Frequency Conversion and New Technologies: Challenges and Opportunities in Spectrum Management

by
Robert Horvitz
Open Spectrum Foundation

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It is a privilege and an honor to have been invited by the Center for Strategic Research to speak to you today. CSR's interest in new approaches to spectrum management has already been established by Vadim Novikov in previous seminars. In a sense, my presentation is a response to his seminar on 26 April,[1] but of course he is not responsible for any errors of fact or judgment that I will make today.

And I apologize for speaking to you in English. When Sputnik was launched, I started studying Russian, like many children in the West, but I did not study hard or long enough to learn the language.

These are exciting times in radio, in Russia and globally. For decades, the Soviet Union and its allies developed allocation tables that were incompatible with the rest of the world. For example, here the band for FM audio broadcasting was 66 - 73 MHz while in Western Europe it was 87.5 - 104 MHz. Because Russia is vast, shortwave was used for domestic broadcasting; The NATO countries did not have that option under ITU rules.[2]

But perhaps the greatest difference was that here, hardly any frequencies were available for private or business use. Last year, *RIA Novosti* said 8 - 10 percent of the spectrum in Russia is available for non-governmental use on an exclusive basis, with an additional 5 - 7 percent being shared between governmental and non-governmental uses and 85 percent used exclusively by the government.[3] That's after the allocations table was updated in the mid-1990s. The situation in Ukraine is apparently much worse. Last year *Podrobnosti* claimed that only 0.5 percent of Ukraine's spectrum was for non-governmental use on an exclusive basis.[4] But as you may have

[1] "Рыночные подходы к регулированию радиочастотных взаимодействий"

[2] Except for Russia and China, the ITU limits the domestic use of shortwave for broadcasting to the tropics and countries whose territory is distributed across a set of islands.

[3] "Россвязь объявила конкурс на проведение исследовательских работ," *РИА Новости*, 09.08.2005 – online at http://www.rian.ru/economy/20050809/41120552.html

[4] "Кабмин занялся вопросом конверсии радиочастот," Подробности, 09.11.2005 – online at http://www.podrobnosti.ua/ptheme/mobile/2005/11/09/259968.html

heard, last week Prime Minister Yekhanurov signed a new radio plan.[5] It should help Ukraine move toward its goal of raising the non-governmental allocation to at least 70 percent by 2015.[6]

Unusual band usage under communism was linked to an isolationist trade policy in media hardware. As a result, Soviet manufacturers did not have to compete against imports from countries like Japan. On the other hand, band differences limited the marketability of Soviet radio equipment for civilian applications outside the Warsaw Pact.

Fast-forward to the new millenium. Russia's economy is growing rapidly now while integrating with global markets. Wireless communication infrastructure would be one of the fastest growing sectors of the market – if additional spectrum was available. Foreign imports like WiFi-enabled laptops – and even land-mobile radio networks operating on frequencies assigned to Russian security services – are forcing the table of allocations to harmonize with global norms. As *IT-daily* put it a year ago, Russia's band plans no longer "correspond to reality."[7]

Today I want to share some information with you about frequency conversion in the United States, as well as a conversion just starting in Western Europe. Military/civilian sharing of the 2.4 GHz band in the UK may soon change radically, so I'll tell you what I know about that. And finally, I want to suggest some ways that Russia can make the best of conversion – because there really are advantages to starting late with so much spectrum to work with.

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The end of the Cold War happened to come during a period of profound innovation in radio technology. Integrated circuits (ICs) – fast, small, reliable, cheap and newly available – enabled the digital processing of radio signals. ICs proved as revolutionary as the vacuum tube, but many would argue that the rule adopted by the US Federal Communications Commission (FCC) in 1985 allowing "spread spectrum" communications – with no license requirement – in the bands for industrial, scientific and medical (ISM) devices was just as important.[8] License exemption has the same effect on radio development that the Internet's open architecture has on the development of computer communications. Free space attracts creativity.

The US's long-term spectrum plans were revised several times between 1985 and 1991 although the changes were minor, so requests for new allocations from businesses kept accumulating and could not be fulfilled.

Coincidentally, after generations of unfriendly rivalry, tensions between the communist and capitalist countries unexpectedly relaxed during the same period. These tensions had justified a large commitment of resources to the militaries on both sides – including huge blocks of radio frequencies – and without such tensions, the resource commitments suddenly seemed excessive – at least to non-military people in the US Congress.

