Valuing the use of spectrum in the EU

AN INDEPENDENT ASSESSMENT FOR THE GSMA

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In this report we provide an overview of the applications that use spectrum (in Europe) and their economic value. The opinions and conclusions expressed are those of Plum alone and do not represent official GSMA viewpoints.

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Executive Summary

S1 The aim of the study

For many applications spectrum is an essential input. But technology is changing spectrum requirements. In some cases technology stimulates demand for an application and the existing allocation is insufficient to maximise economic value; in other cases technology enables more efficient use of spectrum and less spectrum is required.

Recognising that the optimal allocation of spectrum between applications is changing, the European Commission is developing its wireless policy to improve spectrum allocation in Europe. This report, commissioned by the GSMA, provides an input to the European Commission's wireless policy. It offers an independent assessment in which we estimate, for 2013 and 2023, the economic value generated across the EU27 by applications which are major users of spectrum. Our estimates are as transparent as we can make them. Throughout the report we specify the methods we use and the assumptions we make, so that others can reproduce our findings.

S2 The selected applications

Figure S1 specifies the nine applications we have selected for assessment and indicates, for each, those components where we have quantified economic value. In making our selection we have selected those applications which make the greatest use of spectrum.

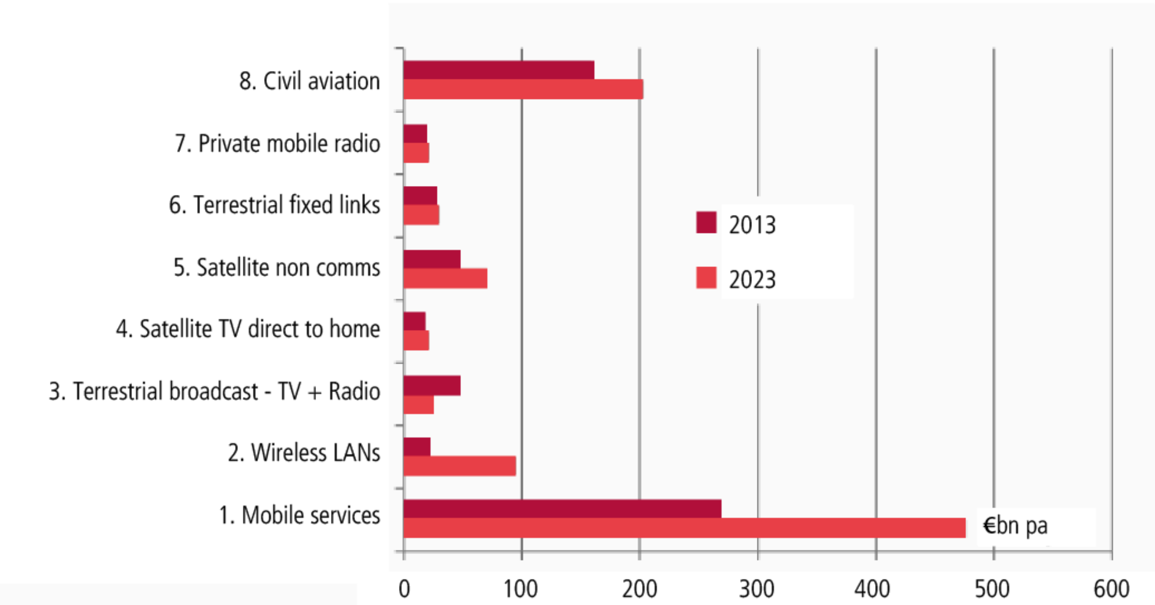
Figure S1: The applications selected for assessment

Application	Use of spectrum for	Quantified?
1. Mobile services	Mobile voice and SMS services Mobile data services	Yes Yes
2. Wireless LAN	Wi-Fi in the home, office and public places	Yes
3. Terrestrial broadcasting	Terrestrial TV broadcasting Terrestrial radio broadcasting	Yes Yes
4. Satellite communications	Direct to home (DTH) TV Satellite fix broadband Video distribution Marine and air passenger communications	Yes No No No
5. Satellite – non-communications	Positioning services Earth observation	Yes No
6. Terrestrial fixed links	Mobile and fixed backhaul Private networks	Yes Yes
7. PMR	Commercial uses – local and wide area Emergency services use	Yes Yes
8. Civil aviation services	Ensuring safe operation of civil aviation	Yes
9. PMSE	Studio and outside broadcasting Conferences and theatres	No No

S3 The main findings

Figure S2 presents our estimates of economic value.

Figure S2: The economic value of the selected applications in the EU at 2012 prices



Source: Plum Consulting

Mobile services already generate the greatest economic value by some distance - 269 billion in the EU27 in 2013. The next most valuable application is civil aviation, with an economic value of 159 billion.

We expect this gap to increase over the next 10 years as the economic value of mobile services grows to 477 billion in 2023. This growth is fuelled by two main developments:

- The central role which mobile services will play in the provision of broadband services. As end-users move to smart phones and operators roll out LTE, we will see a dramatic increase in the functionality which end users enjoy when using mobile services
- The development of the Internet of Things, where mobile networks are likely to provide an important transport mechanism for machine-to-machine communications. This development is uncertain but could generate just under €90 billion of additional economic value in 2023.

We also predict strong growth in the economic value of WLANs (Wi-Fi) over the next 10 years - from 22 billion in 2013 to 95 billion in 2023. This growth is largely complementary to that for mobile services. There are three main sources. WLANs:

- Enhance fixed broadband by allowing users more flexible use of devices in the home, office and many public places;
- Increase the opportunity for mobile offloads so as to reduce mobile network costs;
- Are likely to play an important role in connecting the Internet of Things.

The economic value of the other applications is also predicted to grow, but at a more modest rate. There is one exception – terrestrial broadcasting. Here we predict that:

- The economic value of terrestrial TV broadcasting will continue to decline as the households with the highest willingness to pay continue to move to pay satellite platforms, and as end users switch to IPTV and over-the-top broadband based services when viewing video content
- The economic value of terrestrial radio broadcasting will decline as users switch from broadcast radio to Internet radio – both at fixed locations and in cars.

S4 Interpreting the economic values

There are a number of important qualifiers to take into account when interpreting the economic values of Figure S2. The estimates and projections of economic value:

- Relate to the application, for which spectrum is an essential input, rather than to the spectrum *per se*
- Assume that the supply of spectrum will not constrain growth in the economic value of each application. In other words, we assume that the necessary steps are taken to allocate spectrum between applications in an efficient way over the next 10 years
- Include the value of civilian but not military use of spectrum
- Include private value[1] but exclude any public value. Almost all applications will have some public value. But this will vary between applications
- Include only the consumer surplus generated by the application and not the producer surplus[2]. In a competitive market producer surplus tends to zero. As suppliers seek to attract users so excess returns are competed away to zero[3].
- Do not indicate which applications need more spectrum. To assess the optimum allocation of spectrum between the applications we would need to consider, for each application, the change in economic value which results from adding or removing a MHz of spectrum.

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[1] That is the economic welfare generated because the end user who consumes the application has a willingness to pay which is greater than the cost of supply

[2] The producer surplus is that part of the private economic value which flows to the suppliers of the application. It measures the excess profit, over and above that which represents a normal return on capital employed.

[3] A previous study by Europe Economic for Ofcom in the UK in 2006 suggests that producer surpluses are sometimes negative and rarely more than 10% of consumer surplus, depending on the application

1 Introduction

1.1 The context and scope of the study

For many applications spectrum is an essential input. But technology is changing spectrum requirements. In some cases technology stimulates demand for an application and the existing allocation is insufficient to maximise economic value; in other cases technology enables more efficient use of spectrum and less spectrum is required.

Recognising that the optimal allocation of spectrum between applications is changing, the European Commission is developing its wireless policy to improve spectrum allocation in Europe. This report, commissioned by the GSMA, provides an input to the European Commission's wireless policy. It offers an independent assessment in which we:

- Estimate the economic value generated across the EU 27 by major civilian applications[4] which have been selected as major users of spectrum
- Estimate how these economic values might change by 2023.

Our estimates are as transparent as we can make them. In each of Chapters 3 to 11 we specify the methods we use and the assumptions we make, so that others can reproduce our findings and can calculate the impact which a change of input assumptions would have on our estimates of economic values.

1.2 Our definition of economic values

In estimating the economic value of each application we quantify the ***private*** value of the application but exclude any ***public*** value (sometimes termed social value[5]). We define the private value of the application as:

- The willingness to pay for the application by those who use it *less*
- The cost of providing the application.

The user does not necessarily pay for the application, as in the case of free-to-air terrestrial TV, and the value is determined by the willingness to pay rather than the actual price paid.

There may be wider public value, as well as private value, associated with the application. The public value is the value which the application generates in addition to the private value. Sometimes this is socio-political in nature - for example the contribution of public service broadcasting to a coherent society. Sometimes it is economic in nature – for example the increase in value for existing mobile subscribers when new subscribers join the network. Quantifying the public value often involves subjective judgement and we exclude such quantification from our analysis. That does not mean that public value is unimportant in reaching policy decisions.

[4] Military applications are excluded from our study

[5]. Social or public value is often not well understood (e.g. amount of pollution, gain in feeling secure, social cohesion), as it relates to impacts that are not mediated through market transactions.

Our estimates of the economic value of each application:

- Assume that the supply of spectrum will not constrain growth in the economic value of each application. In other words we assume that the necessary steps are taken to allocate spectrum between applications in an efficient way over the next 10 years
- Are expressed at constant 2012 prices throughout and do not include any inflationary effects
- Are expressed, as appropriate, in terms of both midpoint estimates and ranges. The latter measure the uncertainty in our estimates.

It is important to note that the economic values relate to the selected applications. They do not measure the value of the spectrum which is used by the application.

1.3 Our approach to measuring the economic value

The method we use to estimate economic values varies with the application under consideration. We use four methods:

- Where they exist, we use data from willingness-to-pay surveys and then subtract the economic costs of supply[6] (e.g. when estimating the economic value of TV broadcasting applications). This is the most direct way to measure private economic value. But willingness-to-pay estimates are not always available and so we also use other approaches
- We combine estimates of the price elasticity of demand with supplier revenues. Appendix A provides a discussion of this approach. It is applicable to commercial applications where the price charged for the application is designed to recover the costs of supply (e.g. for satellite pay TV services)
- We use estimates from other studies of the productivity gains generated by use of the application (e.g. for global positioning satellite services)
- We estimate the efficiency savings which are generated by using the (wireless) application rather than a wireline alternative (e.g. for terrestrial fixed links)

We state which approach is used in each of the chapters on the individual applications. In some cases we are able to use more than one method. This helps establish the likely range within which the true economic value will fall.

In making our estimates we consider only the consumer surplus generated by the application and not the producer surplus. The producer surplus is that part of the private economic value which flows to the suppliers of the application. It measures the excess profit, over and above that which represents a normal return on capital employed. In a competitive market producer surplus tends to zero. Previous similar studies[7] indicate that the producer surplus is small compared with the consumer surplus and may be either positive or negative. We assume that it is zero and hence that the revenues flowing to suppliers are a good approximation of the economic costs of supply.

[6] i.e. the financial costs plus a reasonable return on capital employed

[7] *Economic impact of the use of radio spectrum in the UK*, Europe Economics, November 2006

2 The selected applications

Figure 2-1 specifies the nine applications we have selected for assessment and indicates, for each, those components where we have quantified economic value. In making our selection we have:

- Excluded military applications
- Selected those applications which make the greatest use of spectrum – especially at frequencies below 10 GHz, where utilisation of spectrum is at its greatest
- Selected applications which are under investigation by the European Commission in its current study on demand for spectrum in the EU[8]. This will be published in mid-2013.

We have quantified economic value where suitable data is available, as indicated in the third column of Figure 2-1. Wherever possible we have tried to use data which cover the EU as a whole or a significant subset of its member states. But in many cases such data are not available. So we have had to rely on data limited to one or a small number of member states and have extrapolated to the EU as a whole. In some cases the values for the EU rely on extrapolation from the UK alone.

In the nine chapters which follow we assess each of the applications in turn.

Figure 2-1: The applications selected for assessment

Application	Use of spectrum for	Quantified?
1. Mobile services	Mobile voice and SMS services Mobile data services	Yes Yes
2. Wireless LAN	Wi-Fi in the home, office and public places	Yes
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8. Civil aviation services	Ensuring safe operation of civil aviation	Yes
9. PMSE	Studio and outside broadcasting Conferences and theatres	No No

[8] *Analysis of technology trends, future needs and demand for spectrum in line with Art. 9 of the RSPP*, Analysys Mason for the European Commission,2013

3 The economic value of public mobile services

3.1 Introduction

We include under the heading of public mobile services:

- Cellular mobile voice services
- SMS
- Mobile data services made available through mobile broadband access to the Internet
- The wide range of applications available on smart phones using 3G or 4G networks
- Use of mobile networks for machine-to-machine communication.

We consider terrestrial but not satellite mobile services. The latter are included within the definition of satellite communications services discussed in Chapter 5.

3.2 The scale of the application

Mobile services are now ubiquitous across the EU. According to the European Commission's Digital Agenda database[9]:

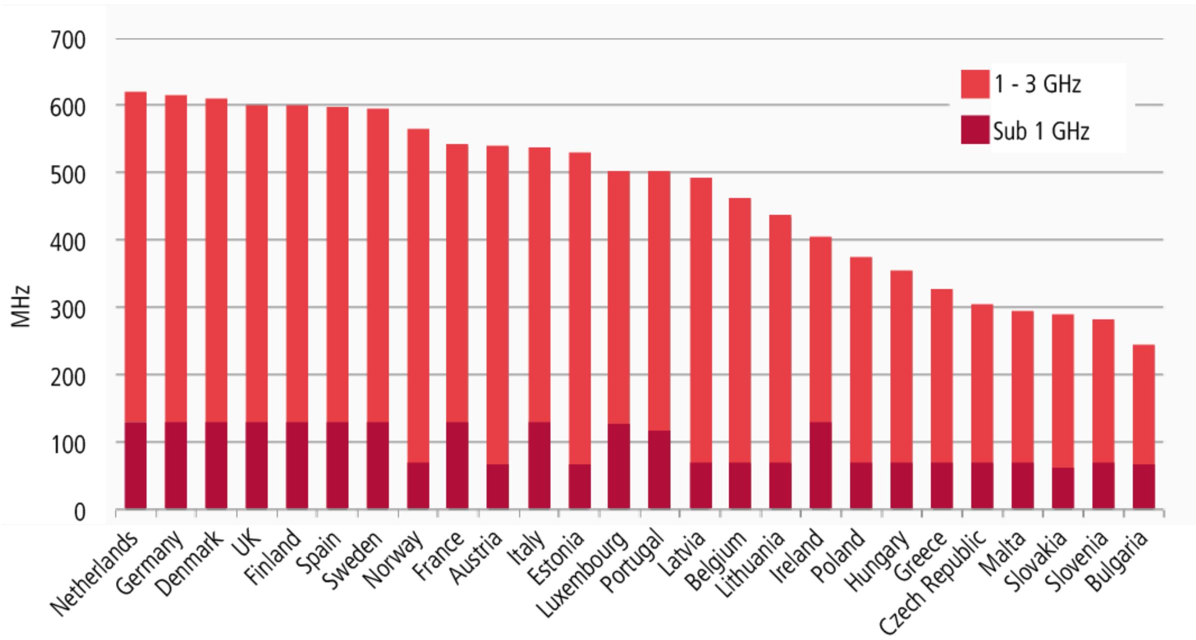
- There are now 650 million mobile subscriptions in the EU27 serving 505 million people
- These subscriptions generate service revenues of €200 billion each year.
- The penetration of mobile services varied relatively little across the EU27 in 2011 - from 163 subscribers per 100 people in Finland to 99 subscribers per 100 people in France.

3.3 The application's use of spectrum

Mobile services in the EU typically use spectrum in the 900, 1800 and 2100 MHz bands. Spectrum authorities have also recently auctioned significant quantities of spectrum at 800 and 2600 MHz. As a result mobile services in a typical member state now have access to over 500 MHz of spectrum at frequencies below 3 GHz. Figure 3-1 illustrates.

[9] http://ec.europa.eu/digital-agenda/en/download-data

Figure 3-1: The spectrum allocated to mobile services in the EU



Source: Plum Consulting

The spectrum allocated to public mobile services is likely to increase in future. A draft Opinion from the Radio Spectrum Policy Group identifies the following bands as candidates for meeting future spectrum demand for mobile broadband. Most of which will not be available until after 2015[10]:

- 470 to 790MHz. This is the entire UHF TV band. The report recommends that a long term strategy for the band is required. In respect of the 694 to 790MHz part of the band there is a draft mandate from the European Commission to CEPT[11] to undertake technical work required for wireless broadband use of 700MHz in advance of any policy decisions on future use of the band. At a policy level debate has now started at a European level[12] on possible approaches to reorganise the band.
- 1300 to 1518 MHz: In September 2012 CEPT started regulatory work to harmonise the 1.4 GHz band for a supplemental downlink (SDL)[13] and an ECC Decision is expected by September 2013[14]. The frequency arrangement across the frequency range 1300 to 1518 MHz is being considered more generally in the context of preparations for WRC 15 Agenda item 1.1.
- 1800 to 1900MHz. This band is already harmonised but is used for DECT services

[10] https://circabc.europa.eu/d/d/workspace/SpacesStore/9367e691-df81-408c-a17e-ef895449bd7f/RSPG13-511_Rev1_Draft%20Opinion%20Wireless%20Broadband.pdf; https://circabc.europa.eu/sd/d/02b8e0db-957c-4a86-9f82-8d361290c5cd/RSPG13-511_Annex%202_Rev1_Candidate%20bands%20for%20wireless%20broadband%20docx.pdf

[11] https://circabc.europa.eu/sd/d/9ef9311a-5b0e-4e80-b92c-e387cb885d6d/RSCOM12-37rev1_Mandate_CEPT_700_MHz_draft_updated.pdf.

