DE-REGULATING THE SPECTRUM – IMPLICATIONS FOR TECHNOLOGY

V. A. Jervis

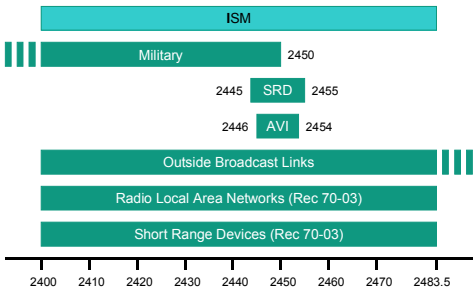
DE-REGULATION WORKS

The thought of de-regulation may cause spectrum managers great concern but you could argue that currently the only thriving part of the spectrum is the licence exempt bands! The advantage of these bands is no administrative process or fee for access to the spectrum.

However the diverse, and increasingly intensive use of these bands brings with it the potential for congestion and consequent potential degradation in service quality. For many some loss of quality may be an acceptable consequence of using licence exempt spectrum and of course technological developments help in allowing more dynamic frequency usage and overcoming many of the potential problems. Polite technologies such as dynamic frequency selection (DFS) and transmitter power control (TPC) can permit far more intensive use of the spectrum as they can keep the level of interference down. Interference is also minimised by imposing limits on certain technical parameters such as output power.

The use of the 2.4 GHz licence-exempt band is shown below (1).

UK Use of the Band 2400-2500 MHz



Notes: AVI - Automatic Vehicle Identification for railways. 500mW in 2446 - 2454 MHz.
Radio Local Area Networks - also used for Radio Fixed Access and planned to be used by Bluetooth.
SRDs - Short Range Devices. 10mW in 2400 - 2483.5 MHz; 500 mW in 2445 - 2455 MHz for movement detection (tagging).
2445 - 2455 MHz also used for short range indoor data links (no analogue speech).

TOTAL DE-REGULATION

So why can't this model work in other frequency bands and all radio spectrum become de-regulated in a similar way?

There are a number of practical reasons:

- Restrictions imposed internationally on the use of spectrum by the ITU, CEPT and EU.
- Radio waves do not observe national boundaries. In the UK radio users in the 450 to 470 MHz band, particularly those located towards the south and east coasts, have suffered interference from Europe which uses a different frequency plan (2). This demonstrates why the use of frequencies may need to be harmonised, especially in the lower frequency bands, and this may also mean the utilised technologies also have to be limited.
- Licence exempt spectrum generally is not appropriate for emergency communications or other services which require high levels of reliability / availability.
- Economies of scale needed for equipment development and production. The 2.4 GHz band is used on a global basis thereby providing the necessary economies of scale. This wouldn't be the case if such equipment was only deployed in say the UK.

MARKET MECHANISMS (3)

To facilitate de-regulation in licensed bands other means, such as market mechanisms, therefore need to be considered as a complement to or replacement for the traditional hands-on regulatory approach. Market mechanisms include:

- Spectrum trading and auctions
- Use of overlay licences[1]
- Placing the responsibility for interference management on the spectrum users.

The use of market mechanisms is not a new idea and a number of countries, such as the US, Canada, New Zealand and Australia, have considerable experience of using them. The trend is to provide flexibility in services and use of technologies. This is clearly easier to achieve in countries where there are no or limited bi-lateral constraints.

However even in these countries some constraints are placed on the use of the spectrum. In Australia and New Zealand the way the spectrum is packaged for auction is done on the basis of the most likely usage and therefore does not result in a technology neutral outcome. In the US and Canada the degree of service and technology flexibility is considered on a case by case basis. Decisions take into account issues such as compatibility with adjacent frequency bands, border co-ordination, and availability of equipment.