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[5] "Ukraine's PM signs plan to allocate radio frequencies," Prime-TASS news agency, 13 June 2006 – online at http://www.cellular-news.com/story/17785.php

[6] "Проект концепції державної цільової програми конверсії радіочастотного ресурсу України на 2006-2015 роки," Ukrainian Ministry of Transport and Communications, May 2005 – online at http://www.stc.gov.ua/data-storage/1275/doc1275.doc

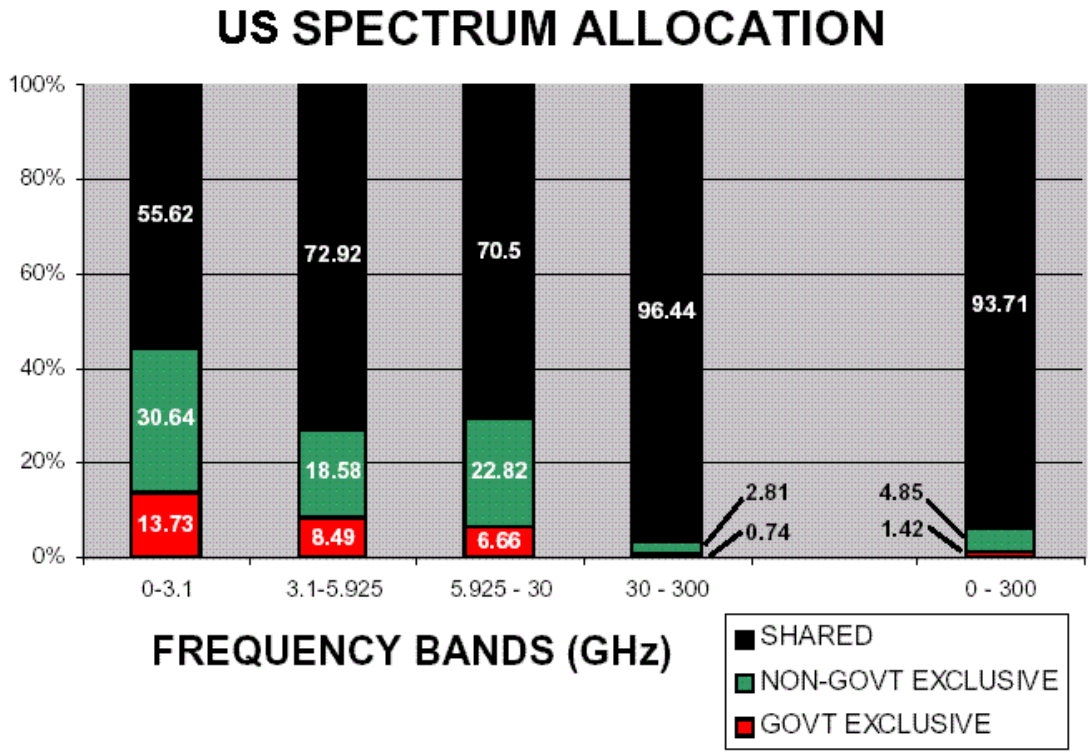
[7] "Эти документы были утверждены еще в 1993 и 1996 годах и в настоящее время не соответствуют реальности..." ---"ГКРЧ вплотную занялась новым «Планом перспективного использования радиочастотного спектра»," *IT-daily*, 7 April 2005 – online at http://it-daily.ru/?ID=47883

[8] "Report and Order in Docket 83-114: Authorization of Spread Spectrum Systems Under Parts 15 and 90 of the FCC Rules and Regulations," US Federal Communications Commission,18 June 1985 – online at http://www.marcus-spectrum.com/documents/81413RO.txt

The combination of rapidly growing demand for spectrum from businesses and weakening arguments for spectrum to support military preparedness led Congress, in 1993, to order the first large blocks of US spectrum to be transferred from governmental to non-governmental use as part of the law that authorized spectrum auctions.[9] The Secretary of Commerce was told to identify at least 200 MHz of Government spectrum and transfer it to the FCC for re-allocation. The FCC was to auction at least 10 MHz of that spectrum for new services based on "emerging" technologies. The National Telecommunications and Information Administration (NTIA , which manages the government's spectrum) identified 235 MHz as transferable[10]: 133 MHz became shared government/non-government while 102 MHz was converted from exclusive governmental to exclusive non-governmental.

This conversion program did not target military spectrum. But the military was the largest user of government spectrum, so any general conversion program affected them most of all.

