AEGIS NEWSLETTER MARCH 2008

THE DIGITAL DIVIDEND—OPPORTUNITY AND CHALLENGE

Introduction

As the process of switching European television from analogue to digital technology gathers pace, there has been growing interest in how any radio frequencies that are released as a result of switchover might be used. Digital television requires considerably less radio spectrum than its analogue counterpart to deliver the same content—for example in the UK each analogue programme channel requires up to eleven 8 MHz frequency channels to deliver national coverage, whereas digital technology allows all five programme channels to be delivered with as few as four frequency channels.

The frequencies used for TV transmission provide wide area coverage in both urban and rural environments and are therefore of particular interest to mobile and other wireless operators. A wireless base station operating at 700 MHz can serve over twice the area of a station operating in existing 3G cellular bands at 2 GHz, meaning far fewer base stations are required to provide national coverage and yielding substantial cost savings to a network operator.

However, the broadcasting community also have plans for this spectrum. Digital television provides the opportunity to deliver many more channels and to upgrade to high definition—providing sufficient spectrum is available. For example, in the UK, viewers already have access to over forty TV channels over terrestrial digital networks and the government plans to introduce terrestrial high definition services once the analogue services cease. Nevertheless, most countries will see some release of spectrum as a result of the switchover and in this article we consider the options for future use of this “digital dividend”.

International Activities

A number of influential international bodies are currently addressing the digital dividend. Perhaps the most significant development was the agreement reached at the 2007 World Radio Conference of the ITU (WRC-07) to designate the frequency band 790–862 MHz (the upper part of the analogue TV band) for future use by 3G mobile systems (generically referred to as IMT or International Mobile Telecommunications). This decision does not mean that individual countries will be required to make the spectrum available for mobile services, but does provide a clear indication that if spectrum from the UHF TV band is made available it should sit within this range. The choice of the 790–862 MHz band is logical in that it lies close to the existing 900 MHz band used already for 2G mobile communications such as GSM (and earmarked for upgrade to 3G). The proximity of the new frequency band simplifies equipment design and reduces cost—for example, many existing antenna systems will operate effectively down to 790 MHz.

Within Europe, the international regulatory body CEPT has set up an engineering task group (TG4) to develop suitable technical criteria for deployment of mobile services in the digital dividend spectrum and is focusing on the higher end of the band, in line with the WRC outcome. The European Commission has also made clear its preference for a subdivision of the band, with the highest frequencies being set aside as a harmonised band for new applications such as broadband wireless access or high-speed mobile data.

Whilst such “re-farming” of the upper part of the band is broadly compatible with the spectrum release plans of some EU counties, for others it would present a significant problem. At an earlier regional ITU Conference held in Geneva in 2006, a complex plan was agreed defining the use of the entire UHF band for digital TV broadcasting throughout Europe, the Middle East and Africa. Under this plan, countries such as Spain, Portugal and Belgium are particularly dependent on frequencies above 790 MHz for implementation of their digital TV networks—indeed Spain has three networks already operating within this range. Any move to re-farm this spectrum throughout Europe would require major changes to the Geneva ‘06 plan, potentially incurring significant costs in countries that have already installed transmitters based on the plan. On the other hand, failure to adopt the new frequencies could lead to potentially even greater costs on the part of the mobile industry, so it is likely that some compromise will ultimately be required.

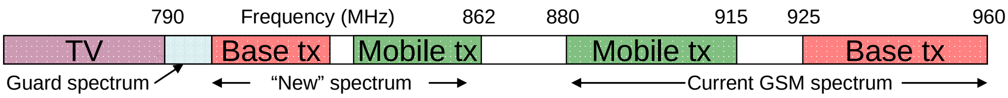
The Technical Challenge

Identification of part of the UHF band for new wireless services is merely the first step in the process of actual deployment. Unlike television, wireless voice or data services generally require two-way communication, which involves partitioning the available frequencies so that the forward and reverse links do not interfere with one another. This process, known as *duplexing*, can be done in either the time or frequency domains—time division duplexing (TDD) is used in digital cordless phones and in some new WiMAX networks, whilst frequency division duplexing (FDD) is used in GSM and current 3G mobile networks.