[12] Draft RSPG Report on proposed spectrum co-ordination approach for broadcasting in the case of reallocation of the 700MHz band, RSPG12-433, October 2012

[13] See Minutes of the 75th WG FM Meeting. Note: in CEPT, SDL is referred to as Mobile/Fixed Communication Networks (MFCN) Supplemental Downlink (MFCN SDL).

[14] CEPT FM 50 is to develop least restrictive technical conditions for SDL use at 1452-1492 MHz and this work is expected to be completed in May 2013.

- 1980 to 2010MHz/2170 to 2200MHz. This band is assigned to mobile satellite services though in many EU countries services are not operational
- 2.3 to 2.4GHz. This band is used by programme makers and military and aeronautical systems in some countries. CEPT is examining the possibility of developing harmonised implementation measures for mobile broadband including 1) least restrictive technical conditions (LRTC), taking into account the existing standardisation framework and activities at the worldwide level, and an appropriate frequency arrangement and 2) regulatory provisions based on licensed shared access ensuring the long term incumbent use of the band in the territory of the administrations that wish maintain such use.
- 3.8 to 4.2GHz. This band is currently used by satellite services and terrestrial fixed links and the RSPG has suggested that sharing options could be examined in Europe.

3.4 The main sources of economic value

The sources of economic value for mobile services are changing rapidly. Ten years ago almost all of the value was generated by voice services and SMS. Mobile phones were used in business to increase the value of otherwise unproductive travelling time, to improve logistics and decision-making and to empower small businesses with staff frequently on the move. For consumers, and especially young people, mobile phones enriched their social lives.

Now the combination of mobile data services running on 3G networks using smartphones has greatly expanded the functionality of mobile services. Typically users spend less than 15% of their time[15] using the mobile device to make voice calls. The bulk of the time is spent browsing the Internet, accessing Internet services such as Facebook, or using one of the many hundreds of thousands of Internet-based applications which are available for smartphone users. In addition smartphone users have access to many local functions. For many the smartphone is now their diary, camera, photo album, alarm clock and principal source of recorded music.

3.5 Drivers of future economic value

When considered from a qualitative perspective it is clear that the economic value of mobile services has increased substantially over the past five years, in ways which few would have envisaged in 2007. So it is difficult to predict all of the changes which might occur over the next ten years. However we can identify two changes which we quantify in the next section.

- The transition of users from basic phones to smartphones and from 2G to 4G networks will increase economic value overall. Figure 3-2 illustrates why, as they make such a transition, the willingness to pay by end users increases. Figure 3-3 then provides our estimates of how the mix of users in the three categories shown in Figure 3-2 might change by 2023.
- The development of the Internet of Things, in which machines communicate with each other and with the people they serve. Mobile networks are likely to be the communications network which enables machine-to-machine communication in a significant number of cases.

[15] See O_2 survey http://news.o2.co.uk/?press-release=making-calls-has-become-fifth-most-frequent-use-for-a-smartphone-for-newly-networked-generation-of-users

Figure 3-2: How willingness to pay for mobile services is increasing

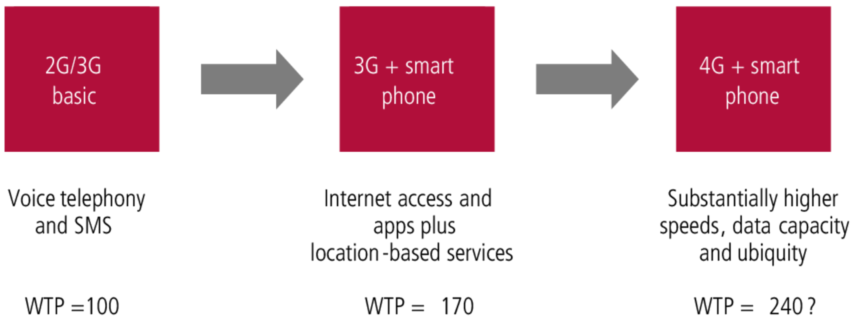
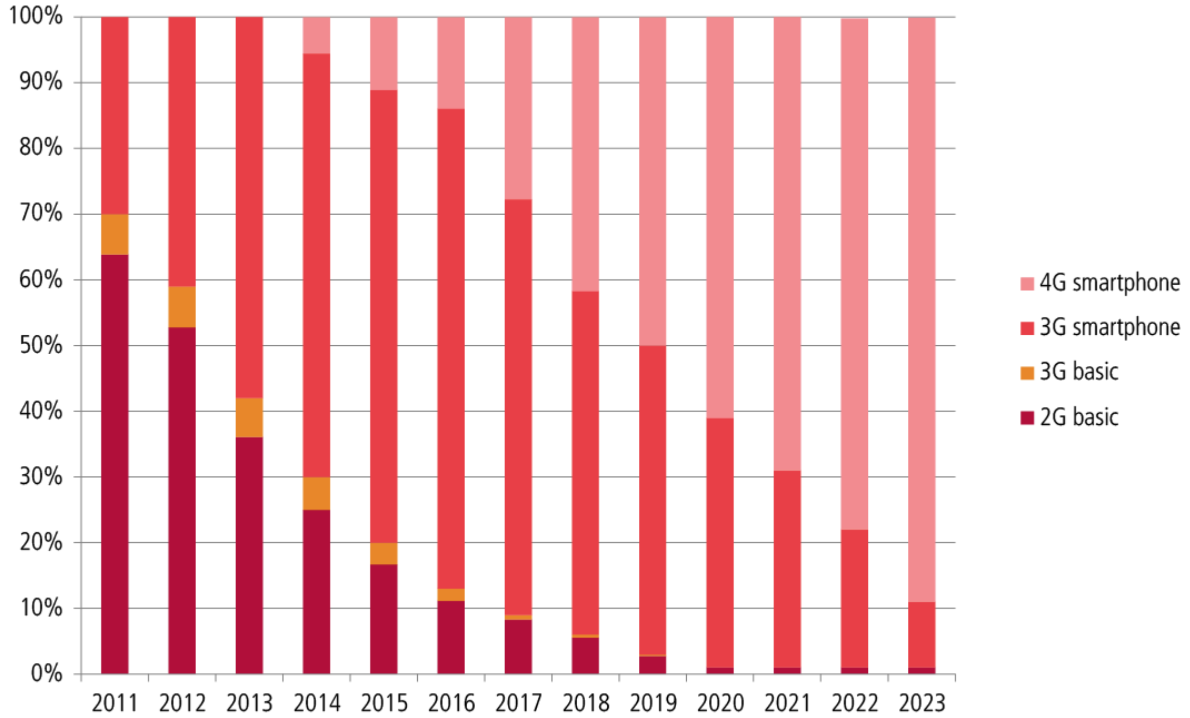


Figure 3-3: How people are migrating to mobile services with greater functionality



Source: Analysys Mason – study for DCMS (2012)

3.6 Estimating the economic value of mobile services

The economic value of mobile services used by people

To estimate the value of mobile services used by people, rather than machines, we use a willingness-to-pay approach. This is based on the equation set out in Figure 3-4 below.

Figure 3-4: The economic value of mobile services based on willingness to pay

$$EV(t) = S(t)*[a(t)*w1(t) + b(t)*w2(t) + c(t)*w3(t)] - R(t)$$

where :

- $EV(t)$ = economic value at time t
- $S(t)$ = total number of mobile subs at time t
- $a(t)$ = % subs with 2G or 3G but no smartphone at time t
- $b(t)$ = % subs with 3G + smartphone at time t
- $c(t)$ = % subs with 4G + smartphone at time t
- $w1(t)$ = WTP by subs type a at time t
- $w2(t)$ = WTP by subs type b at time t
- $w3(t)$ = WTP by subs type c at time t
- $R(t)$ = total end user revenues at time t (i.e. we assume the economic profit of the mobile sector is zero)

The values and sources for each variable on the right-hand side of this equation are tabulated in Figure 3-5.

Figure 3-5: The values used in estimating the economic value

Variable	Plum estimate for		Source
	2013	2023	
Subs in EU27 (m)	650	700	Digital Agenda Europe database + Plum extrapolation
Revenues in EU27 (bn)	200	220	Digital Agenda Europe database + Plum extrapolation
% of subscribers with: 2G/3G + basic phone 3G + smartphone 4G + smartphone	 42% 58% 0%	 <2% 11% >87%	See Figure 3-3
WTP by subscribers (pa): 2G/3G + basic phone 3G + smartphone 4G + smartphone	 526 841 1262	 388 620 931	See text below

Source: Plum Consulting. All monetary values are expressed in constant 2012 prices

Willingness to pay by subscribers using basic phones (and 2G or 3G networks) is based on the willingness to pay implied by two studies – one by Europe Economics for Ofcom[16] and the other by Analysys Mason for the UK Government[17]. These calculate the economic value of mobile services in the UK. Our estimates suggest that willingness to pay declined at 3% per annum between 2006 and 2011. We apply this reduction in willingness to pay through to 2023[18] and assume that our estimates apply to the EU 27 as a whole.

The willingness to pay by subscribers using smart phones over 3G networks is set at a 70% premium to these values. From inspection of mobile tariffs we note that subscribers using smartphones and 3G networks typically pay twice as much as basic users. We take a conservative view and assume a 70%, rather than a 100%, premium.

Estimating the willingness to pay by subscribers using a smart phone over a 4G network is more speculative. However, we note that the move from 3G to 4G networks typically offers a five-fold increase in broadband speeds and a five-fold reduction in operator costs per gigabyte[19]. In addition the use of sub 1 GHz spectrum by 4G networks will significantly increase the indoor coverage of mobile broadband – from 82% to 98% in the UK, according to a mix of industry reports and Ofcom publications[20]. We also note that, in recent surveys, Ofcom reports[21] that many users are prepared to pay a 50% premium for greater mobile broadband capacity and coverage. We assume a 40% premium in willingness to pay by 4G smartphone users relative to 3G smartphone users.

Putting the estimates of Figure 3-5 into the equation of Figure 3-4 gives us an economic value for the EU 27 of:

- €269 billion per annum in 2013
- €388 billion per annum in 2023.

The economic value of mobile services used by machines

We expect machine-to-machine (M2M) communications to grow rapidly over the next 10 years and to generate substantial economic value. M2M communications complements person-to-machine and person-to-person communications to provide what Cisco calls the *Internet of Everything*. Just as the Internet has generated substantial economic gains in the past from person-to-machine communications, Cisco predicts that M2M communications could lead to corresponding economic gains in future. In its recent White Paper[22] it estimates that, over the next 10 years, M2M communication could generate cumulative economic value for the global economy of $6,400 billion. This estimate is consistent with estimates produced by Machina Research for the GSMA[23], when we compare on a like-for-like basis. The economic value is generated through a wide range of productivity and efficiency effects which include:

- Smart factories and smart energy grids
- Better targeted advertising

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[16] *Economic impact of the use of radio spectrum in the UK*, Europe Economics, November 2006

[17] *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand*, Analysys Mason for DCMS, November 2012

[18] This reflects the fact that end-users who move from basic to higher functionality mobile service have a greater willingness to pay than those who remain using the basic service.

[19] See for example Verizon statement of 25 February 2013 at http://www22.verizon.com/investor/DocServlet?doc=vz_morganstanley_transcript.pdf

[20] *Assessment of future mobile competition and award of 800 MHz and 2.6 GHz*, Ofcom, July 2012

[21] *Securing long term benefits from scarce low frequency spectrum: UHF strategy statement*, Ofcom, November 2012

[22] *Embracing the Internet of everything*, Cisco, 2013

[23] *Connected life: a US$4.5 trillion global impact by 2020*, Machina Research, February 2012

- Intelligent buildings and transport systems
- Major improvements in home health and social care.

If Cisco's predictions are correct then they would mean an annual economic value for Europe of 220 billion or more by 2023 from M2M communications.

The proportion of this economic value which should be assigned to mobile networks is uncertain. According to the OECD [24] mobile networks, WLANs and PANs[25] will all play a role in M2M communication. It is also reasonable to assume that other dedicated networks might play a role. We expect mobile networks will generate a significant proportion of the total economic value, given that many of the high-value applications of M2M communication will require a nationwide wide area network to be viable. So we assume that:

- A 40% share of the economic value is attributable to mobile services in 2023.
- A 25% share of the economic value is attributable to WLANs in 2023. This assumption is used in Chapter 4
- The remaining 35% is attributable to other networks such as personal area networks, proprietary terrestrial M2M networks, and satellite-based networks.

For 2013 we assume that the economic value for M2M communications over mobile networks is zero, given that M2M communications is still in its infancy. According to Machina Research[26] revenues will grow from $0.2 billion in 2011 to $1200 billion by 2022 worldwide. For 2023 we estimate an economic value of 89 billion[27].

The total economic value of mobile services

Adding together the economic values from personal and machine use of mobile services gives us total economic values of:

- €269 in 2013
- €477 billion in 2023

These estimates are consistent with the estimates produced by Europe Economics in 2006 and Analysys Mason in 2011 for the UK. If we scale these numbers up from the UK to the EU pro-rata to GDP, we get the estimates shown in Figure 3-6.

[24] *Machine-to-Machine Communications: Connecting Billions of Devices,* OECD, January 2012

[25] Personal area networks

[26] *M2M Global Forecast and Analysis 2011-22,* Machina Research, November 2012

[27] 220 billion x 40%

Figure 3-6: Plum estimates compared with previous studies

Year	Economic value (bn)	Study
2006	183[28]	Europe Economics
2011	253[29]	Analysys Mason
2013	269	Plum
2023	477	Plum

Source: Plum Consulting - at 2012 prices

[28] UK estimate grossed up to EU27 pro rata to GDP

[29] UK estimate grossed up to EU27 pro rata to GDP

4 The economic value of wireless LANs

4.1 Introduction

Wireless LANs (WLANs)[30] use spectrum allocated to short range devices to provide short-range[31] wireless access to fixed broadband services for a range of devices. This includes desktop PCs, laptops, printers and other ancillary devices, tablets and smart phones.

4.2 The scale of the application

WLAN connections are widely used around the world:

- Almost all fixed broadband connections[32] now use wireless routers to provide access to fixed broadband for multiple devices in the home and office
- WLAN services are offered in many public places – such as cafes, libraries, and shops as well as airport and railway terminals. In some cases access is free. In others there is a charge, which is often bundled with monthly mobile subscriptions
- In some cases WLAN services are offered, usually free of charge, by a university campus or a town.

Figure 4-1 provides estimate of the extent to which WLAN capability is embedded into devices.

Figure 4-1: The global population of WLAN enabled devices worldwide

Device type	Installed base (millions)	% with WLAN capability	Source
Desktop PCs	1900	Tens of %	Gartner 2012
Laptops	200	Near 100%	Cisco VNI 2013
Smart phones	1500	Near 100%	Cisco VNI 2013
Tablets	200	Near 100%	Transparent Market Research 2012

Source: Plum Consulting

In total we estimate that nearly 3 billion devices are WLAN capable. In Europe the figure is around 900 million. The widespread use of WLAN access reflects the fact that:

- The cost of adding a WiFi chip is only a tiny fraction of the cost of the device itself
- Evolving WiFi standards are backward compatible

30 Commonly known by the brand-name Wi-Fi

31 Typically less than 100 metres using the 802.11n standard

32 Of which there are 150 million in Europe according to the Digital Agenda database

Figure 4-2 shows how the WiFi standards have evolved to match growing demand for higher broadband speeds.

Figure 4-2: The evolving WiFi standards

Standard	Spatial streams	Headline speed (Mbps)	Maximum feasible speed (Mbps)	Average speed (Mbps)	Channel width (MHz)	Headline spectral efficiency (Mbps/MHz)
802.11n	1	150	90	29	40	3.75
802.11n	2	300	180	59	40	7.50
802.11ac	1	325	195	63	80	4.06
802.11ac	2	870	522	170	80	10.88
802.11ac	3	1,300	780	254	80	16.25
802.11ac	4	3,467	2,080	676	160	21.67

Source: From http://www.wca.org/event_archives/2011/WCA_Peter_Ecclesine_White%20Space_Broad_20_Oct2011_r3.pdf

4.3 The application's use of spectrum

WLAN access uses spectrum on a licence exempt basis at:

- 2.4 GHz (2400 to 2483.5 MHz) where WLAN shares spectrum with emissions from a wide range of industrial, scientific and medical applications. The best known and most ubiquitous application is microwave ovens.
- 5 GHz (5150 to 5350 MHz and 5470 to 5725 MHz) where the band is shared with radars. Dynamic frequency selection (DFS) technology must be used in part of the band to limit interference with radars.