Spectrum trading per se has not been a major success to date in the US. Since 1996 the FCC has been introducing measures to encourage secondary trading. Very little trading has occurred under a system in which licensees are allowed to disaggregate and sell on spectrum rights. Although there has been some consolidation of PCS licences as a result of trades and swaps between licensees. It is believed this is because of the cost of trading and also uncertainty about

[1] Overlay licences are licences that are encumbered by "sitting tenants" with defined rights for both the newly licensed users and incumbents.

future spectrum requirements. Spectrum leasing may prove to be a more attractive alternative. In Australia and New Zealand there has also been little trading but this is probably because there is an abundance of spectrum for both existing and new services. The sale of Management Rights, from TelstraClear to Vodafone, for 5 MHz of 3G mobile spectrum in New Zealand was due to a merger between TelstraSaturn and CLEAR Communications. Government regulations do not allow a 3G licensee to own more than 15 MHz of spectrum and the merged company held 20 MHz.

Overlay licences have been successfully awarded in all four countries. The incumbents have typically been licensees who have site specific licences such as fixed links or broadcast transmitters. Slightly different approaches have been taken but in general

- Incumbents' rights are time limited
- Incumbents must be paid compensation to vacate spectrum before their licences expire
- Incumbents retain the same interference protection while they remain
- New entrants are given the same level of protection from interference.

In the US incumbent microwave link users were given 3 years to stay in the case of broadband PCS – public safety incumbents had this extended to 5 years.

Interference management for tradable spectrum licences has been delegated to the licensees. The regulator may set the initial limit for interference parameters (NZ, Australia and the US) or they may be set by industry with oversight from the regulator (Canada). Means are provided to change the parameters where required.

In all of these countries publicly available on-line data base(s) of information are available. This is essential to allow effective secondary trading.

EUROPEAN DIMENSION

In Europe we are subject to the mandatory regulation of the European Union and the optional regulation of CEPT and these impose constraints as does compliance with ITU regulations. The European Common Frequency Allocation Table covers major uses of the frequency bands and it is intended that it should be adopted by CEPT administrations by 2008. There are also cross border bilateral agreements, between countries, which constrain spectrum use. In terms of technology it must adhere to the "essential requirements" of the R&TTE Directive. This requires equipment to meet health and safety and EMC protection requirements. Additionally the equipment must be constructed to make effective use of the spectrum so as to avoid harmful interference. The primary drivers of this Directive were:

- Free circulation
- Deregulation by putting the responsibility on vendors to conform.

One of the outcomes is technology neutrality, which is discussed later.

The new EC Communications Directives, which entered into force on 24 April 2002, define the conditions (4) that may be attached to rights of use for radio frequencies. It is interesting to note that conditions can include:

- obligations under relevant international agreements relating to the use of frequencies,
- technical and operational conditions necessary for the avoidance of harmful interference and for the limitation of exposure of the general public to electromagnetic fields where these differ to those in the general authorisations.

EQUIPMENT CONSIDERATIONS

Whether adopting a technology neutral approach is beneficial to the radiocommunications market is open to discussion. If we consider Europe, the impact of spectrum and standards harmonisation for the mobile industry has led to lower prices, faster take-up and higher production volumes. Whereas in the US where there is a choice of standards for cellular and personal communication services (PCS) this has led to a mix of standards being adopted by the operators and caused interoperability problems and delayed customer take-up.

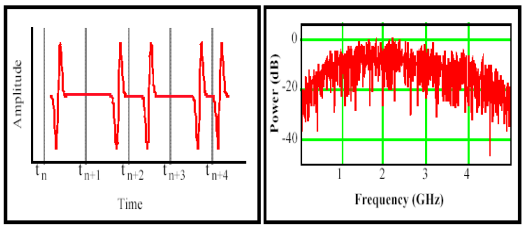
Then if we consider CT2, ERMES and Fixed Wireless Access even with harmonised standards they have not been a success story. Clearly harmonised standards are not the only criteria for success – there needs to be a market demand and a viable business plan.

HOW CAN INTERFERENCE BE MANAGED?

