each group. The licences were weighted

according to the number of awards in their respective frequency bands. For example, group 2 consist of spectrum awards in the 400 MHz, 450 MHz, 700 MHz, 800 MHz, 870 MHz and 900 MHz bands. Given that there are many more awards in the 900MHz band than the 450 MHz band in the database, we attach more weight to the 900 MHz licences when calculating the average price of licences in group 2. As awards have a varying number of licences, weighting individual licences this way minimises the bias that large regional awards[21] could otherwise create. The drawback of this approach is that every licence within each frequency band is given equal weight, regardless of the characteristics of the licensed area, e.g. a 450MHz licence in Luxembourg would have the same weight in the calculation as a 450MHz licence in Germany or Turkey. While this can be corrected by weighting individual licences within each frequency band according to population covered by the licence, population density, GDP, mobile penetration etc, we have found in previous benchmark studies that many of the variables one would expect to be explanatory variables are in fact not significant. Licence duration is not taken into consideration either as we have not found this to be a significant driver of spectrum value. For example, the 3G licences awarded by auction in July 2000 in the Netherlands have a 15-year licence duration but achieved a higher price per population per MHz than the Austrian 3G licences with 20-year duration which were awarded by auction in November 2000. The licence duration may also be insignificant because bidders include a terminal value in their valuation of the licence, i.e. the business established on the basis of a fixed duration licence has value beyond the licence expiration.

Figure 4 provides graphical illustrations of the average prices paid per MHz for spectrum in different bands.

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[21] For example the 700 MHz auctions held in the US in 2003 sold over 250 regional licences.

Figure 4: Weighted Average Price Per Pop Per MHz across different frequency bands
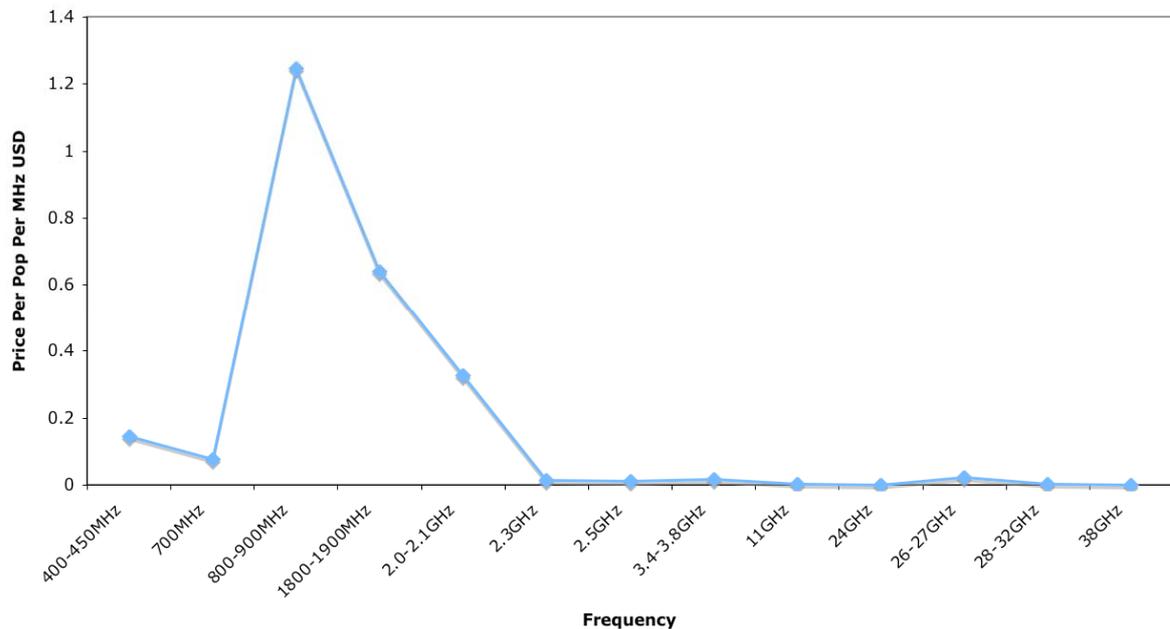
Source: DotEcon Spectrum Awards Database