It is possible that the 5GHz band will be expanded in future. In February 2013 the FCC published a Notice of Proposed Rulemaking (NPRM)[33] on use of Unlicensed National Information Infrastructure (U-NII) devices (i.e. Wi-Fi devices) in the 5 GHz band. The main proposals include making available an additional 195 MHz of spectrum for U-NII use at 5350 to 5470 MHz and 5850 to 5925 MHz. It is widely expected that this NPRM will result in expansion of the 5GHz WiFi band in the US.

If the same frequency range was made available in Europe then this would have the effect of adding 320 MHz to the use of this frequency range by WLANs. There is 270MHz of additional spectrum currently not allocated for WiFi and there is also a significant reduction in the amount of spectrum required for guard bands. Similar moves to those of the FCC are currently under consideration by the European Commission in the context of its work on the spectrum inventory.

4.4 The main sources of economic value

WLAN access creates three main sources of economic value:

[33] http://transition.fcc.gov/Daily_Releases/Daily_Business/2013/db0220/FCC-13-22A1.pdf

- It enhances the value of fixed broadband by allowing multiple devices to connect seamlessly for use from any location within a home or office. We do not have data for the EU. But in the US the average household owns five Internet connected devices and 6% of households own 15 or more such devices.[34]
- It significantly lightens the load on mobile networks. Mobile devices are mostly used in the home, office, or locations where public Wi-Fi is available and, according to Cisco[35], smartphone and tablet users generate four times more traffic over WLANs than over cellular networks. Without WiFi a significant portion of this traffic might otherwise be carried over mobile networks at an additional cost to the economy
- It is an obvious way to provide machine to machine communications for many applications. In 2003 the price of a Wi-Fi chipset was around €15; today the price is nearly two orders of magnitude lower[36]. Such cheap chips are an obvious way to enable many devices to communicate machine to machine. For example Wi-Fi might be used to collect information from monitoring devices in the home of a frail elderly person for relay to a centre which monitors the health and well-being of the householder.

4.5 Drivers of future economic value

We expect all three sources of economic value for WLAN access to grow over the next 10 years.

First WLAN access will increase the value of fixed broadband as the number of devices which communicate within the home continues to grow. At the same time the speed of WLAN access will increase – partly with a move to the new 802.11ac standard and partly as result of additional spectrum at 5 GHz being allocated for WLAN use. In particular we anticipate:

- Considerable use of WLAN to connect TVs to the Internet
- Use of WLAN for local device-to-device communication. For example WLANs might connect a smartphone to a full-size monitor to display video content captured on the former.

Secondly WLANs will become a more important complement to mobile cellular networks in providing broadband connectivity to mobile devices like tablets and smart phones. Over the next five years Cisco[37] forecasts an eight-fold increase in mobile data traffic. At the same time it estimates that, for every GB sent over a mobile network, mobile devices send 4 GB of traffic over the fixed network using WLAN access. It would be very expensive for the mobile operators to carry this additional traffic on their networks, while the incremental cost of using a WLAN and a fixed broadband network is close to zero. Without the additional capacity provided by WLANs, users would find their mobile devices substantially less valuable.

Finally we can expect machine-to-machine (M2M) communications to grow rapidly over the next 10 years and to generate substantial economic value. WLANs have an important role to play here, as discussed in more detail in Chapter 3.

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[34] http://go.bloomberg.com/tech-blog/2012-08-29-average-household-has-5-connected-devices-while-some-have-15-plus/

[35] *Cisco Visual Networking Index; 2012-2017*, Cisco, February 2013

[36] Compare current prices at http://www.alibaba.com/showroom/wifi-chipset-price.html with prices 10 years ago. See http://www.crn.com/news/networking/18822711/wi-fi-chip-prices-expected-to-drop-dramatically-this-year.htm

[37] *Cisco Visual Networking Index; 2012-2017*, Cisco, February 2013

4.6 Estimating the economic value of WLANs

Enhancing fixed broadband

Based on an end-user survey by Perspective Associates in the US in 2009, Thanki[38] estimates that use of WLANs with fixed broadband increases the willingness to pay by the average home household by between $118 and $225 each year. Let us assume that:

- These estimates are valid and we assume an increased willingness to pay of $171 pa
- There are 195 million households in Europe
- 80% of them use fixed broadband[39]
- The cost of providing a wireless router is €20 per household

It is then a relatively simple matter to calculate the economic value of WLAN access at **18 billion**[40] in 2013.

Another way to estimate this component of the economic value of WLAN access is to consider what percentage of households might disconnect their fixed broadband if WLAN access were not available. Let us assume that:

- 15% of households (23 million) using fixed broadband would disconnect if WLAN access were not available[41]
- Each of them pays €25 per month or €300 per year
- Price elasticity of demand for fixed broadband is -0.3 and the demand curve is linear

Then the reduction in consumer surplus without WLAN access is **12 billion** in 2013[42] Averaging over the two estimates gives us an economic value of **15 billion** in 2013.

To predict how this consumer surplus might change by 2023 let us assume that:

- The percentage of households with fixed broadband grows to 95%
- The value per household grows by a further 30% in real terms to reflect the increased number of digital devices in the home.

With these assumptions the consumer surplus might grow from **15 billion** in 2013 to **23 billion** in 2023[43].

The economic value of mobile offloads

To estimate the value of mobile offloads in 2013 we assume that:

- Mobile networks in Europe carried 276 PB per month[44]

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[38] *The economic significance of licence exempt spectrum to the future of the Internet*, Richard Thanki, June 2012

[39] Digital Agenda database

[40] [$171 x 0.76 /$ x 195 million households x 80%] less [20 x 195 million households x 80%]

[41] Thanki estimates disconnections at between 11% and 25%

[42] [300 x 23 million households]/[2 x0.3]. See Appendix A for details

[43] 15 billion x 95/80 x 1.3

[44] Cisco VNI 2012 to 2017

- For every GB generated by a mobile device and carried over a mobile network there are 4 GBs carried using WLAN access[45]
- In the absence of WLANs 33% this traffic would be carried over a mobile network[46]
- The incremental cost of carrying data over a cellular mobile network is €1 per GB[47] and the incremental cost of carrying it over a WLAN and fixed broadband network is zero.

The avoided cost of carrying WLAN traffic over the mobile networks is then **5 billion** in 2013[48][49].

We can use the same method to estimate the economic value of mobile offerings in 2023 if we assume that:

- Mobile networks carry 4000 PB per month in 2023[50]
- The ratio of mobile to WLAN traffic generated by mobile devices remains at 1:4
- The cost of carrying data over a mobile networks falls for €1 to €0.2 per GB[51]

With these assumptions the avoided cost of carrying WLAN traffic over the mobile networks in 2023 is **13 billion[52].**

Using WLAN access for M2M communication

As discussed in Chapter 3, we assume that:

- The economic value of M2M communications in the EU in 2013 is close to zero
- The economic value of M2M communications in the EU in 2023 is €220 billion
- 25% of this value is assigned to WLANs.

This gives us an economic value for M2M communications using WLANs in the EU of:

- €0 billion in 2013
- €55 billion in 2023

Clearly this estimate is highly uncertain. Cisco's predictions may be wide of the mark and the 25% share is simply a plausible Plum assumption.

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[45] Ibid

[46] From Cisco VNI 2012 to 2017

[47] Plum estimate based on cost modelling for a range of clients

[48] 276 PB per month x 12 months x 10^6 x 4 x 1.5 x 50%

[49] This estimate is consistent with one made recently by Analysys Mason for the UK's DCMS. This assessed the value of mobile offloads at £1.8 billion per annum for the UK. Scaling by GDP gives us **16 billion** per annum for Europe - [£1.8 billion x1.2 /£ x $17.6tn GDP Europe]/$2.4tn GDP for UK

[50] Extrapolation of Cisco VNI forecasts and *Mobile traffic forecasts 2010-2020*, IDATE for UMTS Forum 2011

[51] Plum estimate based on cost modelling for a range of clients. See also http://www.ericsson.com/ericsson/corpinfo/publications/ericsson_business_review/pdf/111/111_in_search_of_the_sweet_spot.pdf

[52] 20 billion x 3200/276 x 2/1.5

The overall economic value from WLAN access

Figure 4-3 summarises our various estimates. It suggests that the overall economic value from WLAN access in 2013 is 22 billion and that this might grow to 95 billion by 2023.

Figure 4-3: The overall economic value from WLAN access in billions of

Source of value	Economic value in 2013	Economic value in 2023
Enhance the value of fixed BB	17	27
Mobile costs avoided through offloads	5	13
Enabling M2M applications	0	55
Total	22	95

Source: Plum estimates – at 2012 prices

5 The economic value of terrestrial TV broadcasting

5.1 Introduction

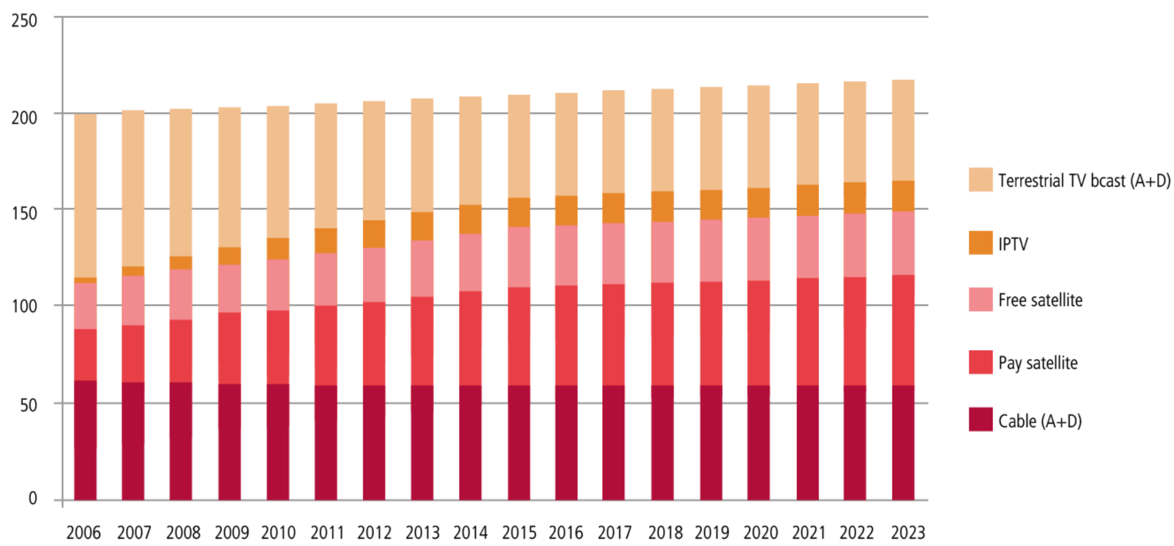
This profile and the one following cover terrestrial broadcasting. In this chapter we assess the value of ***TV broadcasting*** and in the next the value of ***radio broadcasting***. Our analysis of terrestrial TV broadcasting:

- Includes the delivery of both paid and free-to-air video audio-visual content to end-users
- Includes both analogue and digital TV platforms in our analysis. Most EU Member states have already switched off analogue frequencies for TV broadcasting. However there are a small but significant number of households which still use analogue TV in the EU.
- Excludes direct-to-home satellite broadcasting. This is covered in the chapter on satellite communications.
- Excludes cable TV broadcasting.

5.2 The nature and scale of terrestrial TV broadcasting

Before we can estimate the economic value of terrestrial TV and satellite broadcasting it is necessary to consider how the mix of TV platforms and TV revenues will evolve over time. To do so we developed a model predicting the evolution of TV by platforms in Europe for the period 2006 to 2023. Our model is mainly based on past trends. Actual data is used between 2006 and 2010[53], and we then extrapolate from 2011 on.

Figure 5-1: TV Households by primary platform (millions in EU27)



Source: Plum from EAVO

[53] *Television and on-demand audio-visual services in Europe,* European Audio Visual Observatory, 2011

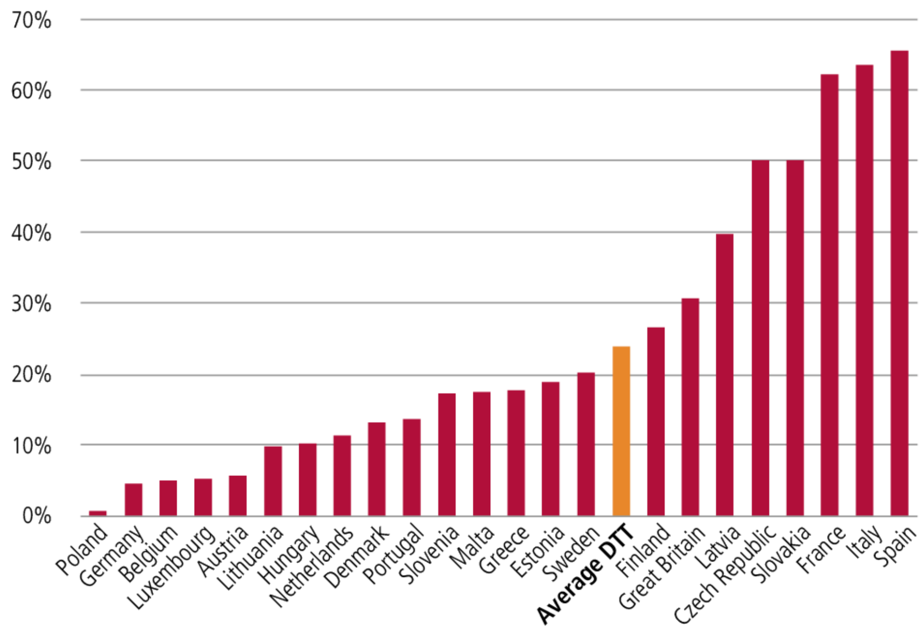
Using this model we estimate that:

- 59 million households or 28% of the total TV households in the EU will use terrestrial TV broadcast platforms in 2013 as their primary means of viewing TV
- This number will fall to 53 million households (i.e. from 28% to 24% of households) by 2023.

It is important to note that these estimates refer to the primary TV set only, without taking into account second or subsequent TV sets. Yet households which use satellite or cable as their primary platform for TV viewing often use the free to air terrestrial platform for secondary viewing. This adds to the economic value of the terrestrial TV platform.

The use of the terrestrial TV platform varies significantly across Europe. Figure 5-2 illustrates. It shows that the proportion of households using ***digital*** terrestrial TV[54] as the primary platform varies in between 0.5% and 65%.

Figure 5-2: penetration of DTT in EU 27 in 2011



Source: Plum from EAVO

[54] In interpreting this figure it is important to note that the penetration of digital terrestrial TV has changed rapidly during the period 2011 to 2013. All EU countries are scheduled to complete digital switch over by 2013 with the exception of Bulgaria and Romania, where digital switch over is scheduled by 2015.

5.3 The application's use of spectrum in Europe

Terrestrial TV broadcasting currently uses the spectrum tabulated in Figure 5-3. Note that the 790 MHz to 862 MHz is being reallocated for wireless broadband use.

Figure 5-3: Frequency band used by TV broadcasting [55]

Frequency band	Application	Comments
174 MHz to 216 MHz	Broadcasting (terrestrial)	Geneva Agreement 2006. TV Broadcasting, T-DAB
216 MHz to 223 MHz	Broadcasting (terrestrial)	Geneva Agreement 2006. TV Broadcasting, T-DAB
223 MHz to 225 MHz	Broadcasting (terrestrial)	Geneva Agreement 2006. TV Broadcasting, T-DAB
225 MHz to 230 MHz	Broadcasting (terrestrial)	Geneva Agreement 2006.This band is within the military tuning range 225-400 MHz. Sharing with defence on national basis. TV Broadcasting, T-DAB
470 MHz to 790 MHz	Broadcasting (terrestrial)	Geneva Agreement 2006. TV Broadcasting

5.4 The main sources of economic value

The main source of economic value for terrestrial TV broadcasting comes from the fact that the consumer's willingness to pay for TV audio-visual content is significantly greater than the cost of production and delivery of that content.

The public value of terrestrial TV broadcasting

Our estimates refer only to the private value of each application and exclude the public value. This is particularly relevant for terrestrial TV broadcasting services, which are often associated with delivering public value to citizens. Besides its economic contribution, public service broadcasting also plays a crucial role in fulfilling the social, cultural and democratic needs of society through promoting pluralism, including cultural and linguistic diversity, and enriching public debate. This public service role is recognised in the European Union's Council Resolution on public service broadcasting[56]. In Europe public funding of PSB services in the form of TV licence fees is common and is permitted under the European Commission's state aid rules.

We recognize that TV terrestrial broadcasting may therefore generate significant public value. However, given the subjective nature of this value, we have excluded it from our estimates and concentrate on the private value alone.