TDD has the advantage that there is no requirement to divide the spectrum into go and return channels. However, it does mean that forward and reverse transmissions in geographically nearby networks have to be precisely synchronised in time. This is not a problem for short-range applications like cordless phones, or even for longer-range systems like WiMAX, as they operate in higher frequency bands where the signals do not travel so far. However, at UHF where interference can traverse hundreds of km under certain conditions this would be a serious limitation and in practice it is almost certainly the case that an FDD approach will be required.

Much of the discussion underway in CEPT TG4 relates to the optimum duplex arrangements within the released spectrum. Traditionally, mobile networks have operated on fixed, pre-defined duplex bands with the base station to mobile transmissions in the higher band (because range tends to be limited by the mobile transmit power and transmission losses are lower in the lower band). In the UHF case, it is likely that a reverse duplex configuration will be favoured (i.e. base station transmissions in the lower band). This is partly to reduce filtering in the mobile terminal (the upper UHF and lower 900 MHz mobile transmit bands effectively form a single band) and partly to facilitate co-existence with TV services in the adjacent spectrum (base station transmissions are more manageable from an interference perspective than mobiles).

Possible configuration of a "re-farmed" UHF band



Much further work is required to establish just how much frequency and/or geographic separation is required between mobile services and TV to avoid interference between the two, especially if Europe does not eventually achieve fully harmonised spectrum. Interference works both ways. Mobile base stations operating close to a domestic TV aerial could prevent reception of TV programmes on adjacent frequencies (though in practice it should be possible to overcome this by simply locating a repeater TV station alongside the base station). However, a potentially bigger problem is the impact of high power TV transmitters on mobile base station receivers. TV transmitters often operate at tens of kilowatts and the signals can travel hundreds of km under certain climatic conditions, whilst the base station is trying to receive signals from mobiles typically operating at no more than a few hundred milliwatts—not an easy task!

Aegis is playing a key role in advancing thinking on the digital dividend, working closely with national regulators, potential users and international bodies like the European Commission. Our expertise covers both technical and regulatory policy aspects. Contact us now if you require any assistance in making the most of the opportunities digital switchover provides.

As well as our work to support decisions on the Digital Dividend, we have been involved in a number of other projects as described further in this Newsletter. If you require further information, please do not hesitate to contact either John Burns, Val Jervis or enquiry-2008@aegis-systems.co.uk.

SPECTRUM REGULATION

Cellular Spectrum Demand

In conjunction with Ovum Australia, we undertook a study for ACMA, the Australian regulator, to provide *quantitative* estimates of spectrum demands for wireless access and cellular services in Australia for the years 2012, 2017 and 2022.

The approach we took to forecast demand was to use the established spectrum demand forecasting model from the ITU-R and adapt it for Australian conditions. The advantage of using the model was that it builds in increasing spectrum efficiency for the air interfaces and so tracks the likely technology improvements in equipment.

Health socio-economic study

In order to determine the likely future demand for spectrum from the health sector 10 to 20 years hence, Ofcom commissioned a wide ranging socio-economic study from Fathom, a telecoms, media & technology strategy consultancy, in collaboration with Aegis and Imperial College.

This work, which is due to be completed shortly, has involved:

- a review of the health sector in the UK as it currently stands
- identification of the major driving forces (drivers and barriers) within the health sector that would impact the uptake of ICT and derivation of five scenarios that describe a number of possible healthcare futures
  - identification of future ICT (Information and Communications Technology) applications
  - mapping of ICT applications (in terms timing and degree of uptake) to scenarios
  - identification of the wireless architectures that would be deployed to support the applications
  - derivation of the spectrum requirements of the applications / architectures associated with each scenario

The study has identified that many of the foreseen applications will be most appropriately supported by existing and planned public and private networks. While the data throughput demand of some applications (e.g. high quality video) will undoubtedly have an impact on the spectrum required by these networks, the study focused on the spectrum required by the more critical applications associated with healthcare. There is currently spectrum provision for some of the critical applications (e.g. social alarms and communication with and between medical implants) but there is concern that others such as wireless links between diagnostic equipment (e.g. vital signs monitoring), whether in the hospital or at incidents that ambulances attend, should not be reliant on licence-exempt spectrum for Local Area Networks. It is notable that in the US explicit provision has been made for this under the Wireless Medical Telemetry Service (WMTS).

