Report for the GSM Association

Benefits of the digital dividend spectrum in Russia

Final report

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1 Executive summary

This is the final report of a study conducted by Analysys Mason Limited for the GSM Association (GSMA), to estimate the economic value associated with the potential release in Russia of digital dividend spectrum within the UHF frequency band (470-862 MHz).

1.1 Background and objectives

A number of countries across Europe and around the world are making plans to create a sub-band of spectrum for mobile broadband services within UHF Bands IV and V (470-862 MHz). Drivers for creation of this sub-band are the significant growth in mobile data consumption, and the need to develop more cost-effective solutions to expand mobile broadband coverage, particularly in rural areas.

Whilst the location of the sub-band varies between different countries and regions, the sub-band in Europe is proposed to be from 790-862 MHz. Creating this sub-band requires the migration of terrestrial TV services from this part of the Band IV/V spectrum – a process which is taking place alongside the migration from analogue to digital terrestrial TV (the digital switchover). The spectrum released through this process, called the digital dividend, can then be released for new uses.

In Europe, many countries are now aligning their digital dividend so to make the 790-862 MHz band available for mobile broadband services. However, in Russia, the situation is more complex because Aeronautical Radio Navigation Service (ARNS) systems currently operate within Bands IV/V and, under international rules, these need to be protected from interference until 2015. Notwithstanding this, there could be significant benefits for the Russian economy if ARNS uses were migrated from Bands IV/V into alternative spectrum. With this in mind, the GSMA asked Analysys Mason to conduct this study to investigate the potential value created from such a migration.

Given that the two primary alternative uses of Band IV/V spectrum are digital TV and mobile broadband, the objective of this study has therefore been to estimate the economic benefits of creating a sub-band of spectrum for mobile broadband systems within spectrum released from ARNS use in Russia, with any extra spectrum gained from the migration being used to deliver additional DTT services, over and above those already being developed as part of the Russian DTT switchover plan.

1.2 Scenarios for alternative use of released UHF spectrum and approach to valuation

Whilst the migration of ARNS would involve significant costs[1], overall it is likely to generate economic benefits because of the value realised by the alternative uses. We have modelled two scenarios, which are summarised below:

- **ARNS not migrated –** the base case, in which ARNS usage continues within Bands IV/V, and
- **ARNS migrated** – a scenario in which ARNS systems are migrated to another band.

[1] These costs have not been evaluated as part of this study.

In the *ARNS not migrated* case, we assume that DTT services will be deployed in Russia in line with government plans, which will create four national multiplexes – three standard definition and one high definition. Regarding mobile broadband, if a sub-band is not created from ARNS migration, we assume that it will be difficult for mobile operators to provide high-speed mobile broadband services across the entire geography of Russia, due to the cost of having to do this using higher frequency bands. We have considered the 3G and the LTE mobile broadband markets in both rural and urban areas.

In other markets in Europe, creation of a sub-band for mobile broadband services using digital dividend spectrum will significantly supplement the availability of sub-1GHz spectrum for mobile broadband services over and above the other sub-1 GHz spectrum band commonly available for mobile services, which is the GSM900 band. GSM 900 can be used to deliver high speed broadband services if can be refarmed from current 2G use for use by 3G and LTE services. However, in Russia, we understand that there is some uncertainty regarding availability of refarmed GSM 900 spectrum since this band is also shared with ARNS and so subject to sharing arrangements.

Owning to the uncertainty surrounding the ability of the operators to refarm their 900MHz spectrum for 3G mobile broadband, we have therefore modelled two variants of our base case, one in which we assume that no rural 3G can be provided at all without the 800MHz sub-band being released from ARNS use, and the second in which we assume that limited 900MHz refarming will occur, making it possible to provide 3G coverage to around half the rural population without the 800MHz sub-band being required.

For modelling purposes, we have divided Russia into urban and rural areas and assumed that the mix of technologies used to provide mobile services will differ between these areas, as follows:

- In *urban areas* we assume that both 3G and LTE are deployed, either using frequencies above 1GHz (e.g. 2.6GHz), or using re-farmed 900MHz spectrum (if available). Accordingly, the level of urban deployment and take-up do not vary by scenario.
- In *rural areas*, if no spectrum is released by ARNS migration we assume that operators will either not be able to offer 3G+ mobile broadband at all (variant 1 – *No rural 3G*), or will only be able to offer services to a limited proportion of the population using refarmed 900MHz spectrum (variant 2 – *Limited rural 3G*). In the *ARNS migrated* scenario, where a mobile broadband sub-band is created, we assume that LTE will be used to deliver mobile broadband services and that 3G will not be deployed in rural areas at all.

In terms of our approach to the estimation of the economic benefits realised under each scenario, and the two variants of the *ARNS migrated* scenario, the methodology we have used is similar to that previously developed by Analysys Mason in several other studies of the value of digital dividend spectrum elsewhere in Europe. In this approach, economic benefit is calculated based on the well-established economic concept of the *private value* of the spectrum to consumers and producers (namely the broadcasters and operators using the spectrum), comprised of:

- *Consumer surplus*, which is defined as the difference between the value consumers place on a product/service and the price they actually pay for the service. The value that consumers place on a service is also referred to as their 'willingness to pay'.
- *Producer surplus*, which is defined as the difference between the revenues that all producers in the market could obtain from producing a given product or service, minus the costs incurred in doing so (including the cost of capital).

The private value generated by a product or service is defined as the sum of its consumer surplus and producer surplus. We have developed models to calculate the total private value generated by both the DTT services and the mobile broadband services that are offered under each scenario. These models are characterised by the current price and demand for a given service, and either a constant elasticity (the approach used for the mobile broadband model) or by directly estimating the willingness to pay for the service, which provides the choke price[2] (the approach used for the DTT model).

Having modelled the combined producer and consumer surplus for each service under each scenario, we then calculate the net present value (NPV) of the private value generated over the period 2015–2030. For this purpose, we have used a discount rate of 10%. This figure has been judged to be reflective of an appropriate social rate, factoring in the projected growth in inflation over the period.

The final stage is to calculate the *incremental* private value generated by each scenario compared to the *ARNS not migrated* base case, in order to identify the incremental economic benefit that could be generated.

1.3 Value of the spectrum for different services

The results of our analysis of the value created through DTT are shown in Figure 1.1 below. These figures demonstrate that by clearing the Bands IV/V of ARNS and deploying an extra two DTT multiplexes, an additional RUB0.1 trillion (EUR3 billion) of value can be achieved. This additional value is primarily derived from the increase in consumer surplus, owing to the increase in TV channels from 40 to 64.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated*
ARNS not migrated	1.5	0.5	2.0	N/A
ARNS migrated	1.8	0.4	2.2	0.1

Figure 1.1: Value generated by DTT services under the two scenarios (RUB trillions) [Source: Analysys Mason]

2 Price above which demand is zero.

Figure 1.2 below shows the total economic benefit of the *ARNS migrated* scenario compared to the two variants of *ARNS not migrated*, and the incremental value that can be achieved through migration.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	4.3	1.8	6.1	N/A
ARNS no migrated – limited rural 3G	4.5	1.8	6.4	0.3
ARNS migrated	5.2	1.8	7.0	0.8

Figure 1.2: Total value generated by both DTT and mobile broadband services under the two scenarios and two variants (RUB trillions) [Source: Analysys Mason]

These results demonstrate that, overall, an additional RUB0.8 trillion (EUR19 billion) of value can be gained from migrating the ARNS service out of Bands IV/V, creating a mobile broadband sub-band and deploying two additional multiplexes. Over two-thirds of this additional value is derived from delivering mobile broadband services in rural areas. Furthermore, the majority of the additional value gained is provided by the *consumer* surplus created through additional channels or Internet speeds, rather than the *producer* surplus.

1.4 Sensitivity analysis

In addition to our two scenarios, we have run sensitivity tests in order to examine how sensitive these results are to variations in the key assumptions. Within the TV market, the key assumption that we sought to test was the potential change in penetration of the pay-TV platform in the *ARNS migrated* scenario, owing to the increase in the number of channels provided over the terrestrial platform (compared to the *ARNS not migrated scenario*). Our sensitivity analysis demonstrates that a 7% reduction in the penetration of the pay-TV platform has a limited impact on the *total* private value of the *ARNS migrated* scenario. It has a modest impact on the *incremental* value provided compared to the *ARNS not migrated – no rural 3G* scenario, creating an extra RUB0.8 trillion to RUB0.9 trillion (EUR19 billion to EUR21. billion).

An analysis of these results demonstrates that although pay-TV platform penetration is an important factor in determining the value of the DTT market, variations in this assumption do not significantly change the incremental value gained through migrating ARNS out of Bands IV/V – the *ARNS migrated* scenario therefore remains attractive in terms of the value provided.

We also conducted sensitivity analysis on the key mobile broadband results. Key assumptions tested include overall mobile broadband penetration and the percentage of LTE take-up within this market. These variables will depend on technology (3G versus LTE) and the number of operators, as modelled in our scenarios, but may also be affected by pricing, economic circumstances and developments in fixed-line communications. The results showed that if mobile broadband penetration is 25% *lower* than we have assumed, the incremental value of the *ARNS migrated* scenario (compared to the *ARNS not migrated – no rural 3G* scenario) still remains substantial at RUB0.6 trillion. If penetration is 25% *higher* than assumed, the incremental value of the *ARNS migrated* scenario reaches RUB1.1 trillion. This sensitivity analysis therefore demonstrates that even if our assumptions for mobile broadband penetration are reduced by 25%, the incremental increase in value is still large.[3]

We found that changes in the assumed take-up of LTE compared to 3G have a less significant impact on the incremental value of migrating ARNS services. If LTE take-up is 25% lower than assumed in 2021[4] the incremental value of the *ARNS migrated* scenario compared to the *ARNS not migrated – no rural 3G* scenario is RUB0.8 trillion.

1.5 Social value

We have modelled only economic benefits, and have not quantified the other benefits to society (social value) that would be gained through the creation of new mobile broadband services and additional DTT services by migrating ARNS systems. These benefits will primarily arise through the greater availability of broadband services in rural areas, and are likely to include:

- better access to goods and services (access to public services, online channels, etc.)
- improved ICT skills (better educated citizens)
- increased access to online communities via virtual networking in the form of connecting with other people over the Internet, use of social networking websites, etc.
- better access to government services (education, health, community, etc.)
- maintaining of populations (encouraging continuation of, and diversity in, rural communities, reversing population declines in rural areas)
- enhanced quality of life (e.g. by enabling a better work-life balance and supporting family life).

3 It is noted that, in the longer term, it is expected that further innovation in the development of mobile devices will substantially increase the range and types of device using mobile broadband networks. In turn, the development of a wider range of devices, including smart phones, notebooks, smart-books and embedded devices is likely to lead to further increases in the size of the mobile broadband market, and in the traffic being carried by mobile networks. By 2030 therefore, these trends could result in the size of the mobile broadband market significantly exceeding current forecasts.

4 Note this date is used as a proxy for the speed of take-up of LTE.

1.6 Conclusions

Based on our analysis, we have drawn the following conclusions:

- **The migration of ARNS systems from the UHF spectrum would enable significant value to be created**. If the released spectrum were used for a combination of mobile broadband and DTT services, we calculate that the total NPV to the Russian economy from 2015 to 2030 would be RUB7 trillion (EUR160 billion). In comparison, if no extra spectrum from ARNS is available, a total of RUB6.1 trillion (EUR141 billion) would arise from the development of mobile broadband and DTT. This means that migrating the ARNS systems and releasing the spectrum would create an incremental value of up to RUB0.8 trillion (EUR19 billion) from 2015 to 2030.

- **Using the released spectrum to create a sub-band for mobile broadband services (e.g. LTE) could create substantial incremental consumer and producer surplus**. Of the total RUB0.8 trillion (EUR19 billion) of incremental value created, we have estimated that RUB0.7 trillion (EUR16 billion) would be generated through greater availability of mobile broadband services. This value arises from lowering the cost for operators to provide coverage of less populated areas, and also from the increased availability of services in rural areas (we estimate that UHF spectrum could increase mobile broadband coverage of the rural population to 50% by 2030).

- **There is also some value in making extra spectrum (outside of the sub-band) available for DTT services**. Of the total RUB0.8 trillion (EUR19 billion) of incremental value, we estimate that RUB0.3 trillion (EUR6 billion) should be generated through consumer surplus arising from the existence of more channels (and additional value) to DTT users. However, the additional costs associated with deploying two extra multiplexes (only marginally offset by additional advertising revenues gained through an increased market share) mean that the producer surplus drops in value by RUB0.1 trillion (EUR3 billion). As such, the net effect of the extra spectrum made available for DTT services is only RUB0.1 trillion (EUR3 billion) – a relatively minor portion of the total incremental value gained from migrating ARNS services out of Bands IV/V.

If a UHF sub-band is *not* created, mobile operators will be reliant on using higher-frequency bands (i.e. 2100MHz and 2600MHz) to deliver mobile broadband services, unless refarming of GSM900 spectrum is allowed. There appears to be significant uncertainty in the market place at the moment about when this re-farming will happen, and also how feasible it will be to use refarmed spectrum for mobile broadband services across the country (ARNS systems also use the 900MHz band, resulting in significant restrictions on its use for mobile services). In our base-case *ARNS not migrated* scenario we have therefore compared a case where some re-farming is possible in rural areas, and compared this with a case where re-farming is only possible in urban areas (and consequently, there is no mobile broadband coverage at all in rural areas). If we assume that limited GSM900 re-farming is possible in rural areas in our *ARNS not migrated* scenario, the incremental value gained in the *ARNS migrated* scenario falls to a still substantial RUB0.6 trillion (EUR14 billion).

2 Background and objectives of the study

This is the draft final report of a study conducted by Analysys Mason Limited (Analysys Mason) on behalf of the GSM Association to estimate the value of the release in Russia of digital dividend spectrum in UHF Bands IV and V (470–862MHz, hereafter referred to as 'Bands IV/V').

Most countries around the world are planning to migrate the delivery of terrestrial TV broadcasting services from analogue signals to digital. In Russia, the switchover process is progressing in line with objectives and processes set out in a document titled 'Plan for the Development of Digital Television', approved by the government of the Russian Federation.[5] According to this plan, 2015 is the target date for full switchover to digital TV (and switch-off of analogue signals). One of the main objectives of the switchover in Russia is to make available between 20 and 24 free-to-view digital TV (DTT) channels across the entire country, with a target of at least 20 of these being available to the entire population. This will bring substantial benefits in terms of availability of terrestrial TV services, since currently the number of channels available over the analogue TV network is limited to three or less in many rural areas. There are an estimated 1 million people living in rural areas that do not have any terrestrial TV service at all.[6]

As well as increasing the number of channels available over the terrestrial TV platform, the switchover has the potential to release spectrum previously used for analogue services to other, alternative uses, as a result of the improved spectrum efficiency of DTT signals compared to analogue. In countries around the world, one of the primary candidate uses being proposed for this 'digital dividend' spectrum is for mobile broadband services. This is because spectrum in Bands IV/V has propagation characteristics particularly suitable to deliver mobile broadband in rural areas, making it possible to use fewer base stations than would be required using higher frequencies. Earlier this year, the European Commission adopted Decision 2010/627/EC, which harmonises the 790–862MHz sub-band for the use of mobile broadband services across the EU. This is in line with the decision taken at the ITU World Radiocommunication Conference 2007 (WRC-07), to allocate the whole or parts of the 790–862MHz sub-band to the mobile service.[7] Many EU countries are now making plans to align their digital dividend with this Decision, in order to create a sub-band for mobile use.

However, in Russia the digital dividend is impacted by the fact that some frequencies within Bands IV/V are being used for aeronautical radio navigation services (ARNS), including air-to-ground transmission from aircraft and ground radar systems. These ARNS systems, which have a protected status until 2015, use a number of the channels within Bands IV/V, including the entire 790–862MHz sub-band that European countries will use for mobile broadband. Hence, to make

[5] Decree 985, "The development of broadcasting in the Russian Federation, 2009 - 2015", Russian Ministry of Communications.

[6] Source: http://www.dvb.org/about_dvb/dvb_worldwide/russian_federation

[7] The situation is more complex than this, and is described in more detail in Section 3 below.

spectrum in Bands IV/V available in Russia for mobile broadband services would require the migration of ARNS systems to another frequency band. Although such a migration would involve significant costs, it is likely that overall it would generate benefits through the spectrum being made available for alternative uses. Accordingly, the GSMA has asked us to conduct this study in order to quantify the potential benefits of moving ARNS systems from Bands IV/V and releasing spectrum for other uses, notably mobile broadband and DTT.

Our report is laid out as follows:

- Section 3 describes ITU's recommendations regarding the future use of Bands IV/V, and summarises the current uses of UHF spectrum in Russia. It then discusses alternative possible uses of spectrum released from migrating ARNS services. It also describes the two scenarios we have developed in order to assess the value of this released spectrum.
- Section 4 describes the assumptions underlying our economic analysis of the value of spectrum released under the different scenarios, and presents our results for the value generated by (a) DTT services and (b) mobile broadband services offered under the two scenarios.
- Section 5 presents the conclusions from the study.

The report includes a number of annexes containing supplementary material:

- Annex A provides details of the model we have developed to estimate the value of extra spectrum being used for DTT services.
- Annex B describes the model to estimate the value of a sub-band being created for the use of mobile broadband services.