The data available in DotEcon's Spectrum Awards Database lie within the 400MHz – 40 GHz range and focus on mobile and broadband spectrum awards.   There is limited data on technologically neutral and radio broadcasting licence awards because so far there has only been a few auctions of service and technology neutral licences.   There is no data on spectrum awards of frequencies below 300MHz hence value of this group of frequencies cannot be determined.[22]

That aside, it is clear from Figure 4 that the value of spectrum bands that can be used for mobile is many times that of spectrum bands used for wireless broadband and in general, the average value of spectrum decreases as frequency of spectrum increases.

The relative difference in value of various categories of frequencies illustrated in Figure 4 is the basis for the proportion each category will contribute to NITA's revenue requirement.   To do so, we need to find the value of each group of frequencies relative to the entire spectrum.   This is done by first calculating the proportion of average value of the entire spectrum that each group accounts for.   Normalising this proportion will

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[22] Further, there are less than a handful of auctions in the 2.3-2.5GHz, 10-11GHz, 24GHz and above 33GHz frequency bands, suggesting caution when looking at the values of these bands.   The spike in the average price of the 26-27GHz band in Figure 4 is due to the relatively smaller dataset of that band and the consequent skew by the outliers in that band.   In particular the Swiss broadband auction in March 2000 as well as the subsequent Spanish beauty contest in April 2000 awarded spectrum in the 26-27Ghz band at high prices.

yield the weight that each respective group will take. These weights are shown in Table 7 with the exception of 0-300MHz for which we have no data.

Table 7: Nominal weights before adjustment

Frequencies	Nominal Weight
300MHz–1GHz	111
1–3GHz	217
3–10GHz	19
10–33GHz	2
Above 33GHz	1

Source: DotEcon Spectrum Awards Database

The dataset of competitive awards in 300MHz – 1GHz is small because most European countries awarded spectrum in the 900MHz band by administrative processes before auctions became common and so far there has only been few auctions of 450MHz spectrum. As a result, the average price for 300MHz – 1GHz is less competitive than the rest of the groups and hence takes a lower weight in Table 7. However, as discussed in the previous section, "Setting boundaries based on broad categorisation of types of use", we know that the value of 300MHz – 1GHz should be higher than that of 1–3GHz as the former has superior propagation qualities.

We can get an indication as to how much higher the value of 300MHz–1GHz is compared to 1–3GHz, by considering the relative value between the two GSM bands (800-900MHz and 1800-1900MHz) in auctions that have sold lots in both bands. The Netherlands and Australia in 1998, Greece in 2001 and Austria in 2004 have all awarded spectrum by auction in the 900MHz and 1800MHz band concurrently. The Netherlands and Greece auctioned spectrum from both bands in the same lots as well as other 1800MHz lots whereas Australia and Austria auctioned spectrum from both bands in distinct lots. Looking at relative value of the bands within the same auctions controls for time and country effects on auction price. The average price ratio of the 900MHz band versus the 1800MHz band across all the above mentioned auctions is approximately 3. However, the lots containing both 900MHz and 1800MHz spectrum in the Netherlands and Greece could be worth more due to complementary value of spectrum in both bands. The same ratio excluding the auctions in the Netherlands and Greece is 1.4. This suggests that the relative value of the two bands ranges from 1.4-3. Further, considering the relative value of the 800-900MHz and 1800-1900MHz band as illustrated in Figure 4 is 2, we shall assume that the value of group 2 is twice that of group 3. It is reasonable to assume that the relative value of 900MHz versus 1800MHz band would apply throughout 300MHz–1GHz and 1–3GHz since 900MHz is the top bound of the lower group and 1800MHz is at the lower bound of the upper group. Hence the superior propagation characteristics of 300MHz–1GHz relative to 1–3GHz can only increase with the distance to the break point at 1 GHz, which

suggests that the spectrum throughout 300MHz–1GHz is at least twice as valuable as spectrum in 1–3GHz.