[55] EFIS data base: http://www.efis.dk/views2/search-applications.jsp

[56] Council Resolution (1999/C 30/01) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:41999X0205:EN:HTML

Estimating willingness to pay

In estimating the average willingness to pay by viewers we make reference to the existing literature. We assume that the average willingness to pay for the average bouquet of channels is the sum of the willingness to pay for public service broadcasting and commercial channels.

Estimating the cost of supply of TV content

When looking at the cost of production of terrestrial TV we assume, as for other applications, that broadcasters make only normal returns so that there is no producer surplus. Instead we assume that economic costs and revenues are equal. As a consequence we can use reported revenues to estimate costs of production for TV.

There are essentially three broad categories of revenues for TV broadcasting - TV advertising spend, public funding and pay TV subscriptions. It is worth noting here that, while advertising spend is an important source of income for commercial broadcasters, we do not count it as a direct revenue, and therefore as a component of the cost of production, in estimating economic value. This is because end users take these costs into account when they provide willingness to pay estimates. End-users pay for the adverts indirectly through the time they spend watching advertisements and provide their willingness to pay estimates net of these time costs when they respond to questionnaires on the value of advertising funded channels[57].

5.5 Drivers of future economic value

There are three main drivers of the future economic value of the terrestrial broadcast TV platform:

- The move to HD formats
- The impact of over-the-top TV
- Increased competition with other platforms.

High Definition TV formats will increase willingness to pay

It is reasonable to assume that, over the next ten years, we will see a move to HD formats, both in terms of increased availability of HD content and TV sets capable of reproducing HD content, which will stimulate willingness to pay for terrestrial broadcast (and other) TV platforms. 3D TV and ultra-high definition TV may also have an impact. But we exclude them from our calculations:

- There are still many technical uncertainties over the development of 3D TV. Current technologies have so far failed to create significant demand
- Meeting the bandwidth transmission requirements and supplying appropriate devices for the production (cameras) and consumption (TV screens) make the future of ultra-high definition TV uncertain.

[57] The same argument applies to the equipment costs incurred by end users

Internet TV will increasingly substitute for terrestrial TV

Internet based TV is likely to substitute for terrestrial TV over the next decade. Two trends are particularly relevant here - time-shifted TV viewing and the development and growth of Internet video offerings.

- Time-shifted TV viewing takes place today mainly through catch-up TV services like the BBC's iPlayer. Statistics show that time-shifted TV consumption is becoming more popular over time. With ease of access to broadband connections, end users will tend to consume more TV content when they want by downloading it or streaming it. According to Ofcom, the proportion of adults using the Internet to watch online catch-up TV in the UK has increased from 23% in 2009 to 37% in 2012, with the younger generations using catch-up TV even more often[58].
- We expect Internet-based video services to become partial substitutes for traditional terrestrial broadcasting (and other platforms). Demand for these services is growing strongly today. According to UKCOM/Nielsen, in the UK LoveFilm's unique audience grew by 56% in the past year, from 1.6 million in March 2011 to 2.5 million in March 2012 in the UK. At the same time Netflix generated 1.2 million unique users in March 2012, while Yahoo Movies grew from 1.1 million to 1.4 million unique users in the same period. [59]

If we assume that the amount of time spent on TV entertainment remains constant[60], then the combined effect of these two trends is to reduce the time spent on viewing terrestrial TV and hence the willingness to pay for viewing on this platform.

Competition with other platforms will decrease the appeal of terrestrial broadcast TV

The increasing competition with pay TV platforms is likely to:

- Lower the willingness to pay for the terrestrial platform as high willingness to pay households continue to migrate to IPTV, cable and satellite-based TV platforms
- Shrink the number of households where terrestrial TV broadcast is the main platform. (See Figure 5-1.)

In addition, as platform competition evolves, it is likely that more households will migrate away from free-to-air terrestrial TV as their primary platform to some form of subscription TV. The trend towards increased take-up of both terrestrial and satellite pay TV is currently strong[61], as Figure 5-1 illustrates.

5.6 Calculating the economic value of terrestrial TV broadcasting

To calculate the economic value of terrestrial TV broadcasting we use data from willingness-to-pay surveys and then subtract the economic costs of supply.

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[58] Ofcom – communications market report 2012

[59] Ofcom – communications market report 2012

[60] On average, viewers watched four hours of television per day in 2011 in the UK ; this has remained stable over time

[61] For example EAVO (2011) indicates that number of DTT Pay TV subscribers increased from 1.5 million in 2006 to 8.8 million in 2010 in EU 27.

Willingness to Pay

Total willingness to pay is calculated as the product of willingness to pay per household times the number of households using terrestrial broadcast TV as their primary platform.

To estimate the ***willingness to pay per households for free-to-air terrestrial TV broadcasting*** we have reviewed a number of studies conducted for the UK to assess willingness to pay for the BBC and other public sector broadcasting channels. We then estimated willingness to pay for non-public sector broadcasting channels and added a mark-up of 10% for HDTV. Specifically:

- A Holden Permain study for Ofcom[62] suggests a willingness to pay for BBC channels of between £11.6 and £13.8 per month, while the willingness to pay for other PSB channels is estimated to be between £3.3 and £3.5 per month
- The French regulator ARCEP provides estimates of total willingness to pay by number of channels[63]. Using these estimates we calculate willingness to pay for non-PSB channels at £6 per month
- Adding together the mid-point estimates for BBC, PSB and non-PSB channels and adding a 10% mark-up to allow for additional willingness to pay generated by HD content produces a willingness to pay estimate of £24.31 per month or **€30 per month per household** in 2012 prices

We estimate willingness to pay for terrestrial pay TV as twice the average subscription[64]. This is in line with the relationship between willingness to pay and subscription for satellite pay TV. We estimate the average subscription for terrestrial pay TV at 18.4 per month and a willingness to pay **of 36.9 per month per household.**

The number of terrestrial broadcast TV households

Appendix B estimates the number of TV households by platform. There are 59 million terrestrial broadcast TV households in the EU in 2013 of which:

- **12.8 million** use pay services as their primary platform
- **46.2 million** use free-to-air services as their primary platform

Total willingness to pay

The total willingness to pay is then calculated at **22 billion p.a.** by multiplying willingness to pay per household by the relevant number of households.

The economic cost of supply

As discussed in Section 5.4 we estimate the economic cost of supply of terrestrial broadcast TV as:

- Subscription revenues for terrestrial TV. According to Appendix B these will be **€2.8 billion** in 2013

[62] *Assessing the value of public service programming on ITV1, Channel 4 and Five*, Holden Permain report for Ofcom, 2008

[63] *Exploiting the digital dividend – a European approach*, Analysys Mason for the European Commission, 2009

[64] The monthly subscription represents the willingness to pay by the marginal subscriber rather than the average subscriber.

- An appropriate share of public funding. Total TV Public funding for the EU is estimated at €25.9 billion for 2013, of which 20% goes to radio[65] and 80% to TV (i.e. €20.7 billion goes to TV).

We assume that the public funding provided to public sector broadcasters to produce content is apportioned across platforms pro-rata to the number of TV households by primary platform. Given that 28% of TV households primarily use terrestrial broadcast TV, we attribute **5.8 billion p.a.** of this to terrestrial broadcast TV. The total cost of supply is therefore **8.7 billion p.a.**

Total economic value in 2013

The difference between total willingness to pay and cost of supply is 13.3 billion p.a. But this does not take into account secondary TV sets. We estimate that the average household in developed countries owns 2.3 TV sets[66]. We do not have any estimates of the value of terrestrial TV to users of second and subsequent sets. However we expect it to be substantial, since it generates value in most TV households and not just those where terrestrial broadcast is the primary platform. We therefore double our estimates to **26.6 billion p.a.**

Economic value in 2023

To estimate the economic value for 2023 we use the same methodology as for 2013. However it is important to note that:

- All values for household numbers, market shares by primary platform, and revenues have been updated according to our estimates for 2023. See Appendix B
- We assume that price elasticities and willingness to pay remain unchanged.

This then gives us a total economic value for 2023 of **18.5 billion.**

[65] The allocation of public funding between radio and TV services in the UK

[66] 1.8 in the UK (Telescope survey 2013); 2.9 in the US (Nielson survey 2010); 2.2 in Australia (ACMA estimate 2012)

6 Radio broadcasting

6.1 Introduction

In this application we assess the economic value of terrestrial radio broadcasting, including both analogue and digital transmission. We do not include radio services which are delivered over the Internet, satellite, cable or via a terrestrial TV broadcast platform.

6.2 The nature and scale of radio broadcasting

Radio broadcasting is important for many users in the EU but generates relatively little revenues when compared with TV:

- OBS[67] estimates that the net revenues of private radio broadcasters were €3.8 billion Europe in 2010. Revenues are stable
- EAVO reports radio ad-spend in 2010 of €4.8billion in Europe. This represents roughly 5% of total revenues for radio and TV in Europe
- 20% of public funding for audio visual content in the UK goes to radio.
- In the UK 90% of the UK population tuned in to the radio each week in the twelve months to Q1 2012 according to Ofcom[68] research. On average people listened for 20 hours per week.
- A London Economics survey conducted for the DCMS[69] indicates that, in the UK, 67% of the population listens to radio in a vehicle.

6.3 The application's use of spectrum

Radio broadcasting now mainly uses spectrum in the VHF band. In addition:

- There are low/medium wave frequencies allocated for amplitude modulation radio broadcasting
- Frequencies at 1400MHz allocated to digital audio broadcasting. These are expected to be reallocated for mobile use in Europe. Figure 6-1 tabulates the main bands used.

[67] *Television and on-demand audio-visual services in Europe* ; European Audio Visual Observatory, 2011

[68] Ofcom market research in 2012

[69] *Digital Radio switchover: consumer research to inform the CAB*, 2011

Figure 6-1: Frequency band used by radio broadcasting[70]

Frequency band	Application	Comments
150-279 kHz	AM sound analogue	Geneva Agreement GE 75
522-1602 kHz	AM sound analogue	Geneva Agreement GE 75
87.5 MHz to 100 MHz	FM sound analogue	Geneva Agreement GE84
100 MHz to 108 MHz	FM sound analogue	Geneva Agreement GE84
230 MHz to 235 MHz	T-DAB	T-DAB sharing with defence on a national basis. Wiesbaden 1995 Special Arrangement, as revised in Constanta, 2007
235 MHz to 240 MHz	T-DAB	T-DAB sharing with defence on a national basis. Wiesbaden 1995 Special Arrangement, as revised in Constanta, 2007
1452 MHz to 1492 MHz	T-DAB	Within the band 1452.0-1479.5 MHz. Maastricht 2002 Special Arrangement, as revised in Constanta, 2007. 1479.5-1492 MHz is allocated to satellite DAB.

Source: Plum Consulting

6.4 The main sources of economic value for radio broadcasting

As for TV services, the economic value of radio derives from the consumer's willingness to pay over and above the economic cost of supply for the service. There is still significant willingness to pay to access radio content. A survey by Aegis[71] in 2000 indicated a willingness to pay by radio listeners of £6.20 per month per household for improved digital radio service and £2.30 per month per household for existing analogue services. More recent studies by London Economics, Europe Economics and Analysys Mason suggest a willingness to pay for radio which remains significant.

6.5 Drivers of future economic value for radio broadcasting

The evolution of radio is uncertain and depends on the rate of migration to Internet radio. This is likely to be substantial in the future given:

- The much wider range of radio stations which are available over Internet radio
- The likely ubiquity of WLANs in the home and office and the growing ubiquity of WLANs in public places, which make Internet radios portable
- The cheapness of embedding Internet radios in smartphones and tablets
- Improvements in the coverage and speed of mobile broadband services following LTE rollout. The mobile network could provide a satisfactory alternative to terrestrial radio broadcast transmission within the next five years for listening in many situations.

[70] EFIS database: http://www.efis.dk/views2/search-applications.jsp

[71] Aegis Systems. Survey to determine consumer surplus accruing to TV viewers and radio listeners. Final report for Radiocommunications Agency, October 2000.

We also note that digital radio has not generated substantial consumer interest in the EU, except for the UK where 21% of radio listening is via DAB[72].

6.6 Calculating the economic value

Given the lack of available data for making direct estimates of the economic value of radio, we estimate the value as a proportion of the aggregated value of total broadcasting in Europe. For 2013 we proceed as follows:

- The combined economic value for terrestrial and satellite TV in the EU 27 is €44 billion in 2013
- Europe Economics[73] estimated that 22% of the economic value of broadcasting was attributable to radio in the UK in 2006. Analysys Mason[74] estimated that this proportion had risen to 31% by 2011. We assume 33% for 2013
- Using these estimates gives us an economic value for radio of **€22 billion**[75]

We then assume that, by 2023, 70% of radio will have migrated to Internet radios. This leaves 30% onto broadcast platforms and reduces the economic value of radio in 2023 to **6.5billion**.

Note that these values assign all of the value of radio listening to terrestrial broadcasting platforms. In practice a large proportion of popular radio stations are available on satellite TV and terrestrial TV digital platforms as well. However, the static nature of TV sets and the importance of radio listening in a vehicle, mean that listening to the radio via TV platforms is limited.

6.7 The economic value for TV and radio broadcasting combined

Combining our estimates for terrestrial TV and radio broadcasting we obtain the following values:

- €48.4 billion p.a. for 2013
- €25.1 billion p.a. for 2023.

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[72] http://www.rajar.co.uk/docs/2012_12/RAJAR%20Q4%202012%20-%20Chart%202%20-%20All%20Digital%20Radio%20Listening%20-%20Clean.pdf

[73] *Economic impact of the use of radio spectrum in the UK*, Europe Economics, November 2006

[74] [74] *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand*, Analysys Mason for DCMS, November 2012

[75] 44 billion x 33%/(1-33%)

7 The economic value of satellite communications

7.1 Introduction

In this chapter we assess the economic value of satellite communications. This application includes:

- Direct to home satellite TV broadcast
- Fixed broadband delivered to end users by satellite
- Satellite mobile communications for aeronautical and maritime users, e.g. Inmarsat services
- Fixed communications links used for example for moving TV programmes between locations and remote backhaul of voice and data.

The economic value of this application is dominated by direct to home satellite TV broadcast. Other components make only a modest contribution and are excluded from our assessment. For example:

- It may be cost effective to deliver fixed broadband by satellite, rather than by terrestrial means, to 1% of EU households - i.e. two million households. In contrast 60 million households use direct to home satellite as their primary TV platform and this number will grow over the next 10 years
- Global revenues for fixed link satellite services are in decline and now generate 15% of the total while broadcastings account for around 82% [76]

Non-communication satellite services such as earth-observation and satellite positioning are considered in Chapter 8.

7.2 The nature and scale of satellite TV broadcast

Take up of satellite TV services is substantial and growing in the EU27. Screen Digest[77] reports consumer expenditure in 2010 of 15.6 billion – a growth of 12.7% since 2009 and 24% since 2006. Such strong growth is unusual for a mature product which faces strong competition from digital terrestrial, cable and IPTV platforms.

Satellite TV is now the most common TV platform in the EU. As of December 2010 there were 61million[78] DTH satellite households in the EU27, out of a total of 204 million TV households. This means that 30% of TV households in Europe use satellite TV as their primary TV connection.

7.3 The application's use of spectrum

TV and radio satellite broadcasting in Europe uses the frequency band from 10.7 to 12.5 GHz for DTH TV services with the 11.7 to 12.5 GHz band specifically identified for Broadcasting Satellite Service. Other satellite communications services, which we have excluded from quantification, such as ISP backhauling and distribution of TV programmes, use a variety of bands. This includes 3.6-4.2 GHz/5.85–6.45 GHz, 12.5–13.25 GHz/13.75 – 14.25 GHz and 17.3-20.2 GHz/27.5-30 GHz.

[76] http://www.sia.org/wp-content/uploads/2012/06/Final-2012-State-of-Satellite-Industry-Report.pdf

[77] *Television and on-demand audio-visual services in Europe*, European Audio Visual Observatory, 2011 The reported figure is at 2011 prices

[78] As above

7.4 The main sources of economic value

As for terrestrial TV, the main source of economic value for satellite TV broadcasting comes from the fact that the consumer's willingness to pay for services is substantially higher than the cost of production and delivery of the services.

It is worth remembering that, in this report, we focus on the private value of satellite TV broadcasting and exclude the potentially significant public value attached to satellite broadcasting.

7.5 Drivers of future economic value

The economic value of satellite TV broadcasting will be subject to the same drivers as terrestrial TV broadcasting over the next decade. As mentioned in Section 5.5 the three key trends affecting the value of broadcasting are:

- The move to High Definition TV
- Increasing competition from over the top TV and IPTV offerings
- Greater competition from other platforms, including a greater role for cellular mobile broadcast technologies

As described in Section 5.2 we assume that use of satellite TV broadcasting will grow over the next decade. We also assume that the revenue per user will slowly decline to reflect increasing competition from other platforms. In particular we assume that:

- The number of satellite TV households will grow over the period 2013 to 2023 at a CAGR of 2%. See Appendix B
- Pay satellite TV will grow up to 62% of total satellite subscribers by 2016 and will then remain constant.