3 UHF spectrum in Russia and scenarios for uses of the released spectrum

This section first describes the ITU's recommendations regarding the future use of Bands IV/V and then summarises the current situation in Russia. We then provide an overview of the ways in which spectrum released from ARNS use in Russia might be re-deployed for other services, and describe the scenarios we have developed for analysis within this study.

3.1 International context and WRC-07

At an international level within the ITU, Bands IV and V have historically been allocated to the broadcasting service. Since the switchover to digital TV services began, there has been an ongoing debate with the communications industry as to alternative uses of digital dividend spectrum. Discussions have focussed on two uses:

- **digital terrestrial broadcasting**, using the spectrum to support additional DTT multiplexes providing either standard-definition or high-definition TV (HDTV) services, and potentially extending the audience share of terrestrial TV services compared to other transmission platforms
- **wireless broadband services**, particularly high-speed mobile broadband services such as Long Term Evolution (LTE).

At WRC-07, this debate resulted in a co-primary allocation of part of the UHF spectrum being made for the mobile service, potentially enabling a sub-band of this spectrum to be created for mobile broadband services. The location of this sub-band varies between ITU regions: in Region 1 (including Europe, Africa and the Middle East), the sub-band will be 790–862MHz, while in Region 2 (including the USA, South America and Canada) it will be 698–806MHz.

Note that we refer to a *co-primary* allocation of the spectrum to mobile services. This qualification is necessary because there is still an allocation to the broadcasting service across Bands IV/V. In addition, in a number of countries in ITU Region 1 (including Russia, Poland and Belarus), parts of Bands IV/V are used for ARNS services.[8] Until 2015, any existing ARNS systems already using parts of Bands IV/V must be protected from interference from any new incoming services.

After 2015, the 790–862MHz sub-band will be allocated to mobile services throughout all countries in ITU Region 1, including Russia.[9] Making this spectrum available for mobile broadband services in Russia will involve moving ARNS services to alternative spectrum, unless appropriate sharing conditions can be determined enabling ARNS systems to continue using the spectrum alongside new

8 As specified in footnote S5.316A of the ITU Radio Regulations.

9 See footnote S5.316B of the ITU Radio Regulations, and draft CEPT brief on agenda item 1.17 for WRC-11, CPGTD(09)013.

mobile broadband services. Sharing studies to consider the protection of the ARNS systems that are operational in Russia and a number of other countries are ongoing at the time of producing this report. Agenda Item 1.17 at WRC-11 will consider the results of these studies.[10]

3.2 UHF spectrum in Russia

A range of ARNS systems are in use in Russia, including air-to-ground transmission from aircraft, and ground radar systems.[11] As a result, availability of spectrum for TV services is more limited than in other countries, since sharing arrangements are in place with these ARNS systems. Our understanding of the current UHF band plan is summarised in Figure 3.1 below.

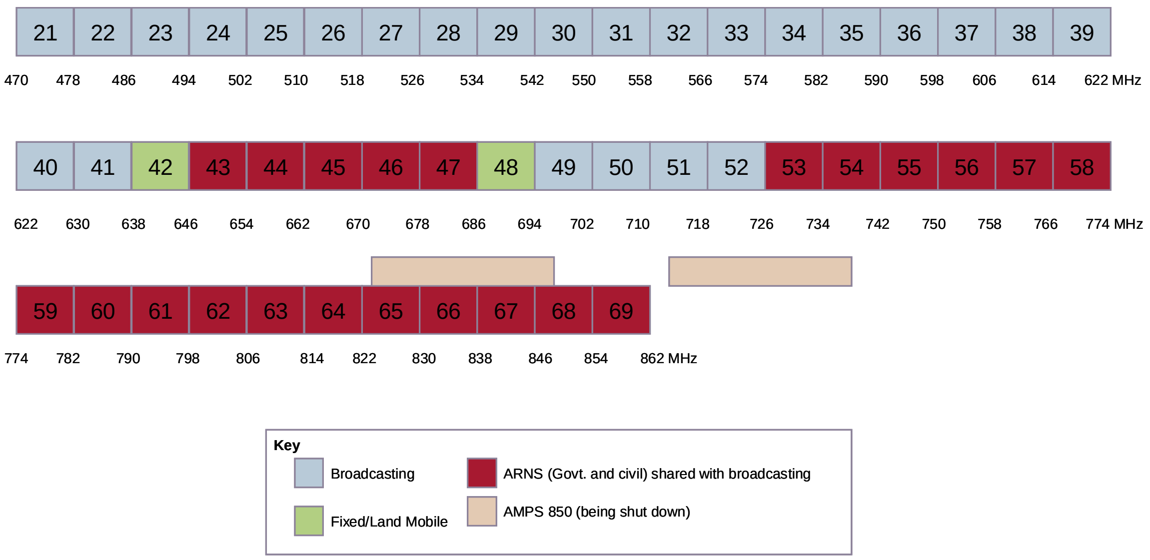

Figure 3.1: *UHF band plan in Russia – current situation [Source: ITU, Analysys Mason]*

Although the ARNS service has a protected status until 2015, there could be benefits from releasing spectrum in Bands IV/V from ARNS use after that date. In particular, if ARNS services were migrated from Bands IV/V, this would create an opportunity to form a sub-band for telecoms services, either consistent with the ITU Region 1 sub-band (790–862MHz, equivalent to nine physical 8MHz channels), or alternatively, consistent with the Region 2 sub-band (698–806MHz, or 14 physical 8MHz channels). In addition, remaining spectrum released from ARNS migration that will not form part of the sub-band could be used to provide additional DTT services. For the purposes of this study, we have assumed that a sub-band is created consistent with the Region 1 sub-band; however, our analysis applies equally to a sub-band consistent with Region 2 (which would give have the benefit of providing slightly more spectrum for mobile broadband, although slightly less for DTT).

[10] Agenda item 1.17 is “to consider the results of sharing studies between the mobile service and other services in the band 790-862 MHz in Regions 1 and 3, in accordance with Resolution 749 (WRC-07), to ensure the adequate protection of services to which this frequency band is allocated, and take appropriate action.”

[11] Recommendation ITU-R M.1830, *Technical characteristics and protection criteria of ARNS systems in the 645-862MHz frequency band*

The government has set a number of targets for the roll-out of DTT[12] which are summarised in Figure 3.2 below. The plan is to deploy three standard DTT multiplexes, and one HDTV multiplex before the analogue switch-off in 2015. A fifth multiplex is also planned after this date, to provide mobile TV services using DVB-H technology. Using these multiplexes, by 2015 the Ministry of Communications intends to offer 100% of the population access to at least 20 free-to-view DTT channels, with a further three HDTV channels and 10 mobile TV channels planned thereafter. Throughout the remainder of this report and in our modelling we have assumed that there will be only one network operator of these multiplexes, the public service broadcaster.

	2010	*2011*	*2012*	*2013*	*2014*	*2015*
Population not covered by broadcasting	1.6 m	1.2 m	1.2 m	0.6 m	0	0
Area of Russian Federation covered by DTT broadcasting (sq km)	3 189	5 848	9 768	17 103	17 103	17 103
Proportion of population able to receive 20 free-to-view channels			25%	50%	75%	100%
Proportion of population able to receive DTT channels	15%	30%	75%	98.8%	98.8%	98.8%

Figure 3.2: DTT targets extracted from Decree 985 [Source: Russian Ministry of Communications]

We understand that all of the DTT services planned up to 2015 will be provided using UHF spectrum already allocated to broadcasting in the current band plan (the channels coloured blue in Figure 3.1 above). Until such time as the analogue TV network is switched off, both analogue and digital networks will be simulcast, which, as is the case in other countries, requires slightly more spectrum in the interim than will be required for the fully digital plan.

The Ministry of Communications estimates that the total cost of the digital switchover will be RUB122 billion (EUR2.8 billion) and of this the construction of the digital terrestrial TV broadcasting networks will account for RUB60 billion (EUR1.4 billion). The project will be funded partially by the government and partially by private investors (the contribution of the state will be RUB76 billion, 63% of the total).

3.3 Scenarios for alternative uses of the released spectrum

Whilst the migration of ARNS would involve significant costs, overall it is likely to generate economic benefits because of the value realised by the alternative uses. We have set out to estimate the economic value that could be derived by re-locating ARNS services, creating a sub-band for mobile broadband services, and using any extra spectrum released from the ARNS migration that is not part of that sub-band for the provision of additional DTT services. We have modelled two scenarios, which are summarised below:

(a) **ARNS not migrated –** the base case, in which ARNS usage continues within Bands IV/V; and

(b) **ARNS migrated** – a scenario in which ARNS systems are migrated to another band.

[12] Source: Ministry of Communications, Decree 985 – "The development of broadcasting in the Russian Federation, 2009-2015"

ARNS not migrated (base case)

ARNS is not migrated from Bands IV/V, and so after 2015 there are three standard definition multiplexes and one HDTV multiplex operating in Russia, using DVB-T technology. In addition, one multiplex will be available for the broadcast of mobile TV services using DVB-H (which is constant across both scenarios).

We have assumed that if a sub-band is not created in Bands IV/V for mobile broadband services, mobile broadband will be developed using a combination of frequencies above 1GHz (2100MHz and 2600MHz), as well as refarmed GSM frequencies in the 900MHz band, if this is available. However, since we understand that ARNS systems also use part of the GSM900 band, we assume that using 900MHz for mobile broadband will not be possible everywhere in the country. We have therefore modelled two variants of the base case:

- *Limited rural 3G* – in this first variant, some mobile broadband coverage is possible in rural areas using refarmed 900MHz frequencies.
- *No rural 3G* – in the second variant there is no mobile broadband service using refarmed frequencies, and therefore coverage does not extend into rural areas, but is instead limited to the main population centres where it is provisioned using higher frequency bands.

ARNS migrated

In this scenario, ARNS systems currently using Bands IV/V are migrated to alternative spectrum and a sub-band is created which is allocated for the use of mobile broadband systems. We assume that the sub-band has sufficient spectrum for three mobile operators to provide mobile broadband services, with each operator being assigned 2×10MHz spectrum, sufficient to provide high-speed 3G services (e.g. 3G+ or LTE). We have considered the 3G and the LTE mobile broadband markets in both rural and urban areas. We assume that re-farming of GSM900 spectrum will not be possible across the entire geography of Russia (in view of the sharing with ARNS in the 900MHz band too), and so the sub-band will provide mobile operators with valuable sub-1GHz spectrum. The operators are therefore likely to rely on the availability of the sub-band for 3G and LTE coverage in rural areas. In these areas we assume that the sub-band will be used to provide the majority of LTE coverage, but we have also considered the impact of some limited GSM900 spectrum re-farming being possible, providing an alternative source of sub-1 GHz spectrum.

In addition to the sub-band for mobile broadband created from spectrum released from ARNS use, there will be extra released spectrum that does *not* lie within this sub-band. We have assumed this is available for broadcast services, and is used to provide two additional, nationwide multiplexes over and above those existing in the base case. These additional multiplexes are standard definition and provide free-to-view services.

4 Analysis of the value of spectrum under each scenario

This section describes our analysis of the value generated by (a) the DTT services and (b) the mobile broadband services that are offered under the two scenarios defined above. It describes our overall approach to the valuation, the different components of value we have considered, and the quantitative results we have generated.

4.1 Approach to modelling economic value for each scenario

In previous studies for the European Commission and several EU regulators, Analysys Mason has developed a methodology to compare the economic benefit of several possible uses of digital dividend spectrum. We have also applied this methodology to assess the scenarios for Russia. In this approach, economic benefit is calculated based on the well-established economic concept of the *private value* of the spectrum to consumers and producers (namely the broadcasters and operators using the spectrum). This approach is illustrated in Figure 4.1 and explained in more detail below.

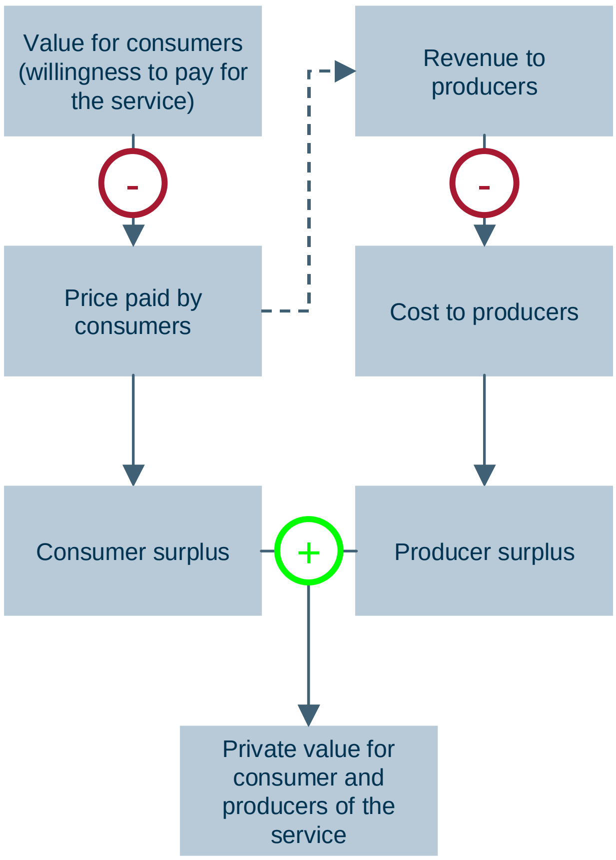

Figure 4.1: Estimating economic value for each of the scenarios [Source: Analysys Mason]

It should be noted that in addition to private value, some products or services can be of benefit to society for reasons that are not strictly economic: for example, access to mobile broadband services in rural areas may reduce the 'digital divide' and promote social inclusion among isolated communities. We have made no attempt to include this social benefit (also called social value) in our modelling: it is generally recognised as extremely difficult to quantify. Some comments on social benefit are provided in Section 4.6.

We begin by quantifying the *consumer surplus* and *producer surplus* associated with each of the scenarios we have defined.

- The consumer surplus is defined as the difference between the value consumers place on a product/service and the price they actually pay for the service. The value that consumers place on a service is also referred to as their 'willingness to pay'.
- The producer surplus is defined as the difference between the revenues that all producers in the market could obtain from producing a given product or service, minus the costs incurred in doing so (including the cost of capital).

The *private value* generated by a product or service is defined as the sum of its consumer surplus and producer surplus. We have developed models to calculate the total private value generated by (a) the digital TV services and (b) the mobile broadband services that are offered under each scenario. These models are based on the principle of a simple demand and supply equilibrium, characterised by the current price and demand for a given service, and either a constant elasticity (the approach used for the mobile broadband model) or by directly estimating the willingness to pay for the service, which provides the choke price[13] (the approach used for the DTT model). This is shown in Figure 4.2 below.

[13] Price above which demand is zero.

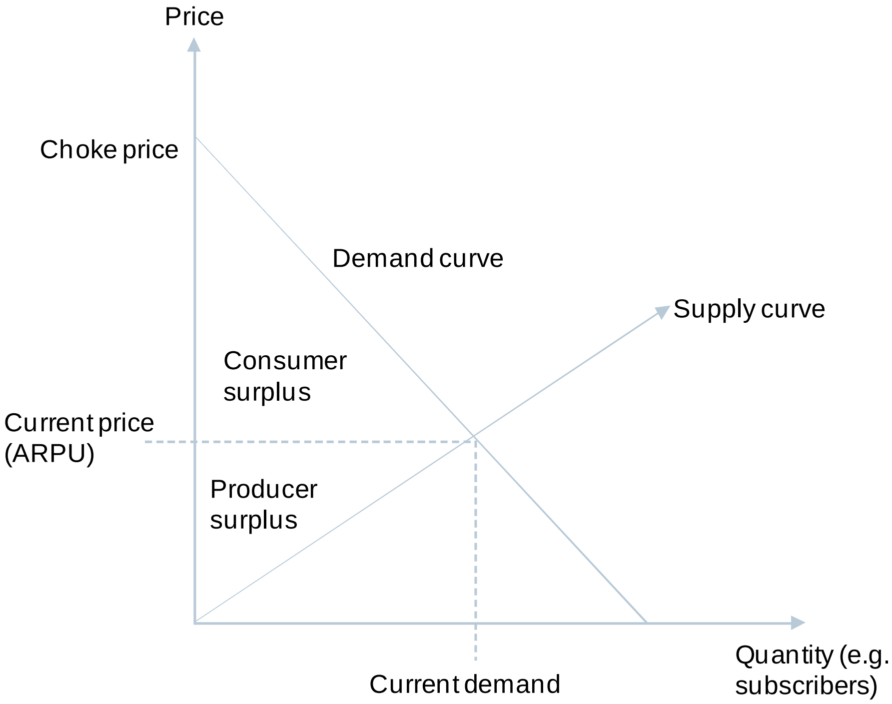

Figure 4.2: Demand and supply equilibrium with a straight-line demand curve [Source: Analysys Mason]

Having modelled the combined producer and consumer surplus for each service under each scenario, we then calculate the net present value (NPV) of the private value generated over the period 2015–2030. For this purpose, we have used a discount rate of 10%. This figure has been judged to be reflective of an appropriate social rate, factoring in the projected growth in inflation over the period.

The final stage is to calculate the *incremental* private value generated by each scenario compared to the *ARNS not migrated* scenario, in order to identify the incremental economic benefit that could be generated. The incremental value can be illustrated using the simple demand and supply equilibrium, as shown in Figure 4.3 below.

