Cross border considerations

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It is a well-known scientific fact, but one that is sometimes ignored, that radio waves do not respect borders between countries and geographic regions[i]. This means that radio networks deployed in one country or region can cause interference to networks deployed across the border. The impact of the interference can vary considerably and in the worst case may lead to network deployments and services being limited, of poorer quality, or even unavailable in localised areas. Cross border interference is of particular concern where there are long borders between adjoining countries, where there are large towns and cities close to border or where there are small countries with one or more neighbouring countries; in these cases, differences in spectrum use can limit planned spectrum awards, introduction of new technologies and network deployments. This Insight paper examines some specific examples of cross border issues and considers mitigation mechanisms available to reduce the likely impact of interference due to planned changes in the use of the radio spectrum.

Identifying problem areas

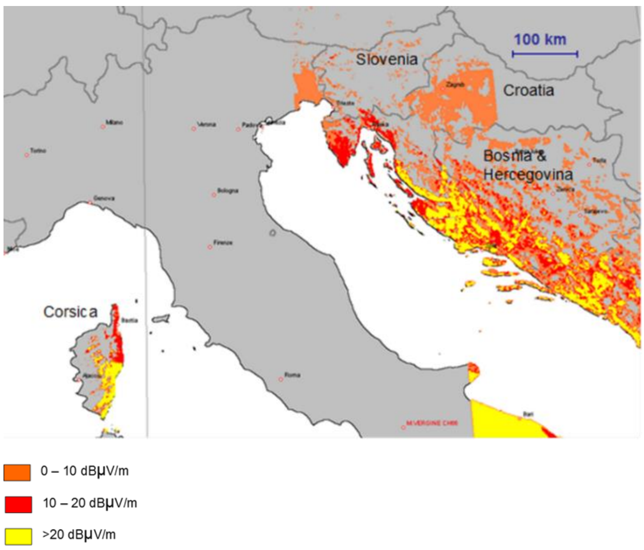
Interference may be the result of co-channel (where the transmit channel overlaps the receive channel) or adjacent channel (where there is no overlap between the transmit and receive channel) deployments on either side of the border. The problem can vary over time as frequencies are redeployed ('refarmed') to support the introduction of new services and technologies on a per-country or per-operator basis.

There are a number of reasons why interference occurs. Geographic proximity of the networks, strong transmitter emission levels (such as high-power and high-altitude transmitter masts), imperfect transmitter and receiver characteristics (like poor filtering) and propagation effects (such as 'ducting' of signals during high-pressure weather conditions[2]) to name a few.

The situation may be exacerbated due to interference aggregation from other services operating in co-channel or adjacent frequency bands. For example, a key consideration during analogue TV switch off and deployment of mobile broadband was interference from broadcasting transmitters, often operating at high power (around 10 kW) and using high masts into new cellular (4G) networks in the 700 MHz and 800 MHz bands. Studies undertaken previously by Plum[3] have examined the implications of such high power, high site broadcasting transmitters. In the example shown in Figure 1 a broadcasting transmitter at Monte Vergine in Italy radiates the same power in all directions; the modelling[4] of potential cross border interference showed a relatively high risk of interference into Corsica, Croatia and Bosnia and Hercegovina[5].

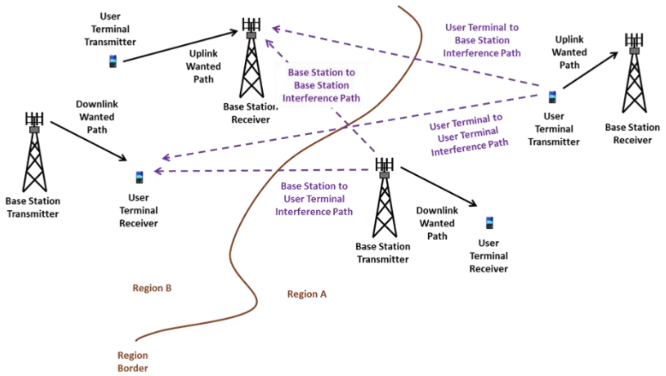
This example highlights the importance of developing a harmonised approach to spectrum usage across the borders including migration steps necessary to redeploy (refarm) spectrum for new services – in this instance the new service is mobile broadband. The spectrum will not be usable for mobile broadband at the borders, or significantly inside the borders, of Italy's neighbouring countries as shown by the yellow (high risk of interference) and red (moderate risk of interference) shaded areas in the interference plot below in Figure 1. To minimise the impact of interference, it would be necessary to migrate the broadcasting transmitter site to a new frequency away from the planned mobile broadband frequencies, or alternatively, to re-design the broadcast antenna to direct power away from the border area or even to switch off the transmitter.