7.6 Calculating the economic value of satellite TV

Again, we use estimates of willingness to pay to quantify the economic value of DTH satellite TV. In doing so we make separate estimates for pay TV subscribers and for free-to-air viewers.

To estimate the economic value of ***satellite pay*** TV broadcasting we have used two methods. Method 1 is based on price elasticity of demand and supplier revenues; Method 2 is based on willingness-to-pay less the economic costs of supply. To estimate the economic value of ***free-to-air*** satellite TV broadcasting we use only Method 2.

Pay TV satellite – Method 1 -2013

We estimate the consumer surplus (CS) as:

$$CS = R/2\varepsilon$$

Here **R** is the revenue generated by the sector and **ε** is the price elasticity of demand. This formula assumes a linear demand curve and provides an estimate of **5.4 billion** per annum in economic value given that:

- We estimate pay TV satellite revenues **R** of €16.4 billion per annum using data from EAVO[79].

[79] Television and on-demand audio-visual services in Europe ; European Audio Visual Observatory(2011), the reported figure is in 2011 prices

- We use an average elasticity **ε** of -1.52. This is the weighted average of elasticities for basic and premium packages from Ofcom consumer research[80]

We then make a second estimate assuming a constant elasticity demand curve and a choke price[81] which is three times the average price paid (see Appendix A for details of this formula). Using these assumptions we calculate an economic value of **13.7 billion** per annum.

Pay TV satellite – Method 2 - 2013

Here we estimate willingness to pay, multiply by the number of households, and then deduct the economic costs of supply. Specifically we estimate that:

- The average willingness to pay per subscriber is €64 per month[82]
- There are 45.1 million pay satellite TV subscribers in Europe
- The total willingness to pay is €34.6 billion per annum
- The economic cost of supply is €22 billion
- The economic value is **€12.6 billion per annum**.

To calculate the economic cost of supply we:

- Assume that the producer surplus is zero i.e. TV broadcasters make no economic profit and economic costs equal revenue
- Take into account consumer subscriptions plus public funding (in the form of licence fees or other direct or indirect financial support)
- Exclude revenues from advertising and subscriber expenditure on TV-sets. Here we follow convention and assume that these items of expenditure are already netted off in the willingness to pay estimates. (See Section 5.4).
- Assume that public funding provided to public sector broadcasters to produce content is apportioned across platforms pro-rata to the number of TV households by primary platform. 22% of TV households primarily use satellite pay TV, while there is €25.8 billion in public funding each year. We therefore attribute €5.6 billion of this to satellite pay TV[83].
- Estimate consumer subscriptions on satellite pay TV at €16.4 billion p.a.,

The annual economic cost of supply is therefore 22 billion[84] .

[80] http://stakeholders.ofcom.org.uk/binaries/consultations/second_paytv/annexes/annex10.pdf ; Ofcom consumer research (2008); -1.52 = -2.13 x 40% + -1.11 x 60%

[81] The price at which all demand disappears

[82] Aegis and Plum Consulting confidential study in 2011

[83] We estimate the total amount of public funding to be at 25.9 billion based on estimates from EAVO and apportion 25,882 x 22% = 5,620 million to satellite pay TV

[84] 16.4 billion + 5.6 billion

Free-to-air satellite – Method 2 - 2013

To estimate the economic value of free-to-air satellite TV we use Method 2 in which we estimate that:

- The willingness to pay per subscriber is €30 per month
- The total number of free-to-air satellite TV subscribers is 29.4 million in the EU27. This gives a total willingness to pay of €10.6 billion per annum
- The economic cost of supply of free-to-air satellite is €3.7 billion per annum. Here we use the same assumptions as for satellite pay TV. However in this case revenues from subscribers are nil, and the fraction of households for which free-to-air satellite is the primary platform is 14%

This gives an economic value for free-to-air satellite TV of **6.9 billion** for 2013.

Total economic value for satellite TV broadcast in 2013

Combining the above results we get the following estimates of the economic value of pay and free-to-air services combined in 2013:

- Method 1, assuming a linear demand curve for satellite pay TV, plus Method 2 for free-to-air satellite = **€12.3 billion**
- Method 1, assuming a constant-elasticity demand curve for satellite pay TV plus Method 2 for free-to-air satellite = **€20.7 billion**
- Method 2 for both pay and free-to-air satellite TV = **€19.5 billion**

The average of the three estimates above is **17.5 billion**

The economic value for satellite TV broadcast in 2023

To estimate economic value for 2023 we use the same methodology as for 2013. However it is important to note that:

- All values for household numbers, market shares by platform, and revenues have been updated according to our estimates for 2023. See Appendix B
- We assume that price elasticities and willingness to pay remain unchanged.

This then gives us the following estimates for 2023:

- Method 1 with linear demand curve for satellite pay TV plus Method 2 for free-to-air satellite = **€12.6 billion**
- Method 1with constant elasticity demand curve for satellite pay TV plus Method 2 for free-to-air satellite = **€19.2 billion**
- Method 2 for both pay and free-to-air satellite TV = **€31.3 billion**

The average of the three estimates above is **21.1 billion**

8 The economic value of other civilian satellite applications

8.1 Introduction

We can divide civil use of satellites into two main categories[85]:

- Communication services. There are dominated by satellite TV broadcast and are considered in Chapter 7
- Non-communication services. There are two main types – earth observation and positioning services. These are considered here.

8.2 The nature, scale and economic value of earth observation services

Earth observation services involve both low earth orbit[86] and geo-stationary orbit satellites[87]. Services are used in a wide variety of ways, such as:

- For weather forecasting
- To monitor fish stocks and illegal fishing
- To measure coastal erosion and ocean changes
- To monitor land use and environmental changes on land
- As an input to some public protection and disaster recovery services.

The scale of revenues is modest. Of the 83 billion in annual revenues generated by satellite services globally only 1% comes from earth observation services[88] and Europe accounts for 30% of these revenues at most.

Estimating economic value is challenging. Most earth observation services are non-commercial in nature, willingness to pay is difficult to measure, and quantification of benefits often involves judgements about the benefits of minimising environmental degradation. We do not attempt quantification here. But we note that:

- There are studies which suggest that economic value may be two orders of magnitude greater than the satellite service revenue generated by earth observation services[89]
- The scale of economic benefits is likely to grow over the next 10 years as climate change and other environmental effects become more important.

8.3 The nature and scale of positioning services

Satellites make possible a wide range of positioning services. These include:

[85] Here we follow the classification used in *Why satellites matter*, Booz and Co, 2012

[86] Typically 700 km above the Earth's surface

[87] At 36,000 km above the Earth's surface

[88] *Why satellites matter*, Booz and Co, 2012

[89] For example a 2010 Australian study, *The economic value of earth observation from space*, by ACIL Tasman, estimates annual economic benefits to Australia of AU$4.3 billion. Scaling for Europe using GDP gives an annual benefit of 44 billion

- Navigation services used by all types of vehicles including cars, trucks, aircraft, boats and ships, as well as cyclists and walkers
- Fleet management where positioning services are an essential component when optimising transport of goods
- Tracking high-value assets such as containers and livestock to minimise theft
- High precision agriculture, mining and civil engineering. For example, a tractor which always drives in the same wheel tracks increases crop yields
- Asset mapping and maintenance.

A recent European Commission study[90] estimates that the global market for positioning services was worth 124 billion in 2011 and will grow to 244 billion by 2020. Almost all of the value is in the market for positioning equipment rather than in the satellite services themselves. The revenues are split between business users (25%), consumers (55%), and military use (20%). We estimate that the global market is growing at around 6% per annum at constant prices.

8.4 The spectrum used in Europe

Positioning services operate in the L-band at frequencies between 1134 and 1300MHz and between 1559 and 1610MHz. Earth observation services use a much more diverse set of frequencies. A lot of these services use the X-band, with a focus on frequencies between 8 and 9 GHz.

8.5 The main sources of economic value from positioning services

Positioning services lead to:

- More efficient use of people's time. For example, navigation services get people to their destinations more quickly
- Productivity gains in sectors such as agriculture, mining and construction, where precise positioning of equipment is important
- More effective transport of goods. Knowing where trucks are in real-time, fleet managers can optimise routes and load factors.

8.6 Drivers of future economic value from positioning services

Over the next 10 years we can expect satellite-based positioning services:

- To become cheaper as equipment prices continue to fall
- To become more accurate – for example following the deployment of the Galileo satellites in combination with and the ground based systems EGNOS

As result we can expect positioning services to be used for a wide range of new applications. This expectation is reflected by the fact that revenues from positioning services are forecast to double over the next decade.

[90] http://europa.eu/rapid/press-release_MEMO-12-776_en.htm

8.7 Estimating the economic value from positioning services

Our estimates of the economic value from satellite positioning services in Europe are based on three studies. They all involve making reasonable assumptions and they provide broadly consistent findings.

Estimate 1: based on revenues and price elasticities

Here we measure economic value in terms of consumer surplus. We assume that:

- The price elasticity of demand for positioning services is -0.5, similar to observed prices elasticities for mobile services
- European revenues can be derived from global revenues pro rata to GDP
- The demand curve is linear

With these three assumptions we estimate the consumer surplus for positioning services at:

- €31 billion in 2013 at 2012 prices
- €55 billion in 2023 at 2012 prices

Estimate 2: based on productivity gains from use of positioning services in Australia

The Allen Consulting Group in Australia estimated the productivity gains from use of positioning services in agriculture, mining and construction[91] at between AU$830 million and AU$1490 million in 2008. If we assume that:

- Estimates can be scaled for Europe pro rata to GDP
- Productivity gains grow in line with expected revenue growth

then we get an estimate of economic value for Europe of 12 billion to 21 billion in 2013. This estimate is a lower limit in that the study on which it is based does not consider important applications of positioning services such as fleet management navigation.

Estimate 3: based on productivity losses in the US if positioning services could no longer work

Nam Pham[92] has estimated that the US would lose between $68 billion and $122 billion in efficiency and productivity gains if satellite positioning services were no longer available in the US. Using the same assumptions as Estimate 2, this translates into an economic value from satellite positioning services for Europe of 60 billion per annum in 2013.

Figure 8-1 compares the three estimates. Based on this table we conclude that the economic value for satellite positioning services lies between 30 billion and 60 billion in 2013 and will increase by around 70 or 80% by 2023.

[91] *Economic benefits of high-resolution positioning services*, Allen Consulting Group, November 2008

[92] *The economic benefits of commercial GPS used in the US and the costs of potential disruption*, NDP consulting, November 2011

Figure 8-1: The three estimates for satellite positioning services compared

Estimate (in € billion pa)	2013	2023
Method 1	31	55
Method 2 (a lower limit)	12 to 21	Na
Method 3	60	Na

Source: Plum Consulting – at 2012 prices

9 The economic value of terrestrial fixed links

9.1 Introduction

Fixed terrestrial links are radio links which provide a transmission path between two or more fixed points for the provision of telecommunication services, such as voice, data or video transmission. They are used for a variety of applications within telecom networks:

- As backhaul components of public networks: **f**ixed wireless links are used to provide connectivity between switching centres and various end-user access nodes. The growth of 4G networks in the next decade will be the main driver for future growth of fixed links - in particular at higher frequencies above 7 GHz
- Long haul trunking components of public networks: this is the oldest and most traditional use. Fixed links are used for the transmission of long-distance telephone traffic between the regional switching centres within a PSTN network. Typical hop lengths are 40 to 50 km. These backbone components have largely been replaced by higher capacity fibre links; however, some wireless connections still remain in remote regions and to provide redundancy
- Broadband wireless access**: t**hese are direct connections between a customer and the operator’s core network. Fixed Wireless Access solutions normally use point-to-multipoint radio technology to serve a large number of CPEs. The use of this technology is now declining with the advent of other lower cost mobile/wireless technologies. For this reason we ignore point-to-multipoint access links in our calculations of economic value
- Other uses: **t**hese include utilities and public safety organisations - for example monitoring water reservoirs and video surveillance, and backhaul in private networks.

9.2 The nature and scale of terrestrial fixed links

An Electronic Communication Committee (ECC) study[93] reports that there were 201,000 fixed links in 19 European countries[94] in 2001 and 363,000 in 2010. Most of this growth came from use of fixed links for backhaul. Based on the ECC report, we estimate that the number of fixed links in the EU27 was 429,000 in 2010. This estimate is based on adjusting the ECC estimate pro-rata to GDP.

9.3 The application’s use of spectrum

Fixed links in Europe use a wide range of frequencies from below 2 GHz up to 95 GHz with a substantial variation by country. Figure 9-1 provides a summary of uses, level of occupancy and other information based on the recent ECC study.[95]

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[93] *Fixed service in Europe; current use and future trends post 2011*, CEPT –ECC Report 173, 2012

[94] Austria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Norway, Portugal, Slovenia, Sweden, Switzerland, United Kingdom

[95] *Fixed service in Europe; current use and future trends post 2011*, CEPT –ECC Report 173, 2012

Figure 9-1: Use of spectrum for fixed terrestrial links

Band	No of links	Main use	Other comments
Below 2GHz	N/A	P-P applications exist in almost all countries and very low level of harmonisation P-MP applications have been reported by some administrations	• Harmonized bands • 1350-1375 MHz paired with 1492-1517 MHz • 1375-1400 MHz paired with 1427-1452 MHz • Few links; potentially suitable for Non Line Of Site (NLOS) links
2-2.4 GHz	1000 P-P links 120 BS (31 countries review)	P-P exist in about 30 countries	The use of this band for the fixed service seems to be in decline or stable in almost all countries. However, the 2 GHz band (CEPT Recommendation T/R 13-01 Annex C), providing ~ 80 MHz of paired bandwidths (presently up to 5 14 MHz paired channels), might be potentially suitable for NLOS backhauling applications.
3.4-4.2GHZ	More than 15500 base stations in operation, in addition to about 6500 P-P links (31 Countries review)	IMT, P -MP including WIMAX as well as traditional Fixed Service P-P traditional applications	Growing use: number of BS is underestimated, as block and link based licenses are foreseen in many countries potentially suitable for NLOS but sharing with FSS also considered
4.4-5 GHz	140 links in HU and 320 SPA	Scarcely used; military use in some countries	-
5.9- 7.1GHz	12 K decreasing from 20 k in the late '90	P-to-P; high bandwidth link used for mobile and broadcasting	Decreasing use in the early 2000s due to digital adoption, moderate increase for the future; some countries indicate the band is close to congestion
7.1- 8.5 GHz	17K links active, slightly declining from 1990; overall stable situation	High and medium capacity P-P links for mobile broadcasting infrastructure Some military use	A significant number of countries plan to increase the usage of this range (10 to 30% increase), some indicate an even higher percentage, no major congestion is reported. Hop length 53km
10-10.68GHz	3000 active links and 100 BS	All type of capacity for mobile and broadcasting infra (P-P)	Potential growth; Hop length 40 km
10.7-12.5 GHz	Roughly 6000 links active and 300 BS (P-MP)	High capacity P-P links for mobile and broadcasting infrastructure	Expected increase in years to come from 10-30%. Congested in Italy. In some countries satellite sharing problems; Hop length 40 km
12.75-13.25 GHz	58K P-P links in 19 countries in EU	Fixed mobile and network infra; medium-high capacity links	Moderate increase expected (from 5-30%) congested in some countries. Average hop length is 25 km
14.24-15.35 GHz	50K P-P links	Fixed and mobile networks low-medium capacity links	Heavy use in EU; six countries congested; moderate increase in the future; average hop length is 23 km
17.7-19.7GHz	90 K links	High, Medium, Low P-P links for fixed and mobile infra	Hop length 20 km; significant increase expected and moderate congestion reported
21.2-22 GHz	900 links only	Poorly used, only in 6 countries; P-P links medium-low links	Partly congested where used; Hop length is 5 km or below. Very limited expectation of growth
22- 23.6 GHz	115K links heavily used (75K in the 19 countries)	P-P fixed and mobile infra links for all capacities	Heavily used and expected to grow (10-50%) some congestion reported; average Hop length is 14 km.

24.5- 26.5 GHz	33K links and about 1K P-MP(BS)	All capacities P-P links for fixed and mobile industry	Average Hop is 9 km; significant increase reported by 20 administrations (10-30%)
27.5-29.5 GHz	2100 links and 170 BS	Medium and high capacity P-P links for fixed and mobile infra networks	Average Hop is 4 km; most likely use will be increasing over the next years, moderate congestion
31.8- 33.4 GHz	3,500 links	Medium and high capacity P-P links	3.5 km average hop; 10 countries reported increase expected (10-50%)
37-39.5 GHz	93K links	Medium and high capacity P-P links for fixed and mobile infra	5km average hop; 18 countries report an increasing use over next years (10-50%)- congestion reported in four countries
40.5-43.5 GHz	100 –just opened in 2010	P-P and P-MP links for network infra expected	No indication on hop length; 12 countries foresees use in the future
57-64 GHz	700 links operational	P-P with Multi gigabit Wireless system(MGWS) in support of mobile infra NATO /military use	New links deployed in Norway; others should follow
71-76; 81-86 GHz	150 links	NATO /military use Other uses only started recently like P-P links for fixed and mobile infra In Portugal Short Range Device use	1-2 km hop length; No indications on future use
92-95 GHz	3 links in Czech rep;	P-P links for fixed and mobile infra	No indications on future use

Source: ECC

9.4 The main sources of economic value of fixed terrestrial links

Fixed links are often more cost effective than wireline alternatives. For example:

- Mobile operators can often use towers which are already used for base stations to provide fixed links. This can lower their overall cost of provision
- A wireline alternative may require the laying down of fibre with significant additional work and digging costs. Often fibre is not viable on routes where the traffic carried on the link is limited in volume.