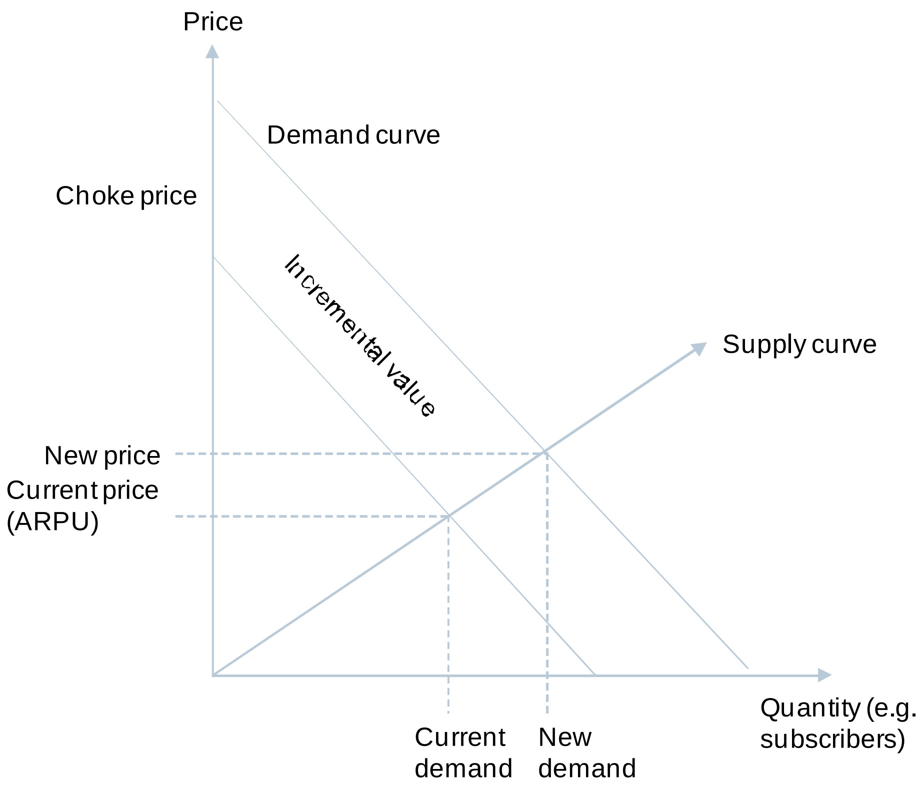

Figure 4.3: *Demand and supply equilibrium with a straight-line demand curve, showing the incremental value of increased demand/price compared to the 'ARNS not migrated' scenario [Source: Analysys Mason]*

It should be noted that, as part of our modelling, we do not explicitly calculate the economic value of DVB-H as it is constant across all three of our scenarios: a single DVB-H is assumed to be present in each case.

4.2 Economic benefits from DTT

DTT consumer surplus

The consumer surplus within the DTT model has been calculated based on average willingness to pay for the DTT service and the number of users – i.e. total TV households less market share of pay-TV platforms (i.e. cable, satellite, IPTV). Willingness to pay is calculated based on the number of channels that are offered and the average value that consumers would put on the service. This value will vary in proportion to the number of channels: the value of each channel will fall as the total number of channels increases. The curve used to generate this value per channel is discussed in more detail in Annex A.

The number of channels that can be offered is calculated based on the number of standard- and high-definition multiplexes. Within our *ARNS not migrated* scenario, we assume DTT roll-out in line with government targets (see Annex A for details), which include three standard-definition and one high-definition multiplex, in addition to one mobile TV multiplex based on DVB-H standards.

The *ARNS migrated* scenario assumes that Bands IV/V are cleared completely of ARNS use, allowing the creation of a sub-band for mobile broadband, plus the deployment of two extra DTT multiplexes. We have assumed that both these additional multiplexes will be standard definition and used to offer free-to-view services.

In summary, we assume that up to 40 DTT channels will be available in the *ARNS not migrated* scenario (four of which will be high definition) and up to 64 channels will be available in the *ARNS migrated* scenario (four of which will be high definition).

We have assumed a significant slow-down in the growth of pay-TV penetration in our *ARNS not migrated* scenario, based on the fact that the DTT service will become more similar to the pay-TV packages in terms of the number of channels. At present only around three free-to-view analogue channels are available in all areas,[14] but this will increase to at least 20, if not 40, on DTT. The additional channels provided by the *ARNS migrated* scenario are likely to further slow growth in the penetration of pay-TV, stabilising DTT's overall user base in terms of number of households.

DTT producer surplus

We have calculated the producer surplus based on the revenues gained from advertising[15] and the costs associated with providing the service.

Assuming that the total TV advertising revenues in the market are stable (i.e. will not vary depending on the number of channels or platforms available), the amount of advertising revenue that a DTT service can earn is dependent on its market share of subscribers. Thus, as the market share of DTT increases, so the total advertising revenues attributable to the service grows. Additional advertising revenues accrue in the *ARNS migrated* scenario owing to our assumption that the additional channels provided will increase the market share of DTT. For the purpose of this study, we have assumed that the total advertising revenue available to TV platforms increases in line with inflation.

On the cost side, we have considered network opex per site, in addition to programming costs and other associated costs. In addition, we have assumed capex costs and investments for the upgrade from analogue to digital, and the roll-out of DTT multiplexes. The costs associated with the *ARNS migrated* scenario have been increased to take into account the extra multiplexes deployed.

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14 In some rural areas the number of channels may be even less than this, and about 1 million people cannot receive any terrestrial TV service at all.

15 Although the terrestrial TV market is partially funded by the Russian government, the exact contribution is unclear and appears to be minimal (it has been publicly stated that the main government TV channel 'Russia' is purely funded through advertising revenues). We have therefore omitted any incoming revenues from government funding from our analysis.

DTT summary results

In assessing the total private value associated with each of our scenarios, we calculate the NPV associated with using the digital dividend spectrum, providing a detailed breakdown of both the consumer and producer surplus, split between the DTT and mobile broadband market. Throughout this study, we have calculated the NPV (2015–30) of the consumer and producer surplus using an estimated social discount rate of 10%, based on estimated GDP growth and an inflation forecast. The base year for the calculation is 2015. All calculations are made in roubles, where appropriate converted into euros using the forecast exchange rate for 2015 of 43.6 roubles to the euro.

The results of our analysis are shown below.[16] All figures are in trillions of roubles. The results are also quoted in billions of euros in Figure 4.5 below.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated*
ARNS not migrated	1.5	0.5	2.0	N/A
ARNS migrated	1.8	0.4	2.2	0.1

Figure 4.4: Value generated by DTT services under the two scenarios (RUB trillions) [Source: Analysys Mason]

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated*
ARNS not migrated	35	12	47	N/A
ARNS migrated	41	8	50	3

Figure 4.5: Value generated by DTT services under the two scenarios (EUR billions) [Source: Analysys Mason]

These figures demonstrate that by clearing the Bands IV/V of ARNS and deploying an extra two DTT multiplexes, an additional RUB0.1 trillion (EUR3 billion) of value can be achieved. This additional value is primarily derived from the increase in consumer surplus, owing to the increase in TV channels from 40 to 64.

4.3 Economic benefits from mobile broadband

In calculating the economic benefits of migrating ARNS out of the UHF spectrum and creating a mobile broadband sub-band, we have divided Russia into urban and rural areas and assumed that the mix of technologies used to provide mobile services will differ between these areas, as follows:

- In *urban areas* we assume that both 3G and LTE are deployed, either using frequencies above 1GHz (e.g. 2.6GHz), or using refarmed 900MHz spectrum (if available). Accordingly, the level of urban deployment and take-up do not vary by scenario.
- In *rural areas*, if no spectrum is released by ARNS migration we assume that operators will either not be able to offer 3G+ mobile broadband at all (variant 1 – *No rural 3G*), or will only be able to offer services to a limited proportion of the population using refarmed 900MHz spectrum (variant 2 – *Limited rural 3G*). In the *ARNS migrated* scenario, where a mobile broadband sub-band is created, we assume that LTE will be used to deliver mobile broadband services and that 3G will not be deployed in rural areas at all.

Mobile broadband consumer surplus

The consumer surplus for mobile broadband has been split between 3G and LTE services and is a product of the willingness to pay and the total number of subscribers. For 3G, we have derived the willingness to pay based on current market prices and penetration, and used this to define a choke price. This choke price is increased over time at an average of 2% below inflation, which in real terms provides a 2% annual decrease. For LTE, we assume a 30% premium relative to 3G services, to reflect the substantial increases in speed provided.

In urban areas penetration of mobile broadband is assumed to reach 50%[17] of the population by 2030 under both scenarios, based on almost 100% coverage (mirroring the urban 2G network).

Under the *ARNS migrated* scenario, in rural areas LTE penetration is also expected to reach 50% by 2030, though with a more delayed growth. This assumes that rural mobile networks are upgraded to achieve a coverage of almost 100% by 2030 – at present we estimate that they cover only around 75% of the rural population, based on an overall national coverage of 90–95% and an assumption that around 30% of the total population lives in rural areas.

In comparison, under the *ARNS not migrated – Limited rural 3G* scenario, we assume that by 2030 penetration in rural areas will reach 30%, with around 50% population coverage. However, in the *ARNS not migrated – no rural 3G* scenario, where the sub-band is not available, we assume a 0% penetration of 3G mobile broadband in rural areas.

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17 One industry representative has suggested that the total mobile data user penetration may be as high as 88% in 2030. Our sensitivity analysis considers the impact on our study results of higher and lower levels of mobile broadband penetration.

Mobile broadband producer surplus

The producer surplus for mobile broadband services is calculated by subtracting the opex and capex costs associated with providing the service from the revenues generated. Revenues are derived from the total subscribers to a service multiplied by the average revenue per user (ARPU)[18] for that service. We assume that the ARPU for LTE is 30% higher than the corresponding 3G service, reflecting the hugely enhanced speeds provided. ARPUs are assumed to increase by an average of 4–5% per annum, meaning in real terms (taking into account inflation); we expect a 1-2% annual decline. Price reductions beyond this are deemed to be uneconomic owing to the already low prices in the market and the costs associated with providing mobile broadband services in Russia.

Operating costs associated with mobile broadband services include costs per site (maintenance and running costs), per subscriber (staff, marketing and commission) and G&A. Capital expenses include site upgrade costs (we assume that new sites will not be required to upgrade to mobile broadband, but that existing sites can be used to deploy these services) and replacement capex. Equipment and maintenance costs for LTE are initially higher than 3G, though we expect these to fall fairly rapidly to around the same levels.

Mobile broadband summary results

As above with the DTT results, we have calculated the NPV 2015–30 under each of our scenarios in order to assess the incremental value of ARNS migration and the creation of a mobile broadband sub-band. The results of our analysis are shown below.[19] All figures are in trillions of roubles. The results are also quoted in billions of euros in Figure 4.7 below.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	2.8	1.3	4.1	N/A
ARNS not migrated – limited rural 3G	3.0	1.3	4.3	0.2
ARNS migrated	3.3	1.4	4.8	0.7

Figure 4.6: Value generated by mobile broadband services under the two scenarios and two variants (RUB trillions) [Source: Analysys Mason]

18 One industry representative has indicated slightly lower projected ARPUs than those assumed in this study. However, owing to the cost of roll-out, and looking at international examples, we believe our levels of ARPU are justified.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	65	29	94	N/A
ARNS not migrated – limited rural 3G	69	31	100	6
ARNS migrated	77	33	110	16

Figure 4.7: Value generated by mobile broadband services under the two scenarios and two variants (EUR billions) [Source: Analysys Mason]

These figures demonstrate that by migrating the ARNS service and creating a mobile broadband sub-band, an additional RUB0.7 trillion (EUR16 billion) of value can be created (assuming that it is unfeasible to deploy rural 3G using refarmed 900MHz spectrum). In the event that operators are able to provide a limited 3G service in rural areas using refarmed 900MHz spectrum, the incremental increase in value of deploying a mobile broadband sub-band in the UHF spectrum is RUB0.5 trillion (EUR10 billion).

4.4 Total economic benefit

Figure 4.8 below shows the total economic benefit of the *ARNS migrated* scenario compared to the two variants of *ARNS not migrated*, and the incremental value that can be achieved through migration. For convenience, these results are also presented in euros in Figure 4.9.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	4.3	1.8	6.1	N/A
ARNS no migrated – limited rural 3G	4.5	1.8	6.4	0.3
ARNS migrated	5.2	1.8	7.0	0.8

Figure 4.8: Total value generated by both DTT and mobile broadband services under the two scenarios and two variants (RUB trillions) [Source: Analysys Mason]

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	100	41	141	N/A
ARNS no migrated – limited rural 3G	104	42	146	6
ARNS migrated	118	41	160	19

Figure 4.9: Total value generated by both DTT and mobile broadband services under the two scenarios and two variants (EUR billions)] [Source: Analysys Mason]

These results demonstrate that, overall, an additional RUB0.81 trillion (EUR19 billion) of value can be gained from migrating the ARNS service out of Bands IV/V, creating a mobile broadband sub-band and deploying two additional multiplexes. Over two-thirds of this additional value is derived from delivering mobile broadband services in rural areas. Furthermore, the majority of the additional value gained is provided by the *consumer* surplus created through additional channels or Internet speeds, rather than the *producer* surplus.

4.5 Sensitivity analysis of the results

In addition to our two scenarios and two variants, we have run sensitivity tests in order to examine how sensitive these results are to variations in the key assumptions. Within the TV market, the key assumption that we sought to test was the potential change in penetration of the pay-TV platform in the *ARNS migrated* scenario, owing to the increase in the number of channels provided over the terrestrial platform (compared to the *ARNS not migrated scenario*).

The results of our sensitivity tests, in which the assumptions regarding pay-TV platform penetration in 2030 in the *ARNS migrated* scenario were flexed by ±7%, are shown in Figure 4.10 below. All figures are in RUB trillions. Note: the effect of increasing the pay-TV penetration in the *ARNS migrated* scenario by 7% in reality assumes no change in pay-TV penetration from the *ARNS not migrated* scenario.

Scenario	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
Pay-TV platform penetration: default assumptions		
ARNS not migrated – no rural 3G	6.1	N/A
ARNS not migrated – limited rural 3G	6.4	0.3
ARNS migrated	7.0	0.8
Pay-TV platform penetration in 2030 increased by 7%in *ARNS migrated* scenario		
ARNS not migrated – no rural 3G	6.1	N/A
ARNS not migrated – limited rural 3G	6.4	0.3
ARNS migrated	7.0	0.8
Pay-TV platform penetration in 2030 reduced by 7%in *ARNS migrated* scenario		
ARNS not migrated – no rural 3G	6.1	N/A
ARNS not migrated – limited rural 3G	6.4	0.3
ARNS migrated	7.0	0.9

Figure 4.10: Sensitivity analysis of assumptions regarding penetration of pay-TV platform (RUB trillions) [Source: Analysys Mason]

Our sensitivity analysis demonstrates that a 7% reduction in pay-TV platform penetration has a limited impact on the total private value of the ARNS migrated scenario, but does have a modest impact on the incremental value provided compared to the *ARNS not migrated – no rural 3G* scenario, around RUB0.8 trillion to RUB0.9 trillion (EUR19 billion to EUR21. billion).

An analysis of these results demonstrates that although pay-TV platform penetration is an important factor in determining the value of the DTT market, variations in this assumption do not significantly change the incremental value gained through migrating ARNS out of Bands IV/V – the *ARNS migrated* scenario remains attractive.

We also conducted sensitivity analysis on the key mobile broadband results. Key assumptions tested include overall mobile broadband penetration and the percentage of LTE take-up within this market. These variables will depend on technology (3G versus LTE) and the number of operators, as modelled in our scenarios, but may also be affected by pricing, economic circumstances and developments in fixed-line communications. The results of our sensitivity analysis are shown in Figure 4.11 below.

Scenario	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
Default assumptions		
ARNS not migrated – no rural 3G	6.1	N/A
ARNS not migrated – limited rural 3G	6.4	0.3
ARNS migrated	7.0	0.8
Mobile broadband penetration in 2030 reduced by 25%*		
ARNS not migrated – no rural 3G	4.9	N/A
ARNS not migrated – limited rural 3G	5.1	0.2
ARNS migrated	5.5	0.6
Mobile broadband penetration in 2030 increased by 25%*		
ARNS not migrated – no rural 3G	7.4	N/A
ARNS not migrated – limited rural 3G	7.6	0.2
ARNS migrated	8.4	1.1
LTE take-up in 2021 reduced by 25%		
ARNS not migrated – no rural 3G	6.1	N/A
ARNS not migrated – limited rural 3G	6.3	0.2
ARNS migrated	6.8	0.8
LTE take-up in 2021 increased by 25%		
ARNS not migrated – no rural 3G	6.2	N/A
ARNS not migrated – limited rural 3G	6.4	0.2
ARNS migrated	7.1	0.9

* Changes in penetration are assumed for urban areas and for rural LTE in the *ARNS migrated* scenario. No changes are assumed for rural areas in the *ARNS not migrated* scenario for either variant.

Figure 4.11: Sensitivity analysis of key assumptions regarding mobile broadband (RUB trillions) [Source: Analysys Mason]

Our sensitivity analysis demonstrates that should mobile broadband penetration be 25% lower than assumed, the incremental value of the *ARNS migrated* scenario remains substantial at RUB0.6 trillion, compared to the *ARNS not migrated – no rural 3G* scenario. If penetration is 25% higher than assumed, the incremental value of the *ARNS migrated* scenario compared to the *ARNS not migrated – no rural 3G* scenario reaches RUB1.1 trillion.

Changes in the assumed take-up of LTE compared to 3G have a less significant impact on the incremental value of migrating ARNS services. If LTE take-up is 25% lower than assumed in 2021[20] the incremental value of the *ARNS migrated* scenario compared to the *ARNS not migrated – no rural 3G* scenario is RUB0.8 trillion.