Figure 1: Analysis of potential impact of broadcasting transmitter into neighbouring countries



Interference may still be an issue even if the frequency use either side of a border is for the same services and utilises the same technologies. Unsynchronised time-division duplex (TDD) deployments can lead to high levels of interference. The potential interference paths in the case of unsynchronised TDD base stations deployed either side of a geographic border are shown below (see Figure 2); this is a similar scenario to a frequency-division duplex (FDD) network operating on one side of a border to a TDD network, where both radio stations transmit on the same frequency .

Figure 2: Impact of cross-border deployments



In such deployment scenarios, the significant impact is base station interference, as the height and EIRP[6] of base stations are greater than those of user terminals. Also, the base stations are at fixed locations so the potential for the interference is always present. Any co-ordination thresholds that are designed to limit base station to base station interference will also cover, by proxy, the coordination threshold requirements of base station to user terminal, user terminal to base station and user terminal to user terminal co-channel interference paths[7].

A further example is the impact of cross-border deployments in the 3.4 to 4.2 GHz bands, a topic that is currently high profile in those countries where there is extensive use of C-band for satellites and a demand to release frequencies for mobile broadband (5G). This is particularly challenging where one country may decide to use the same frequencies for satellite and the neighbouring country for mobile broadband, as the two services cannot readily co-exist. This can lead to spectrum not being viable for mobile broadband in border areas leading to inefficient spectrum use and restrictions on the economic benefit available.

Effectively addressing cross-border interference

From our studies, an effective solution can be developed to harmonise the use and associated band plans between neighbouring countries[8] – to minimise the potential for interference. This can be undertaken on a regional basis; for example, within EU countries which may be subject to European Commission Regulations, Directives, and harmonising and implementing Decisions. However, it may not always be appropriate to render a common agreement due to varied spectrum or services demands across countries. In all instances, it will be necessary to determine and agree on appropriate interference threshold levels that will mitigate the impact of interference[9].

If the potential for interference is identified, then there are options for mitigation inclusive of:

- locating the transmitter sites to take advantage of local shielding, such as trees or buildings;
- limiting transmitter powers noting this will impact on coverage and potentially service quality;
- minimising antenna heights to that necessary to meet coverage requirements;
- using antenna downtilts;
- using directional antennas to direct the emissions towards the target area while minimising spillage into the neighbouring regions;
- locating transmitters at the borders facing inwards to minimise the signals transmitting into the neighbouring region or country;
- deploying heterogenous networks so that pico-cells and micro-cells, with less potential for interference, are deployed in border areas;
- identifying preferred and non-preferred frequencies either side of the border;
- use of guard bands; and
- synchronising networks and using common uplink-downlink ratios in the case of TDD deployments.

In the case of land mobile (professional and private mobile radio) countries have typically used preferred and non-preferred frequencies either side of the border with the non-preferred frequencies having more stringent levels identified as the trigger for co-ordination. Outside of border areas all frequencies will typically be available.

In Europe there is existing guidance that defines planning criteria and provides indicative threshold protection levels such as CEPT ECC Recommendation 25/08[10] which applies to land mobile in the frequency range 29.7 to 470 MHz. Such guidance can potentially be applied to other regions.

Synchronisation of mobile broadband networks between operators is becoming an accepted solution although it limits an operator's flexibility to modify the uplink and downlink ratio based on real time traffic. Different frame configurations are available and for example to attain synchronisation between LTE TDD and 5G New Radio the frame structure for LTE can use 3:1 DL/UL ratio and 5G NR a frame structure of 8:2 DL/UL ratio both with a 5ms DL/UL switching period.