In these circumstances there are economic savings to be made by using a radio fixed link rather than a wireline connection.

9.5 Drivers of future economic value for fixed links

The key driver of future demand for fixed links is backhaul for public networks. Over the next few years mobile operators plan a substantial increase in the number of small cells deployed in urban areas as they roll out LTE. Fixed links, along with fibre, will play an important role here, and their use should generate additional economic value.

Analysys Mason, in its work for the European Commission[96], estimates growth of mobile base stations from 300,000 to one million base stations by 2017. The implied CAGR is 29% per annum over the next five years. A more conservative approach

[96] *Consumers and community driven spectrum usage demand for commercial services*, Analysys Mason 2013

is to use the historic ECC figures. The ECC[97] reports a CAGR growth in fixed links of 7.3% for the period 1997 to 2001 and of 6.4 % between 2001 and 2010.

In the area of long-haul trunking we might expect some decommissioning or replacement of fixed links with fibre. Substantial activity in this area has already taken place over the past decade; wireless links are now used mainly for redundancy or to serve remote areas. We assume they will continue to do so in future.

9.6 Calculating the economic value of fixed links

The economic value in 2013

To estimate the economic value of fixed terrestrial links in 2013 in the EU we first estimate the number of existing links and then multiply it by the economic value per link.

The ***number of existing links*** is based on the ECC report. We estimate that there were 517,000 links in the EU27 in 2013[98].

To estimate the ***economic value per link***:

- We use data from the UK on the economic value of fixed links in the absence of data on other EU27 member states
- The Analysys Mason study for the DCMS[99] indicates an economic value for fixed links of £3.3 billion per annum, while the ECC report[100] and the Aegis report for Ofcom[101] suggest that there were 36,000 active fixed links in the UK in 2011. This gives an economic value per link of €108,000 per annum in 2012 prices
- We assume that the alternative to fixed links is now Ethernet access circuits in urban and sub-urban areas
- We then reduce the economic value per link by 50% to reflect the fact that the cost of leased lines in urban areas has fallen by 75% with the migration from TDM to Ethernet leased lines access. This means that the efficiency savings from the use of fixed links rather than leased lines has fallen substantially since 2006[102]. We use a 50%, rather than a 75%, reduction factor because of the costs of digging and vertical wiring which would apply to some of the links if they were replaced with a wired alternative.

Using these assumptions gives an economic value per link of 54,000 per annum and a total economic value for the EU27 in 2013 of **27.8 billion**.

The economic value in 2023

We estimate the economic value of fixed links in EU in 2023 as:

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[97] *Fixed service in Europe; current use and future trends post 2011*, CEPT –ECC Report 173, 2012

[98] Extrapolating from the estimate for the EU27 in 2010

[99] *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand; final report for the DCMS;* Analysys Mason, 2012

[100] *Fixed service in Europe; current use and future trends post 2011*, CEPT –ECC Report 173, 2012

[101] *Frequency band review for fixed wireless services; A report for Ofcom*; Aegis, Ovum and DB spectrum, 2011

[102] This is the year when the initial calculation for the economic value of fixed links was performed. So it is important to consider the avoided costs' evolution since then

- The value of fixed links in 2013 (see above) plus
- The economic value of new links deployed. The value of new links is calculated as the number of newly deployed links multiplied by the value of a new link.

To estimate the number of links deployed in 2023 we have made two estimates:

- We use historic trends. The ECC report observes an historic rate of growth of fixed links between 2001 and 2010 of 6.4% per annum. Applying this rate to the 2010 base gives 796,000 fixed links in 2023
- We assume that fixed links will grow in line with number of BTSs in Europe. Analysys Mason estimates[103] that by 2017 the number of BTS in EU will be 990,000; out of which 690,000 are newly deployed[104]. We assume that 50% of these new base stations will use fixed links and the rest will use wired connections. This means 774,000 links by 2023.

Averaging the two estimates gives us 785,000 fixed links or 269,000 new links.

We estimate the economic value of a new fixed link as the costs of using an Ethernet access circuit minus the cost of the microwave fixed link. In doing so we assume that:

- The average hop length is 6 km, in line with the findings of the ECC report
- The cost of an Ethernet access circuit at this length is £ 9,100[105] per annum
- The cost of a microwave link is £800 per link per annum[106].

Converting to 2012 prices and into Euros gives us an economic value per link of 9,890, a total economic value for the EU27 in 2023 of 2.7 billion for the new links, and **30.3 billion** for new and existing links combined.

[103] Analysys Mason workshop for EC 15/2/2013

[104] Our estimates of current BTS number is 300,000

[105] BT price list –connection charges are amortised, we assume a link of 1000Mbps

[106] Plum estimate for small cell deployment based on discussions with industry figures

10 The economic value of private mobile radio systems

10.1 Introduction

Private Mobile Radio (PMR) systems are used by organisations to operate their own private mobile communication networks. PMR is mainly used in the logistics, construction, transport[107], chemicals[108], entertainment, and health sectors as well as by the emergency services. Given the close link between PMR and business/professional applications, we also refer to PMR as business radio.

PMR systems can be used:

- Over a local area, operating within a 3 km radius, for example on construction sites, or in hospitals, airports, or warehouses, and
- Over a wide area, roughly within a 30 km radius, for example to control taxis or fleets of emergency services vehicles.

10.2 The nature and scale of PMR

A recent workshop in Brussels by Analysys Mason[109] reported a global installed base of 39 million active PMR users in 2008, growing to over 52 million by 2020. The same research indicated that approximately a third of global users were in the EU. This suggests an EU installed base of active radio users of 15 million in 2013.

10.3 The application's use of spectrum

The main frequency bands used across Europe for PMR and PAMR systems are:

- 68 to 87.5MHz;
- 146 to 174MHz;
- 380 to 400MHz, which is allocated for public protection and disaster relief (PPDR) use;
- 406.1 to 410MHz;
- 410 to 430MHz;
- 440 to 450 MHz;
- 450 to 470MHz.

10.4 The main sources of economic value

There are three main sources of value for PMR:

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[107] Aerospace, airports, ports, bus operators, taxi fleets

[108] e.g. on oil extraction platforms

[109] *Community-Driven spectrum usage demand for governmental services*; Analysys Mason 2013

- **To implement safety rules**: In many cases in the transport industry (underground, buses, over ground trains) and emergency services (police forces) safety rules require the use of dedicated professional business radio.
- **Cost efficiency**: PMR systems enable ground operations to be more cost effective in airports, ports and construction sites than if they had to rely on wired solutions. PMR is also more cost-effective than commercial mobile services in supporting airport logistics or running large hotels or resorts, where PMR is used frequently by staff. Furthermore the need for indoor coverage or coverage in rural areas can limit the use of commercial mobile networks.
- **Ad-hoc features:** PMR features such as group calling or the emergency service button on the PMR devices make it attractive to police forces, emergency services staff, security guards, and safety staff in power stations.

In a recent review[110] the UK's Federation of Communication Services highlighted a number of applications where PMR is business critical. This included use by airports, ports, trams, underground railways and buses. The FCS argues that:

- PMR has an important role to play in all logistics. Costs would be substantially higher without the use of dedicated business radio
- Business radio is critical for safety: police patrols, safety guards, tower crane operators, and power station monitoring are all examples where the value of PMR is extremely high because it is associated with value of life or a safer society. The use of alternative means would not provide as high a quality of service as PMR.

In our estimates we focus on the efficiency gains which the use of PMR generates and do not consider the wider issue of public value.

10.5 Drivers of future economic value

The use of PMR systems has been fairly stable over time. The lack of detailed data makes it difficult to identify future trends, but our research suggests that:

- The number of PMR licences is declining as small operators/users switch to commercial mobile networks
- This decline is matched by an increasing number of users per licence in larger organisations.

We assume that these two trends will cancel out and leave the number of users unchanged.

Other observers have similar views. Analysys suggests[111] that some PMR users will leave PMR to switch to commercial mobile networks, driven by cost of equipment or coverage considerations. On the other hand, some users will adopt PMR to take advantage of features such as indoor coverage and the lower cost of the service when compared with commercial mobile networks. Overall, these two trends will tend to balance out or slightly reduce demand.

[110] *The strategic future of Business radio,* Federation of Communication Services, 2010

[111] *Community-Driven spectrum usage demand for governmental services*; Analysys Mason, 2013

10.6 Calculating the economic value for PMR

Due to the lack of specific data for the EU we have used data for the UK to calculate the economic value of PMR for 2013 and 2023. In particular we use as an input the consumer surplus estimates for the UK made by Analysys in its work for the UK's DCMS in 2012[112]. We then gross up to calculate the economic value for the EU27.

To calculate the economic value of PMR for 2013 we reason as follows:

- Analysys Mason estimates the total consumer surplus for PMR in 2013 to be £2.25 billion per annum for the UK at 2012 prices
- We gross up from this estimate to calculate the economic value for PMR in the EU pro rata to GDP. The GDP of the UK is 13.6% of that of the EU and we use an exchange rate of €1.15/£

This yields an economic value for PMR for the EU of **19 billion** per annum

To calculate the 2023 economic value of PMR we again start with an Analysys Mason estimate – that the consumer surplus for PMR in the UK will be £3.0 billion in 2021. We then:

- Calculate the nominal rate of growth between 2013 and 2021 at 2.5% per annum
- Use this rate of growth to estimate the 2023 value for the UK at £3.15 billion (in 2023 prices)
- Gross up from this estimate to calculate the economic value for PMR in the EU pro rata to GDP, convert to Euros and adjust to 2012 prices

This yields an economic value for PMR for the EU in 2023 of **21.4 billion.**

[112] *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand; final report for the DCMS*; Analysys, 2012

11 The economic value of civil aviation services

11.1 Introduction

Spectrum is an essential input to the safe functioning of the civil aeronautical sector in Europe. It is currently used in three main ways - for communications, for radio navigation and for radio determination. The following table lists the main aeronautical functions that use radio spectrum.

Figure 11-1: The Main Aeronautical Systems using Radio Spectrum and their Functions

System	Function
Primary Radars	Detect the position of aircraft by means of reflected signals.
Secondary Radars	Detect the position, identity and altitude of (typically large) aircraft fitted with transponders and can exchange other digital information between aircraft and ground.
DME - Distance Measuring Equipment	Provides an aircraft's distance from a ground station.
NDB - Non Directional Beacons	A navigational aid for aircraft which broadcast signals from a known location. Being replaced by VORs and GPS.
VOR – VHF Omni-directional Radio Range	A navigation system which indicates the identity of the station and the direction (but not the range) the aircraft lies from the VOR station. Often co-located with a DME to allow a one-station fix.
VHF communications	Used for communication between aircraft and ground.
HF communications	Used for long-range ATC communications over the North Atlantic
Instrument Landing Systems (ILS)	Provides precise guidance to an aircraft approaching a runway.
Microwave Landing Systems (MLS)	A precision landing system with advantages over ILS - particularly its all-weather performance.
Weather Radars	Ground and airborne radar used to locate precipitation its intensity, motion and type.
Radio altimeters	Airborne radar that allow the height of aircraft to be calculated
Doppler navigation aids	Airborne equipment that is used to provide ground speed and drift angle information

Source: Plum Consulting

The airspace in Europe is one of the most crowded in the world. Without the appropriate spectrum the number of aircraft movements which could use this air space safely would be drastically reduced - perhaps to 10% or less of current levels.

11.2 The scale of activity in the sector

The aeronautical sector makes a very significant contribution to the European economy. In 2010 it carried 700 million passengers and 48 million tons of freight[113] while it generated revenues from passengers (80%) and freight (20%) of around 118 billion[114][115].

[113] *Aviation – benefits beyond borders*, Oxford Economics for ATAG, March 2012

In addition to the airlines themselves, the value chain of the aviation sector involves a number of other activities such as airport operations, air-traffic control, and aircraft maintenance and manufacture. In all, Oxford Economics estimates that the value chain directly supports 1.86 million jobs in Europe.

The sector also helps stimulate international tourism - tourism and civil aviation are strong complements to one another. We exclude benefits from the tourism sector in our estimates below.

11.3 The spectrum used in Europe

The frequency bands allocated for use by aeronautical services are shown in Figure 11-2. These bands are normally shared between civil and military aeronautical users.

Figure 11-2: Frequency bands allocated to aeronautical services

Frequency Band (MHz)		Aeronautical Usage	Location of Use
From	To		
0.255	0.5265	Non-directional beacon	Ground
2.85	22	HF Comms	Ground & airborne
74.8	75.2	Marker beacons	Ground
108	118	108-112 MHz ILS (localiser) 108-118 MHz VOR & GBAS	Ground
118	137	VHF Communications	Ground & airborne
328.6	335.4	ILS (Glide Path)	Ground
406	406.1	EPIRBS/ELTs	Ground
960	1215	DME, Secondary radar (1030/1090 MHz)	Ground & airborne
1215	1350	Primary radar (L-band)	Ground
2700	3100	Primary radar (S-band)	Ground
4200	4400	Radio Altimeters	Airborne
5000	5150	MLS	Ground
5350	5470	Airborne Weather Radars	Airborne
9000	9500	Ground movement and airborne radar (X-band)	Ground & airborne
13250	13400	Doppler navigation aids	Airborne
15400	15700	Ground movement radar (Ku-band)	Ground

Source: Plum Consulting

Figure 11-2 specifies spectrum use in the UK, which is typical of use in the EU. Note that aeronautical services also use PMR and satellite bands for communications; these bands are not allocated to aeronautical services and so are not considered here. Bands solely allocated to military aeronautical or maritime use are also not considered.

There may be some scope to rationalise aeronautical systems after 2020 with greater use of satellite navigation and improved radar and communications technology. However, there is also likely to be growing demand for spectrum for

[114] $547 billion x 27% in Europe x 0.76 /$ x 1.05 to convert 2012 prices

[115] *Industry financial forecasts*, IATA, March 2012

aeronautical applications to support unmanned aeronautical vehicles. An allocation for this use was made at WRC-12 in 5030 to 5091MHz[116].

11.4 The main sources of economic value

The sector generates a substantial economic welfare in terms of consumer surplus. The willingness to pay by the average passenger or freight company is significantly higher than the charges levied. We estimate this consumer surplus below.

There is little evidence to suggest any additional producer surplus. Over the past five years global profits in the airline industry averaged around 1.5% of revenues[117]. We assume that the producer surplus is zero in our analysis.

11.5 Drivers of future economic value

How will the economic value generated by the sector change between 2013 and 2023?

- Over the past 20 years global passenger numbers have grown at 5% per annum on average. In Europe, however, growth in passenger numbers is weaker. In 2012 growth rates were roughly half global rates[118]. We assume in our analysis that a lower growth rate of 2.5% p.a. continues over the next decade to reflect the comparative weakness of European economies.
- While passenger numbers continue to grow the real unit price of air travel and air cargo has remained virtually constant over the past seven years, despite strong and continuing increases in the price of oil. Fuel now represents around 26% of airline costs and oil prices have grown at 16% per annum in real terms for the last seven years.

Given this analysis we assume that sector revenues in Europe will continue to grow at 2.5% per annum in real terms through to 2023 when estimating growth in the consumer surplus generated by the sector.

11.6 Estimating the economic value from the aeronautical sector

We measure the economic value from the European civil aeronautical sector in terms of the consumer surplus generated. This we estimate at:

- €58 billion in 2013
- €74 billion in 2023.

These estimates are based on the following assumptions:

- Consumer surplus is given by the formula $R/2\varepsilon$ should where R is the revenue generated by the sector and ε is prices elasticity of demand. This formula assumes a linear demand curve. See Appendix A for details
- The price elasticity of demand for air travel in Europe is -1.1[119]

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116 http://apps.ero.dk/eccnews/feb2-2012/world-radio-conference.html

117 *Industry financial forecasts*, IATA, March 2012

118 *Air transport market analysis*, December 2012, IATA

119 *Estimating air travel demand elasticities*, InterVistas for IATA, December 2007

- Revenues in 2010 were €118 billion in Europe at 2012 prices
- Revenues grow at 2.5% per annum between 2010 and 2023
- Inflation runs at 2% pa.

If the spectrum required for the sector to function safely were not available, then we estimate that the consumer surplus would fall very substantially.

The estimates of consumer surplus set out above assume a linear demand curve. If instead we assume a demand curve with constant elasticity, of -1.1, and a choke price120 of five times the average price per trip of €200121, then our estimate of the consumer surplus rises substantially to:

- €171 billion in 2013
- €219 billion in 2023.