20 Note this date is used as a proxy for the speed of take-up of LTE.

The range of results provided by the sensitivity analysis for mobile broadband is provided in Figure 4.12 below.

	NPV of private value, 2015–30: range of values	*Incremental increase in private value compared to ARNS not migrated – no rural 3G: range of values*
Mobile broadband penetration		
ARNS not migrated – no rural 3G	4.9-7.4	N/A
ARNS not migrated – limited rural 3G	5.1-7.6	0.2
ARNS migrated	5.5–8.4	0.6–1.1
LTE take-up		
ARNS not migrated – no rural 3G	6.1-6.2	N/A
ARNS not migrated – limited rural 3G	6.3-6.4	0.2
ARNS migrated	6.8-7.1	0.8-0.9

Figure 4.12: Range of value generated by mobile broadband under different assumptions (RUB trillions) [Source: Analysys Mason]

It is noted that, in the longer term, it is expected that further innovation in the development of mobile devices will substantially increase the range and types of device using mobile broadband networks. In turn, the development of a wider range of devices, including smart phones, notebooks, smart-books and embedded devices is likely to lead to further increases in the size of the mobile broadband market, and in the traffic being carried by mobile networks. By 2030 therefore, these trends could result in the size of the mobile broadband market significantly exceeding current forecasts.

4.6 Social benefits

Social value is the value that the public derives from services because of their broader contribution to society, such as social cohesion, universal service provision and contributions to culture and education,. It is important not only to consider the private value but also the social value, which is otherwise not reflected in the value of a service or product to consumers.

Whilst social value has proven notoriously difficult to quantify, a number of studies have been conducted in an attempt to qualitatively define the comparative benefits of different uses of the digital dividend spectrum.[21] Some examples of the types of social value considered include: education development, community development, social inclusion, sustainable development, cultural understanding, regional development, health and security, quality of life.

21 Studies include: DotEcon Ltd and Dr Damian Tambini (2006), “External value of candidate uses for the digital dividend spectrum”, prepared for Ofcom as part of the ‘Preparatory Study for UHF spectrum award, Oliver & Ohlbaum Associates and DotEcon for EBU (2008), “The Effects of a Market-Based Approach to Spectrum Management of UHF and the Impact on Digital Terrestrial Broadcasting”, An estimate from WIK Consult (2008), “Safety first – Reinvesting the digital dividend in safeguarding citizens”.

These studies have concluded that only minimal incremental social value is generated by additional DTT channels on top of those already provided (or in Russia's case, those that will be provided by the proposed plans – Scenario 1). Furthermore, the provision of HDTV over DTT is likely to provide only modest additional social value, as it is widely considered to be a luxury item, and it is *content* rather than picture quality that typically provides public value.

Mobile broadband is considered to be of particular social value if it enables broadband access where fixed-line services are not available, or provides a more affordable alternative. This is particularly applicable in the rural areas of Russia, where roll-out of rural mobile broadband is likely to contribute to better regional development as well as create a number of additional benefits through improve access to services including healthcare, education, information, business and social networking.

Improving broadband connectivity in rural areas is a goal of many Governments around the world, and the lack of commercial network investment in rural areas (as a result of the limited return on investment that can be achieved) has led many Governments to consider their own intervention (e.g. by making public funds available) to improve broadband connectivity. This intervention of public funds is often beneficial as a result of the economic benefit that it creates, due to the proven links between broadband connectivity, business productivity and growth, which are particularly critical to ensure that rural populations can survive.

The social benefits gained through enabling people in rural areas via high speed internet services are varied, and create extra impetus for Governments to encourage the necessary investments in rural connectivity. In today's market, where mobile and fixed broadband services are increasingly substitutable, these social benefits apply equally to broadband services delivered over either fixed or mobile networks. Examples of some of the broader contributions to society that improved broadband connection provides, particularly in rural areas, often considered as 'social benefits' of broadband, are set out below.

Benefit	***Summary***
Better access to goods and services	The online economy is an increasingly important part of the Russian economy as a whole, with Internet sales growing substantially year-on-year. The remoteness of populations living in rural areas means that online purchasing is particularly beneficial for those areas, where limited retail facilities are likely to be available compared to urban areas.
Improving ICT skills	Access to broadband networks encourages people to familiarise themselves with ICT systems, therefore creating educated citizens, and improving job and salary prospects.
Access to online communities	The rapid rise in use of telecoms for social interaction (email, SMS and social networking websites) illustrates that broadband connection is becoming a core component of social interaction. Society now expects to be connected regardless of location, or device, and younger populations in particular have embraced social networking as a means of continual interaction and communication with their peers. This interaction can be particularly important in rural areas to compensate for the increased physical distance between people, making face-to-face interaction harder. Broadband connectivity is therefore generally considered to be a key part of living in modern society, with large, intangible, social benefit through online engagement and enabling people to 'keep in touch' with what is happening elsewhere.

Benefit	***Summary***
Access to government services	Rural areas can suffer from a lack of services that are taken for granted in urban areas – for example, a lack of proper medical facilities, government services and education. Broadband connectivity can bridge the gap between urban and rural areas through allowing access to virtual services as and where they require, such as online healthcare, remote access to Government forms and information and remote learning.
Quality of life	An important social benefit of broadband services is that it enables people to carry out day-to-day and work tasks from wherever they are located, therefore reducing commuting time and improving work-life balance. This in turn offers a number of benefits including better family life and inclusion.
Maintaining populations	Decline of populations is a particular problem in rural areas, particularly of the younger population who migrate to living in urban areas, due to the better range of opportunities available for education and employment, as well as a far greater range of services being available (entertainment, restaurants, museums, etc.). This younger population drift towards urban areas can threaten the stability of rural populations, without action being to address population decline through attempts to retain younger populations in rural areas e.g. through ensuring adequate access to education facilities, jobs provision and services availability. Online channels are key to this.

5 Conclusions from the study

As discussed in Section 2, the objective of this study has been to estimate the potential value of migrating ARNS systems from the UHF spectrum in Russia, enabling the creation of a sub-band for mobile broadband services, with extra spectrum being available for DTT. Based on our analysis, we have drawn the following conclusions:

- **The migration of ARNS systems from the UHF spectrum would enable significant value to be created**. If the released spectrum were used for a combination of mobile broadband and DTT services, we calculate that the total NPV to the Russian economy from 2015 to 2030 would be RUB7 trillion (EUR160 billion). In comparison, if no extra spectrum from ARNS is available, a total of RUB6.1 trillion (EUR141 billion) would arise from the development of mobile broadband and DTT. This means that migrating the ARNS systems and releasing the spectrum would create an incremental value of up to RUB0.8 trillion (EUR19 billion) from 2015 to 2030.

- **Using the released spectrum to create a sub-band for mobile broadband services (e.g. LTE) could create substantial incremental consumer and producer surplus**. Of the total RUB0.8 trillion (EUR19 billion) of incremental value created, we have estimated that RUB0.7 trillion (EUR16 billion) would be generated through greater availability of mobile broadband services. This value arises from lowering the cost for operators to provide coverage of less populated areas, and also from the increased availability of services in rural areas (we estimate that UHF spectrum could increase mobile broadband coverage of the rural population to 50% by 2030).

- **There is also some value in making extra spectrum (outside of the sub-band) available for DTT services**. Of the total RUB0.8 trillion (EUR19 billion) of incremental value, we estimate that RUB0.3 trillion (EUR6 billion) should be generated through consumer surplus arising from the existence of more channels (and additional value) to DTT users. However, the additional costs associated with deploying two extra multiplexes (only marginally offset by additional advertising revenues gained through an increased market share) mean that the producer surplus drops in value by RUB0.1 trillion (EUR3 billion). As such, the net effect of the extra spectrum made available for DTT services is only RUB0.1 trillion (EUR3 billion) – a relatively minor portion of the total incremental value gained from migrating ARNS services out of Bands IV/V.

If a UHF sub-band is *not* created, mobile operators will be reliant on using higher-frequency bands (i.e. 2100MHz and 2600MHz) to deliver mobile broadband services, unless refarming of GSM900 spectrum is allowed. There appears to be significant uncertainty in the market place at the moment about when this re-farming will happen, and also how feasible it will be to use refarmed spectrum for mobile broadband services across the country (ARNS systems also use the 900MHz band, resulting in significant restrictions on its use for mobile services). In our base-case *ARNS not migrated* scenario we have therefore compared a case where some re-farming is possible in rural areas, and compared this with a case where re-farming is only possible in urban areas (and consequently, there is no mobile broadband coverage at all in rural areas). If we assume that limited GSM900 re-farming is possible in rural areas in our *ARNS not migrated* scenario, the incremental value gained in the *ARNS migrated* scenario falls to a still substantial RUB0.6 trillion (EUR14 billion).

As described in Section 4, by migrating ARNS systems and introducing a sub-band for mobile broadband, *social benefits* would also be created through the greater availability of broadband services in rural areas. Whilst this social value is intangible (i.e. not quantified), the benefits are likely to include:

- better access to goods and services (access to public services, online channels, etc.)
- improved ICT skills (better educated citizens)
- increased access to online communities via virtual networking in the form of connecting with other people over the Internet, use of social networking websites, etc.
- better access to government services (education, health, community, etc.)
- maintaining of populations (encouraging continuation of, and diversity in, rural communities, reversing population declines in rural areas)
- enhanced quality of life (e.g. by enabling a better work-life balance and supporting family life).

Annex A: DTT model

This annex provides a detailed description of the methodology and assumptions used in the model for DTT developed to support this study. Similarly, Annex B provides details on the mobile broadband business model. We here describe the methodology we have used to evaluate the net present economic value (2015–30) of DTT. This value is defined as the benefits that users get from a service minus what this service costs to produce, and is often split between *consumer surplus* (benefit to consumers minus the price they pay) and *producer surplus* (revenue of the producer minus the costs to provide the service).

A.1 Consumer surplus for DTT users

Figure A.1 below illustrates the approach we have used to estimate the consumer surplus for DTT services:

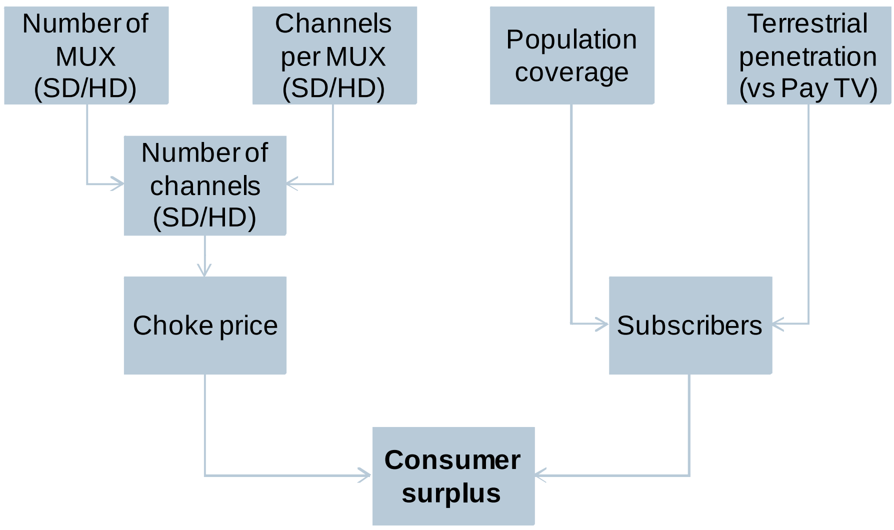

Figure A.1: Approach to calculating DTT consumer surplus [Source: Analysys Mason]

Market forecasts

In 2009, colour TV penetration of households was 97%, corresponding to 51.3 million households. We anticipate that the total TV market will grow to 99% household penetration by 2015, but will ultimately fall as a result of the declining population, as demonstrated in Figure A.2, below.

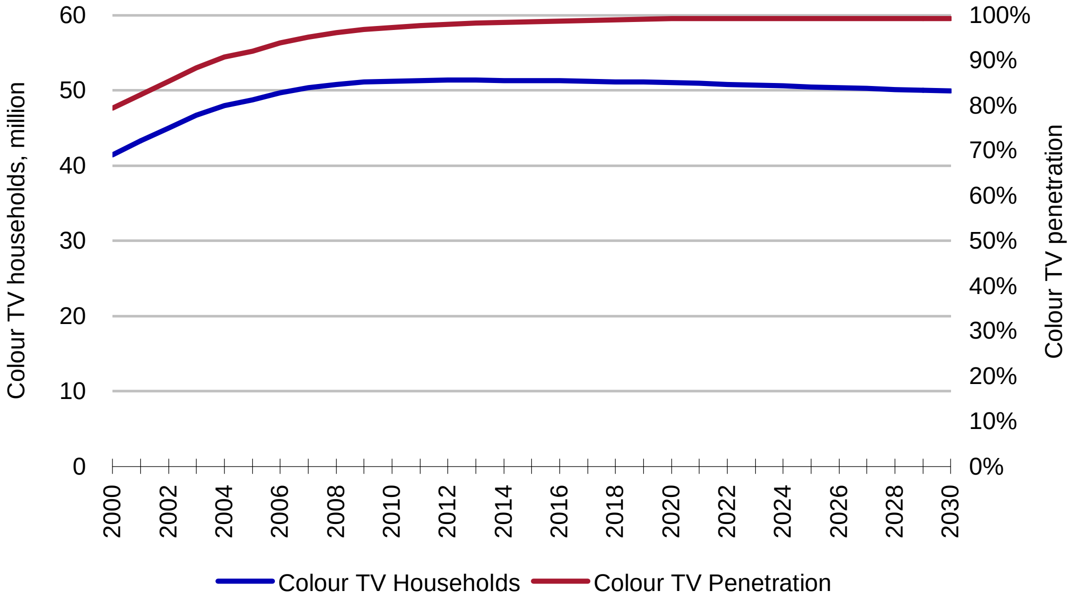

Figure A.2: *Colour TV households in Russia [Source: Euromonitor]*

Pay-TV platform penetration reached 37% in 2009, corresponding to 19 million households. Within the pay-TV subscriber base, the majority remain cable TV subscribers, however, satellite TV has seen the most significant growth in the last five years (shown in Figure A.3 below).

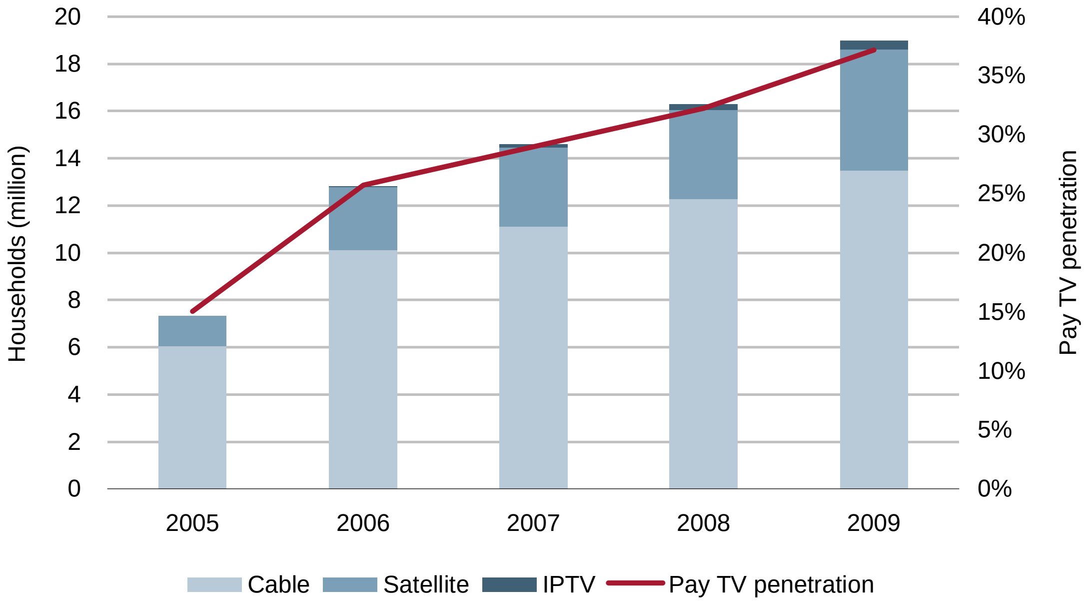

Figure A.3: *Pay TV subscribers in Russia by access type and total Russian pay-TV platform penetration [Source: iKS Consulting, Price Waterhouse Cooper, Analysys Mason]*

Our *ARNS not migrated* scenario assumes that by increasing the number of free-to-view terrestrial TV channels from a minimum of three national channels to a minimum of 20 channels[22] as standard through the digital switchover, the growth of pay-TV platform penetration will be curbed. Within the *ARNS not migrated* scenario we assume that, following an initial continuation of pay-TV platform growth in the years before 2015, pay-TV platform penetration stabilises at around 45% by 2030. This compares to an assumed 48% pay-TV platform penetration if analogue TV were to continue in operation.

Through the clearing of the ARNS spectrum, our *ARNS migrated* scenario allows for additional free-to-view DTT channels (in addition to a mobile broadband sub-band). Accordingly, in this scenario, we have assumed that pay-TV platform penetration will reach only 42% by 2030. These trends are demonstrated in Figure A.4 below.