As mentioned we do not have any data to indicate the value of spectrum in 0-300MHz. However, this is valuable, contested spectrum for radio as the signals travel very far. When the Danish Ministry of Culture awarded an FM and DAB radio broadcasting licence in August 2006 (i.e. a broadcasting licence bundled with frequencies to achieve approx. 80% coverage), there were several bidders. We would suggest attaching the same weight to 0-300MHz as to 1-GHz. Licensees in this group have very small amounts of bandwidth and hence the administrative charges that each licensee pays will be relative small.

Taking this into account, the new weights based on the value of spectrum are presented in Table 8. For simplification (and to avoid spurious precision that cannot justified), we have rounded double-digit numbers to the nearest ten units and triple-digit numbers to the nearest 100, as illustrated in the rounded weight column.

Table 8: Nominal weights with adjustment

Frequencies	Nominal Weight	Rounded weight/ band value factor
0- 300MHz	217	200
300MHz–1GHz	433	400
1–3GHz	217	200
3–10GHz	19	20
10–33GHz	2	2
Above 33GHz	1	1

Annex 2: Mathematical formulae for new calculation methodology

This annex sets out the equations in mathematical form for the allocation of charges to individual licences in section 5.3.2:

Wireless network licences

If licences in the Wireless network licence group are each labelled from 1 to n, the charge per MHz per band value factor for a national licence can be calculated as:

$$\sum_{i=1}^{n} B_i \times f_i \times pop_i \times X = R_{WN} - R_{WN}^{F} \Leftrightarrow X = \frac{R_{WN} - R_{WN}^{F}}{\sum_{i=1}^{n} B_i \times f_i \times pop_i}$$

where B_i is the bandwidth of licence i in MHz;

f_i is the band value factor associated with licence i (which can take one of six values);

pop_i is the population coverage of licence i as a percent of total population;

X is the charge per MHz per band value factor for a national licence;

R_{WN} is the total charges to be recovered from Wireless network licences; and

R_{WN}^{F} is the sum of the fixed charges to be collected from Wireless network licences.

Fixed link (point-to-point) licences

If licences in the Fixed link licence group are each labelled from 1 to m, the charge per transmitter location per MHz per band value factor can be calculated as:

$$\sum_{i=1}^{m} B_i \times f_i \times T_i \times Y = R_{FL} - R_{FL}^{F} \Leftrightarrow Y = \frac{R_{FL} - R_{FL}^{F}}{\sum_{i=1}^{m} B_i \times f_i \times T_i}$$

where B_i is the bandwidth of licence i in MHz;

f_i is the band value factor associated with licence i (which can take one of six values);

T_i is the number of transmitter locations of licence i;

Y is the charge per transmitter location per MHz per band value factor;

R_{FL} is the total charges to be recovered from Fixed link licences; and

R_{FL}^{F} is the sum of the fixed charges to be collected from Fixed link licences.

Broadcast licences

TV broadcasting:

If there are *M* multiplexes and all multiplexes have the right to use the same number of channels in the same band, the charge per multiplex can be calculated as:

$$S = \frac{R_{TV} - R_{TV}^F}{M}$$

where S is the charge per multiplex;

R_{TV} is the total charges to be recovered from multiplex licences; and

R_{TV}^F is the sum of the fixed charges to be collected from multiplex licences.

FM radio broadcasting:

If the population coverage of each licence is known, and radio broadcasting licences are each labelled from 1 to q, the charge per channel for a national licence can be calculated as:

$$\sum_{i=1}^{q} pop_i \times Z = R_{FM} - R_{FM}^F \Leftrightarrow Z = \frac{R_{FM} - R_{FM}^F}{\sum_{i=1}^{q} pop_i}$$

where pop_i is the population coverage of licence i as a percent of total population;

Z is the charge per channel for a national licence;

R_{FM} is the total charges to be recovered from FM radio broadcasting licences; and

R_{FM}^F is the sum of the fixed charges to be collected from FM radio broadcasting licences.