[120] A price above which demand falls zero

[121] *Industry financial forecasts*, IATA, March 2012

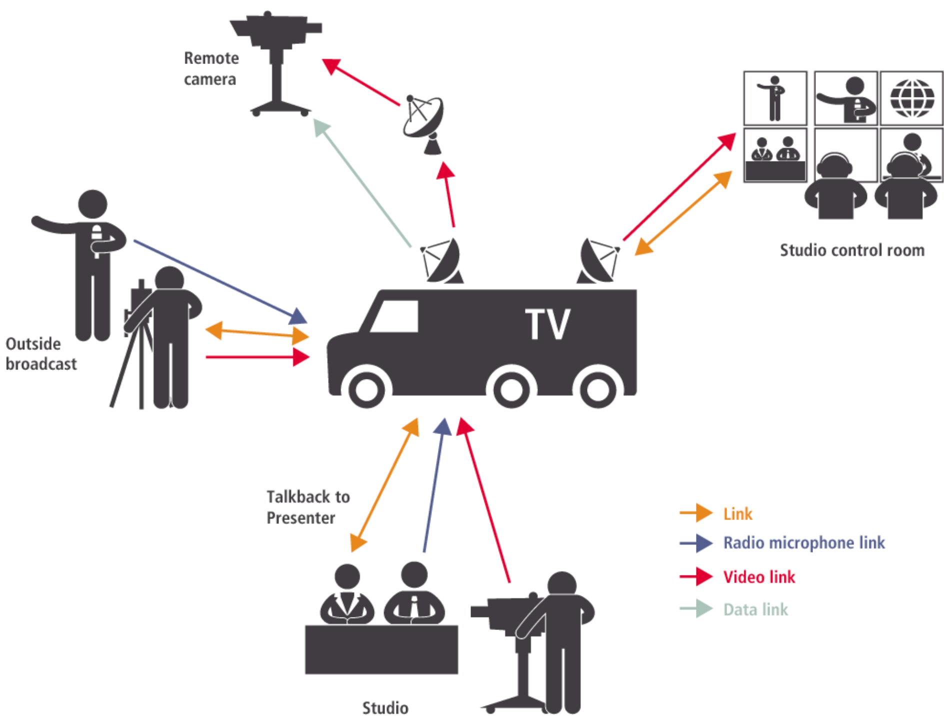
12 The economic value of programme making and special events (PMSE)

12.1 Introduction

Spectrum is now an important enabler in the creation of TV and radio programmes and in the running of conferences, live shows and theatre productions. For example:

- Wireless cameras, both static and mobile, are used extensively for outside broadcasts and, to a lesser extent, for studio productions. Figure 12-1 illustrates the use of wireless equipment in an outside broadcast
- Wireless microphones are now used almost universally in conferences and theatres
- Wireless equipment is an important part of news gathering – giving the news providers the ability to provide live reports from difficult locations
- Big touring events, often international in nature, use wireless equipment extensively. Examples include Formula One racing and touring rock bands
- Wireless has the potential to substantially enhance sporting events for those who attend the event by offering close-up views and replays of key elements on big stadium screens.

Figure 12-1: Use of spectrum in an outside broadcast



Source: Entertainment in the UK in 2028, Plum for Ofcom, February 2009

12.2 The scale of the application

Given its diverse nature, it is difficult to make measure the scale of PMSE. But we note that:

- Theatre revenues in London alone exceed €0.6 billion each year[122]. Wireless microphones are important in many of the theatre productions
- TV and radio production across the EU, funded by public money, subscriptions and advertising spend, generates revenue of €91 billion per annum. A small but significant proportion of programmes use wireless technology in their production.

12.3 The application's use of spectrum

Demand for PMSE is localised and time-limited. So PMSE uses spectrum on a secondary basis – on a temporary basis and/or confined to limited geographical areas where spectrum is not used for its primary purpose[123]. PMSE currently uses spectrum in the VHF and UHF bands, at 1.5 GHz and at various frequencies above 2 GHz.

As demand for spectrum grows, especially from broadband wireless access applications, PMSE users face the prospect of losing secondary use of spectrum. For example:

- The recent CEPT decision to assign spectrum at 1.5 GHz for co-primary use as a supplemental downlink from mobile services has extinguished hopes by PMSE users of a permanent band for their use
- The RSPG recently reported[124] that it expects PMSE users will not have access to the 700 MHz band in the relatively near future.

However, there are initiatives underway in Europe to identify harmonised bands for PMSE use. These activities are examining options for wireless microphones in the 821-832 MHz and 1785-1805 MHz bands and for cordless video cameras in various frequency bands including bands in the 2-3 GHz range.

12.4 The main sources of economic value

Use of wireless based equipment for PMSE generates three main types of economic value:

- It enhances the end-user experience. For example:
  - Televising Formula One racing now brings viewers much closer to the action through the use of wireless cameras
  - Wireless equipment (including microphones) gives freedom of movement to stage performers, which enhances the spectacle
- It enables journalists to gather more immediate news from remote locations in the world
- It reduces costs by eliminating expensive cabling at temporary locations, e.g. by use of wireless cameras

[122] *London theatre sales undented by Olympics,* FT, 29/1/13

[123] For example interleaved television spectrum

[124] *Draft RSPG opinion on strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband*, RSPG, February 2013

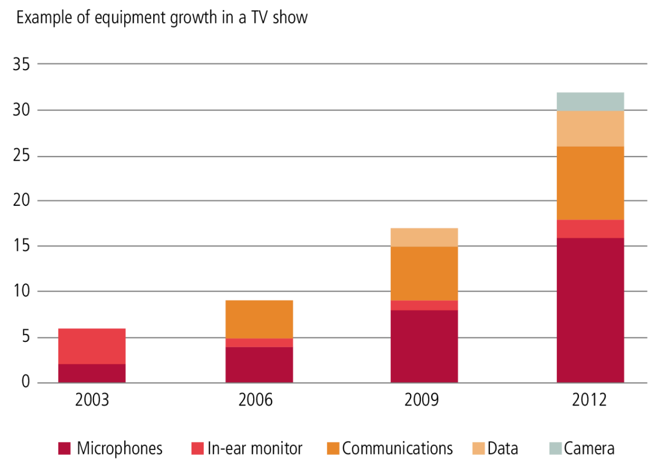
12.5 Drivers of future economic value

There is a clear and steady trend towards greater use of wireless devices for PMSE. For example:

- The use of wireless equipment in the production of a typical television show has grown significantly over the past few years, as Figure 12-2 illustrates. This trend helps reduce production costs and enhance the end-user experience
- There is a strong trend towards the use of high-definition cameras, a significant proportion of which are wireless, as Figure 12-3 illustrates. This trend should further enhance the end user experience

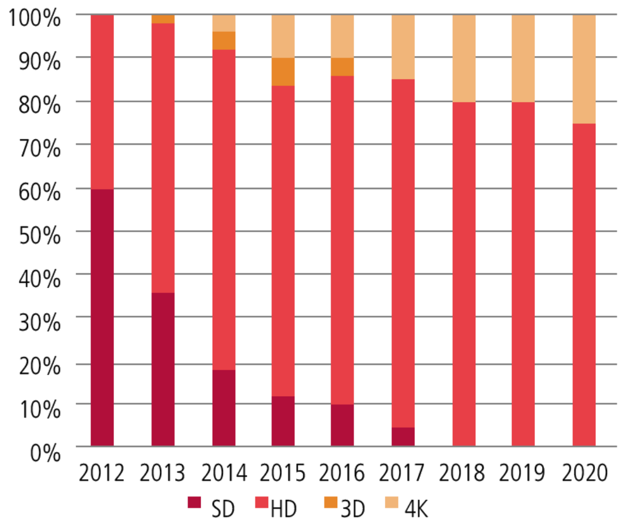
It is likely that these trends will lead to a growing economic value for use of spectrum in PMSE.

Figure 12-2: Wireless equipment used for a television show



Source: PMSE.nl

Figure 12-3: The growing use of HD cameras



Source: PMSE.nl

12.6 Estimating the economic value of the PMSE

It is difficult to establish the economic value of PMSE or how this value might grow given the wide range of ways in which spectrum is used for PMSE and the difficulty of judging the extent to which wireless based PMSE increases the value of live and broadcast events. What is clear at a qualitative level is that:

- Wireless PMSE makes a significant contribution to the cultural life of the EU
- This contribution is likely to grow in future
- A harmonised, permanent allocation of spectrum for secondary use by PMSE would have value. In particular such an allocation would:
    - Enable suppliers to produce wireless equipment with greater confidence at greater scale and so offer equipment at lower prices to PMSE users.
    - Reduce the radio interference which international road shows often generate as they use wireless equipment at frequencies which are approved for use in one member state but not in another.

13 Comparing the economic values

13.1 Introduction

In this final chapter we:

- Validate Plum's estimates of economic value by comparing them with those produced by earlier studies
- Look at how economic value, and growth in economic value, varies across the quantified applications
- Discuss how our value estimates should be interpreted.

13.2 Validating the estimates

We have identified two previous studies which estimate economic values for use of spectrum in Europe:

- A 2006 study by Europe Economics for Ofcom[125], which estimated economic values for the UK
- A 2011 study by Analysys Mason for the UK Government's Department for Culture, Media and Sport[126], which also estimated economic values for the UK. In some cases the study simply updated the Europe Economic estimates; in others it uses a fresh approach and different data

Figure 13-1 provides a comparison between the Plum estimates produced in this report and the Analysys Mason estimates - where we have scaled up the latter from the UK to the EU27 pro-rata to GDP.

We can see that:

- With one exception, TV broadcasting, the Plum and Analysys Mason estimates are consistent. We discuss the exception below
- In particular the estimates and projections of economic value for mobile services are very similar, despite the different methods used by the two studies to estimate economic values
- The difference for WLANs reflects the fact that the Analysys Mason estimates exclude two sources of economic value i.e. the future use of WLANs for M2M communication and the economic value which WLANs generate by enhancing the value of fixed broadband.

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125 *Economic impact of the use of radio spectrum in the UK*, Europe Economics, November 2006

126 *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand*, Analysys Mason for DCMS, November 2012

Figure 13-1: Validating the Plum estimates

Application	Plum estimate (€ bn pa)	AM for DCMS (€ bn pa)**	Comment
1. Mobile services (excluding M2M EV)	269 (2013) 390 (2023)	248 (2013) 394 (2021)	Consistent
2. WLAN	22 (2013) 95 (2023)	22 (2013) 41 (2021)	Big difference but AM focuses only on EV of mobile offloads
3. Terrestrial TV broadcast[127]	27 (2013)	48 (2013)	Big difference. See text below for analysis
4. Satellite TV broadcast	16 (2013)	11 (2013)	Plum EV consistent with estimate from 2011 confidential study by Plum
5. Satellite non-comms	30 (2013)	No estimate	No comparison possible
6. Terrestrial fixed links	24 (2013)	27 (2013)	Consistent
7. PMR	20 (2013)	20 (2013)	Consistent but Plum estimate based on same method as AM
8. Civil aviation	114 (2013)	No estimate	No comparison possible

*** AM estimate for UK grossed up to EU27 pro-rata to GDP*

Figure 13-1 suggests that the Plum estimate of economic value for terrestrial TV broadcasting is out of line with that produced by Analysys Mason. A more detailed analysis presents a different picture. In Figure 13-2 we have compared estimates from Plum, Europe Economics and Analysys Mason for the UK alone (with any producer surplus excluded from all estimates).

Figure 13-2: The economic values of radio and TV broadcasting compared for the UK

Measure	EE 2006	AM 2011	Plum 2013
EV terrestrial TV (£ bn pa)	8.0	5.3	3.6
EV satellite TV (£ bn pa)	2.3	1.0	2.2
EV radio broadcast (£ bn pa)	2.9	2.8	2.8
Total EV for broadcasting	13.2	9.1	8.5
% total economic value attributed to radio	22%	31%	33%

Source: Plum Consulting

The comparison of the three studies indicates that:

- The Plum estimate for the three broadcast applications combined is consistent with that from the other two studies. The total economic value of broadcasting shows a steady decline over the past seven years

127 Excluding terrestrial radio broadcast

- There is a discrepancy between the Analysys Mason and Plum estimates of the economic value of satellite TV broadcasting. But it is, on balance, more likely that Analysys Mason has underestimated this value, rather than that Plum has over estimated it. The Plum estimate is consistent with both the 2006 Europe Economics study and a confidential Plum estimate in 2011.

We have also compared the estimates of willingness to pay for TV viewing from a study in 2000[128] with those used to produce the Plum 2013 estimates. This comparison shows that, when expressed at constant prices, willingness to pay has remained static while the functionality of the services offered, both in terms of number of channels and use of high definition formats, has grown significantly.

This analysis provides a potential explanation for the declining economic value shown in Figure 13-2:

- The cost of providing TV broadcast services has grown[129] while
- Willingness to pay per household has remained static and
- The number of households which use terrestrial TV broadcasting as their primary platform for viewing has declined.

We can already see that the economic value of terrestrial TV broadcasting is of little importance in certain states. For example in Germany significantly fewer than 10% of households now use this platform as their primary means of viewing television content. Indeed one of the main commercial broadcasters has stopped providing its content over the terrestrial platform.

Overall we conclude that the Plum estimates for terrestrial TV broadcasting from the current study are sound.

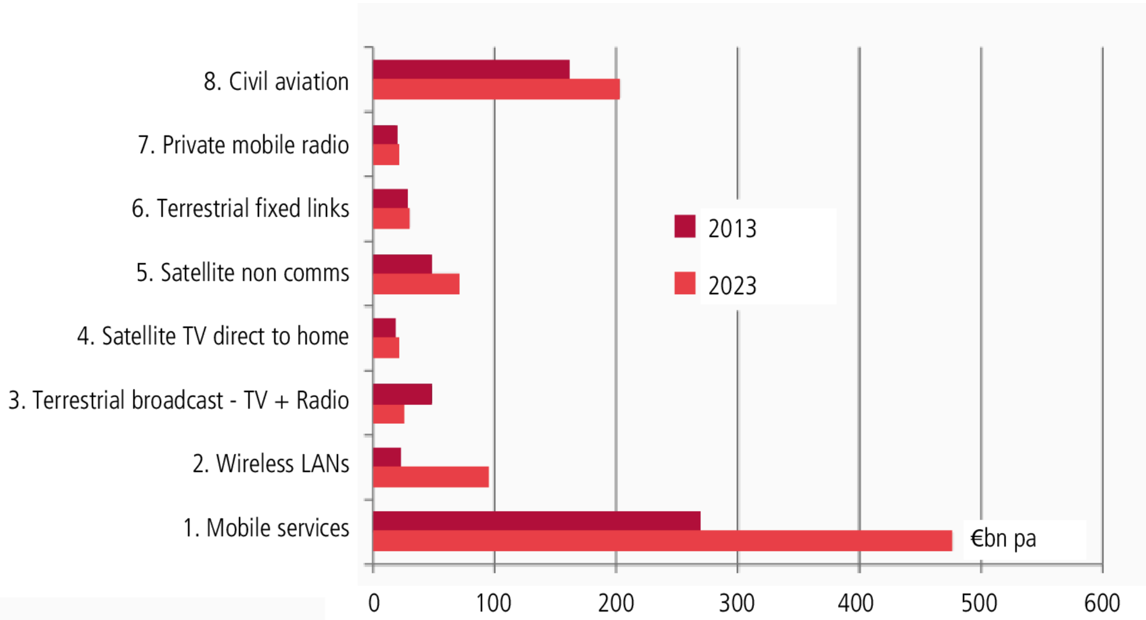
[128] *Survey to determine consumer surplus accruing to TV viewers and radio listeners*. Aegis Systems. for the UK's Radiocommunications Agency, October 2000

[129] We note that the funding of TV broadcasting grew by 3% in real terms between 2006 and 2010 according to the EAVO

13.3 A comparison of economic values between applications

Figure 13-3 plots Plum's estimates of the economic values of the eight applications in 2013 and 2023.

Figure 13-3: The economic value of the applications compared



Source: Plum Consulting

The figure indicates that:

- Mobile services generate the greatest economic value by some way followed by civil aviation
- In absolute terms we predict that the economic value of mobile services will grow more than for any other application
- We also predict strong growth in the economic value of WLANs between 2013 and 2023. This growth largely reflects the complementary nature of mobile services and WLAN use
- The economic values for all the other applications are predicted to grow, if less strongly, between 2013 and 2023
- There is one exception to this rule - terrestrial broadcasting. Here we predict that:
  - The economic value of terrestrial radio broadcasting will decline as users switch from broadcast radio to Internet radio – both at fixed locations and in vehicles
  - The economic value of terrestrial TV broadcasting will continue to decline as the households with the highest willingness to pay continue to move to pay satellite platforms, and as end users switch to IPTV and over-the-top broadband based services when viewing video content.

In some member states we might even see the terrestrial TV broadcast platform being replaced by 2023 – perhaps by some combination of satellite television broadcasting and mobile broadcasting technologies.