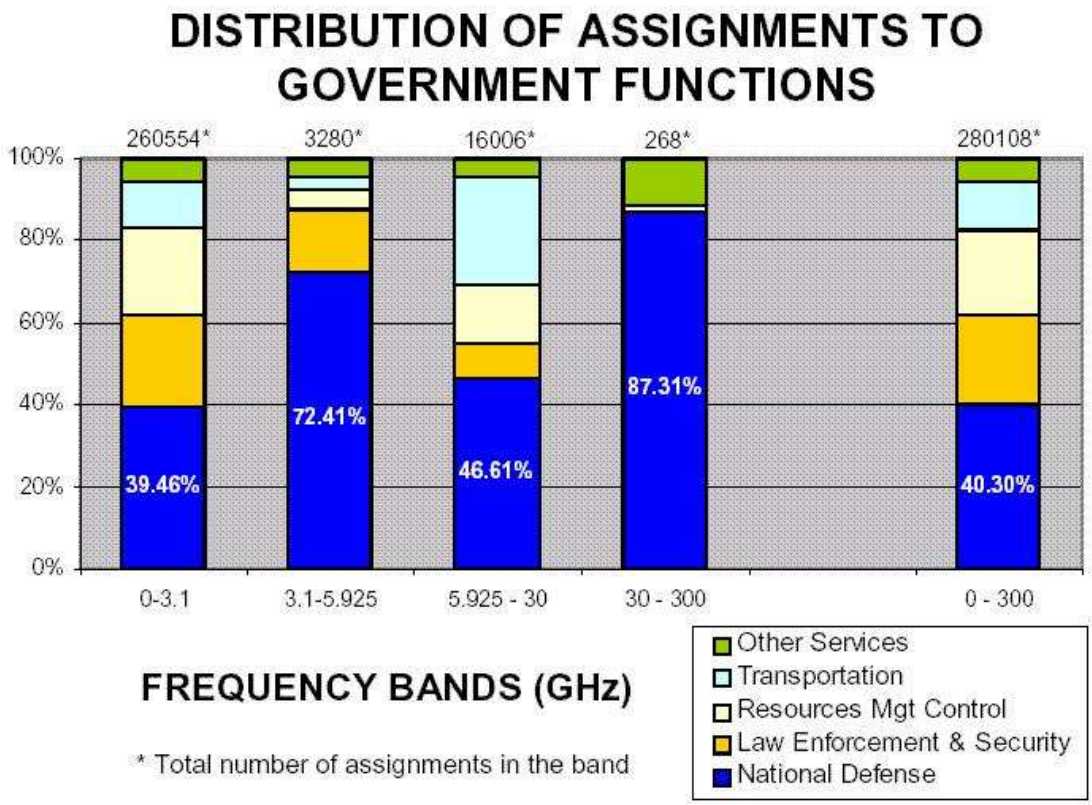
However, by the time conversion started, there wasn't much exclusive government spectrum left. Only 1.42% of US spectrum was still for exclusive government use; 4.85% was exclusively for non-governmental use and 93.71% was shared between non-governmental and governmental users.[11] Most government spectrum had been quietly opened to sharing with the private sector during the "anti-big-government" administration of Ronald Reagan.



[9] The name of this law was the "Omnibus Budget Reconciliation Act of 1993." In other words, it was the Government's annual budget.

[10] *Spectrum Re-allocation Report: Response to Title III of the Balanced Budget Act of 1997*, NTIA Special Publication 98-36, US Commerce Department (February 1998) – online at http://www.ntia.doc.gov/osmhome/reports/bba97/execsum.pdf

[11] *Spectrum 101: An Introduction to Spectrum Management* by J. A. Stine and D. L. Portigal, MITRE Corporation, March 2004, page 3-6 – online at http://public.ccsds.org/documents/SpectrumManagement101.pdf If one limits one's view to the spectrum under 3 GHz, the proportions are different: about 31% of this range was exclusively non-governmental; about 14% was exclusively governmental; and about 55% was shared.



Both charts from *Spectrum 101: An Introduction to Spectrum Management*, page 3-6 (see footnote 11 for full reference) . Data are from 1993-2000 and do not include the effects of conversion..

Among the first frequencies designated for re-allocation were some used by long-range air defense radars, missile test range telemetry, and part of NASA's command and control network. It is not clear whether the inclusion of such high-priority systems in the first conversion was unavoidable, or a painful choice to protect even more important systems, or a political tactic intended to raise doubts about conversion – as when the mayor of a city says the only way he can cut his budget is to close the fire department and sell all the ambulances. Later we will argue that conversion is best understood as a game in which any player destined to lose spectrum rights has a strong incentive to make the game end early. One way to do this is by sacrificing shockingly valuable assets in the first round, to suggest even greater suffering if the game continues into round 2, round 3, etc.