Alternatively, FM licences can be included in the Wireless network licences group.

If the population coverage of regional and local licences is not known, the charges can be calculated in two steps, with the first step as above counting all local and regional licences as one national licence. Secondly, the charges to local and regional FM radio broadcasters are calculated using the number of transmitters. If regional and local radio broadcasting licences are each labelled from 1 to u, the charge per transmitter below 160W can be calculated as:

$$\sum_{i=1}^{u} T_{FM,i} \times D_i \times W = Z \Leftrightarrow W = \frac{Z}{\sum_{i=1}^{u} T_{FM,i} \times D_i}$$

where $T_{FM,i}$ is the number of transmitters of licence i;

D_i takes the value 2 if the allowed power emission is above 160W, otherwise 1;

W is the charge per transmitter below 160W for local and regional FM radio broadcasting licences; and

Z is the charge per channel for a national licence;

Land mobile licences

If licences in the Land mobile licence group are each labelled from 1 to v, the charge per transmitter location can be calculated as:

$$\sum_{i=1}^{v} T_{PMR,i} \times f_i \times U_i \times Q = R_{PMR} - R_{PMR}^{F} \Leftrightarrow Q = \frac{R_{PMR} - R_{PMR}^{F}}{\sum_{i=1}^{v} T_{PMR,i} \times f_i \times U_i}$$

where $T_{PMR,i}$ is the number of transmitter locations of licence i;

f_i is the band value factor associated with licence i (which can take one of six values);

U_i takes the value 4 if the allowed number of mobile units is above 30, otherwise 1;

Q is the charge per transmitter location per band value factor for licences with less than 30 mobile units;

R_{PMR} is the total charges to be recovered from Land mobile licences; and

R_{PMR}^{F} is the total fixed charges to be collected from Land mobile licences.

Shared use licences

If each licence in the Shared use licence group is labelled from 1 to w, the charge per licence per band value factor can be calculated as:

$$\sum_{i=1}^{w} f_i \times P = R_{SU} - R_{SU}^{F} \Leftrightarrow P = \frac{R_{SU} - R_{SU}^{F}}{\sum_{i=1}^{w} f_i}$$

where f_i is the band value factor associated with licence i (which can take one of six values);

P is the charge per licence per band value factor;

R_{SU} is the total charges to be recovered from Shared use licences; and

R_{SU}^{F} is the sum of the fixed charges to be collected from Shared use licences.

Annex 3: Current administrative charges for frequency licences

Fixed element

There is a fixed annual charge of DKK 180 for all licences, including new licences issued.

Service dependent element

In addition to the fixed element, there is a service dependent element to the administrative charge as listed below:

1) Frequency for use by land mobile base station per position, per 25 kHz - DKK 163

2) Frequency for use by land mobile base station nationwide, per 25 kHz - DKK 1,304