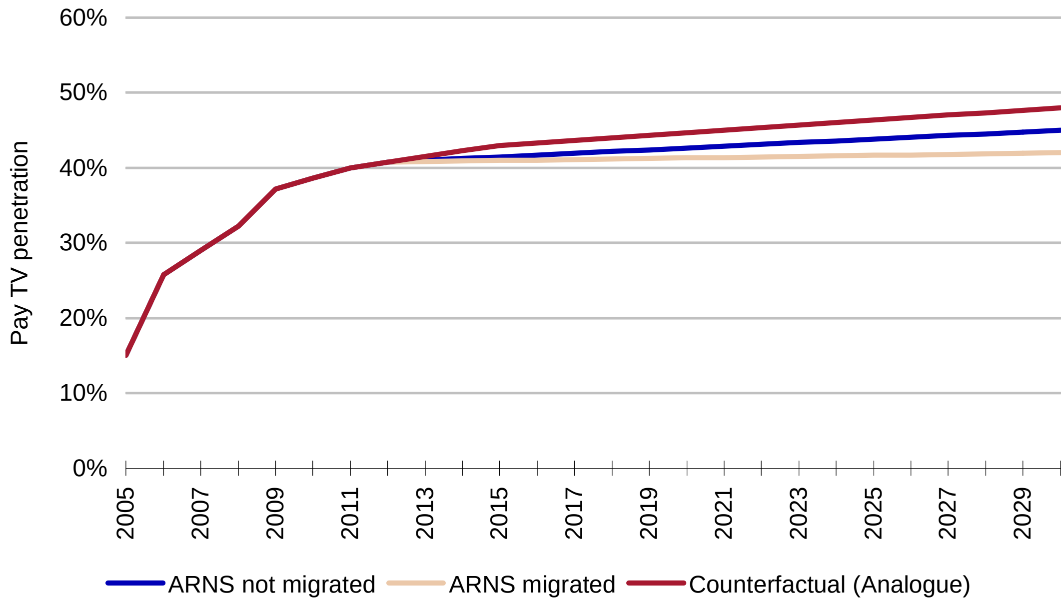

Figure A.4: Impact of digital switchover on pay-TV penetration by scenario, compared to the counterfactual case of a continuation of analogue TV [Source: Analysys Mason]

Number of multiplexes and terrestrial TV channels available

In line with government targets, our *ARNS not migrated* scenario assumes four multiplexes will be available by 2015, one of which will be high-definition and all of which will be used for free-to-view services. In the *ARNS migrated* scenario, we believe that in addition to creating a mobile broadband sub-band, there will also be sufficient additional spectrum to create two more multiplexes, which we have assumed to be standard definition. We have assumed that these

22 According to government targets, at least 20 digital terrestrial TV channels will be made available to 100% of the population. However, capacity should in fact be available for around 40 nationwide channels, see Figure A.5.

additional multiplexes will be available by 2017. See Figure A.5 below for a summary of the number of channels and multiplexes assumed per scenario.

Availability in 2017	*MUX*	*Free-to-view channels*
Standard definition		
ARNS not migrated	3	36
ARNS migrated	5	60
High definition		
ARNS not migrated	1	4
ARNS migrated	1	4
Total		
ARNS not migrated	4	40
ARNS migrated	6	64

Figure A.5: Total multiplexes and channels available by scenario [Source: Analysys Mason]

In addition to these multiplexes and channels, we assume that one mobile TV multiplex will be deployed, providing 10 channels. However, as this assumption does not change by scenario, we have not specifically modelled the mobile TV value.

Willingness to pay for TV channels

Terrestrial TV in Russia offer free-to-view services. It is partially funded by the government, but predominantly funded by advertising revenues, with no form of individual household licence fee. As such, we are unable to assume an average revenue per user (ARPU) in the DTT market as would usually be the case for a standard consumer surplus calculation. Therefore, our consumer surplus calculations rely on the willingness to pay of terrestrial TV subscribers, which is directly linked to the quantity and quality of the channels provided. In the absence of primary research specific to Russia, we have used the results of a study conducted in the UK[23] to estimate the willingness of Russian consumers to pay for TV channels. This has allowed us to generate the curve shown in Figure A.6 below for both standard and high-definition channels.

23 *Stated and revealed preference survey of digital TV services*, Department for Trade and Industry, November 2004.

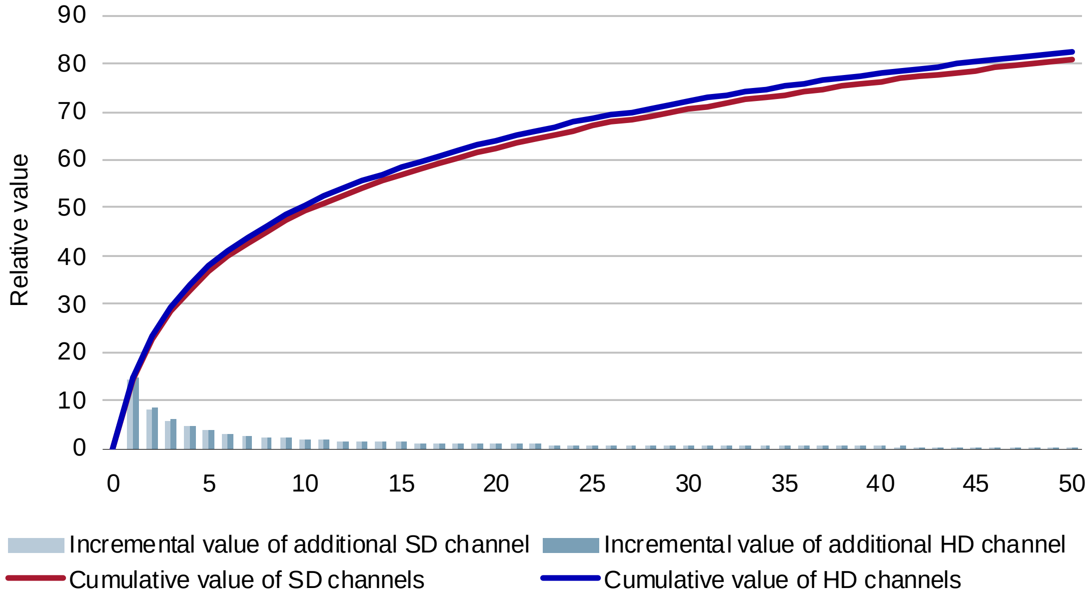

Figure A.6: *Willingness to pay for TV channels [Source: UK Department for Trade and Industry, Analysys Mason]*

Based on these estimates, as well as the evolution of the number of free-to-view standard and high-definition channels for our two scenarios, we have derived an average willingness to pay for DTT services over time. This is illustrated in Figure A.7 below.

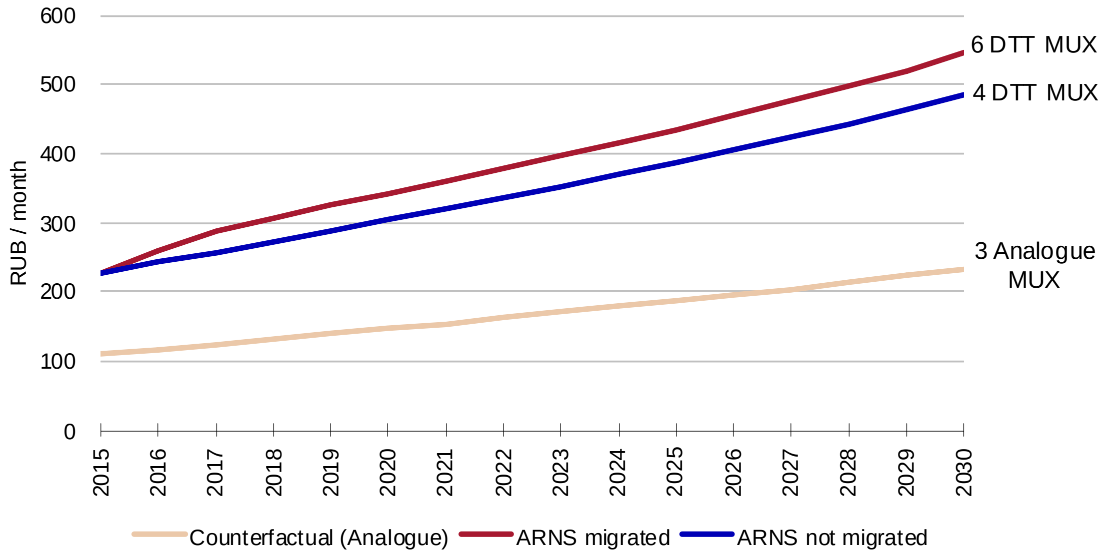

Figure A.7: *Comparison of the average willingness to pay for terrestrial TV [Source: Analysys Mason]*

This methodology presents evident limitations in the sense that the willingness to pay for TV channels is likely to be strongly influenced by local circumstances. However, at a high level, it provides a good indication of the magnitude of the consumer surplus at the levels of projected demand.

The evolution of the willingness to pay over time once all multiplexes have been deployed, is based on inflation, which is forecast to fall from around 7% today to 5% by 2030 (EIU estimates).

Adjustment of consumer surplus owing to loss of viewers to pay-TV market

During the course of this study, we have considered the impact of the use of released spectrum on the pay-TV market. We have made the assumption that the improvement in the terrestrial TV service owing to the increased number of channels provided by the digital switchover will slow the growth in pay-TV platform penetration in Russia (see Figure A.4 above). For those subscribers that migrate from pay-TV platforms to DTT, or choose not to migrate to pay-TV platforms owing to the improvement in the DTT service, their value must be added to the DTT market, but then removed from the pay-TV market. In order to simplify the calculation, we assume that the willingness to pay of the migrating subscriber does not change (they will be receiving a similar value, i.e. number of channels, as if they were to stay on the lower end pay TV packages). This provides a net effect of zero for the consumer surplus of the total TV market (i.e. the same value is added to the DTT platform as is removed from pay–TV platforms). Thus, in our calculations, these subscribers are excluded from the overall DTT consumer surplus.

A.2 Producer surplus for DTT operators

Figure A.8 illustrates the approach we have used to estimate the producer surplus for DTT services.

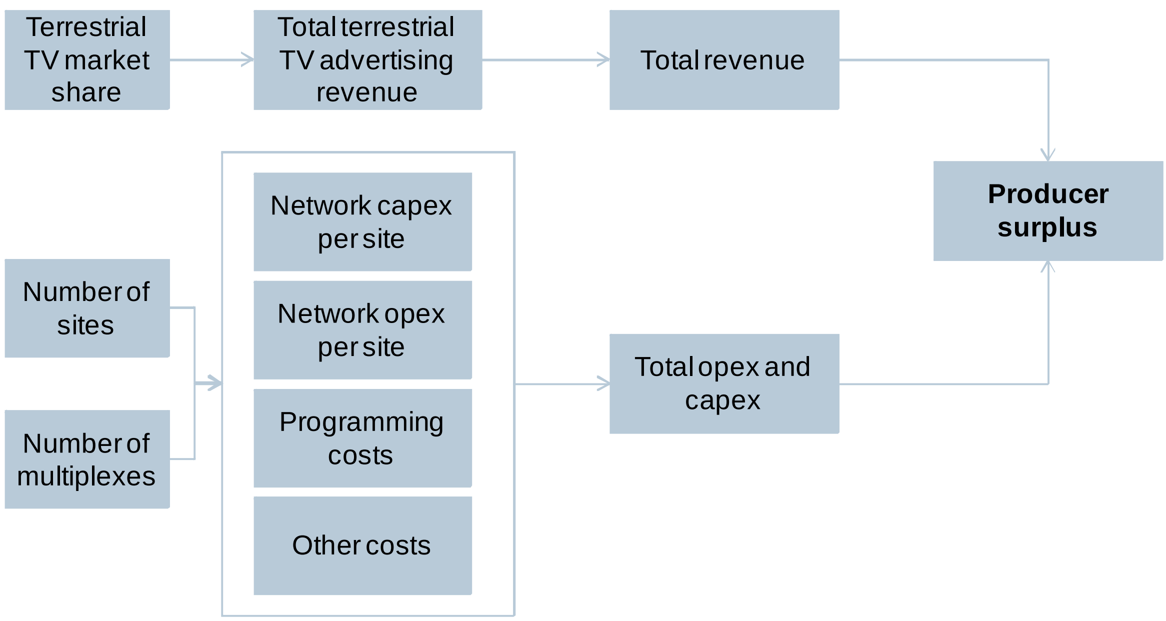

Figure A.8: DTT producer surplus approach [Source: Analysys Mason]

Revenue of the DTT operator

The first component of producer surplus is the revenue earned by DTT operators. As described above, aside from a small government contribution[24], the revenues gained by DTT operators are derived directly from advertising. Looking at the market as a whole, the total TV advertising market is supplemented by subscription revenues for pay-TV operators; the historical landscape is shown in Figure A.9 below.

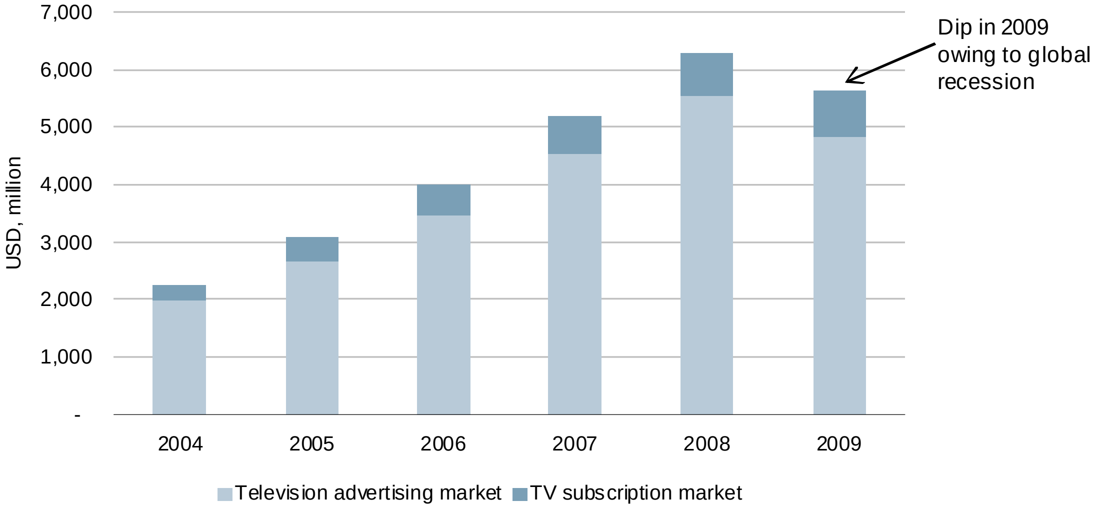

Figure A.9: TV revenues in Russia 2004-2009 [Source: PWC, Global entertainment and media outlook 2009–2013]

For the purpose of this study, we have assumed that the total advertising spend that companies allocate to TV is relatively stable and is split across all platforms in proportion to their market share. As the DTT platform gains market share, advertising spend will be progressively redirected from other platforms towards terrestrial TV. We have assumed that the total spend on TV advertising will increase in line with Russian inflation. Figure A.10 below illustrates advertising revenues in the two scenarios.

24 The level of government funding is unclear. However, it is claimed that the largest state channel, 'Russia' is funded solely using advertising revenues. As such, we have not included government funding within our producer surplus revenue calculations.

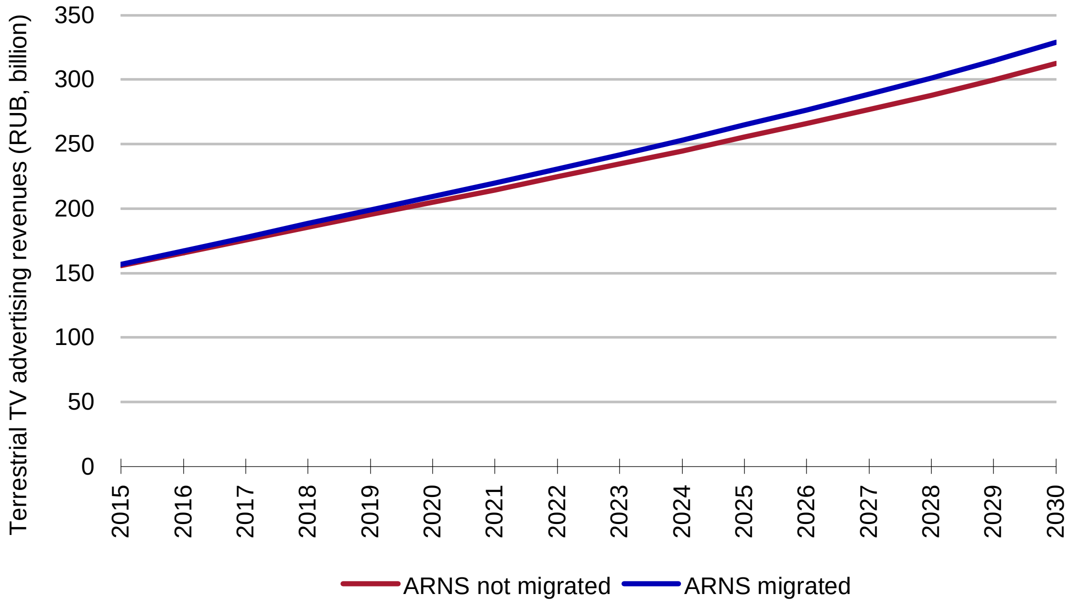

Figure A.10: Evolution of terrestrial TV advertising revenues by scenario [Source: Analysys Mason]

Costs of the DTT operator

In order to estimate the producer surplus, we modelled both operating expenses (opex) and capital expenses (capex). The opex model considers three types of costs: (a) network opex, (b) programming costs and (c) other costs (modelled as a percentage of revenues). Figure A.11 and Figure A.12 below illustrate DTT opex and EBITDA margin in the two scenarios.