13.4 Interpreting the economic values

In interpreting Figure 13-3 it is important to note that:

- The estimates and projections of economic value are uncertain. Figure 13-4 tabulates the range within which we are reasonably confident that the true economic value of the application will fall in 2013
- Are expressed at constant 2012 prices throughout and do not include any inflationary effects
- Relate to the application, for which spectrum is an essential input, rather than to the spectrum *per se*
- Assume that the supply of spectrum will not constrain growth in the economic value of each application. In other words, we assume that the necessary steps are taken to allocate spectrum between applications in an efficient way over the next 10 years
- Include the value of civilian but not military use of spectrum
- Include private value[130] but exclude any public value. Public value is likely to be significant for certain applications. For example terrestrial TV broadcasting, together with satellite TV broadcasting, generates public value in terms of social inclusion, social cohesion and education
- Include only the consumer surplus generated by the application and not the producer surplus[131]. In a competitive market producer surplus tends to zero.
- Do not indicate which applications need more spectrum. To assess the optimum allocation of spectrum between the applications we need to consider, for each application, the change in economic value which results from adding or removing a MHz of spectrum.

[130] That is the economic welfare generated because the end user who consumes the application has a willingness to pay which is greater than the cost of supply

[131] The producer surplus is that part of the private economic value which flows to the suppliers of the application. It measures the excess profit, over and above that which represents a normal return on capital employed.

Figure 13-4: The uncertainty in our estimates of economic value for 2013

Application	EV in bn pa			Why the range?
	Mid-point	Low	High	
1. Mobile services	269	200	320	Uncertainty over WTP estimates
2. WLAN	22	14	34	Uncertainty over enhanced value of fixed BB
3. Terrestrial broadcast	48	30	70	Uncertainty over WTP estimates
4. Satellite TV broadcast	18	12	21	Different methods used to estimate EV
5. Satellite non-comms	48	20	98	Different methods used to estimate EV
6. Terrestrial fixed links	28	20	40	Uncertainty over % reduction in EV per link with migration from TDM to Ethernet access circuits
7. PMR	19	10	30	WTP estimates 10 years old
8. Civil aviation	159	79	239	Uncertainty over demand curve and price elasticity estimates

Source: Plum Consulting

Appendix A: Using revenues and price elasticities to estimate economic values

A.1 Introduction

We can use revenues and price elasticities to estimate consumer surplus and hence economic values. In this appendix we provide details on this approach and consider how estimates of consumer surplus depend on the assumed shape of the demand curve.

A.2 Linear demand curve

Figure A-1 shows a linear demand curve. Although the demand curve is linear, elasticity varies along the curve. Elasticity is -1 in the middle of the curve, more elastic to the left and more inelastic to the right. If the demand curve is defined as:

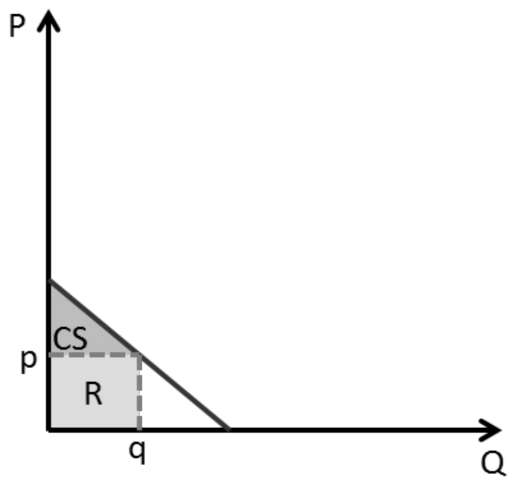
$$q = A - bp$$

where q is quantity, p is price and A and b are constants. The consumer surplus (CS) is given by:

$$CS = \frac{q2}{2b} = \frac{qp}{2e} = \frac{R}{2e}$$

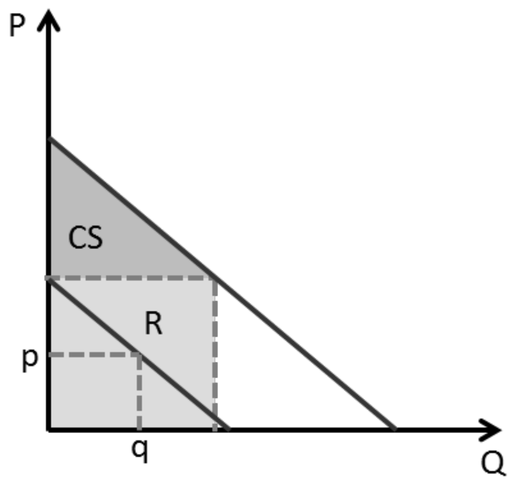
Where e is the absolute value of the price elasticity of demand and R is revenue.

Figure A-1: Linear demand curve



To estimate a change in consumer surplus we need to estimate the change in revenue and the change in elasticity. Figure A-2 and Figure A-3 illustrate how the elasticity assumption affects the size of the change in consumer surplus (for an assumed constant change in revenue).

Figure A-2: Same elasticity of demand



In Figure A-2 the elasticity is assumed to be the same as in Figure A-1. Iin this case the change in consumer surplus is given by:

$$\Delta CS = \frac{R_2}{2e_1} - \frac{R_1}{2e_1} = \frac{\Delta R}{2e_1}$$

Figure A-3: Same price

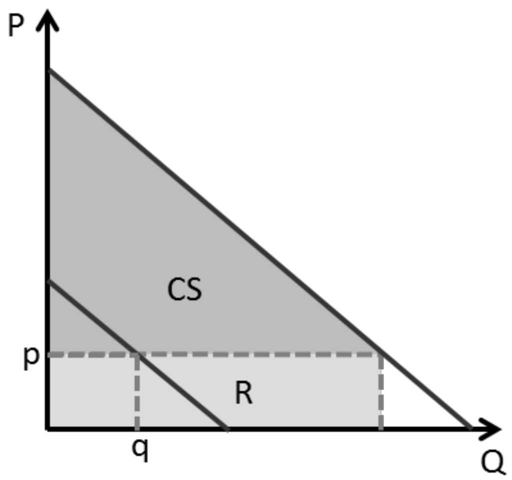


Figure A-3 illustrates an example in which the change in revenue is the same as in Figure A-2; however the elasticity is allowed to vary and the price is held constant. Here the outward shift in the demand curve means the elasticity (at the same price) falls. As demand increases the good is increasingly seen as a necessity and demand becomes inelastic. In this case the change in consumer surplus is given by:

$$\Delta CS = \frac{R_2}{2e_2} - \frac{R_1}{2e_1}$$

As e_2 is less than e_1 the change in consumer surplus is greater than in Figure A-2: . An approximate estimate of the change in consumer surplus when $p_1 = p_2$ and Δq is small is given by the following formula:

$$\Delta CS = \frac{\Delta R}{e_1}$$

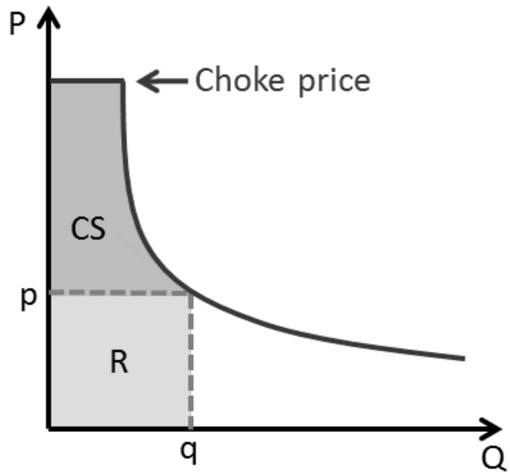
Therefore by assuming the elasticity is constant (as in Figure A-2) when the situation is in fact more like that in Figure A-3 the change in consumer surplus is underestimated. Arguably Figure A-3 better reflects the situation for mobile broadband where coverage and capacity enhancements are provided at little or no extra price.

A.3 Constant elasticity demand curve

Although the linear demand curve allows changes in consumer surplus to be easily calculated it may not be an accurate approximation of reality. There is also a risk that this assumption may result in overestimates of consumer surplus. This is because as the linear demand curve shifts out, the choke price (i.e. the price at which demand falls to zero) can increase unrealistically and result in significant increases in consumer surplus.

A constant elasticity demand curve, with specified choke price, as illustrated in Figure A-4, may give a more accurate reflection of demand.

Figure A-4: Constant elasticity demand curve



The equation for the consumer surplus with a constant elasticity demand curve and a choke price is[132]:

$$CS = R\left[\frac{1 - \left(\frac{p_{choke}}{p_1}\right)^{-(e-1)}}{e-1}\right]$$

The change in consumer surplus can be derived as:

[132] When the elasticity is one, the formula is $CS = R.\ln\left(\frac{p_{choke}}{p_1}\right)$

$$\Delta CS = CS_1 \frac{\Delta R}{R_1}$$

And if we assume that the choke price is a fixed multiple of the current price, i.e. $p_{choke} = c.p_1$, then consumer surplus is as follows:

$$\Delta CS = \left[\frac{1 - c^{-(e-1)}}{e - 1}\right].\Delta R$$

If the elasticity is one, then:

$$\Delta CS = \ln(c).\Delta R$$

Appendix B: TV households and revenues by primary platform

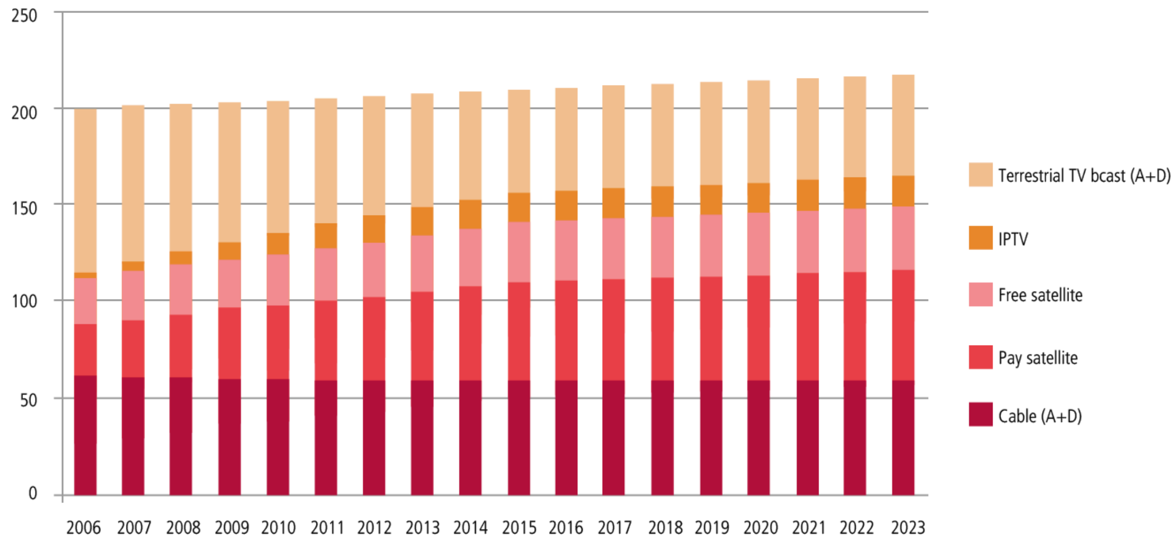
B.1 TV households by primary platform

We use estimates of the number of TV households by platform to calculate economic values for terrestrial and satellite TV broadcasting. We estimate future take up for all platforms using past data from EAVO[133] on historic trends from 2006 to 2010. In extrapolating historic trends we make the following assumptions:

- Total TV households, both analogue and digital, will grow at 0.5% p.a.;
- Combined analogue and digital cable TV households will remain constant;
- Combined pay and free to air satellite TV will grow at 6% p.a, declining to 2% p.a. by 2020;
- Pay satellite TV households, as a proportion of total satellite TV households, will reach 62% by 2016 and will then remain constant;
- IPTV households will grow at 12% p.a. in 2011. Growth rates will slow and the number of IPTV households will stabilise at 15 million in 2016;
- The number of terrestrial TV households will decline at 5% p.a. from 2011 to 2016 and then remain constant.

Figure B-1: Chart of TV households past data and projections in millions (2006-2023)

TV HH by primary platform (millions in EU27



Source: Plum Consulting elaboration on EAVO data (2011)

[133] Television and on-demand audio-visual services in Europe ; European Audio Visual Observatory(2011)

Figure B-2: Number of TV households in millions - past data and projections from 2006 to 2023

Platform	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cable (A+D)	61.4	61.4	61.4	60.9	60.1	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*	*60.1*
Pay satellite	26.5	29.6	32.7	35.4	37.8	*40.0*	*42.6*	*45.1*	*47.6*	*50.2*	*51.2*	*51.8*	*52.5*	*53.1*	*53.8*	*54.5*	*55.1*
Free satellite	24.6	25.2	25.5	26.2	26.9	*27.8*	*28.4*	*29.4*	*30.4*	*31.4*	*31.4*	*31.8*	*32.2*	*32.6*	*33.0*	*33.4*	*33.8*
IPTV	2.1	4	6.2	8.6	11.1	*12.5*	*13.5*	*14.1*	*14.6*	*14.8*	*15*	*15*	*15*	*15*	*15*	*15*	*15*
Terrestrial TV broadcast (A+D)	85.4	80.8	76.2	71.9	68.5	*65.1*	*61.8*	*58.7*	*55.8*	*53.0*	*53.0*	*53.0*	*53.0*	*53.0*	*53.0*	*53.0*	*53.0*
Total	**200**	**201**	**202**	**203**	**204**	***205***	***206***	***207***	***209***	***210***	***211***	***212***	***213***	***214***	***215***	***216***	***217***

Source: Plum Consulting elaboration on EAVO data (2011)

B.2 TV revenue projections by platform

To estimate economic values we need current and future TV revenues by platform. We consider three revenue sources - TV advertising spend, public funding and pay TV subscription. We estimate future revenues for all platforms using past data from EAVO[134] on historic trends from 2006 to 2010. In extrapolating historic trends we make the following assumptions:

- Advertising spend will decline in real terms, at an initial rate of 3.3 % p.a. declining to 2.3% p.a. by 2023;
- TV public funding will remain constant in real terms;
- Satellite TV subscription revenues per household will decline - by 5.4% p.a. initially and by 3.4% p.a. by 2023

Terrestrial broadcast pay TV subscriptions per household will grow at 8 % in 2013, declining to 0.2 % by 2018

[134] Television and on-demand audio-visual services in Europe ; European Audio Visual Observatory(2011)

Figure B-3: TV revenues projections from 2013 to 2023

Item	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TV advertising spend - CAGR	-3.3%	-3.2%	-3.1%	-3.0%	-2.9%	-2.8%	-2.7%	-2.6%	-2.5%	-2.4%	-2.3%
TV advertising spend (€ bn)	27.6	26.7	25.9	25.1	24.4	23.7	23.0	22.4	21.9	21.3	20.9
Public funding - CAGR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Public funding (€ bn)	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
Satellite pay TV subscriptions (m)	45.1	47.6	50.2	51.2	51.8	52.5	53.1	53.8	54.5	55.1	55.8
Pay per satellite sub - CAGR	-5.4%	-5.2%	-5.0%	-4.8%	-4.6%	-4.4%	-4.2%	-4.0%	-3.8%	-3.6%	-3.4%
Pay per satellite sub - (€ pa)	363.8	345.0	327.9	312.2	298.0	284.9	273.1	262.2	252.3	243.3	235.1
Revenues to pay TV satellite (€ bn pa)	16.4	16.4	16.5	16.0	15.4	14.9	14.5	14.1	13.7	13.4	13.1
DTT pay TV subscriptions - CAGR	12%	10.0%	8.0%	6.0%	4.0%	2.0%	0%	0%	0%	0%	0%
DTT pay TV subscriptions (m)	12.8	14.1	15.3	16.2	16.8	17.2	17.2	17.2	17.2	17.2	17.2
Pay per DTT sub - CAGR	8%	7.0%	5.3%	3.6%	1.9%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Pay per DTT sub - (€ pa)	221.3	236.7	249.3	258.3	263.2	263.7	264.2	264.8	265.3	265.8	266.3
Revenues to pay TV DTT (€ bn pa)	2.8	3.3	3.8	4.2	4.4	4.5	4.5	4.5	4.6	4.6	4.6
Revenues to pay TV DTT - CAGR	-	18%	14%	10%	6%	2%	0%	0%	0%	0%	0%

Appendix C: Glossary

Acronym	Meaning
BTS	Base Transceiver Station
CEPT	European Conference of Postal and Telecoms Administrations
CPE	Consumer Premises Equipment
DCMS	Department for Culture, Media & Sport (UK)
DECT	Digital Enhanced Cordless Telecommunications
DTH	Direct to home
EAVO	European Audiovisual Observatory
EGNOS	European Geostationary Navigation Overlay Service
GB/TB/PB	Gigabyte/Terabyte/Petabyte
HD	High definition
IPTV	Internet Protocol TV
LTE	Long Term Evolution
M2M	Machine-to-machine
OBS	European Audiovisual Observatory website
OTT	Over-the-top
PMR/PMAR	Private Mobile Radio
PMSE	Programme-making and special events
PSB	Public-sector broadcasting
PSTN	Public Switched Telephone Network
RSPG	Radio Spectrum Policy Group (Europe)
SDL	Supplementary Downlink
TDM	Time Division Multiplexing
WLAN	Wireless Local Area Network

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