The military complained bitterly about losing radar and telemetry frequencies, but the end of the Cold War reduced public sympathy for their problems. However, NASA did have public support. Their network could not be shut down for reconfiguration because of the many uninterruptible space research projects underway, and the interference risk from sharing with nongovernmental users was politically unacceptable after two fatal shuttle accidents. So other frequencies were swapped into the package to save NASA's, and the military began looking for ways to protect their assets. The total cost of modifying the government systems to allow release of the frequencies ordered in 1993 was about $1.2 billion. That works out to about $5 million per MHz.

Congress took note of these issues and ordered a second round of conversions in 1997. But this round was very much smaller – just 20 MHz and all of it for auction. [12] The results of this auction

[12] Gerald F. Hurt, Ernesto A. Cerezo and W. Russell Slye, *Assessment of Electromagnetic Spectrum Reallocation*, NTIA Special Publication 01-44, US Department of Commerce, January 2001, page vi – online at http://www.ntia.doc.gov/osmhome/reports/ntia01-44/s1059-full.pdf

were less than the cost of clearing the band, so it looked like conversion was not going well. Congress had to admit that

> "government operations had been adversely affected by these reallocations. As a consequence, the 1999 National Defense Authorization Act (NDAA) required reimbursement to government users for costs related to 1997 and later reallocations. The 2000 NDAA returned 8 MHz to government use [and] directed that no [more Defense Department] systems be displaced from their bands until the Secretaries of Defense and Commerce and the Chairman of the Joint Chiefs of Staff certify that alternative frequency band(s) are available to retain the essential military capability that would be otherwise lost..."[13]

The effect of requiring reimbursement and multiple top-echelon certifications was to create an almost insurmountable barrier against future losses of spectrum. That brought the conversion of military spectrum to a halt.

But while the military is the largest user of US Government spectrum, their share is about 40 percent of the total.[14] So it is possible to continue the conversion of *non*-military spectrum as some members of Congress want.[15] However, so little US Government spectrum remains unshared or under-used that improving sharing techniques and increasing the efficiency of everyone's spectrum use through research look like better options than re-allocation.

A recent article in *RBC Daily*[16] said that Mininformsvyazi will allocate 1,120 million rubles this year to frequency conversion in Russia, including the development of planning principles and the replacement of equipment. I have no information about the amount of bandwidth to be released, nor which specific bands. But the article indicated that the first bands to be converted will probably be those with the lowest clearing costs and the greatest economic value to operators and the state as realized through auctions. Digital TV and 3G mobile networks look like the services that will pay the most, so they may be first in line to gain spectrum.

The criteria for choosing which bands to convert in the US were a bit different. According to the 1993 law, they should be bands

- where the primary user is the federal government;
- the frequencies "can feasibly be made available...during the next 15 years";
- not required for the government's "present or identifiable future needs";
- will not result in "excessive" costs to the government, or "losses of services or benefits to the public"; and
- are "most likely to have the greatest potential for productive uses and public benefits..."[17]

Most of those criteria were designed not to facilitate conversion but to protect government services. However, to balance this, the range of possible private uses was wide. Potential "public benefits" might include better understanding of radio technology, safer travel, more rural access to the Internet, etc. So the goal was broader than maximizing economic value.

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[13] *Spectrum 101*, page 4-7.

[14] An additional 21 percent is for "law enforcement and security" according to *Spectrum 101*, page 3-8.

[15] The US House of Representatives approved "The Commercial Spectrum Enhancement Act" in 2003 but it still awaits final action by the Senate.

[16] Светлана Зайцева, "Рейман потратит на конверсию больше миллиарда," *RBC Daily*, 30.05.2006 – online at http://www.rbcdaily.ru/news/market/index.shtml?2006/05/30/219340

[17] Paraphrased from *The Omnibus Budget Reconciliation Act of 1993.*

There were additional criteria specific to the auctioned bands: these were to enable "emerging telecommunications technologies" and create opportunities for firms not already offering wireless services to enter the market. Congress specifically told the FCC not to use income to the Government as the main consideration in setting license conditions and organizing the auctions. Auction rules were designed to favor small businesses, rural telephone companies and businesses owned by women and ethnic minorities; some of the auction income was to be used to increase free access to the spectrum by individual members of the public.[18]

So how is the converted spectrum used now? This list is not complete, but it covers the largest blocks:

- 50 MHz for Fixed Wireless Access to the Internet
- 45 MHz auctioned for 3G mobile services
- 25 MHz for the Amateur Radio Service and unlicensed devices
- 24 MHz for land mobile services
- 8 MHz for medical telemetry

You may also wonder why I'm interested in these issues, particularly in Russia.