OPERATIONAL STUDIES

Assignment Strategies for Fixed Links

The demand for fixed links continues to grow for local access and also in support of the roll-out of cellular and broadband wireless networks. There are a number of different approaches that can be used to assign channels in a block of spectrum:

- 'lowest compatible channel'—also known as sequential channel as the first channel that is interference free is assigned. This approach means that assignments are bunched around the starting point of the frequency band.
- 'next channel'—the first compatible channel higher than the most recent assignment is assigned
- 'random channel'—the first compatible randomly selected channel is assigned
- 'closest fit'—the channel in which the worst interferer satisfies the interference criterion by the smallest margin is assigned
- 'loosest fit'—the channel in which the worst interferer satisfies the interference criterion by the largest margin is assigned.

The study investigated the spectrum efficiency of the different approaches to see if any of the possible methodologies offered significant benefits. It was expected that the various methods would distribute channels differently and potentially that one or other method will provide better spectrum efficiency than that obtained through the sequential-channel approach to assignment, particularly when congestion occurs.

The measure of spectrum use was based on a spectral utilisation factor that takes account of the communications value (measured by throughput and distance) of a set of links and the spectral cost (measured by amount of spectrum and area)—the greater the value and the lower the cost, the higher the utilisation factor; the lower the value and the greater the cost, the lower the utilisation factor.

It was not possible to say categorically that one method is better than another because of the lengthy simulation times and it was not possible to reach the point of congestion for the full band. Nonetheless, at high link densities, the sequential method showed a higher utilisation factor than for the other methods. The other methods had similar utilisation factors and assignment failure rates, though the closest-fit method provided some advantage at low densities.

For the sequential method the result was dominated by the assignment bunching that is implicit in the method but which, with the exception of the closest-fit method, is not present in the other methods. As the assignment density increases, the utilisation factors of the sequential and closest-fit methods tend towards convergence with the other three methods. This is expected as the spectral span of the 'bunched' methods expands to fill the whole band available. Simulations with artificially reduced bandwidth show that the utilisation factors for all methods do indeed converge at high assignment densities.

Spectrum Access

We have been investigating with a number of European Administrations the possibility of identifying suitable spectrum for a customer's product. This has involved identifying any relevant ECC Recommendations and Decisions, the implications of any product variations and also relevant standards currently agreed in Europe.

Ka-band co-ordination and Earth Station PFD Analysis

For a satellite operator Aegis has recently undertaken the detailed coordination of several sites in preparation for their deployment of diversity gateway earth stations operating in Ka-band. The spectrum will potentially be shared with Broadband Fixed Wireless Access (BFWA) systems, which are expected to operate mainly in urban and suburban areas. Existing national coordination procedures have identified a threshold field strength that triggers the coordination procedure.

The field strengths generated by the proposed gateway earth stations were modelled around the various sites to determine the areas affected by the threshold field strength. The impact of shielding was also assessed; initially in general terms with respect to all the sites considered, and then with detailed reference to the physical characteristics of one of the sites. This enabled the satellite operator to apply successfully for the necessary earth station licences.

SHARING STUDIES

Digital Dividend

Aegis continues to support Ofcom regarding the release of spectrum post switchover to digital TV. Our work mainly considers the guard bands that will be necessary between the different services that may use the spectrum once it is released. In parallel with this work ERA technology are undertaking measurements that provide the protection ratios necessary between two adjacent services as a function of guard band. These protection ratios have been used in the Aegis simulations to determine likely service impacts. The results of our work will inform how any freed-up spectrum might be best packaged for release into the market.

RESEARCH STUDIES

Propagation Research Study

The ITU-R has recently adopted a new Recommendation, P.1812, giving a propagation model for use in point-to-area predictions at frequencies between 30 MHz and 3 GHz. It is expected that the Recommendation will find particular application in the planning and international co-ordination of digital broadcast services.

The new model is based on many of the algorithms used in ITU-R Recommendation P.452, which is specifically concerned with the prediction of interference over long paths at frequencies above 1 GHz, and is very widely used for international co-ordination of, for example, satellite Earth stations and fixed links.