Other solutions may be necessary where adjacent countries are located in different ITU Regions and spectrum use differs. In such instances, when spectrum is being refarmed for a new service, it may be necessary to implement temporary measures to avoid interference until spectrum use is aligned in both countries. Temporary measures may include new services not being deployed within a set distance of the border or the need for detailed co-ordination of new sites on a case by case basis.

Real world application

It is becoming increasingly difficult to identify frequencies for new technologies and services that are not currently already used. This requires well thought through new deployment strategies within a country and with neighbouring countries. The changing nature of services and assignments (for example, 5G and spectrum for industry applications) means there is an increasing need to pay attention to cross border interference including coordination of release of spectrum and establishment of agreements that set out conditions to mitigate the risk of interference between countries and regions. Failure to undertake cross border coordination optimally potentially leads to dissatisfied users, lessens confidence in services and creates an inability to maximise benefits. The impact applies to both entrants and incumbents. Ideally the regulator is best placed to put in place such agreements within their country and with neighbouring administrations.

From our experience with broadcast networks (such as the analogue TV Italian case) and from our work with other clients around the world on cross-border deployments, we have concluded that a number of practical and pragmatic solutions can be employed to significantly mitigate the cross-border interference problem. Several of these involve modest implementational cost; others may require larger commitments.

It is important that appropriate cross-border sharing parameters are agreed and these are implemented to facilitate, as necessary, detailed co-ordination. Plum has previously helped regulators and operators carry out analysis of current spectrum usage, identification of existing co-existence requirements, undertaking coexistence analysis, identifying potential mitigation measures and establishing coordination requirements.

Our engineering team have many years of experience in developing impact scenarios, analysing them and identifying spectrum coordination requirements which form the foundation of any cross border interference study and development of an appropriate plan. We apply a combination of analytic calculations and deterministic & probabilistic simulation analysis to analyse scenarios and identify coordination conditions.

Typically, cross border coordination proposals will be subject to discussions between neighbouring administration and in the case of regional borders to a consultation process where parties involved have a chance to express their opinion. Plum can analyse submissions by stakeholders to such a consultation, develop an appropriate response and suggest amendments to the plan, where necessary, in collaboration with the national regulator.

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[i] Geographic regions may be defined within a country for the award of spectrum where national licences are not the preferred option.
[2] Ducting is caused by refraction when there are changes in temperature of the atmosphere leading to a duct of cool air being formed between layers of warm air. Signals captured in the duct can travel over much larger distances. This typically occurs in the VHF and UHF bands.
[3] These studies were undertaken for the GSMA in June 2009.
[4] We modelled the interference for 1% of time to the most likely affected neighbouring countries using the ITU Propagation Model P.1812.
[5] 10 dBµv/m corresponded approximately to the lower threshold being considered by CEPT as a trigger for cross-border co-ordination between TV transmitters and mobile base stations. On this basis 0-10 dBµv/m constitutes a small risk of interference, 10-20 dBµv/m a moderate risk and >20 dBµv/m a relatively high risk.
[6] Effective Isotropic radiated power
[7] This means that the co-existence requirements of other interference paths will be less stringent than those of base station to base station interference.
[8] A similar approach can be adopted for regional licences within a country. In this instance, the expectation is that the administration will define technical licence conditions that will limit the potential for interference between the regional licensees. It may also place the responsibility for mitigating interference with the licensees with the administration becoming involved only if any dispute cannot be resolved between the licensees themselves.
[9] For example, in ECC Report 203 it notes the need "to define threshold levels to identify whether there is the potential for interference between two services". These levels are based on "typical / representative receiver characteristics". The actual value defined for the thresholds depends on how they are set. For example, they may be 6dB below the victim receiver noise floor, at the receiver noise floor or 6 dB above the noise floor.
[10] https://www.ecodocdb.dk/download/063e7311-fba7/TR2508.pdf