3) Frequency for use by mobile/portable radio equipment - DKK 163

4) Mobile/portable radio equipment, 1 unit - DKK 20

5) Mobile/portable radio equipment, 2-5 units - DKK 41

6) Mobile/portable radio equipment, 6-10 units - DKK 122

7) Mobile/portable radio equipment, 11-15 units - DKK-224

8) Mobile/portable radio equipment, 16-20 units - DKK 326

9) Mobile/portable radio equipment, 21-30 units - DKK 428

10) Mobile/portable radio equipment, 31-50 units - DKK 632

11) Mobile/portable radio equipment, 51-100 units - DKK 1,040

12) Mobile/portable radio equipment, 101-150 units - DKK 2,060

13) Mobile/portable radio equipment, 151-200 units - DKK 3,079

14) Mobile/portable radio equipment, 201-250 units - DKK 4,099

15) Mobile/portable radio equipment, 251-300 units - DKK 5,119

16) Mobile/portable radio equipment, 301-350 units - DKK 6,138

17) Mobile/portable radio equipment, 351-400 units - DKK 7,158

18) Mobile/portable radio equipment, 401-450 units - DKK 8,178

19) Mobile/portable radio equipment, 451-500 units - DKK 9,197

20) Mobile/portable radio equipment, 501-1000 units - DKK 10,217

21) Mobile/portable radio equipment, 1001-1500 units - DKK 20,414

22) Mobile/portable radio equipment, 1501-2000 units - DKK 30,610

23) Mobile/portable radio equipment, 2001-2500 units - DKK 40,807

24) Mobile/portable radio equipment, 2501-3000 units - DKK 51,004

25) Mobile/portable radio equipment, 3001-3500 units - DKK 61,201

26) Mobile/portable radio equipment, 3501-4000 units - DKK 71,397

27) Mobile/portable radio equipment, 4001-4500 units - DKK 81,594

28) Mobile/portable radio equipment, 4501-5000 units - DKK 91,791

29) Digital land mobile radio services, per 25 kHz – DKK 163

30) Radio remote control, per frequency - DKK 163

31) Telemetry, per frequency - DKK 163

32) Microwave, per frequency - DKK 163

33) Transmission of measurement data, per frequency - DKK 163

34) Microphone, per frequency - DKK 163

35) Radio paging, per frequency - DKK 163

36) Trial and test operation below 3 GHz, per 25 kHz - DKK 261

37) Trial and test operation above 3 GHz, per MHz - DKK 522

38) Trial and test operation low-power/shared frequencies - DKK 163

39) Local radio broadcasting and gap fillers up to 160 W, per frequency - DKK 522

40) Local TV broadcasting, per channel - DKK 32,127

41) Fixed radio link below 3 GHz, per MHz - DKK 3,260

42) Fixed radio link and FWA per position above 3 GHz, per MHz - DKK 326

43) Fixed radio link above 3 GHz, per MHz, nationwide - DKK 1,630

44) FWA in 3 GHz, nationwide, per 10 MHz - DKK 52,207

45) FWA in 25 GHz, nationwide, per 10 MHz - DKK 52,207

46) FWA in 3 GHz, regional license, Copenhagen municipality, Frederiksberg municipality and Copenhagen county, per MHZ – DKK 1,630

47) Radio determination, per 25 kHz - DKK 163

48) ATC, nationwide - DKK 1,305

49) Radar beacon - DKK 163

50) Radar - DKK 163

51) Nationwide and regional radio broadcasting above 160 W, per frequency - DKK 1,044

52) Nationwide and regional TV broadcasting above 5 kWatt, per channel - DKK 208,828

53) Nationwide and regional broadcasting below 5 kWatt, per channel – DKK 32,127

54) DAB in VHF-band, nationwide, per 1,5 MHz – DKK 78,300

55) DAB in VHF-band, regional, per 1,5 MHz – DKK 39,159

56) DAB in the band 1452-1492 MHz, local, per 1,5 MHz – DKK 4,894

57) SNG earth station - DKK 163

58) VSAT earth station - DKK 163

59) Satellite earth stations, above 3 GHz, per MHz - DKK 326

60) Satellite earth stations, below 3 GHz, per MHz - DKK 3,260

61) Public mobile services, per 200 kHz – DKK 10,441

62) IMT 2000, per 5 MHz – DKK 261,000

63) Audio- and video transmission (ENG/OB), per frequency - DKK 163

64) Reporting sound, per frequency - DKK 1,175

'Discounts'

For fixed radio links and FWA where the use of frequencies are tied to particular positions, there are volume discounts to the service dependent element as follows:

- Land mobile analogue and digital radio services (no. 1): If the same frequency is used on 8 positions or more, the service dependent element is 8 times the charge per position. (The "8x- rule").

- Fixed radio and FWA services (nos. 41 and 42): If the same frequency is used on 5 positions or more, the service dependent element is 5 times the charge per position. (The "5x- rule").

- Fixed radio (nos. 41 and 42): If a frequency is used several times within a distance of 50 km, the charge is only paid once. (The "50 km rule").