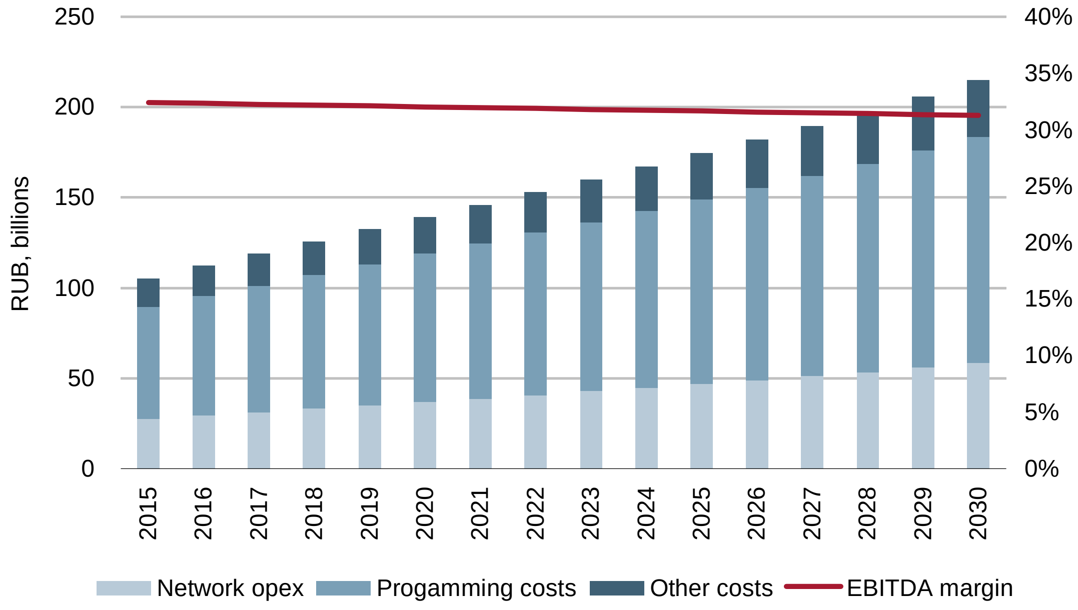

Figure A.11: DTT opex in the ARNS not migrated scenario [Source: Analysys Mason]

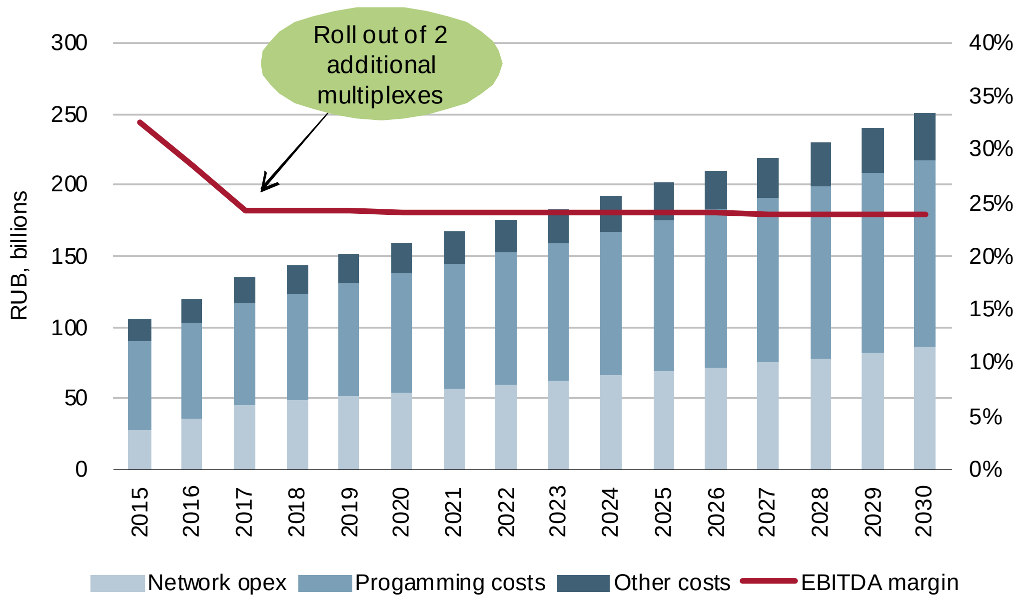

Figure A.12: DTT opex in the ARNS migrated scenario [Source: Analysys Mason]

Figure A.13 below compares the opex incurred by a network operator in the two scenarios.

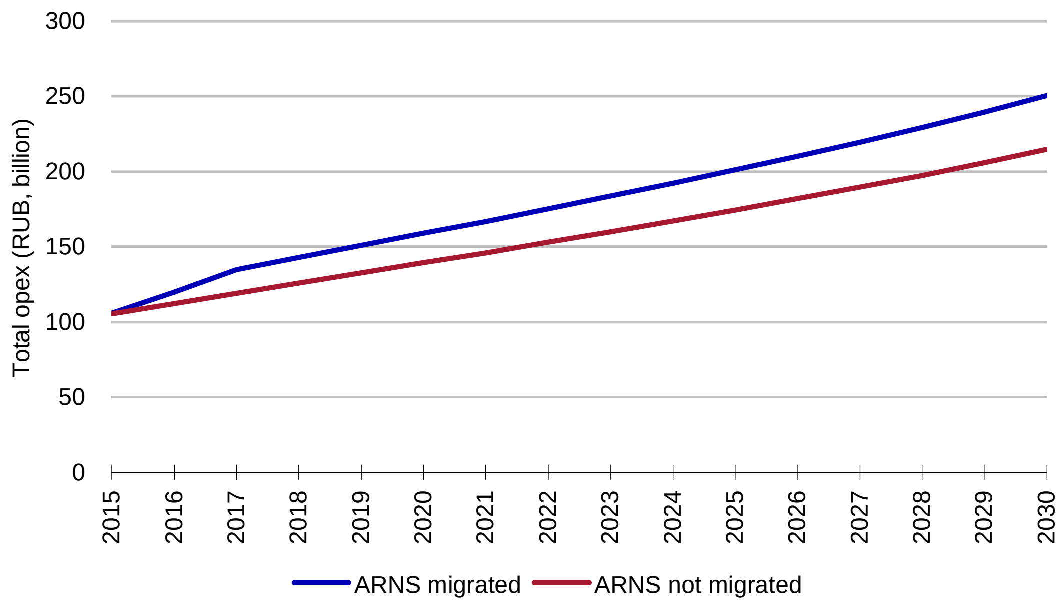

Figure A.13: Comparison of opex for DTT between the two scenarios [Source: Analysys Mason]

The capex model considers three types of costs: (a) one-off cost of migrating from analogue to digital, (b) roll-out cost per DTT multiplex and (c) cost of ongoing upgrades and maintenance. The level of costs that we have assumed for DTT roll-out have been set based on internal Analysys

Mason data and annual reports from European operators. We have also ensured that our roll-out costs are broadly in line with the Russian government targets. Figure A.14 and Figure A.15 below illustrate DTT cumulative capex in the two scenarios.

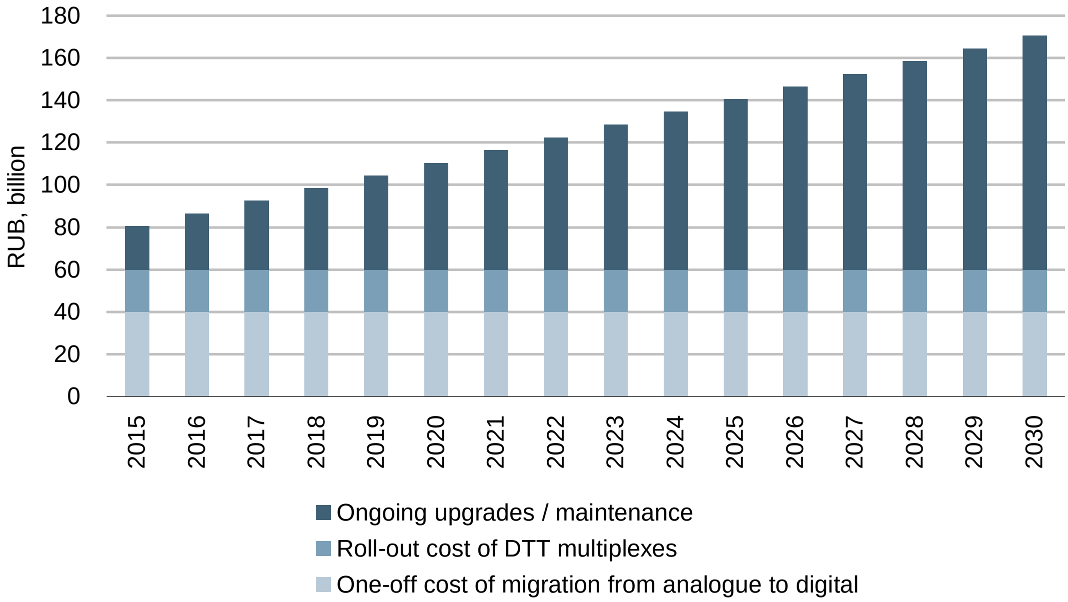

Figure A.14: DTT cumulative capex in the ARNS not migrated scenario [Source: Analysys Mason]

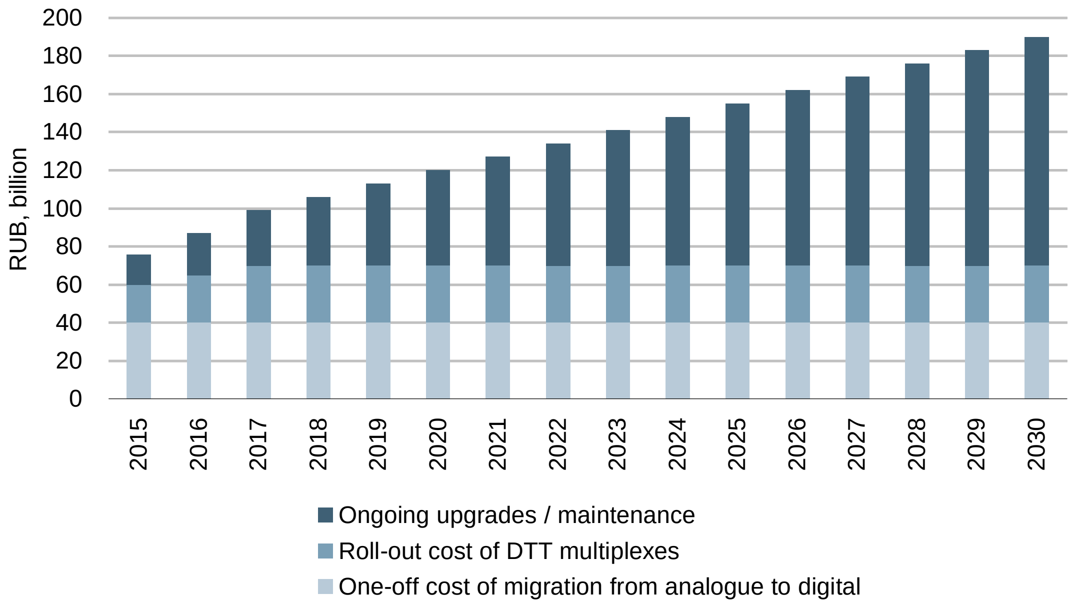

Figure A.15: DTT cumulative capex in the ARNS migrated scenario [Source: Analysys Mason]

Figure A.16 compares the cumulative capex incurred by the network operator in the two scenarios.

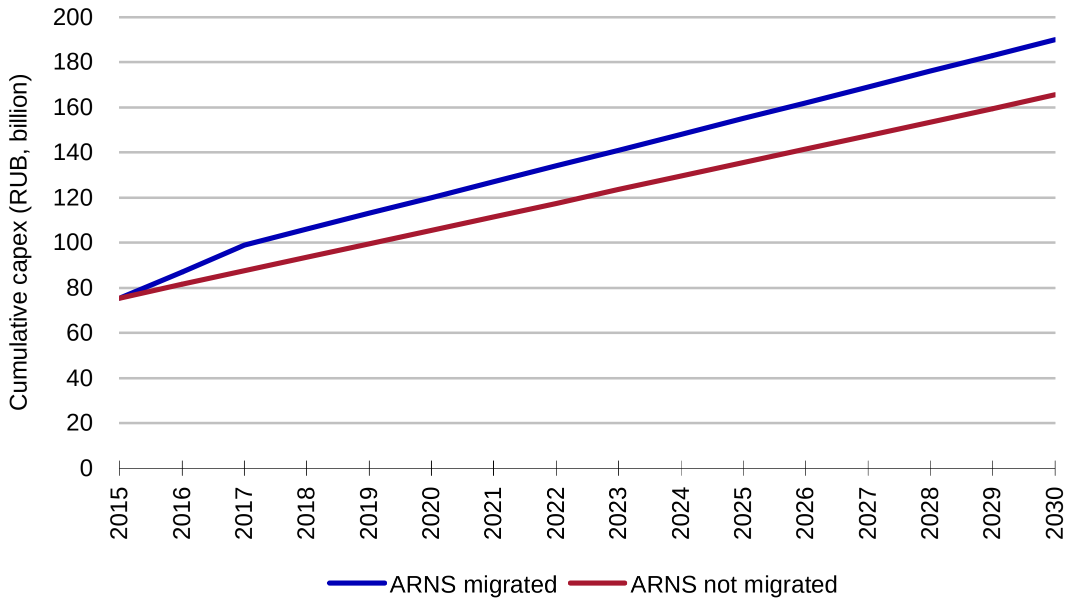

Figure A.16: *Comparison of cumulative capex for DTT in the two scenarios [Source: Analysys Mason]*

Adjustment of producer surplus owing to loss of viewers to the pay-TV market

As noted in the consumer surplus section above, it is necessary to adjust the revenues derived from additional free-to-view DTT users, who would otherwise have subscribed to pay TV services, in order to account for the comparative loss to the pay TV market. In order to do so, we have accounted for the loss is advertising and subscription revenues (based on an average spend calculation) and offset this against the corresponding reduction in costs for the pay-TV platform operators. The net revenues lost have been deducted from the total producer surplus.

A.3 Results of the DTT model

This section provides a summary of the NPV associated with using the released spectrum for the two scenarios, and gives a detailed breakdown of the consumer and producer surplus. Throughout this study, we have calculated the NPV (2015–30) of the consumer and producer surplus using an estimated social discount rate of 10%, based on estimated GDP growth and an inflation forecast. The base year for the calculation is 2015. All calculations are made in roubles and converted in euros where appropriate using the 2015 forecast exchange rate (43.6 roubles to the euro). The results of our analysis are shown in roubles in Figure A.17 below, and for convenience are also presented in euros in Figure A.18.

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated*
ARNS not migrated	1.5	0.5	2.0	N/A
ARNS migrated	1.8	0.4	2.2	0.1

Figure A.17: Value generated by DTT services using released spectrum under the two scenarios (RUB trillions) [Source: Analysys Mason]

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated*
ARNS not migrated	35	12	47	N/A
ARNS migrated	41	8	50	3

Figure A.18: Value generated by DTT services using digital dividend under the two scenarios (EUR billions) [Source: Analysys Mason]

These figures demonstrate that by migrating ARNS out of the Bands IV/V and deploying two additional multiplexes an extra RUB0.1 trillion of private value can be achieved. This is primarily driven by the additional value provided by the consumer surplus owing to the increased number of DTT channels provided.

Annex B: Mobile broadband model

This annex provides a detailed description of the methodology and assumptions used in the model for mobile broadband developed to support this study. We have assumed that deployment of pan-Russian high-speed mobile broadband services will rely on using sub-1GHz spectrum, and this spectrum will only be available if the ARNS spectrum is cleared. The other sub-1GHz spectrum band available for mobile services, at 900 MHz, is currently used for 2G mobile services in Russia, and is itself also shared with ARNS. We understand that refarming of GSM900 spectrum is thought to be difficult across the whole of Russia, as a result of current sharing constraints. Hence, although re-farmed GSM 900 spectrum might be used over time for higher speed 3G/3G+ mobile broadband services in some areas of Russia, it will not be available throughout the country.

In order to estimate the value of clearing the ARNS spectrum and the creation of a mobile broadband sub-band in Russia, we have modelled two scenarios considering the mobile broadband market with and without the digital dividend sub-band. We have considered the 3G and the LTE mobile broadband markets in both rural and urban areas.

In addition, owing to the uncertainty surrounding the ability of the operators to refarm their 900MHz spectrum for 3G mobile broadband, we have modelled two variants, one in which we assume that no rural 3G can be provided without the UHF sub-band and the second in which we assume that limited 900MHz refarming will occur, providing coverage to around half the rural population. Figure B.1 below summarises these two scenarios and variants.

	Urban	*Rural*
ARNS not migrated – no rural 3G	3G and LTE, LTE using frequencies above 1GHz (e.g. 2.6 GHz)	No 3G or LTE (unfeasible to refarm 900MHz)
ARNS not migrated – limited rural 3G	3G and LTE, LTE using frequencies above 1GHz (e.g. 2.6 GHz)	Limited 3G coverage (circa. 50% of rural population)
ARNS migrated	3G and LTE, LTE using frequencies above 1GHz (e.g. 2.6 GHz)	LTE using digital dividend sub-band

Figure B.1: Mobile broadband access technologies in urban and rural areas by scenario [Source: Analysys Mason

In both scenarios, we have assumed that on average, three operators will provide mobile broadband services in rural areas, and four operators will offer mobile broadband in urban areas.