A few years ago I was an advisor to the E-Governance Academy in Tallinn. This is a project launched by Estonia's foreign ministry to help other countries use information technology to improve government efficiency, transparency and accountability. Since Estonia is also a world leader in the use of WiFi, they teach governments how to use that tool and encourage the spread of public hotspots. The Academy created a special program for Kazakhstan in which the president, Nursultan Nazerbayev, personally participated. Apparently, Mr. Nazerbayev got very excited about WiFi and said this was just what Kazakhstan needs to become an "information society." But later his military advisor told him this was impossible because the military was still using those frequencies in Kazakhstan.[19]

I am the director of a small foundation in Amsterdam and Prague, the Open Spectrum Foundation. We try to promote more public access to the radio spectrum. One of our first activities was a global survey of WiFi regulation. We have information from about 170 countries now, and one pattern revealed by this study was that most of the Commonwealth of Independent States (CIS) still restrict the outdoor use of WiFi, because of continuing military use of the 2.4 GHz band.

So when Russia, Ukraine, Kazakstan and the other CIS countries started to talk about conversion, we got excited as it looked like this would be a chance to unblock the development of WiFi.

I don't yet know if or when the 2.4 GHz band will be converted. Ukraine's ministry of communications said last year that WiFi will probably be exempted from licensing between 2008 and 2010.[20] Because conversion must be harmonized across the region, we take that as a hint when it might happen elsewhere.

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[18] See Chapter 5, Section 309(j) "Use of Competitive Bidding" in Title 47 of the United States Code, the statute that defines the FCC's duties: 47 U.S.C.A. § 309(j)

[19] This problem was openly discussed in "Казахстану нужен закон по использованию радиочастотного спектра - Агентство по информатизации и связи," gazeta.kz, 29 April 2005 – online at http://www.gazeta.kz/art.asp?aid=58975.

[20] This was announced at a "Roundtable on Problems in the Use of Limited Resources in the Sphere of Telecommunications" in Kiev last year. Reported in the January-February 2006 issue of *ICT Policy Events Digest* – online at http://www.gipi.internews.ua/eng/events_digest/digest_events_jun-feb_eng.pdf

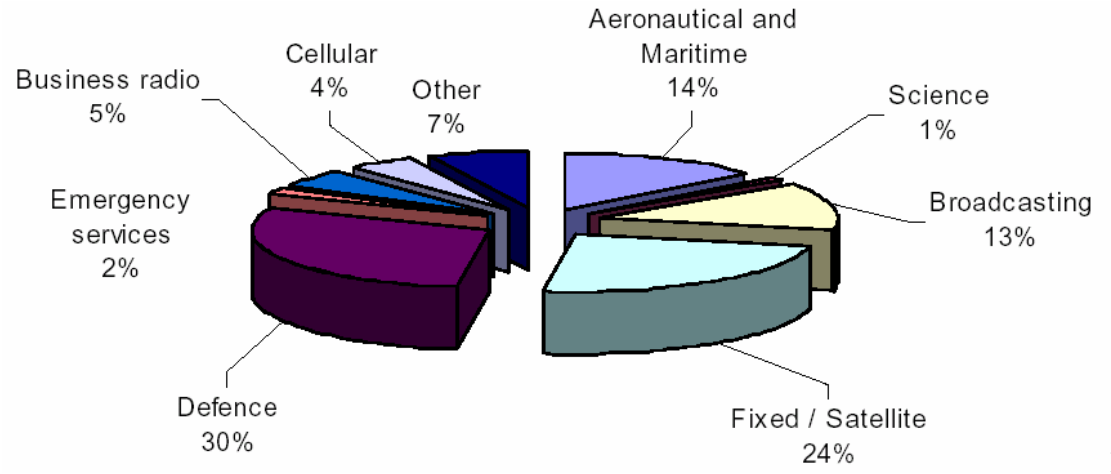
In any case, we read that the Russian Government has given the Ministry of Defense and other security services to the end of this year to prepare plans for releasing spectrum to nongovernment users during 2007 to 2012.[21]

So we are planning a two-day workshop in Tallinn, with the E-Governance Academy, on military/civilian sharing of the 2.4 GHz band. This is for military spectrum managers from all the CIS countries. The presenters will mainly be military spectrum managers from Western Europe, because 2.4 GHz was a military band in that region, too, and in many countries, it still is. When the European Commission strongly endorsed WiFi in 2002, and then in 2003 recommended that it be de-licensed, EU members had to comply. So the military spectrum managers in those countries recently went through a process of accommodation that may not be so different from may happen in the CIS.