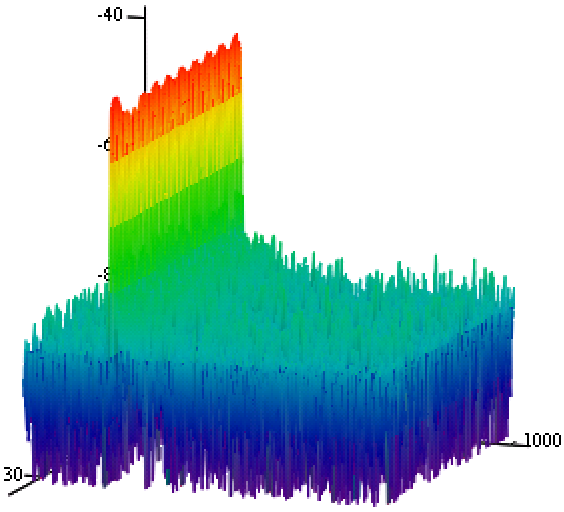
Adaptation of the model for the new purpose has involved the addition of models for clutter loss, and for location variability, as well as verifying that the algorithms for ducting and troposcatter propagation behave reliably at the lower frequencies.

The UK undertook much of the work in developing the new Recommendation. Aegis staff were involved in this process with funding from Ofcom, and attended the meetings of ITU-R Working Party 3K last year at which the model was finalised.

A correspondence group has been set up by WP 3K to address the further testing and potential development of the new Recommendation, and we are currently working within this to produce results to inform the forthcoming meeting of WP 3K in the summer of this year.

Wind Farm Interference Study

With increasing concerns relating to carbon emissions, and to diversity of energy supply, wind farms are becoming an increasingly familiar sight in the UK countryside. One potential downside of these developments is that they have the potential to cause interference to services using the radio spectrum, either by absorbing energy from paths passing through, or near, the turbines, or by scattering it to cause interference to off-axis receivers.



Aegis sounder measurement at 1477 MHz, showing energy arriving over a single path with regular fading

ERA technology has been commissioned by Ofcom to quantify the impact of such wind farms on radio links, with the particular aim of verifying the algorithms used by Ofcom in link assignment. As subcontractors to ERA, we have proposed to make use of the Aegis multiband channel sounder to investigate the characteristics of wind farm interference. The sounder will allow us to distinguish between energy received directly, and that scattered by wind turbines, allowing the determination of the relative level of the two signals, and the fading characteristics of the scattered signals.

Time Varying Interference

One of the most severe constraints in rolling out any radio network is that imposed by interference to or from other services. For many networks, the majority of interference paths are relatively short, and the levels of interference do not vary greatly.

A particular problem for broadcast networks (though present to a greater or lesser extent in any network providing services to outdoor terminals over a wide area) is that posed by interference from high power transmitters between 50 km to some 300 km distant.

For median percentage-times, the signals from such transmitters may be well below the noise floor. The variability of the refractive index of the troposphere, however, can cause such signals to be elevated by many tens of dB for short, but significant, times.

For instance, ITU-R Recommendation P.1546-2, which is based on a large number of measurements made over many decades, predicts that the 10% field strength, on a UHF sea path of 200 km, will be 24 dB higher than the median value, while at 1% time it will be elevated by over 50 dB!

Monitoring of continental signals in East Anglia

There is clearly a requirement for such an interference mechanism to be carefully managed, and we are currently undertaking a study for OFCOM concerned with various aspects of such time-varying interference to broadcast networks. The technical studies include a series of long-term measurements of paths across the North Sea and English Channel, as well as a review of prediction methods.

Receive aerial for long-term measurement campaign

In addition, the study includes an amount of work to help understand the impact on viewers. This part of the study is being undertaken by our partners at i2 Media Limited, based at Goldsmiths, University of London.

OTHER

Determination of Auction Prices

The purpose of this study was to provide advice and make recommendations on the calculation methodology / mathematical model to determine the auction reserve prices and the deposit and performance bond for a forthcoming spectrum. Additionally it was considered how the approach could be applied to other frequency bands and applications.

Key considerations were:

Reserve Price—to deter trivial bids but still ensure adequate participation in the auction.

Deposit—to deter rule breaking within the auction or to default on accepting the licence.

Performance Bond—to send a clear message that the minimum rollout conditions will be enforced and so ensure the successful bidder meets these conditions.

Benchmarking by comparing the approach used by other countries for such prices and also those previously used in the same country, and the development of business cases of potential bidder types were used to determine the auction prices.

Mobile Spectrum Database

For the past year, Aegis has been supporting the GSM Association in developing a database of public mobile networks and associated radio frequencies around the world. The data includes technology and regulatory data for individual networks and countries along with population distribution data that can be helpful for network planning purposes. It is anticipated that the data will be incorporated into the Association's Wireless Intelligence database, an on-line subscription based service.

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