B.1 Consumer surplus for mobile broadband subscribers

Figure B.2 below illustrates the approach we have used to estimate the consumer surplus for mobile broadband.

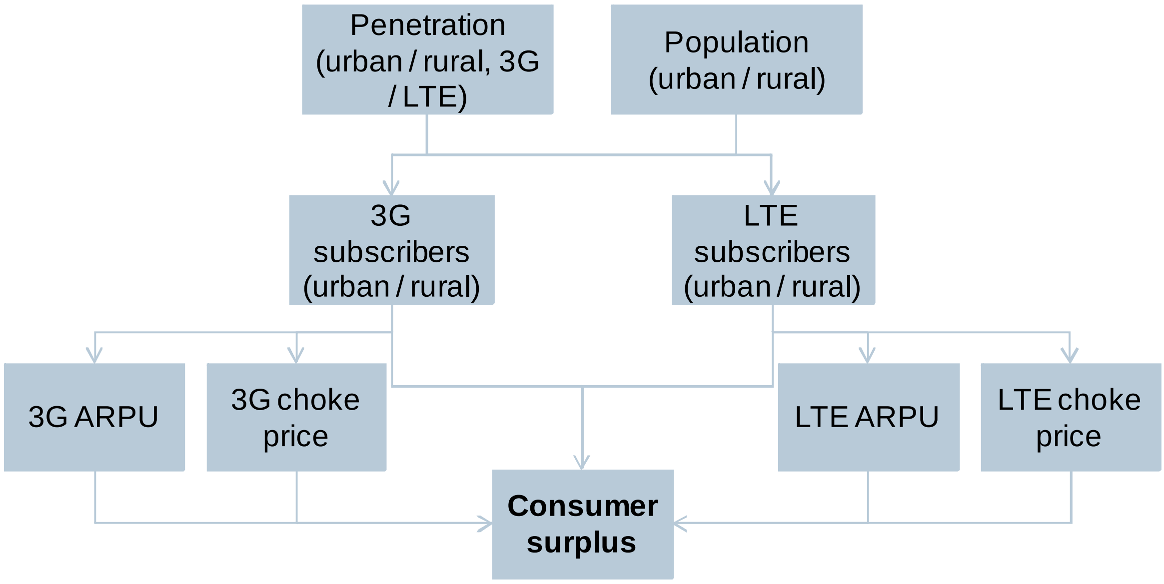

Figure B.2: *Mobile broadband consumer surplus approach [Source: Analysys Mason]*

Market forecasts

As a basis of our market models, we made assumptions regarding the take-up of mobile broadband services. We assumed that in the long-run, in urban areas, mobile broadband penetration will reach 50%[25] of the population (51 million subscribers, 2030). In the *ARNS not migrated – no rural 3G* scenario, we assume 0% mobile broadband penetration in rural areas (excludes 2G services). In comparison, in rural areas, for the *ARNS not migrated – limited rural 3G* scenario we assume penetration would reach only 30% of the covered population (population coverage circa. 50%) in the long run (5 million subscribers, 2030).

This compares to 50% penetration of the population in rural areas for the *ARNS migrated* scenario (circa. 17 million subscribers, 2030). However, we assume a less rapid take-up of mobile broadband in rural areas compared to urban within the *ARNS migrated* scenario, based on existing trends (see Figure B.3 below).

25 One industry representative has suggested that the total mobile data user penetration may be as high as 88% in 2030. Our sensitivity analysis considers the impact on our study results of higher and lower levels of mobile broadband penetration.

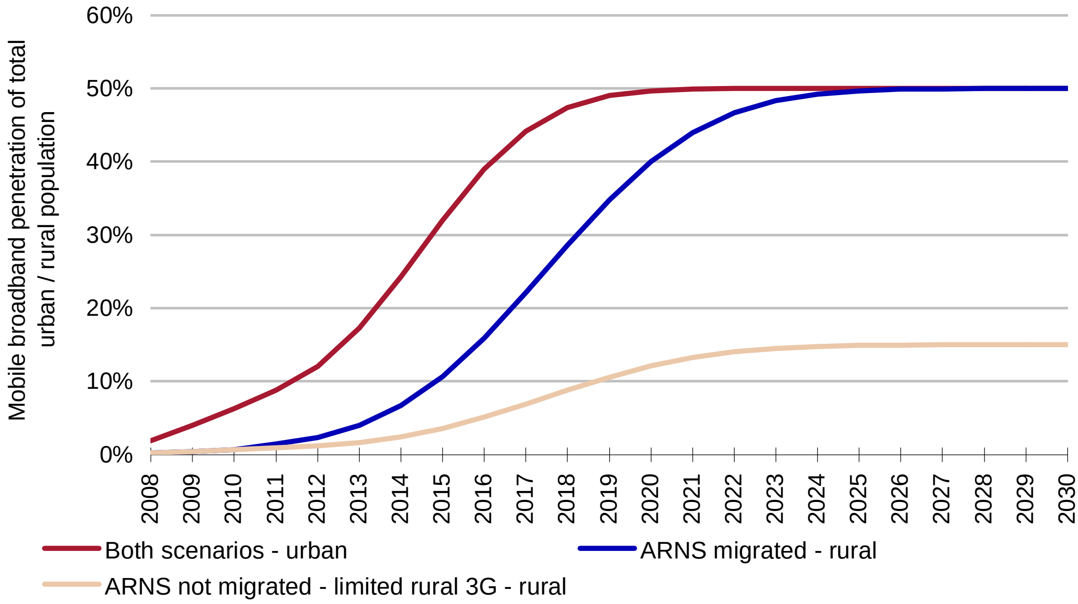

Figure B.3: *Mobile broadband penetration of the total population by scenario, split between urban and rural [Source: Analysys Mason]*

Further to this, we made assumptions on the take-up of LTE services compared to 3G where both are available (i.e. only applicable to urban areas). We assumed that all mobile broadband subscribers will have migrated to LTE by 2030. Figure B.4 and Figure B.5 below, illustrate the take-up of 3G and LTE services in each scenario.

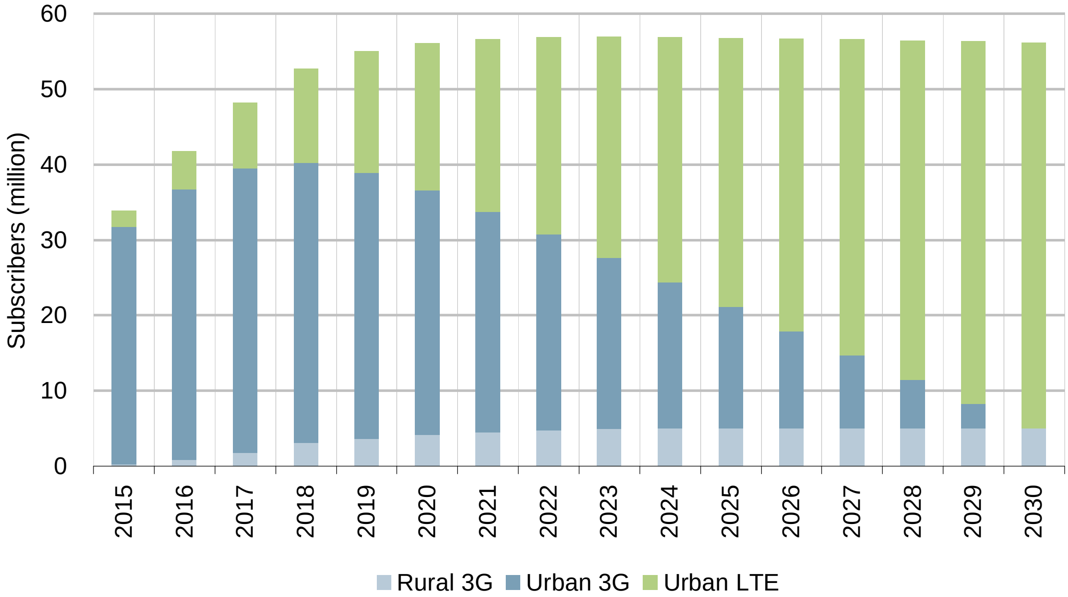

Figure B.4: *Comparison of 3G and LTE subscribers in the ARNS not migrated scenario (limited rural 3G variant illustrated; in no rural 3G variant, simply remove the rural 3G subscribers) [Source: Analysys Mason]*

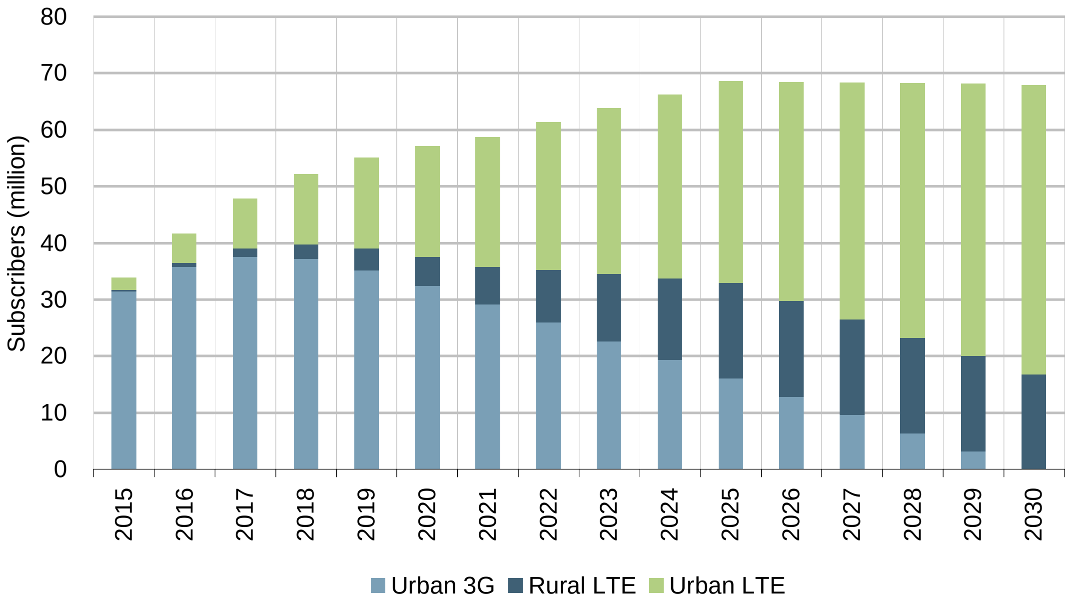

Figure B.5: *Comparison of 3G and LTE subscribers in the ARNS migrated scenario [Source: Analysys Mason]*

Willingness to pay for mobile broadband

The willingness to pay for 3G services has been calculated on the basis of the choke price for the service. This choke price has been derived from the current level of prices and demand for mobile broadband. We have assumed a 4-5% increase in the nominal choke price, translating to a 1-2% annual drop in the choke price in real terms. Choke prices for both 3G and LTE services are compared in Figure B.6 below and are consistent across scenarios (assumes no change in number of mobile operators and penetration to be a factor of coverage rather than price).

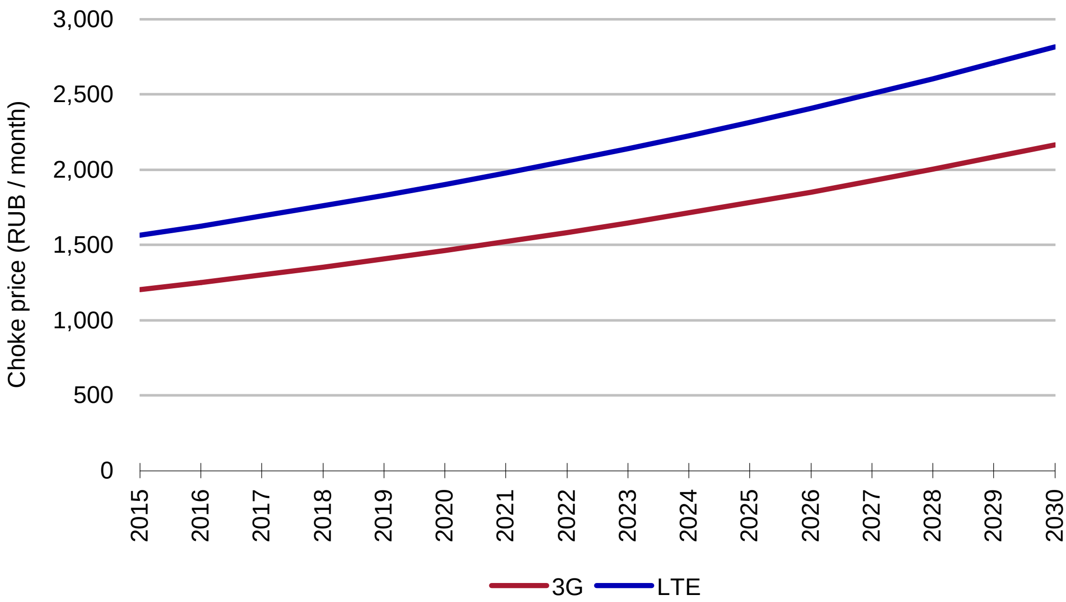

Figure B.6: Comparison of choke price for 3G and LTE mobile broadband [Source: Analysys Mason]

Mobile broadband prices are already relatively low in Russia, with consumer plans at approximately RUB400 (EUR9) per month in 2009. We do not expect it to be economic for these prices to drop significantly in the long run, and anticipate mobile broadband penetration to be driven primarily by increased coverage and speeds provided, rather than any significant drop in prices. We assume a 4-5% increase in choke price a year, which translates to a 1-2% annual reduction in real terms (see Figure B.7 below). LTE prices have been estimated on the basis of 3G prices, on which we applied a 30% premium to reflect the vastly superior bandwidth offered on next-generation networks.

Figure B.7 below compares 3G and LTE mobile broadband ARPUs over time. Prices are provided in real terms, to demonstrate the impact of inflation. These prices are assumed to be consistent across our scenarios.

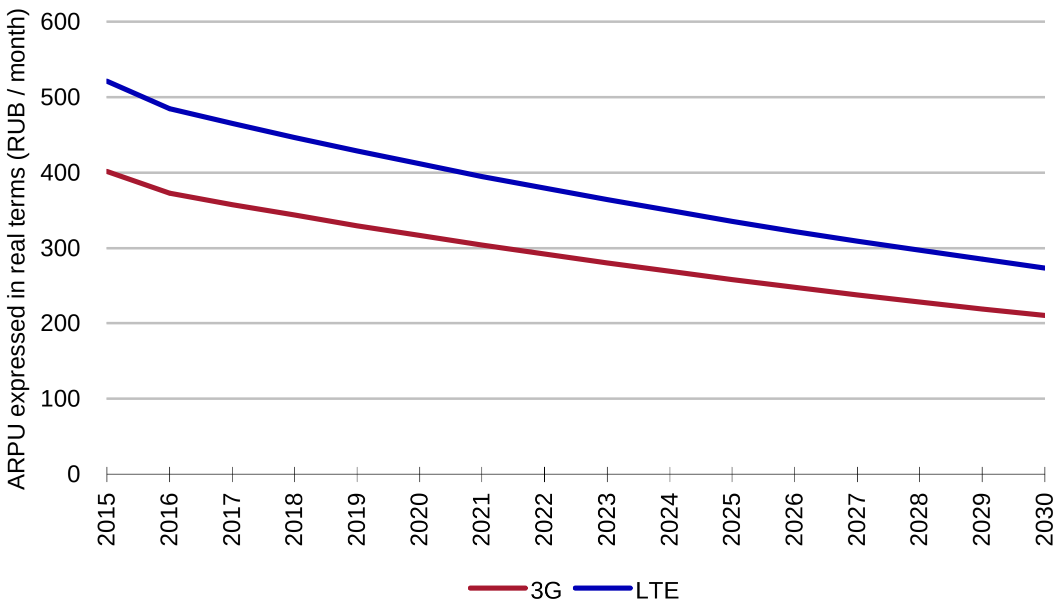

Figure B.7: *Comparison of 3G and LTE ARPUs expressed in real terms (i.e. taking into account inflation) [Source: Analysys Mason]*

B.2 Producer surplus for mobile broadband operators

Figure B.8 below illustrates the approach we have used to estimate the producer surplus for mobile broadband services.