Interference needs to be managed between co-frequency operations in adjacent geographic areas (national) and also between countries (international) to enable de-regulation. In doing this a number of factors have to be considered:

- Generally homogeneous systems are the most spectrally efficient and provide the least problems at boundaries
- Systems that require high availabilities impose greater sharing constraints e.g. some point to point links require co-ordination distances of 200 km.
- Boundary conditions could be set to avoid all potential interference but this will usually be too constraining in practice. Co-ordination will also be required.
- Highly directional antennas can lead to higher potential interference although the probability of this happening is much lower because of the smaller beam widths of the antennas.

- Co-frequency point-to-area systems of similar power levels are more suited to operating in adjacent bands.
- Technologies are available that can reduce the impact of interference. The use of frequency agility has been shown to provide benefits in the 2.4 GHz band. Adaptive antennas are also used where the costs are not prohibitive. Whether low power density methods such as spread spectrum and ultra wide band systems will be effective is still not clear. In these cases the likelihood of interference is reduced because the signal is spread over a bandwidth much wider than that of the victim system. Therefore a smaller proportion of the interfering power is within the bandwidth of the receiver. This allows more interfering systems to operate in the same frequency but at some stage the cumulative level of interference may become a problem. The diagram below demonstrates how randomising the pulse positions in UWB systems reduces the spectral lines and produces a broadly continuous power spectrum.



Pulse Position Modulated and Randomised Pulse Train and its Power Spectrum (taken from 'PulseOn Technology Overview', http://www.timedomain.com)

Even in a de-regulated environment there still needs to be a means of co-ordination, taking into account current approaches, between operators and countries to facilitate efficient use of the radio spectrum. There will be implications if the use of the spectrum differs between operators and countries as the sharing potential depends on the characteristics of the services being provided.

EVOLUTION OF RADIO TECHNOLOGY

As mentioned earlier there are already technologies that provide:

- dynamic traffic-channel monitoring and selection, and
- direct sequence / fast frequency hopping spread spectrum waveforms with interference mitigation.

These enable the potential for interference to be avoided even in a de-regulated environment.

Fast power control is an essential component of CDMA cellular systems. For such systems to operate the receivers must have constant inputs from all the transmitters and this is achieved in CDMA 1X by using an update rate of up to 800 MHz.

In addition to make more efficient use of the available spectrum it is possible to use variable data rates to deliver services that match the quality of the channel (e.g. 3G mobile).

AND WHAT ABOUT THE FUTURE?

De-regulation in the current economic climate is unlikely to stimulate spectrum demand as happened with market liberalisation in the 1990's. The majority of operators and vendors have entered a period of "maintenance" where they are looking to minimise investments and maximise returns. Technologies that can increase communications capacity, increase network flexibility and increase interference protection – in other words maximise, for operators, the use of their licensed radio spectrum could be attractive when considered alongside the introduction of market mechanisms. So technologies that enable waveforms to adapt to available spectrum windows, interference and service demands, and that can provide dynamic spectrum monitoring and utilisation of available spectrum will be increasingly popular.

IN SUMMARY

Clearly de-regulation will have an impact on technologies and vice versa. The new EC Communications Directives require administrations to be technologically neutral and require regulators to issue general authorisations for all electronic communication networks and services. A number of regulators are using market mechanisms as a means to reduce regulation of the wireless market. The degree to which spectrum can be de-regulated and services share the same bands will depend on their parameters. We have examples already where market mechanisms have been effective and over the coming years we will be able to judge ourselves their effectiveness and the impact of de-regulation on the radiocommunications market and the developing technologies.

REFERENCES

(1) Radiocommunications Agency

(2) 450 – 470 MHz Band Alignment Project Information Sheet from the UK Radiocommunications Agency.

(3) Report on "Implications of international regulation and technical considerations on market mechanisms in spectrum management" by Aegis Systems and Indepen Consulting, November 2001.

(4) Oftel consultation on "Draft general conditions of entitlement to provide electronic communications networks and electronic communications services", 22 May 2002.