If you want more information about this workshop, which is planned for late September, feel free to contact me later by email.

I also wanted to talk this evening about the situation in the UK – for two reasons. The first is that they are at the start of a conversion project which may be more interesting for Russians than the US.

I mentioned that the military in the US has about 40 percent of the government's spectrum. Well, the UK's Minstry of Defence (MoD) has about 75 percent of their government's spectrum, which is closer to the situation here.[22] This implies that 40 percent of the spectrum in the UK is governmental, again closer to the situation in Russia than the US model is.[23]



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Spectrum Use in the UK, "weighted by frequency" (Ofcom)

[21] "Семь ведомств должны за три месяца решить, кто и сколько будет «зарабатывать» на распределении частотного спектра," (In 3 months, 7 departments must decide who will 'earn' on the distribution of spectrum), *IT-daily*, 7 April 2006 – online at http://it-daily.ru/?ID=605057

[22] The figure of 75% comes from Martin Cave, *Independent Audit of Spectrum Holdings – Final Report*, December 2005 – online at http://www.spectrumaudit.org.uk/pdf/caveaudit.pdf. This is referred to below as the "Cave Audit."

[23] If MoD has 75 percent of the government's spectrum, as the Cave Audit says, and the Ofcom chart above says MoD has 30% of the entire UK spectrum ("weighted by frequency"), that implies 40 percent of the UK spectrum is governmental. The Ofcom chart is from Adele Morris and Martin Cave, "Getting the best out of public sector spectrum," presented at the Telecommunications Policy Research Conference, Arlington, Virginia, USA, 8 September 2005 – online at http://web.si.umich.edu/tprc/archive-search-abstract.cfm?PaperID=497

More to the point, the UK uses spectrum fees to encourage government agencies to release unneeded frequencies, as Russia is starting to do, and now they are considering increasing the fees to increase the amount of spectrum released. Professor Martin Cave is analyzing the UK Government's spectrum holdings. He says MoD pays £55 million per year for spectrum use, but his recommendations could multiply MoD's annual spectrum costs 2 to 4 times.[24] Actually, he recommends moving away from fixed rates, to a system that more accurately reflects the value of the sharing to specific users. In his scheme, the primary user of the band would pay for the spectrum, and then collect fees from the secondary users, at rates negotiated and agreed between the parties.[25] When a Government service is the primary user, it pays for the spectrum and is entitled to sublet frequencies or make sharing arrangements. When a private firm is the primary user, a government office needing more spectrum could rent frequencies at what both sides consider a fair price. A simple solution, elegant and decentralized, which could reduce the need for auctions.

My second reason for talking about the UK is that an interesting situation is developing in the 2.4 GHz band. It suggests one way to manage sharing between military and civilian users, even when the civilians are allowed to use high-power transmitters without a license.

Along with its many other regulatory duties, Ofcom is supposed to help expand broadband access to the Internet.. They and the Blair Government are worried about the "digital divide" between large cities and rural areas. The cities have many options for connecting to the Internet, and competition keeps prices low. But in rural areas, there may be only one choice – often with an expensive installation fee – or no choice at all. People who live too far from a telephone switching center cannot get DSL even if the phone company offers that service locally. So the obvious alternative is wireless, but even that is costly on a per-subscriber basis when the population is spread thinly. Internet Service Providers prefer license exempt wireless equipment because it is much cheaper than licensed equipment, and they can change their system without waiting for government permission. But very low power limits are imposed on license exempt equipment, to prevent interference in high-density settings like cities.

However, Ofcom realized that low power limits are unnecessary in low-density areas and allowing higher power could reduce the cost of bringing broadband to remote parts of the country because fewer base stations are needed when signals from each station reach farther. So they hired a consultancy to study these issues in detail. The consultants' report was delivered last month.[26]

The consultants found that the case for higher power limits for wireless broadband in rural areas was very strong. The economic benefits are large and they increase as the power limit is raised. When the power limit is 80 watts EIRP, they calculate the net gain to society as about 800 million Euros – even including the cost of dealing with interference to other users. Today's power limit for WLANs in that band is 100 milliwatts.

So the consultants recommend a large increase in power but linked to the use of directional antennas to limit the area in which interference can occur. They also recommend that high power systems be license exempt – but registered or equipped with GPS[27] to verify their location as being outside cities. It is worth mentioning that Ofcom is obliged by UK law[28] – and by the

[24] Cave Audit.

[25] Cave Audit, page 30.