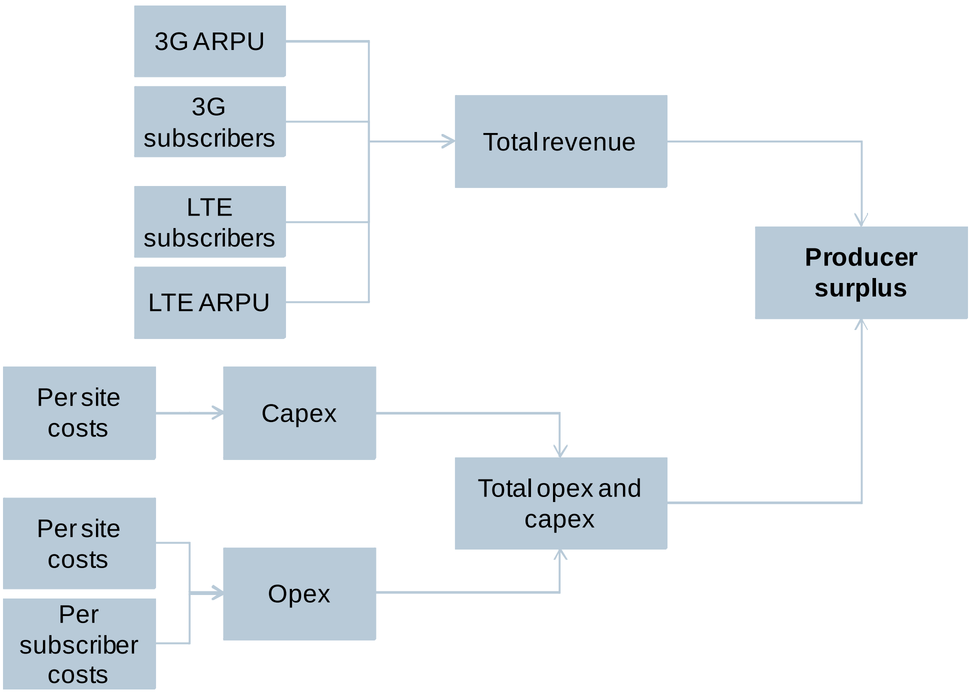

Figure B.8: *Mobile broadband producer surplus approach [Source: Analysys Mason]*

Revenue of the mobile broadband operators

Based on 3G ARPU, LTE ARPU and subscriber forecasts, we have been able to calculate the revenues that mobile broadband brings to the two scenarios. Figure B.9 below illustrates the difference in revenues between the two scenarios.

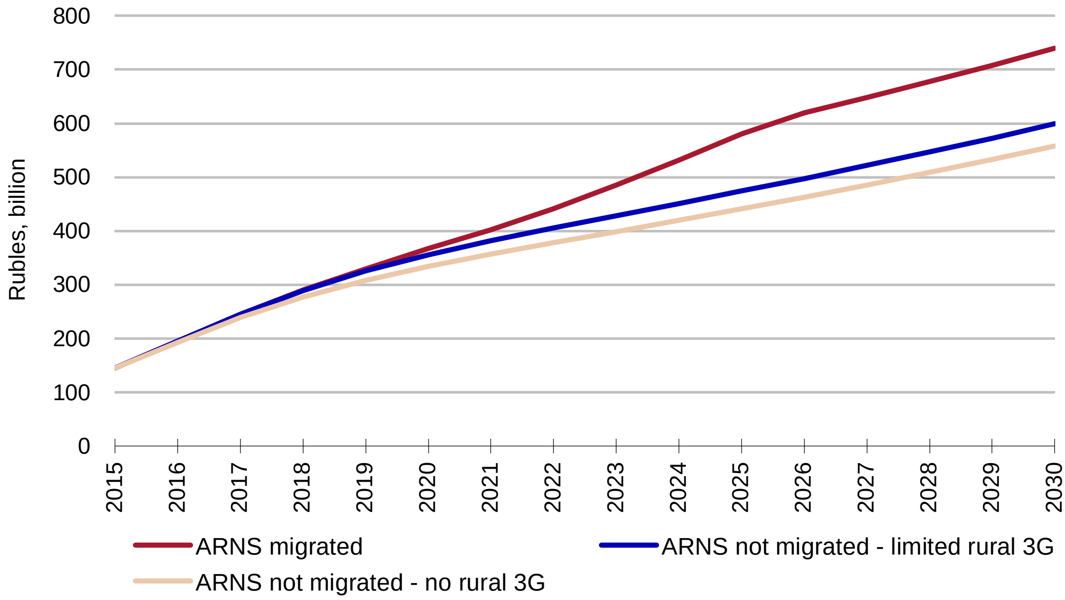

Figure B.9: Comparison of operator revenues in the two scenarios [Source: Analysys Mason]

Costs of the mobile broadband operators

In order to estimate the producer surplus, we modelled both operating expenses (opex) and capital expenses (capex). The opex model considers five types of costs:

- staff costs
- site running costs
- site maintenance costs
- marketing and commission
- G&A.

The level of costs that we have assumed have been set based on our internal databases as well as annual reports from European operators. We have assumed 30% network sharing in rural areas (3 operators), and 50% network sharing in urban areas (4 operators), which we believe will be necessary in order to maintain margins in providing mobile broadband services.

Figure B.10, Figure B.11 and Figure B.12 below illustrate the evolution of opex under the two scenarios (including both ARNS not migrated variants).

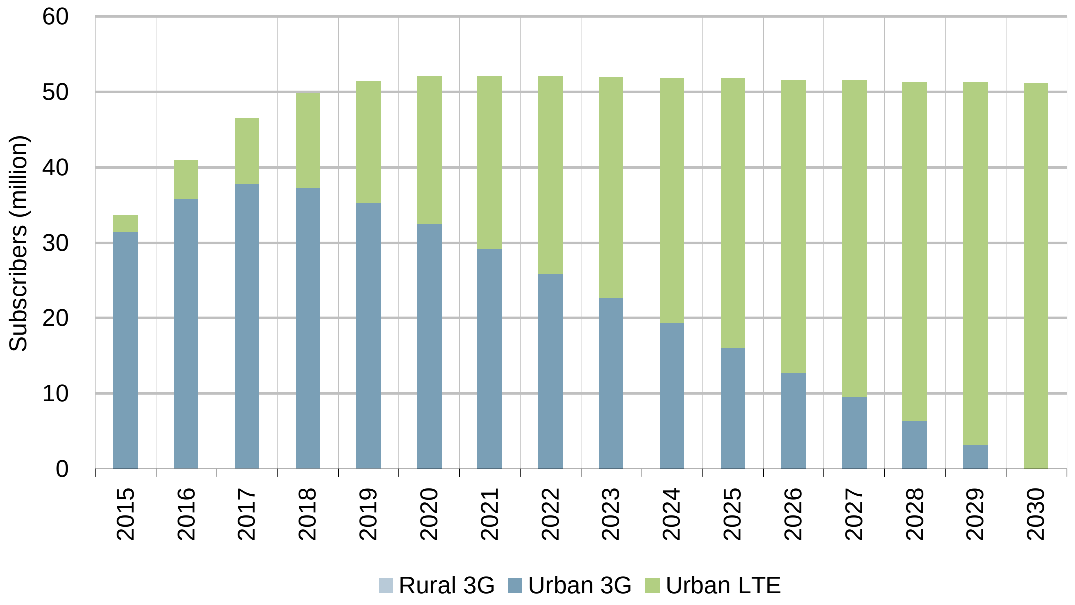

Figure B.10: *Evolution of opex, ARNS not migrated – no rural 3G, for one operator only [Source: Analysys Mason]*

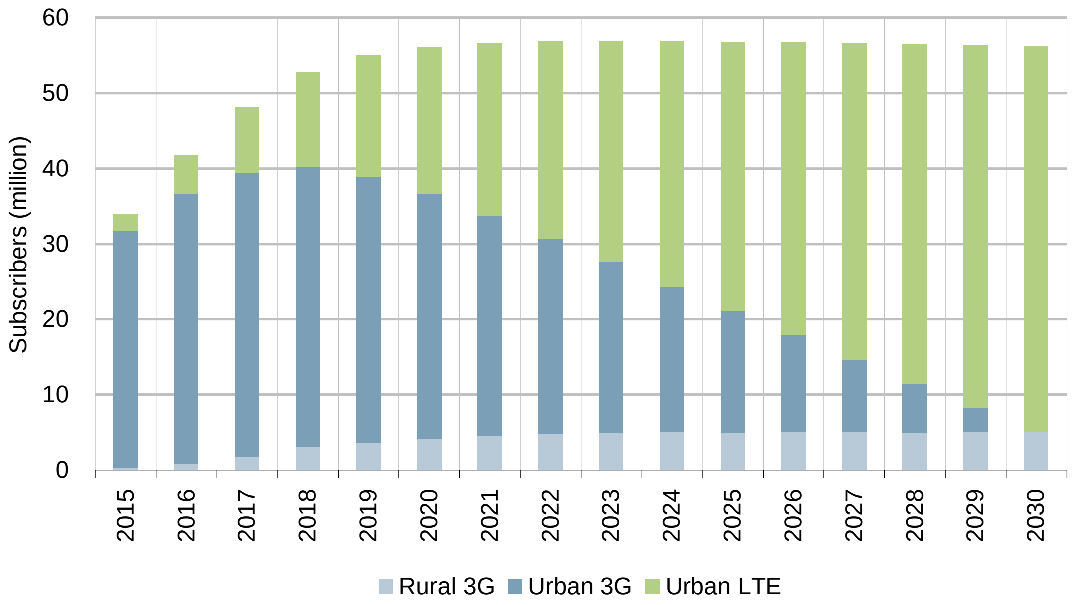

Figure B.11: *Evolution of opex, ARNS not migrated – limited rural 3G, for one operator only [Source: Analysys Mason]*

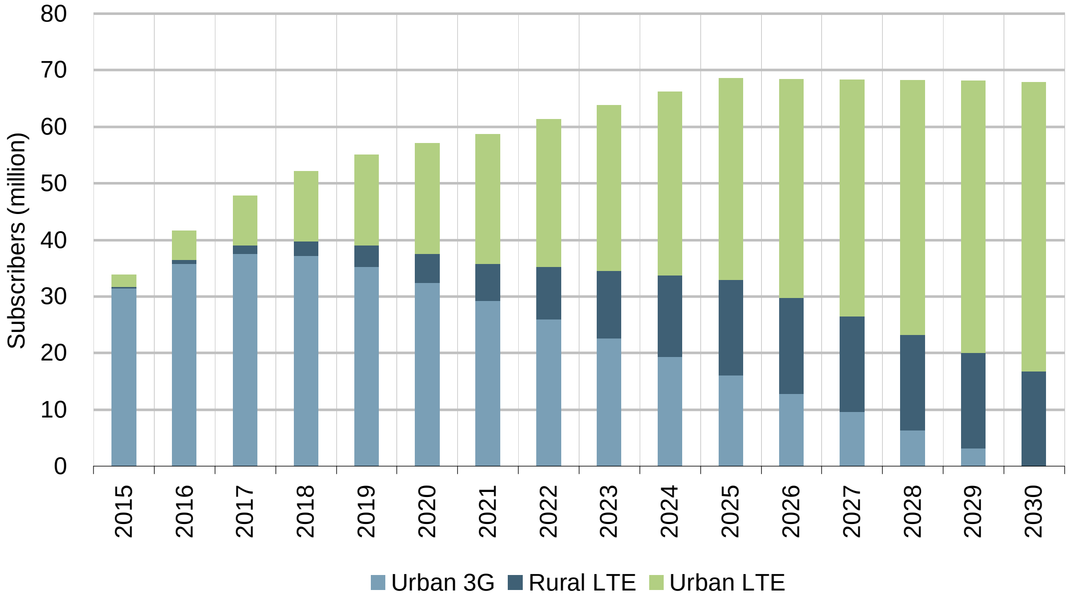

Figure B.12: *Evolution of opex, ARNS migrated, for one operator only [Source: Analysys Mason]*

Figure B.13 below compared the evolution of opex under both scenarios and variants.

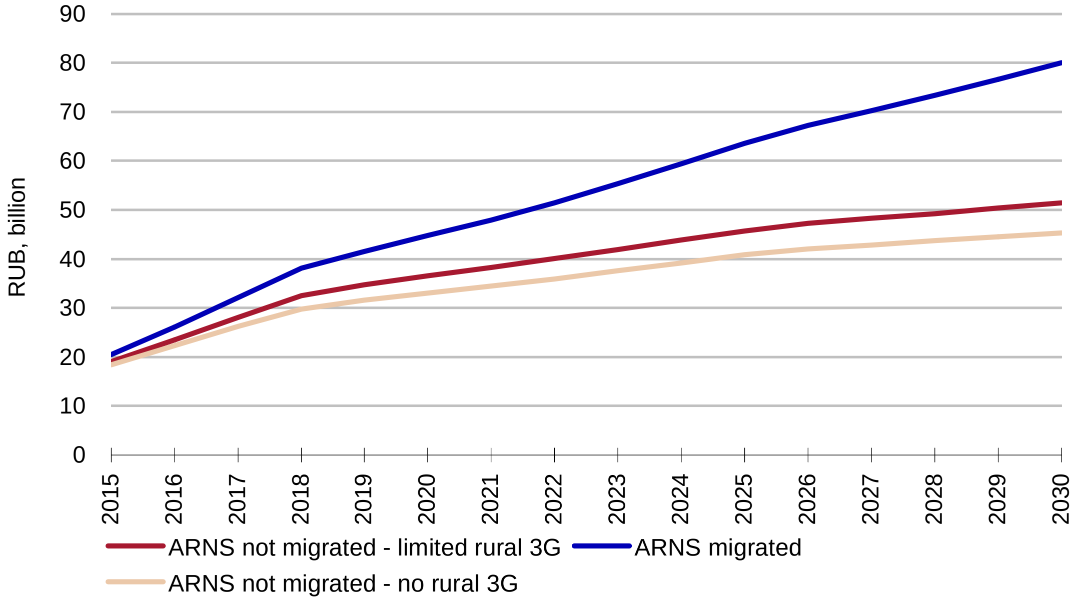

Figure B.13: *Comparison of opex under two scenarios and variants (for one operator only) [Source: Analysys Mason]*

The capex model considers two main types of costs: (a) site upgrade costs (e.g. 2G to LTE), including equipment and backhaul, and (b) replacement capex (as a percentage of cumulative capex). Capex has been calculated separately for 3G and LTE networks and for urban and rural areas. The level of costs that we have assumed have been set based on our internal databases as well as annual reports from European operators. Figure B.14 below compares the evolution of cumulative capex under both scenarios.

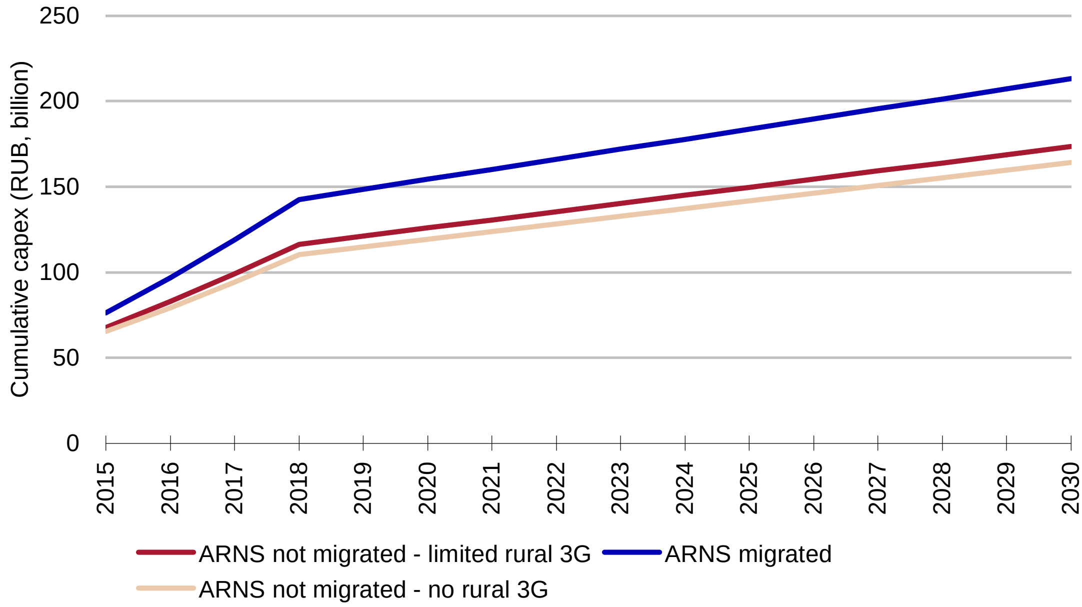

Figure B.14: *Comparison of cumulative capex under the two scenarios and variants (for one operator only) [Source: Analysys Mason]*

B.3 Results of the mobile broadband model

This section provides a summary of the NPV associated with using the released spectrum under the two scenarios (including both variants of the *ARNS not migrated* scenario) considered in this study, providing a detailed breakdown of both the consumer and producer surplus.[26] The results of our analysis are shown in roubles in Figure B.15 below, and in euros in Figure B.16.

26 As before we have calculated the NPV (2015–30) of the consumer and producer surplus using an estimated social discount rate of 10%, based on estimated GDP growth and an inflation forecast. The base year for the calculation is 2015. All calculations are made in roubles and converted in euros using the 2015 forecast exchange rate (43.6 roubles to the euro).

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	2.8	1.3	4.1	N/A
ARNS not migrated – limited rural 3G	3.0	1.3	4.3	0.3
ARNS migrated	3.3	1.4	4.8	0.7

Figure B.15: Value generated by mobile broadband services using digital dividend under the two scenarios (RUB trillions) [Source: Analysys Mason]

Scenario	*NPV of consumer surplus, 2015–30*	*NPV of producer surplus, 2015–30*	*NPV of private value, 2015–30*	*Incremental increase in private value compared to ARNS not migrated – no rural 3G*
ARNS not migrated – no rural 3G	65	29	94	N/A
ARNS not migrated – limited rural 3G	69	31	100	6
ARNS migrated	77	33	110	16

Figure B.16: Value generated by mobile broadband services using digital dividend under the two scenarios and variants (EUR billions) [Source: Analysys Mason]

These figures demonstrate that by migrating the ARNS services out of Bands IV/V, an additional RUB0.7 trillion of private value can be created (compared to *ARNS not migrated – no rural 3G*). Even in the *ARNS not migrated – limited rural 3G* variant, the additional private value created in RUB0.5 trillion. The majority of this additional value is derived from the additional consumer surplus, created by providing mobile broadband services in rural areas.