[26] Scientific Generics Ltd., "Understanding the Scope for a Power Increase for Wireless Broadband Access at 2.4GHz & 5.xGHz," May 2006 – online at http://www.ofcom.org.uk/research/technology/overview/ese/exempt/

[27] Global Positioning Satellite, whose signals can identify a receiver's exact location.

[28] UK Communications Act 2003 - http://www.communicationsact.gov.uk/

European Commission's "Authorisation Directive"[29] – to exempt from licensing the use of any radio device that is unlikely to cause harmful interference. All EU members have this obligation, though not all are equally eager to implement it.

Finally – this is important for military sharing – the consultants recommend that high power rural WLANs be limited to the frequencies over 2.45 GHz – the upper third of the band. This is because the MoD still uses the lower part of the band for things like electronic warfare training and aircraft and missile telemetry. Apparently they pay hundreds of thousands of pounds per year to keep this band so they expect protection, although normal WiFi seems not to be a problem for them..[30]

Ofcom says it will launch a public consultation soon on these recommendations. If the consultants' proposals are accepted and the new rules work, they could spread to other EU countries, because concern about the urban-rural "digital divide" is widespread and Ofcom is regarded as a trendsetter among regulators. We also understand that the World Radio Conference in 2007 (WRC-07) may authorize other bands for air mobile telemetry, reducing the need for protection against interference from civilian networks at 2.4 GHz and perhaps helping the conversion of that band here, too.

To end this presentation, I want to return to the topic of what can be learned from the American experience with frequency conversion. Obviously the situation there is very different from Russia, but some aspects are purely structural – they have nothing to do with the context – so they are relevant anywhere.

In particular, I think it is helpful to look at conversion as a game. I do not mean that cynically. It is exactly the kind of situation that game theory illuminates. Players with an abundance of spectrum rights at the start are destined to lose some of those rights, and at least some players who lack spectrum rights now hope to gain them. Thus the game is assymmetrical but rational, and the government is more or less obliged to act as a referee or the game won't work. Given that they have a closer relationship with those who have alot of spectrum rights, re-positioning the Government as an "honest broker" that both sides can trust could put new strains on the relationship between the military and the Government's civilian leaders.

Those who will lose spectrum rights have strong incentives to bluff, withhold information and loudly publicize their suffering. The same is true for those who want spectrum. For both sides, complaining, bluffing and withholding information are ways to gain tactical advantage by making other players believe in a situation that does not exist when facts cannot be checked:

> "If we give up that band, our soldiers will be unable to communicate on the battlefield."
> "We won't be able to detect missiles coming from Afghanistan."
> "Replacing these radios will cost at least a billion roubles."
> "If we don't get that band, annual economic growth will slow to 1 percent."
> "Foreign investors will shift their capital to India."

Stories are sure to be planted with journalists about the threat to national security posed by uninformed civilian decisions. Call this fellow – he can give you an independent opinion – and if

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[29] "Directive 2002/20/EC of the European Parliament and of the Council of 7 March 2002 on the authorisation of electronic communications networks and services (Authorisation Directive)" *Official Journal of the European Communities*, L 108, Volume 45 (24 April 2002), page 21 – online at http://europa.eu.int/eur-lex/en/archive/2002/l_10820020424en.html

[30] Helena Leeson, Paul Hansell, John Burns and Zoran Spasojević, *Demand for use of the 2.4GHz ISM Band - Final Report*, Aegis Systems Ltd., for the Spectrum Management Advisory Group, 31 July 2000, pages 4-5 – online at http://www.aegis-systems.co.uk/download/ISM2.pdf. More recent MoD usage is reported in the Cave Audit on page 10-3

he corroborates my claim, I'll corroborate his next week when another journalist calls. It's a form of information warfare – inevitably.

To counter the informational advantage that the military has, simply from possessing the convertible assets, those who hope to gain spectrum must gather as much information as possible about the spectrum-holders, their strategies & frequency assets. The commercial radio industry would be smart to hire experienced former military engineers, band managers and spectrum users as consultants and advisors. If it isn't illegal, it would be very useful for the private sector to have recent government band use data based on actual monitoring, especially because after the 3G and DTV auctions, much of the released spectrum may be shared. It will be important to both sides to have accurate information making it possible to avoid interference and coordinate channels efficiently.

Because there were so few bands in the US available for conversion, the process there started close to the end-game, with high-value assets being offered for sacrifice in the first round. It may not happen that way here, but it is a rational strategy even when there are lower-value assets to put into play. Players destined to lose spectrum rights have an interest in trying to end the game early. That can be done by being uncooperative, by emphasizing the unbearable suffering and losses of capability which are sure come, by weakening potential winners' interest in continuing the game, and even by publicizing a security emergency.

But these are worst-case scenarios. One of the great advantages of governmental spectrum, especially in a country like Russia, is that it tends to be available over large areas in relatively large blocks with more flexible use than commercial spectrum. That makes it easier to convert than commercial bands whose service allocation has changed.

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Starting conversion now, Russia has an advantage in knowing that the "emerging best practice" in spectrum management – at least in Europe and North America – is allocating bands in a "technology- and service-neutral" way, without detailed channelization plans. The DTV and 3G bands are not good examples of that – they show the way spectrum was managed last century. However, the recent work on WAPECS[31] by the EC's Radio Spectrum Policy Group suggests how less detailed controls can make spectrum use more efficient, adaptable and tradable. It would be good if at least some auctions of converted spectrum do not specify the services that can operate in the band.

Russia's conversion is also beginning when there is great faith in the "blind wisdom" of market forces in distributing spectrum. We shall see soon enough if that faith is justified. But one shortcoming is already apparent – the idea of spectrum as property depends on the exclusivity provided by licensing. Awarding spectrum by auction actually means selling licenses. An auction has no way to allocate space in a license-free band. Such bands have proven effective in encouraging the development of popular and innovative new short-range services and devices. Bluetooth, WiFi, microwave ovens and cordless phones are the best known now, but RFID and ultrawide-band (UWB) will soon overtake them. America's conversion included the creation of bands for free public (license exempt) access, in addition to licensed bands. That policy reflected the fact that the converted bands were public property to begin with, and they constitute the spectrum's most promising future. If Russia wants to make its name in radio technology, instead of just importing products from abroad, part of the converted spectrum should be opened to unlicensed use without auctions, even at frequencies that are not unlicensed elsewhere – to give entrepeneurs a chance to see what new locally produced devices and services might appeal to people. The same can be done with bands for licensed experimental use.

[31] "Public consultation on Wireless Access Platforms for Electronic Communications Services (WAPECS)," Radio Spectrum Policy Group, 24 June 2005 – online at http://rspg.groups.eu.int/doc/consultations/comments_wapecs/rspg05_87rev_consult_wapecs.doc

Just over two weeks ago the US government launched a consultation on the creation of a national "Spectrum Sharing Innovation Test-Bed."[32] This would be run as a partnership between government and industry to study a wide range of issues related to intensified band sharing between governmental and non-governmental users. Prof. Cave's audit also recommends that the UK launch a testing programme aimed at developing a better understanding of the possibilities and limits of band sharing between radar systems and communications. He also recommends the creation of an advisory group on band-sharing for MoD, Ofcom and other bureaus.[33] It is clear that more intensive band-sharing will be necessary in the future. Yet there are still many sharing situations that are poorly understood, and which require testing because modelling is insufficiently realistic. We don't even have a good idea what the maximum capacity of the 2.4 GHz band might be, or how to calculate it. Given that much of Russia's radio spectrum will eventually be shared, validating and improving sharing principles is a good opportunity for military/civilian and government/industry cooperation.

The superiority of Russia's computer programmers is well-known. This gives the country an obvious opportunity to become a market leader in "software defined radio," a technology that will gradually replace "hardware defined radio" during the next 10 to 20 years. Microprocessors always get faster, more powerful and cheaper. So as time passes, it becomes more cost-effective to implement more radio functions in software. Such a radio is very flexible – able to emulate many special-purpose devices, adapting quickly to its environment and its operators needs. In principle, a software defined radio can act as a mobile phone – launch a different application and it can be modem for a laptop – launch a another application and it's a remote control for a home entertainment center. Many people expect such radios to be able to change their bandwidth, power, frequency and antenna pattern from one moment to the next, in order to exploit any temporarily unoccupied spectrum – potentially eliminating the need for centrally planned channel assignments.. This vision of the future is close to the ideal of "open spectrum." It is considered plausible by many radio engineers, if not inevitable. But there are many, many details to be worked out. Most of the software that will make this vision real has yet to be written. But I would be surprised if the Bill Gates of software defined radio is not Russian.

[32] "The President's Spectrum Policy Initiative – Spectrum Sharing Innovation Test-Bed,: Notice of Inquiry,"National Telecommunications and Information Administration, 2 June 2006 – online at http://www.ntia.doc.gov/ntiahome/frnotices/2006/NOI_SpecShare_060206.htm

[33] Cave audit, pages 13 and 48